FCC PART 15, SUBPART C
ISEDC RSS-247, ISSUE 2, FEBRUARY 2017
TEST AND MEASUREMENT REPORT

For

ROOST, Inc.

1250 Borregas Ave., Sunnyvale, CA 94089, USA

FCC ID: 2AE5A-TRTN
IC: 20891-TRTN

Report Type:	**Product Type:**
Class II Permissive Change Report	ISM Band Transmitter and Receiver

Prepared By:	Matthew Riego de Dios Test Technician
Report Number	R1908063-247
Report Issue Date:	2019-12-19
Reviewed By:	Simon Ma RF Supervisor

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ACCREDITED
CERTIFICATE #3297.02

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DOCUMENT REVISION HISTORY

Revision Number	Report Number	Description of Revision	Date of Revision
0	R1908063-247 DSS	Original	2019-12-19

1 General Description

1.1 Product Description for Equipment Under Test (EUT)

This test and measurement report was prepared on behalf of *Roost, Inc* and their product model: *TRTN,* FCC ID: 2AE5A-TRTN; IC: 20891-TRTN or the "EUT" as referred to in this report. It is a 900 MHz modular ISM Band Transmitter and Receiver with I/O signals to be integrated into IOT products.

1.2 Mechanical Description of EUT

The EUT measures approximately 140 mm (Diameter), 40 mm (Thickness) and weight 0.35lb.

The test data gathered are from typical production sample, serial number: R1906282-1 assigned by BACL

1.3 Objective

This report is prepared on behalf of *Roost, Inc.,* in accordance with Part 2, Subpart J, and Part 15, Subparts B and C of the Federal Communication Commission's rules and ISEDC RSS-247 Issue 2, February 2017.

The objective is is a Permissive Change II submission to determine compliance with FCC Part 15.247 and ISEDC RSS-247 to allow TRTN module colocation with other radio modules installed in host products, Model: RSB-300. The modules includes:

WiFi Radio (FCC ID: 2ADHKATWINC1500, IC: 20266-WINC1500PB)
Or LTE Radio (FCC ID: XMR 201707BG96, IC: 10224A-201709BG96)

1.4 Related Submittal(s)/Grant(s)

N/A

1.5 Test Methodology

All measurements contained in this report were conducted in accordance with ANSI C63.10-2013, American National Standard of Procedures for Compliance Testing of Unlicensed Wireless Devices.

1.6 Measurement Uncertainty

All measurements involve certain levels of uncertainties, especially in the field of EMC. The factors contributing to uncertainties are spectrum analyzer, cable loss, antenna factor calibration, antenna directivity, antenna factor variation with height, antenna phase center variation, antenna factor frequency interpolation, measurement distance variation, site imperfections, mismatch (average), and system repeatability.

Based on CISPR16-4-2:2011, The Treatment of Uncertainty in EMC Measurements, the values ranging from $\pm$2.0 dB for Conducted Emissions tests and $\pm$4.0 dB for Radiated Emissions tests are the most accurate estimates pertaining to uncertainty of EMC measurements at BACL Corp.

1.7 Test Facility

Bay area compliance Laboratories Corp. (BACL) is:
1- An independent Commercial Test Laboratory accredited to **ISO 17025: 2005** by **A2LA**, in the fields of: Electromagnetic Compatibility & Telecommunications covering Emissions, Immunity, Radio, RF Exposure, Safety and Telecom. This includes NEBS (Network Equipment Building System), Wireless RF, Telecommunications Terminal Equipment (TTE); Network Equipment; Information Technology Equipment (ITE); Medical Electrical Equipment; Industrial, Commercial, and Medical Test Equipment; Professional Audio and Video Equipment; Electronic (Digital) Products; Industrial and Scientific Instruments; Cabled Distribution Systems and Energy Efficiency Lighting.

2- An ENERGY STAR Recognized Laboratory, for the LM80 Testing, a wide variety of Luminares and Computers.

3- A NIST Designated Phase-I and Phase-II CAB including: ACMA (Australian Communication and Media Authority), BSMI (Bureau of Standards, Metrology and Inspection of Taiwan), IDA (Infocomm Development Authority of Singapore), IC(Industry Canada), Korea (Ministry of Communications Radio Research Laboratory), NCC (Formerly DGT; Directorate General of Telecommunication of Chinese Taipei) OFTA (Office of the Telecommunications Authority of Hong Kong), Vietnam, VCCI - Voluntary Control Council for Interference of Japan and a designated EU CAB (Conformity Assessment Body) (Notified Body) for the EMC and R&TTE Directives.

4- A Product Certification Body accredited to **ISO Guide 65: 1996** by **A2LA** to certify:
2. Radio Standards Specifications (RSS) in the Category I Equipment Standards List and All Broadcasting Technical Standards (BETS) in Category I Equipment Standards List for Industry Canada.
3. Radio Communication Equipment for Singapore.
4. Radio Equipment Specifications, GMDSS Marine Radio Equipment Specifications, and Fixed Network Equipment Specifications for Hong Kong.
5. Japan MIC Telecommunication Business Law (A1, A2) and Radio Law (B1, B2 and B3).
6. Audio/Video, Battery Charging Systems, Computers, Displays, Enterprise Servers, Imaging Equipment, Set-Top Boxes, Telephony, Televisions, Ceiling Fans, CFLs (Including GU24s),Decorative Light Strings, Integral LED Lamps, Luminaires, Residential Ventilating Fans.

The test site used by BACL Corp. to collect radiated and conducted emissions measurement data is located at its facility in Sunnyvale, California, USA.

The test site at BACL Corp. has been fully described in reports submitted to the Federal Communication Commission (FCC) and Voluntary Control Council for Interference (VCCI). The details of these reports have been found to be in compliance with the requirements of Section 2.948 of the FCC Rules on February 11 and December 10, 1997, and Article 8 of the VCCI regulations on December 25, 1997. The test site also complies with the test methods and procedures set forth in CISPR 22:2008 §10.4 for measurements below 1 GHz and §10.6 for measurements above 1 GHz as well as ANSI C63.10-2013, ANSI C63.4-2014, TIA/EIA-603 & CISPR 24:2010.

The Federal Communications Commission and Voluntary Control Council for Interference have the reports on file and they are listed under FCC registration number: 90464 and VCCI Registration No.: A-0027. The test site has been approved by the FCC and VCCI for public use and is listed in the FCC Public Access Link (PAL) database.

Additionally, BACL Corp. is an American Association for Laboratory Accreditation (A2LA) accredited laboratory (Lab Code 3297-02). The current scope of accreditations can be found at

http://www.a2la.org/scopepdf/3297-02.pdf?CFID=1132286&CFTOKEN=e42a3240dac3f6ba-6DE17DCB-1851-9E57-477422F667031258&jsessionid=8430d44f1f47cf2996124343c704b367816b

2 System Test Configuration

2.1 Justification

The EUT was configured for testing in accordance to ANSI C63.10.

The worst-case data rates are determined by measuring the peak power across all data rates.

2.2 EUT Exercise Software

The test utility used was SmartRF Studio 7*;* the software was verified by *Matthew Riego de Dios* to comply with the standard requirements being tested against.

2.3 Duty Cycle Correction Factor

According to KDB 558074 D01 DTS Meas Guidance v03r04 section 6.0:

Preferably, all measurements of maximum conducted (average) output power will be performed with the EUT transmitting continuously (i.e., with a duty cycle of greater than or equal to 98%). When continuous operation cannot be realized, then the use of sweep triggering/signal gating techniques can be utilized to ensure that measurements are made only during transmissions at the maximum power control level. Such sweep triggering/signal gating techniques will require knowledge of the minimum transmission duration (T) over which the transmitter is on and is transmitting at its maximum power control level for the tested mode of operation. Sweep triggering/signal gating techniques can then be used if the measurement/sweep time of the analyzer can be set such that it does not exceed T at any time that data is being acquired (i.e., no transmitter off-time is to be considered).

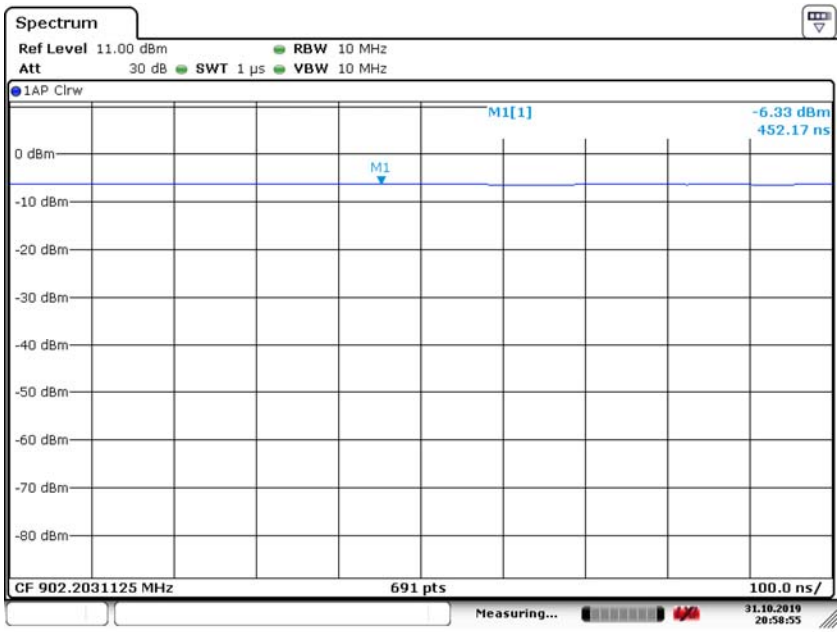
50 kbps, 2-GFSK, 25 kHz deviation, IEEE 802.15.4g MR-FSK PHY mode

Radio frequency (MHz)	On Time (ms)	Period (ms)	Duty Cycle (%)	Duty Cycle Correction Factor (dB)
902.203125	-	-	100	0
915	-	-	100	0
927.796875	-	-	100	0

Duty Cycle = On Time (ms)/ Period (ms)
Duty Cycle Correction Factor (dB) = 10*log(1/Duty Cycle)

Please refer to the following plots.

902.20 MHz



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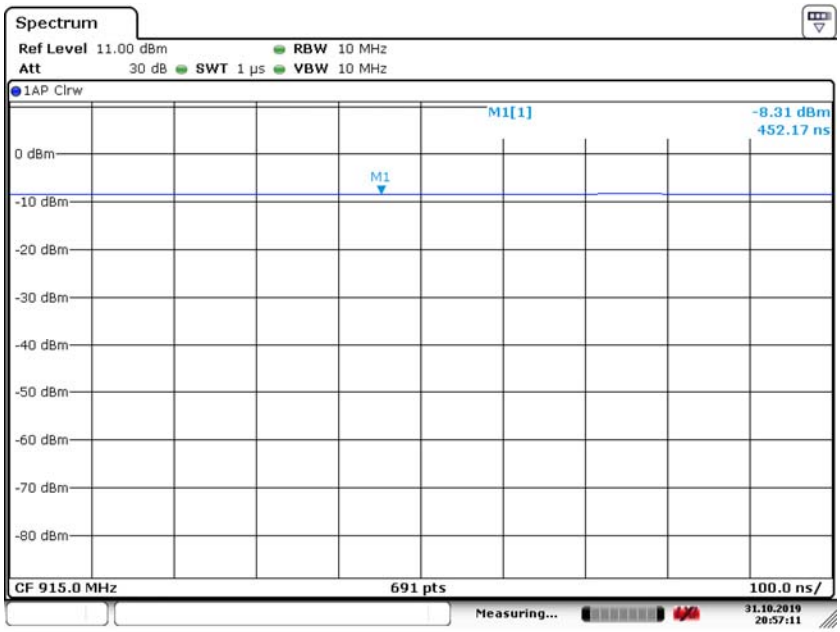
915 MHz



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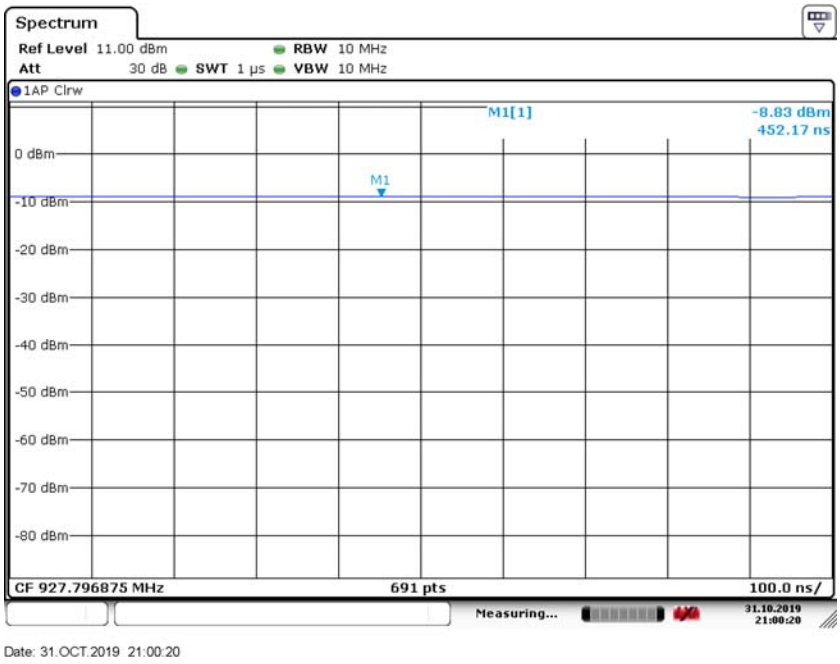
927.80 MHz



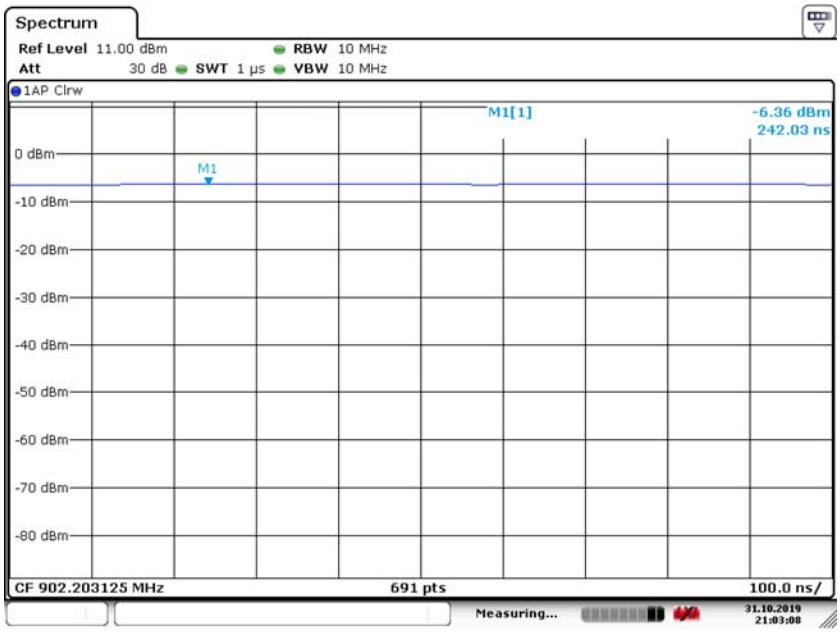
5 kbps, SimpleLink Long Range (20 kchip/s, 2-GFSK, conv. FEC r=1/2 K=7 DSSS SF=2, Tx dev:5 kHz, RX BW: 49 kHz)

Radio frequency (MHz)	On Time (ms)	Period (ms)	Duty Cycle (%)	Duty Cycle Correction Factor (dB)
902.203125	-	-	100	0
915	-	-	100	0
927.796875	-	-	100	0

Duty Cycle = On Time (ms)/ Period (ms)
Duty Cycle Correction Factor (dB) = 10*log(1/Duty Cycle)

Please refer to the following plots.

902.20 MHz



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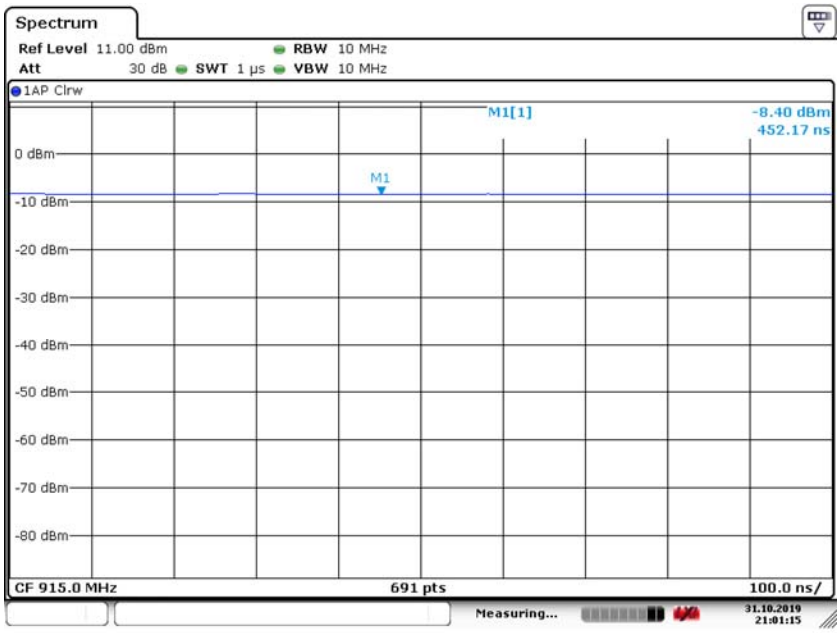
915 MHz



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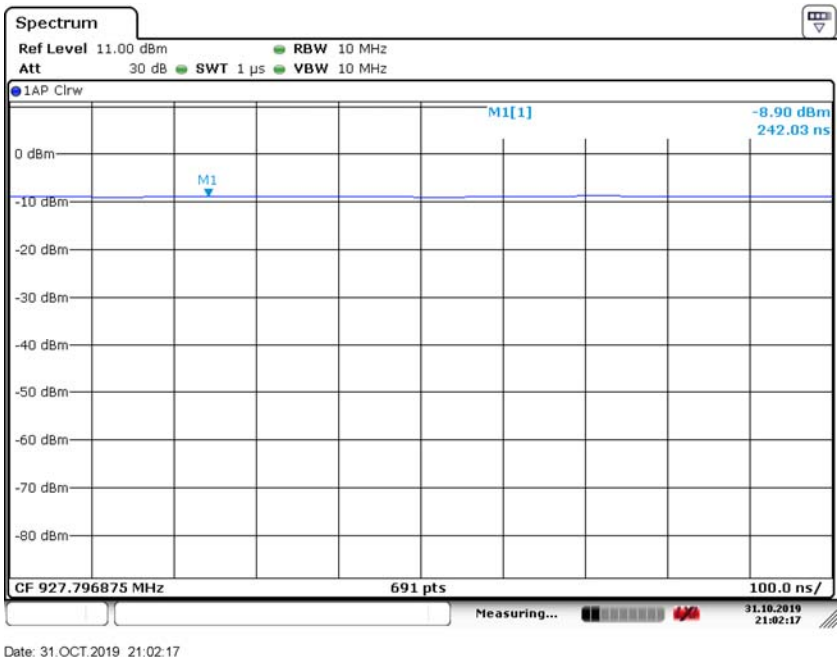
927.80 MHz



2.4 Equipment Modifications

N/A

2.5 Local Support Equipment

Manufacturer	Description	Model
Dell	Laptop	Latitude E6410

2.6 Support Equipment

Manufacturer	Description	Model
Texas Instruments IC	Eval Board	CC1310

2.7 Interface Ports and Cabling

Cable Description	Length (m)	To	From
Type A to Micro B USB Cable	< 1 m	Laptop	Control Board
SMA Cable	< 1 m	EUT	PSA
Jumper Cable	< 1 m	EUT	Control Board
Type B USB	< 1 m	Laptop	Adapter
I^2C/SPI Ribbon Cable	< 1 m	EUT	Adapter

3 Summary of Test Results

Results reported relate only to the product tested.

FCC & ISEDC Rules	Description of Test	Results
FCC §15.207 ISEDC RSS-Gen §8.8	AC Line Conducted Emissions	Compliant
FCC §2.1091, §15.247(i) ISEDC RSS-102	RF Exposure	Compliant
FCC §2.1053, §15.205, §15.209, §15.247(d) ISEDC RSS-247 §5.5 ISEDC RSS-Gen §8.9, §8.10	Radiated Spurious Emissions	Compliant

4 FCC §2.1091, §15.247(i) & ISEDC RSS-102 - RF Exposure

4.1 Applicable Standards

According to FCC §15.247(i) and §1.1307(b)(1), systems operating under the provisions of this section shall be operated in a manner that ensures that the public is not exposed to radio frequency energy level in excess of the Commission's guidelines.

According to KDB 447 498 Section (7.2), "simultaneous transmission of MPE test exclusion applies when the sum of the MPE ratios for all simultaneous transmitting antennas incorporated in a host device, based on calculated or measured field strengths or power density, is ≤ 1.0. The MPE ratio of each antenna is determined at the minimum *test separation distance* required by the operating configurations and exposure conditions of the host device, according to the ratio of field strengths or power density to MPE limit, at the test frequency.

Limits for General Population/Uncontrolled Exposure

Frequency Range (MHz)	Electric Field Strength (V/m)	Magnetic Field Strength (A/m)	Power Density (mW/cm^2)	Averaging Time (minutes)
Limits for General Population/Uncontrolled Exposure				
0.3-1.34	614	1.63	* (100)	30
1.34-30	824/f	2.19/f	* ($180/f^2$)	30
30-300	27.5	0.073	0.2	30
300-1500	/	/	f/1500	30
1500-100,000	/	/	1.0	30

Where: f = frequency in MHz
* = Plane-wave equivalent power density

Before equipment certification is granted, the procedure of IC RSS-102 must be followed concerning the exposure of humans to RF field.

4.2 MPE Prediction

Predication of MPE limit at a given distance, Equation from OET Bulletin 65, Edition 97-01

$$S = PG/4\pi R^2$$

Where: S = power density
P = power input to antenna
G = power gain of the antenna in the direction of interest relative to an isotropic radiator
R = distance to the center of radiation of the antenna

4.3 MPE Results

Sub1G TRTN Radio

Maximum peak output power at antenna input terminal (dBm):	5.16
Maximum peak output power at antenna input terminal (mW):	3.281
Prediction distance (cm):	20
Prediction frequency (MHz):	902.20
Maximum Antenna Gain, typical (dBi):	-1.2
Maximum Antenna Gain (numeric):	0.75858
Power density of prediction frequency at 20.0 cm (mW/cm^2):	0.0005
FCC MPE limit for uncontrolled exposure at prediction frequency (mW/cm^2):	0.60
MPE Ratio (numeric):	0.00083

The device is compliant with the requirement MPE limit for uncontrolled exposure. The maximum power density at the distance of 20 cm is 0.0005 mW/cm^2. Limit is 0.60 mW/cm^2.

Wi-Fi Radio (FCC ID: 2ADHKATWINC1500, IC: 20266-WINC1500PB)

Maximum peak output power at antenna input terminal (dBm):	23.03
Maximum peak output power at antenna input terminal (mW):	200.9
Prediction distance (cm):	20
Prediction frequency (MHz):	2437
Maximum Antenna Gain, typical (dBi):	-3
Maximum Antenna Gain (numeric):	0.501
Power density of prediction frequency at 20.0 cm (mW/cm^2):	0.02003
FCC MPE limit for uncontrolled exposure at prediction frequency (mW/cm^2):	1.0
MPE Ratio(numeric):	0.02003

Note: Please refer to FCC report no: EMC98105-MPE Rev. 1

The device is compliant with the requirement MPE limit for uncontrolled exposure. The maximum power density at the distance of 20 cm is 0.02003 mW/cm^2. Limit is 1.0 mW/cm^2.

LTE Radio (FCC ID: XMR 201707BG96, IC: 10224A-201709BG96)

Band	PG (mW)	Test Result (mW/cm^2)	Limit Value (mW/cm^2)	The MPE ratio
GSM 850	444.84	0.088	0.55	0.161
GSM 1900	222.95	0.044	1.00	0.044
LTE Band 2	447.92	0.089	1.00	0.089
LTE Band 4	355.80	0.071	1.00	0.071
LTE Band 5	447.92	0.089	0.55	0.162
LTE Band 12	447.92	0.089	0.47	0.190
LTE Band 13	447.92	0.089	0.52	0.171
LTE Band 26	447.92	0.089	0.54	0.165
Note: The MPE ratio = Mac Test Result÷Limit Value				

Note: For transmitters, minimum separation distance is 20cm, even if calculations indicate MPE distance is less.

Note: Please refer to FCC report no: RXA1706-0199MPE.
Note: LTE Band 12 is found to be the worst case from the table given. This information is used to analyze the LTE Radio for this report.

The TRTN can transmit with WiFi simultaneously or transmit with LTE radios simultaneously. The combined MPE ratios is 0.00083 + 0.02003 = 0.02086 or 0.00083 + 0.190 = 0.19083 which are less than the limit of 1.0.

4.4 RF exposure evaluation exemption for ISEDC

Sub1G TRTN Radio

Maximum EIRP power = 5.16dBm – 1.2 dBi = 3.96 dBm which is less than $1.31\times10^{-2}f^{0.6834}$ = 1.3706 W = 31.37 dBm

Therefore the RF exposure Evaluation is not required.

Wi-Fi Radio (FCC ID: 2ADHKATWINC1500, IC: 20266-WINC1500PB)

Maximum EIRP power = 23.03dBm – 3 dBi = 20.3 dBm which is less than $1.31\times10^{-2}f^{0.6834}$ = 1.3706 W = 31.37 dBm

Therefore the RF exposure Evaluation is not required.

LTE Radio (FCC ID: XMR 201707BG96, IC: 10224A-201709BG96)

Maximum EIRP power = 26.51 dBm which is less than $1.31\times10^{-2}f^{0.6834}$ = 1.3706 W = 31.37 dBm

Therefore the RF exposure Evaluation is not required.

5 FCC §15.207 & ISEDC RSS-Gen §8.8 – AC Line Conducted Emissions

5.1 Applicable Standards

As per FCC §15.207 and IC RSS-Gen §8.8 Conducted limits:

For an intentional radiator that is designed to be connected to the public utility (AC) power line, the radio frequency voltage that is conducted back onto the AC power line on any frequency or frequencies within the band 150 kHz to 30 MHz shall not exceed the limits in the following table, as measured using a 50 μH/50 ohms line impedance stabilization network (LISN). Compliance with the provisions of this paragraph shall be based on the measurement of the radio frequency voltage between each power line and ground at the power terminal. The lower limit applies at the boundary between the frequencies ranges.

Frequency of Emission (MHz)	Conducted Limit (dBuV)	
	Quasi-Peak	Average
0.15-0.5	66 to 56 Note1	56 to 46 Note2
0.5-5	56	46
5-30	60	50

Note1: Decreases with the logarithm of the frequency.
Note2: A linear average detector is required

5.2 Test Setup

The measurement was performed at shield room, using the setup per ANSI C63.10-2013 measurement procedure. The specification used were FCC §15.207 and IC RSS-Gen §8.8 limits.

External I/O cables were draped along the edge of the test table and bundle when necessary.

The AC/DC power adapter of the laptop (connected to the Host) was connected with LISN-1 which provided 120 V / 60 Hz AC power.

5.3 Test Procedure

During the conducted emissions test, the power cord of the EUT host system was connected to the mains outlet of the LISN-1 and the power cords of support equipment were connected to LISN-2.

Maximizing procedure was performed on the six (6) highest emissions of the EUT.

All data were recorded in the peak, quasi-peak, and average detection mode. Quasi-Peak readings are distinguished with a “QP.” Average readings are distinguished with an “Ave”.

5.4 Corrected Amplitude & Margin Calculation

The Corrected Amplitude (CA) is calculated by adding the Cable Loss (CL), the Attenuator Factor (Atten) to indicated Amplitude (Ai) reading. The basic equation is as follows:

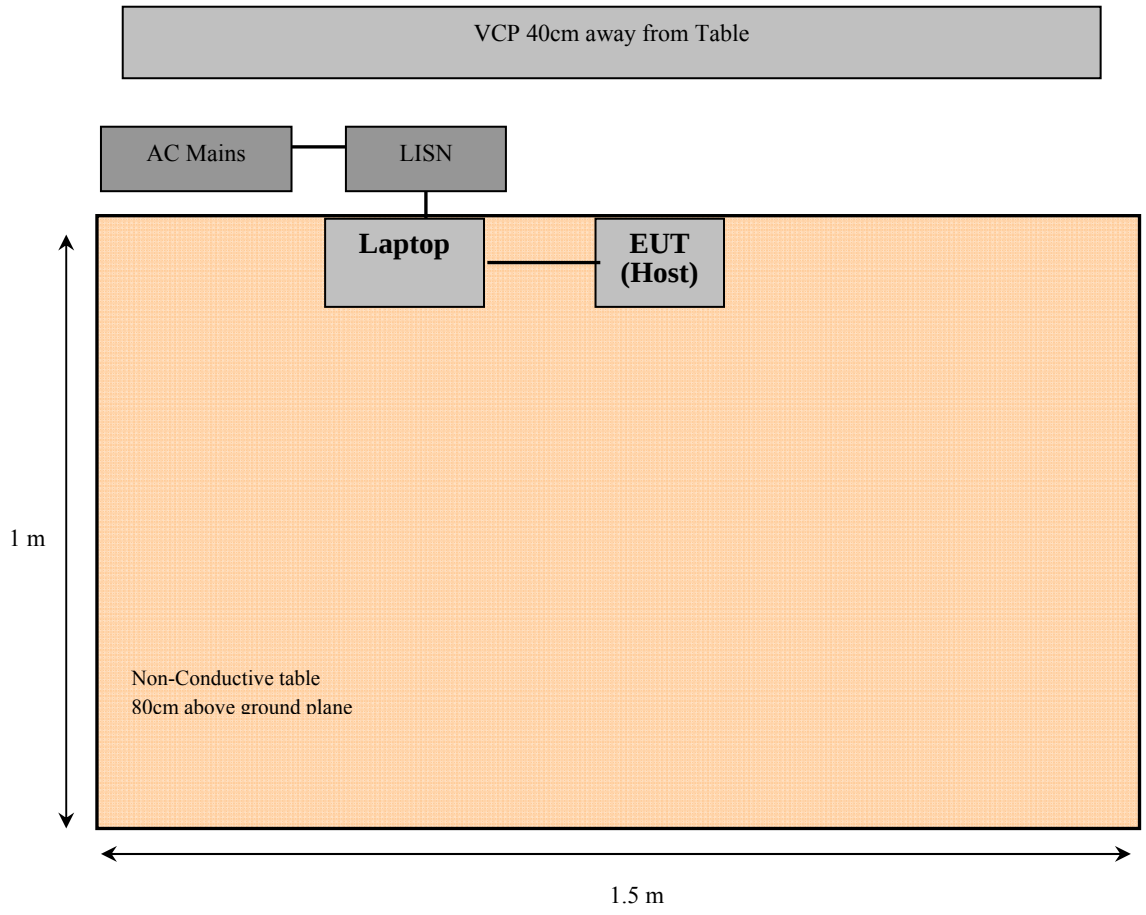
CA = Ai + CL + Atten

For example, a corrected amplitude of 46.2 dBuV = Indicated Reading (32.5 dBuV) + Cable Loss (3.7 dB) + Attenuator (10 dB)

The "**Margin**" column of the following data tables indicates the degree of compliance within the applicable limit. For example, a margin of -7 dB means the emission is 7 dB below the maximum limit. The equation for margin calculation is as follows:

Margin = Corrected Amplitude – Limit

5.5 Test Setup Block Diagram



5.6 Test Equipment List and Details

Manufacturer	Description	Model No.	Serial No.	Calibration Date	Calibration Interval
Rohde & Schwarz	Receiver, EMI Test	ESCI 1166.5950.03	100338	2018-07-05	2 years
Rohde & Schwarz	Impulse Limiter	ESH3-Z2	101964	2019-07-31	1 year
Solar Electronics Company	High Pass Filter	Type 7930-100	7930150202	2019-02-25	1 year
FCC	LISN	FCC-LISN-50-25-2-10-CISPR16	160129	2019-04-11	1 year

Statement of Traceability: BACL Corp. *attests that all calibrations have been performed per the A2LA requirements, traceable to the NIST.*

5.7 Test Environmental Conditions

Temperature:	23° C
Relative Humidity:	44 %
ATM Pressure:	102.1 kPa

The testing was performed by Matthew Riego de Dios on 2019-10-29.

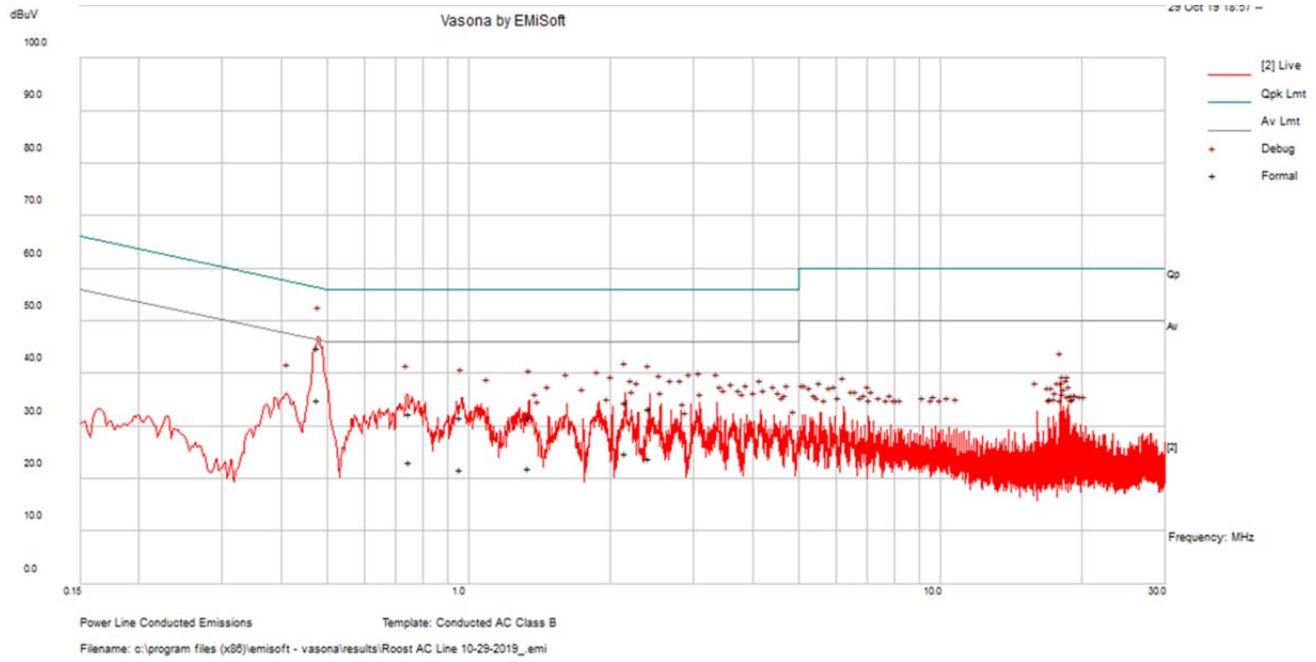
5.8 Summary of Test Results

According to the recorded data in following table, the EUT complied with the FCC 15C and IC RSS-Gen standard's conducted emissions limits, with the margin reading of:

Connection: AC/DC adaptor connected to 120 V/60 Hz, AC			
Margin (dB)	**Frequency (MHz)**	**Conductor Mode (Live/Neutral)**	**Range (MHz)**
-9.20	0.470758	Live	0.15-30

5.9 Conducted Emissions Test Plots and Data

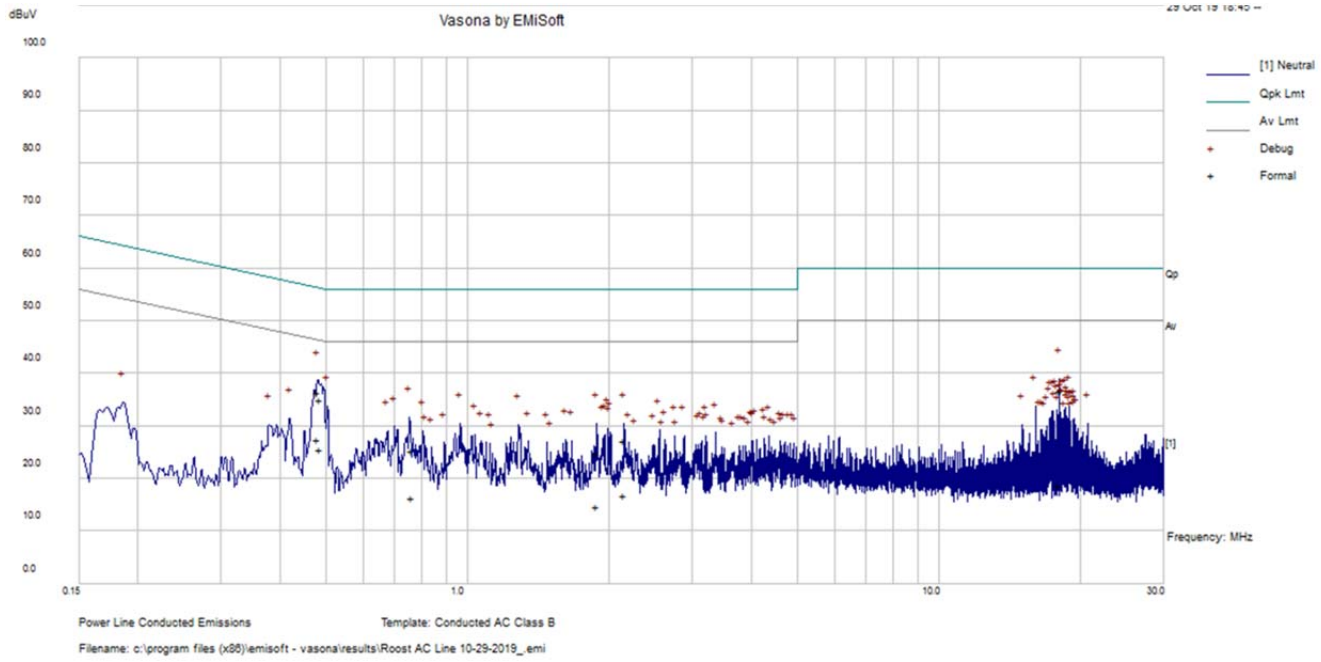
120 V, 60 Hz – Line



Frequency (MHz)	Corrected Amplitude (dBuV)	Conductor (Line/Neutral)	Limit (dBuV)	Margin (dB)	Detector (QP/Ave.)
0.478700	44.88	Line	56.36	-11.48	QP
2.148077	34.40	Line	56.00	-21.60	QP
2.417404	33.23	Line	56.00	-22.77	QP
0.750046	32.49	Line	56.00	-23.51	QP
0.959799	31.74	Line	56.00	-24.26	QP
1.340410	31.58	Line	56.00	-24.42	QP

Frequency (MHz)	Corrected Amplitude (dBuV)	Conductor (Line/Neutral)	Limit (dBuV)	Margin (dB)	Detector (QP/Ave.)
0.478700	35.08	Line	46.36	-11.28	Ave.
2.148077	24.89	Line	46.00	-21.11	Ave.
2.417404	23.93	Line	46.00	-22.07	Ave.
0.750046	23.13	Line	46.00	-22.87	Ave.
0.959799	21.83	Line	46.00	-24.17	Ave.
1.340410	22.03	Line	46.00	-23.97	Ave.

120 V, 60 Hz – Neutral

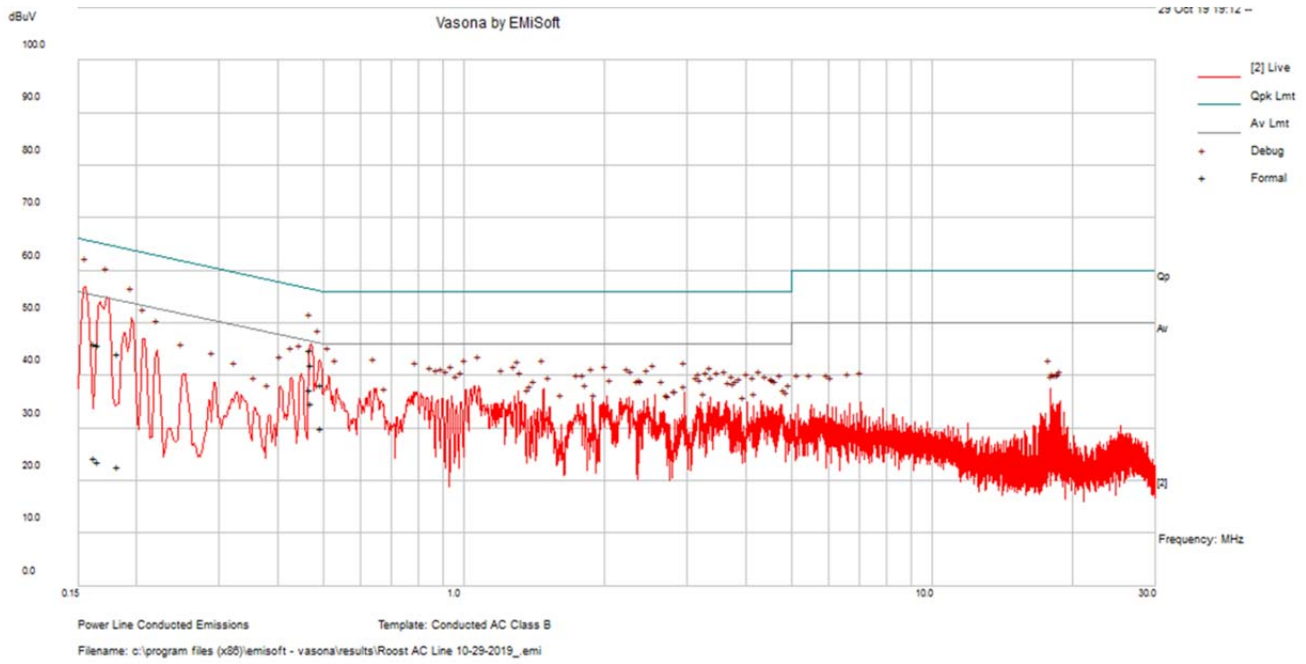


Frequency (MHz)	Corrected Amplitude (dBuV)	Conductor (Line/Neutral)	Limit (dBuV)	Margin (dB)	Detector (QP/Ave.)
0.481094	36.44	Neutral	56.32	-19.88	QP
18.000422	36.53	Neutral	60.00	-23.47	QP
0.487687	35.05	Neutral	56.21	-21.16	QP
0.762205	25.39	Neutral	56.00	-30.61	QP
2.148167	27.2	Neutral	56.00	-28.80	QP
1.876817	24.8	Neutral	56.00	-31.20	QP

Frequency (MHz)	Corrected Amplitude (dBuV)	Conductor (Line/Neutral)	Limit (dBuV)	Margin (dB)	Detector (QP/Ave.)
0.481094	27.45	Neutral	46.32	-18.87	Ave.
18.000422	18.64	Neutral	50.00	-31.36	Ave.
0.487687	25.49	Neutral	46.21	-20.72	Ave.
0.762205	16.25	Neutral	46.00	-29.75	Ave.
2.148167	16.76	Neutral	46.00	-29.24	Ave.
1.876817	14.72	Neutral	46.00	-31.28	Ave.

Worst Case Colocation: TRTN 50 kbps 2-GFSK, 25 kHz deviation, IEEE 802.15.4g MR-FSK PHY mode 915 MHz and LTE Band 4 mid channel 1732MHz

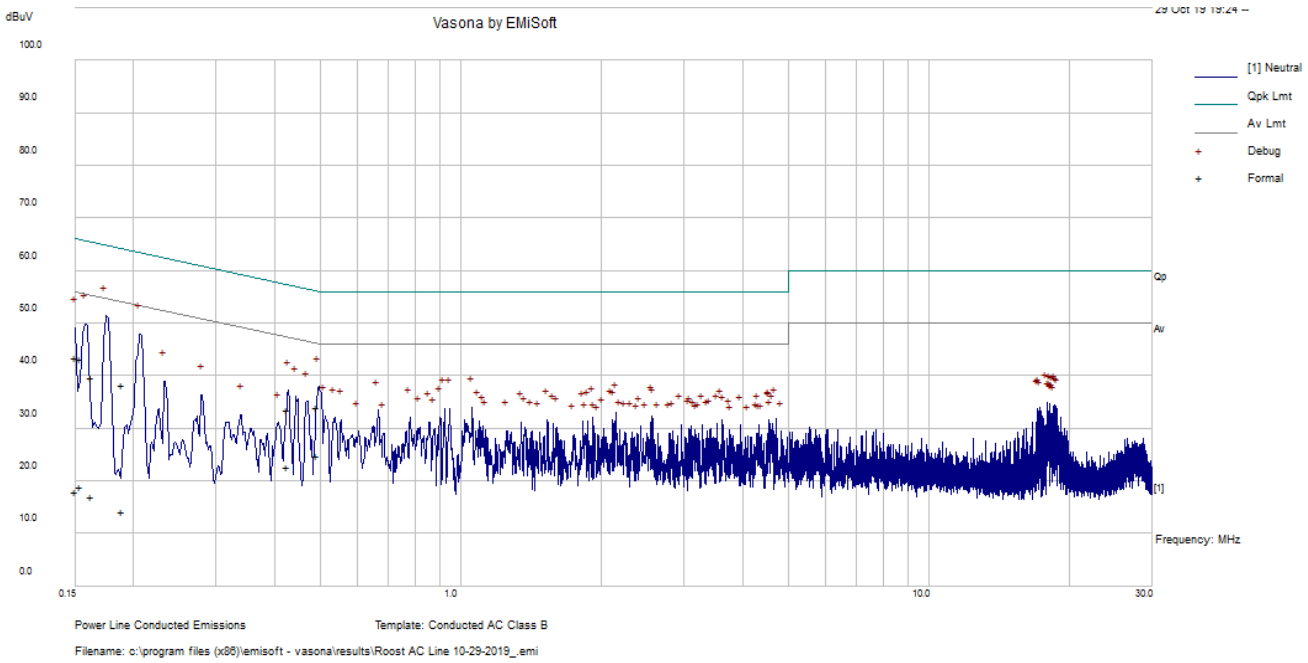
120 V, 60 Hz – Line



Frequency (MHz)	Corrected Amplitude (dBuV)	Conductor (Line/Neutral)	Limit (dBuV)	Margin (dB)	Detector (QP/Ave.)
0.165965	45.78	Line	65.16	-19.38	QP
0.162198	46.09	Line	65.35	-19.26	QP
0.470758	44.99	Line	56.50	-11.52	QP
0.182802	44.08	Line	64.36	-20.28	QP
0.473387	42.18	Line	56.45	-14.27	QP
0.495863	38.23	Line	56.07	-17.84	QP

Frequency (MHz)	Corrected Amplitude (dBuV)	Conductor (Line/Neutral)	Limit (dBuV)	Margin (dB)	Detector (QP/Ave.)
0.165965	23.54	Line	55.16	-31.62	Ave.
0.162198	24.27	Line	55.35	-31.08	Ave.
0.470758	37.3	Line	46.50	-9.20	Ave.
0.182802	22.81	Line	54.36	-31.55	Ave.
0.473387	34.65	Line	46.45	-11.80	Ave.
0.495863	29.93	Line	46.07	-16.13	Ave.

120 V, 60 Hz – Neutral



Frequency (MHz)	Corrected Amplitude (dBuV)	Conductor (Line/Neutral)	Limit (dBuV)	Margin (dB)	Detector (QP/Ave.)
0.162498	39.80	Neutral	65.34	-25.53	QP
0.188703	38.30	Neutral	64.09	-25.79	QP
0.154168	43.20	Neutral	65.77	-22.57	QP
0.150154	43.57	Neutral	65.99	-22.42	QP
0.493635	33.96	Neutral	56.11	-22.14	QP
0.427114	33.67	Neutral	57.31	-23.64	QP

Frequency (MHz)	Corrected Amplitude (dBuV)	Conductor (Line/Neutral)	Limit (dBuV)	Margin (dB)	Detector (QP/Ave.)
0.162498	16.93	Neutral	55.34	-38.41	Ave.
0.188703	14.13	Neutral	54.09	-39.96	Ave.
0.154168	18.89	Neutral	55.77	-36.88	Ave.
0.150154	18.02	Neutral	55.99	-37.98	Ave.
0.493635	24.88	Neutral	46.11	-21.23	Ave.
0.427114	22.80	Neutral	47.31	-24.51	Ave.

6 FCC §15.209, §15.247(d) & ISEDC RSS-247 §5.5, RSS-Gen §8.9, §8.10 - Spurious Radiated Emissions

6.1 Applicable Standards

As per FCC §15.35(d): Unless otherwise specified, on any frequency or frequencies above 1000 MHz, the radiated emission limits are based on the use of measurement instrumentation employing an average detector function. Unless otherwise specified, measurements above 1000 MHz shall be performed using a minimum resolution bandwidth of 1 MHz.

As Per FCC §15.205(a) and RSS-Gen except as show in paragraph (d) of this section, only spurious emissions are permitted in any of the frequency bands listed below:

MHz	MHz	MHz	GHz
0.090 – 0.110 0.495 – 0.505 2.1735 – 2.1905 4.125 – 4.128 4.17725 – 4.17775 4.20725 – 4.20775 6.215 – 6.218 6.26775 – 6.26825 6.31175 – 6.31225 8.291 – 8.294 8.362 – 8.366 8.37625 – 8.38675 8.41425 – 8.41475 12.29 – 12.293 12.51975 – 12.52025 12.57675 – 12.57725 13.36 – 13.41	16.42 – 16.423 16.69475 – 16.69525 25.5 – 25.67 37.5 – 38.25 73 – 74.6 74.8 – 75.2 108 – 121.94 123 – 138 149.9 – 150.05 156.52475 – 156.52525 156.7 – 156.9 162.0125 –167.17 167.72 – 173.2 240 – 285 322 – 335.4 399.9 – 410 608 – 614	960 – 1240 1300 – 1427 1435 – 1626.5 1645.5 – 1646.5 1660 – 1710 1718.8 – 1722.2 2200 – 2300 2310 – 2390 2483.5 – 2500 2690 – 2900 3260 – 3267 3.332 – 3.339 3 3458 – 3 358 3.600 – 4.400	4. 5 – 5. 15 5. 35 – 5. 46 7.25 – 7.75 8.025 – 8.5 9.0 – 9.2 9.3 – 9.5 10.6 – 12.7 13.25 – 13.4 14.47 – 14.5 15.35 – 16.2 17.7 – 21.4 22.01 – 23.12 23.6 – 24.0 31.2 – 31.8 36.43 – 36.5 Above 38.6

As per FCC §15.209(a): Except as provided elsewhere in this Subpart, the emissions from an intentional radiator shall not exceed the field strength levels specified in the following table:

Frequency (MHz)	Field Strength (micro volts/meter)	Measurement Distance (meters)
0.009 - 0.490	2400/F(kHz)	300
0.490 - 1.705	24000/F(kHz)	30
1.705 - 30.0	30	30
30 - 88	100**	3
88 - 216	150**	3
216 - 960	200**	3
Above 960	500	3

** Except as provided in paragraph (g), fundamental emissions from intentional radiators operating under this Section shall not be located in the frequency bands 54-72 MHz, 76-88 MHz, 174-216 MHz or 470-806 MHz. However, operation within these frequency bands is permitted under other sections of this Part, e.g., Sections 15.231 and 15.241.

As per FCC §15.247 (d) In any 100 kHz bandwidth outside the frequency band in which the spread spectrum or digitally modulated intentional radiator is operating, the radio frequency power that is produced by the intentional radiator shall be at least 20 dB below that in the 100 kHz bandwidth within the band that contains the highest level of the desired power, based on either an RF conducted or a radiated measurement, provided the transmitter demonstrates compliance with the peak conducted power limits. If the transmitter complies with the conducted power limits based on the use of RMS averaging over a time interval, as permitted under paragraph (b)(3) of this section, the attenuation required under this paragraph shall be 30 dB instead of 20 dB. Attenuation below the general limits specified in §15.209(a) is not required. In addition, radiated emissions which fall in the restricted bands, as defined in §15.205(a), must also comply with the radiated emission limits specified in §15.209(a) (see §15.205(c).

As per ISEDC RSS-Gen 8.9,

Except when the requirements applicable to a given device state otherwise, emission from licence-exempt transmitters shall company with the field strength limits shown in the table below. Additional, the level of any transmitter emission shall not exceed the level of the transmitter's fundamental emission.

General Field Strength Limits for Licence-Exemption Transmitters at Frequencies above 30 Mhz

Frequency (MHz)	**Field Strength (µv/m at 3 meters)**
30-88	100
88-216	150
216-960	200
Above 960*	500

* Unless otherwise specified, for all frequencies greater than 1 GHz, the radiated emission limits for licence-exempt radio apparatus stated in applicable RSSs (including RSS-Gen) are based on measurements using a linear average detector function having a minimum resolution bandwidth of 1 MHz. If an average limit is specified for the EUT, then the peak emission shall also be measured with instrumentation properly adjusted for such factors as pulse desensitization to ensure the peak emission is less than 20 dB above the average limit.

Note: Transmitting devices are not permitted in restricted frequency bands unless stated otherwise in the specific RSS.

As per ISEDC RSS-247 §5.5, in any 100 kHz bandwidth outside the frequency band in which the spread spectrum or digitally modulated device is operating, the RF power that is produced shall be at least 20 dB below that in the 100 kHz bandwidth within the band that contains the highest level of the desired power, based on either an RF conducted or a radiated measurement, provided that the transmitter demonstrates compliance with the peak conducted power limits. If the transmitter complies with the conducted power limits based on the use of root-mean-square averaging over a time interval, as permitted under Section 5.4(4), the attenuation required shall be 30 dB instead of 20 dB. Attenuation below the general field strength limits specified in RSS-Gen is not required.

6.2 Test Setup

The radiated emissions tests were performed in the 5-meter Chamber, using the setup in accordance with ANSI C63.10-2013. The specification used was the FCC 15 Subpart C limits.

The spacing between the peripherals was 10 centimeters.

External I/O cables were draped along the edge of the test table and bundle when necessary.

6.3 Test Procedure

For the radiated emissions test, the EUT host, and all support equipment power cords was connected to the AC floor outlet.

Maximizing procedure was performed on the highest emissions to ensure that the EUT complied with all installation combinations.

The EUT was set 3 meter away from the testing antenna, which was varied from 1-4 meter, and the EUT was placed on a turntable, which was 0.8 meter and 1.5 meter above the ground plane for below and above 1000 MHz measurements, the table shall be rotated for 360 degrees to find out the highest emission. The receiving antenna should be changed the polarization both of horizontal and vertical.

The spectrum analyzer or receiver is set as:

Below 1000 MHz:

RBW = 100 kHz / VBW = 300 kHz / Sweep = Auto

Above 1000 MHz:

(1) Peak: RBW = 1MHz / VBW = 1MHz / Sweep = Auto
(2) Average: RBW = 1MHz / VBW = 10Hz / Sweep = Auto

6.4 Corrected Amplitude & Margin Calculation

The Corrected Amplitude (CA) is calculated by adding the Antenna Factor (AF), the Cable Loss (CL), the Attenuator Factor (Atten) and subtracting the Amplifier Gain (Ga) to indicated Amplitude (Ai) reading. The basic equation is as follows:

CA = Ai + AF + CL + Atten – Ga

For example, a corrected amplitude of 40.3 dBuV/m = Indicated Reading (32.5 dBuV) + Antenna Factor (+23.5dB) + Cable Loss (3.7 dB) + Attenuator (10 dB) - Amplifier Gain (29.4 dB)

The "**Margin**" column of the following data tables indicates the degree of compliance within the applicable limit. For example, a margin of -7 dB means the emission is 7 dB below the maximum limit. The equation for margin calculation is as follows:

Margin = Corrected Amplitude - Limit

6.5 Test Equipment List and Details

Manufacturer	Description	Model No.	Serial No.	Calibration Date	Calibration Interval
Rohde & Schwarz	EMI Test Receiver	ESCI 1166.5950K03	100044	2018-10-26	2 years
Rhode & Schwarz	Signal Analyzer	FSV40	1321.3008K39 -101203-UW	2019-08-06	1 year
Sunol Science Corp	System Controller	SC99V	011003-1	N/R	N/R
Sunol Sciences	Antenna, Biconi-Log	JB1	A013105-3	2018-02-26	2 years
Sunol Sciences	Antenna, Horn	DRH-118	A052704	2019-04-02	2 years
Agilent	Preamplifier	8449B	3147A00400	2019-05-20	1 year
Insulted Wire Corp.	157 Series 2.92 SM (x2) Armored 33 ft. Cable	KPS-1571AN-3960-KPS	DC 1917	2019-05-08	1 year
-	SMA cable	-	-	Each time[1]	N/A
MDP DIgital	Times Microwave LMR 400 UltraFex Coaxial Cable 35\'	LMR400UF	BACL1904161	2019-04-16	1 year
Agilent	Amplifier, Pre	8447D	2944A10187	2019-04-11	1 year
A. H. Systems	Antenna, Horn	SAS-200/571	261	2019-06-07	2 years
Rohde & Schwarz	EMI Test Receiver	ESU-40	100433	2019-02-06	1 year
HP	Pre-Amplifier	8449B	3008A01978	2019-09-27	1 year
Wisewave	Antenna, Horn	ARH-4223-02	10555-01	2018-02-14	2 years

Note[1]: cable and attenuator included in the test set-up will be checked each time before testing.
Statement of Traceability: BACL *attests that all calibrations have been performed per the A2LA requirements, traceable to NIST.*

6.6 Test Environmental Conditions

Temperature:	20-22 ºC
Relative Humidity:	42-50 %
ATM Pressure:	102.7 kPa

The testing was performed by Matthew Riego de Dios from 2019-10-21 to 2019-11-07 in 5m chamber 3.

6.7 Summary of Test Results

According to the data hereinafter, the EUT complied with FCC Title 47, Part 15C and ISEDC RSS-247 standard's radiated emissions limits, and had the worst margin of:

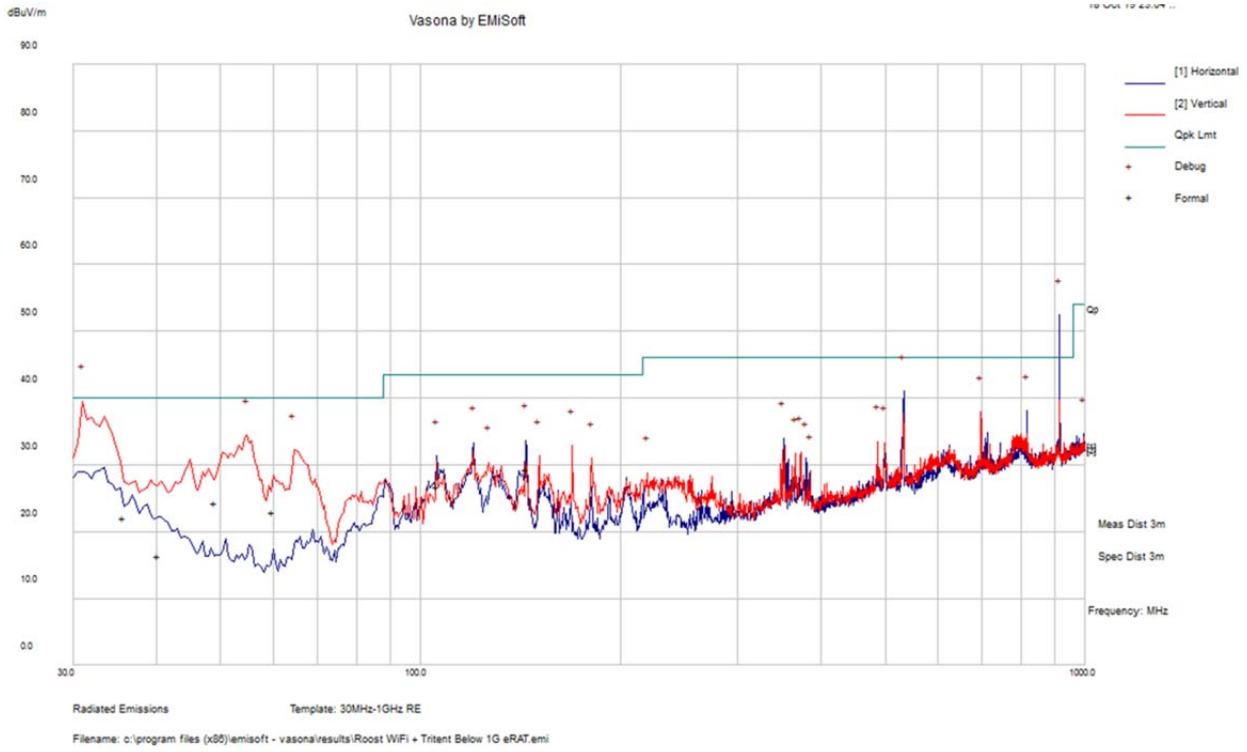
Mode: Transmitting			
Margin (dB)	**Frequency (MHz)**	**Polarization (Horizontal/Vertical)**	**Transmitting Channel**
-0.03	2745	Horizontal	915 MHz

Please refer to the following table and plots for specific test result details.

6.8 Radiated Emissions Test Results

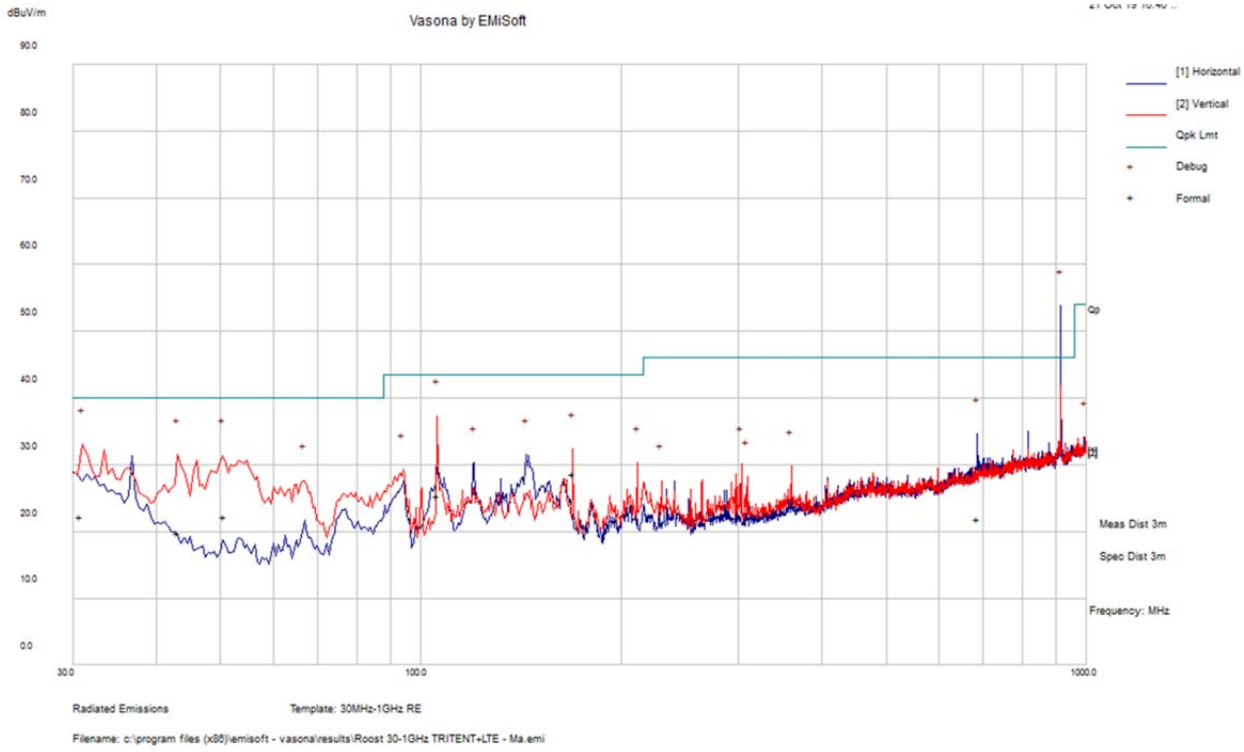
30 MHz – 1 GHz Worst Case, Measured at 3 meters

Worst Case Colocation: TRTN 50 kbps 2-GFSK, 25 kHz deviation, IEEE 802.15.4g MR-FSK PHY mode 915 MHz and Wi-Fi DSSS-1 mode 2437 MHz



Frequency (MHz)	Corrected Amplitude (dBµV/m)	Antenna Height (cm)	Antenna Polarity (H/V)	Turntable Azimuth (degrees)	Limit (dBµV/m)	Margin (dB)	Comment
105.772	26.71	297	V	115	43.5	-16.79	QP
35.6775	22.04	110	V	91	40	-17.96	QP
48.99425	24.27	108	V	113	40	-15.73	QP
40.23	16.34	116	V	248	40	-23.66	QP
59.98625	22.99	197	V	38	40	-17.01	QP
144.1495	29.4	185	H	240	43.5	-14.1	QP

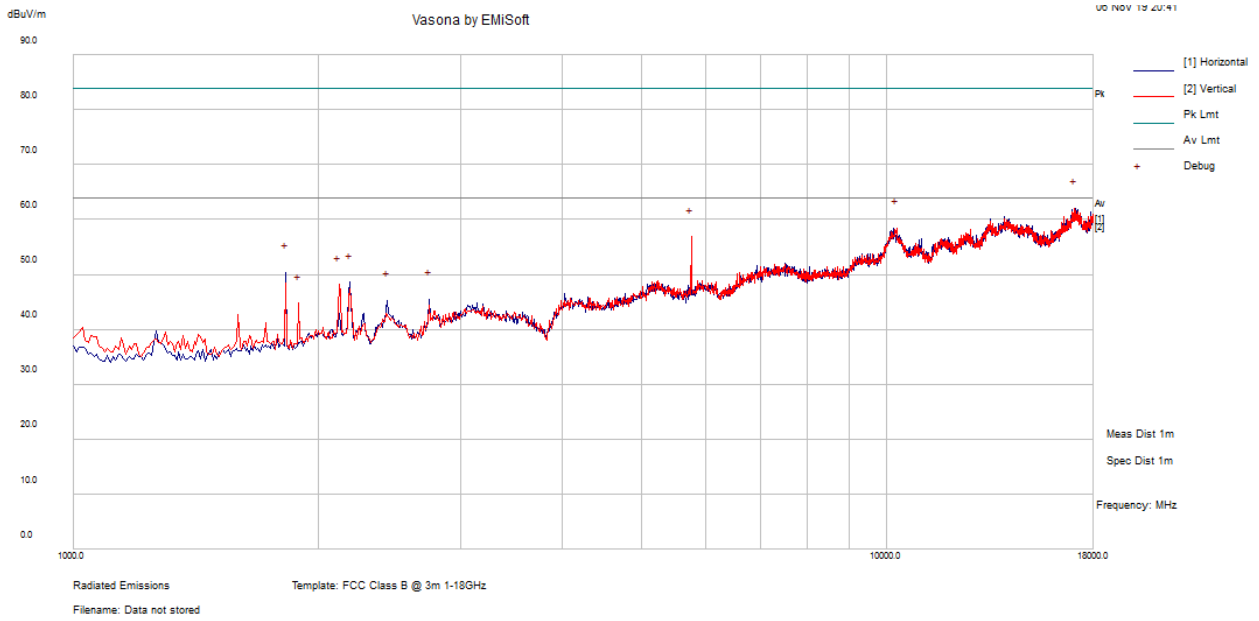
Worst Case Colocation: TRTN 50 kbps 2-GFSK, 25 kHz deviation, IEEE 802.15.4g MR-FSK PHY mode 915 MHz and LTE Band 4 mid channel 1732MHz



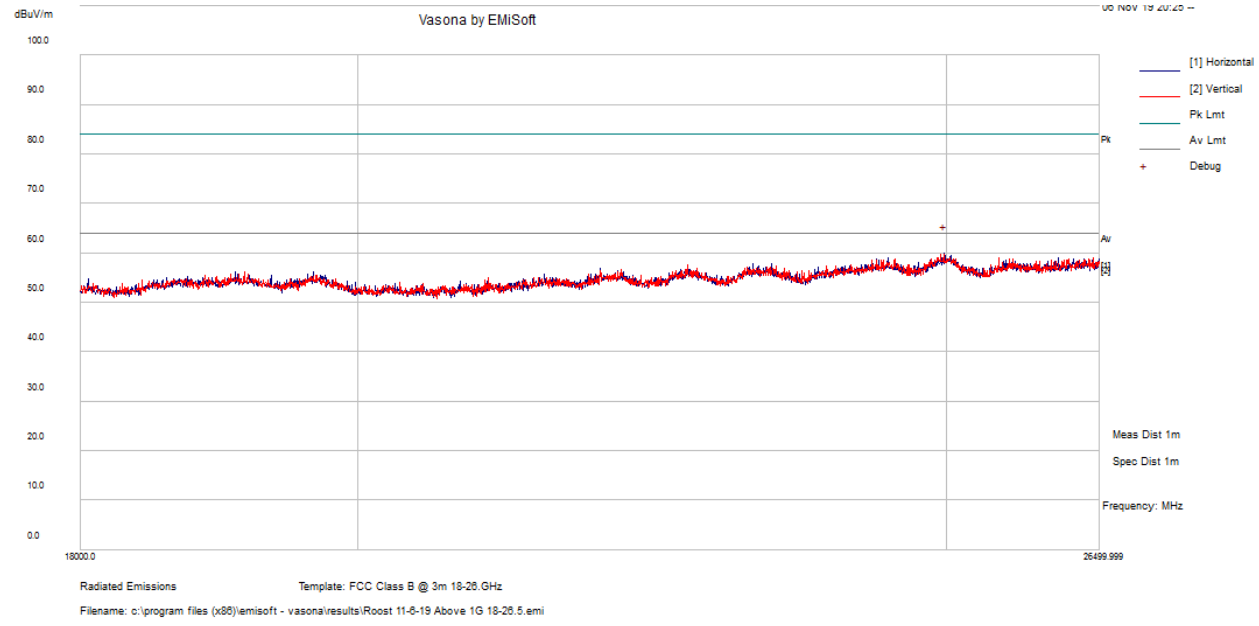
Frequency (MHz)	Corrected Amplitude (dBµV/m)	Antenna Height (cm)	Antenna Polarity (H/V)	Turntable Azimuth (degrees)	Limit (dBµV/m)	Margin (dB)	Comment
105.7305	25.4	224	V	78	43.5	-18.1	QP
30.827	22.21	219	V	125	40	-17.79	QP
43.15075	19.88	155	V	66	40	-20.12	QP
50.59275	22.24	113	V	360	40	-17.76	QP
169.1645	28.62	120	V	149	43.5	-14.88	QP
684.902	21.91	117	H	271	46	-24.09	QP

Worst Case Colocation: TRTN 50 kbps 2-GFSK, 25 kHz deviation, IEEE 802.15.4g MR-FSK PHY mode 915 MHz and Wi-Fi DSSS-1 mode 2437 MHz

1 GHz – 18 GHz Worst Case, Measured at 1 meter

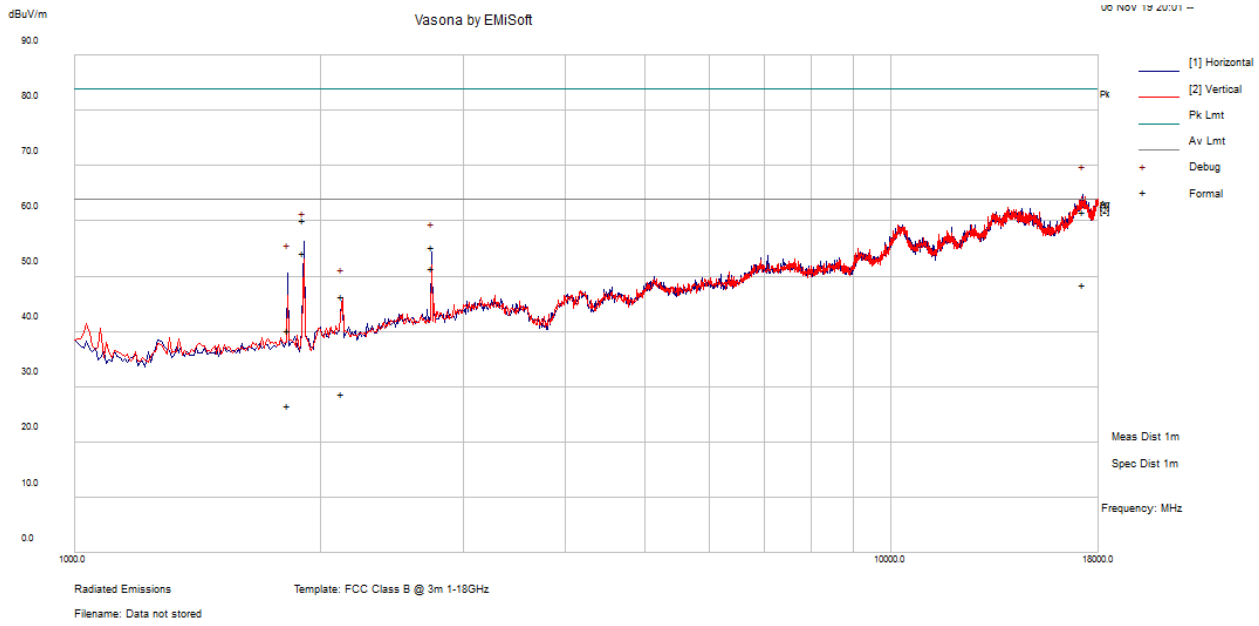


18 GHz – 26.5 GHz Worst Case, Measured at 1 meter

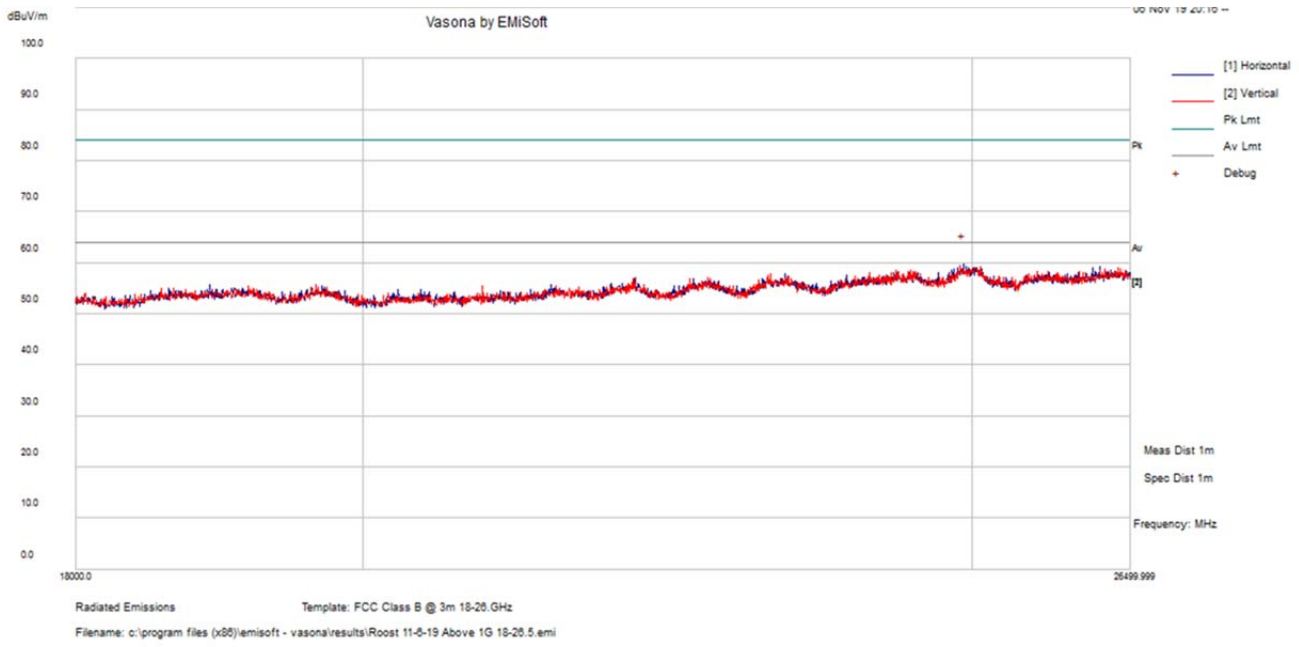


Worst Case Colocation: TRTN 50 kbps 2-GFSK, 25 kHz deviation, IEEE 802.15.4g MR-FSK PHY mode 915 MHz and LTE Band 4 mid channel 1732MHz

1 GHz – 18 GHz Worst Case, Measured at 1 meter



18 GHz – 26.5 GHz Worst Case, Measured at 1 meter



7 Annex A - Test Setup Photographs

Please refer to the attachment

8 Annex B - HOST Photographs

Please refer to the attachment

9 Annex C (Normative) - A2LA Electrical Testing Certificate

Accredited Laboratory

A2LA has accredited

BAY AREA COMPLIANCE LABORATORIES CORP.

Sunnyvale, CA

for technical competence in the field of

Electrical Testing

This laboratory is accredited in accordance with the recognized International Standard ISO/IEC 17025:2005 *General requirements for the competence of testing and calibration laboratories*. This laboratory also meets A2LA R222 - *Specific Requirements EPA ENERGY STAR Accreditation Program*. This accreditation demonstrates technical competence for a defined scope and the operation of a laboratory quality management system (*refer to joint ISO-ILAC-IAF Communiqué dated April 2017*).

Presented this 2nd day of October 2018.

Vice President, Accreditation Services
For the Accreditation Council
Certificate Number 3297.02
Valid to September 30, 2020
Revised June 5, 2019

For the tests to which this accreditation applies, please refer to the laboratory's Electrical Scope of Accreditation.

Please follow the web link below for a full ISO 17025 scope

https://www.a2la.org/scopepdf/3297-02.pdf

--- END OF REPORT ---