Radio Testing of the

Vayyar Imaging LTD
60GHz fixed field-disturbance sensor or a short-range device for interactive-motion sensing Model: vStraw_CTPB2

In accordance with FCC Part 15 Subpart C §15.255

America

Add value.
Inspire trust.

Vayyar Imaging LTD
3 Avramham Giron
Yehud TA 5621717

COMMERCIAL-IN-CONFIDENCE

Date: November 2019
Document Number: 72152870A Issue 02 | Version Number: 01

RESPONSIBLE FOR	NAME	DATE	SIGNATURE
Authorized Signatory	Alex Chang	November 27, 2019	

Signatures in this approval box have checked this document in line with the requirements of TÜV SÜD document control rules.

EXECUTIVE SUMMARY
A sample of this product was tested and found to be in compliance with FCC Part 15 Subpart C §15.255.

A2LA Cert. No. 2955.13

TÜV SÜD America, Inc.
10040 Mesa Rim Road
San Diego, CA 92121-2912

TÜV SÜD America, Inc.
Rancho Bernardo Facility
16936 Via Del Campo
San Diego, CA 92127

Phone: 858 678 1400
www.tuv-sud-america.com

REPORT ON	Radio Testing of the Vayyar Imaging LTD Model vStraw_CTPB2 60GHz fixed field-disturbance sensor or a short-range device for interactive-motion sensing
TEST REPORT NUMBER	72152870A
TEST REPORT DATE	November 2019
PREPARED FOR	Vayyar Imaging LTD 3 Avramham Giron Yehud TA 5621717
CONTACT PERSON	Naftali Chayat Chief Technology Officer naftali.chayat@vayyar.com +972-544-225549
PREPARED BY	Ferdinand S. Custodio **Name** Authorized Signatory Title: Senior EMC Test Engineer / Wireless Team Lead
APPROVED BY	Alex Chang **Name** Authorized Signatory Title: Senior EMC/RF Wireless Test Engineer
DATED	November 27, 2019

Revision History

72152870A Vayyar Imaging LTD Model vStraw_CTPB2 60GHz fixed field-disturbance sensor or a short-range device for interactive-motion sensing					
DATE	OLD REVISION	NEW REVISION	REASON	PAGES AFFECTED	APPROVED BY
11/27/2019	—	Initial Release			Alex Chang
04/13/2020	Initial Release	Issue 2	Included the frequency range the EUT operates (59-64GHz)	8, 13 and 14	Ferdinand Custodio
			Updated antenna gain from 5dBi to 5.7dbi based from extensive electromagnetic simulations performed by the manufacturer	8	

CONTENTS

SECTION 1

1 REPORT SUMMARY

Radio Testing of the
Vayyar Imaging LTD
vStraw_CTPB2 60GHz fixed field-disturbance sensor or a short-range device for interactive-motion sensing

1.1 INTRODUCTION

The information contained in this report is intended to show verification of the Vayyar Imaging LTD vStraw_CTPB2 60GHz fixed field-disturbance sensor or a short-range device for interactive-motion sensing to the requirements of FCC Part 15 Subpart C §15.255.

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	Vayyar Imaging LTD
EUT	60GHz fixed field-disturbance sensor or a short-range device for interactive-motion sensing
Trade Name	vStraw_CTPB2
Model Name	vStraw_CTPB2
FCC ID	2AHIS-V60G-HOME
IC Number	21498-V60GHOME
Serial Number(s)	STRBAB2N399U0063 and STRBAB2N399U0032
Number of Samples Tested	2
Test Specification/Issue/Date	FCC Part 15 Subpart C §15.255 (October 1, 2018).
Start of Test	October 30, 2019
Finish of Test	November 24, 2019
Name of Engineer(s)	Ferdinand Custodio
Related Document(s)	• ANSI C63.10-2013. American National Standard of Procedures for Compliance testing of Unlicensed Wireless Devices. • MPR for b2vStraw - Manual_23Oct19.pdf • Supporting documents for EUT certification are separate exhibits.

1.2 BRIEF SUMMARY OF RESULTS

A brief summary of the tests carried out in accordance with FCC Part 15 Subpart C §15.255 are shown below:

Section	§15.247 Spec Clause	Test Description	Result	Comments/Base Standard
2.1	§15.255(c)(3) and (e)	Transmitter Power	Compliant	
2.2	§15.207(a)	Conducted Emissions	Compliant	
2.3	§15.255(f)	Frequency Stability	Compliant	
2.4	§15.255(e)	Occupied Bandwidth	Compliant	
2.5	§15.255(d)(1)(2) and (3)	Field Strength of Spurious Radiation	Compliant	

1.3 PRODUCT INFORMATION

1.3.1 Technical Description

The Equipment Under Test (EUT) is a Vayyar Imaging LTD vStraw_CTPB2 60GHz fixed field-disturbance sensor or a short-range device for interactive-motion sensing. The EUT is part of the V60GHOME family of modules operating at 60GHz - acting as either fixed field-disturbance sensor or a short-range device for interactive-motion sensing. The models certified under this family are intended to be certified as modules, under modular approval, to be integrated in multiple products, or operated with a host-PC. The family will include, but not restricted to, the following members, having the same RF components, antennas type and array, RF layout and stack-up and same transmissions profile within 57-71GHz - differ only by their DC and digital interfaces:

- vBLU_OK_CTPB2 , vBLU_MW_CTPB2 - SPI interface, 30-pin DC\digital connector (2 types)
- vStraw_CTPB2 - USB + SPI interface and connector

1.3.2 EUT General Description

EUT Description	60GHz fixed field-disturbance sensor or a short-range device for interactive-motion sensing
Trade Name	vStraw_CTPB2
Model Name	vStraw_CTPB2
Rated Voltage	USB powered (5VDC)
Mode Verified	60GHz radar
Capability	60GHz radar
Frequency Range	59-64GHz
Primary Unit (EUT)	☐ Production ☒ Pre-Production ☐ Engineering
Transmission Mode	MIMO (24 x 22)
Number of TX Outputs	8 – 24 (transmitting each time in parallel with 12 TX-ports connected to 12 TX-antennas (MIMO), switching the phase at a high-rate (~1usec rate), changing the momentary beam-form)
Antenna Type	PCB embedded
Manufacturer	Vayyar Imaging LTD.
Single Antenna Gain	5.7 dBi
Effective Gain	16.5 dBi (5.7 dBi + 10*log10(12))

1.4 EUT TEST CONFIGURATION

1.4.1 Test Configuration Description

Test Configuration	Description
Default	The EUT was connected to a support laptop via a short USB cable. Vayyar Multiport Recorder 2.1.1 was used to configure the EUT for verifications. The manufacturer provided detailed instructions to exercise the EUT (MPR for b2vStraw - Manual_23Oct19.pdf). For power measurement, the manufacturer provided a separate test profile in order to stop the sweep. The EUT is capable of both chirp and stepped CW transmissions modes. Default power setting used was -10dBm.

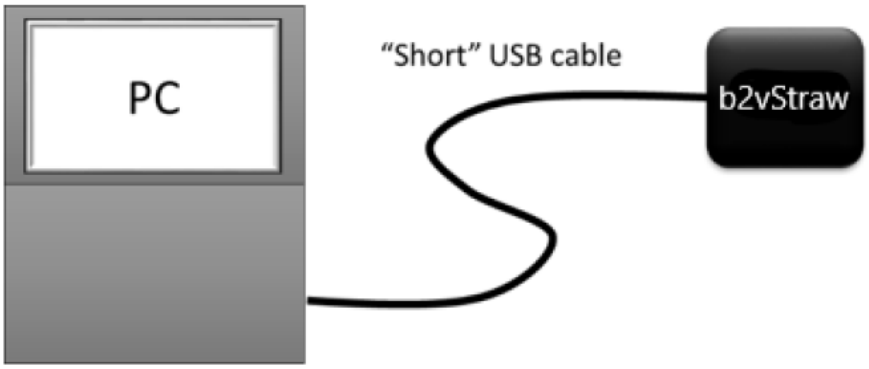
1.4.2 EUT Exercise Software

Vayyar Multiport Recorder 2.1.1

1.4.3 Support Equipment and I/O cables

Manufacturer	Equipment/Cable	Description
Lenovo	Laptop Thinkpad T440S	Type: 20AR-S4250S S/N PC-03BBGR
Lenovo	Laptop Power Supply	Model ADLX45NCC2A S/N 10E75794C1SG7B84A60
Vention	USB Type A to Type B micro cable	2-meters, USB 2.0 cable

1.4.4 Simplified Test Configuration Diagram



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: STRBAB2N399U0063 and STRBAB2N399U0032		
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 LP002 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

2 TEST DETAILS

Radio Testing of the
Vayyar Imaging LTD
vStraw_CTPB2 60GHz fixed field-disturbance sensor or a short-range device for interactive-motion sensing

2.1 Transmitter Power

2.1.1 Specification Reference

FCC 47 CFR Part 15, Clause 15.255(c)(3) and (e)

2.1.2 Standard Applicable

(c) Within the 57-71 GHz band, emission levels shall not exceed the following equivalent isotropically radiated power (EIRP):

(3) or fixed field disturbance sensors other than those operating under the provisions of paragraph (c)(2) of this section, and short-range devices for interactive motion sensing, the peak transmitter conducted output power shall not exceed −10 dBm and the peak EIRP level shall not exceed 10 dBm.

(e) Except as specified paragraph (e)(1) of this section, the peak transmitter conducted output power shall not exceed 500 mW. Depending on the gain of the antenna, it may be necessary to operate the intentional radiator using a lower peak transmitter output power in order to comply with the EIRP limits specified in paragraph (c) of this section.

2.1.3 Equipment Under Test and Modification State

Serial No: STRBAB2N399U0063 / Default Test Configuration

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

November 24, 2019 / FSC

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 Location

Test performed at TÜV SÜD America Inc. Rancho Bernardo facility

Ambient Temperature	22.8 °C
Relative Humidity	33.8 %
ATM Pressure	99.4 kPa

2.1.7 Additional Observations

- This is a radiated test.
- Test methodology is per Section 9.11 of ANSI C63.10-2013.
- The EUT is capable of both Chirp and Stepped CW transmission modes (59-64GHz). The sweep was stopped and only the worst transmission mode presented (single CW).
- The manufacturer provided a test profile with the highest possible duty cycle and the longest burst (10-100msec).
- Test performed using a RF detector, low noise amplifier, active multiplier chain, direct reading attenuator and corresponding horn antenna.

- Multiple frequencies were verified and only the worst presented. It was observed that single CW modes are highest at the middle as verified by using the traditional harmonic mixer method.
- Once the EUT profile was determined using a RF detector, The EUT was replaced with a known source with a variable attenuator. Starting at the max attenuation, the attenuator was adjusted until identical profile of the EUT was achieved. The EIRP at this point was calculated.

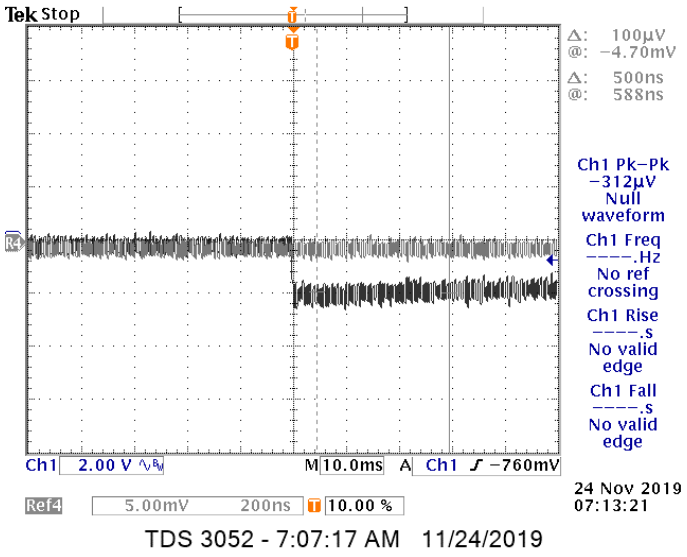
2.1.8 Test Result (worst case stopped CW mode)

Frequency	Peak Power (EIRP)	Conducted Peak Power
62 GHz (representative TX)	5.74 dBm	-10.76 dBm
EUT sweeps from 59GHz to 64GHz. Only the worst frequency presented using RF Detector method.		

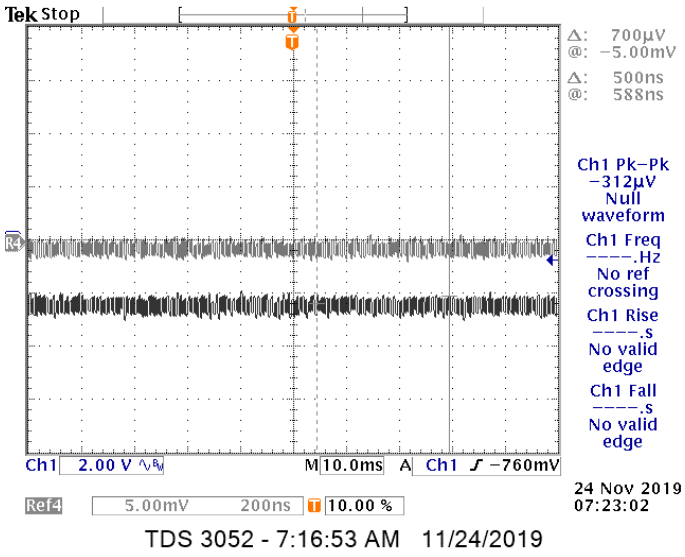
2.1.9 Sample Calculation

Active Multiplier Chain power output @ 62GHz	= 13.50 dBm
Gain Horn -WR15/HO15R (SDGE09004)	= 23.24 dBi
Direct Reading Attenuator setting to replicate EUT profile	= 31.00 dB
Substitution Peak EIRP	= 5.74 dBm

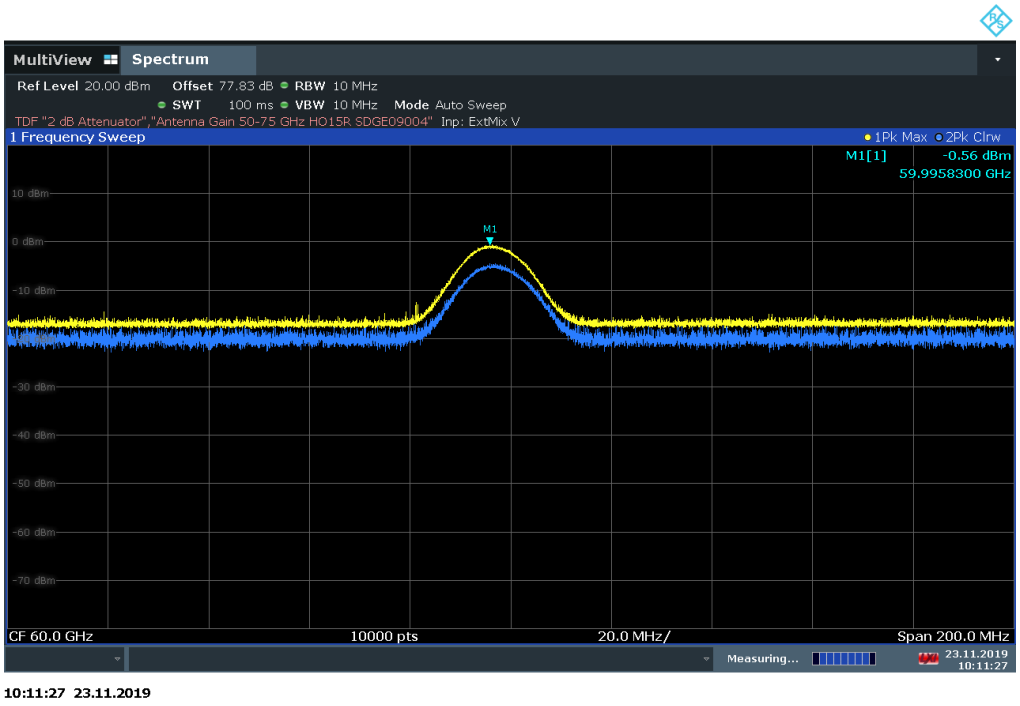
2.1.10 Sample Test Plots



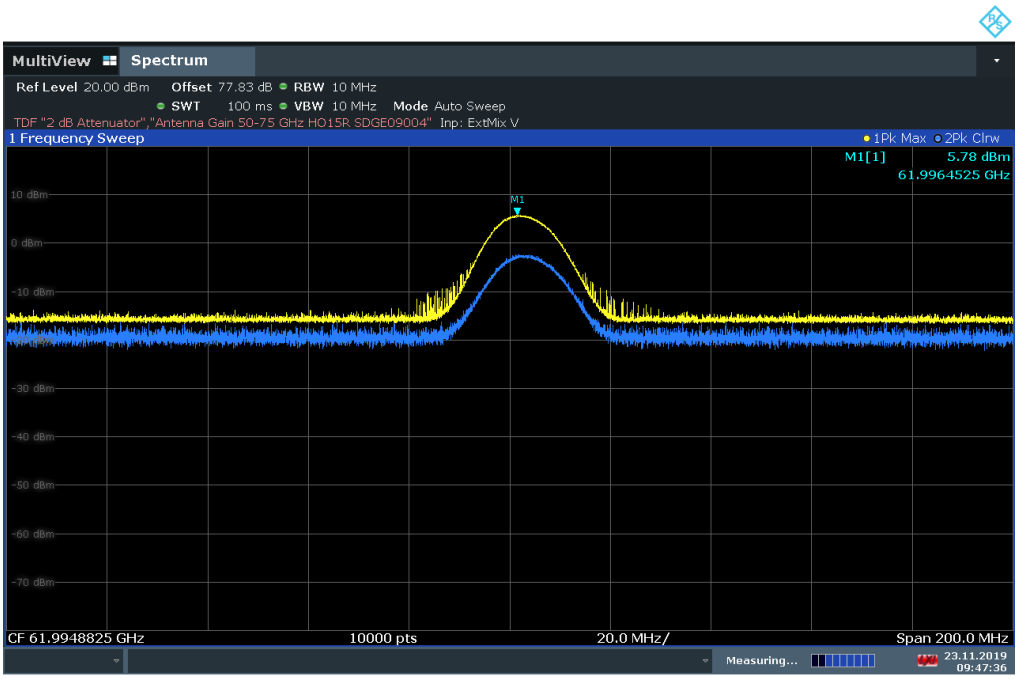
EUT profile using a RF detector



Profile using a known source (active multiplier chain with a direct reading attenuator)



Peak Verification using Harmonic Mixer (Low Range)



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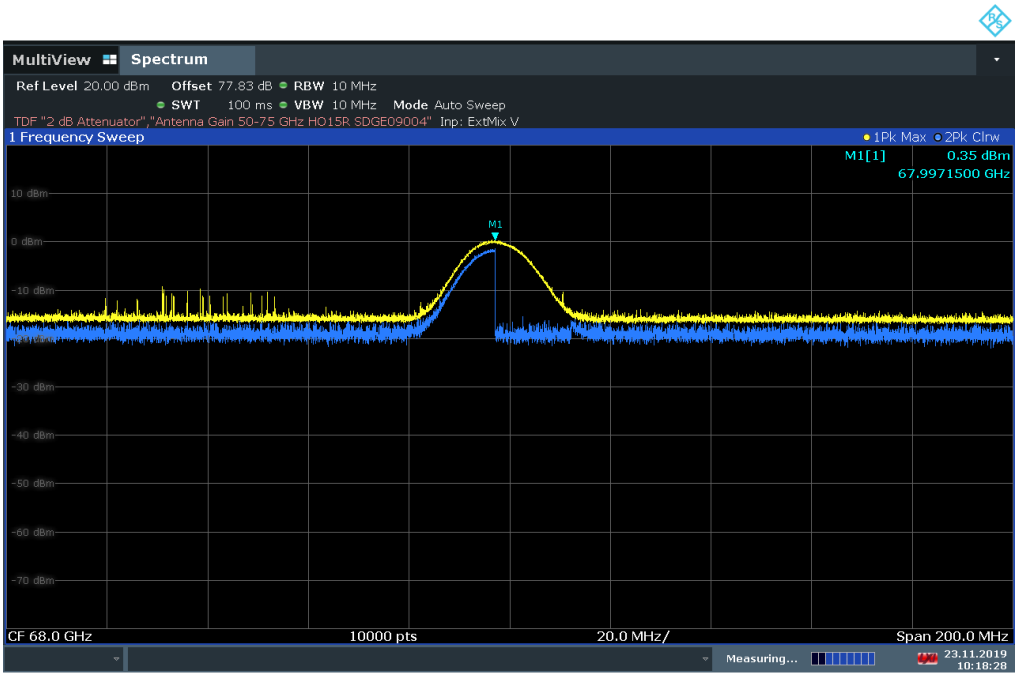
Peak Verification using Harmonic Mixer (Middle Range)



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Peak Verification using Harmonic Mixer (High Range)

2.2 Conducted Emissions

2.2.1 Specification Reference

FCC 47 CFR Part 15, Clause 15.207(a)

2.2.2 Standard Applicable

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).

Frequency of emission (MHz)	Conducted limit (dBµV)	
	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.*

2.2.3 Equipment Under Test and Modification State

Serial No: STRBAB2N399U0063 / Default Test Configuration

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

October 31, 2019 / FSC

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 Location

Test performed at TÜV SÜD America Inc. Rancho Bernardo facility

Ambient Temperature	24.8 °C
Relative Humidity	12.7 %
ATM Pressure	99.5 kPa

2.2.7 Additional Observations

- EUT is USB powered and does not have provision to be connected with the public AC mains. Test was performed only to show general compliance of the EUT with the requirement with a representative support equipment powering the EUT.
- 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 2.2.8 for sample computation.

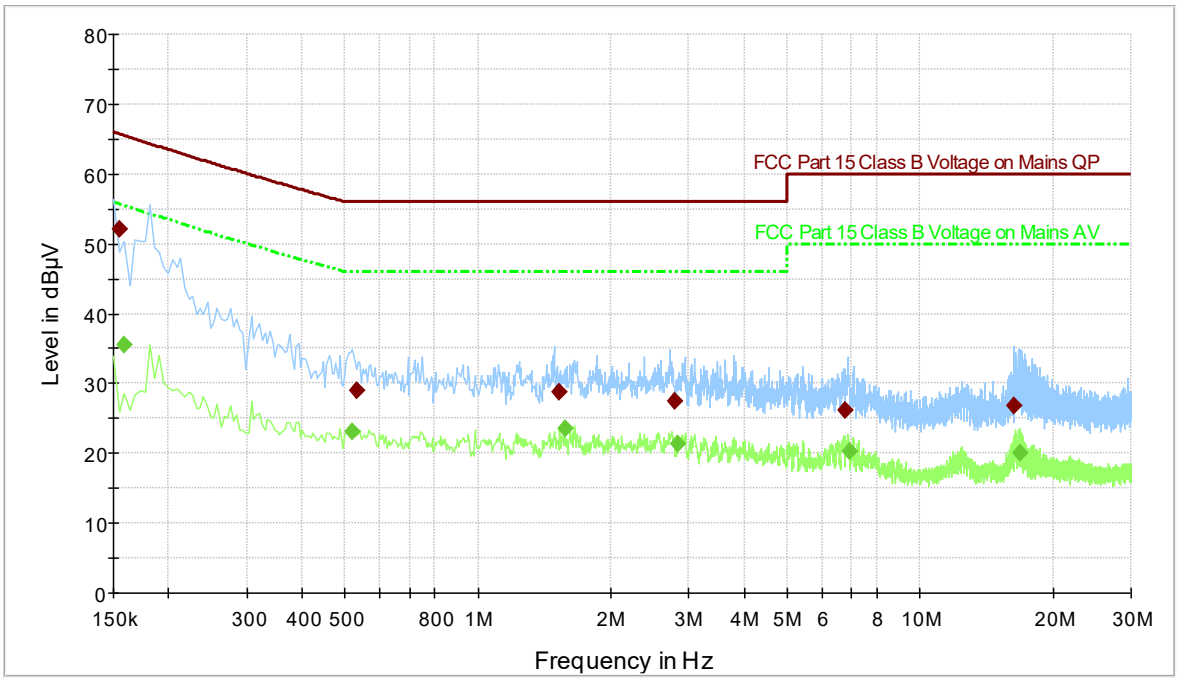
2.2.8 Sample Computation (Conducted Emission – Quasi Peak)

Measuring equipment raw measurement (dbµV) @ 150kHz			5.5
Correction Factor (dB)	Asset# 8607 (20 dB attenuator)	19.9	20.7
	Asset# 1177 (cable)	0.15	
	Asset# 1176 (cable)	0.35	
	Asset# 7568 (LISN)	0.30	
Reported QuasiPeak Final Measurement (dbµV) @ 150kHz			**26.2**

2.2.9 Test Results

Compliant. See attached plots and tables.

2.2.10 Line 1 on the support laptop (representative configuration powering the EUT)



FCC Part 15 Class B Voltage on Mains QP [..\EMI conducted\]
FCC Part 15 Class B Voltage on Mains AV [..\EMI conducted\]
Preview Result 1-PK+ [Preview Result 1.Result:1]
Preview Result 2-AVG [Preview Result 2.Result:2]
Final Result 1-QPK [Final Result 1.Result:1]
Final Result 2-AVG [Final Result 2.Result:1]

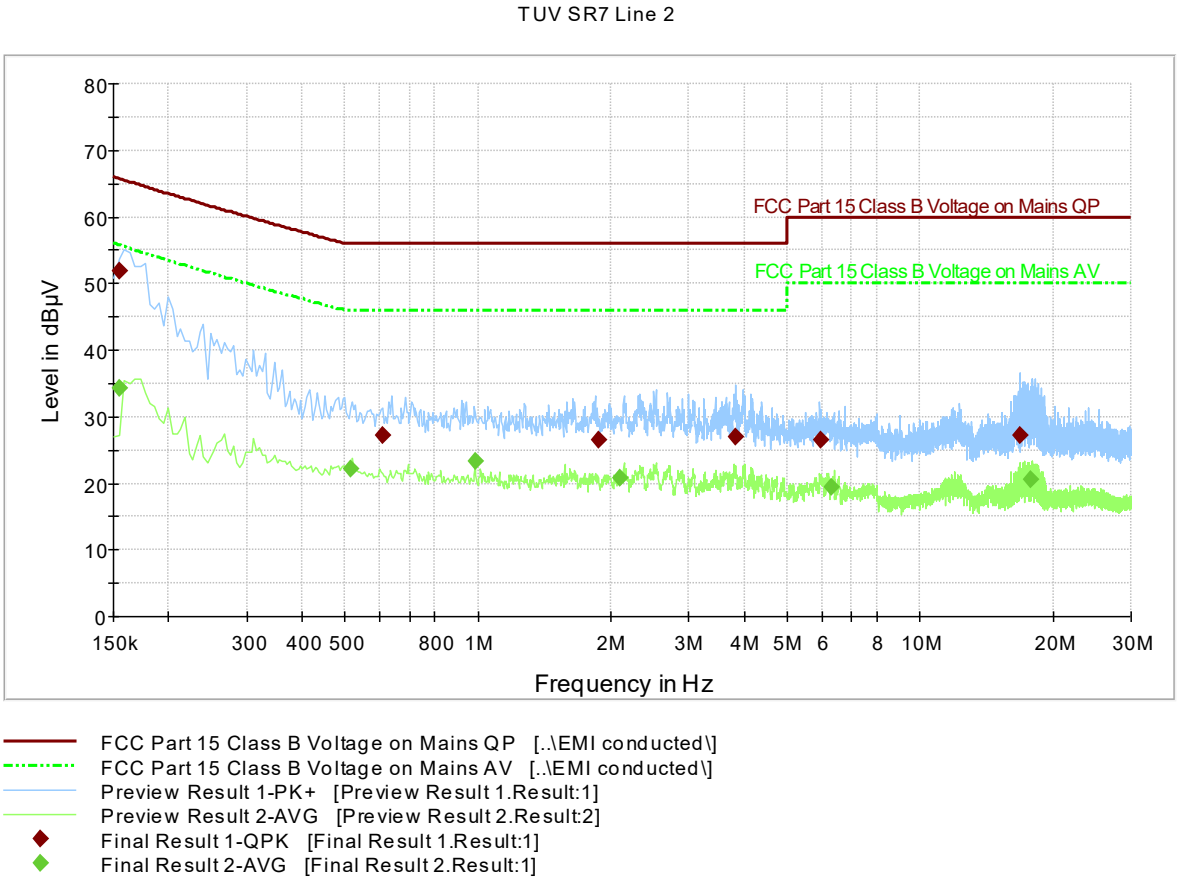
Quasi Peak

Frequency (MHz)	QuasiPeak (dBµV)	Meas. Time (ms)	Bandwidth (kHz)	Filter	Line	Corr. (dB)	Margin - QPK (dB)	Limit - QPK (dBµV)
0.154500	52.1	1000.0	9.000	Off	L1	20.1	13.6	65.7
0.532500	28.9	1000.0	9.000	Off	L1	19.9	27.1	56.0
1.531500	28.8	1000.0	9.000	Off	L1	19.8	27.2	56.0
2.778000	27.6	1000.0	9.000	Off	L1	20.4	28.4	56.0
6.792000	26.2	1000.0	9.000	Off	L1	20.4	33.8	60.0
16.242000	26.8	1000.0	9.000	Off	L1	20.5	33.2	60.0

Average

Frequency (MHz)	Average (dBµV)	Meas. Time (ms)	Bandwidth (kHz)	Filter	Line	Corr. (dB)	Margin - Ave (dB)	Limit - Ave (dBµV)
0.159000	35.6	1000.0	9.000	Off	L1	20.1	19.8	55.5
0.519000	23.1	1000.0	9.000	Off	L1	19.9	22.9	46.0
1.572000	23.6	1000.0	9.000	Off	L1	19.8	22.4	46.0
2.832000	21.4	1000.0	9.000	Off	L1	20.4	24.6	46.0
6.949500	20.2	1000.0	9.000	Off	L1	20.4	29.8	50.0
16.768500	20.1	1000.0	9.000	Off	L1	20.5	29.9	50.0

2.2.11 Line 2 on the support laptop (representative configuration powering the EUT)



Quasi Peak

Frequency (MHz)	QuasiPeak (dBµV)	Meas. Time (ms)	Bandwidth (kHz)	Filter	Line	Corr. (dB)	Margin - QPK (dB)	Limit - QPK (dBµV)
0.154500	51.9	1000.0	9.000	Off	N	20.1	13.9	65.7
0.609000	27.3	1000.0	9.000	Off	N	19.8	28.7	56.0
1.873500	26.6	1000.0	9.000	Off	N	19.9	29.4	56.0
3.835500	26.9	1000.0	9.000	Off	N	20.3	29.1	56.0
5.968500	26.4	1000.0	9.000	Off	N	20.3	33.6	60.0
16.795500	27.2	1000.0	9.000	Off	N	20.6	32.8	60.0

Average

Frequency (MHz)	Average (dBµV)	Meas. Time (ms)	Bandwidth (kHz)	Filter	Line	Corr. (dB)	Margin - Ave (dB)	Limit - Ave (dBµV)
0.154500	34.3	1000.0	9.000	Off	N	20.1	21.4	55.7
0.514500	22.3	1000.0	9.000	Off	N	19.8	23.7	46.0
0.987000	23.2	1000.0	9.000	Off	N	19.8	22.8	46.0
2.098500	20.8	1000.0	9.000	Off	N	20.0	25.2	46.0
6.306000	19.5	1000.0	9.000	Off	N	20.3	30.5	50.0
17.794500	20.6	1000.0	9.000	Off	N	20.6	29.4	50.0

2.3 Frequency Stability

2.3.1 Specification Reference

FCC 47 CFR Part 15, Clause 15.255(f)

2.3.2 Standard Applicable

(f) Fundamental emissions must be contained within the frequency bands specified in this section during all conditions of operation. Equipment is presumed to operate over the temperature range −20 to + 50 degrees Celsius with an input voltage variation of 85% to 115% of rated input voltage, unless justification is presented to demonstrate otherwise.

2.3.3 Equipment Under Test and Modification State

Serial No: STRBAB2N399U0063 / Default Test Configuration

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

October 31, 2019 / FSC

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 Location

Test performed at TÜV SÜD America Inc. Rancho Bernardo facility

Ambient Temperature	24.8 °C
Relative Humidity	12.7 %
ATM Pressure	99.5 kPa

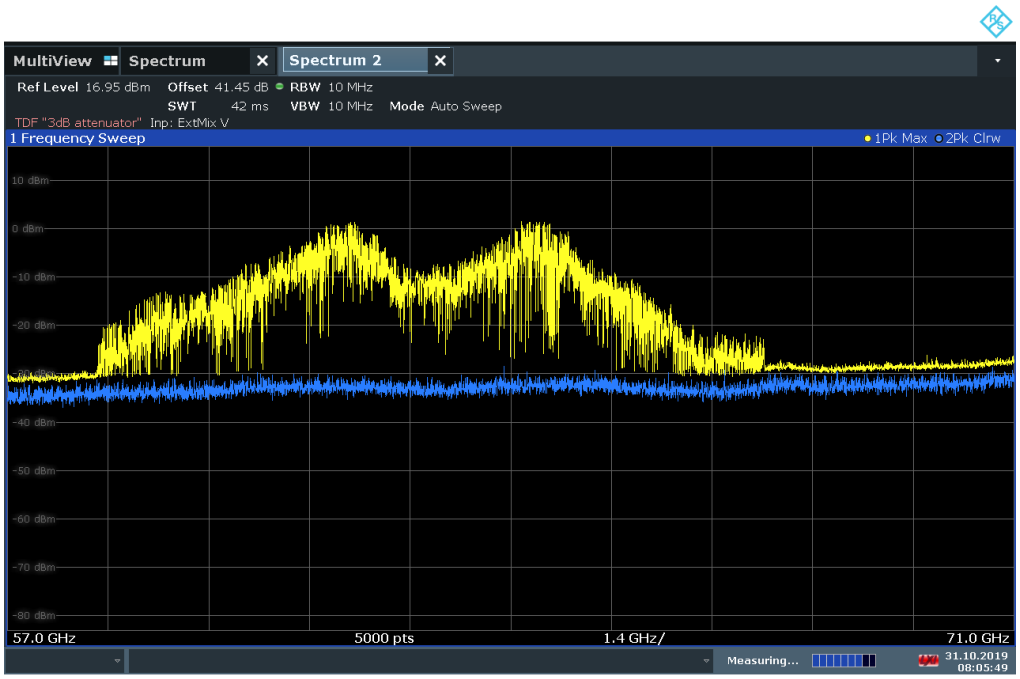
2.3.7 Additional Observations

- The EUT is USB powered (5VDC). Since USB power is regulated, input voltage variation was not performed.
- The temperature chamber has a window, the receive antenna was placed outside the chamber at a distance greater than $2D^2/\lambda$. Where D is the longest single dimension of the receive antenna and λ is the wavelength.
- The EUT was verified without an enclosure (bare board). At ≥40°C, the EUT requires a heatsink. The manufacturer provided a representative heatsink for this purpose. The manufacturer declared that on actual installation, the metal back enclosure will provide identical heat dissipation on the main chip and immediate vicinity of the main board.
- Test methodology is per Section 9.14 of ANSI C63.10-2013.

2.3.8 Test Results

EUT complies. The spectrum mask of the EUT emissions (max hold) stayed within the frequency band 57GHz to 71GHz on all conditions of operation. Operation of the EUT is >1GHz from the edge of the frequency band (57GHz-71GHz).

2.3.9 Sample Test Plots



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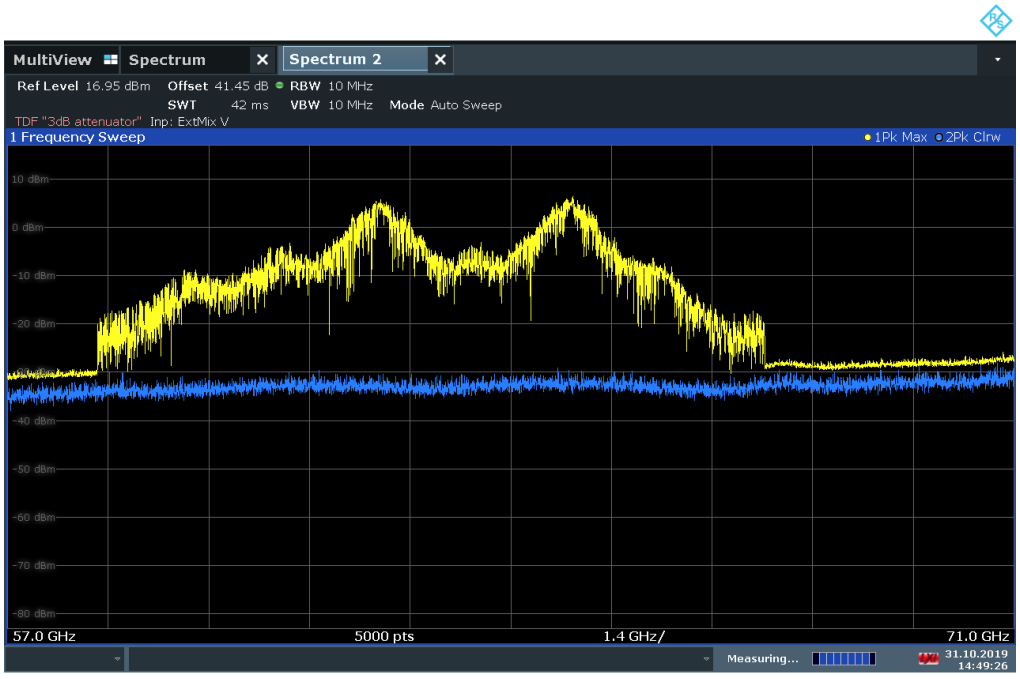
Spectrum Mask @ 50°C



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Spectrum Mask @ -20°C

2.4 Occupied Bandwidth

2.4.1 Specification Reference

FCC 47 CFR Part 15, Clause 15.255(e)(1)

2.4.2 Standard Applicable

(1) Transmitters with an emission bandwidth of less than 100 MHz must limit their peak transmitter conducted output power to the product of 500 mW times their emission bandwidth divided by 100 MHz. For the purposes of this paragraph, emission bandwidth is defined as the instantaneous frequency range occupied by a steady state radiated signal with modulation, outside which the radiated power spectral density never exceeds 6 dB below the maximum radiated power spectral density in the band, as measured with a 100 kHz resolution bandwidth spectrum analyzer. The center frequency must be stationary during the measurement interval, even if not stationary during normal operation (e.g., for frequency hopping devices).

2.4.3 Equipment Under Test and Modification State

Serial No: STRBAB2N399U0063 / Default Test Configuration

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

November 06, 2019 / FSC

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

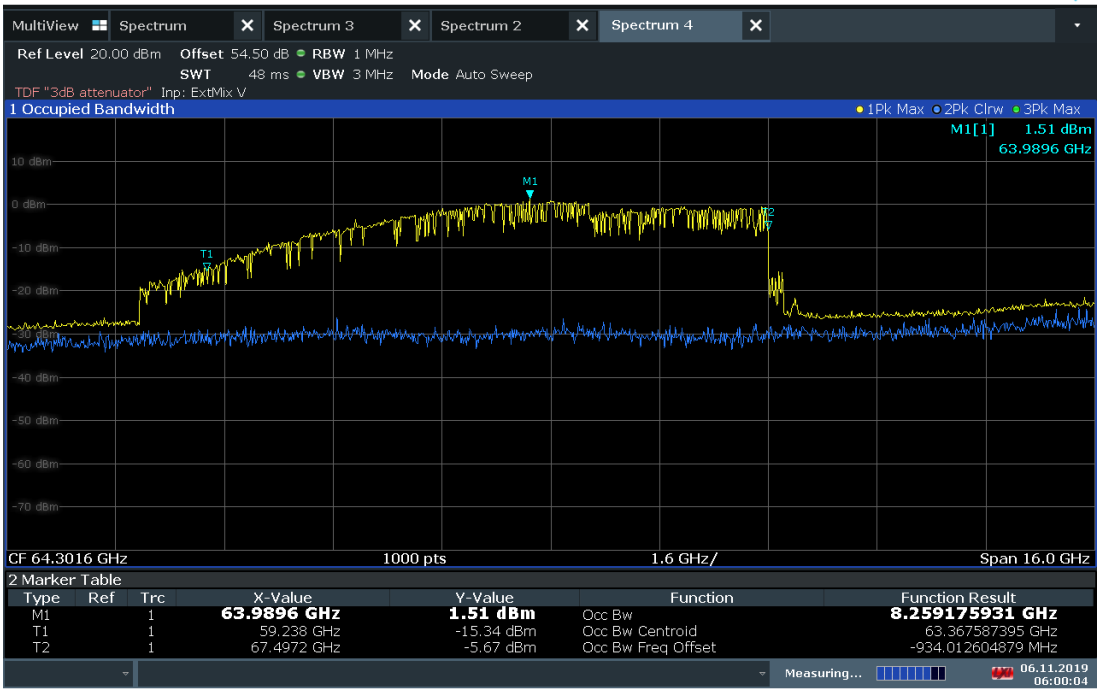
Test performed at TÜV SÜD America Inc. Rancho Bernardo facility

Ambient Temperature	25.8 °C
Relative Humidity	23.9 %
ATM Pressure	99.6 kPa

2.4.7 Additional Observations

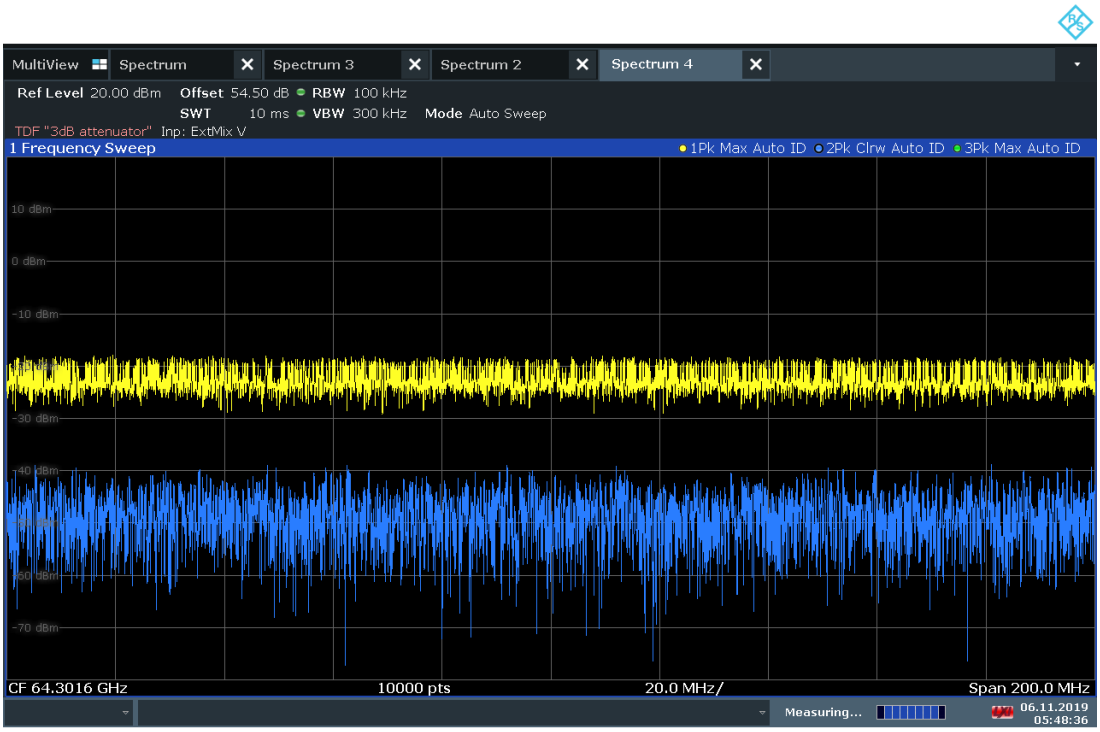
- 6dB BW of the EUT is >100MHz when measured using 100kHz RBW. Therefore, the additional bandwidth requirement per §15.255(e)(1) does not apply.
- Worst case 99% OBW reported as 8.26GHz.
- Plots presented for reference only.

2.4.8 Test Verifications Plots



06:00:05 06.11.2019

99% OBW



05:48:37 06.11.2019

>100MHz 6dB BW verification using 100kHz RBW

2.5 Field Strength of Spurious Radiation

2.5.1 Specification Reference

FCC 47 CFR Part 15, Clause 15.255(d)(1)(2) and (3)

2.5.2 Standard Applicable

(d) Limits on spurious emissions:

(1) The power density of any emissions outside the 57-71 GHz band shall consist solely of spurious emissions.

(2) Radiated emissions below 40 GHz shall not exceed the general limits in §15.209.

(3) Between 40 GHz and 200 GHz, the level of these emissions shall not exceed 90 pW/cm^2 (85.3dBµV/m / -9.93dBm EIRP) at a distance of 3 meters.

2.5.3 Equipment Under Test and Modification State

Serial No: STRBAB2N399U0032 / Default Test Configuration

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

September 10, 2019 / FSC

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 Location

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 9kHz to 200GHz.
- Only the worst-case profile for spurious emissions presented (Stepped CW).
- In-band measurements are covered under Section 2.1 of this test report.
- Measurements below 40GHz were 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.
- Measurement above 40GHz are done using harmonic mixers. Corresponding TDF (Transducer Factor) are programmed for each range.

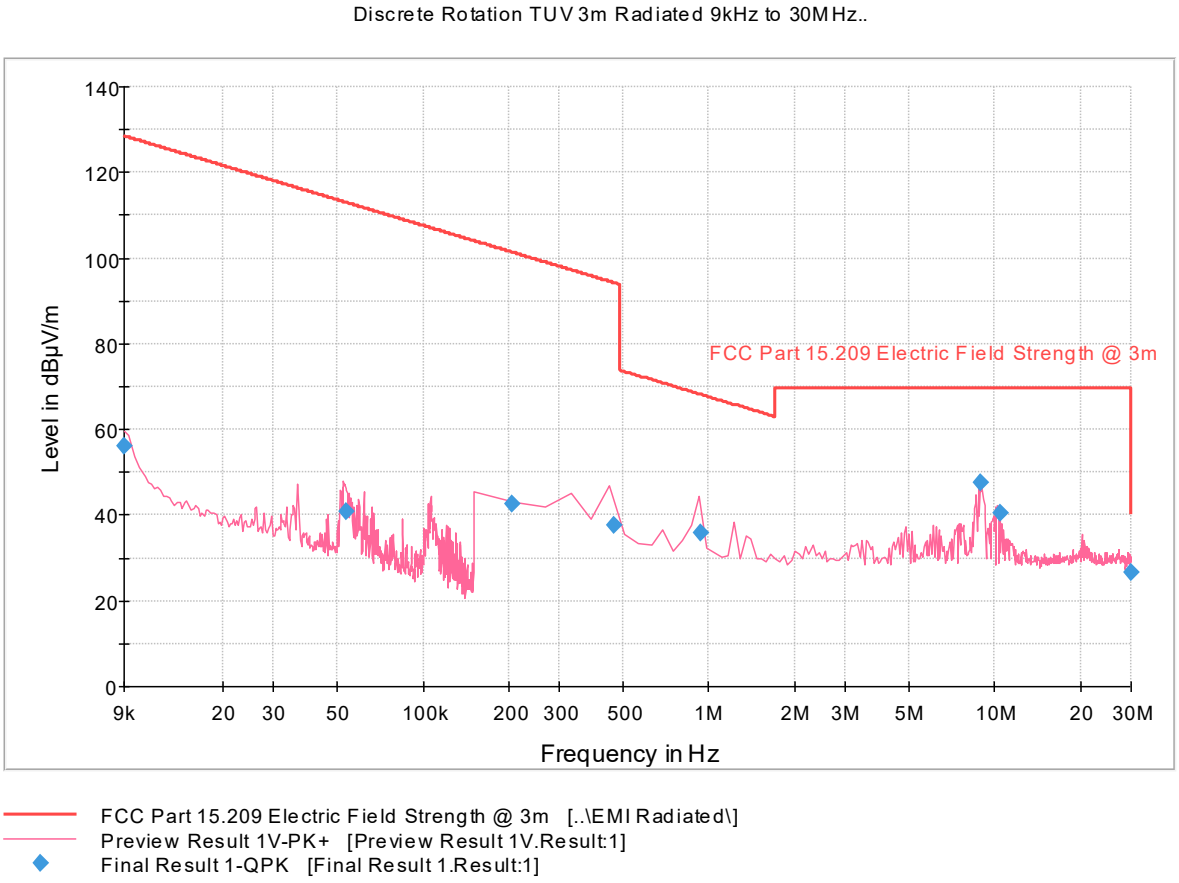
- Tests distance and frequency ranges performed are summarized below:

Frequency Range	Test Distance
9 kHz to 30 MHz	3 meters
30 MHz to 1GHz	3 meters
1 GHz to 18 GHz	3 meters
18 GHz to 26.5 GHz	3 meters
26 GHz to 40 GHz	3 meters
40 GHz to 57 GHz	3 meters
57 GHz to 71 GHz	3 meters
71 GHz to 75 GHz	1 meter
75 GHz to 110 GHz	1 meter
110 GHz to 140 GHz	1 meter
140 GHz to 200 GHz	0.5 meter

2.5.8 Sample Computation (Radiated Emission)

Measuring equipment raw measurement (dbµV) @ 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 QuasiPeak Final Measurement (dbµV/m) @ 30MHz			**11.8**

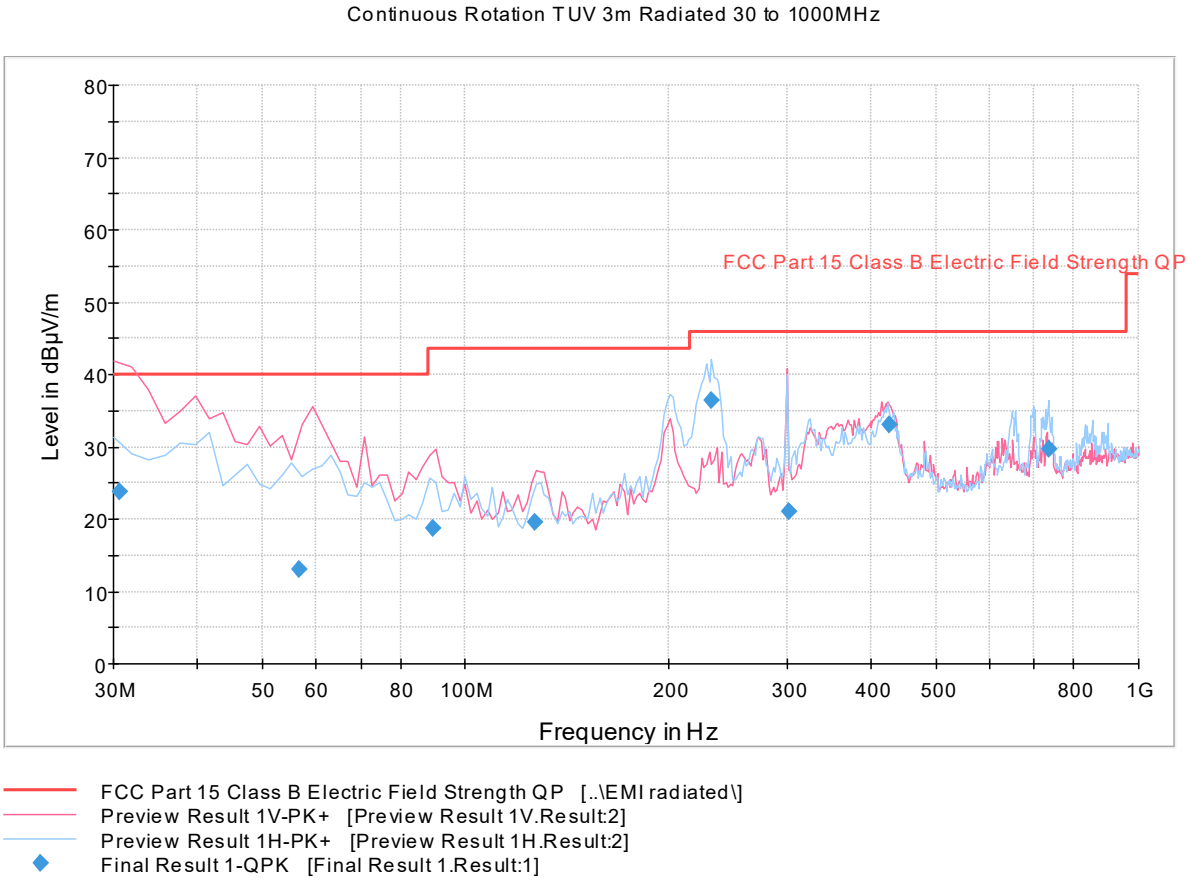
2.5.9 Below 30MHz Radiated Emission Test



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)
0.009000	56.3	1000.0	0.200	100.0	V	50.0	25.0	72.2	128.5
0.053798	40.9	1000.0	0.200	100.0	V	189.0	20.2	72.1	113.0
0.205000	42.8	1500.0	9.000	100.0	V	190.0	19.6	58.6	101.4
0.465918	37.8	1500.0	9.000	100.0	V	213.0	19.7	56.4	94.2
0.936655	36.1	1500.0	9.000	100.0	V	57.0	19.9	32.1	68.2
8.872667	47.6	1500.0	9.000	100.0	V	299.0	20.8	22.0	69.5
10.439978	40.6	1500.0	9.000	100.0	V	286.0	21.2	29.0	69.5
29.993000	26.6	1500.0	9.000	100.0	V	59.0	25.1	42.9	69.5

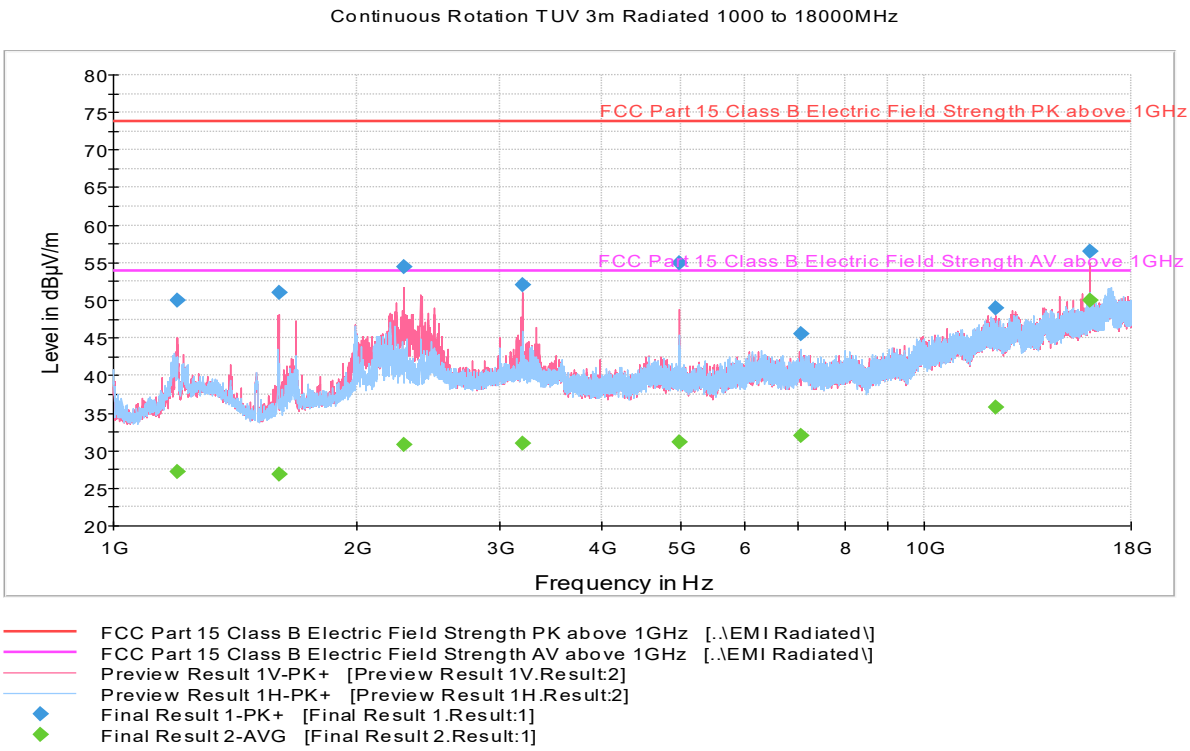
2.5.10 Below 1GHz Radiated Emission Test



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)
30.680000	23.8	1000.0	120.000	100.0	V	104.0	-8.7	16.2	40.0
56.718317	13.1	1000.0	120.000	100.0	V	122.0	-16.2	26.9	40.0
89.572745	18.8	1000.0	120.000	100.0	V	193.0	-16.0	24.7	43.5
126.434389	19.5	1000.0	120.000	100.0	V	37.0	-16.0	24.0	43.5
231.604329	36.4	1000.0	120.000	100.0	H	342.0	-10.4	9.6	46.0
302.120401	21.0	1000.0	120.000	150.0	V	230.0	-7.5	25.0	46.0
425.769218	33.1	1000.0	120.000	105.0	V	106.0	-4.9	12.9	46.0
735.351263	29.6	1000.0	120.000	109.0	H	33.0	1.7	16.4	46.0

2.5.11 Above 1GHz (up to 18GHz) Radiated Emission Test



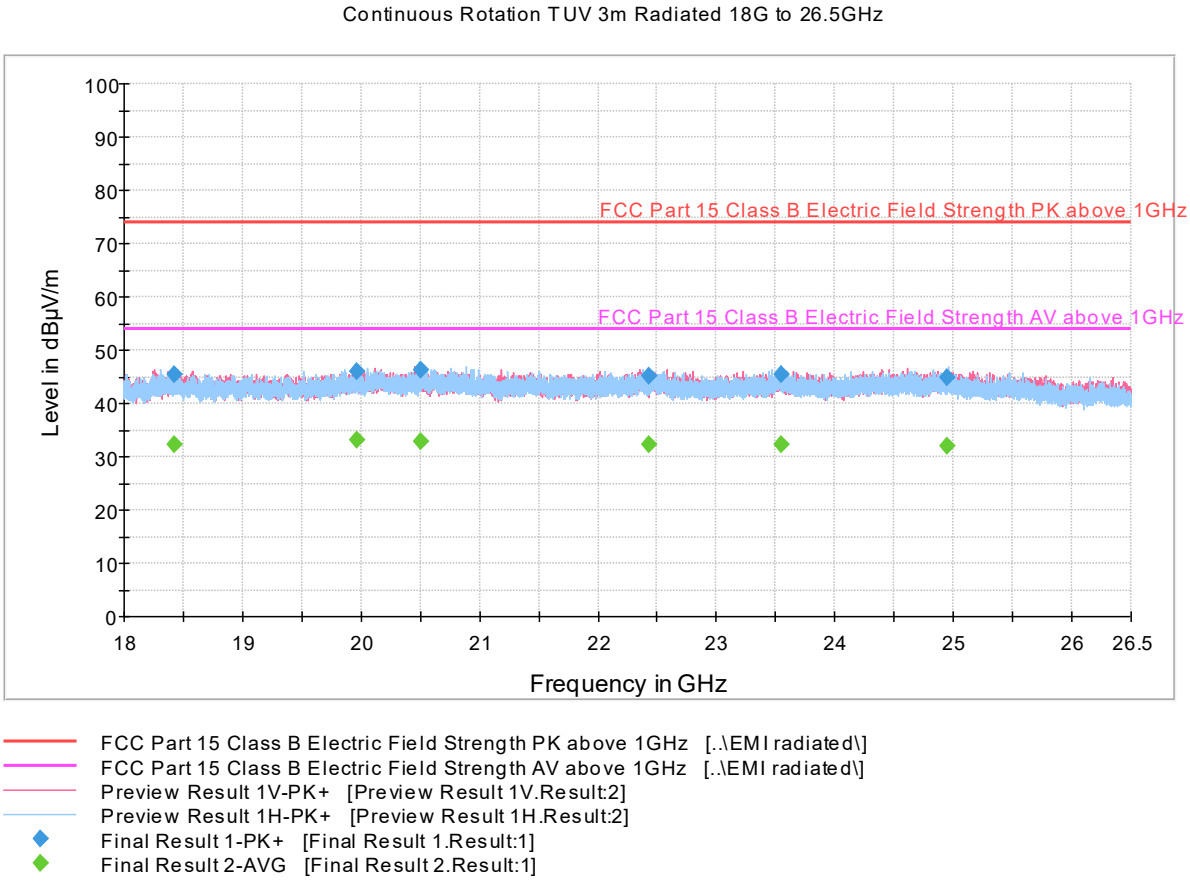
Peak Data

Frequency (MHz)	Max Peak (dBµV/m)	Meas. Time (ms)	Bandwidth (kHz)	Height (cm)	Polarization	Azimuth (deg)	Corr. (dB)	Margin (dB)	Limit (dBµV/m)
1198.700000	50.1	1000.0	1000.000	123.0	V	69.0	-6.4	23.8	73.9
1599.333333	51.0	1000.0	1000.000	150.0	V	89.0	-5.8	22.9	73.9
2285.766667	54.5	1000.0	1000.000	406.9	V	177.0	-1.2	19.4	73.9
3194.366667	52.1	1000.0	1000.000	142.0	V	82.0	1.0	21.8	73.9
4981.633333	54.9	1000.0	1000.000	100.0	V	98.0	3.6	19.0	73.9
7059.733333	45.5	1000.0	1000.000	379.0	H	4.0	6.9	28.4	73.9
12231.333333	48.9	1000.0	1000.000	386.0	V	23.0	13.5	25.0	73.9
15998.900000	56.6	1000.0	1000.000	123.0	V	166.0	16.3	17.3	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)
1198.700000	27.3	1000.0	1000.000	123.0	V	69.0	-6.4	26.6	53.9
1599.333333	26.9	1000.0	1000.000	150.0	V	89.0	-5.8	27.0	53.9
2285.766667	30.7	1000.0	1000.000	406.9	V	177.0	-1.2	23.2	53.9
3194.366667	30.9	1000.0	1000.000	142.0	V	82.0	1.0	23.0	53.9
4981.633333	31.1	1000.0	1000.000	100.0	V	98.0	3.6	22.8	53.9
7059.733333	32.1	1000.0	1000.000	379.0	H	4.0	6.9	21.8	53.9
12231.333333	35.8	1000.0	1000.000	386.0	V	23.0	13.5	18.1	53.9
15998.900000	50.0	1000.0	1000.000	123.0	V	166.0	16.3	3.9	53.9

2.5.12 18GHz to 26.5GHz Radiated Emission Test



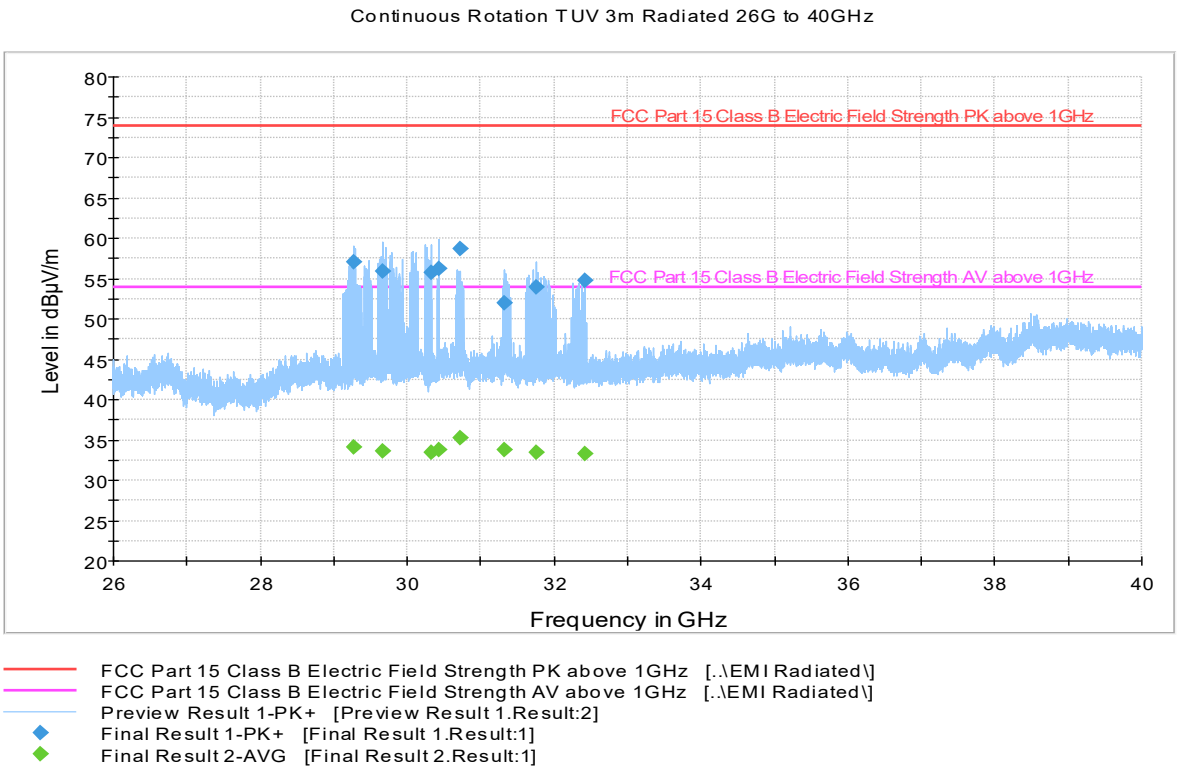
Peak Data

Frequency (MHz)	Max Peak (dBµV/m)	Meas. Time (ms)	Bandwidth (kHz)	Height (cm)	Polarization	Azimuth (deg)	Corr. (dB)	Margin (dB)	Limit (dBµV/m)
18426.216667	45.3	1000.0	1000.000	115.0	V	224.0	-0.4	28.6	73.9
19967.666667	45.9	1000.0	1000.000	115.0	H	160.0	-0.6	28.0	73.9
20507.416667	46.3	1000.0	1000.000	103.0	H	151.0	-0.3	27.6	73.9
22430.883333	45.0	1000.0	1000.000	108.0	H	173.0	0.8	28.9	73.9
23542.516667	45.3	1000.0	1000.000	100.0	H	-7.0	1.0	28.6	73.9
24952.400000	44.8	1000.0	1000.000	105.0	H	340.0	2.0	29.1	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)
18426.216667	32.4	1000.0	1000.000	115.0	V	224.0	-0.4	21.5	53.9
19967.666667	33.1	1000.0	1000.000	115.0	H	160.0	-0.6	20.8	53.9
20507.416667	33.0	1000.0	1000.000	103.0	H	151.0	-0.3	20.9	53.9
22430.883333	32.4	1000.0	1000.000	108.0	H	173.0	0.8	21.5	53.9
23542.516667	32.2	1000.0	1000.000	100.0	H	-7.0	1.0	21.7	53.9
24952.400000	32.1	1000.0	1000.000	105.0	H	340.0	2.0	21.8	53.9

2.5.13 26GHz to 40GHz Radiated Emission Test



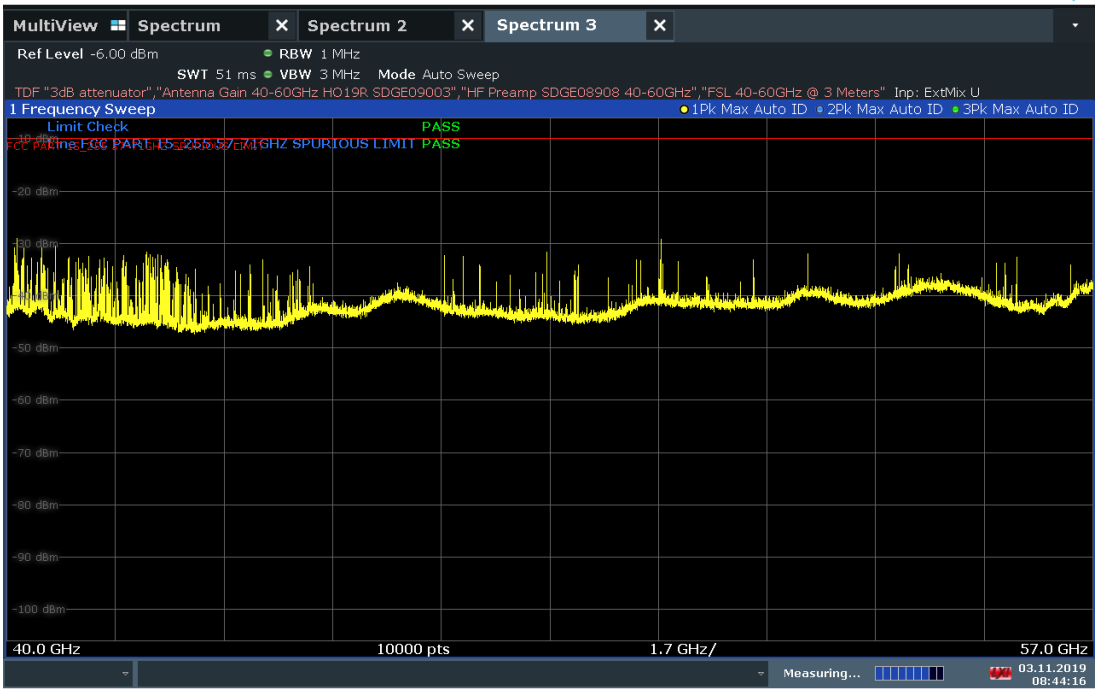
Peak Data

Frequency (MHz)	Max Peak (dBµV/m)	Meas. Time (ms)	Bandwidth (kHz)	Height (cm)	Polarization	Azimuth (deg)	Corr. (dB)	Margin (dB)	Limit (dBµV/m)
29270.333333	57.1	1000.0	1000.000	100.0	V	202.0	3.4	16.8	73.9
29674.333333	55.9	1000.0	1000.000	125.0	V	156.0	3.4	18.0	73.9
30329.533333	55.7	1000.0	1000.000	125.0	V	158.0	3.8	18.2	73.9
30427.666667	56.2	1000.0	1000.000	125.0	V	153.0	3.8	17.7	73.9
30715.600000	58.6	1000.0	1000.000	100.0	H	193.0	4.1	15.3	73.9
31320.266667	52.0	1000.0	1000.000	139.0	V	213.0	4.3	21.9	73.9
31749.600000	53.9	1000.0	1000.000	125.0	V	171.0	4.2	20.0	73.9
32429.933333	54.8	1000.0	1000.000	155.0	H	119.0	4.5	19.1	73.9

Average Data

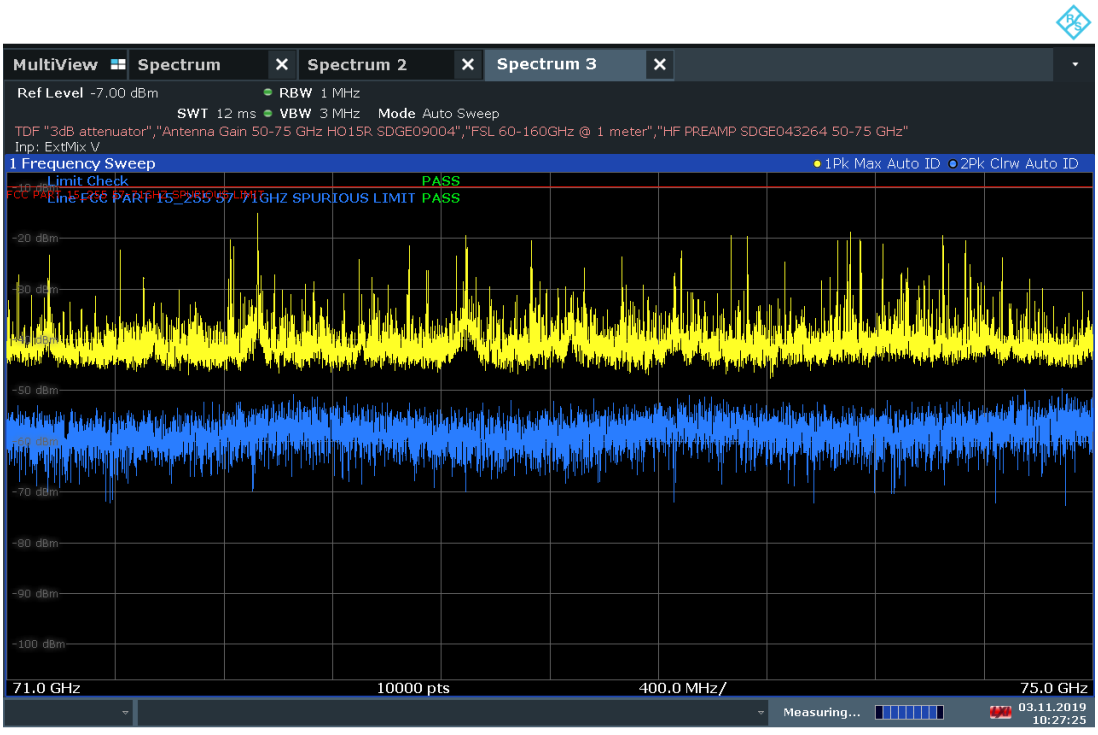
Frequency (MHz)	Average (dBµV/m)	Meas. Time (ms)	Bandwidth (kHz)	Height (cm)	Polarization	Azimuth (deg)	Corr. (dB)	Margin (dB)	Limit (dBµV/m)
29270.333333	34.1	1000.0	1000.000	100.0	V	202.0	3.4	19.8	53.9
29674.333333	33.6	1000.0	1000.000	125.0	V	156.0	3.4	20.3	53.9
30329.533333	33.5	1000.0	1000.000	125.0	V	158.0	3.8	20.4	53.9
30427.666667	33.8	1000.0	1000.000	125.0	V	153.0	3.8	20.1	53.9
30715.600000	35.2	1000.0	1000.000	100.0	H	193.0	4.1	18.7	53.9
31320.266667	33.8	1000.0	1000.000	139.0	V	213.0	4.3	20.1	53.9
31749.600000	33.5	1000.0	1000.000	125.0	V	171.0	4.2	20.4	53.9
32429.933333	33.3	1000.0	1000.000	155.0	H	119.0	4.5	20.6	53.9

2.5.14 40GHz to 200GHz Maximized Plots



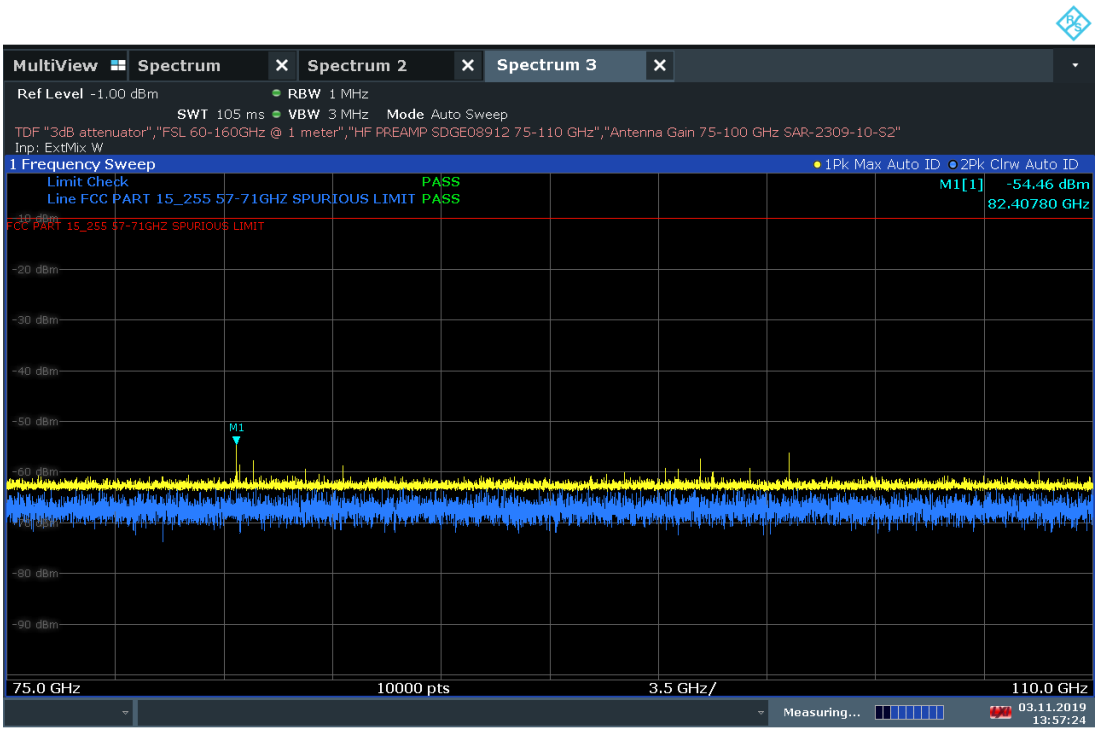
08:44:17 03.11.2019

40GHz to 57GHz Plot



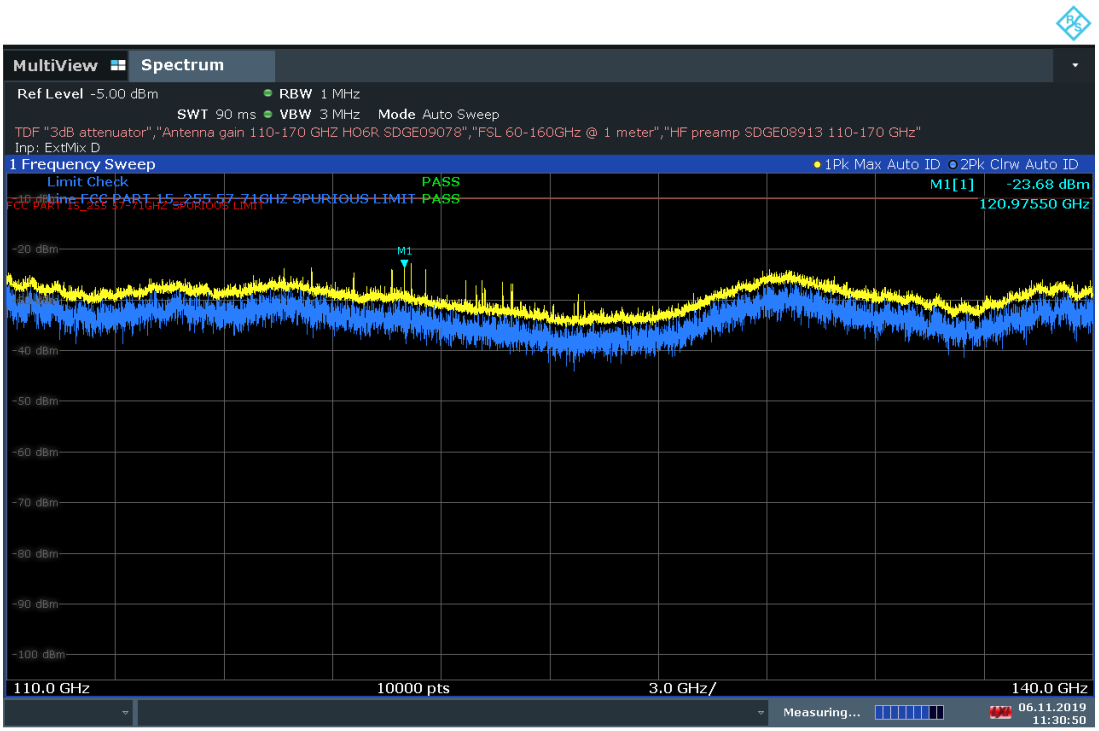
10:27:25 03.11.2019

71GHz to 75GHz Plot



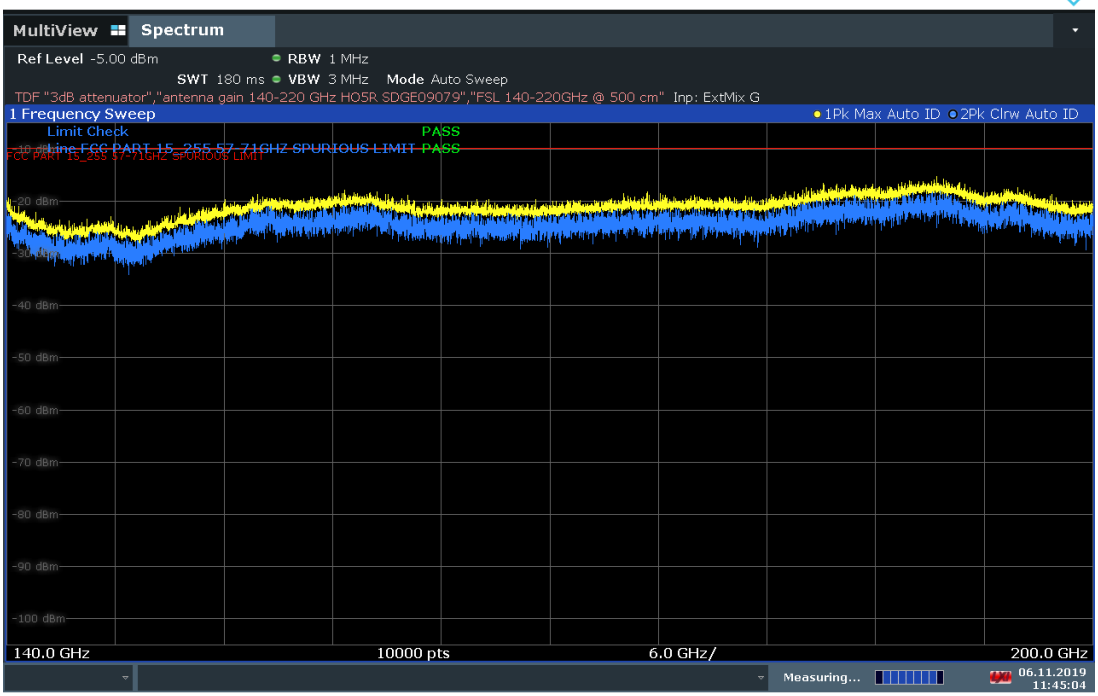
13:57:24 03.11.2019

75GHz to 110GHz Plot



11:30:50 06.11.2019

110GHz to 140GHz Plot



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140GHz to 200GHz Plot

SECTION 3

3 TEST EQUIPMENT USED

3.1 Test Equipment Used

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
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	01/14/19	01/02/20
8822	20dB Attenuator	34-20-34	N/A	MCE / Weinschel	03/05/19	03/05/20
8824	20dB Attenuator	34-20-34	N/A	MCE / Weinschel	03/05/19	03/05/20
Radiated Emission						
1033	Bilog Antenna	3142C	00044556	EMCO	11/06/18	11/06/20
7631	Double-ridged waveguide horn	3117	00205418	ETS-Lindgren	08/20/18	08/20/20
8628	Pre-amplifier	QLI-01182835-JO	8986002	Quinstar	03/07/19	03/07/20
9004	Horn antenna (50-75 GHz)	HO15R	104	Custom Microwaves	10/10/19	10/10/21
7628	Horn antenna (75-110 GHz)	SAR-2309-10-S2	13481-01	Sage Millimeter, Inc.	Verified by 7611 and corresponding antenna/Active multiplier combination	
9003	Horn antenna (40-60 GHz)	HO19R	103	Custom Microwaves		
9081	Horn antenna (110-170 GHz)	HO6R	N/A	Custom Microwaves		
9082	Horn antenna (140-220 GHz)	HO5R	N/A	Custom Microwaves		
9080	Horn antenna (220-325 GHz)	HO3R	N/A	Custom Microwaves		
-	Harmonics mixer (50-75 GHz)	FS-Z75	101564	Rhode & Schwarz	01/24/19	01/24/20
7637	Harmonics mixer (40-60 GHz)	FS-Z60	100009	Rhode & Schwarz	05/31/18	05/31/20
7636	Harmonics mixer (60-90 GHz)	FS-Z90	100092	Rhode & Schwarz	04/11/18	04/11/20
7633	Harmonics mixer (75-110 GHz)	HM-110-7	101000	Radiometer Physics	Verified by 7611 and corresponding antenna/mixer combination	
7634	Harmonics mixer (110-170 GHz)	HM-170	0062	Radiometer Physics		
7635	Harmonics mixer (170-220 GHz)	HM-220	020022	Radiometer Physics		
7632	Harmonics mixer (220-325 GHz)	HM-325	020075	Radiometer Physics		
1153	High-frequency cable	SucoFlex 100 SX	N/A	Suhner	Verified by 1003 and 7620	
8543	High-frequency cable	Micropore 19057793	N/A	United Microwave Products	Verified by 1003 and 7620	
40815	Pre-amplifier (18-40 GHz)	19D18	15G27	Spacek Labs	Verified by 1003 and 7620	
44137	V Band waveguide Detector	PE80T3002	V0011860417 20158046	Pasternack	Verified by 1003 and 7611	

ID Number (SDGE/SDRB)	Test Equipment	Type	Serial Number	Manufacturer	Cal Date	Cal Due Date
8872	Direct Reading Attenuator (40-60	STA-60-19-D1	11875-01	Sage Millimeter, Inc.	Verified by 7611 and corresponding antenna/mixer combination	
8860	Direct Reading Attenuator (50-75	STA-60-15-D1	11466-01	Sage Millimeter, Inc.		
8861	Direct Reading Attenuator (75-110	STA-60-10-D1	11466-01	Sage Millimeter, Inc.		
8919	Direct Reading Attenuator (90-140	STA-60-08-D1	12605-01	Sage Millimeter, Inc.		
8909	Direct Reading Attenuator (140-220	STA-60-05-D1	12020-01	Sage Millimeter, Inc.		
8873	Active Multiplier (40-60 GHz)	AMC-19-RFH00	124	Millitech, Inc.		
8914	Active Multiplier (50-75 GHz)	AMC-15-RFH00	283	Millitech, Inc.		
8915	Active Multiplier (75-110 GHz)	AMC-10-RFH00	606	Millitech, Inc.		
8920	Active Multiplier (90-140 GHz)	AMC-08-RFH00	58	Millitech, Inc.		
8909	Active Multiplier (140-220 GHz)	MCA-05-150096	13	Millitech, Inc.		
9001	Horn antenna (18-26.5GHz)	HO42S	101	Custom Microwave	09/09/19	09/09/21
9003	Horn antenna (26-40 GHz)	HO28S	102	Custom Microwaves	09/09/19	09/09/21
7611	Signal/Spectrum Analyzer	FSW26	102017	Rhode & Schwarz	09/12/19	09/12/20
1003	Signal Generator	SMR-40	1104.0002.40	Rhode & Schwarz	06/20/19	06/20/20
1040	EMI Test Receiver	ESIB40	100292	Rhode & Schwarz	10/11/19	10/11/20
7620	EMI Test Receiver	ESU40	100399	Rhode & Schwarz	10/18/19	10/18/20
1016	Pre-Amplifier	PAM-0202	187	PAM	03/08/19	03/08/20
Miscellaneous						
11312	Mini Environmental Quality Meter	850027	CF099-56010-340	11312	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 Antenna Conducted Port 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	Rectangular	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 AC 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	dB	U-shaped	1.414	0.05	0.00
10	LISN impedance	2.65	dB	Triangular	2.449	1.08	1.17
11	Effect of mains disturbance	0.00	dB			0.00	0.00
12	Effect of the environment						
	Combined standard uncertainty			Normal		1.66	dB
	Expanded uncertainty			**Normal, k=2**		**3.31**	**dB**

3.2.3 Radiated Measurements (Below 1GHz)

	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	0.45	dB	Normal, k=2	2.000	0.23	0.05
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	3.76	dB	Triangular	2.449	1.54	2.36
16	Separation distance at 3 m	0.30	dB	Rectangular	1.732	0.17	0.03
17	Effect of setup table material	0.77	dB	Rectangular	1.732	0.44	0.20
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	2.95	dB	
	Expanded uncertainty			**Normal, k=2**	**5.90**	**dB**	

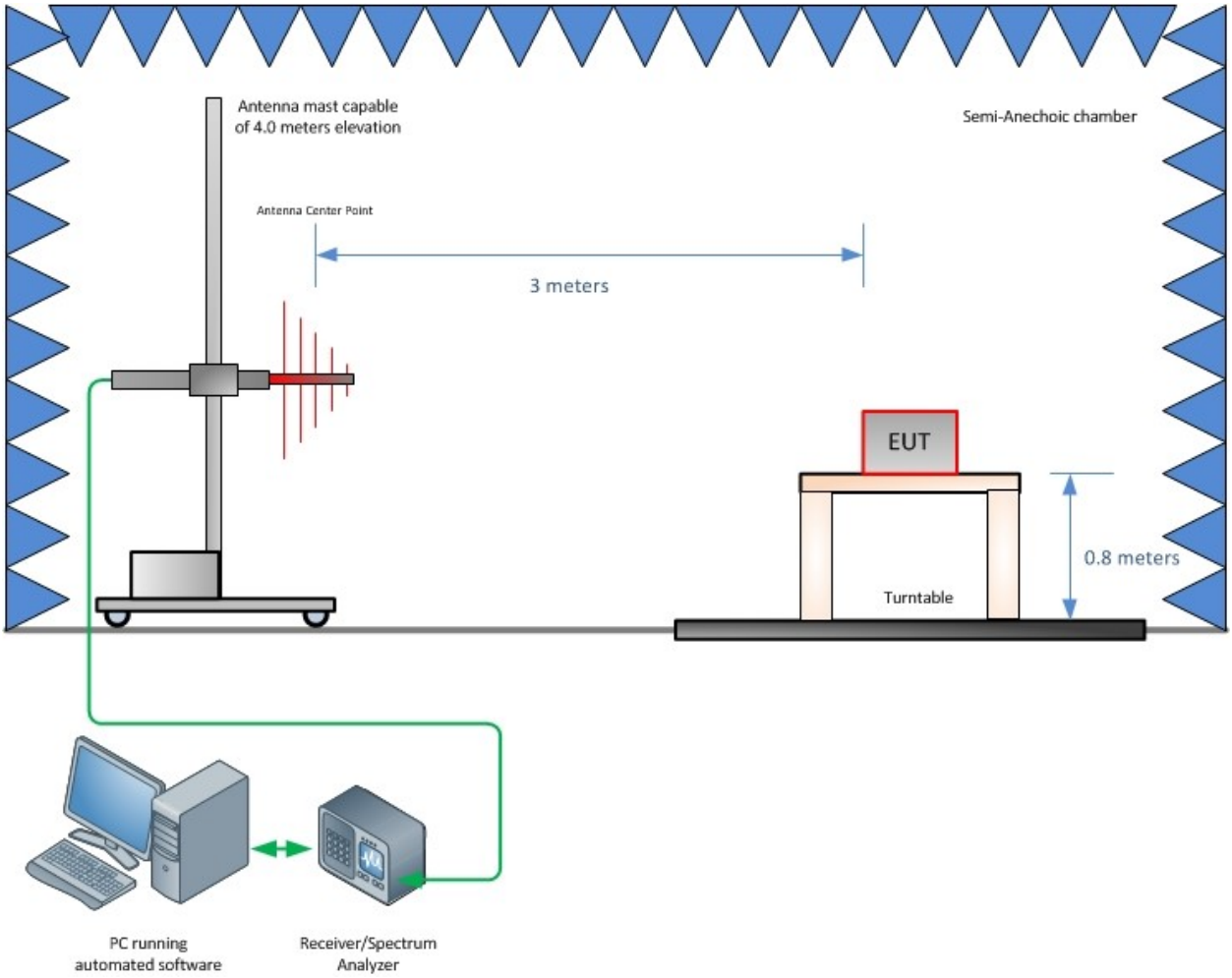
3.2.4 Radiated Emission Measurements (Above 1GHz)

	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	0.45 dB	Normal, k=2	2.000	0.23	0.05
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	3.25 dB	Triangular	2.449	1.33	1.76
16	Separation distance at 3 m	0.30 dB	Rectangular	1.732	0.17	0.03
17	Effect of setup table material	0.77 dB	Rectangular	1.732	0.44	0.20
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	2.85 dB		
	Expanded uncertainty		**Normal, k=2**	**5.70 dB**		

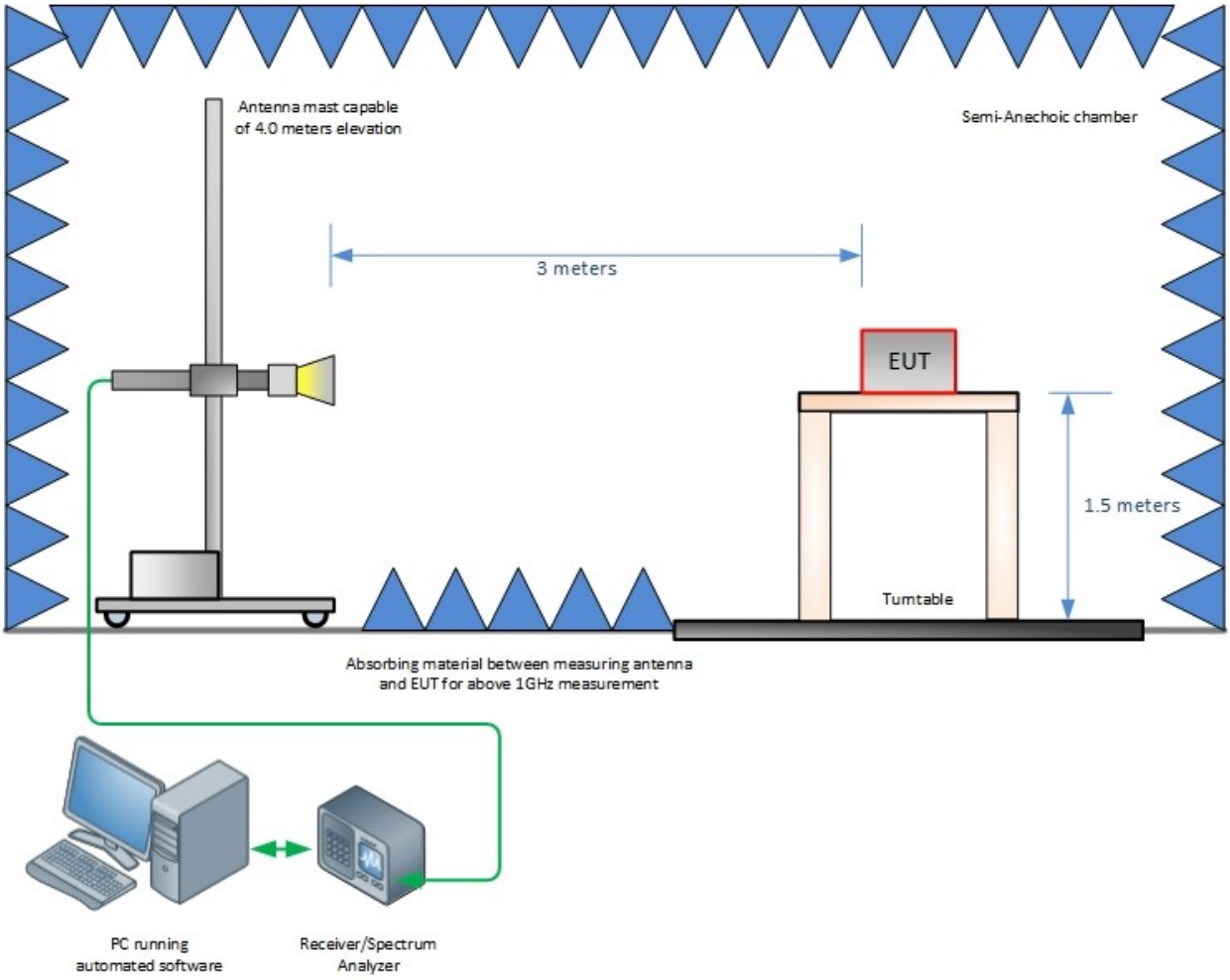
SECTION 4

4 Diagram of Test Setup

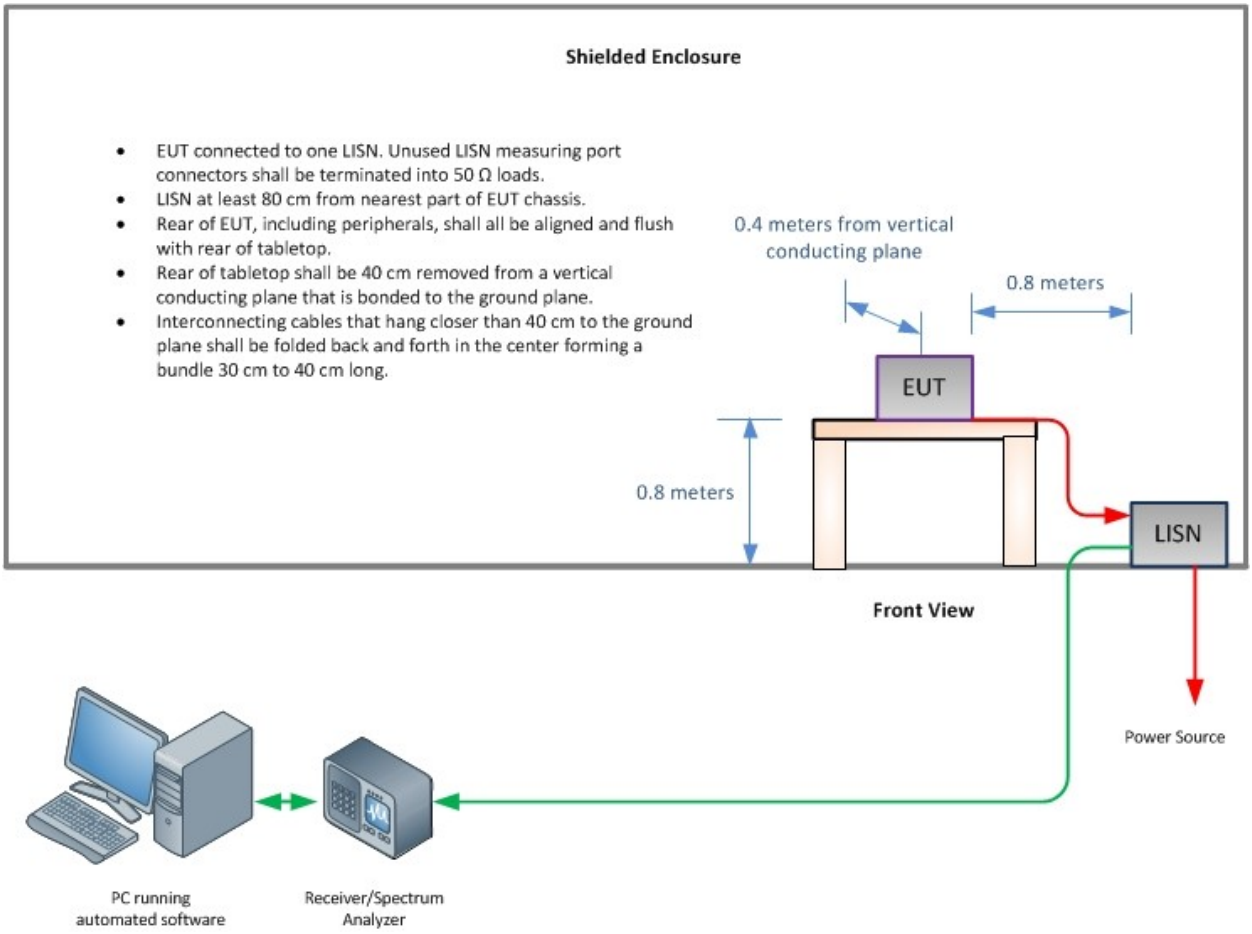
4.1 Test Setup Diagram



Radiated Emission Test Setup (Below 1GHz)



Radiated Emission Test Setup (Above 1GHz)



Conducted Emission Test Setup

SECTION 5

5 ACCREDITATION, DISCLAIMERS AND COPYRIGHT

5.1 Accreditation, Disclaimers and Copyright

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