Radio Testing of the

Spot LLC
Sat-Fi2 Remote Antenna Station Model: SF2 RAS

In accordance with FCC Part 25 Subpart C and ISED RSS-170 Issue 3 July 2015

Spot LLC
1351 Holiday Square Blvd.
Covington, LA 70433 USA

COMMERCIAL-IN-CONFIDENCE

Date: October 2019
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RESPONSIBLE FOR	NAME	DATE	SIGNATURE
Authorized Signatory	Alex Chang	October 08, 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 25 Subpart C and ISED RSS-170 Issue 3 July 2015.

A2LA Cert. No. 2955.13

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REPORT ON	Radio Testing of the Spot LLC Model SF2 RAS Sat-Fi2 Remote Antenna Station
TEST REPORT NUMBER	72150190A
TEST REPORT DATE	October 2019
PREPARED FOR	Spot LLC 1351 Holiday Square Blvd. Covington, LA 70433 USA
CONTACT PERSON	Tom Maher Director of Quality and Manufacturing tom.maher@globalstar.com (985) 335-1518
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	October 08, 2019

Revision History

72150190A Spot LLC Model SF2 RAS Sat-Fi2 Remote Antenna Station					
DATE	OLD REVISION	NEW REVISION	REASON	PAGES AFFECTED	APPROVED BY
10/08/2019	—	Initial Release			Alex Chang

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SECTION 1

1 REPORT SUMMARY

Radio Testing of the
Spot LLC
SF2 RAS Sat-Fi2 Remote Antenna Station

1.1 INTRODUCTION

The information contained in this report is intended to show verification of the Spot LLC SF2 RAS Sat-Fi2 Remote Antenna Station to the requirements of FCC Part 25 Subpart C and ISED RSS-170 Issue 3 July 2015.

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	Spot LLC
EUT	Sat-Fi2 Remote Antenna Station
Trade Name	SF2 RAS
Model Name	SF2 RAS
FCC ID	L2V-SF2RAS
IC Number	3989A-SF2RAS
Serial Number(s)	N/A
Number of Samples Tested	1
Test Specification/Issue/Date	• FCC Part 25 Subpart C (October 1, 2018). • ISED RSS-170 Issue 3 July 2015: Mobile Earth Stations (MESs) and Ancillary Terrestrial Component (ATC) Equipment Operating in the Mobile-Satellite Services (MSS)
Start of Test	September 25, 2019
Finish of Test	October 08, 2019
Name of Engineer(s)	Ferdinand Custodio
Related Document(s)	• ANSI C63.26-2015. American National Standard for Compliance Testing of Transmitters Used in Licensed radio Services. • ANSI C63.10-2013. American National Standard of Procedures for Compliance Testing of Unlicensed Wireless Devices • 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 25 Subpart C and ISED RSS-170 Issue 3 July 2015 with cross-reference to the corresponding IC RSS standard are shown below.

Part 2	Part 25	RSS-170	Test Description	Result	Comments /Base Standard
§2.1046	§25.204(a)	Sec. 5.3.2	RF Power Output	Compliant	
§2.1049			Occupied Bandwidth	Compliant	
§2.1051	§25.202(f)	Sec. 5.4.3.1	Spurious Emissions at Antenna Terminals	Compliant	
§2.1053	§25.202(f)	Sec. 5.4.3.1	Field Strength of Radiated Spurious Emissions	Compliant	
§2.1055	§25.202(d)	Sec. 5.2	Frequency Stability	Compliant	
-	§25.216 (c)(f)(g)(i)and (j)	Sec. 5.4.3.2.1, Sec. 5.4.4	Protection of Aeronautical Radio Navigation Satellite Service	Compliant	

1.3 Product Information

1.3.1 Technical Description

The Equipment Under Test (EUT) is a Spot LLC SF2 RAS Sat-Fi2 Remote Antenna Station. The EUT consists of a self-contained electronics housing, RF cables, an active GPS antenna, and an active satellite antenna. The EUT uses a certified Sat-Fi 2 satellite modem (FCC ID L2V-SATFI2 / IC: 3989A-ATFI2) with a helix antenna which contains an active front end for the transmit path in addition to the receive path.

1.3.2 EUT General Description

EUT Description	Sat-Fi2 Remote Antenna Station
Model Name	SF2 RAS
Model Number	SF2 RAS
Serial Number	N/A
Input Voltage	12-24VDC
Output RF Power	1.47 W EIRP
Frequency Range (TX)	1610.73 – 1620.57 MHz in the 1610.0-1626.5 MHz L-Band Mobile Satellite Service
Emission Designator	1M56G1W
Antenna Type	Active TX/RX Globalstar Quadrafilar Helix (QFH) Antenna
Antenna Model	P/N: 826422-901-TG
Antenna gain	3.3 dBi
Modulation	HPSK for transmit and QPSK for receive
EUT Sample Type	Pre-production

Transmit Channel Table

Channel	Hexadecimal Input for TX ARFCN	Frequency (MHz)
1	**4**	**1610.73**
2	2D	1611.96
3	56	1613.19
4	7F	1614.42
5	**A8**	**1615.65**
6	D1	1616.88
7	*FA*	1618.11
8	123	1619.34
9	**14C**	**1620.57**

1.4 EUT Test configuration

1.4.1 Test Configuration Description

Test Configuration	Description
A	Antenna Conducted Port Single Channel Mode. EUT connects to a support Laptop via Ethernet and is set to transmit in fixed channel using Putty and RTDM.
B	Case/Cabinet Radiated Emission Single Channel Mode. EUT connects to a support Laptop via USB Cable to setup the channel and is set to transmit in fixed channel using Putty and RTDM, Antenna port is terminated by a 50 Ω Load.

1.4.2 EUT Exercise Software

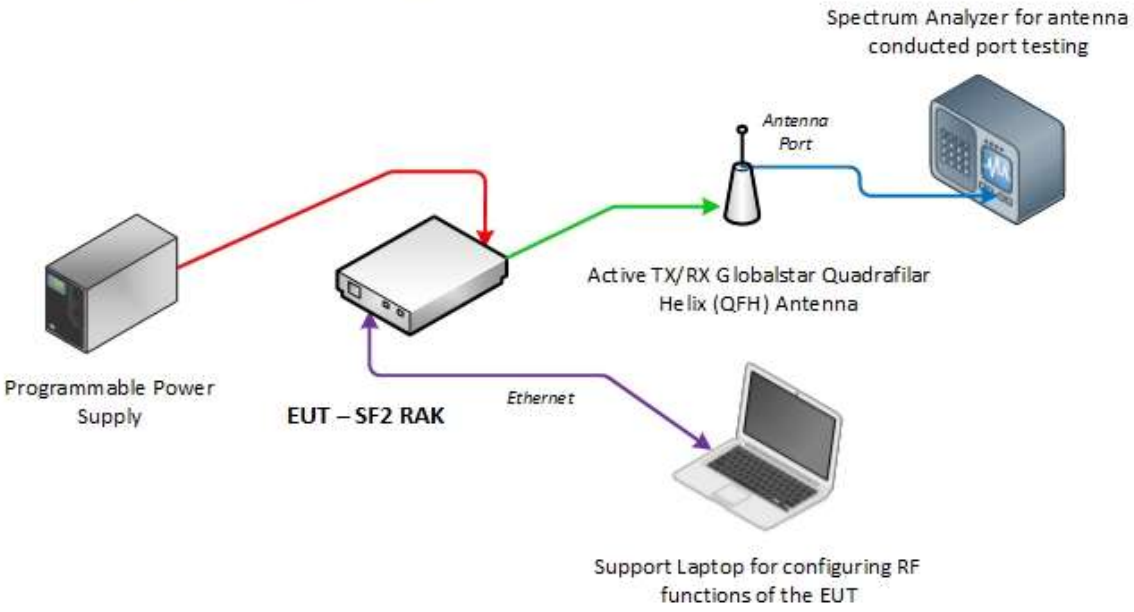
EUT is configured via Ethernet. Once connected to the support Laptop, putty.exe and RTDM.exe application was used to send radio configuration commands to set the EUT in continuous modulated transmission mode at Low, Mid and High channels

1.4.3 Support Equipment and I/O cables

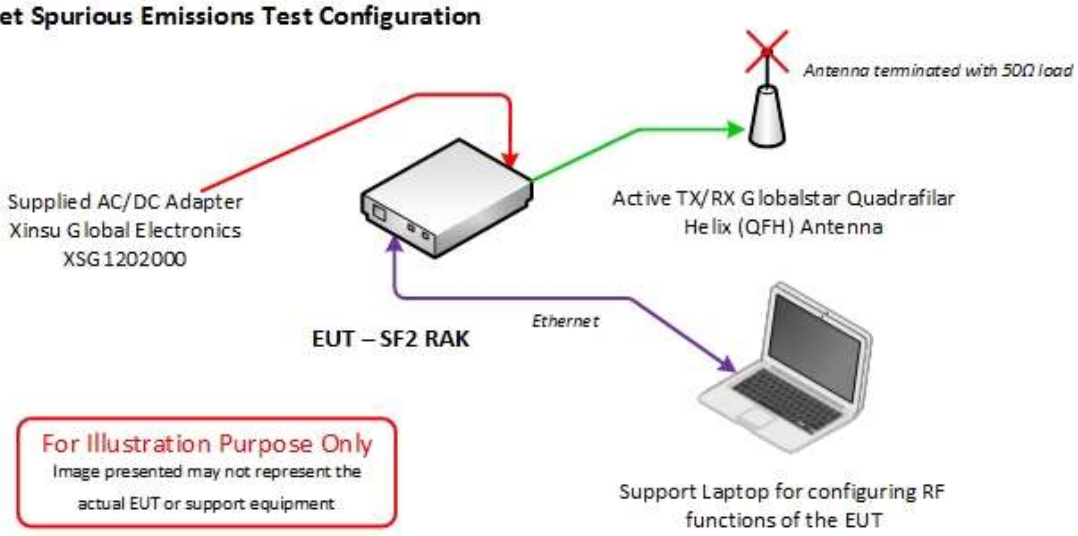
Manufacturer	Equipment/Cable	Description
HP	Laptop ProBook 440 G2	Model: HSTNN-C83C
HP	Laptop Power Supply	Part No.: 744481-0002
N/A	Ethernet Patch Cable	1 meter, CAT5 unshielded patch cable
HP	System DC PowerSupply	M/N 6632B SDGE40923 S/N US37472178
MCL	Attenuator (Load x4)	BW-S20W5+ 5W 20dB DC-18GHz
-	Termination (x3)	Generic SMA type 50Ω

1.4.4 Simplified Test Configuration Diagram

Antenna Conducted Port Test Configuration



Cabinet Spurious Emissions Test Configuration



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 C63.26-2015. American National Standard for Compliance Testing of Transmitters Used in Licensed radio Services.

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 C63.26-2015. 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 (IC) 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
Spot LLC
Sat-Fi2 Remote Antenna Station

2.1 RF Power Output

2.1.1 Specification Reference

FCC 47 CFR Part 15, Clause 15.247(b)(3)
RSS-247, Clause 5.4 (d)

2.1.2 Specification Reference

Part 25 Subpart C §25.204(a),
RSS-170 Issue 3 Sec. 5.3.2

2.1.3 Standard Applicable

(a) In bands shared coequally with terrestrial radio communication services, the equivalent isotropically radiated power transmitted in any direction towards the horizon by an earth station, other than an ESV, operating in frequency bands between 1 and 15 GHz, shall not exceed the following limits except as provided for in paragraph (c) of this section:
+40 dBW in any 4 kHz band for Θ ≤ 0°
+40 + 3Θ dBW in any 4 kHz band for 0° < Θ ≤ 5°
where Θ is the angle of elevation of the horizon viewed from the center of radiation of the antenna of the earth station and measured in degrees as positive above the horizontal plane and negative below it.

2.1.4 Equipment Under Test and Modification State

Serial No: N/A / Test Configuration A

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

September 25, 2019 / FSC

2.1.6 Test Equipment Used

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

2.1.7 Environmental Conditions

Test performed at TÜV SÜD America Inc. Rancho Bernardo facility

Ambient Temperature	25.0 °C
Relative Humidity	49.4 %
ATM Pressure	99.0 kPa

2.1.8 Additional Observations

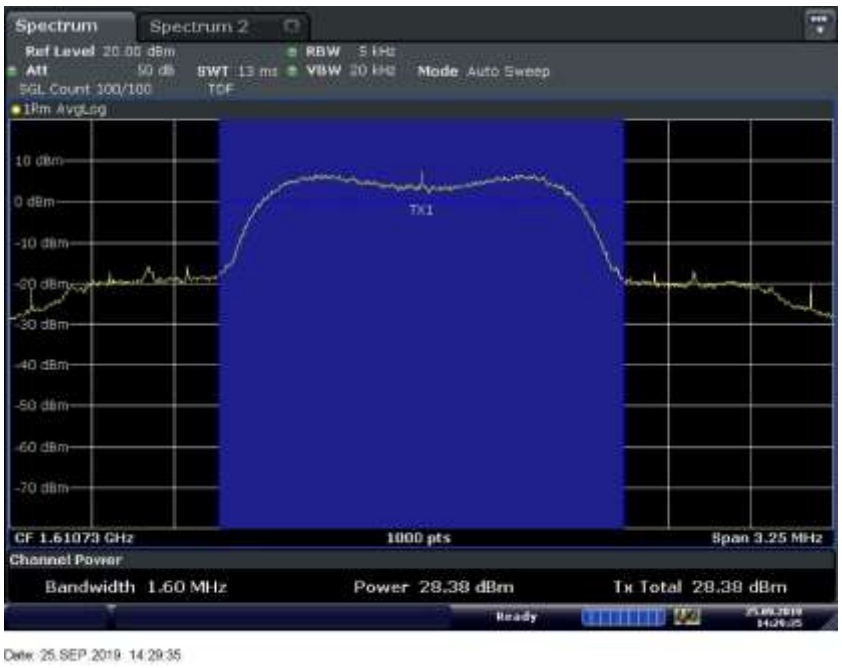
- This is a conducted test utilizing a spectrum analyzer.
- The attenuation for the external attenuator, adapter and cable is measured and entered as a Transducer factor (TDF).

- RBW of 4 kHz is not available on the instrument used. RBW is set to 5 kHz, which is worst case.
- The transmitter was set to transmit at full power and using 9.6kbps data rate which was verified as the worst-case data rate.
- Power integration function of the spectrum analyser used. Power integration bandwidth is based from the occupied bandwidth data (see Section 2.2 of this test report).

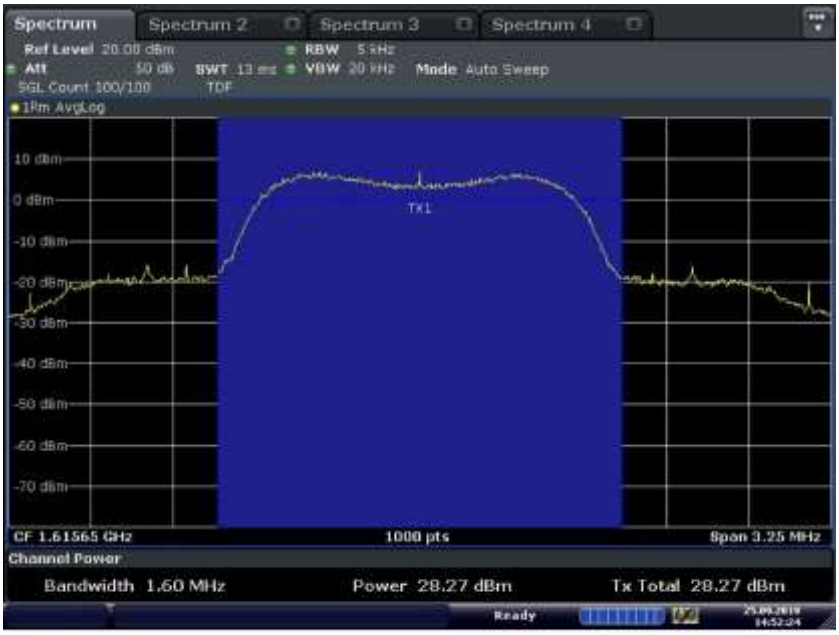
2.1.9 Test Results

Frequency (MHz)	Output Power (dBm)	Antenna Gain (dBi)	E.I.R.P. (dBm)	E.I.R.P (dBW)	E.I.R.P. (W)
1610.73	28.38	3.3	31.68	1.68	1.47
1615.65	28.27	3.3	31.57	1.57	1.44
1620.57	28.00	3.3	31.30	1.30	1.35

2.1.10 Test Plots



Low Channel



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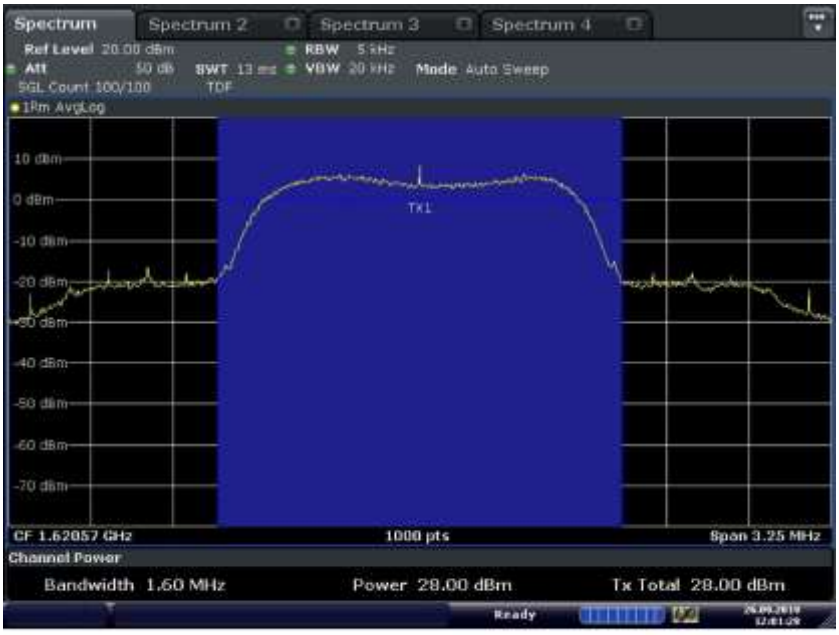
Mid Channel



Date: 26.SEP.2019 12:01:28

High Channel

2.2 Occupied Bandwidth

2.2.1 Specification Reference

Part 2 Subpart J §2.1049

2.2.2 Standard Applicable

The occupied bandwidth, that is the frequency bandwidth such that, below its lower and above its upper frequency limits, the mean powers radiated are each equal to 0.5 percent of the total mean power radiated by a given emission.

2.2.3 Equipment Under Test and Modification State

Serial No: N/A / Test Configuration A

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

September 26, 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 performed at TÜV SÜD America Inc. Rancho Bernardo facility

Ambient Temperature	25.0 °C
Relative Humidity	49.4 %
ATM Pressure	99.0 kPa

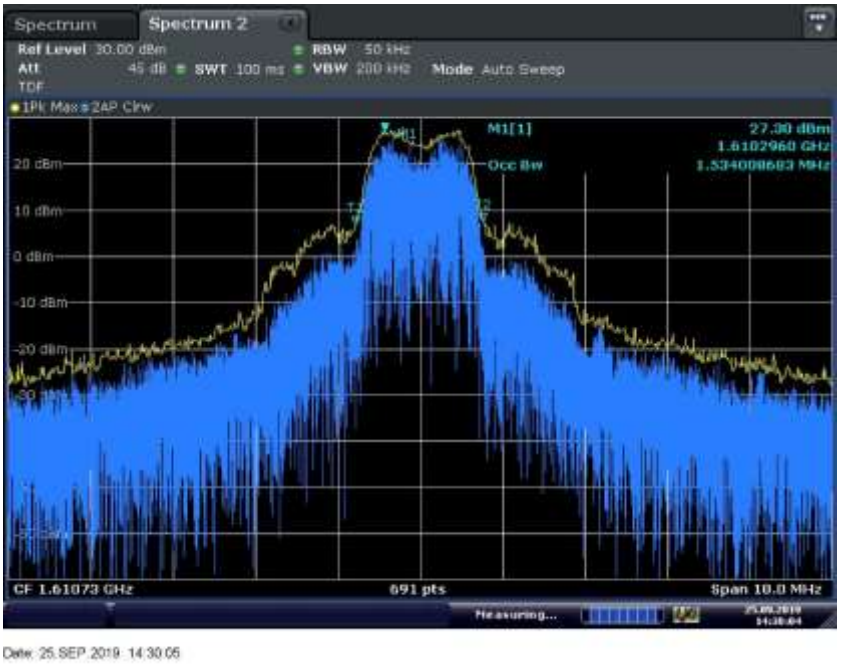
2.2.7 Additional Observations

- This is a conducted test utilizing a spectrum analyser.
- The attenuation for the external attenuator, adapter and cable is measured and entered as a Transducer factor (TDF).
- Occupied bandwidth measurement function of the spectrum analyser was utilized for this test.
- Span is wide enough to capture the channel transmission.
- RBW is 1% to 5% of the occupied bandwidth.
- VBW is >3 X RBW.
- Sweep is auto.
- Detector is peak.
- Trace is max hold.

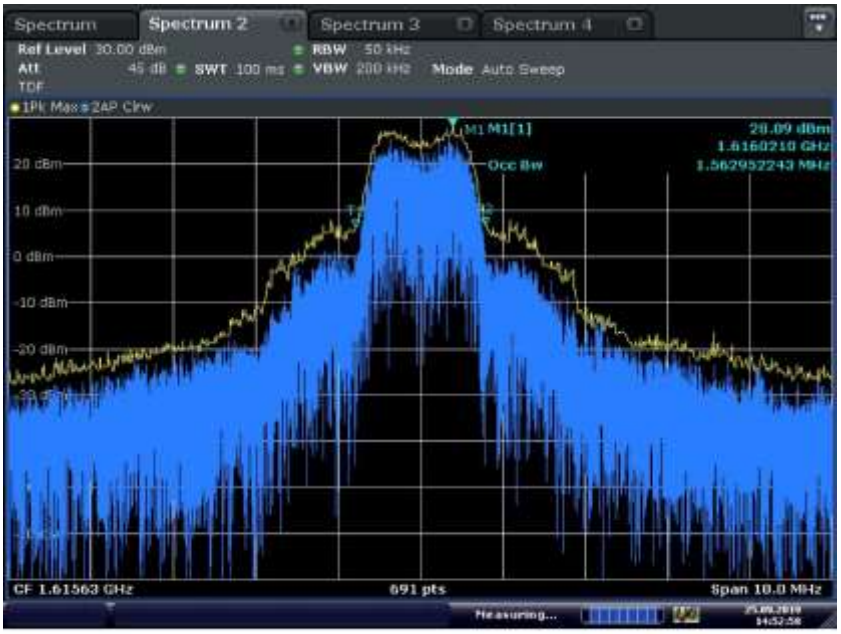
2.2.8 Test Results

Channel	Frequency (MHz)	Occupied Bandwidth (MHz)
Low	1610.73	1.534
Mid	1615.65	1.563
High	1620.57	1.491

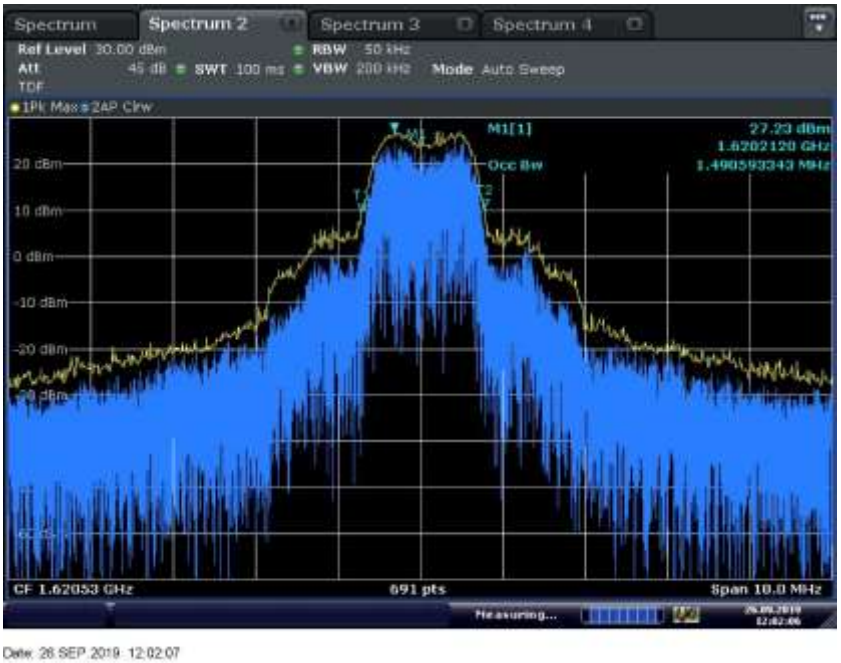
2.2.9 Test Plots



Low Channel



Mid Channel



High Channel

2.3 Spurious Emissions at Antenna Terminals

2.3.1 Specification Reference

Part 25 Subpart C §25.202(f), RSS-170 Issue 3 Sec. 5.4.3.1

2.3.2 Standard Applicable

FCC CFR Part 25, Section 25.202(f):
(f) Emission limitations. Except for SDARS terrestrial repeaters, the mean power of emissions shall be attenuated below the mean output power of the transmitter in accordance with the schedule set forth in paragraphs (f)(1) through (f)(4) of this section. The out-of-band emissions of SDARS terrestrial repeaters shall be attenuated in accordance with the schedule set forth in paragraph (h) of this section.
(1) In any 4 kHz band, the center frequency of which is removed from the assigned frequency by more than 50 percent up to and including 100 percent of the authorized bandwidth: 25 dB;
(2) In any 4 kHz band, the center frequency of which is removed from the assigned frequency by more than 100 percent up to and including 250 percent of the authorized bandwidth: 35 dB;
(3) In any 4 kHz band, the center frequency of which is removed from the assigned frequency by more than 250 percent of the authorized bandwidth: An amount equal to 43 dB plus 10 times the logarithm (to the base 10) of the transmitter power in watts;
(4) In any event, when an emission outside of the authorized bandwidth causes harmful interference, the Commission may, at its discretion, require greater attenuation than specified in paragraphs (f) (1), (2) and (3) of this section.

RSS-170 issue 3, Section 5.4.3:
The average power of unwanted emissions shall be attenuated below the average output power, P (dBW), of the transmitter, as specified below:
(1) 25 dB in any 4 kHz band, the centre frequency of which is offset from the channel frequency by more than 50%, up to and including 100% of the occupied bandwidth or necessary bandwidth, whichever is greater;
(2) 35 dB in any 4 kHz band, the centre frequency of which is offset from the channel frequency by more than 100%, up to and including 250% of the occupied bandwidth or necessary bandwidth, whichever is greater; and
(3) 43 + 10 log p (watts) in any 4 kHz band, the centre frequency of which is offset from the channel frequency by more than 250% of the occupied bandwidth or necessary bandwidth, whichever is greater.

2.3.3 Equipment Under Test and Modification State

Serial No: N/A / Test Configuration A

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

September 26, 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

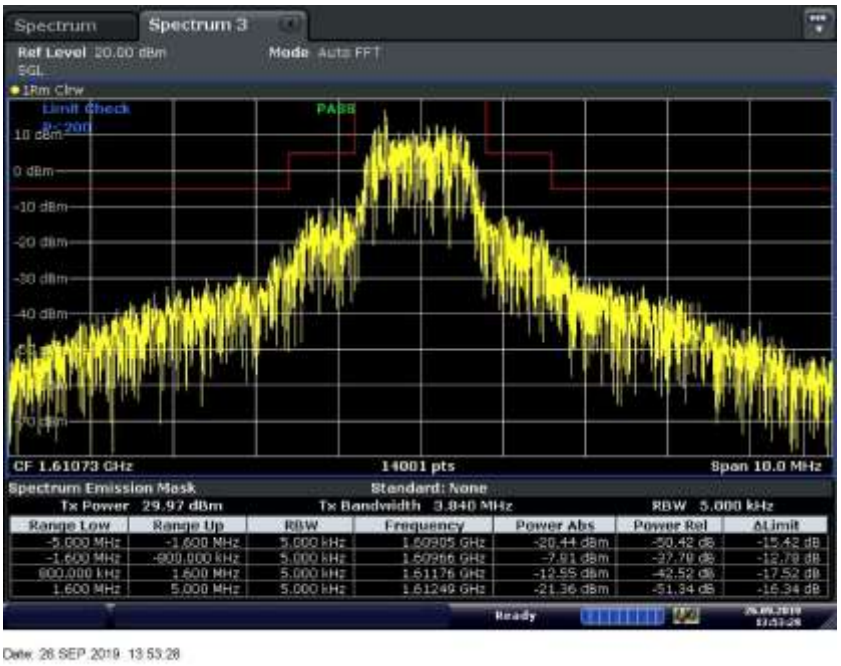
Test performed at TÜV SÜD America Inc. Rancho Bernardo facility

Ambient Temperature	25.0 °C
Relative Humidity	49.4 %
ATM Pressure	99.0 kPa

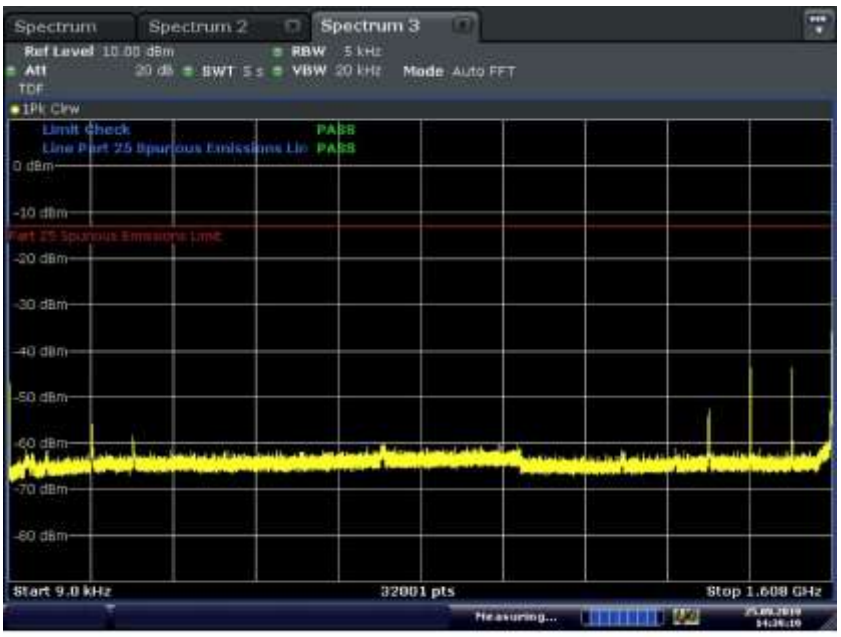
2.3.7 Additional Observations

- This is a conducted test utilizing a spectrum analyzer.
- The attenuation for the external attenuator, adapter and cable is measured and entered as a Transducer factor (TDF).
- RBW of 4 kHz is not available in the instrument used. RBW is set to 5 kHz, which is worst case.
- The emission mask as per §25.202(f)(1) to (3) was drawn for each channel and modulation scheme investigated. The Spectrum Mask function of the Spectrum Analyzer was used for this test, the mask was referenced to the mean power of the signal being investigated.
- Separate plots outside ±250% from the center frequency were also provided.
- The emission mask was calculated each time based from the mean output power and occupied bandwidth of each channel/modulation investigated.

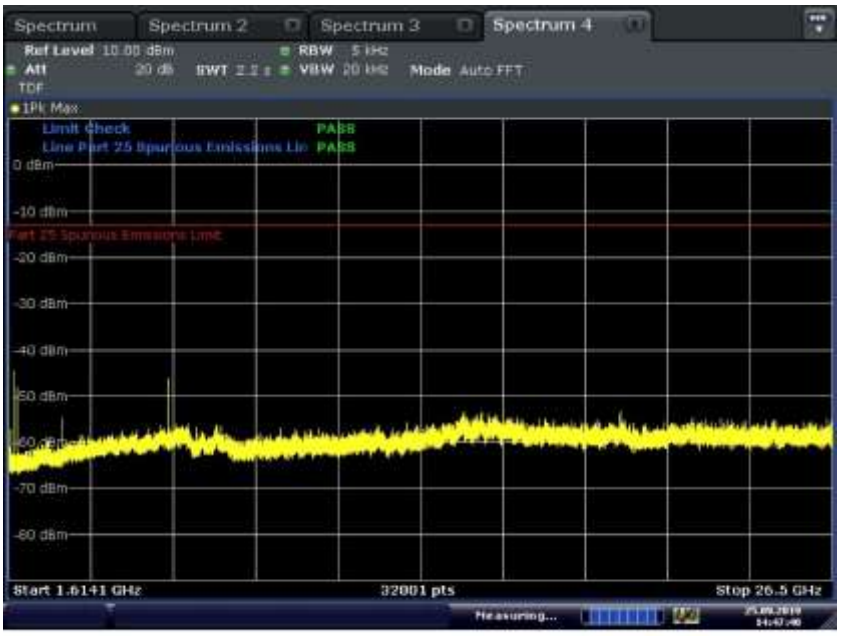
2.3.8 Test plots



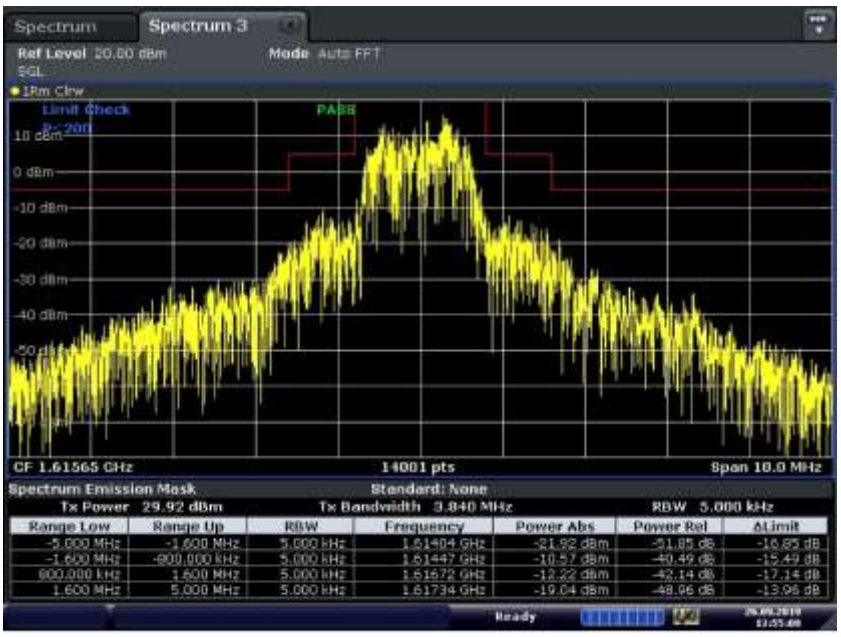
Low Channel (centred at the transmit frequency)



Low Channel (9 kHz to lower edge sweep)

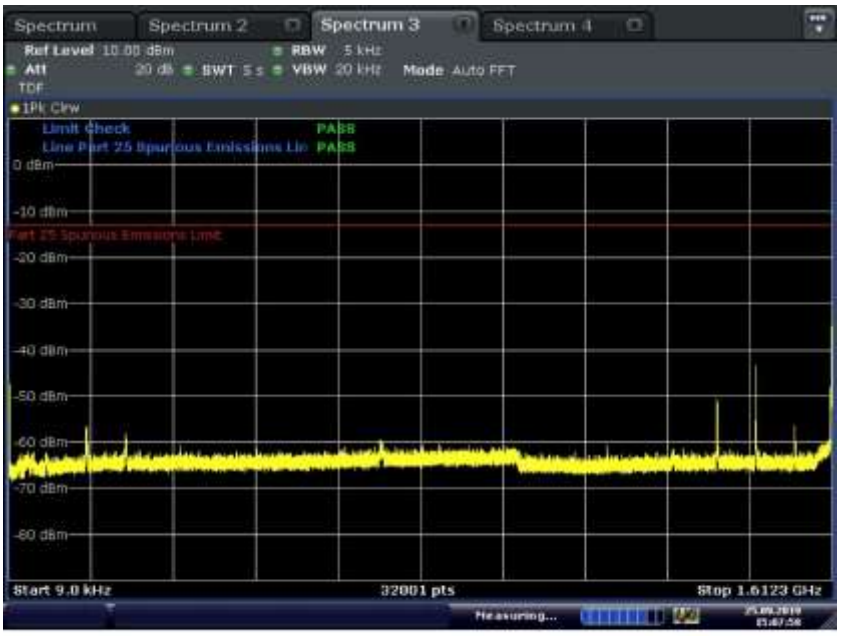


Low Channel (upper edge to 26.5 GHz sweep)



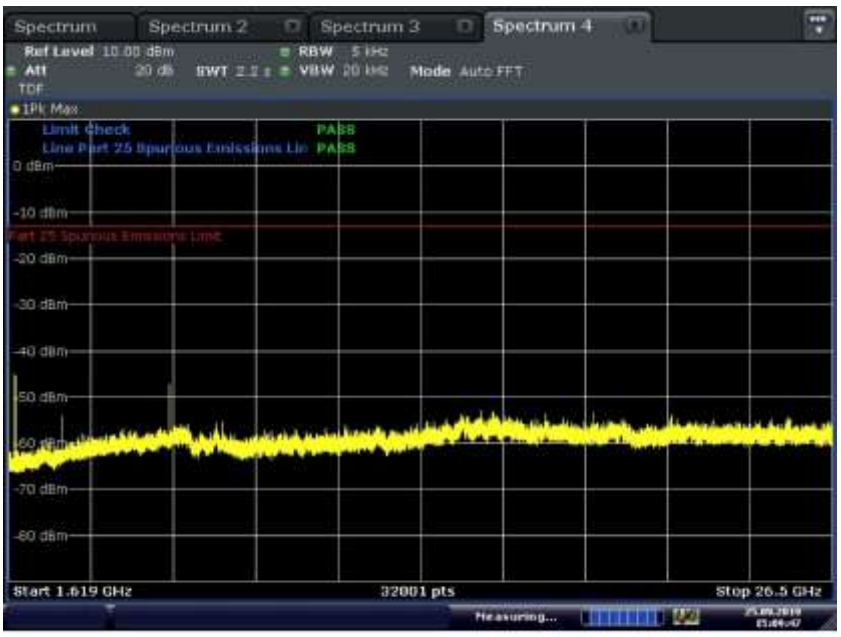
Date: 26.SEP.2019 13:55:08

Mid Channel (centred at the transmit frequency)

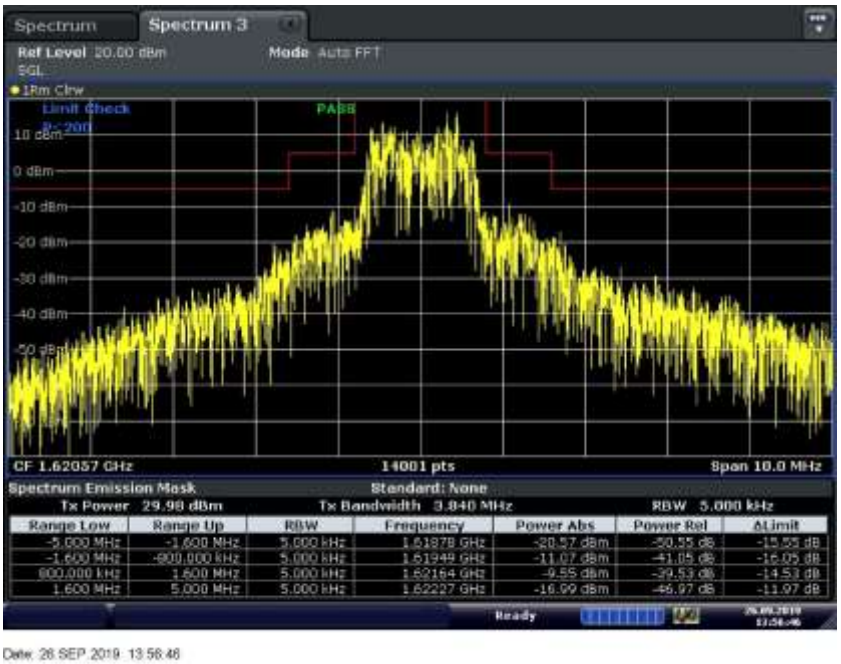


Date: 25.SEP.2019 15:07:57

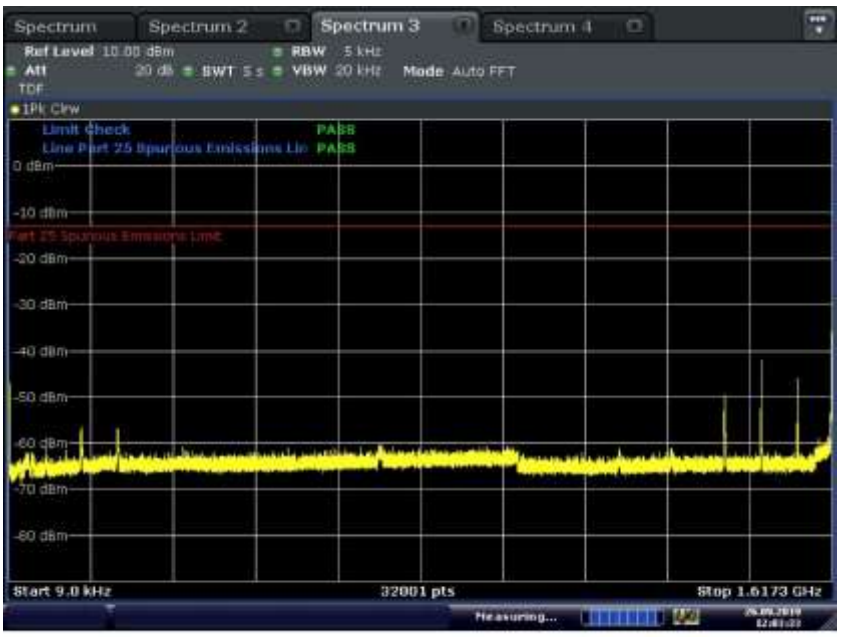
Mid Channel (9 kHz to lower edge sweep)



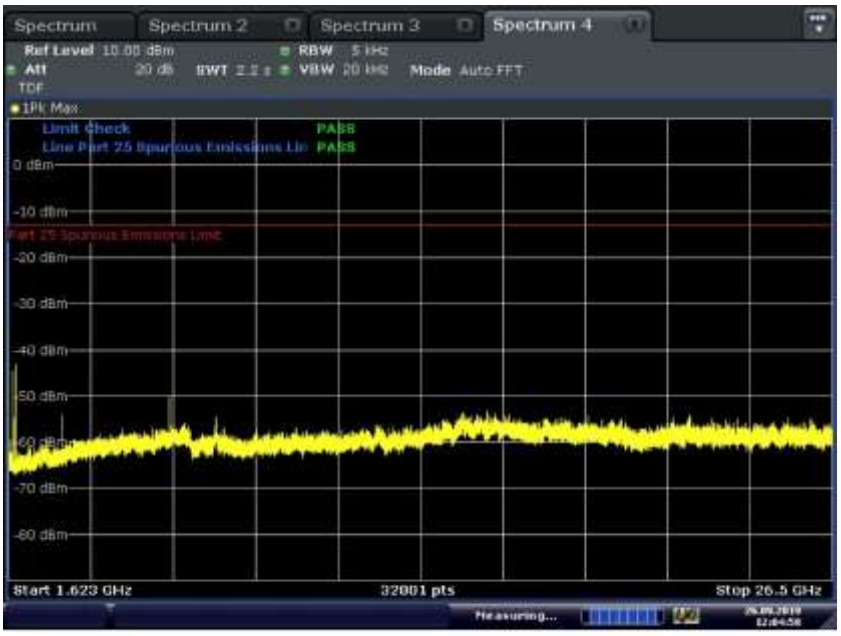
Middle Channel (upper edge to 26.5 GHz sweep)



High Channel (centred at the transmit frequency)



High Channel (9kHz to lower edge sweep)



High Channel (upper edge to 26.5GHz sweep)

2.4 Field Strength of radiated Spurious Emissions

2.4.1 Specification Reference

Part 2 Subpart J §2.1053
Part 25 Subpart C §25.202(f)
RSS-170 Issue 3 Sec. 5.4.3.1

2.4.2 Standard Applicable

FCC CFR Part 25, Section 25.202(f):
(f) Emission limitations. Except for SDARS terrestrial repeaters, the mean power of emissions shall be attenuated below the mean output power of the transmitter in accordance with the schedule set forth in paragraphs (f)(1) through (f)(4) of this section. The out-of-band emissions of SDARS terrestrial repeaters shall be attenuated in accordance with the schedule set forth in paragraph (h) of this section.
(1) In any 4 kHz band, the center frequency of which is removed from the assigned frequency by more than 50 percent up to and including 100 percent of the authorized bandwidth: 25 dB;
(2) In any 4 kHz band, the center frequency of which is removed from the assigned frequency by more than 100 percent up to and including 250 percent of the authorized bandwidth: 35 dB;
(3) In any 4 kHz band, the center frequency of which is removed from the assigned frequency by more than 250 percent of the authorized bandwidth: An amount equal to 43 dB plus 10 times the logarithm (to the base 10) of the transmitter power in watts;
(4) In any event, when an emission outside of the authorized bandwidth causes harmful interference, the Commission may, at its discretion, require greater attenuation than specified in paragraphs (f) (1), (2) and (3) of this section.

RSS-170 issue 3, Section 5.4.3:
The average power of unwanted emissions shall be attenuated below the average output power, P (dBW), of the transmitter, as specified below:
(1) 25 dB in any 4 kHz band, the centre frequency of which is offset from the channel frequency by more than 50%, up to and including 100% of the occupied bandwidth or necessary bandwidth, whichever is greater;
(2) 35 dB in any 4 kHz band, the centre frequency of which is offset from the channel frequency by more than 100%, up to and including 250% of the occupied bandwidth or necessary bandwidth, whichever is greater; and
(3) 43 + 10 log p (watts) in any 4 kHz band, the centre frequency of which is offset from the channel frequency by more than 250% of the occupied bandwidth or necessary bandwidth, whichever is greater.

2.4.3 Equipment Under Test and Modification State

Serial No: N/A / Test Configuration B

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

September 29 and October 02, 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	25.1 - 26.0 °C
Relative Humidity	45.0 - 53.6 %
ATM Pressure	98.9 - 99.1 kPa

2.4.7 Additional Observations

- This is a radiated test.
- The spectrum was searched from 30MHz to 10X the transmit frequency (up to 18GHz).
- Test procedure is per ANSI C63.10-2013. As the EUT is a wireless product with multiple radios within a single enclosure, therefore the use of a validated test site, in accordance with ANSI C63.10, to satisfy unlicensed intentional radiator compliance measurement requirements is required. Conversion of a field strength measurement (or received power measurement) to an equivalent EIRP or ERP value based on the equations in Section 5.2.7 of ANSI C63.26-2015 without using the substitution method is acceptable provided that they are performed on a test site that is validated to the requirements of ANSI C63.10. The EUT also satisfies the requirement having both licensed and unlicensed transmitters within a single enclosure for using this exception.
- Plots presented are when both the Satellite and WLAN radios are active (intermodulation verification).
- 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.

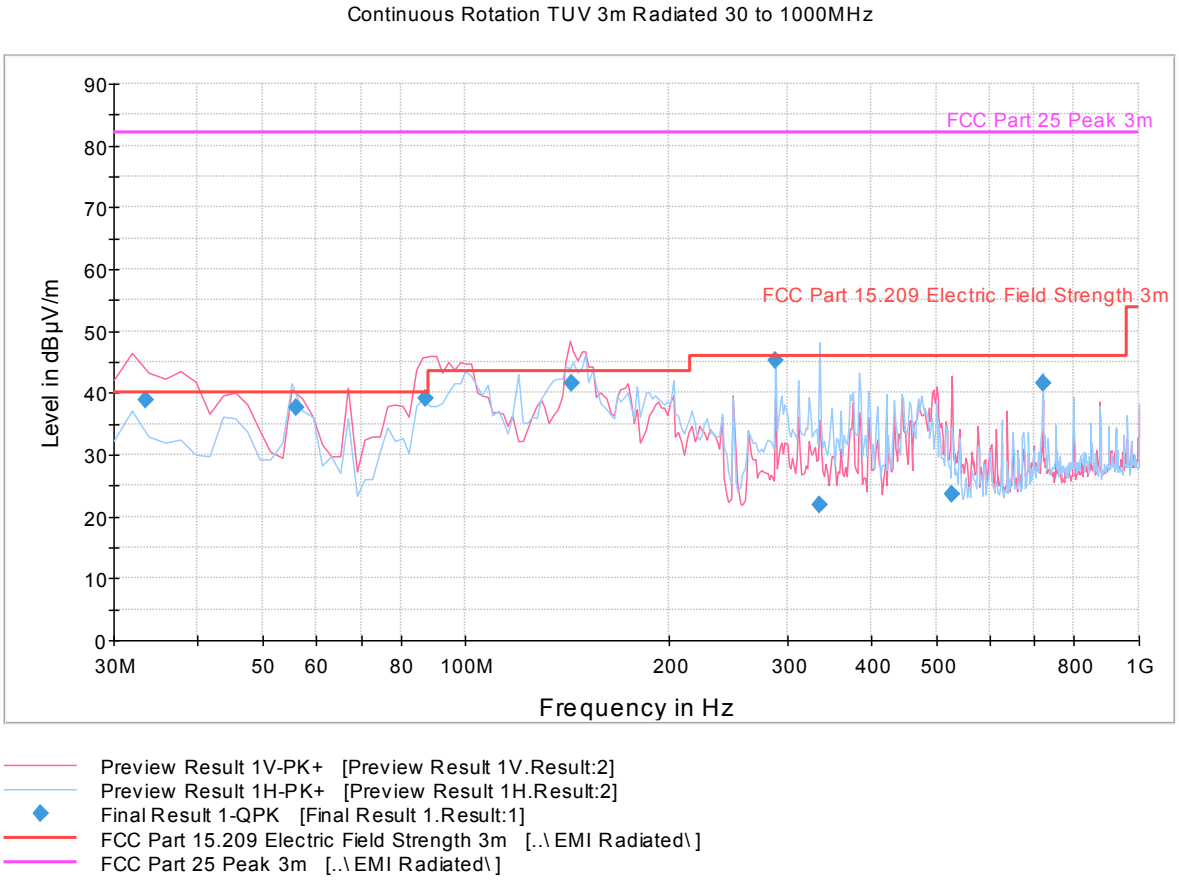
2.4.8 Sample Computation (Radiated Emission)

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**

2.4.9 Test Results

See attached plots.

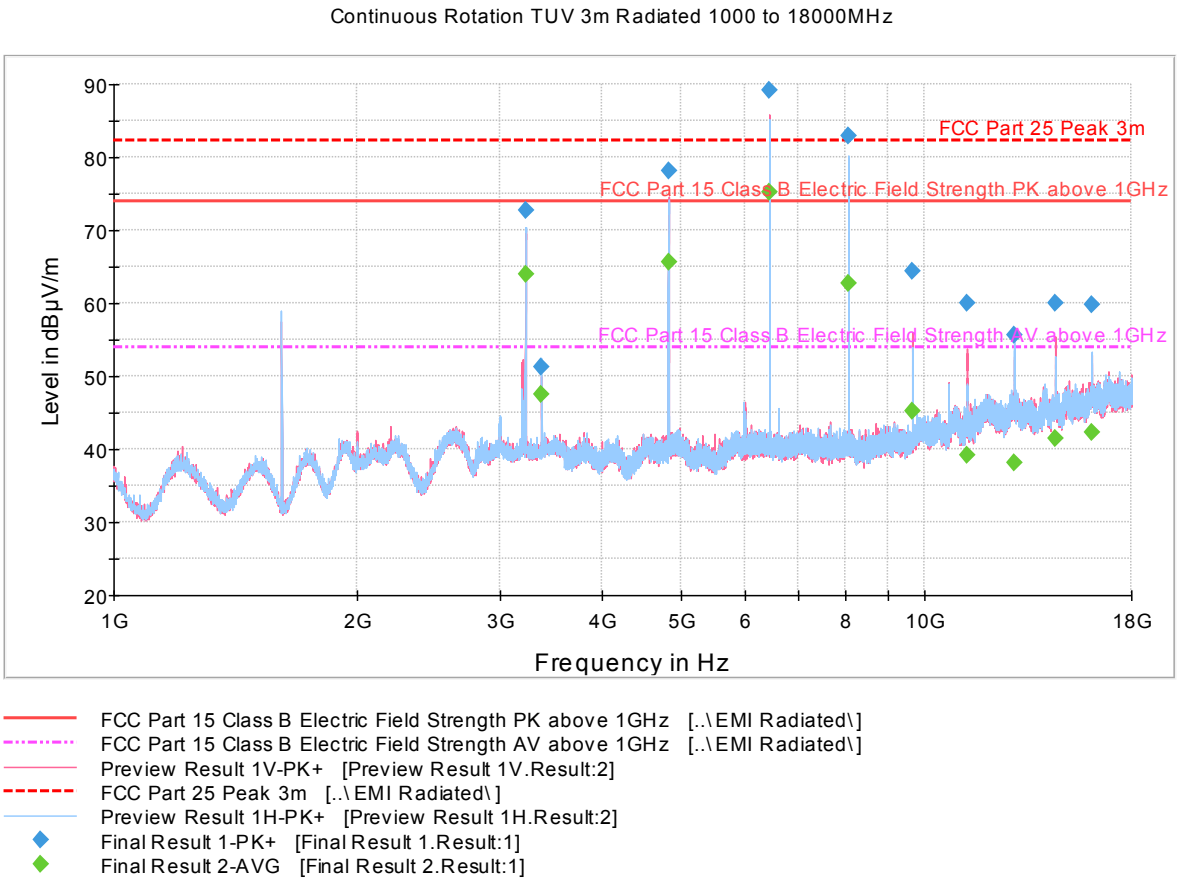
2.4.10 Below 1GHz Radiated Emission Test (Transmit Mode, Worst Case Channel)



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)
33.400000	38.9	1000.0	120.000	100.0	V	210.0	-9.3	0.1	40.0
55.870541	37.6	1000.0	120.000	355.0	H	189.0	-16.0	2.4	40.0
86.932745	39.2	1000.0	120.000	100.0	V	122.0	-15.7	0.8	40.0
143.305491	41.5	1000.0	120.000	100.0	V	0.0	-14.0	2.0	43.5
288.017074	45.3	1000.0	120.000	100.0	H	22.0	-7.8	0.7	46.0
335.870381	21.9	1000.0	120.000	240.0	H	96.0	-5.8	24.1	46.0
527.835271	23.6	1000.0	120.000	250.0	V	140.0	-1.0	22.4	46.0
719.760160	41.6	1000.0	120.000	100.0	H	152.0	2.8	4.4	46.0

2.4.11 From 1GHz to 18GHz Radiated Emission Test (Transmit Mode, Low Channel)

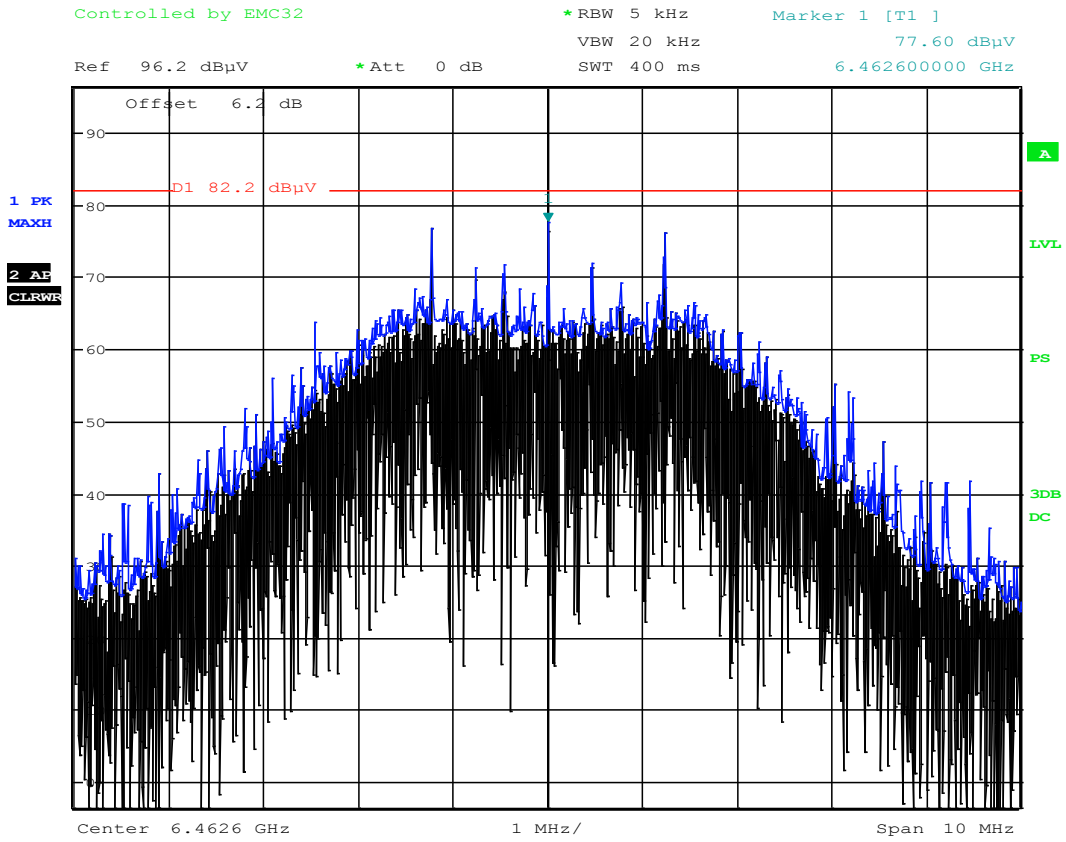


Peak Data

Frequency (MHz)	Max Peak (dBµV/m)	Meas. Time (ms)	Bandwidth (kHz)	Height (cm)	Polarization	Azimuth (deg)	Corr. (dB)	Margin (dB)	Limit (dBµV/m)
3220.60000	72.6	1000.0	1000.000	167.6	H	164.0	1.1	1.3	73.9
3373.56666	51.2	1000.0	1000.000	301.2	H	184.0	0.9	22.7	73.9
4833.33333	78.0	1000.0	1000.000	331.1	V	128.0	3.7	-4.1	73.9
6444.56666	89.3	1000.0	1000.000	326.2	V	135.0	6.1	-15.4	73.9
8052.00000	82.9	1000.0	1000.000	135.7	H	177.0	6.8	-9.0	73.9
9665.83333	64.3	1000.0	1000.000	383.0	V	152.0	8.8	9.6	73.9
11273.2333	60.0	1000.0	1000.000	353.1	V	-11.0	12.3	13.9	73.9
12884.1666	55.6	1000.0	1000.000	146.7	H	99.0	13.7	18.3	73.9
14493.8333	60.1	1000.0	1000.000	315.2	V	116.0	15.4	13.8	73.9
16103.9000	59.8	1000.0	1000.000	235.4	H	143.0	16.6	14.1	73.9

Test Notes: The RBW used for this test is 1MHz, Part 25 requirement is 4KHz. To satisfy unlicensed transmitters test requirements, please see Section 2.4.12 for sample verifications performed to confirm Part 25 spurs still complies with the requirement using the correct RBW.

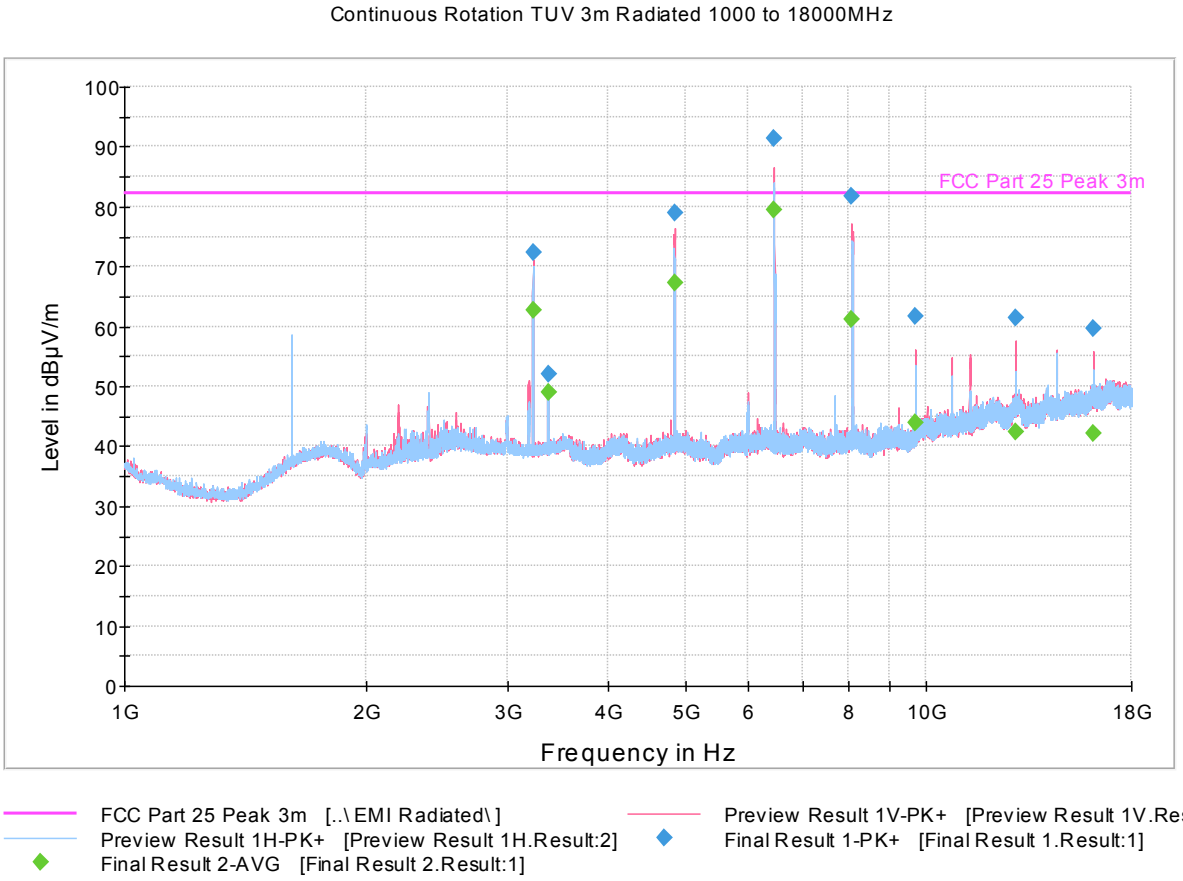
2.4.12 Sample Part 25 Spurious Verification Using 5KHz RBW



- Once the emission is maximized (turntable azimuth and receive antenna height), the RBW setting of the Receiver was changed from 1MHz to 5KHz (SA limitation).
- Offset was programmed using the calculated correction factor from EMC32.
- Only the worst spur presented (Mid Channel).
- The maximum detectable emission (field strength) was converted to equivalent power level and was compared to FCC Part 25 limit of -13 dBm for emissions >±250% OBW offset from the center frequency:

EIRP (dBm) = E (dBµV/m) + 20log(D) – 104.8, where D is 3 meters (measurement distance)
= 77.6 dBµV/m + 9.54 – 104.8
= -17.66 dBm (Complies)

2.4.13 From 1GHz to 18GHz radiated Emission Test (Transmit Mode, Mid Channel)

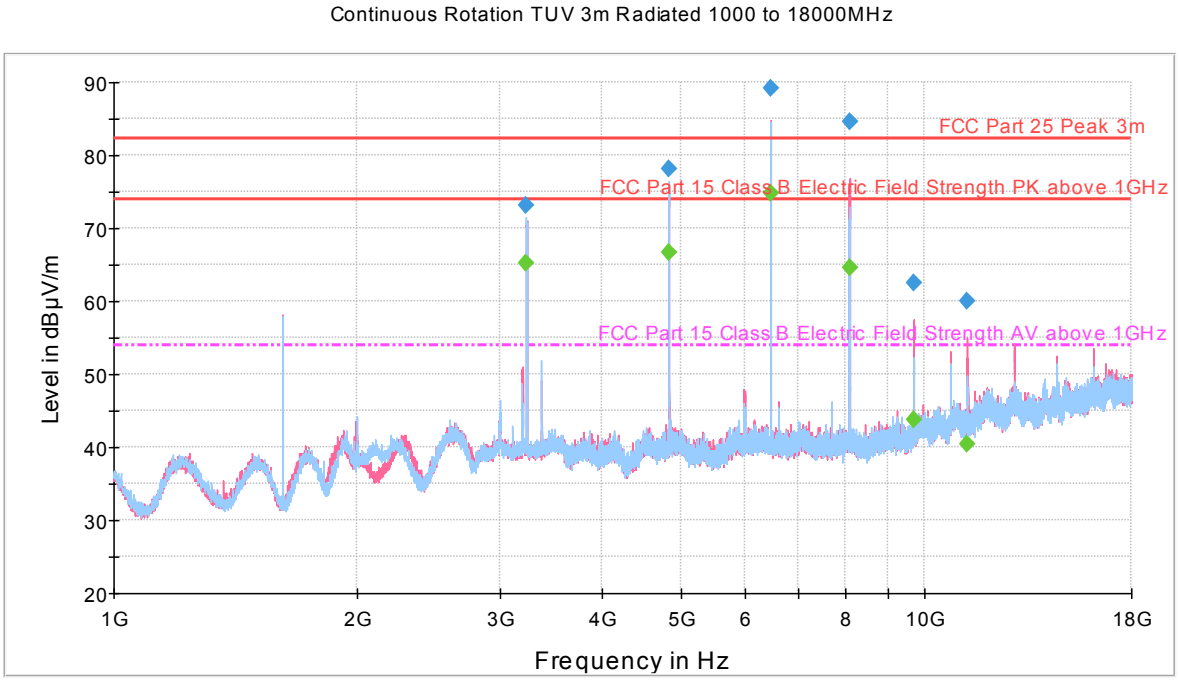


Peak Data

Frequency (MHz)	Max Peak (dBµV/m)	Meas. Time (ms)	Bandwidth (kHz)	Height (cm)	Polarization	Azimuth (deg)	Corr. (dB)	Margin (dB)	Limit (dBµV/m)
3230.20000	72.3	1000.0	1000.000	354.1	V	139.0	1.1	10.0	82.2
3373.60000	52.1	1000.0	1000.000	249.4	H	151.0	0.9	30.1	82.2
4847.86666	78.8	1000.0	1000.000	263.3	V	154.0	3.7	3.4	82.2
6463.66666	91.3	1000.0	1000.000	278.3	V	161.0	6.2	-9.0	82.2
8076.76666	81.8	1000.0	1000.000	250.3	V	150.0	6.8	0.4	82.2
9693.76666	61.6	1000.0	1000.000	135.7	V	36.0	8.8	20.7	82.2
12925.5333	61.4	1000.0	1000.000	377.1	V	178.0	13.6	20.9	82.2
16153.6333	59.6	1000.0	1000.000	300.6	V	209.0	16.7	22.7	82.2

Test Notes: See separate sample evaluation of 6464.7MHz using the required 4KHz RBW from the previous Section of this test report (2.4.12).

2.4.14 Above 1GHz to 18GHz Radiated Emission Test (Transmit Mode, High Channel)

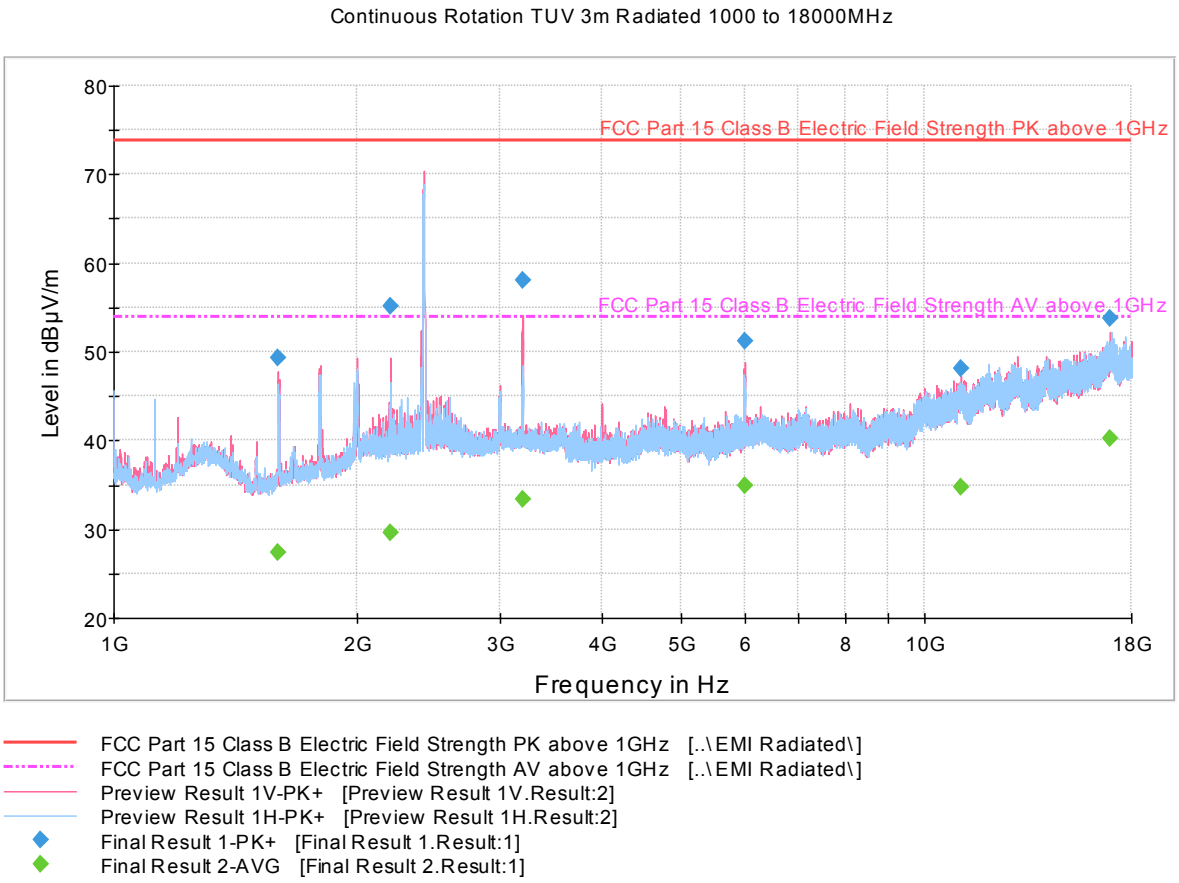


Peak Data

Frequency (MHz)	Max Peak (dBµV/m)	Meas. Time (ms)	Bandwidth (kHz)	Height (cm)	Polarization	Azimuth (deg)	Corr. (dB)	Margin (dB)	Limit (dBµV/m)
3230.60000	73.0	1000.0	1000.000	149.6	H	163.0	1.1	0.9	73.9
4847.86666	78.1	1000.0	1000.000	130.7	H	148.0	3.7	-4.2	73.9
6464.20000	89.2	1000.0	1000.000	186.5	V	130.0	6.2	-15.3	73.9
8076.73333	84.5	1000.0	1000.000	179.5	V	116.0	6.8	-10.6	73.9
9691.90000	62.6	1000.0	1000.000	401.1	V	133.0	8.8	11.3	73.9
11307.3000	60.1	1000.0	1000.000	154.6	V	131.0	12.2	13.8	73.9

Test Notes: See separate sample evaluation of 6464.7MHz using the required 4KHz RBW from Section 2.4.12 of this test report.
4.8GHz harmonics from all above 1GHz plots presented were verified harmonics of the Satellite radio and not the second harmonic of WLAN (2412 MHz). Please see verification scan on the following page showing only the WLAN radio active (Satellite radio not transmitting).

2.4.15 Above 1GHz to 18GHz Radiated Emission Test (WLAN Transmit Mode)



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)
1594.56666	49.4	1000.0	1000.000	365.1	V	207.0	-5.8	24.5	73.9
2195.70000	55.2	1000.0	1000.000	235.4	V	76.0	-1.7	18.7	73.9
3193.76666	58.1	1000.0	1000.000	376.1	V	270.0	1.0	15.8	73.9
5998.56666	51.3	1000.0	1000.000	134.7	V	261.0	5.7	22.6	73.9
11109.7333	48.0	1000.0	1000.000	201.3	V	215.0	12.2	25.9	73.9
16961.5000	53.8	1000.0	1000.000	300.6	V	252.0	17.9	20.1	73.9

Test Notes: No emissions observed that doesn't comply with the requirement of FCC Part 15.205 and Part 15.247 when 802.11 radio transmitter is active by itself.

2.5 Frequency Stability

2.5.1 Specification Reference

Part 2, Section 2.1055
FCC CFR Part 25, Section25.202(d)

2.5.2 Standard Applicable

FCC CFR Part 25, Section25.202:
(d) Frequency tolerance, Earth stations. The carrier frequency of each earth station transmitter authorized in these services shall be maintained within 0.001 percent of the reference frequency.

RSS-170 issue 3, Section 5.2:
For mobile earth station equipment, the carrier frequency shall not depart from the reference frequency by more than ±10 ppm.

2.5.3 Equipment Under Test and Modification State

Serial No: N/A / Test Configuration A

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

September 28, 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 performed at TÜV SÜD America Inc. Rancho Bernardo facility

Ambient Temperature	26.2 °C
Relative Humidity	47.1 %
ATM Pressure	98.8 kPa

2.5.7 Additional Observations

- This is a conducted test.
- For the channel investigated, the reference is the frequency at 20°C/nominal voltage (12VDC).
- At each observed point, the EUT transmission frequency is compared to the reference.
- The frequency stability under temperature variation was performed from -30°C to 50°C. The frequency stability under voltage variation was performed on EUT at the extreme input voltage from 10.2VDC to 13.8VDC.
- OBW function of the Spectrum Analyzer was used to determine T1 and T2 (OBW frequency edges).

2.5.8 Test Results

Complies. See attached table and test plots.

2.5.9 Frequency Stability (Temperature and Voltage Variations) Results

	T1 (GHz)	T2 (GHz)	Center Frequency (GHz)	Frequency Deviation (%)	ppm
50°C	1.609947245	1.611455861	1.610701553	0.0004	4.13
40°C	1.609953696	1.611453364	1.61070353	0.0003	2.90
30°C	1.609933274	1.611480163	1.610706719	0.0001	0.92
20°C (10.2VDC)	1.609975307	1.611446327	1.610710817	-0.0001	-1.07
20°C (12VDC)	1.609947746	1.611468651	1.610708199	0.0000	0.00
20°C (13.8 VDC)	1.609940327	1.611477859	1.610709093	-0.0001	-0.56
10°C	1.609956821	1.611468931	1.610712876	-0.0003	-2.90
0°C	1.609962418	1.611459705	1.610711062	-0.0002	-1.78
-10°C	1.609962418	1.611459705	1.610711062	-0.0002	-1.78
-20°C	1.609956821	1.611468931	1.610712876	-0.0003	-2.90
-30°C	1.609981748	1.611471539	1.610721644	-0.0008	-8.35

2.5.10 Sample Calculations

Sample calculation to determine center frequency using OBW edges (T1 and T2):

Center frequency at 20°C: $= \frac{T1+T2}{2}$

$= \frac{1.609947746\ \text{GHz}+1.611468651\ \text{GHz}}{2}$

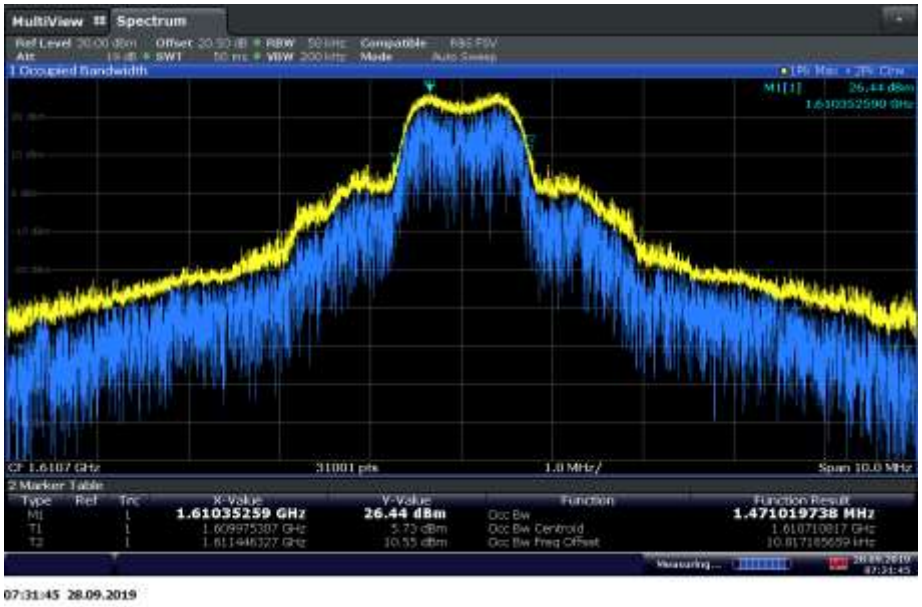
$= 1.610708199\ \text{GHz}$

Frequency Deviation at 40°C: = ((20°C Reference – Center Frequency)/ 20°C Reference) x 100
= ((1.610708199 GHz - 1.61070353 GHz)/1.610708199 GHz) x 100
= (0.000004669 GHz/1.610708199 GHz) x 100
= 0.0003 %

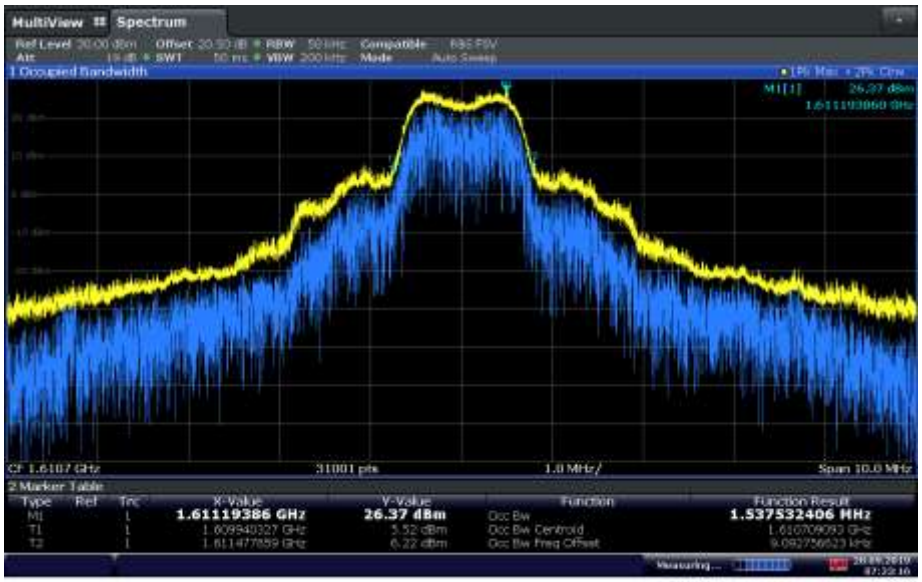
Since 1% = 10000ppm, therefore multiplying the above result in % with 10000 will results in ppm value.

2.5.11 Sample Test Plots

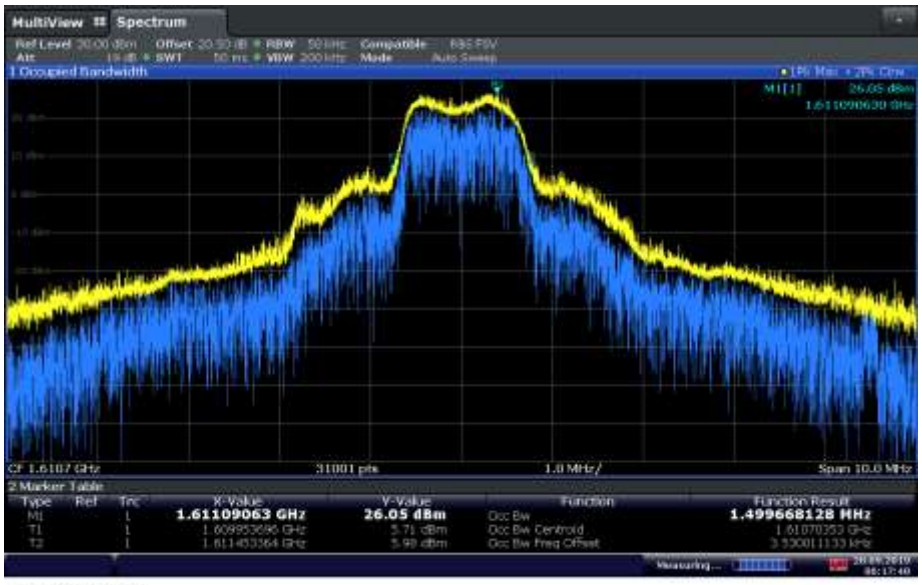
20°C, 12 VDC



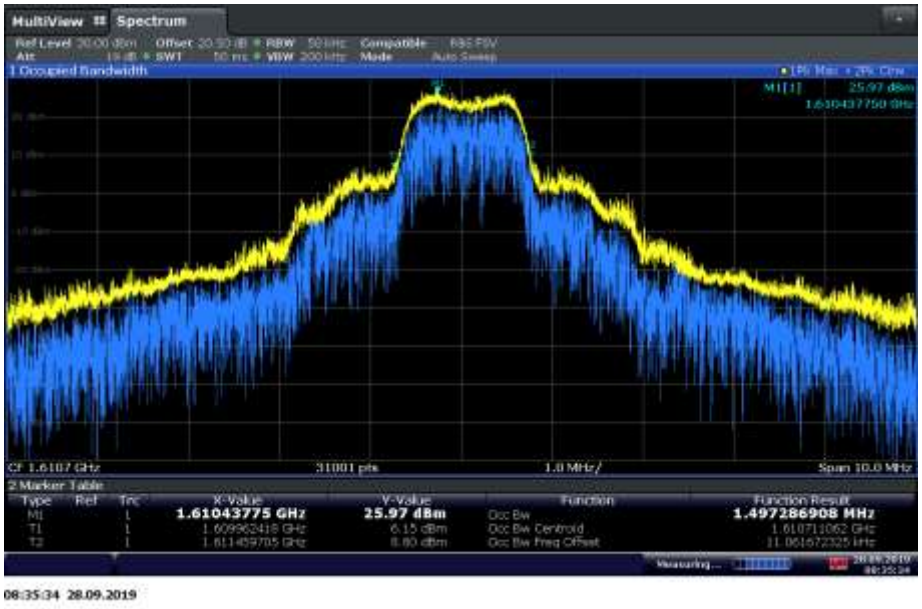
20°C, 10.2 VDC



20°C, 13.8 VDC



40°C, 12 VDC



0°C, 13.8 VDC

-20°C, 12 VDC

2.6 Protection of Aeronautical Radio Navigation Satellite Service

2.6.1 Specification Reference

FCC CFR Part 25, Section25.216(c)(f)(g)(i) and (j)
RSS-170 Issue 3, Section 5.4.3.2.1 and 5.4.4

2.6.2 Standard Applicable

Part 25 Subpart C §25.216:

(c) The e.i.r.p. density of emissions from mobile earth stations placed in service after July 21, 2002 with assigned uplink frequencies between 1610 MHz and 1660.5 MHz shall not exceed −70 dBW/MHz, averaged over any 2 millisecond active transmission interval, in the band 1559-1605 MHz. The e.i.r.p. of discrete emissions of less than 700 Hz bandwidth from such stations shall not exceed −80 dBW, averaged over any 2 millisecond active transmission interval, in the 1559-1605 MHz band.

(f) Mobile earth stations placed in service after July 21, 2002 with assigned uplink frequencies in the 1610–1660.5 MHz band shall suppress the power density of emissions in the 1605–1610 MHz band to an extent determined by linear interpolation from -70 dBW/MHz at 1605 MHz to -10 dBW/MHz at 1610 MHz.

(g) Mobile earth stations manufactured more than six months after Federal Register publication of the rule changes adopted in FCC 03-283 with assigned uplink frequencies in the 1610-1626.5 MHz band shall suppress the power density of emissions in the 1605-1610 MHz band-segment to an extent determined by linear interpolation from −70 dBW/MHz at 1605 MHz to −10 dBW/MHz at 1610 MHz averaged over any 2 millisecond active transmission interval. The e.i.r.p of discrete emissions of less than 700 Hz bandwidth from such stations shall not exceed a level determined by linear interpolation from −80 dBW at 1605 MHz to −20 dBW at 1610 MHz, averaged over any 2 millisecond active transmission interval.

(i) The e.i.r.p density of carrier-off state emissions from mobile earth stations manufactured more than six months after Federal Register publication of the rule changes adopted in FCC 03–283 with assigned uplink frequencies between 1 and 3 GHz shall not exceed -80 dBW/MHz in the 1559–1610 MHz band averaged over any two millisecond interval.

(j) A Root-Mean-Square detector shall be used for all power density measurements

RSS-170 Issue 3:
5.4.3.2.1. Band 1610-1660.5 MHz
Mobile earth stations with transmitting frequencies between 1610 MHz and 1626.5 MHz shall have the e.i.r.p. density of unwanted emissions in the band 1605-1610 MHz, averaged over any 2-ms active transmission interval, not exceed the following limits:
(1) -70 dBW/MHz at 1605 MHz, linearly interpolated to -10 dBW/MHz at 1610 MHz, for broadband emissions; and
(2) -80 dBW/kHz at 1605 MHz, linearly interpolated to -20 dBW/kHz at 1610 MHz, for discrete emissions.

5.4.4. Carrier-off State Emissions
Mobile equipment with transmitting frequencies between 1 GHz and 3 GHz shall have the e.i.r.p. density of carrier-off state emissions in the band 1559-1610 MHz not exceed -80 dBW/MHz.

2.6.3 Equipment Under Test and Modification State

Serial No: N/A / Test Configuration A

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

October 08, 2019 / FSC

2.6.5 Test Equipment Used

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

2.6.6 Environmental Conditions

Test performed at TÜV SÜD America Inc. Rancho Bernardo facility

Ambient Temperature	25.8 °C
Relative Humidity	41.0 %
ATM Pressure	98.5 kPa

2.6.7 Additional Observations

- This is a conducted test utilizing a spectrum analyser.
- The attenuation for the external attenuator, adapter and cable is measured and entered as a Transducer factor (TDF) including the declared antenna gain of 3.3 dBi (EIRP measurements).
- The spectrum was investigated from 1605 MHz to 1610 MHz and 1559 MHz to 1605 MHz for carrier-on state and from 1559 MHz to 1610 MHz for carrier-off state.
- For Low Channel broadband verification (§25.216(c)), RBW was adjusted from 1MHz to 100kHz and the limits adjusted accordingly (10 log (100kHz/1MHz)) to separate broadband noise for better resolution and to determine if any discrete emissions are present.
- There are no other discrete emissions observed (including those with less than 700 Hz bandwidth) to justify additional GNSS 10dB protection verifications against such emissions.

2.6.8 Test Results

Low Channel (§25.216(c))

Mid Channel (§25.216(c))

High Channel (§25.216(c))

Low Channel (§25.216(c)) verification to determine presence of any discrete emissions <700Hz BW

Low Channel (100 kHz RBW (§25.216(f) and (g))

Middle Channel (§25.216(f) and (g))

Date: 8.OCT.2019 14:27:17

High Channel (§25.216(f) and (g))

Date: 8.OCT.2019 14:55:11

Carrier-off state (§25.216(i))

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 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	
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
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	
8816	2.4GHz Notch Filter	BRM 50702	N/A	Micro-Tronics	Verified by 7643 and 7654	
8809	2.0GHz High Pass Filter	HPM50110	072	Micro-Tronics	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
Miscellaneous						
6708	Multimeter	34401A	US36086974	Hewlett Packard	07/18/18	01/07/20
7579	Temperature Chamber	115	151617	TestQuity	09/09/19	09/09/20
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

Antenna Port Conducted Measurements							
	Input Quantity (Contribution) Xi	Value		Prob. Dist.	Divisor	ui(x)	ui(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**

3.2.1 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-polarisation	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**

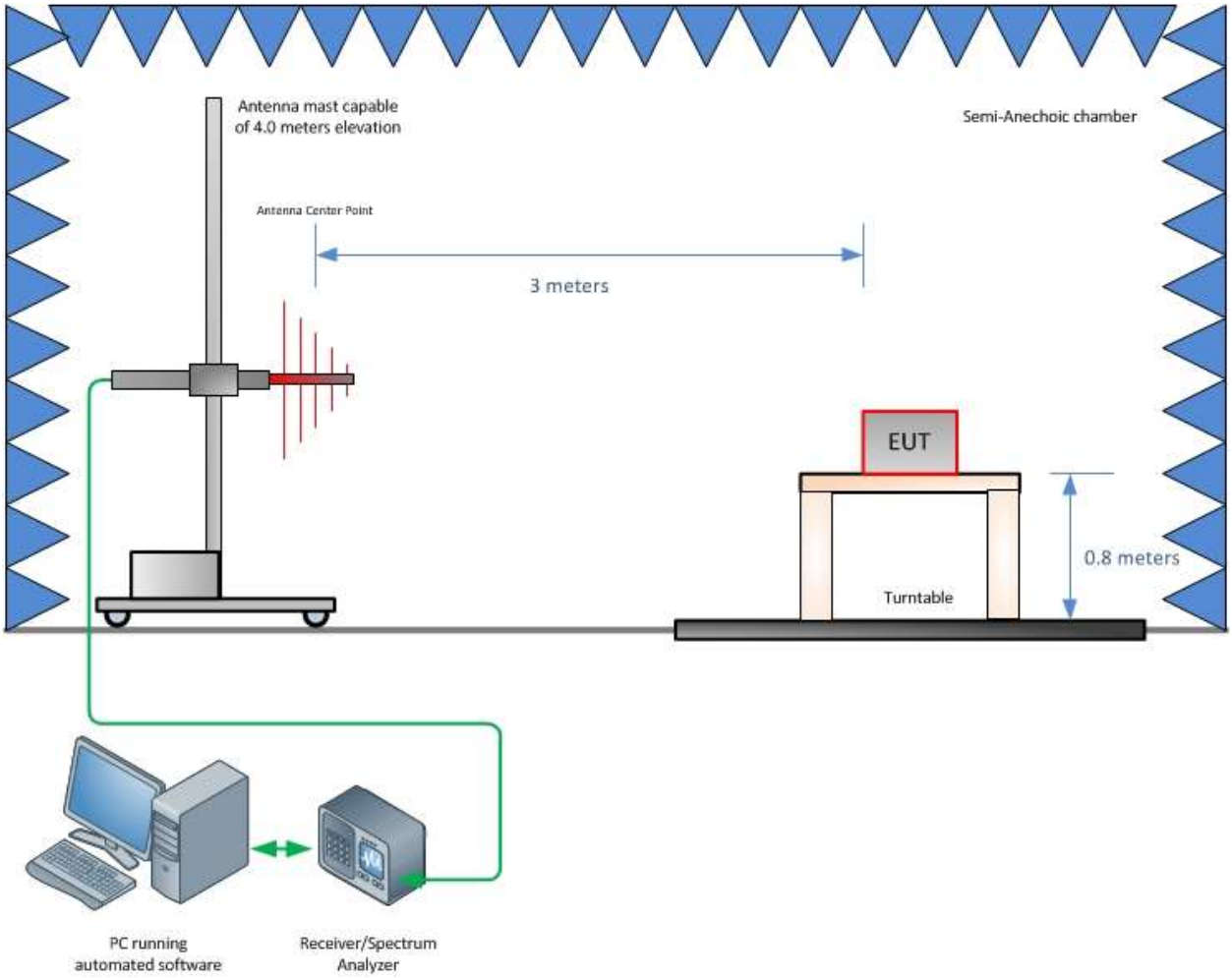
3.2.2 Radiated Emission Measurements (Above 1GHz)

	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-polarisation	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**	

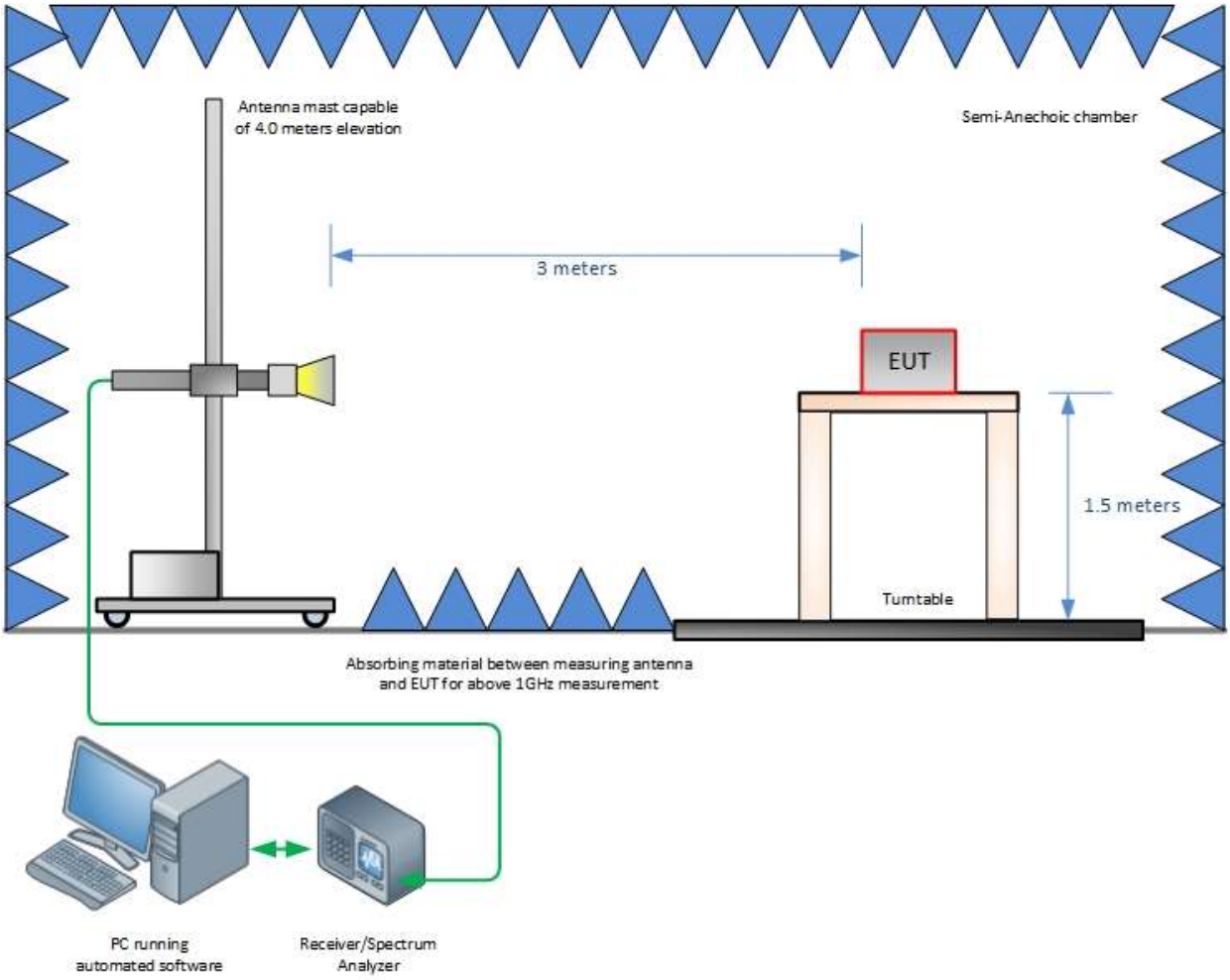
SECTION 4

4 Diagram of Test Setup

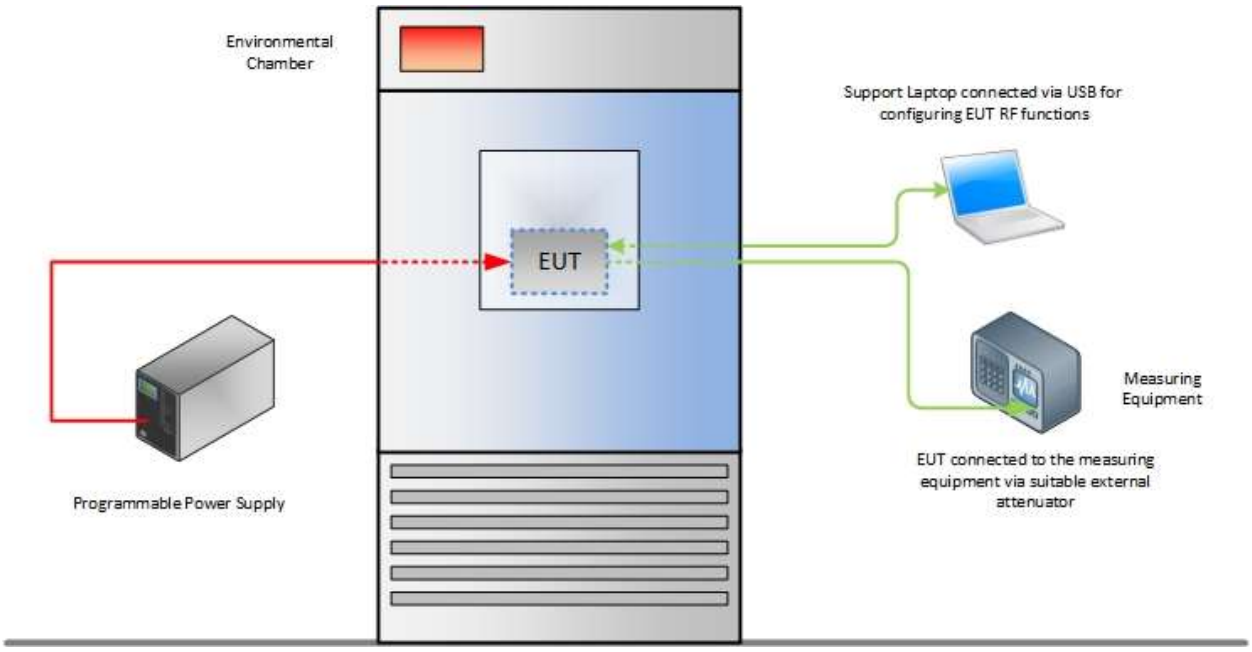
4.1 Test Setup Diagram



Radiated Emission Test Setup (Below 1GHz)



Radiated Emission Test Setup (Above 1GHz)



Frequency Stability Test Configuration

SECTION 5

5 ACCREDITATION, DISCLAIMERS AND COPYRIGHT

5.1 Accreditation, Disclaimers and Copyright

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