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Report On

Radio Testing of the
Abbott Laboratories
BLE Dongle
Model: BLU2000

 Telecom Technical Regulations Test Regulations LP0002

Report No. 72159029B Rev.02

August 2020



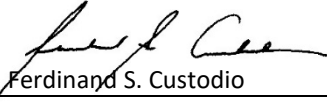
REPORT ON Radio Testing of the
Abbott Laboratories
BLE Dongle Model: BLU2000

TEST REPORT NUMBER 72159029B Rev.02

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DATED August 03, 2020

Revision History

72159029B Rev.02 Abbott Laboratories BLE Dongle Model: BLU2000					
DATE	OLD REVISION	NEW REVISION	REASON	PAGES AFFECTED	APPROVED BY
04/20/2020	—	Initial Release			Ferdinand Custodio
06/16/2020	Initial Release	Rev.01	Added Conducted Emission test results, reference doc, photos, test equipment and MU	6, 7, 44, 45, 46, 47, 48, 56 and 58	Ferdinand Custodio
			Peak output power EIRP result correction	17	
08/03/2020	Rev.01	Rev.02	Update Conducted Emission test results, photos, test equipment and test setup diagram	6, 7, 44, 45, 46, 47, 48, 56 and 62	Ferdinand Custodio

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SECTION 1

REPORT SUMMARY

Radio Testing of the
Abbott Laboratories
BLE Dongle Model: BLU2000

1.1 INTRODUCTION

The information contained in this report is intended to show verification of the Abbott Laboratories BLE Dongle to the requirements of Telecom Technical Regulations Test Regulations LP0002.

Objective	To perform Radio testing to determine the Equipment Under Test's (EUT's) compliance with the test specification, for the series of tests carried out.
Manufacturer	Abbott Laboratories
Trade Name	BLU2000
Model Name	BLU2000
Serial Number(s)	N/A
Number of Samples Tested	1
Test Specification/Issue/Date	Telecom Technical Regulations Test Regulations LP0002. Low-power Radio-frequency Devices Technical Regulations (10 January 2018 revised)
Name of Engineer(s)	Alex Chang
Related Document(s)	• TÜV SÜD test report 72152653A Rev.01 BLE Dongle FCC IC Part 15.247 RSS247 BT LE Test Report.pdf issued on October 04, 2019

1.2 BRIEF SUMMARY OF RESULTS

A brief summary of the tests carried out in accordance with Telecom Technical Regulations Test Regulations LP0002 standard is shown below.

Section	LP0002 Spec Clause	Test Description	Result	Comments/Base Standard
2.1	3.10.1.2(1)(C)	Peak Output Power	Compliant*	See Notes
2.2	3.10.1.6(2)(A)	Minimum 6 dB RF Bandwidth	Compliant*	See Notes
2.3	3.10.1.5	Spurious RF Conducted Emissions	Compliant*	See Notes
2.4	3.10.1.5	Band-edge Compliance of RF Conducted Emissions	Compliant*	See Notes
2.5	3.10.1.5	Spurious Radiated Emissions	Compliant*	See Notes
2.6	3.10.1.5	Radiated Band Edge Measurements And Immediate Restricted Bands	N/A**	See Notes
2.7	3.10.1.6(2)(B)	Peak Power Spectral Density	Compliant*	See Notes
2.8	2.3	Conducted Emissions	Compliant	
2.9	2.2	Antenna Requirement	Compliant	

N/A* The EUT is USB powered and will be used with a dedicated host. Conducted Emissions verification of the host when tested as a system applies.

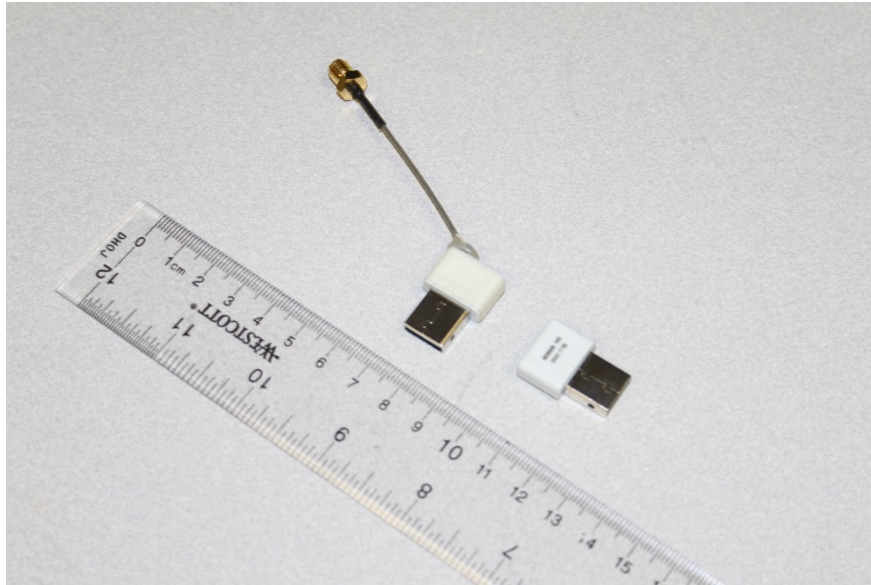
N/A** Not performed. Radiated Band Edge was performed via conducted sample; therefore, test results from the Section 2.4 apply.

Compliant* The device was originally evaluated previously in 2019 under TÜV SÜD test reports ref. no. 72152653A Rev.01 BLE Dongle FCC IC Part 15.247 RSS247 BT LE Test Report.pdf. After reviewing the technical testing requirement between FCC 15.247 and LP0002, it was found there are no additional tests required per LP0002. Therefore, throughout this test report results were leveraged from FCC report which originally evaluated and accepted.

1.3 PRODUCT INFORMATION

1.3.1 Technical Description

The Equipment Under Test (EUT) is an Abbott Laboratories BLU2000 BLE Dongle. The EUT is a Bluetooth Low Energy radio to USB interface which operates in the 2.4GHz ISM band. The EUT is an accessory to Merlin 3650 Programmer used as an interface with an implanted device.



Equipment Under Test

1.3.2 EUT General Description

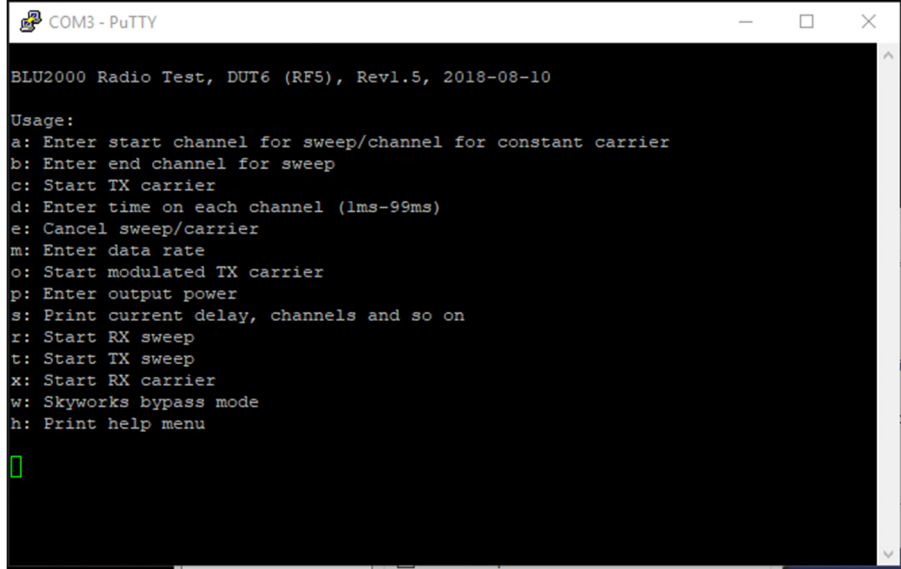
EUT Description	BLE Dongle
Trade Name	BLU2000
Model Name	BLU2000
Rated Voltage	USB powered
Mode Verified	Bluetooth LE
Capability	Bluetooth LE
Primary Unit (EUT)	☒ Production ☐ Pre-Production ☐ Engineering
Manufacturer Declared Temperature Range	10°C to 40°C (Host – Merlin 3650 Programmer)
Antenna Type	SMT Mini Antenna
Manufacturer	Johanson Technology
Antenna Model	P/N 2450AT18A100
Antenna Gain	0.5 dBi

1.3.3 Maximum Conducted Output Power

Bluetooth Low Energy (LE)	Frequency Range (MHz)	Gated RMS (dBm)	Gated EIRP (dBm)	Duty Cycle (%)
	2402-2480	6.9	7.4	90.2

1.4 EUT TEST CONFIGURATION

1.4.1 Test Configuration Description

Test Configuration	Description
Default	EUT is connected to the support laptop. Using PuTTY Release 0.72 and the assigned COM Port, the test firmware (BLU2000 Radio Test) is loaded:  Variables during configuration are Channels, Data Rate and Output Power (Manufacturer recommended value is "4").

1.4.2 EUT Exercise Software

PuTTY Release 0.72 and BLU2000 Radio Test, DUT6 (RF5), Rev 1.5, 2018-08-10.

1.4.3 Support Equipment and I/O cables

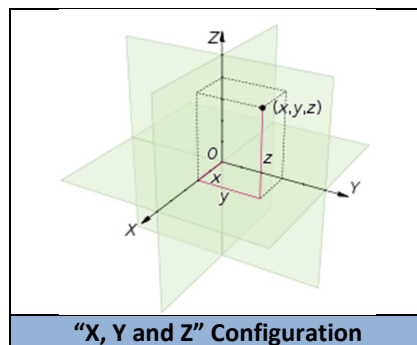
Manufacturer	Equipment/Cable	Description
Lenovo	Support Laptop	Model: Thinkpad T530 Type 2392-45U S/N R9-RM96L
Lenovo	Support AC Adapter	PA-1900-171 S/N 11S92P1109Z1ZBTZ71C9A1

1.4.4 Worst Case Configuration

Worst-case configuration used in this test report as per maximum conducted output power measurements:

Mode	Channel	Data Rate
Bluetooth LE	37 (Low Channel)	1Mbps

EUT is a mobile device. Final installation position is only at X orientation when installed with the host (Merlin 3650 Programmer). For radiated measurements verifications performed using "X" configuration.

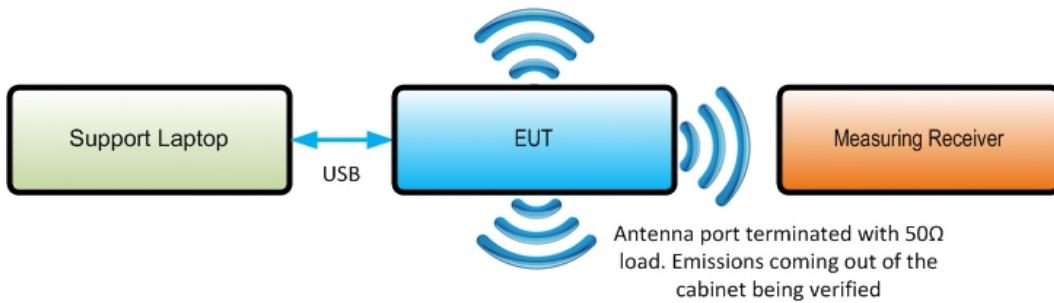


1.4.5 Simplified Test Configuration Diagram

Antenna Port Conducted Test Setup



Cabinet Spurious Emissions Test Setup



1.5 DEVIATIONS FROM THE STANDARD

No deviations from the applicable test standards or test plan were made during testing.

1.6 MODIFICATION RECORD

Description of Modification	Modification Fitted By	Date Modification Fitted
Serial Number: N/A		
None	—	—

The table above details modifications made to the EUT during the test programme. The modifications incorporated during each test (if relevant) are recorded on the appropriate test pages.

1.7 TEST METHODOLOGY

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

For conducted and radiated emissions, the equipment under test (EUT) was configured to measure its highest possible emission level. This level was based on the maximized cable configuration from exploratory testing per ANSI C63.10-2013. The test modes were adapted according to the Operating Instructions provided by the manufacturer/client.

1.8 TEST FACILITY LOCATION

1.8.1 TÜV SÜD America Inc. (Mira Mesa)

10040 Mesa Rim Road, San Diego, CA 92121-2912 (32.901268,-117.177681). Phone: (858) 678 1400 Fax: (858) 546 0364.

1.8.2 TÜV SÜD America Inc. (Rancho Bernardo)

16936 Via Del Campo, San Diego, CA 92127-1708 (33.018644,-117.092409). Phone: (858) 678 1400 Fax: (858) 546 0364.

1.9 TEST FACILITY REGISTRATION

1.9.1 FCC – Designation No.: US1146

TÜV SÜD America Inc. (San Diego), is an accredited test facility with the site description report on file and has met all the requirements specified in §2.948 of the FCC rules. The acceptance letter from the FCC is maintained in our files and the Designation is US1146.

1.9.2 Innovation, Science and Economic Development Canada (ISED) Registration No.: 3067A-1 & 22806-1

The 10m Semi-anechoic chamber of TÜV SÜD America Inc. (San Diego Rancho Bernardo) has been registered by Certification and Engineering Bureau of Innovation, Science and Economic Development Canada for radio equipment testing with Registration No. 3067A-1.

The 3m Semi-anechoic chamber of TÜV SÜD America Inc. (San Diego Mira Mesa) has been registered by Certification and Engineering Bureau of Innovation, Science and Economic Development Canada for radio equipment testing with Registration No. 22806-1.

1.9.3 BSMI – Laboratory Code: SL2-IN-E-028R (US0102)

TÜV Product Service Inc. (San Diego) is a recognized EMC testing laboratory by the BSMI under the MRA (Mutual Recognition Arrangement) with the United States. Accreditation includes CNS 13438 up to 6GHz.

1.9.4 NCC (National Communications Commission - US0102)

TÜV SÜD America Inc. (San Diego) is listed as a Foreign Recognized Telecommunication Equipment Testing Laboratory and is accredited to ISO/IEC 17025 (A2LA Certificate No.2955.13) which under APEC TEL MRA Phase 1 was designated as a Conformity Assessment Body competent to perform testing of equipment subject to the Technical Regulations covered under its scope of accreditation including RTTE01, PLMN01 and PLMN08 for TTE type of testing and LP0002 for Low-Power RF Device type of testing.

1.9.5 VCCI – Registration No. A-0280 and A-0281

TÜV SÜD America Inc. (San Diego) is a VCCI registered measurement facility which includes radiated field strength measurement, radiated field strength measurement above 1GHz, mains port interference measurement and telecommunication port interference measurement.

1.9.6 RRA – Identification No. US0102

TÜV SÜD America Inc. (San Diego) is National Radio Research Agency (RRA) recognized laboratory under Phase I of the APEC Tel MRA.

1.9.7 OFCA – U.S. Identification No. US0102

TÜV SÜD America Inc. (San Diego) is recognized by Office of the Communications Authority (OFCA) under Appendix B, Phase I of the APEC Tel MRA.

SECTION 2

TEST DETAILS

Radio Testing of the
Abbott Laboratories
BLE Dongle Model: BLU2000

2.1 PEAK OUTPUT POWER

2.1.1 Specification Reference

Section 3.10.1.2(1)(C)

2.1.2 Standard Applicable

For systems using digital modulation in the 2400-2483.5MHz, and 5725-5850MHz bands: below 1 Watt.

In addition to the peak output power described in Appendix 2 for measurement, the maximum conducted output power may also be used.

Maximum Conducted Output Power is defined as the average of all symbols of the signaling alphabet delivered to all antennas and antenna when the transmitter is operating at its maximum power level. The average must not include any time intervals during which the transmitter is off or is transmitting at a reduced power level. If multiple modes of operation are possible (e.g. alternative modulation methods), the maximum conducted output power is the highest total transmit power occurring in any mode.

2.1.3 Equipment Under Test and Modification State

Default Test Configuration (Please refer to original test reports ref. no 72152653A Rev.01 for the actual S/N used)

2.1.4 Date of Test/Initial of test personnel who performed the test

Please refer to original test reports ref. no: 72152653A Rev.01 for actual test date and initial of test engineer who performed the test

2.1.5 Test Equipment Used

The major items of test equipment used for the above tests are identified in Section 3.1.

2.1.6 Environmental Conditions

Test performed at TÜV SÜD America Inc. Rancho Bernardo facility.

Ambient Temperature	26.3 °C
Relative Humidity	48.5 %
ATM Pressure	98.8 kPa

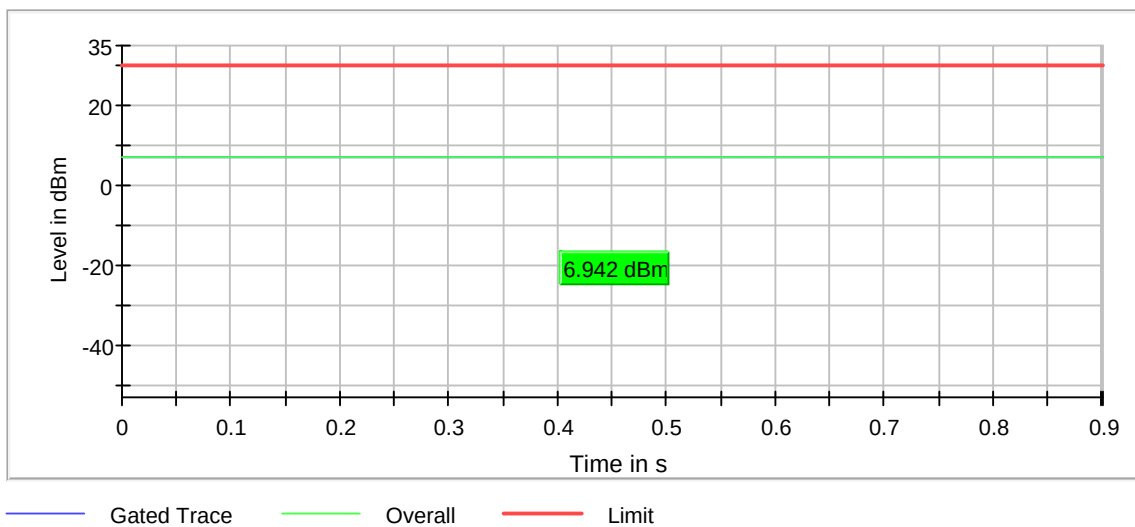
2.1.7 Additional Observations

- This is a conducted test using direct connection to the TS8997 Test System.
- The path loss was all accounted for with the test system calibration.
- Test methodology is per Test according to FCC title 47 part 15 §15.247(b), KDB 558074 D01 DTS Meas Guidance v05 and ANSI C63.10-2013 11.9.2.3.2.
- Only the worst-case data rate presented.

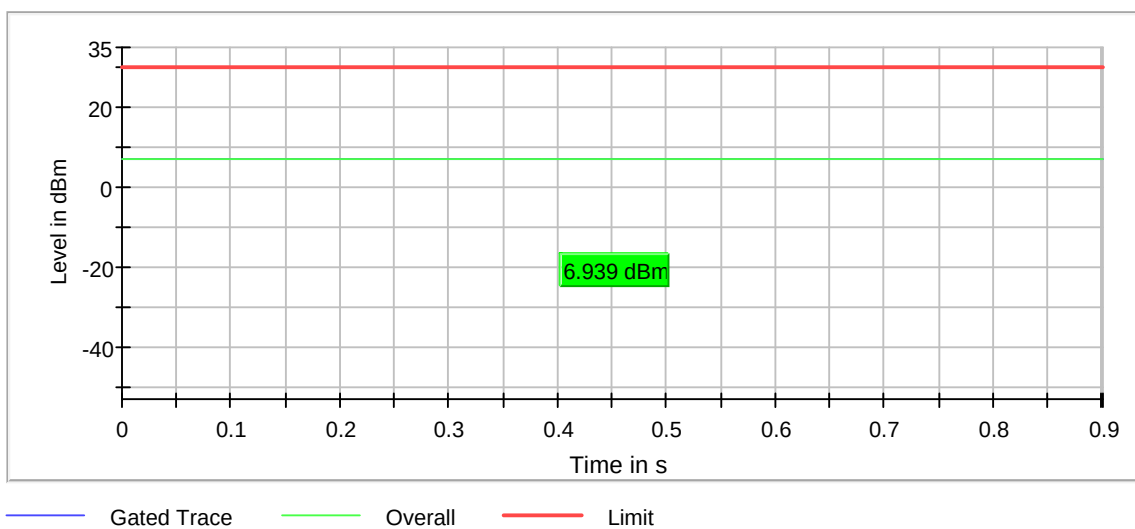
2.1.8 Test Results

DUT Frequency (MHz)	Gated RMS (dBm)	Limit Max (dBm)	Gated EIRP (dBm)	DutyCycle (%)	Result
2402.000000	6.9	30.0	7.4	90.169	PASS
2440.000000	6.9	30.0	7.4	90.171	PASS
2480.000000	6.2	30.0	6.7	90.177	PASS

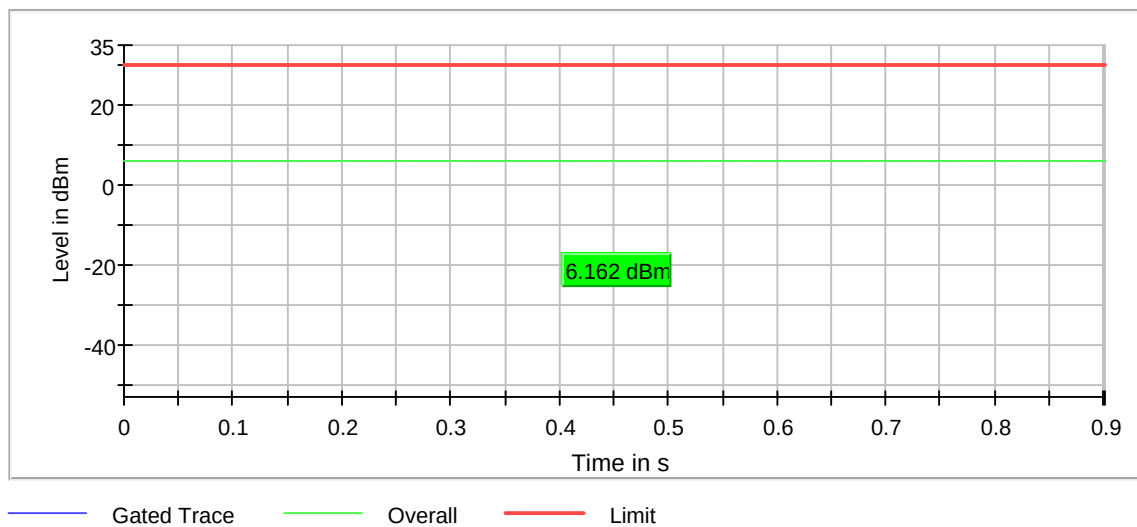
2.1.9 Test Plots



Bluetooth LE. Low Channel 2Mbps



Bluetooth LE. Mid Channel 2Mbps



Bluetooth LE. High Channel 2Mbps

2.1.10 Test Setup Photo



2.2 MINIMUM 6 DB RF BANDWIDTH

2.2.1 Specification Reference

Section 3.10.1.6(2)(A)

2.2.2 Standard Applicable

For digitally modulated systems, the minimum 6dB bandwidth shall be at least 500 kHz.

2.2.3 Equipment Under Test and Modification State

Default Test Configuration (Please refer to original test reports ref. no 72152653A Rev.01 for the actual S/N used)

2.2.4 Date of Test/Initial of test personnel who performed the test

Please refer to original test reports ref. no: 72152653A Rev.01 for actual test date and initial of test engineer who performed the test

2.2.5 Test Equipment Used

The major items of test equipment used for the above tests are identified in Section 3.1.

2.2.6 Environmental Conditions

Test performed at TÜV SÜD America Inc. Rancho Bernardo facility

Ambient Temperature	26.3 °C
Relative Humidity	48.5 %
ATM Pressure	98.8 kPa

2.2.7 Additional Observations

- This is a conducted test using direct connection to the TS8997 Test System.
- The path loss was all accounted for with the test system calibration.
- Test methodology is per Test according to FCC title 47 part 15 §15.247(a), KDB 558074 D01 DTS Meas Guidance v05 and ANSI C63.10-2013 11.8.1.
- Only the worst-case data rate presented.
- Test setup is identical to Section 2.1.10.

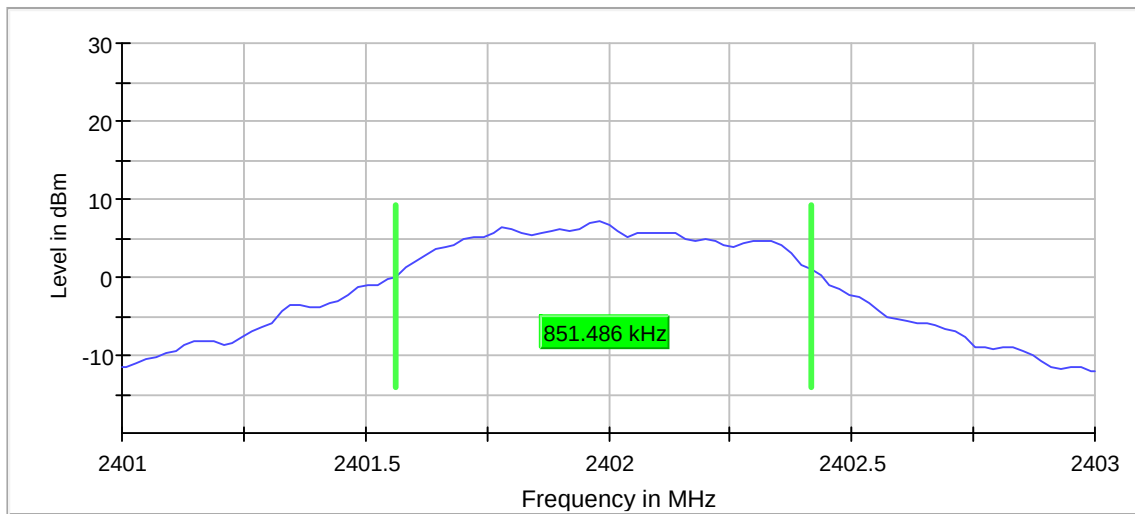
2.2.8 Measurement Settings

Setting	Instrument Value	Target Value
Span	2.000 MHz	2.000 MHz
RBW	100.000 kHz	~ 100.000 kHz
VBW	300.000 kHz	~ 300.000 kHz
SweepPoints	101	~ 40
Sweeptime	18.938 μ s	AUTO
Reference Level	0.000 dBm	0.000 dBm
Attenuation	20.000 dB	AUTO
Detector	MaxPeak	MaxPeak
SweepCount	100	100
Filter	3 dB	3 dB
Trace Mode	Max Hold	Max Hold
SweepType	FFT	AUTO
Preamp	off	off
Stablemode	Trace	Trace
Stablevalue	0.50 dB	0.50 dB
Run	13 / max. 150	max. 150
Stable	5 / 5	5
Max Stable Difference	0.14 dB	0.50 dB

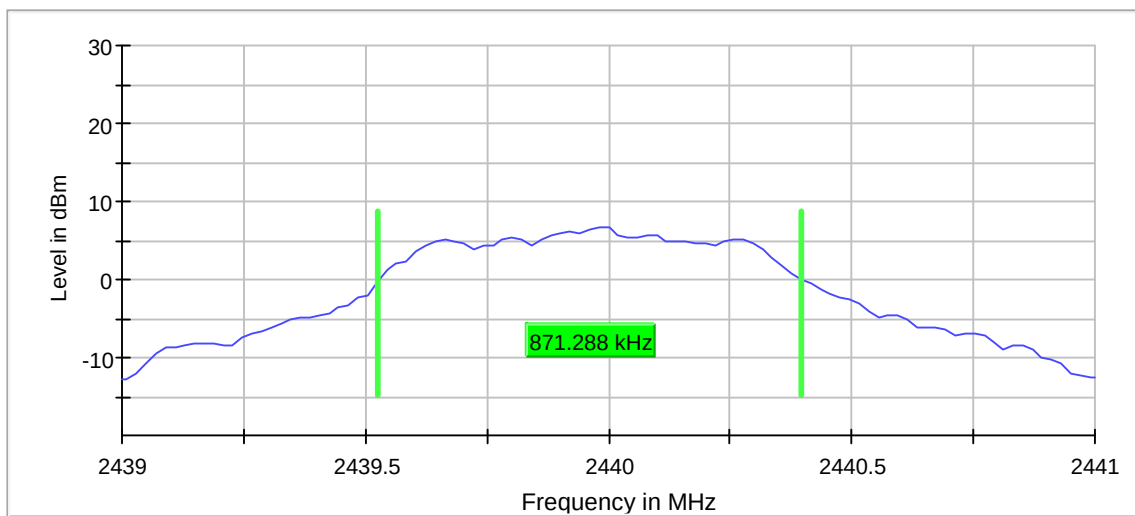
2.2.9 Test Results

DUT Frequency (MHz)	Bandwidth (MHz)	Limit Min (MHz)	Band Edge Left (MHz)	Band Edge Right (MHz)	Result
2402.000000	0.851486	0.500000	2401.564356	2402.415842	PASS
2440.000000	0.871288	0.500000	2439.524752	2440.396040	PASS
2480.000000	0.871288	0.500000	2479.544554	2480.415842	PASS

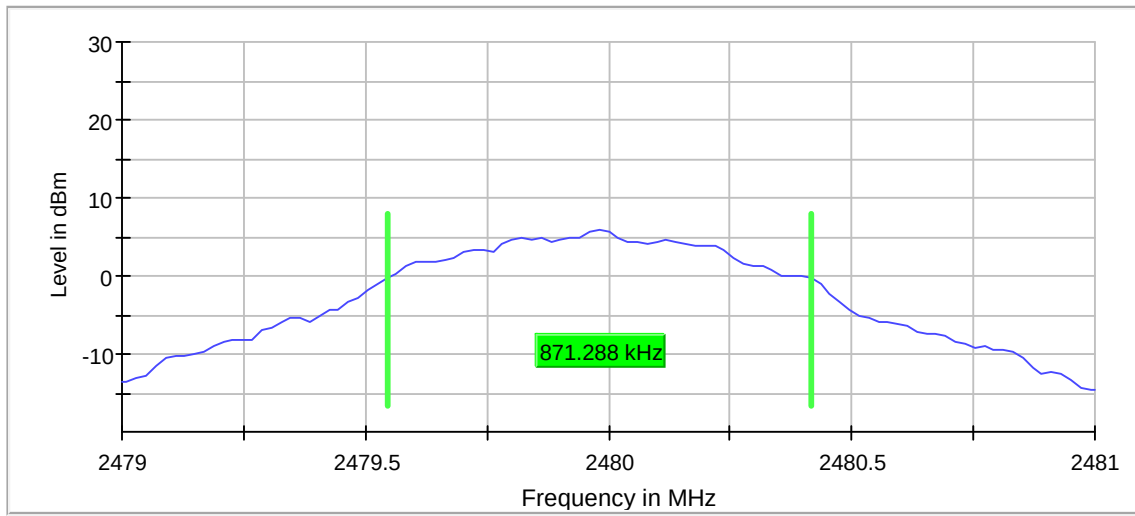
2.2.10 Test Results Plots



Bluetooth LE Low Channel



Bluetooth LE Mid Channel



Bluetooth LE High Channel

2.3 SPURIOUS RF CONDUCTED EMISSIONS

2.3.1 Specification Reference

Section 3.10.1.5

2.3.2 Standard Applicable

In any 100kHz 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 below that in the 100kHz bandwidth within the band that contains the highest level of the desired power, the attenuation shall be as below:

- (1) The attenuation shall be at least 20dB when the conducted power is measured according to the Appendix II of this part, based on either an RF conducted or a radiated measurement.
- (2) The attenuation shall be at least 30dB when the conducted power is measured according to the section 3.10.1.2(1)(C) of the standard.

In addition, radiated emissions which fall in section 2.7 the restricted bands must also comply with the radiated emission limit specified in section 2.8.

2.3.3 Equipment Under Test and Modification State

Default Test Configuration (Please refer to original test reports ref. no 72152653A Rev.01 for the actual S/N used)

2.3.4 Date of Test/Initial of test personnel who performed the test

Please refer to original test reports ref. no: 72152653A Rev.01 for actual test date and initial of test engineer who performed the test

2.3.5 Test Equipment Used

The major items of test equipment used for the above tests are identified in Section 3.1.

2.3.6 Environmental Conditions

Test performed at TÜV SÜD America Inc. Rancho Bernardo facility

Ambient Temperature	26.3 °C
Relative Humidity	48.5 %
ATM Pressure	98.8 kPa

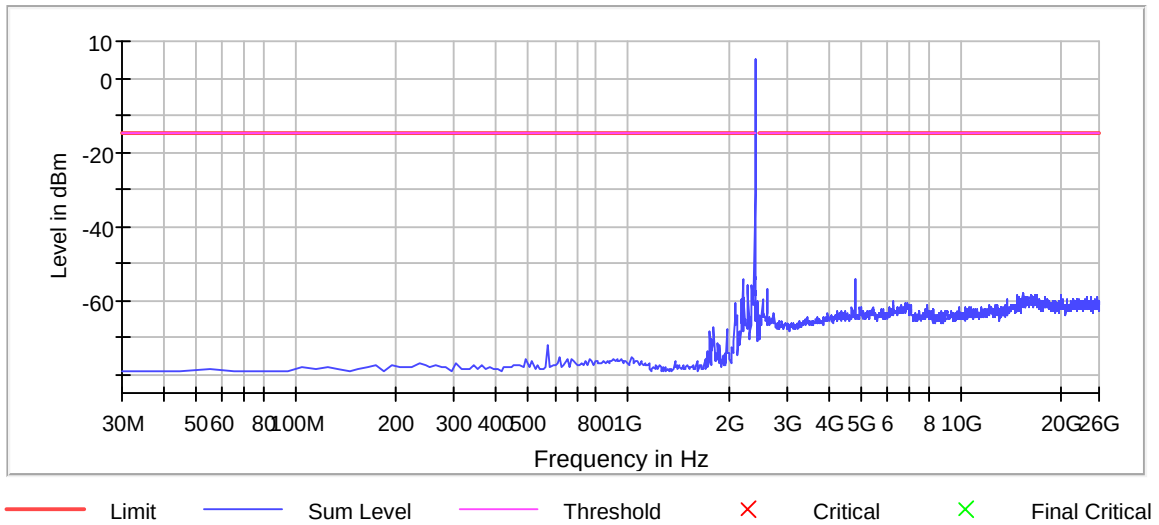
2.3.7 Additional Observations

- This is a conducted test using direct connection to the Spectrum Analyzer being controlled by the TS8997 Test System.
- The path loss was all accounted for with the test system calibration.
- Test methodology is per Test according to FCC title 47 part 15 §15.247(d), KDB 558074 D01 DTS Meas Guidance v05 and ANSI C63.10-2013 11.11.2 & 11.11.3.
- Only the worst-case data rate presented.
- EUT **complies** on all three channels verified. Observed margin from the limit is >20dB.
- Test setup is identical to Section 2.1.10.

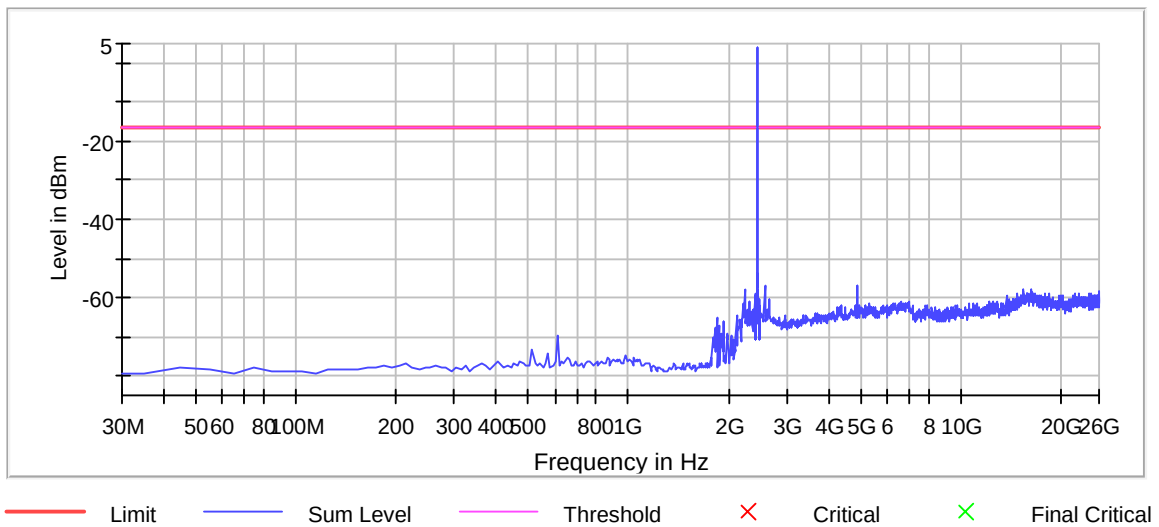
2.3.8 Pre Measurement Settings

Setting	Instrument Value	Target Value
RBW	100.000 kHz	<= 100.000 kHz
VBW	300.000 kHz	>= 300.000 kHz
SweepPoints	238	~ 238
SweepTime	23.700 ms	AUTO
Reference Level	-20.000 dBm	-30.000 dBm
Attenuation	10.000 dB	AUTO
Detector	MaxPeak	MaxPeak
SweepCount	3	3
Filter	3 dB	3 dB
Trace Mode	Max Hold	Max Hold
SweepType	Sweep	AUTO
Preamplifier	off	off
Stablemode	Trace	Trace
Stablevalue	0.50 dB	0.50 dB
Run	7 / max. 40	max. 40
Stable	3 / 3	3
Max Stable Difference	0.00 dB	0.50 dB

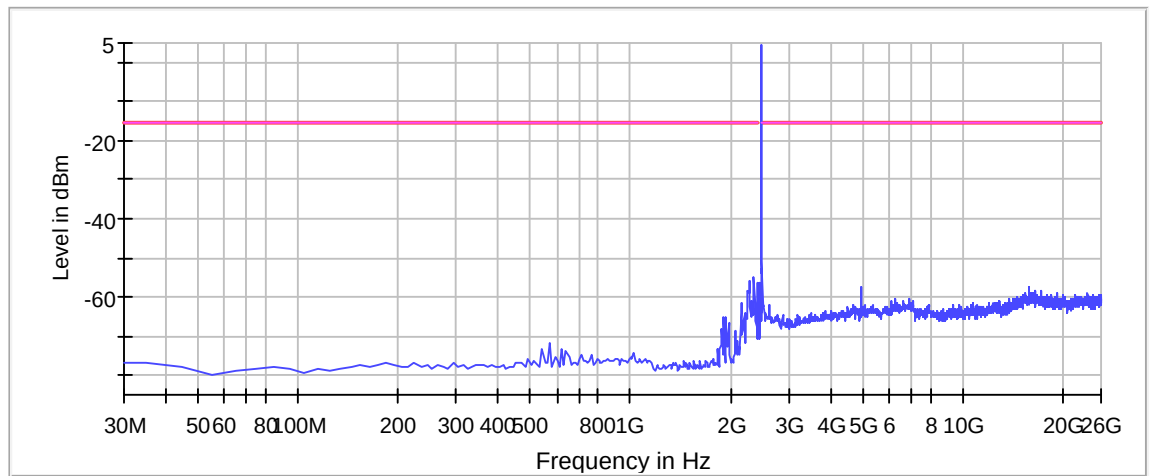
2.3.9 Test Results Plots



Bluetooth LE Low Channel



Bluetooth LE Mid Channel



— Limit — Sum Level — Threshold × Critical × Final Critical

Bluetooth LE High Channel

2.4 BAND-EDGE COMPLIANCE OF RF CONDUCTED EMISSIONS

2.4.1 Specification Reference

Section 3.10.1.5

2.4.2 Standard Applicable

In any 100kHz 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 below that in the 100kHz bandwidth within the band that contains the highest level of the desired power, the attenuation shall be as below:

- (1) The attenuation shall be at least 20dB when the conducted power is measured according to the Appendix II of this part, based on either an RF conducted or a radiated measurement.
- (2) The attenuation shall be at least 30dB when the conducted power is measured according to the section 3.10.1.2(1)(C) of the standard.

In addition, radiated emissions which fall in section 2.7 the restricted bands must also comply with the radiated emission limit specified in section 2.8.

2.4.3 Equipment Under Test and Modification State

Default Test Configuration (Please refer to original test reports ref. no 72152653A Rev.01 for the actual S/N used)

2.4.4 Date of Test/Initial of test personnel who performed the test

Please refer to original test reports ref. no: 72152653A Rev.01 for actual test date and initial of test engineer who performed the test

2.4.5 Test Equipment Used

The major items of test equipment used for the above tests are identified in Section 3.1.

2.4.6 Environmental Conditions

Test performed at TÜV SÜD America Inc. Rancho Bernardo facility

Ambient Temperature	26.3 °C
Relative Humidity	48.5 %
ATM Pressure	98.8 kPa

2.4.7 Additional Observations

- This is a conducted test using direct connection to the Spectrum Analyzer being controlled by the TS8997 Test System.
- The path loss was all accounted for with the test system calibration.
- Test methodology is per Test according to FCC title 47 part 15 §15.247(d), KDB 558074 D01 DTS Meas Guidance v05 8.7 and ANSI C63.10-2013.
- Only the worst-case data rate presented.
- Test setup is identical to Section 2.1.10.

2.4.8 Measurement Settings

Setting	Instrument Value	Target Value
Span	83.500 MHz	83.500 MHz
RBW	100.000 kHz	<= 100.000 kHz
VBW	300.000 kHz	>= 300.000 kHz
SweepPoints	1670	~ 1670
SweepTime	94.727 μ s	AUTO
Reference Level	0.000 dBm	0.000 dBm
Attenuation	20.000 dB	AUTO
Detector	MaxPeak	MaxPeak
SweepCount	100	100
Filter	3 dB	3 dB
Trace Mode	Max Hold	Max Hold
SweepType	FFT	AUTO
Preamplifier	off	off
Stablemode	Trace	Trace
Stablevalue	0.50 dB	0.50 dB
Run	9 / max. 150	max. 150
Stable	3 / 3	3
Max Stable Difference	0.42 dB	0.50 dB

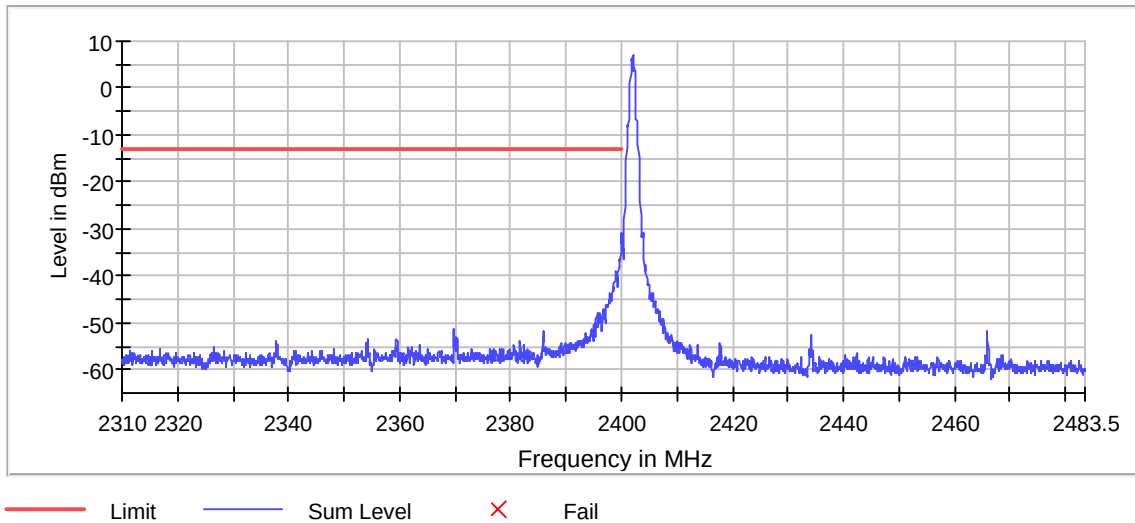
2.4.9 Test Results (Lower Band Edge)

Frequency (MHz)	Level (dBm)	Margin (dB)	Limit (dBm)	Result
2399.975000	-30.8	17.7	-13.1	PASS
2399.925000	-31.8	18.7	-13.1	PASS
2399.875000	-32.3	19.3	-13.1	PASS
2399.825000	-35.1	22.0	-13.1	PASS
2399.675000	-36.5	23.4	-13.1	PASS
2399.625000	-36.7	23.6	-13.1	PASS
2399.775000	-36.7	23.6	-13.1	PASS
2399.725000	-36.7	23.7	-13.1	PASS
2399.575000	-37.5	24.4	-13.1	PASS
2399.525000	-37.9	24.9	-13.1	PASS
2399.475000	-38.2	25.1	-13.1	PASS
2399.025000	-38.9	25.8	-13.1	PASS
2399.075000	-39.1	26.0	-13.1	PASS
2398.975000	-39.3	26.2	-13.1	PASS
2399.425000	-39.6	26.5	-13.1	PASS

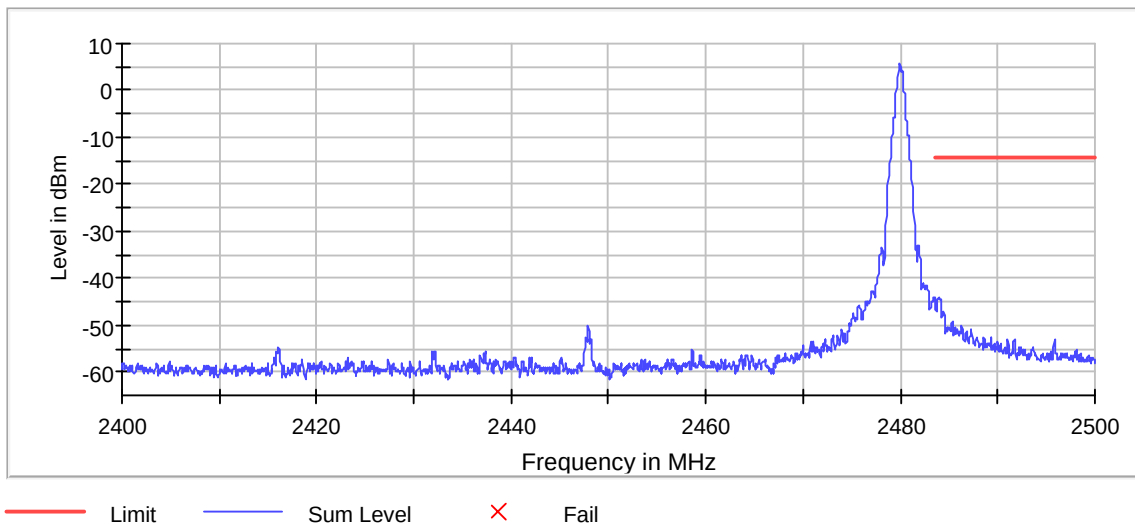
2.4.10 Test Results (Upper Band Edge)

Frequency (MHz)	Level (dBm)	Margin (dB)	Limit (dBm)	Result
2483.975000	-44.0	29.7	-14.3	PASS
2484.025000	-44.0	29.7	-14.3	PASS
2483.925000	-44.1	29.8	-14.3	PASS
2483.875000	-44.3	30.1	-14.3	PASS
2484.075000	-44.6	30.3	-14.3	PASS
2484.125000	-44.7	30.5	-14.3	PASS
2483.825000	-45.4	31.1	-14.3	PASS
2483.525000	-45.7	31.4	-14.3	PASS
2484.175000	-45.9	31.6	-14.3	PASS
2483.625000	-46.1	31.9	-14.3	PASS
2483.575000	-46.2	31.9	-14.3	PASS
2483.675000	-46.6	32.3	-14.3	PASS
2483.775000	-46.7	32.5	-14.3	PASS
2483.725000	-47.1	32.8	-14.3	PASS
2484.425000	-47.1	32.8	-14.3	PASS

2.4.11 Test Plots



Bluetooth LE Low Band Edge 2400MHz



Bluetooth LE Upper Band Edge 2483.5MHz

Upper band edge calculation (2483.5 MHz) within Restricted Band:

- 2483.5 MHz (in the restricted bands)
- Procedure is per Clause 12.7.2 of ANSI C63.10-2013.
- Use the following formula as per Clause 12.7.2(d) of ANSI C63.10-2013.

$$\begin{aligned}
 E(\text{dB}\mu\text{V}/\text{m}) &= \text{EIRP (dBm)} + 95.2 \\
 &= (-45.7 \text{ dBm} + 0.5 \text{ dBi antenna gain}) + 95.2 \\
 &= 50 \text{ dB}\mu\text{V}/\text{m} @ 3 \text{ meters (Peak complies with 54 dB}\mu\text{V}/\text{m Average limit)}
 \end{aligned}$$

2.5 SPURIOUS RADIATED EMISSIONS

2.5.1 Specification Reference

Section 3.10.1.5

2.5.2 Standard Applicable

In any 100kHz 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 below that in the 100kHz bandwidth within the band that contains the highest level of the desired power, the attenuation shall be as below:

- (1) The attenuation shall be at least 20dB when the conducted power is measured according to the Appendix II of this part, based on either an RF conducted or a radiated measurement.
- (2) The attenuation shall be at least 30dB when the conducted power is measured according to the section 3.10.1.2(1)(C) of the standard.

In addition, radiated emissions which fall in section 2.7 the restricted bands must also comply with the radiated emission limit specified in section 2.8.

2.5.3 Equipment Under Test and Modification State

Default Test Configuration (Please refer to original test reports ref. no 72152653A Rev.01 for the actual S/N used)

2.5.4 Date of Test/Initial of test personnel who performed the test

Please refer to original test reports ref. no: 72152653A Rev.01 for actual test date and initial of test engineer who performed the test

2.5.5 Test Equipment Used

The major items of test equipment used for the above tests are identified in Section 3.1.

2.5.6 Environmental Conditions

Test performed at TÜV SÜD America Inc. Rancho Bernardo facility

Ambient Temperature	26.2 °C
Relative Humidity	42.1 %
ATM Pressure	98.6 kPa

2.5.7 Additional Observations

- This is a radiated test. The spectrum was searched from 30MHz to the 10th harmonic.
- There are no emissions found that do not comply to the restricted bands defined in FCC Part 15 Subpart C, 15.205 or Part 15.247(d).
- Only the worst case BLE (Low Channel) presented for below 1GHz. There are no significant differences in emissions between all channels.
- Only noise floor measurements observed above 18GHz.
- Measurement was done using EMC32 automated software. Reported level is the actual level with all the correction factors factored in. Correction Factor column is for informational purposes only. See Section 2.5.8 for sample computation.

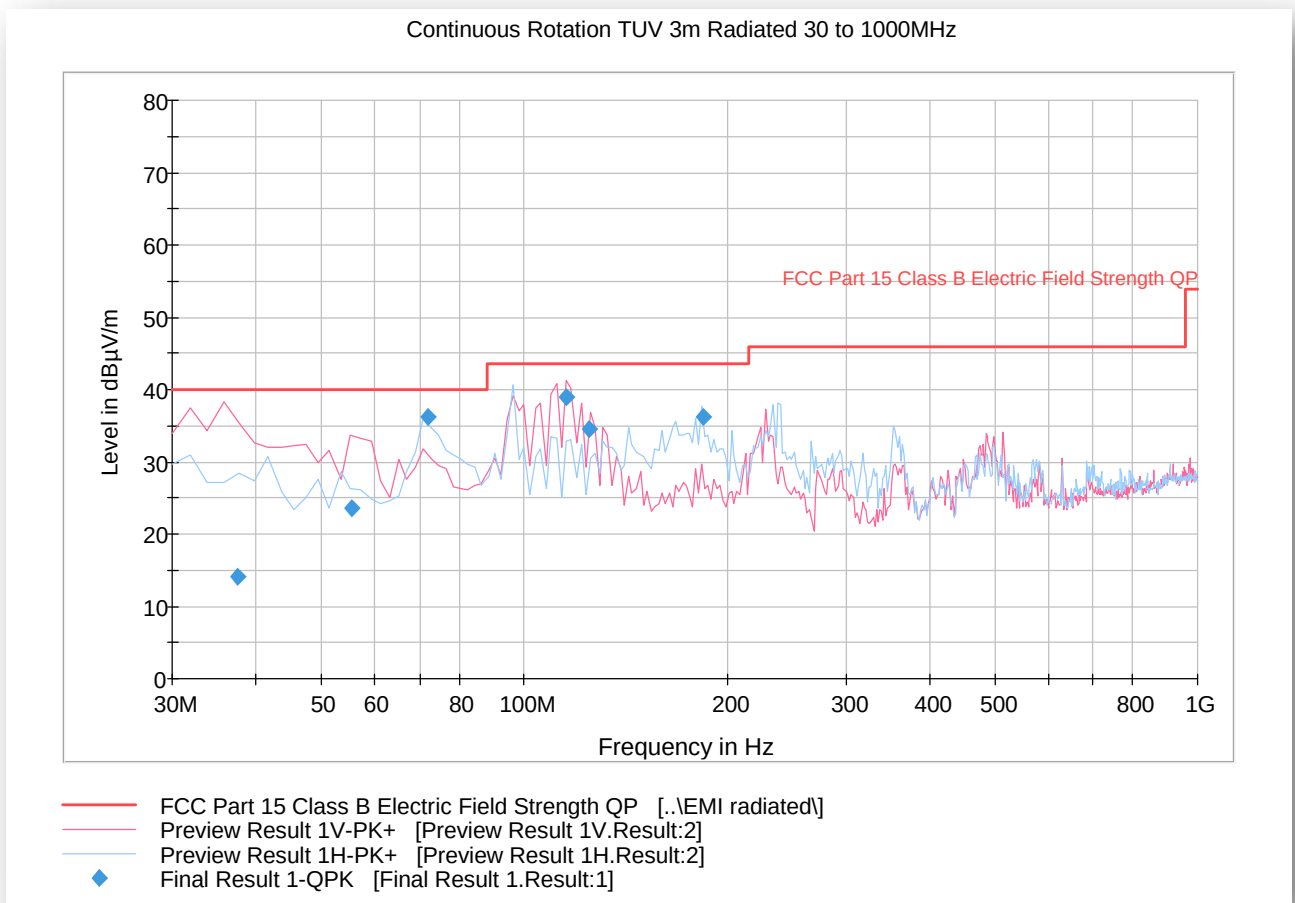
2.5.8 Sample Computation (Radiated Emission)

Measuring equipment raw measurement (dB μ V) @ 30 MHz			24.4
Correction Factor (dB)	Asset# 1066 (cable)	0.3	-12.6
	Asset# 1172 (cable)	0.3	
	Asset# 1016 (preamplifier)	-30.7	
	Asset# 1175(cable)	0.3	
	Asset# 1002 (antenna)	17.2	
Reported Quasi Peak Final Measurement (dB μ V/m) @ 30MHz			11.8

2.5.9 Test Results

See attached plots.

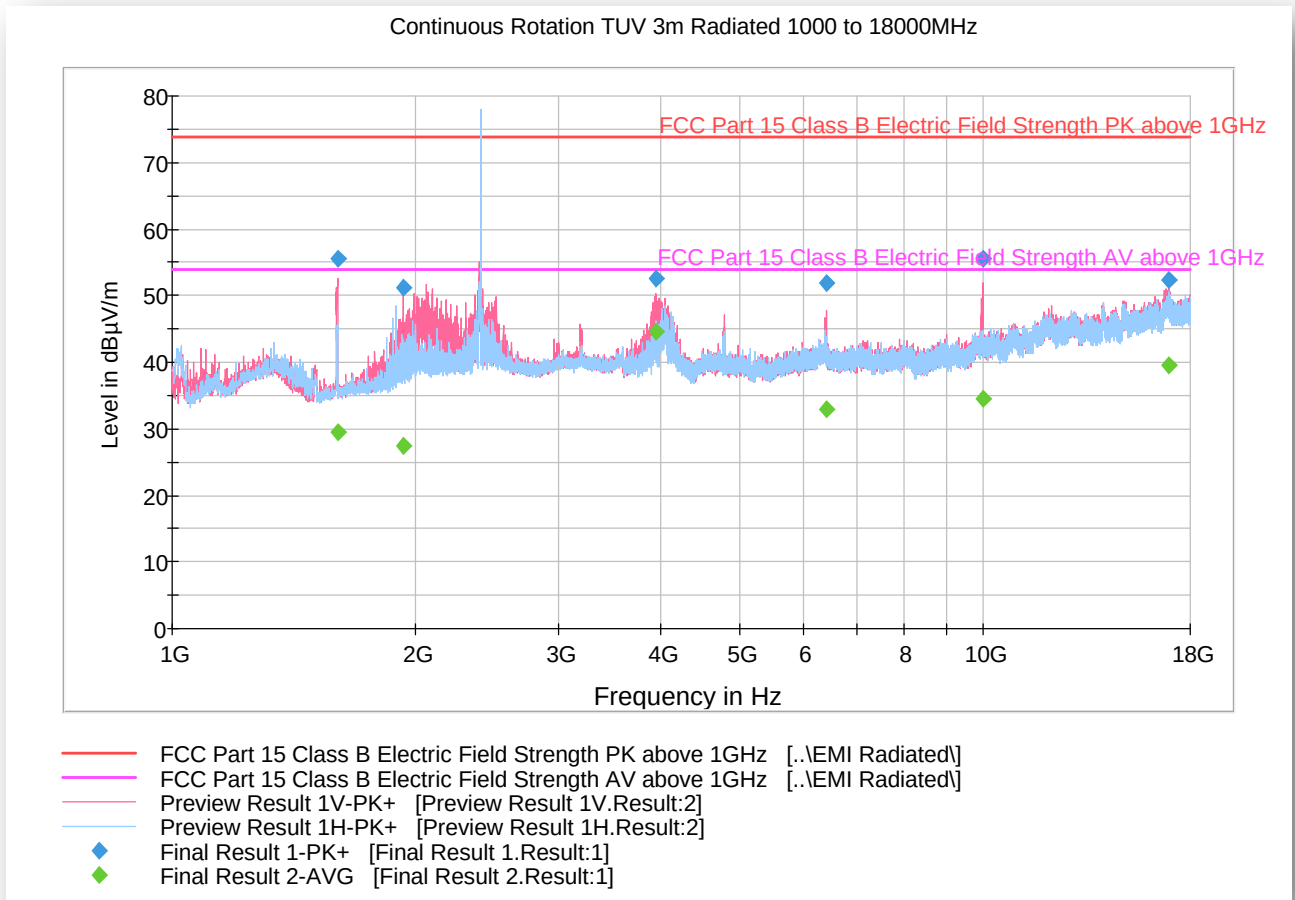
2.5.10 Worst case Test Results for Below 1GHz – Low Channel



Quasi Peak Data

Frequency (MHz)	QuasiPeak (dBμV/m)	Meas. Time (ms)	Bandwidth (kHz)	Height (cm)	Polarization	Azimuth (deg)	Corr. (dB)	Margin (dB)	Limit (dBμV/m)
37.431663	14.0	1000.0	120.000	100.0	V	256.0	-11.0	26.0	40.0
55.390541	23.6	1000.0	120.000	100.0	V	128.0	-15.9	16.4	40.0
72.021643	36.2	1000.0	120.000	250.0	H	133.0	-17.2	3.8	40.0
115.731062	39.0	1000.0	120.000	100.0	V	267.0	-14.5	4.5	43.5
124.850501	34.6	1000.0	120.000	100.0	V	267.0	-14.5	8.9	43.5
184.767134	36.2	1000.0	120.000	150.0	H	95.0	-11.4	7.3	43.5

2.5.11 Test Results for Above 1GHz - Low Channel



Peak Data

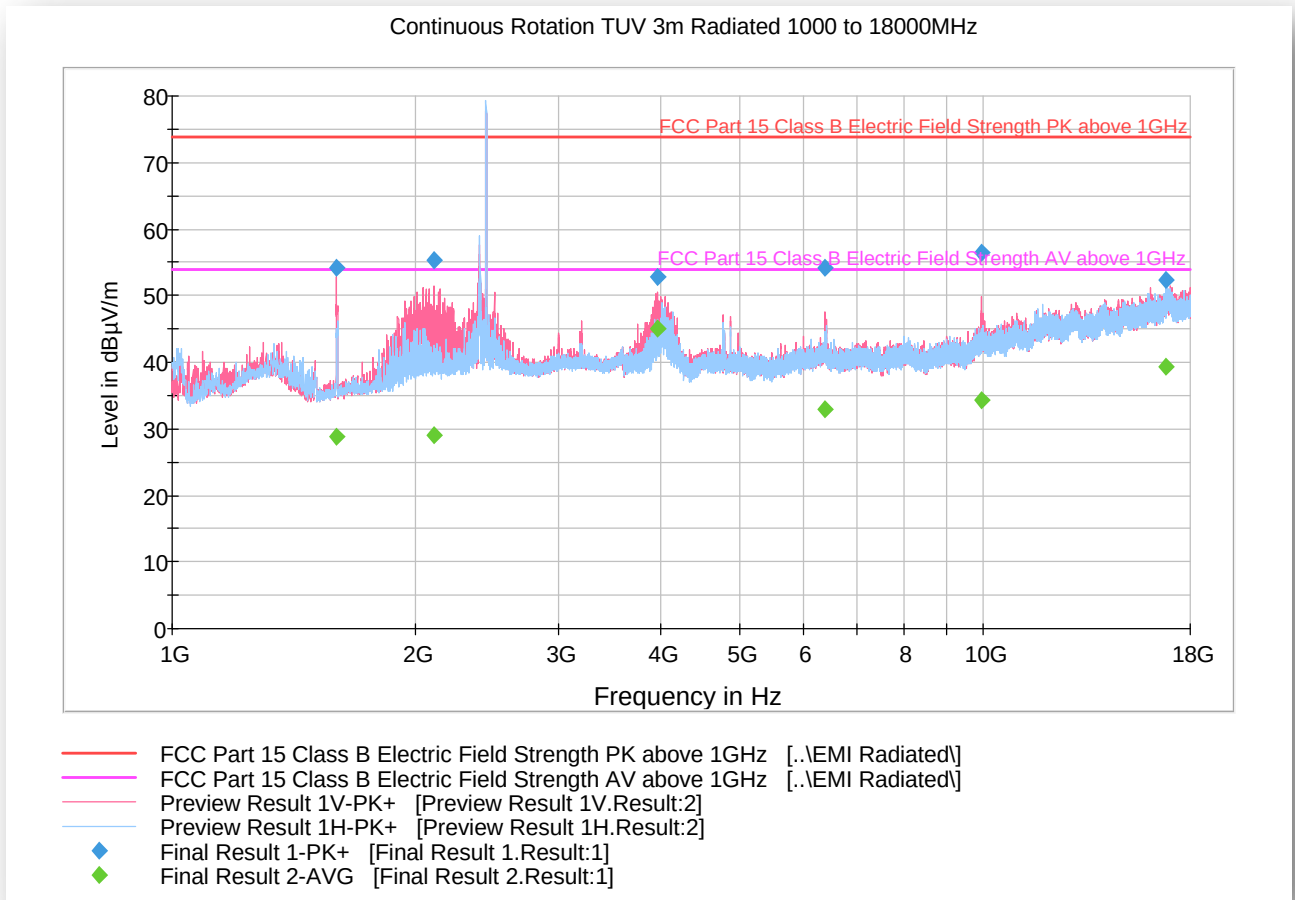
Frequency (MHz)	MaxPeak (dBμV/m)	Meas. Time (ms)	Bandwidth (kHz)	Height (cm)	Polarization	Azimuth (deg)	Corr. (dB)	Margin (dB)	Limit (dBμV/m)
1598.600000	55.6	1000.0	1000.000	102.7	V	81.0	-5.8	18.3	73.9
1925.333333	51.3	1000.0	1000.000	151.2	V	14.0	-2.4	22.6	73.9
3944.966667	52.6	1000.0	1000.000	135.7	V	100.0	2.2	21.3	73.9
6398.500000	51.8	1000.0	1000.000	151.6	V	127.0	6.4	22.1	73.9
9996.600000	55.6	1000.0	1000.000	103.7	V	124.0	9.6	18.3	73.9
16959.06666	52.3	1000.0	1000.000	389.1	V	131.0	17.9	21.6	73.9

Average Data

Frequency (MHz)	Average (dBμV/m)	Meas. Time (ms)	Bandwidth (kHz)	Height (cm)	Polarization	Azimuth (deg)	Corr. (dB)	Margin (dB)	Limit (dBμV/m)
1598.600000	29.4	1000.0	1000.000	102.7	V	81.0	-5.8	24.5	53.9
1925.333333	27.4	1000.0	1000.000	151.2	V	14.0	-2.4	26.5	53.9
3944.966667	44.6	1000.0	1000.000	135.7	V	100.0	2.2	9.3	53.9
6398.500000	32.8	1000.0	1000.000	151.6	V	127.0	6.4	21.1	53.9
9996.600000	34.4	1000.0	1000.000	103.7	V	124.0	9.6	19.5	53.9
16959.06666	39.6	1000.0	1000.000	389.1	V	131.0	17.9	14.3	53.9

Test Notes: Measurement was performed without a 2.4GHz notch filter. Fundamental will be ignored for this test. No significant emissions observed above 18GHz. Measurements above 18GHz are noise floor figures.

2.5.12 Test Results for Above 1GHz - Middle Channel



Peak Data

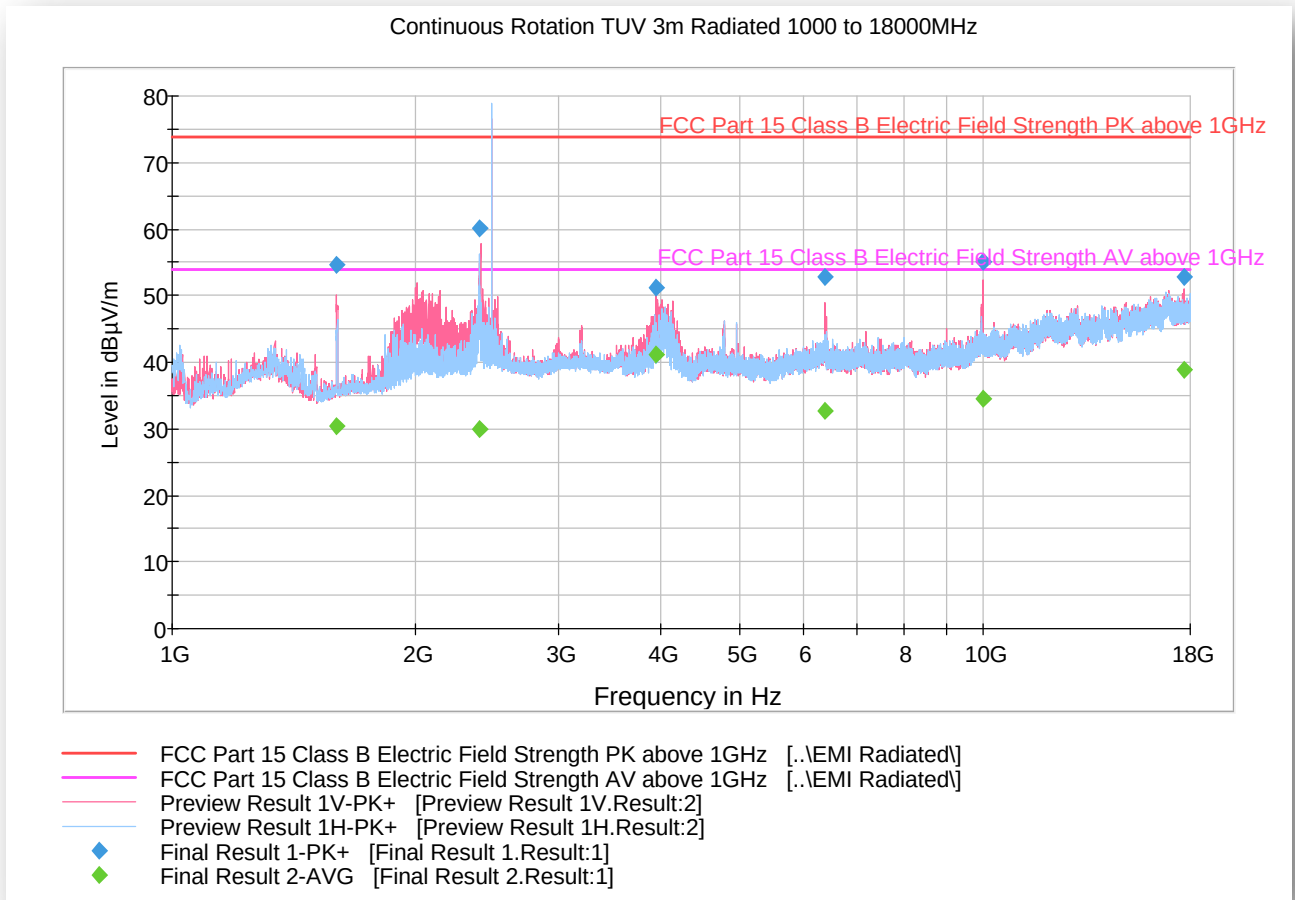
Frequency (MHz)	MaxPeak (dBμV/m)	Meas. Time (ms)	Bandwidth (kHz)	Height (cm)	Polarization	Azimuth (deg)	Corr. (dB)	Margin (dB)	Limit (dBμV/m)
1596.133333	54.2	1000.0	1000.000	103.7	V	84.0	-5.8	19.7	73.9
2102.866667	55.3	1000.0	1000.000	103.7	V	93.0	-2.1	18.6	73.9
3972.166667	52.9	1000.0	1000.000	395.1	V	101.0	2.3	21.0	73.9
6371.800000	54.1	1000.0	1000.000	124.7	V	107.0	6.4	19.8	73.9
9957.300000	56.6	1000.0	1000.000	132.7	V	114.0	9.5	17.3	73.9
16827.70000	52.4	1000.0	1000.000	309.2	H	350.0	17.9	21.5	73.9

Average Data

Frequency (MHz)	Average (dBμV/m)	Meas. Time (ms)	Bandwidth (kHz)	Height (cm)	Polarization	Azimuth (deg)	Corr. (dB)	Margin (dB)	Limit (dBμV/m)
1596.133333	28.8	1000.0	1000.000	103.7	V	84.0	-5.8	25.1	53.9
2102.866667	28.9	1000.0	1000.000	103.7	V	93.0	-2.1	25.0	53.9
3972.166667	45.1	1000.0	1000.000	395.1	V	101.0	2.3	8.8	53.9
6371.800000	32.9	1000.0	1000.000	124.7	V	107.0	6.4	21.0	53.9
9957.300000	34.4	1000.0	1000.000	132.7	V	114.0	9.5	19.5	53.9
16827.70000	39.3	1000.0	1000.000	309.2	H	350.0	17.9	14.6	53.9

Test Notes: Measurement was performed without a 2.4GHz notch filter. Fundamental will be ignored for this test. No significant emissions observed above 18GHz. Measurements above 18GHz are noise floor figures.

2.5.13 Test Results for Above 1GHz - High Channel



Peak Data

Frequency (MHz)	MaxPeak (dBμV/m)	Meas. Time (ms)	Bandwidth (kHz)	Height (cm)	Polarization	Azimuth (deg)	Corr. (dB)	Margin (dB)	Limit (dBμV/m)
1593.866667	54.6	1000.0	1000.000	99.7	V	287.0	-5.8	19.3	73.9
2391.533333	60.2	1000.0	1000.000	151.2	H	243.0	-1.0	13.7	73.9
3956.266667	51.3	1000.0	1000.000	384.0	V	108.0	2.2	22.6	73.9
6371.566667	52.8	1000.0	1000.000	127.7	V	114.0	6.4	21.1	73.9
9983.766667	55.0	1000.0	1000.000	99.7	V	123.0	9.5	18.9	73.9
17684.80000	52.9	1000.0	1000.000	244.4	V	91.0	17.9	21.0	73.9

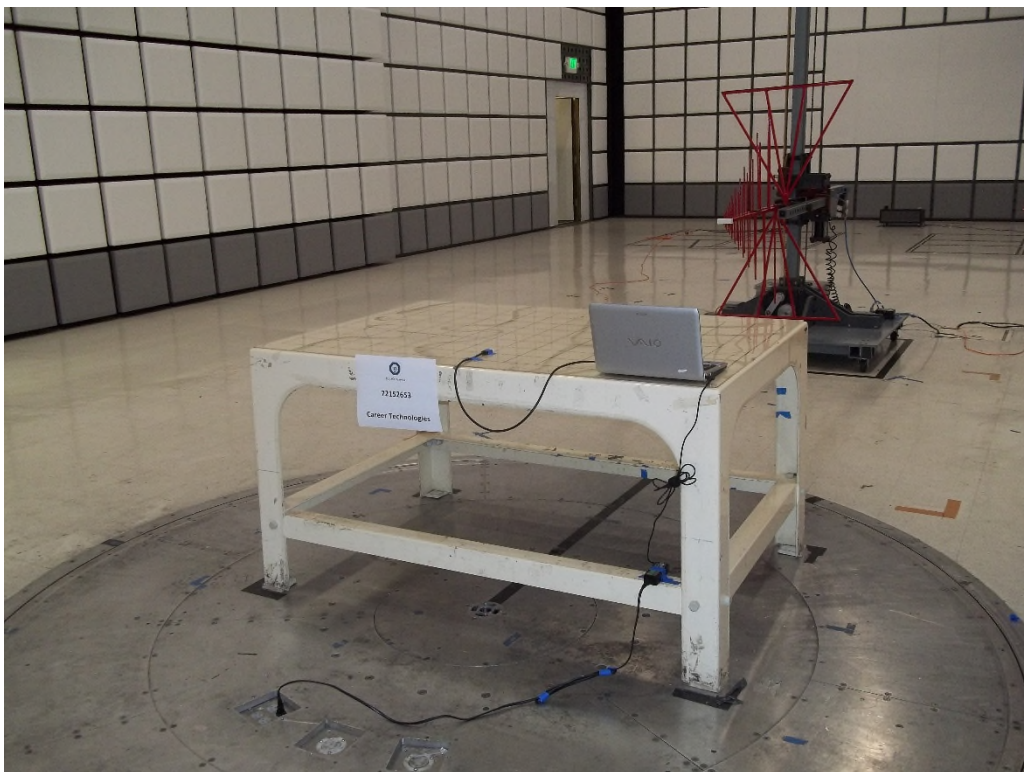
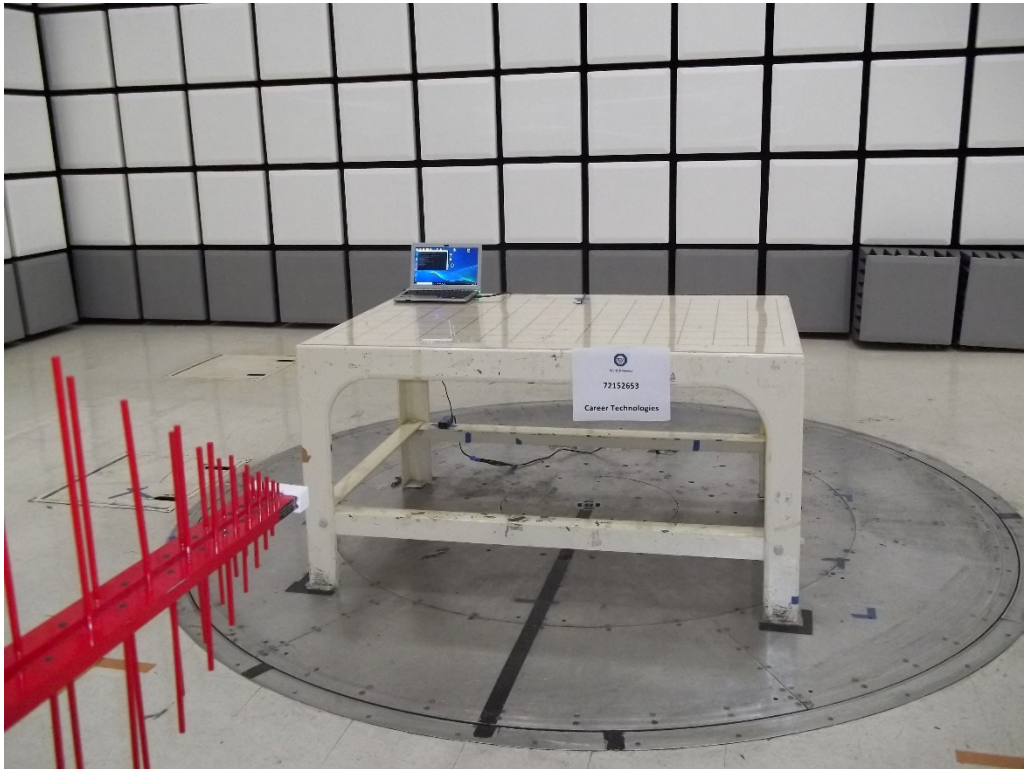
Average Data

Frequency (MHz)	Average (dBμV/m)	Meas. Time (ms)	Bandwidth (kHz)	Height (cm)	Polarization	Azimuth (deg)	Corr. (dB)	Margin (dB)	Limit (dBμV/m)
1593.866667	30.3	1000.0	1000.000	99.7	V	287.0	-5.8	23.6	53.9
2391.533333	29.9	1000.0	1000.000	151.2	H	243.0	-1.0	24.0	53.9
3956.266667	41.1	1000.0	1000.000	384.0	V	108.0	2.2	12.8	53.9
6371.566667	32.7	1000.0	1000.000	127.7	V	114.0	6.4	21.2	53.9
9983.766667	34.5	1000.0	1000.000	99.7	V	123.0	9.5	19.4	53.9
17684.80000	39.0	1000.0	1000.000	244.4	V	91.0	17.9	14.9	53.9

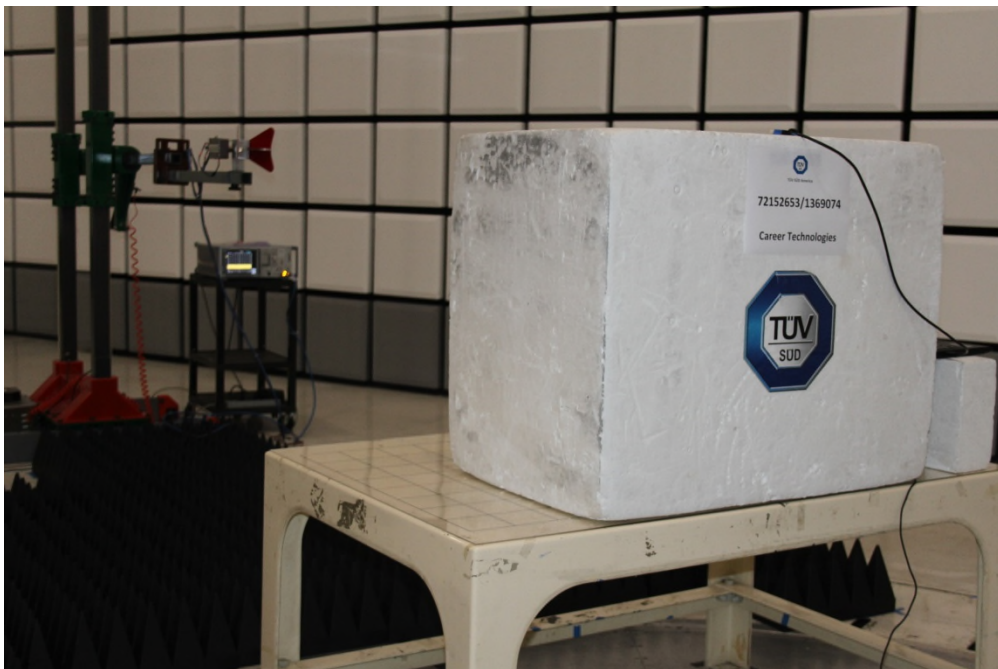
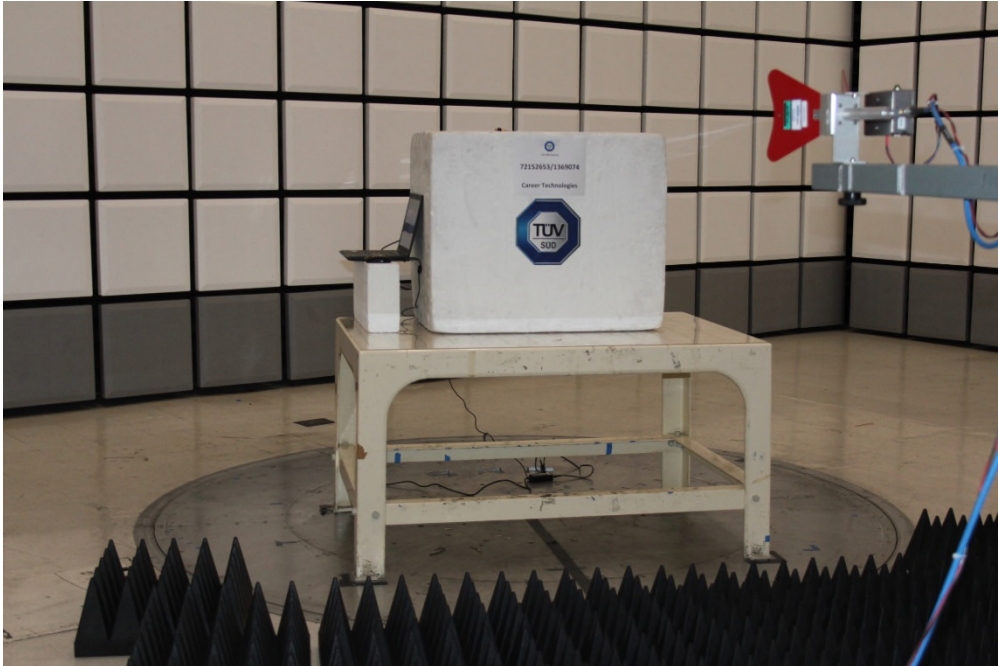
Test Notes:

Measurement was performed without a 2.4GHz notch filter. Fundamental will be ignored for this test. No significant emissions observed above 18GHz. Measurements above 18GHz are noise floor figures.

2.5.14 Test Setup Photos Radiated Emission Below 1GHz – 30MHz to 1000MHz (Front and Back)



2.5.15 Test Setup Photos Radiated Emission Above 1GHz – 1000MHz to 18000MHz (Front and Back)



2.6 RADIATED BAND EDGE MEASUREMENTS AND IMMEDIATE RESTRICTED BANDS

2.6.1 Specification Reference

Section 3.10.1.5

2.6.2 Standard Applicable

In any 100kHz 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 below that in the 100kHz bandwidth within the band that contains the highest level of the desired power, the attenuation shall be as below:

- (1) The attenuation shall be at least 20dB when the conducted power is measured according to the Appendix II of this part, based on either an RF conducted or a radiated measurement.
- (2) The attenuation shall be at least 30dB when the conducted power is measured according to the section 3.10.1.2(1)(C) of the standard.

In addition, radiated emissions which fall in section 2.7 the restricted bands must also comply with the radiated emission limit specified in section 2.8.

2.6.3 Equipment Under Test and Modification State

Not performed. Radiated Band Edge was performed via conducted sample; therefore, test results from the section 2.4 apply.

2.7 PEAK POWER SPECTRAL DENSITY

2.7.1 Specification Reference

Section 3.10.1.6(2)(B)

2.7.2 Standard Applicable

For digitally modulated systems, the peak power spectral density conducted from the intentional radiator to the antenna shall not be greater than 8dBm in any 3 kHz band during any time interval of continuous transmission.

2.7.3 Equipment Under Test and Modification State

Default Test Configuration (Please refer to original test reports ref. no 72152653A Rev.01 for the actual S/N used)

2.7.4 Date of Test/Initial of test personnel who performed the test

Please refer to original test reports ref. no: 72152653A Rev.01 for actual test date and initial of test engineer who performed the test

2.7.5 Test Equipment Used

The major items of test equipment used for the above tests are identified in Section 3.1.

2.7.6 Environmental Conditions

Test performed at TÜV SÜD America Inc. Rancho Bernardo facility

Ambient Temperature	26.3 °C
Relative Humidity	48.5 %
ATM Pressure	98.8 kPa

2.7.7 Additional Observations

- This is a conducted test using direct connection to the TS8997 Test System.
- The path loss was all accounted for with the test system calibration.
- Test methodology is per Test according to FCC title 47 part 15 §15.247(a),(e), KDB 558074 D01 DTS Meas Guidance v05 F and ANSI C63.10-2013.
- Only the worst-case data rate presented.
- Test setup is identical to Section 2.1.10.

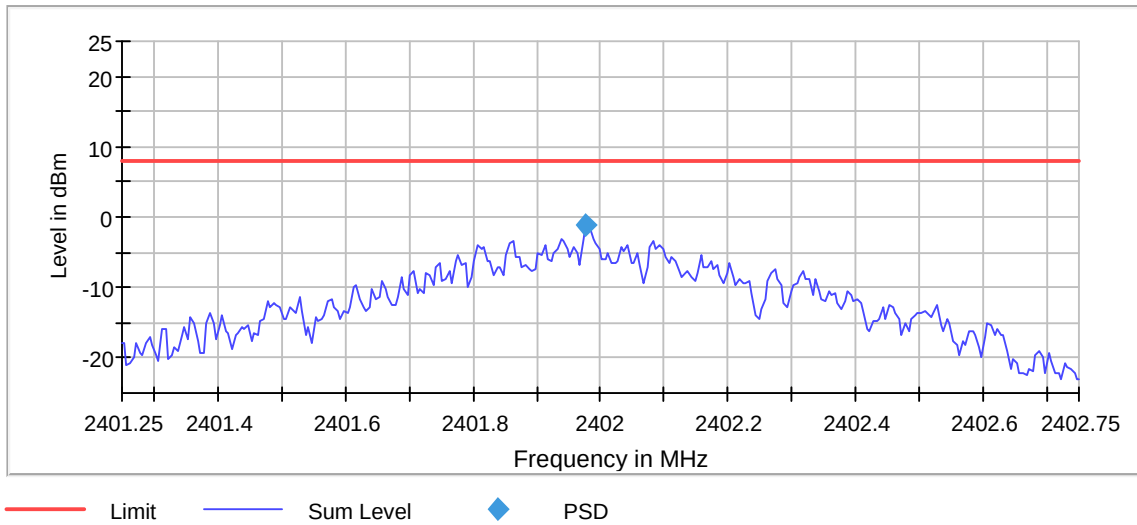
2.7.8 Measurement Settings

Setting	Instrument Value	Target Value
Span	1.500 MHz	1.500 MHz
RBW	10.000 kHz	<= 10.000 kHz
VBW	30.000 kHz	>= 30.000 kHz
SweepPoints	300	~ 300
SweepTime	6.000 ms	6.000 ms
Reference Level	0.000 dBm	0.000 dBm
Attenuation	20.000 dB	AUTO
Detector	RMS	RMS
SweepCount	1	1
Filter	3 dB	3 dB
Trace Mode	Max Hold	Max Hold
SweepType	Sweep	Sweep
Preamp	off	off
Stablemode	Trace	Trace
Stablevalue	0.50 dB	0.50 dB
Run	34 / max. 150	max. 150
Stable	3 / 3	3
Max Stable Difference	0.16 dB	0.50 dB

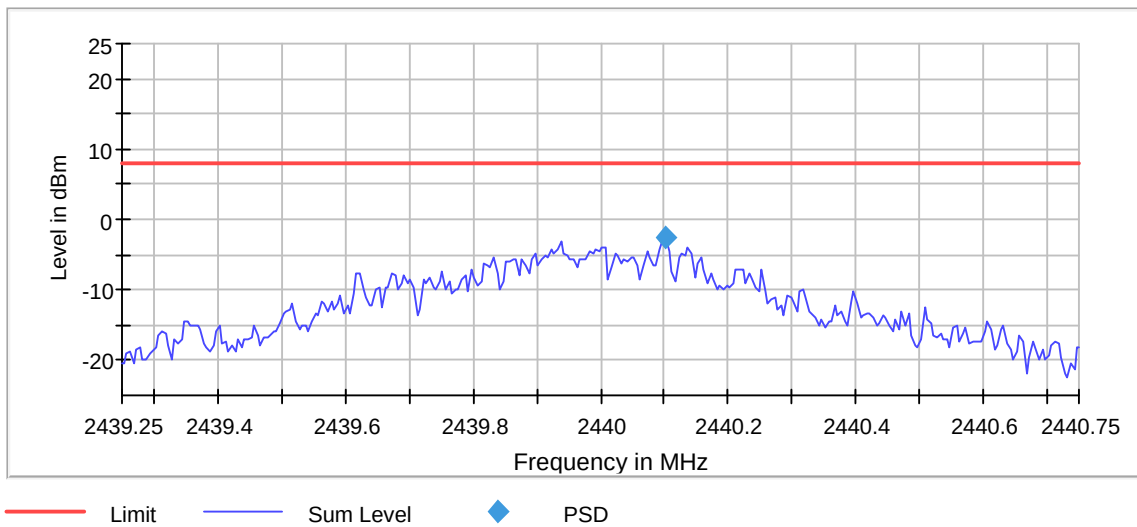
2.7.9 Test Results Summary

DUT Frequency (MHz)	Frequency (MHz)	PSD (dBm)	Limit Max (dBm)	Result
2402.000000	2401.977500	-1.111	8.0	PASS
2440.000000	2440.102500	-2.533	8.0	PASS
2480.000000	2479.852500	-2.846	8.0	PASS

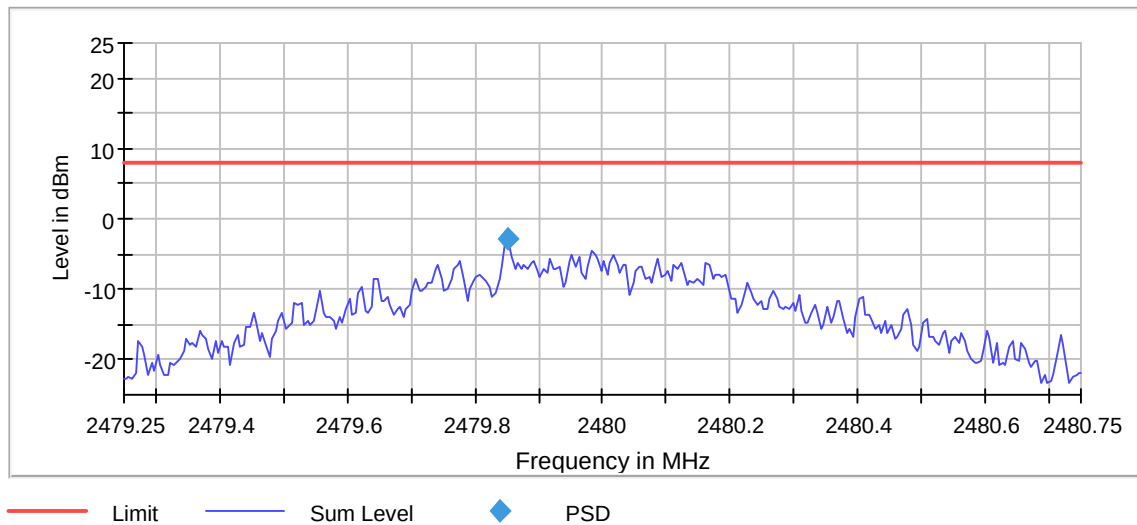
2.7.10 Test Results Plots



Bluetooth LE Low Channel



Bluetooth LE Middle Channel



Bluetooth LE High Channel

2.8 CONDUCTED EMISSIONS

2.8.1 Specification Reference

Section 2.3

2.8.2 Standard Applicable

For Low-power radio-frequency devices that is designed to be connected to the public utility (AC) power line, the radio frequency voltage that is conducted back onto the AC power line on any frequency or frequencies, within the band 150 kHz to 30 MHz, shall not exceed the limits in the following table, as measured using a 50 μ H/50 ohms line impedance stabilization network (LISN). The lower limit applies at the boundary between the frequency ranges.

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

**Decreases with the logarithm of the frequency.*

2.8.3 Equipment Under Test and Modification State

Serial No: N/A / Default Test Configuration

2.8.4 Date of Test/Initial of test personnel who performed the test

July 24, 2020 / AC

2.8.5 Test Equipment Used

The major items of test equipment used for the above tests are identified in Section 3.1.

2.8.6 Environmental Conditions

Test performed at TÜV SÜD America Inc. Rancho Bernardo facility

Ambient Temperature	23.6 °C
Relative Humidity	46.0 %
ATM Pressure	98.7 kPa

2.8.7 Additional Observations

- The EUT is controlled and programmed via support laptop. EUT transmission is being monitored through a support spectrum analyzer.
- The support laptop provided as a representative for EUT to be connect and exercise during test.
- Measurement was done using EMC32 automated software. Reported level is the actual level with all the correction factors factored in. Correction Factor column is for information purposes only. See Section 2.8.8 for sample computation.

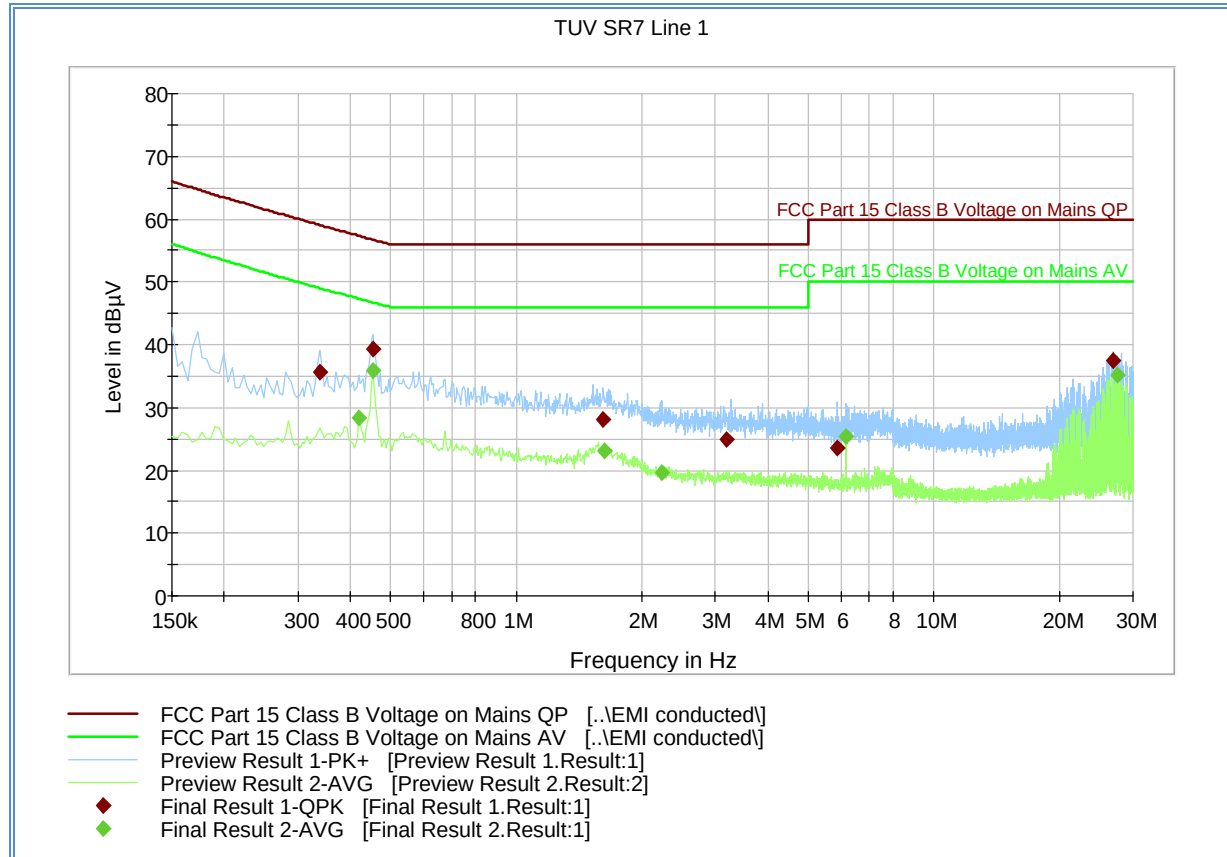
2.8.8 Sample Computation (Conducted Emission – Quasi Peak)

Measuring equipment raw measurement (dB μ V) @ 150kHz			5.5
Correction Factor (dB)	Asset# 8822 (20dB attenuator)	19.9	20.7
	Asset# 1177 (Cable)	0.15	
	Asset# 1176 (Cable)	0.35	
	Asset# 7567 (LISN)	0.30	
Reported QuasiPeak Final Measurement (dB μ V) @ 150kHz			26.2

2.8.9 Test Results

See attached plots and tables.

2.8.10 FCC Class B Line 1 (120VAC/60Hz)



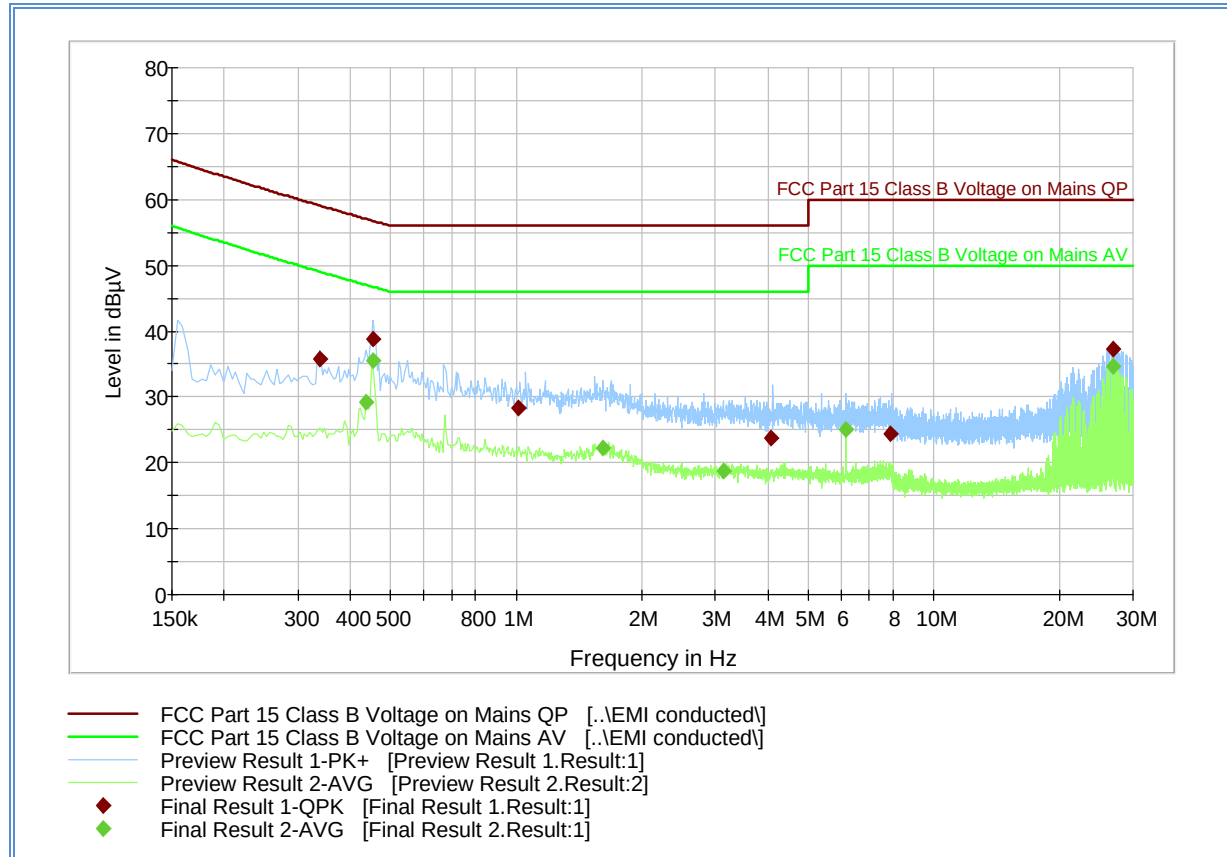
Quasi Peak Data

Frequency (MHz)	QuasiPeak (dBμV)	Meas. Time (ms)	Bandwidth (kHz)	Filter	Line	Corr. (dB)	Margin (dB)	Limit (dBμV)
0.339000	35.8	1000.0	9.000	Off	L1	20.4	23.3	59.0
0.456000	39.3	1000.0	9.000	Off	L1	20.2	17.4	56.7
1.612500	28.1	1000.0	9.000	Off	L1	20.4	27.9	56.0
3.192000	24.8	1000.0	9.000	Off	L1	20.3	31.2	56.0
5.883000	23.5	1000.0	9.000	Off	L1	20.2	36.5	60.0
26.808000	37.6	1000.0	9.000	Off	L1	20.5	22.4	60.0

Average Data

Frequency (MHz)	QuasiPeak (dBμV)	Meas. Time (ms)	Bandwidth (kHz)	Filter	Line	Corr. (dB)	Margin (dB)	Limit (dBμV)
0.420000	28.4	1000.0	9.000	Off	L1	20.3	18.9	47.3
0.456000	36.0	1000.0	9.000	Off	L1	20.2	10.7	46.7
1.626000	23.0	1000.0	9.000	Off	L1	20.3	23.0	46.0
2.229000	19.7	1000.0	9.000	Off	L1	20.3	26.3	46.0
6.144000	25.3	1000.0	9.000	Off	L1	20.3	24.7	50.0
27.460500	35.2	1000.0	9.000	Off	L1	20.4	14.8	50.0

2.8.11 FCC Class B Line 2 (120VAC/60Hz)



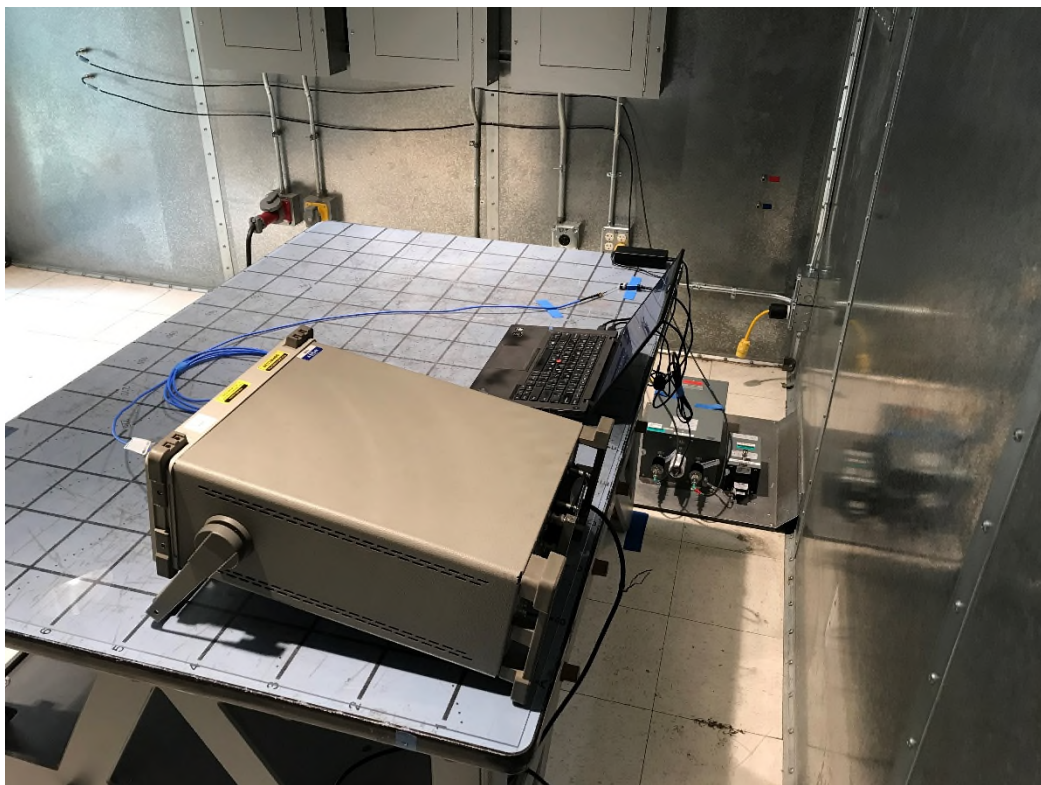
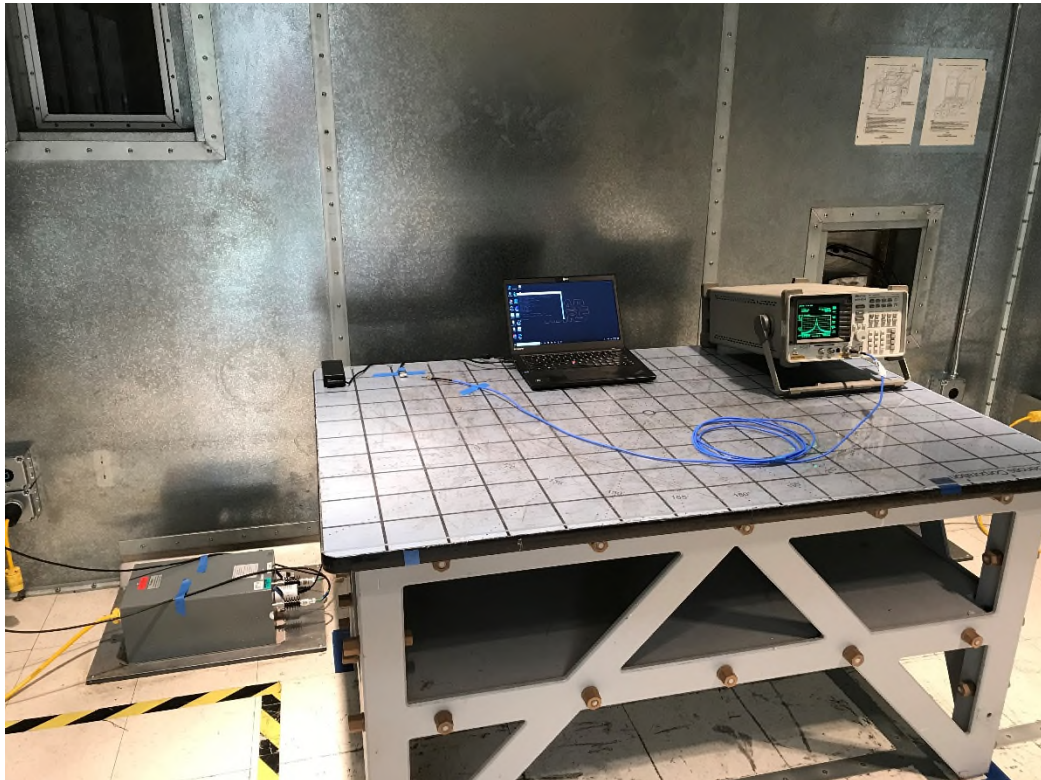
Quasi Peak Data

Frequency (MHz)	QuasiPeak (dBμV)	Meas. Time (ms)	Bandwidth (kHz)	Filter	Line	Corr. (dB)	Margin (dB)	Limit (dBμV)
0.339000	35.8	1000.0	9.000	Off	N	20.4	23.3	59.0
0.456000	38.9	1000.0	9.000	Off	N	20.3	17.8	56.7
1.014000	28.2	1000.0	9.000	Off	N	20.3	27.8	56.0
4.092000	23.9	1000.0	9.000	Off	N	20.2	32.1	56.0
7.881000	24.5	1000.0	9.000	Off	N	20.2	35.5	60.0
26.808000	37.2	1000.0	9.000	Off	N	20.5	22.8	60.0

Average Data

Frequency (MHz)	QuasiPeak (dBμV)	Meas. Time (ms)	Bandwidth (kHz)	Filter	Line	Corr. (dB)	Margin (dB)	Limit (dBμV)
0.438000	29.2	1000.0	9.000	Off	N	20.3	17.8	47.0
0.456000	35.5	1000.0	9.000	Off	N	20.3	11.2	46.7
1.608000	22.1	1000.0	9.000	Off	N	20.4	23.9	46.0
3.142500	18.8	1000.0	9.000	Off	N	20.3	27.2	46.0
6.144000	25.2	1000.0	9.000	Off	N	20.3	24.8	50.0
26.808000	34.7	1000.0	9.000	Off	N	20.5	15.3	50.0

2.8.12 Test Setup Photo (Front and Back)



2.9 ANTENNA REQUIREMENTS

2.9.1 Specification Reference

Section 2.2

2.9.2 Standard Applicable

Antenna requirement: Low-power radio frequency transmitter or transceiver (receiver) shall utilize a permanently, half- permanently attached antenna or uses a unique coupling at the antenna and at any cable connector between the transmitter and the antenna. The antenna shall be omni-directional type. The manufacturer may design the unit so that the user can replace a broken antenna, but the use of a standard antenna jack or electrical connector or other than authorized is prohibited. Such standard connectors are for example: BNC, F type, N type, M type, UG type, RCA, SMA, SMB, and other standard type antenna connectors.

2.9.3 Verification Results

The EUT complies with this requirement by implementing a solder-on ceramic antenna. The manufacturer provided a separate exhibit "2450AT18A100 Antenna Radiation Measurement.pdf" detailing the antenna used. The radiation pattern plots from the measurement test report are attached on the following pages for reference.

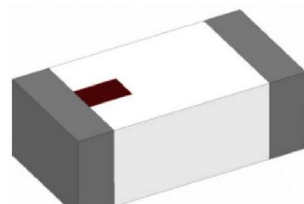
"High Frequency Ceramic Solutions"

2.4GHz Mini Antenna, SMT**P/N 2450AT18A100**

Detail Specification: 7/9/2018

Page 1 of 5

*Let us help you with the antenna design, optimization, and tuning!***General Specifications**

Part Number	2450AT18A100		
Frequency (MHz)	2400 - 2500		
Avg. Rad Efficiency*	76%		
Peak Gain (dBi typ.)	0.5		
Average Gain (dBi typ.)	-0.5		
Return Loss (dB)	9.5 min.		
Impedance	50 Ω	Storage Period	18 months max.
Input Power	2 Watts max. (CW)	Storage Temperature	-40 to +125°C
		Operating Temperature	-40 to +125°C
		Reel Quantity	3000

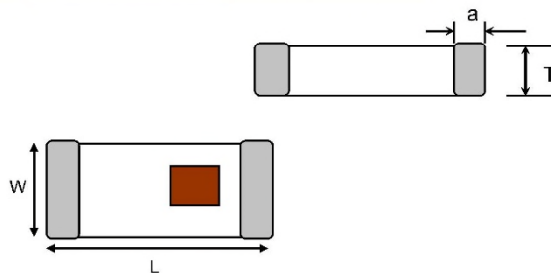
*Efficiency based on Johanson's standard evaluation board

Part Number Explanation

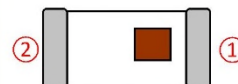
P/N Suffix	Packing Style	Bulk (loose)	Suffix = S	e.g. 2450AT18A100S
		T & R	Suffix = E	e.g. 2450AT18A100E
		100% Tin	Suffix = E or S	e.g. 2450AT18A100(E or S)
	Evaluation Board	2450AT18A100-EBSMA (see page 2&3 for details)		

Mechanical Dimensions

	In	mm
L	0.126 $\pm$ 0.008	3.20 $\pm$ 0.2
W	0.063 $\pm$ 0.008	1.60 $\pm$ 0.2
T	0.051 $\pm$ 0.004/-0.008	1.30 $\pm$ 0.1/-0.2
a	0.020 $\pm$ 0.012	0.50 $\pm$ 0.3

Want the layout file? Request it at: www.johansontechnology.com/ask-a-question**Terminal Configuration**

No.	Function
1	FEED
2	NC



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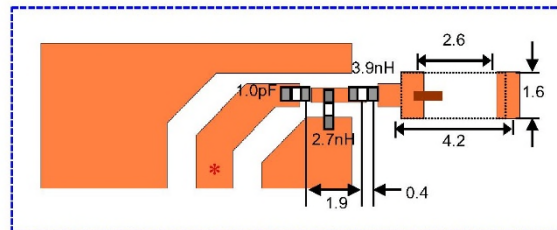
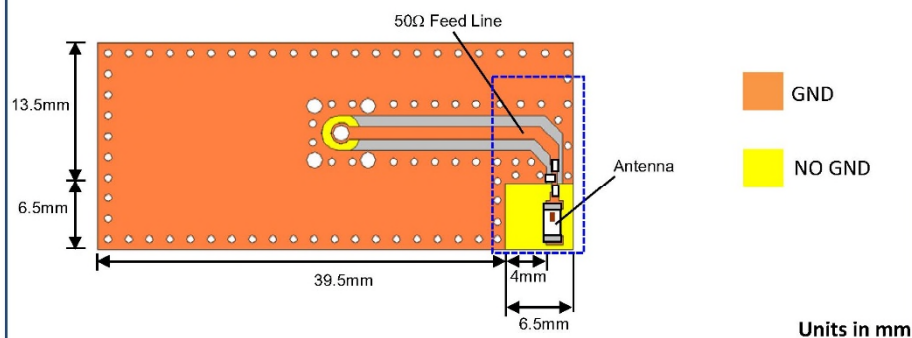
2.4GHz Mini Antenna, SMT

P/N 2450AT18A100

Detail Specification: 7/9/2018

Page 2 of 5

Mounting Considerations 1: Evaluation Board



JTI P/N for Matching Circuit:

Cap (1.0pF): 500R07S1R02BV4T

Inductor (2.7nH): L-07C2N7SV6T

Inductor (3.9nH): L-07C3N9SV6T

To order a pre-tuned 50Ω EVB with a female SMA connector click here: www.johansontechnology.com/request-a-sample
Reference p/n: 2450AT18A100-EBSMA

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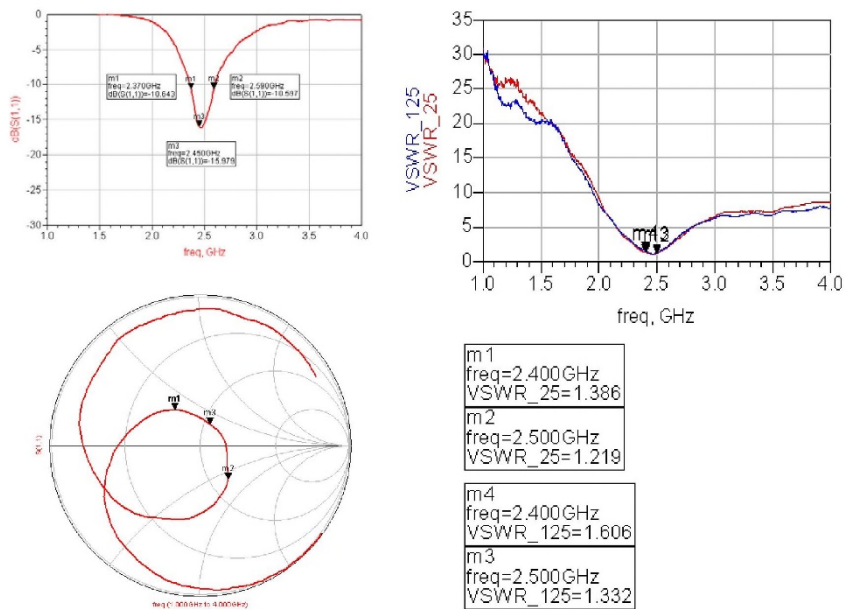
"High Frequency Ceramic Solutions"

2.4GHz Mini Antenna, SMT
Detail Specification: 7/9/2018

P/N 2450AT18A100
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Mounting Considerations 1: Typical Electrical Performance (T=25°C)

Return Loss with matching circuit @ +25C VSWR with matching circuit @ +25C and +125C



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2.4GHz Mini Antenna, SMT

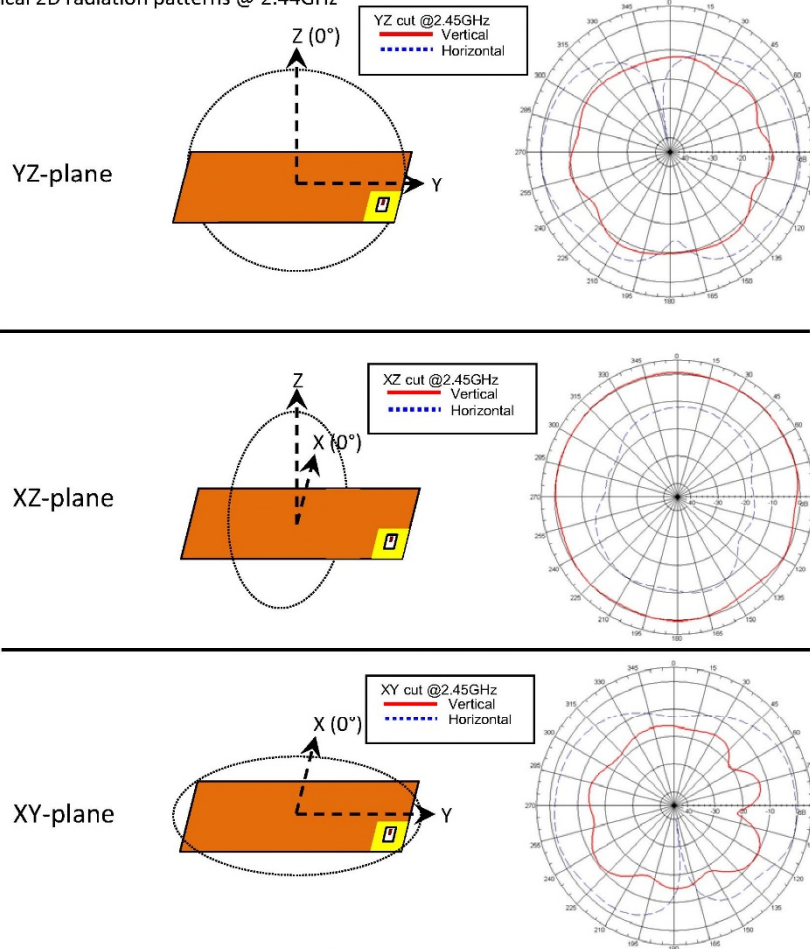
P/N 2450AT18A100

Detail Specification: 7/9/2018

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Mounting Considerations 1: Antenna Performance

Typical 2D radiation patterns @ 2.44GHz



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Detail Specification: 7/9/2018

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Antenna tuning, optimization, and validation services:

www.johansontechnology.com/ipc-antenna-services

For more antennas and to download measured S-parameters, go to:

www.johansontechnology.com/antennas

Soldering Information

www.johansontechnology.com/ipcsoldering-profile

MSL Info

www.johansontechnology.com/msl-rating

Packaging information

www.johansontechnology.com/tape-reel-packaging

For layout review contact our Applications Team at:

www.johansontechnology.com/ask-a-question

RoHS Compliance

www.johansontechnology.com/rohs-compliance

Need help designing the antenna in? Use our antenna design services!

www.johansontechnology.com/ipc-antenna-services

We provide 2 free layout reviews and if you need us to tune and characterize the antenna on your product (inside anechoic chamber) we can do that too. Small lab fee may apply for the latter.

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SECTION 3

TEST EQUIPMENT USED

3.1 TEST EQUIPMENT USED

(Originally evaluated under TÜV SÜD test reports ref. no. 72152653A Rev.01 and 72152653C Rev.01)
List of absolute measuring and other principal items of test equipment.

ID Number (SDGE/SDRB)	Test Equipment	Type	Serial Number	Manufacturer	Cal Date	Cal Due Date
Antenna Conducted Port Setup						
7643	Signal/Spectrum Analyzer	FSV30	1321.3008K30/103166	Rhode & Schwarz	04/04/18	04/04/20
7655	Vector Signal Generator	SMBV100A	260734	Rhode & Schwarz	11/19/18	11/19/19
7654	Signal Generator	SMB 100A	175750	Rhode & Schwarz	11/16/18	11/16/19
7656	OSP with B157	OSP120	101310	Rhode & Schwarz	01/23/19	01/23/20
8825	20dB Attenuator	46-20-34	BK5773	Weinschel Corp.	Verified by 7643 and 7654	
8832	20dB Attenuator	34-20-34	BP4150	MCE/Weinschel	Verified by 7643 and 7654	
Conducted Emissions						
7620	EMI Test Receiver	ESU40	100399	Rhode & Schwarz	10/18/19	10/18/20
7567	LISN	FCC-LISN-50-25-2-10	120304	Fisher Custom Comm	01/27/20	01/27/21
7568	LISN	FCC-LISN-50-25-2-10	120305	Fisher Custom Comm	02/25/20	02/25/21
8822	20dB Attenuator	34-20-34	BP4180	MCE/Weinschel	07/14/20	07/14/21
8824	20dB attenuator	34-20-34	BP4150	MCE/Weinschel	07/14/20	07/14/21
Radiated Test Setup						
1033	Bilog Antenna	3142C	00044556	EMCO	11/06/18	11/06/20
7631	Double-ridged waveguide horn antenna	3117	00205418	ETS-Lindgren	08/20/18	08/20/20
8628	Pre-amplifier	QLI-01182835-JO	8986002	Quinstar	03/07/19	03/07/20
1153	High-frequency cable	SucoFlex 100 SX	N/A	Suhner	Verified by 7643 and 7654	
8543	High-frequency cable	Micropore 19057793	N/A	United Microwave Products	Verified by 7643 and 7654	
1040	EMI Test Receiver	ESIB40	100292	Rhode & Schwarz	10/15/18	10/15/19
7620	EMI Test Receiver	ESU40	100399	Rhode & Schwarz	10/18/18	10/18/19
1016	Pre-Amplifier	PAM-0202	187	PAM	03/08/19	03/08/20
1033	Bilog Antenna	3142C	00044556	EMCO	11/06/18	11/06/20
Miscellaneous						
11312	Mini Environmental Quality Meter	850027	CF099-56010-340	Sper Scientific	04/16/19	04/16/20
-	Test Software	EMC32	V8.53	Rhode & Schwarz	N/A	

3.2 MEASUREMENT UNCERTAINTY

Calculation of Measurement Uncertainty per CISPR 16-4-2:2011 with Corr. 1

3.2.1 Radiated Emission Measurement 30 MHz – 1000 MHz at a distance of 3 m

	Input Quantity (Contribution) X_i	Value	Prob. Dist.	Divisor	$u_i(x)$	$u_i(x)^2$
1	Receiver reading	0.10 dB	Normal, k=1	1.000	0.10	0.01
2	Attenuation: antenna-receiver	0.20 dB	Normal, k=2	2.000	0.10	0.01
3	Antenna factor AF	0.75 dB	Normal, k=2	2.000	0.38	0.14
4	Receiver sinewave accuracy	1.10 dB	Normal, k=2	2.000	0.55	0.30
5	Receiver pulse amplitude	1.50 dB	Rectangular	1.732	0.87	0.75
6	Receiver pulse repetition rate	1.50 dB	Rectangular	1.732	0.87	0.75
7	Noise floor proximity	0.50 dB	Rectangular	1.732	0.29	0.08
8	Mismatch: antenna-receiver	0.95 dB	U-shaped	1.414	0.67	0.45
9	AF frequency interpolation	0.30 dB	Rectangular	1.732	0.17	0.03
10	AF height deviations	0.10 dB	Rectangular	1.732	0.06	0.00
11	Directivity difference at 3 m	3.12 dB	Rectangular	1.732	1.80	3.24
12	Phase center location at 3 m	1.00 dB	Rectangular	1.732	0.58	0.33
13	Cross-polarization	0.90 dB	Rectangular	1.732	0.52	0.27
14	Balance	0.00 dB	Rectangular	1.732	0.00	0.00
15	Site imperfections	3.91 dB	Triangular	2.449	1.60	2.55
16	Separation distance at 3 m	0.30 dB	Rectangular	1.732	0.17	0.03
17	Effect of setup table material	0.40 dB	Rectangular	1.732	0.23	0.05
18	Table height at 3 m	0.10 dB	Normal, k=2	2.000	0.05	0.00
19	Near-field effects	0.00 dB	Triangular	2.449	0.00	0.00
20	Effect of ambient noise on OATS	0.00 dB				0.00
		Combined standard uncertainty	Normal	3.00	dB	
		Expanded uncertainty	Normal, k=2	6.00	dB	

3.2.2 Radiated Emission Measurements Above 1GHz at a distance of 3 m

	Input Quantity (Contribution) X_i	Value	Prob. Dist.	Divisor	$u_i(x)$	$u_i(x)^2$
1	Receiver reading	0.10 dB	Normal, k=1	1.000	0.10	0.01
2	Attenuation: antenna-receiver	0.30 dB	Normal, k=2	2.000	0.15	0.02
3	Preamplifier Gain	0.20 dB	Normal, k=2	2.000	0.10	0.01
4	Antenna factor AF	0.37 dB	Normal, k=2	2.000	0.19	0.03
5	Sinewave accuracy	0.57 dB	Normal, k=2	2.000	0.29	0.08
6	Instability of preamp gain	1.21 dB	Rectangular	1.732	0.70	0.49
7	Noise floor proximity	0.70 dB	Rectangular	1.732	0.40	0.16
8	Mismatch: antenna-preamplifier	1.41 dB	U-shaped	1.414	1.00	0.99
9	Mismatch: preamplifier-receiver	1.30 dB	U-shaped	1.414	0.92	0.85
10	AF frequency interpolation	0.30 dB	Rectangular	1.732	0.17	0.03
11	Directivity difference at 3 m	1.50 dB	Rectangular	1.732	0.87	0.75
12	Phase center location at 3 m	0.30 dB	Rectangular	1.732	0.17	0.03
13	Cross-polarization	0.90 dB	Rectangular	1.732	0.52	0.27
14	Site imperfections VSWR (Method 2)	5.30 dB	Triangular	2.449	2.16	4.68
15	Effect of setup table material	1.15 dB	Rectangular	1.732	0.66	0.44
16	Separation distance at 3 m	0.30 dB	Rectangular	1.732	0.17	0.03
17	Table height at 3 m	0.00 dB	Normal, k=2	2.000	0.00	0.00
		Combined standard uncertainty	Normal	2.98	dB	
		Expanded uncertainty	Normal, k=2	5.96	dB	

3.2.1 Antenna Port Conducted Measurements

	Input Quantity (Contribution) X_i	Value	Prob. Dist.	Divisor	$u_i(x)$	$u_i(x)^2$
1	Receiver reading	0.10 dB	Normal, k=1	1.000	0.10	0.01
2	Cable attenuation	1.00 dB	Normal, k=2	2.000	0.50	0.25
3	Receiver sinewave accuracy	0.08 dB	Normal, k=2	2.000	0.04	0.00
4	Receiver pulse amplitude	0.00 dB	Normal, k=2	1.732	0.00	0.00
5	Receiver pulse repetition rate	0.00 dB	Rectangular	1.732	0.00	0.00
6	Noise floor proximity	0.00 dB	Rectangular	1.732	0.00	0.00
7	Frequency interpolation	0.10 dB	Rectangular	1.732	0.06	0.00
8	Mismatch	0.07 dB	U-shaped	1.414	0.05	0.00
		Combined standard uncertainty	Normal	0.52 dB		
		Expanded uncertainty	Normal, k=2	1.03 dB		

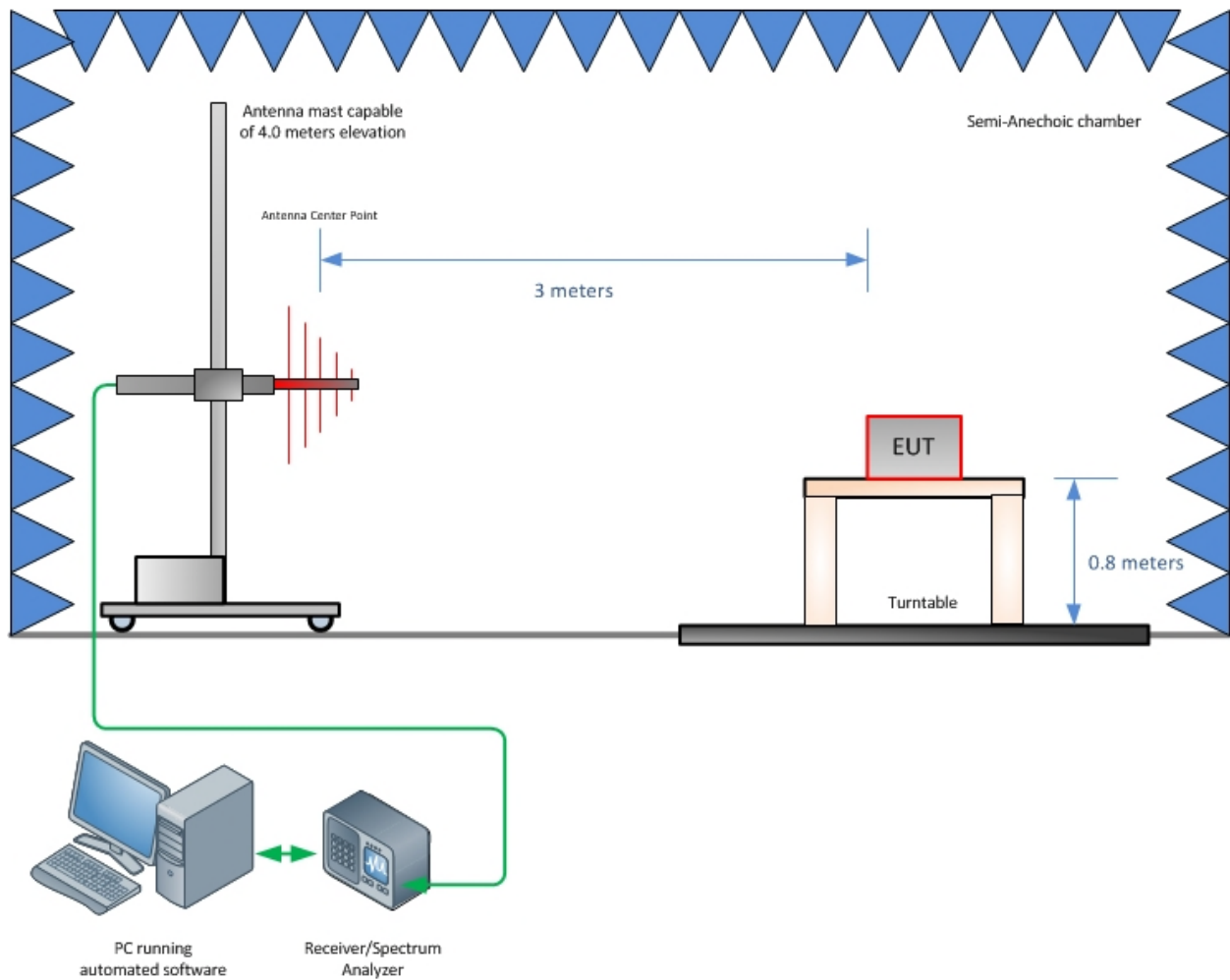
3.2.2 Conducted Emissions Measurements

	Input Quantity (Contribution) X_i	Value	Prob. Dist.	Divisor	$u_i(x)$	$u_i(x)^2$
1	Receiver reading	0.10 dB	Normal, k=1	1.000	0.10	0.01
2	LISN-receiver attenuation	0.10 dB	Normal, k=2	2.000	0.05	0.00
3	LISN voltage division factor	0.30 dB	Normal, k=2	2.000	0.15	0.02
4	Receiver sinewave accuracy	0.36 dB	Normal, k=2	2.000	0.18	0.03
5	Receiver pulse amplitude	1.50 dB	Rectangular	1.732	0.87	0.75
6	Receiver pulse repetition rate	1.50 dB	Rectangular	1.732	0.87	0.75
7	Noise floor proximity	0.00 dB	Rectangular	1.732	0.00	0.00
8	AMN VDF frequency interpolation	0.10 dB	Rectangular	1.732	0.06	0.00
9	Mismatch	0.07	U-shaped	1.414	0.05	0.00
10	LISN impedance	2.65	Triangular	2.449	1.08	1.17
11	Effect of mains disturbance	0.00			0.00	0.00
12	Effect of the environment					
		Combined standard uncertainty	Normal	1.66 dB		
		Expanded uncertainty	Normal, k=2	3.31 dB		

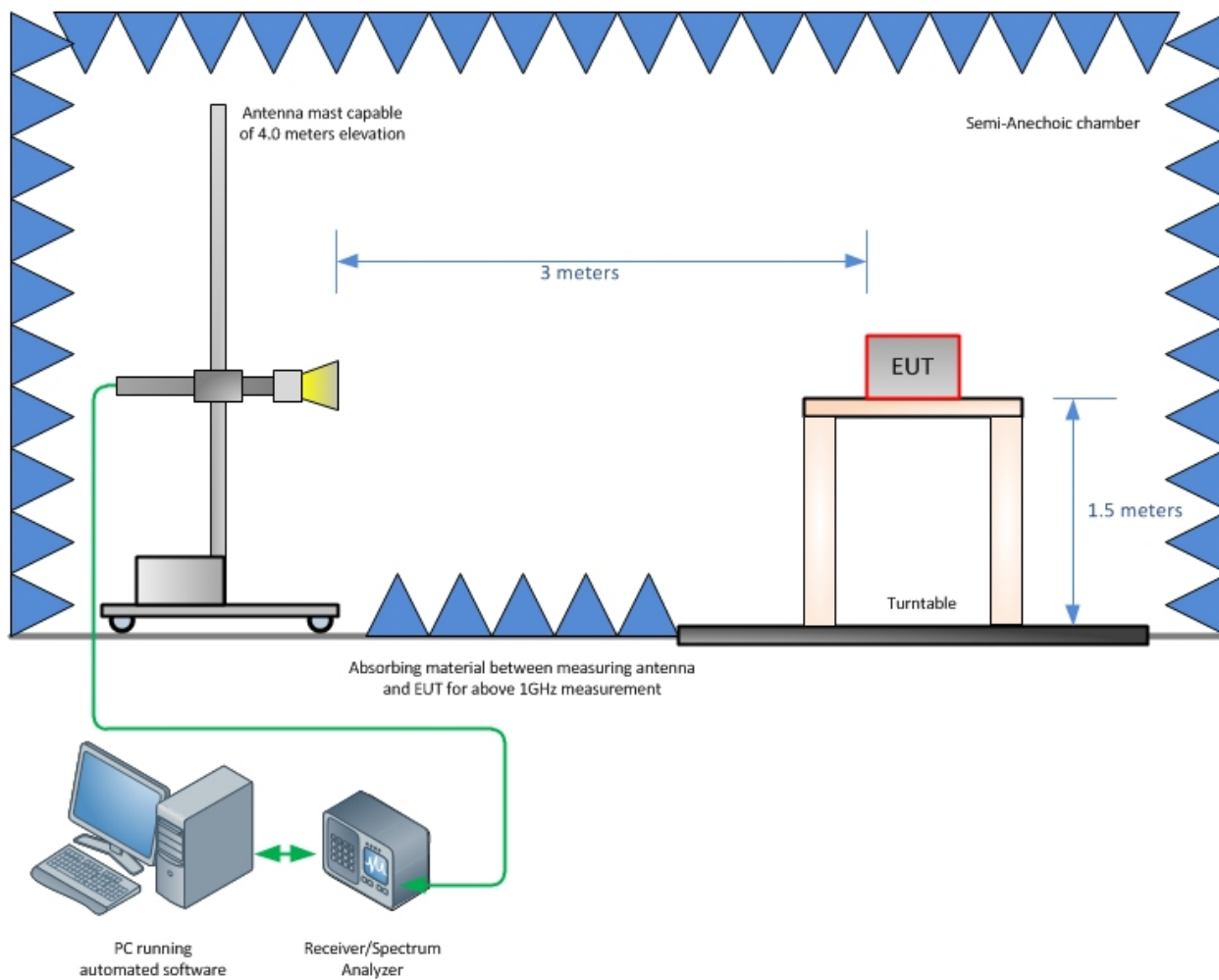
SECTION 4

DIAGRAM OF TEST SETUP

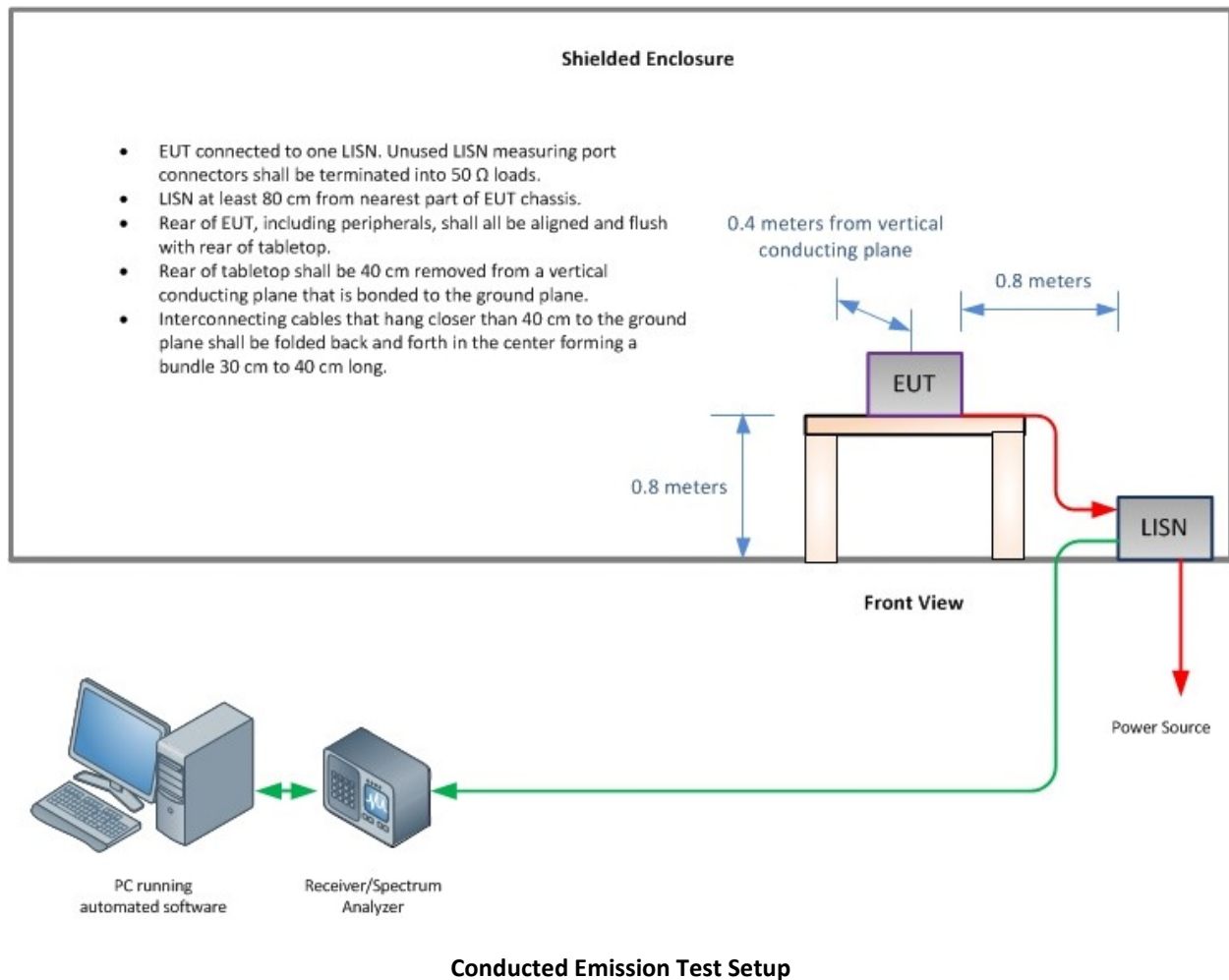
4.1 TEST SETUP DIAGRAM



Radiated Emission Test Setup (Below 1GHz)



Radiated Emission Test Setup (Above 1GHz)





SECTION 5

ACCREDITATION, DISCLAIMERS AND COPYRIGHT

5.1 ACCREDITATION, DISCLAIMERS AND COPYRIGHT

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