



America

**Choose certainty.
Add value.**

Report On

Application for Grant of Equipment Authorization of the
ViaSat, Inc.
L-Band Satellite Aviation Terminal AT2220

FCC Part 15 Subpart C §15.247 (FHSS)
IC RSS-247 Issue 1 May 2015
IC RSS-Gen Issue 4 November 2014

Report No. SD72111016-1015B

January 2016

REPORT ON Radio Testing of the
ViaSat, Inc.
L-Band Satellite Aviation Terminal AT2220

TEST REPORT NUMBER SD72111016-1015B

PREPARED FOR ViaSat, Inc.
6155 El Camino Real
Carlsbad, CA 92009
USA

CONTACT PERSON Waiman Wong
Compliance Engineer
(760) 893-3704
Waiman.Wong@viasat.com

PREPARED BY



Alex Chang
Name
Authorized Signatory
Title: EMC/Wireless Test Engineer

APPROVED BY



Juan Manuel Gonzalez
Name
Authorized Signatory
Title: Commercial/Wireless EMC Lab Manager

DATED

January 13, 2016



Revision History

SD72111016-1015B ViaSat, Inc. L-Band Satellite Aviation Terminal AT2220					
DATE	OLD REVISION	NEW REVISION	REASON	PAGES AFFECTED	APPROVED BY
01/13/2016	Initial Release				Juan M. Gonzalez

CONTENTS

Section	Page No
1	REPORT SUMMARY 5
1.1	Introduction 6
1.2	Brief Summary Of Results 7
1.3	Product Information 8
1.4	EUT Test Configuration 10
1.5	Deviations From The Standard 12
1.6	Modification Record 12
1.7	Test Methodology 12
1.8	Test Facility Location 12
1.9	Test Facility Registration 12
2	TEST DETAILS 14
2.1	Carrier Frequency Separation 15
2.2	Number Of Hopping Frequencies 18
2.3	Time Of Occupancy (Dwell Time) 20
2.4	20 dB Bandwidth 25
2.5	99% Emission Bandwidth 31
2.6	Peak Output Power 38
2.7	Band-Edge Compliance Of RF Conducted Emissions 41
2.8	Spurious RF Conducted Emissions 48
2.9	Spurious Radiated Emissions 54
2.10	Radiated Immediate Restricted Bands 66
2.11	Receiver Spurious Emissions 72
3	TEST EQUIPMENT USED 73
3.1	Test Equipment Used 74
3.2	Measurement Uncertainty 75
4	DIAGRAM OF TEST SETUP 76
4.1	Test Setup Diagram 77
5	ACCREDITATION, DISCLAIMERS AND COPYRIGHT 79
5.1	Accreditation, Disclaimers And Copyright 80

SECTION 1

REPORT SUMMARY

Radio Testing of the
ViaSat, Inc.
L-Band Satellite Aviation Terminal AT2220

1.1 INTRODUCTION

The information contained in this report is intended to show verification of the ViaSat, Inc. L-Band Satellite Aviation Terminal, model AT2220 to the requirements of FCC Part 15 Subpart C §15.247 and IC RSS-247 Issue 1 May 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	ViaSat, Inc.
Model Number(s)	AT2220
FCC ID Number	2ABLPAT2220
IC Number	20546-AT2220
Serial Number(s)	C20015440005
Number of Samples Tested	1
Test Specification/Issue/Date	• FCC Part 15 Subpart C §15.247 (October 1, 2014). • RSS-247 - Licence-exempt Radio Apparatus (All Frequency Bands): Category I Equipment (Issue 1, May 2015). • RSS-Gen - General Requirements for Compliance of Radio Apparatus (Issue 4, November 2014). • Public Notice (DA 00-705 Released March 30, 2000) Filing and Measurement Guidelines for Frequency Hopping Spread Spectrum Systems.
Start of Test	December 15, 2015
Finish of Test	December 16, 2015
Name of Engineer(s)	Alex Chang
Related Document(s)	• None. Supporting documents for EUT certification are separate exhibits. • Conducted port measurement leveraged from previously evaluated under TÜV SÜD test report ref No. SD72107151C-0615 BT test report.

1.2 BRIEF SUMMARY OF RESULTS

A brief summary of the tests carried out in accordance with FCC Part 15 Subpart C §15.247 with cross-reference to the corresponding IC RSS standard is shown below.

Section	§15.247 Spec Clause	RSS	Test Description	Result	Comments/ Base Standard
—	§15.207 (a)	RSS-Gen 8.8	Conducted Emissions	N/A	
2.2	§15.247(a)(1)	RSS-247 Sec. 5.1(2)	Carrier Frequency Separation	N/P	See notes
2.3	§15.247(a)(1)(iii)	RSS-247 Sec. 5.1(4)	Number of Hopping Frequencies	N/P	See notes
2.4	§15.247(a)(1)(iii)	RSS-247 Sec. 5.1(4)	Time of Occupancy (Dwell Time)	N/P	See notes
2.5	§15.215(c)	RSS-247 Sec. 5.1(1)	20 dB Bandwidth	N/P	See notes
2.6		RSS-Gen 6.6	99% Emission Bandwidth	N/P	See notes
2.7	§15.247(b)(1)	RSS-247 Sec. 5.4(2)	Peak Output Power	N/P	See notes
2.8	§15.247(d)	RSS-247 Sec. 5.5	Band-edge Compliance of RF Conducted Emissions	N/P	See notes
2.9	§15.247(d)	RSS-247 Sec. 5.5	Spurious RF Conducted Emissions	N/P	See notes
2.10	§15.247(d)	RSS-247 Sec. 5.5	Spurious Radiated Emissions	Compliant	
2.11	§15.247(d)	RSS-247 Sec. 5.5	Radiated Immediate Restricted Bands	Compliant	
2.12		RSS-Gen 7.1	Receiver Spurious Emissions	Compliant	

N/A EUT is a DC voltage operated device.

N/P BT conducted port test results were leveraged from original BT module which was previously evaluated under TÜV SÜD test report ref. No. SD72107151C-0615. No further evaluation considered necessary.

1.3 PRODUCT INFORMATION

1.3.1 Technical Description

The Equipment Under Test (EUT) is a ViaSat, Inc. Aviation Terminal 2220 (L-Band Satellite Aviation Terminal) model no. AT2220. The ViaSat AT2220 Terminal enables reliable and instant IP-based communications via satellite for rotor and fixed-wing aircraft. Powered by ViaSat L-band Managed Service (VMS), this satcom terminal's two-way networking capability enables both real-time monitoring of position location information using built in GPS receiver, and data and voice communications. AES-256 encrypted data link layer encryption is employed to ensure the integrity of user data is protected. The terminal features easy-to-use interfaces and provides flexibility to configure to nearly any sensor system or IP data application. Examples of operational scenarios that the AT2220 Terminal supports range from fleet management, emergency first responders, homeland security forces, disaster aid workers, corresponders, mobile workforce management and tracking of high-valued assets. This is all within an integrated single assembly package that is optimized for airborne data transmission. A single cable provides DC power and Ethernet for wired connections to an IP device, eliminating the need of RF cable typically required for connection between modem and antenna. The transceiver also supports Wi-Fi and Bluetooth for wireless connections to multiple tablets or smartphones. The AT2220 Terminal is powered by ViaSat advanced waveform that allows for a low latency and highest capacity of users to operate on a single L-band channel. The AT2220 incorporates Wi-Fi and Bluetooth functions. A shielded power/Ethernet CAT5e combine cable was provided and used by customer for final evaluation. The classic and EDR BT functions of the EUT were verified in this test report.

1.3.2 EUT General Description

EUT Description	L-Band Satellite Aviation Terminal
Model Name	Aviation Terminal 2220
Model Number(s)	AT2220
Rated Voltage	10-32 VDC
Mode Verified	Bluetooth EDR (FHSS)
Capability	802.11 b/g WLAN and Bluetooth 3.0 + HS (w/out BLE)
Primary Unit (EUT)	☐ Production ☒ Pre-Production ☐ Engineering
Antenna Type	Integral PCB trace type (multilayer chip antenna)
Antenna Gain	-6.23 dBi (2.412 GHz) -6.01 dBi (2.437 GHz) -4.79 dBi (2.472 GHz)

1.3.3 Maximum Conducted Output Power

Modulation	Frequency Range (MHz)	Average Output Power (dBm)	Peak Output Power (dBm)	Peak Output Power (mW)
GFSK	2402-2480	7.25	7.99	6.30
$\pi/4$ -DQPSK	2402-2480	5.06	7.83	6.07
8DPSK	2402-2480	5.06	8.20	6.61

1.4 EUT TEST CONFIGURATION

1.4.1 Test Configuration Description

Test Configuration	Description
A	Antenna conducted port test configuration. A conducted test sample was provided for this setup. The integral antenna was removed and an on-board surface mount coaxial connector was made accessible. EUT configuration was set to BT test mode via Ethernet connection using SSH/Telnet client application. Manufacturer provided the instructions for EUT configuration.
B	Radiated emissions test configuration. Identical programming procedure as Test Configuration A. EUT transmitting through the integral antenna.

1.4.2 EUT Exercise Software

EUT is configured via TCP/IP (Ethernet). EUT IP address is set to 192.168.100.1. This address is used to connect to the EUT via SSH/Telnet client application (PuTTY). Once connected, corresponding programming commands were issued in order to set the EUT in Bluetooth test mode. Afterwards the EUT has been connected to CMW500 wireless communications tester, which was used to control the EUT modulation, data rate and operational channel.

1.4.3 Support Equipment and I/O cables

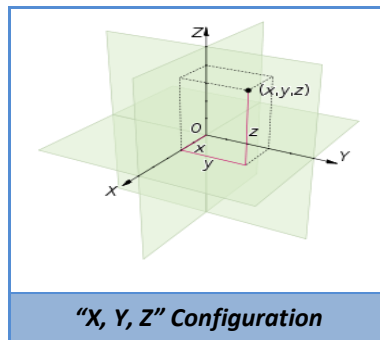
Manufacturer	Equipment/Cable	Description
Sony	Support Laptop	Model PCG-31311L
Sony	Support AC-DC Power Adapter	Model: ACDP-120E03
—	Ethernet EUT to Laptop	2.1 meters, shielded CAT5 cable w/ RJ-45 connectors

1.4.4 Worst Case Configuration

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

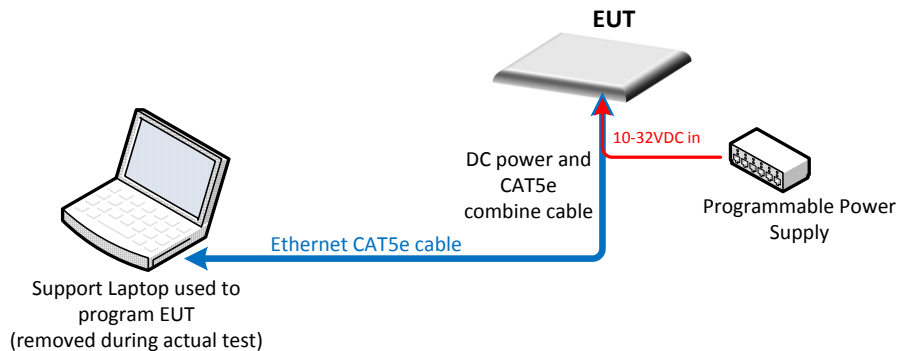
Modulation	Channel/Packet Type	Mode
GFSK	38 (Mid Channel)	Non-hopping
GFSK	-	Hopping

For radiated measurements X, Y and Z orientations were verified. No major variation in emissions observed between the three (3) orientations. Verifications performed using "Y" configuration.



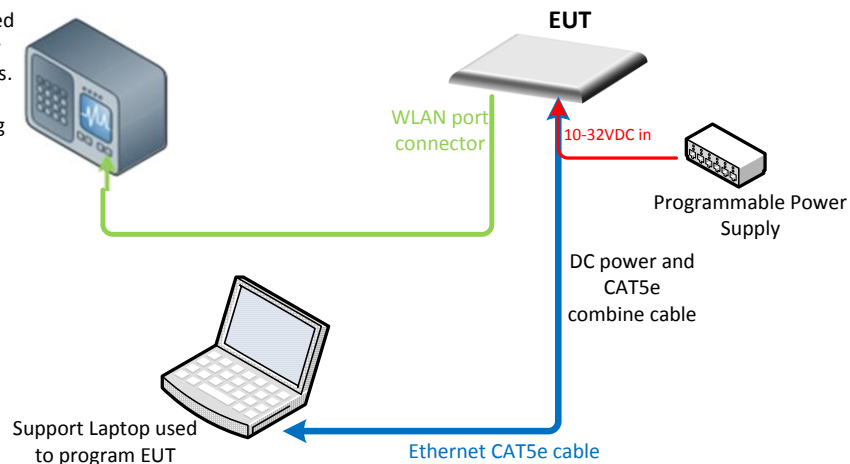
1.4.5 Simplified Test Configuration Diagram

Radiated Emission Test Setup



Conducted Port Measurement Test Setup

Antenna test port provided by the manufacturer for conducted measurements. The output is connected directly to the measuring equipment, external attenuators are used.



Not To Scale – Illustration Purpose Only
 Objects may not represent actual image of original equipment/s or set-up.

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: C20015440005		
N/A	—	—

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 C63.4-2009, American National Standard for Methods of Measurement of Radio-Noise Emissions from Low-Voltage Electrical and Electronic Equipment in the range of 9 kHz to 40 GHz.

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 C63.4-2009. 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)

Sony Electronics Inc., Building #8 16530 Via Esprillo, San Diego, CA 92127-1708 (33.018644,-117.092409). Phone: 858 942 5542 FAX: 858-546 0364

1.9 TEST FACILITY REGISTRATION

1.9.1 FCC – Registration No.: US1146

TUV SUD 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 Registration is US1146.



1.9.2 Industry Canada (IC) Registration No.: 3067A

The 10m Semi-anechoic chamber of TÜV SÜD America Inc. (San Diego) has been registered by Certification and Engineering Bureau of Industry Canada for radio equipment testing with Registration No. 3067A.

SECTION 2

TEST DETAILS

Radio Testing of the
ViaSat, Inc.
L-Band Satellite Aviation Terminal AT2220

2.1 CARRIER FREQUENCY SEPARATION

2.1.1 Specification Reference

Part 15 Subpart C §15.247(a)(1)

2.1.2 Standard Applicable

(1) Frequency hopping systems shall have hopping channel carrier frequencies separated by a minimum of 25 kHz or the 20 dB bandwidth of the hopping channel, whichever is greater. Alternatively, frequency hopping systems operating in the 2400–2483.5 MHz band may have hopping channel carrier frequencies that are separated by 25 kHz or two-thirds of the 20 dB bandwidth of the hopping channel, whichever is greater, provided the systems operate with an output power no greater than 125 mW. The system shall hop to channel frequencies that are selected at the system hopping rate from a pseudo randomly ordered list of hopping frequencies. Each frequency must be used equally on the average by each transmitter. The system receivers shall have input bandwidths that match the hopping channel bandwidths of their corresponding transmitters and shall shift frequencies in synchronization with the transmitted signals.

2.1.3 Equipment Under Test and Modification State

Serial No: C20015440005 /Test Configuration B

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

August 03, 2015 / NS

2.1.5 Test Equipment Used

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

2.1.6 Environmental Conditions

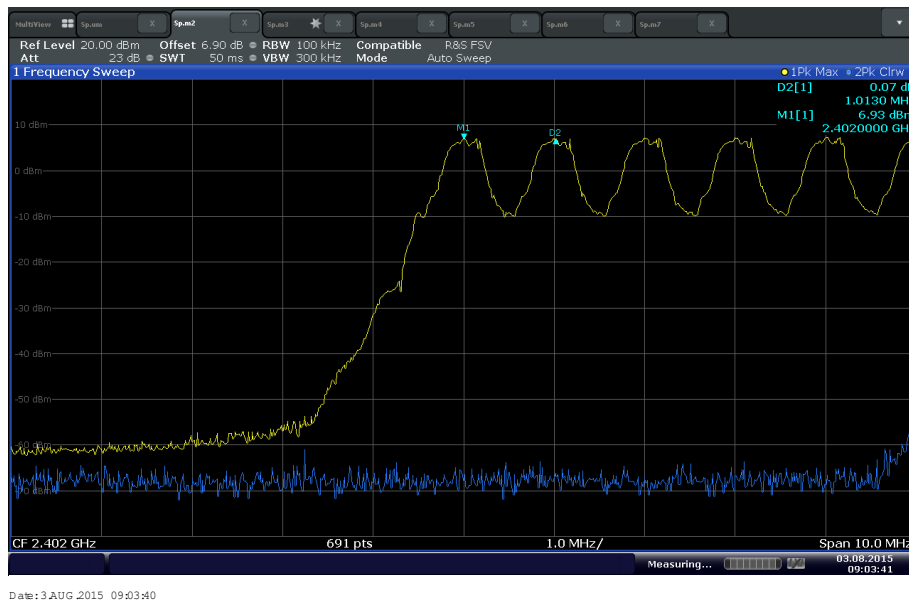
Test performed at TÜV SÜD America Inc. Rancho Bernardo facility.

Ambient Temperature	24.8 °C
Relative Humidity	57.1 %
ATM Pressure	99.1 kPa

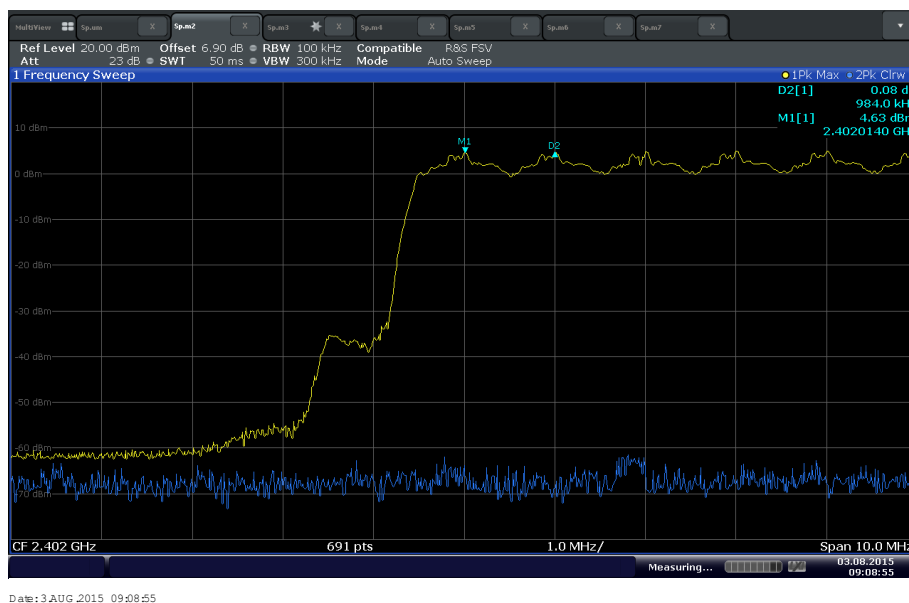
2.1.7 Additional Observations

- Hopping function enabled.
- Span is wide enough to capture the peaks of two adjacent channels.
- RBW is 1% of the span.
- VBW is 3x RBW
- Sweep is auto
- Detector is peak.
- Trace is max hold.
- An offset of 6.9 dB was added to compensate the power splitter and coaxial cable attenuation.
- Marker-delta function is used between the peaks of the adjacent channels.
- Limit used is >946.67 kHz (2/3 of worst case 20dB BW).

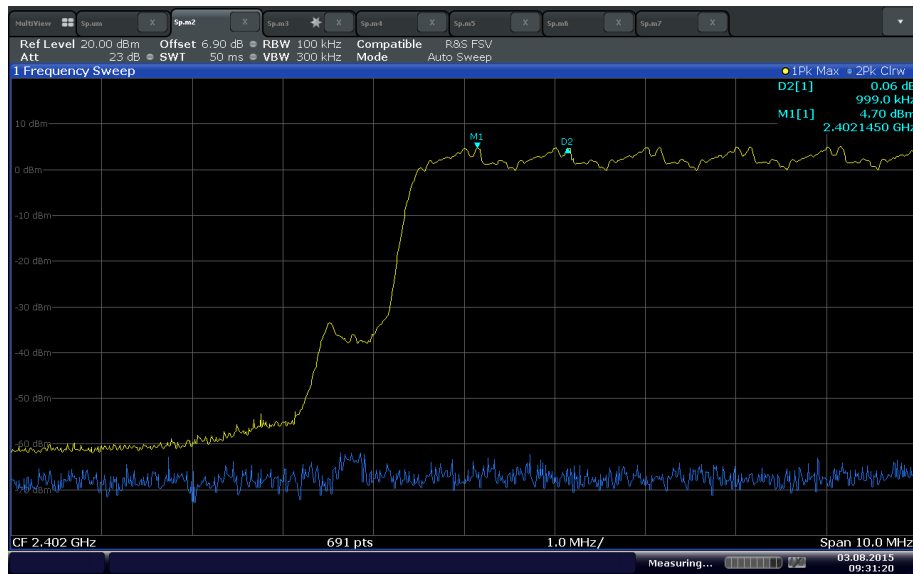
2.1.8 Test Results



GFSK, observed carrier frequency separation between Ch0 and Ch1 is 1.013 MHz (**Complies**. Greater than 946.67 kHz, this is 2/3 of 1.42MHz 20 dB BW)



$\pi/4$ -DQPSK, observed carrier frequency separation between Ch0 and Ch1 is 0.984 MHz (**Complies**. Greater than 946.67 kHz, this is 2/3 of 1.42MHz 20 dB BW)



Date: 3 AUG 2015 09:31:20

8DPSK, observed carrier frequency separation between Ch0 and Ch1 is 0.999 MHz (**Complies**. Greater than 946.67 kHz, this is 2/3 of 1.42MHz 20 dB BW)

2.2 NUMBER OF HOPPING FREQUENCIES

2.2.1 Specification Reference

Part 15 Subpart C §15.247(a)(1)(iii)

2.2.2 Standard Applicable

(iii) Frequency hopping systems in the 2400–2483.5 MHz band shall use at least 15 channels. The average time of occupancy on any channel shall not be greater than 0.4 seconds within a period of 0.4 seconds multiplied by the number of hopping channels employed. Frequency hopping systems may avoid or suppress transmissions on a particular hopping frequency provided that a minimum of 15 channels are used.

2.2.3 Equipment Under Test and Modification State

Serial No: C20015440005 /Test Configuration B

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

August 03, 2015 / NS

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.

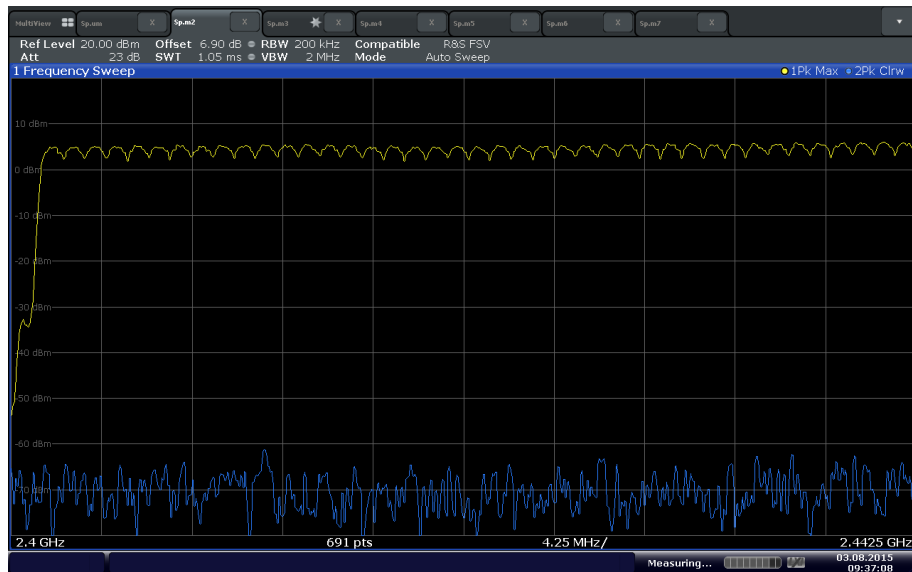
Ambient Temperature	24.8 °C
Relative Humidity	64.1 %
ATM Pressure	99.1 kPa

2.2.7 Additional Observations

- Hopping function enabled.
- Span is wide enough to capture the channels of interests.
- The span was broken up to two sections in order to clearly show all of the hopping frequencies.
- Sweep is auto
- Detector is peak, trace is max hold.
- An offset of 6.9dB was added to compensate for the external attenuator and cable used.

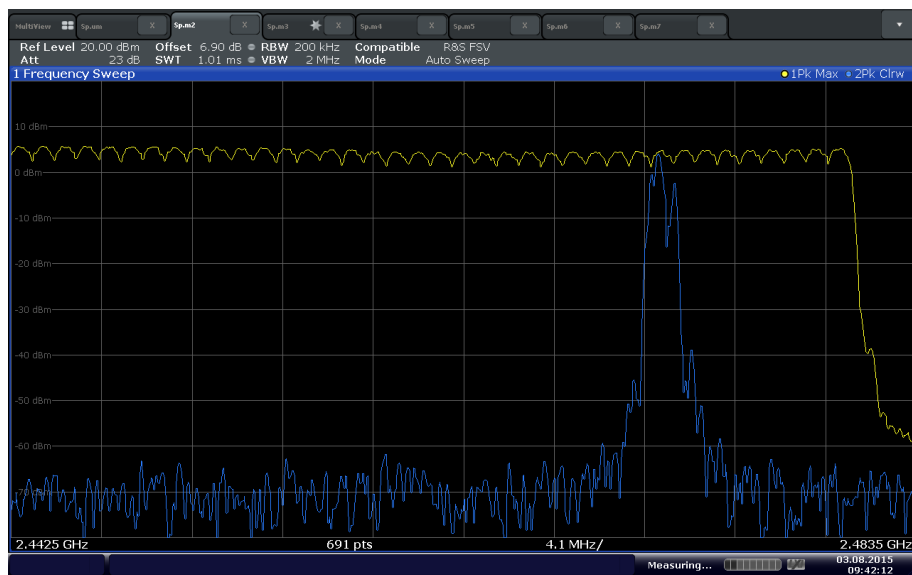
2.2.8 Test Results

Observed Number of Hopping Frequencies is	= 79 (Complies)
	= Plot #1 + Plot #2
	= 41 + 38



Date: 3 AUG 2015 09:37:08

Plot #1



Date: 3 AUG 2015 09:42:12

Plot #2



2.3 TIME OF OCCUPANCY (DWELL TIME)

2.3.1 Specification Reference

Part 15 Subpart C §15.247(a)(1)(iii)

2.3.2 Standard Applicable

(iii) Frequency hopping systems in the 2400–2483.5 MHz band shall use at least 15 channels. The average time of occupancy on any channel shall not be greater than 0.4 seconds within a period of 0.4 seconds multiplied by the number of hopping channels employed. Frequency hopping systems may avoid or suppress transmissions on a particular hopping frequency provided that a minimum of 15 channels are used.

2.3.3 Equipment Under Test and Modification State

Serial No: C20015440005 /Test Configuration B

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

August 03, 2015 / NS

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	24.8 °C
Relative Humidity	64.1 %
ATM Pressure	99.1 kPa

2.3.7 Additional Observations

- Hopping function enabled.
- Span = zero span, centered on a hopping channel.
- RBW is 1MHz.
- VBW is 3x RBW
- Detector is peak.
- A single pulse is first measured. This measurement is then used to compute the average time of occupancy in the required period (no. of channels x 0.4 second).
- The EUT was configured using the instructions provided by the manufacturer. Modulation type was PRBS9, logical channel were between ACL EDR and ACL Basic, packet type used were DH1, 2DH3 and 3DH1. Packet length was set to default value of 1000.

2.3.8 Test Results

Modulation	Measured time of occupancy	Requirement
GFSK	122.44 ms	<400 ms
$\pi/4$ -DQPSK	262.49 ms	<400 ms
8DPSK	123.36 ms	<400 ms

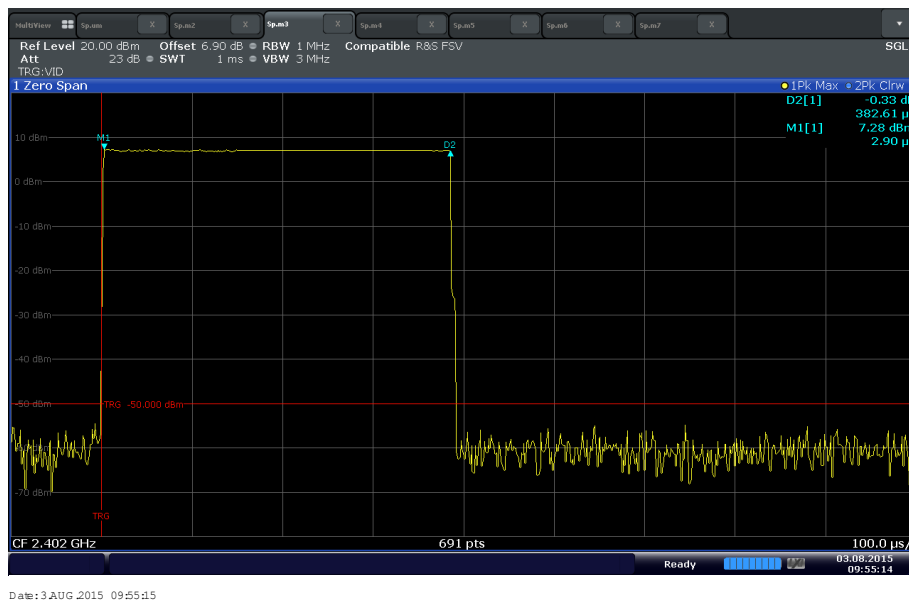
2.3.9 Sample Computation (8DPSK)

Width of single pulse = 0.0003855 second
 Observed occurrence = 32 pulses/3.16 seconds
 Required period = 79 channels x 0.4 second
 = 31.6 seconds

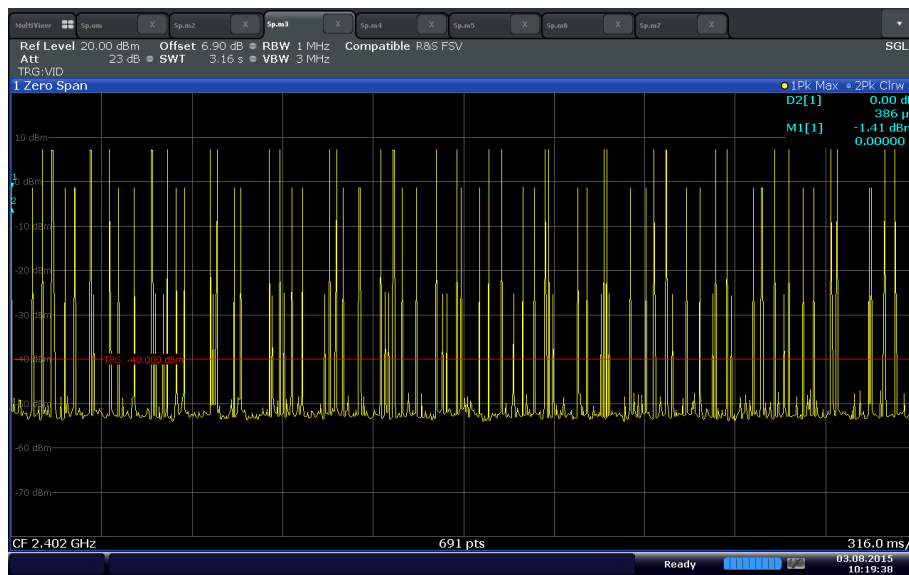
Average time of occupancy = Pulse width x #pulses in 3.16 seconds x 10
 = 0.0003855 second x 32x 10
 = 0.12336 second

Compliance = Complies. 0.12336 second < 0.4 second

2.3.10 Test Results Plots

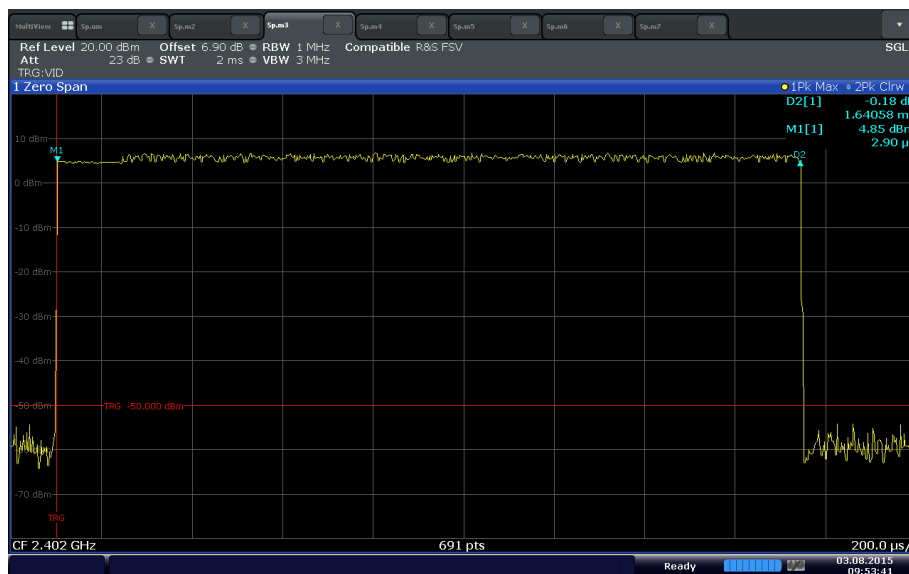


GFSK width of single pulse (0.38261ms)



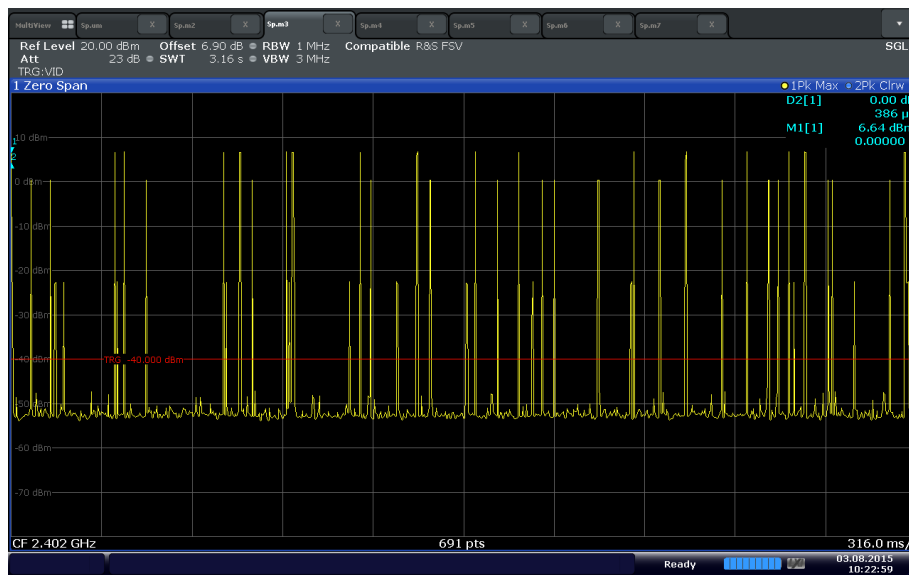
Date: 3 AUG 2015 10:19:38

32 pulses/3.16 seconds (DH1)



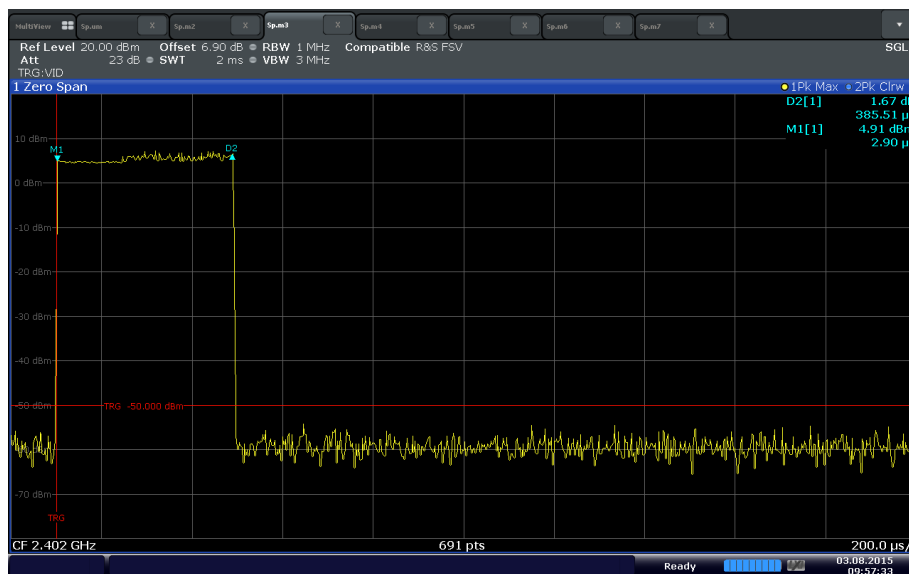
Date: 3 AUG 2015 09:53:41

$\pi/4$ -DQPSK width of single pulse (1.64058 ms)



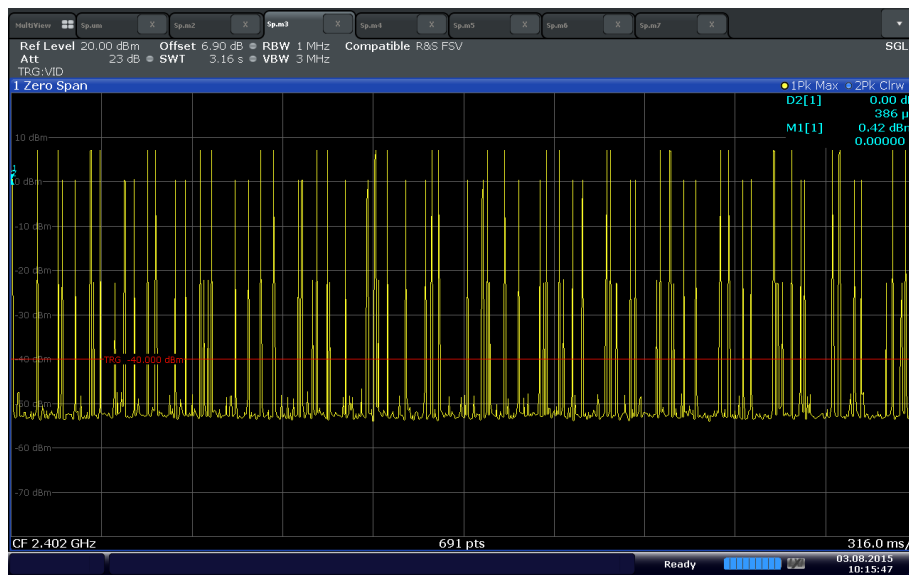
Date: 3 AUG 2015 10:22:59

16 pulses/3.16 seconds ($\pi/4$ -DQPSK, 2 DH3)



Date: 3 AUG 2015 09:57:34

8DPSK width of single pulse (0.38551 ms)



Date: 3 AUG 2015 10:15:48

32 pulses/3.16 seconds (8DPSK, 3 DH1)



2.4 20 dB BANDWIDTH

2.4.1 Specification Reference

Part 15 Subpart C §15.215(c)

2.4.2 Standard Applicable

(c) Intentional radiators operating under the alternative provisions to the general emission limits, as contained in §§15.217 through 15.257 and in Subpart E of this part, must be designed to ensure that the 20 dB bandwidth of the emission, or whatever bandwidth may otherwise be specified in the specific rule section under which the equipment operates, is contained within the frequency band designated in the rule section under which the equipment is operated. The requirement to contain the designated bandwidth of the emission within the specified frequency band includes the effects from frequency sweeping, frequency hopping and other modulation techniques that may be employed as well as the frequency stability of the transmitter over expected variations in temperature and supply voltage. If a frequency stability is not specified in the regulations, it is recommended that the fundamental emission be kept within at least the central 80% of the permitted band in order to minimize the possibility of out-of-band operation.

2.4.3 Equipment Under Test and Modification State

Serial No: C20015440005 /Test Configuration B

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

July 23, 2015 / NS

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	24.8 °C
Relative Humidity	64.1 %
ATM Pressure	99.1 kPa

2.4.7 Additional Observations

- This is a conducted test.
- An offset of 6.9 dB was added to compensate the power splitter and coaxial cable attenuation.
- Span is approximately 2 to 3 times the expected 20dB bandwidth.
- RBW is $\geq 1\%$ of the expected 20dB bandwidth while VBW is $\geq$ RBW.
- Sweep is auto.
- Detector is peak.
- Max hold function activated.

- “n dB down” marker function (20dB) of the spectrum analyzer was used for this test.

2.4.8 Test Results

Modulation	Channel	Frequency (MHz)	Measured 20dB Bandwidth (MHz)
GFSK	0	2402	1.13
	38	2440	1.13
	78	2480	1.13
$\pi/4$ -DQPSK	0	2402	1.42
	38	2440	1.42
	78	2480	1.42
8DPSK	0	2402	1.41
	38	2440	1.41
	78	2480	1.41

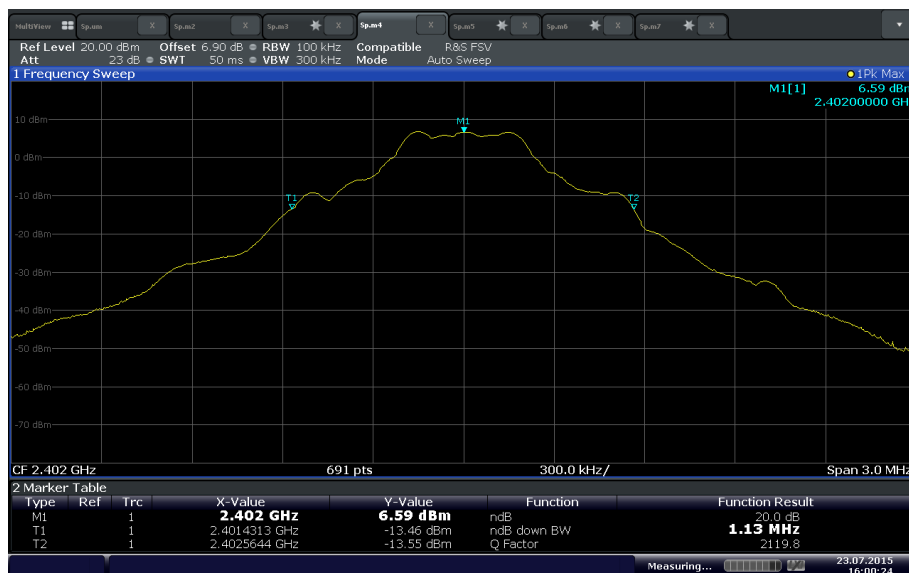
Worst case configuration ($\pi/4$ -DQPSK)

2402 MHz – (20dB BW/2) = 2401.29 MHz (within the frequency band - **Compliant**)

Worst case configuration ($\pi/4$ -DQPSK)

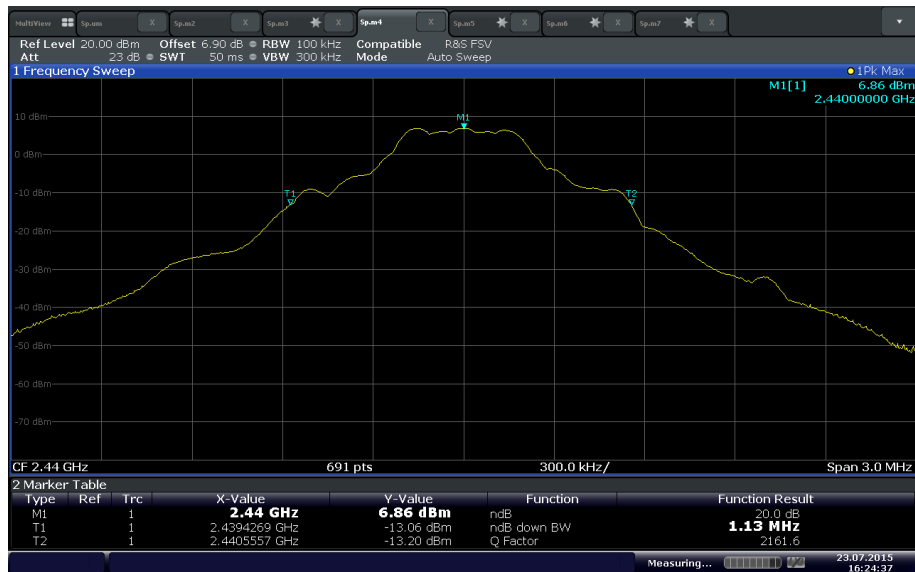
2480 MHz + (20dB BW/2) = 2480.71 MHz (within the frequency band - **Compliant**)

2.4.9 Test Results Plots



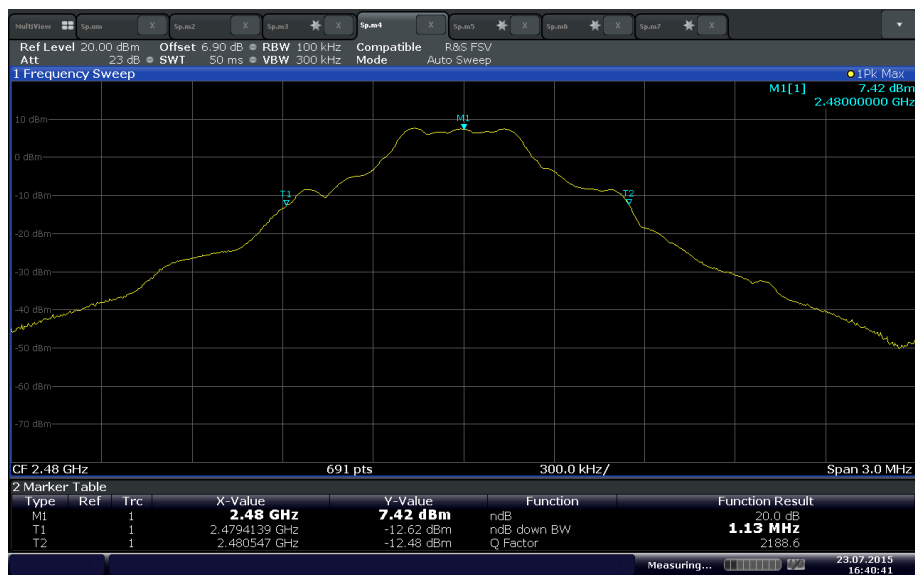
Date: 23 JUL 2015 16:00:24

GFSK Low Channel



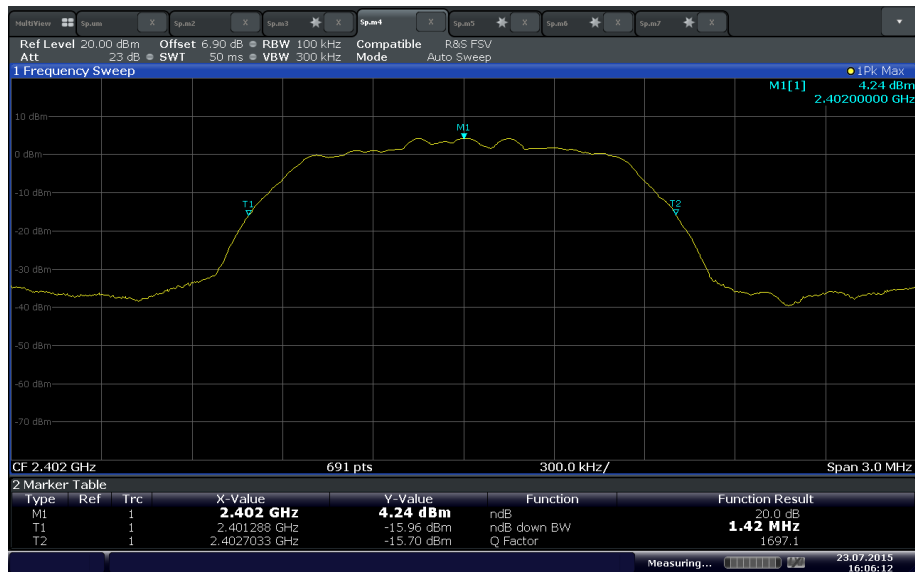
Date: 23.JUL.2015 16:24:38

GFSK Mid Channel



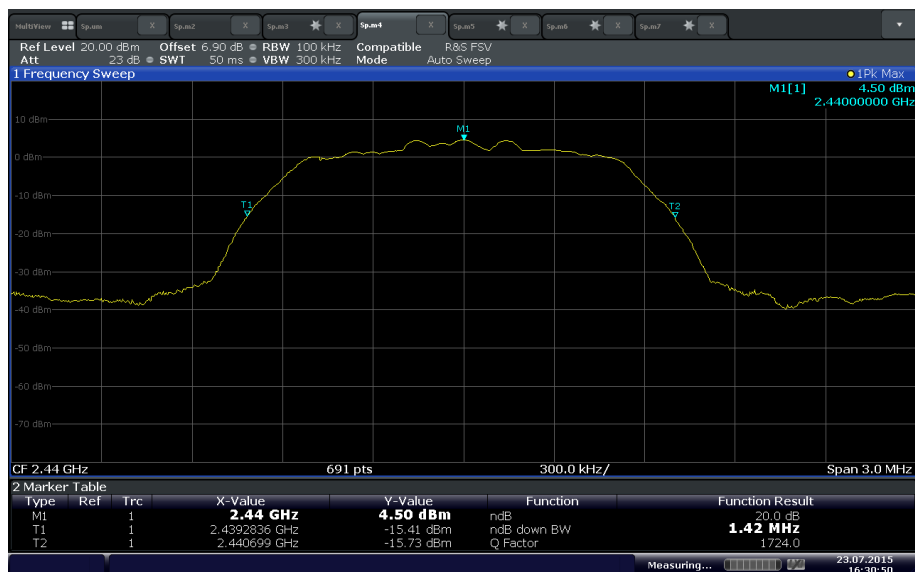
Date: 23.JUL.2015 16:40:41

GFSK High Channel



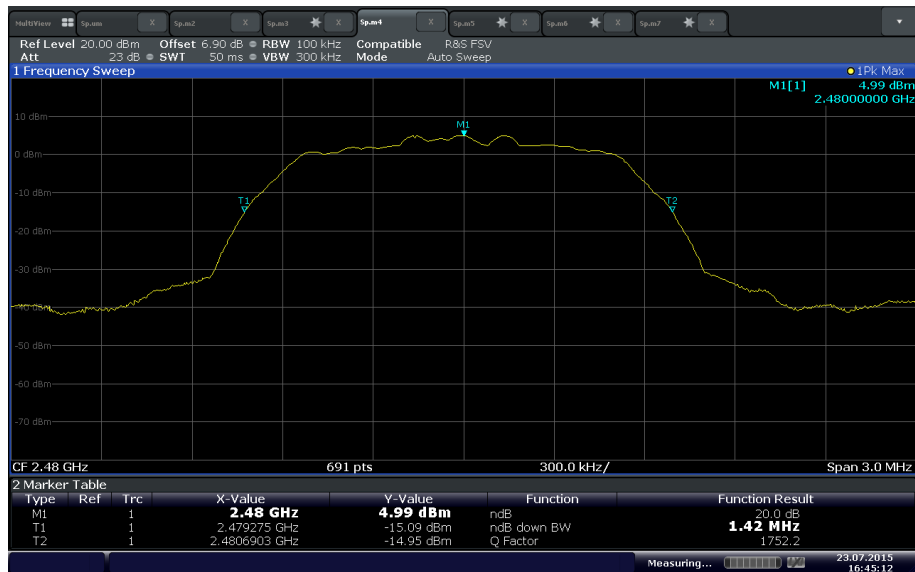
Date: 23 JUL 2015 16:06:12

$\pi/4$ -DQPSK Low Channel



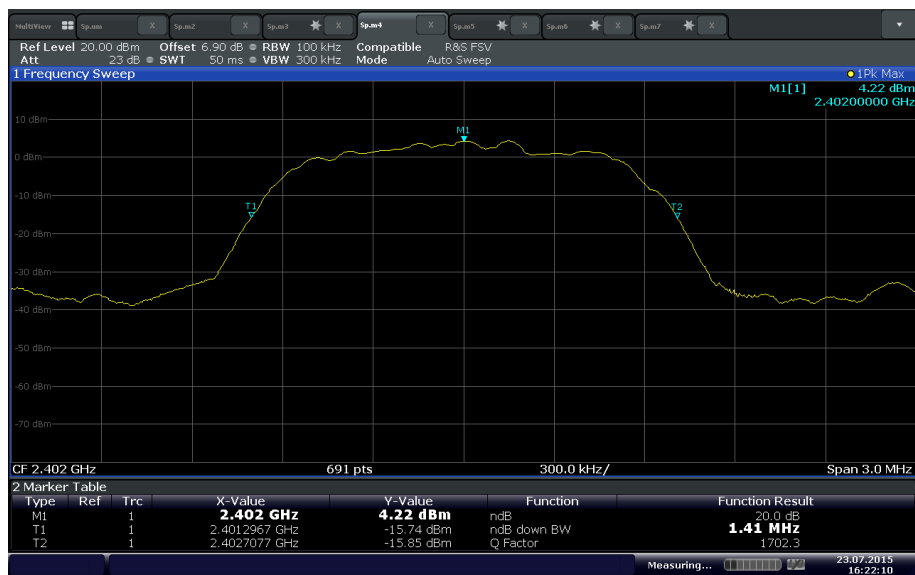
Date: 23 JUL 2015 16:30:51

$\pi/4$ -DQPSK Mid Channel



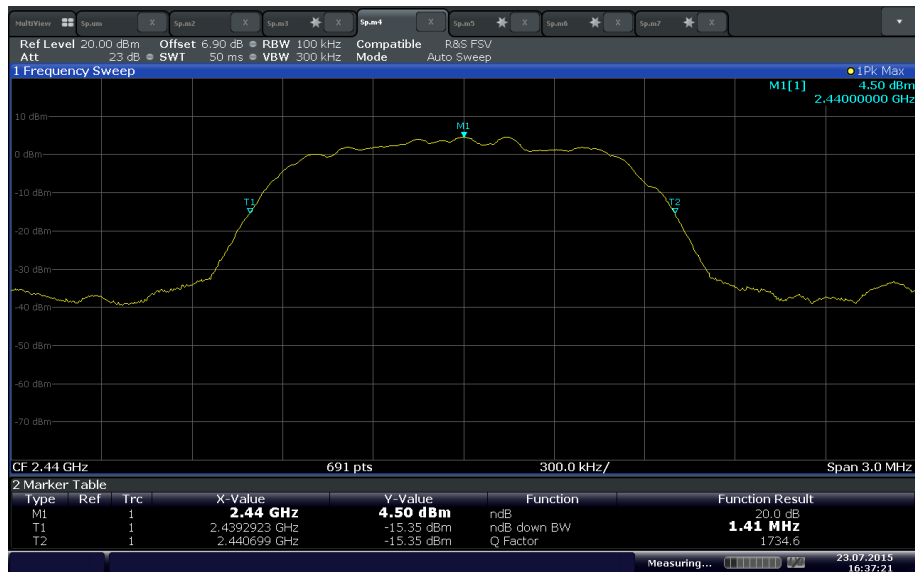
Date: 23 JUL 2015 16:45:13

$\pi/4$ -DQPSK High Channel



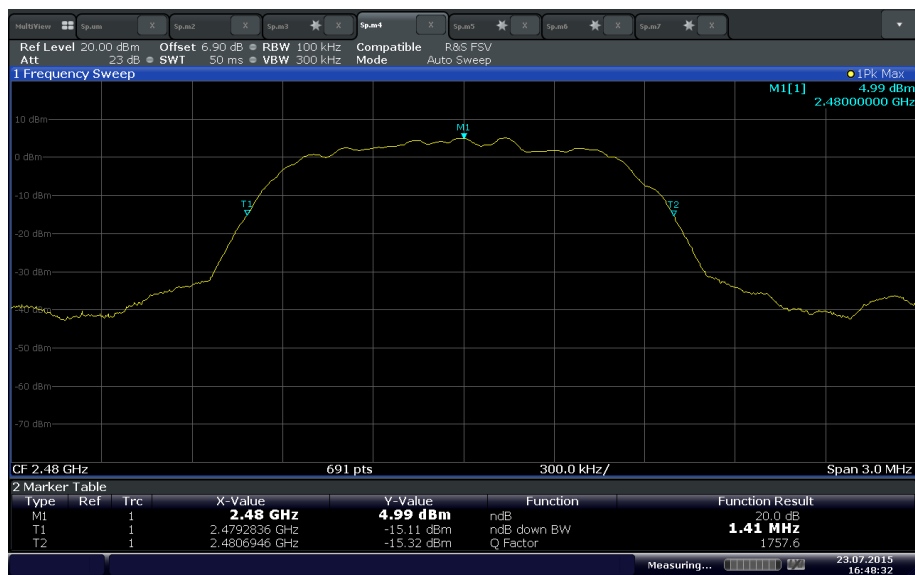
Date: 23 JUL 2015 16:22:11

8DPSK Low Channel



Date: 23 JUL 2015 16:37:21

8DPSK Mid Channel



Date: 23 JUL 2015 16:48:32

8DPSK High Channel

2.5 99% EMISSION BANDWIDTH

2.5.1 Specification Reference

RSS-Gen Clause 6.6

2.5.2 Standard Applicable

The emission bandwidth (x dB) is defined as the frequency range between two points, one above and one below the carrier frequency, at which the spectral density of the emission is attenuated x dB below the maximum in-band spectral density of the modulated signal. Spectral density (power per unit bandwidth) is to be measured with a detector of resolution bandwidth in the range of 1% to 5% of the anticipated emission bandwidth, and a video bandwidth at least 3x the resolution bandwidth.

When the occupied bandwidth limit is not stated in the applicable RSS or reference measurement method, the transmitted signal bandwidth shall be reported as the 99% emission bandwidth, as calculated or measured.

- The transmitter shall be operated at its maximum carrier power measured under normal test conditions.
- • The span of the analyzer shall be set to capture all products of the modulation process, including the emission skirts.
- • The resolution bandwidth (RBW) shall be in the range of 1% to 5% of the occupied bandwidth (OBW) and video bandwidth (VBW) shall be approximately 3x RBW.

Note: Video averaging is not permitted.

A peak, or peak hold, may be used in place of the sampling detector as this may produce a wider bandwidth than the actual bandwidth (worst-case measurement). Use of a peak hold may be necessary to determine the occupied bandwidth if the device is not transmitting continuously.

The trace data points are recovered and are directly summed in linear power level terms. The recovered amplitude data points, beginning at the lowest frequency, are placed in a running sum until 0.5% of the total is reached and that frequency recorded. The process is repeated for the highest frequency data points (starting at the highest frequency, at the right side of the span, and going down in frequency). This frequency is then recorded.

The difference between the two recorded frequencies is the 99% occupied bandwidth.

2.5.3 Equipment Under Test and Modification State

Serial No: C20015440005 /Test Configuration B

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

July 23, 2015 / NS

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 24.8 °C
 Relative Humidity 64.1 %
 ATM Pressure 99.1 kPa

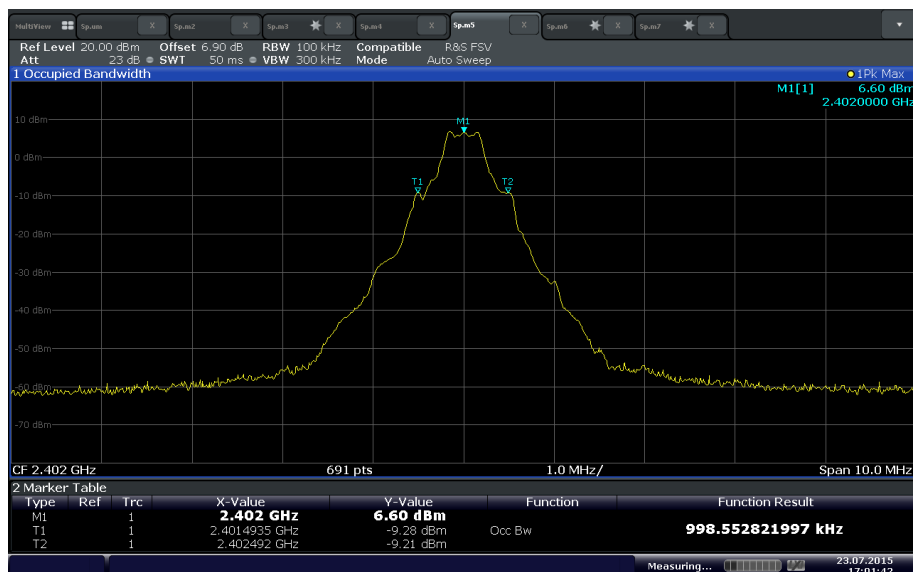
2.5.7 Additional Observations

- This is a conducted test.
- An offset of 6.9 dB was added to compensate the power splitter and coaxial cable attenuation.
- Span is wide enough to capture the channel transmission.
- RBW is 1% of the span.
- VBW is 3X RBW.
- Sweep is auto.
- Detector is peak.
- The % Power Bandwidth setting in the spectrum analyzer was set to 99% (default).
- The OBW power measurement function of the spectrum analyzer was used for this test.

2.5.8 Test Results (For reporting purposes only)

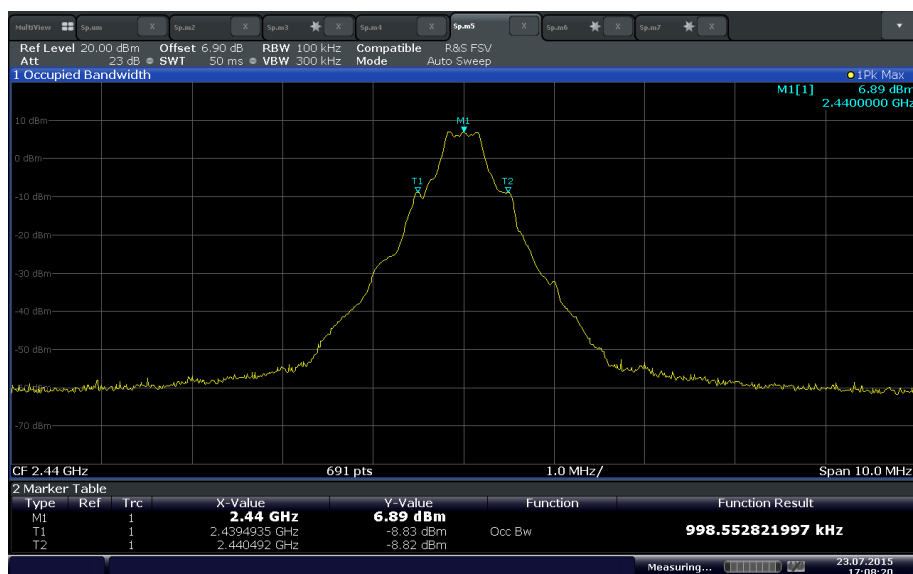
Modulation	Channel	Frequency (MHz)	Measured 20dB Bandwidth (MHz)
GFSK	0	2402	0.998
	38	2440	1.013
	78	2480	0.998
$\pi/4$ -DQPSK	0	2402	1.230
	38	2440	1.216
	78	2480	1.230
8DPSK	0	2402	1.230
	38	2440	1.216
	78	2480	1.230

2.5.9 Test Results Plots



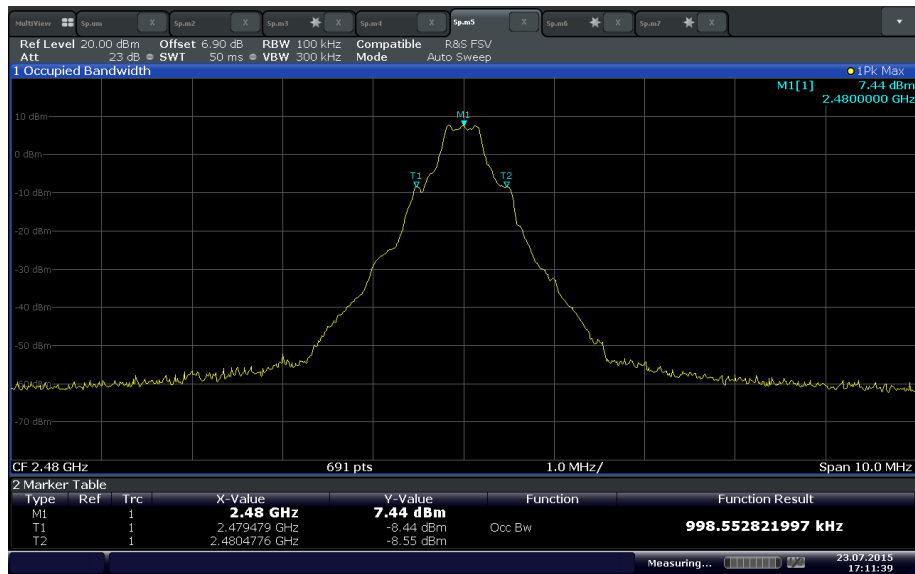
Date: 23.JUL.2015 17:01:42

GFSK Low Channel



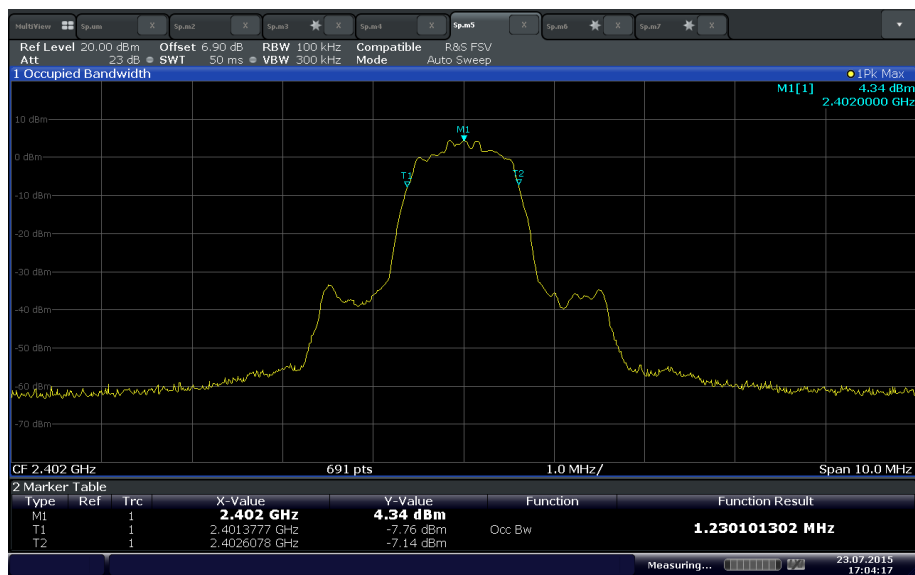
Date: 23.JUL.2015 17:08:20

GFSK Mid Channel



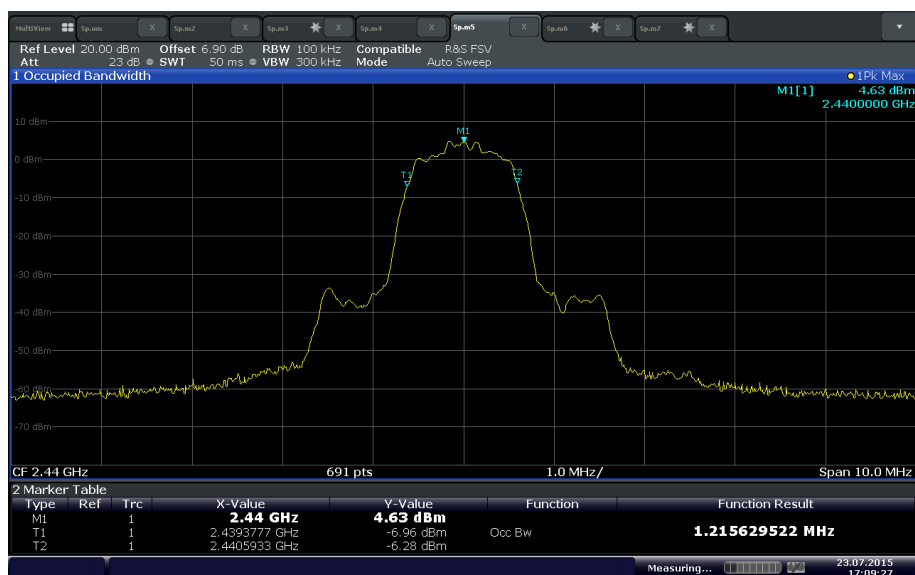
Date: 23.JUL.2015 17:11:39

GFSK High Channel



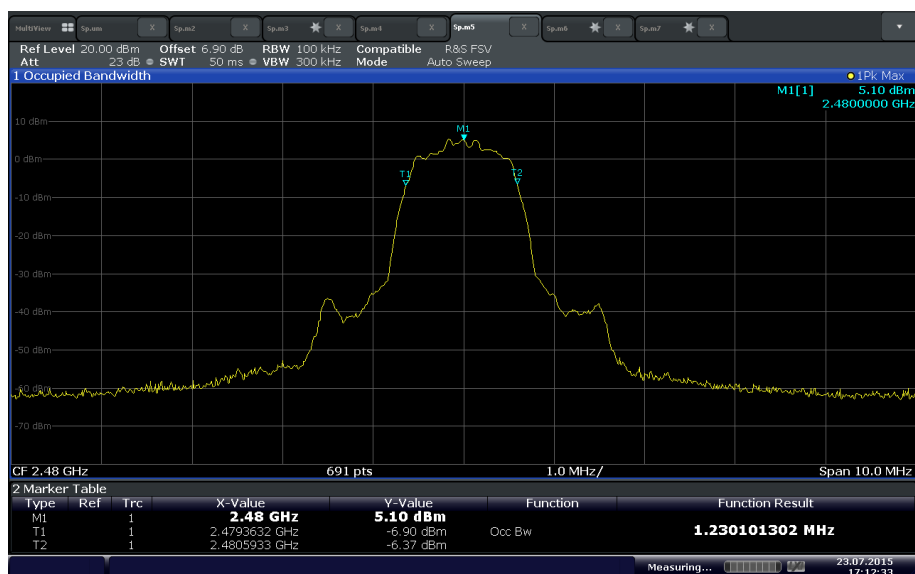
Date: 23.JUL.2015 17:04:17

$\pi/4$ -DQPSK Low Channel



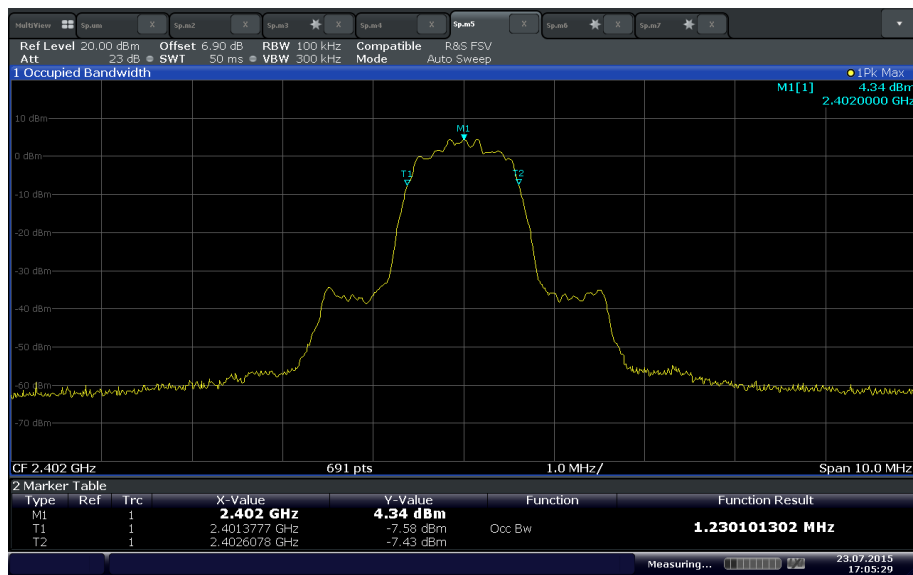
Date: 23.JUL.2015 17:09:28

$\pi/4$ -DQPSK Mid Channel



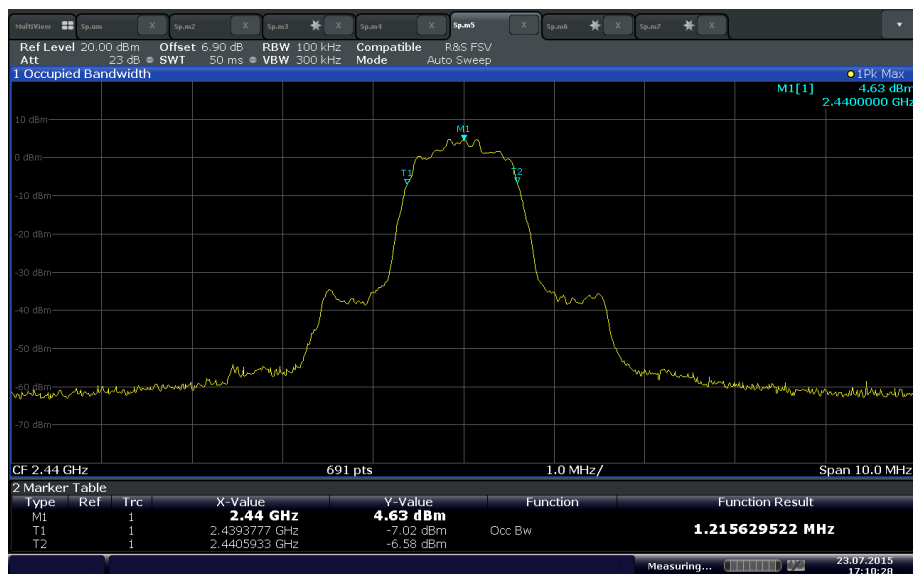
Date: 23.JUL.2015 17:12:33

$\pi/4$ -DQPSK High Channel



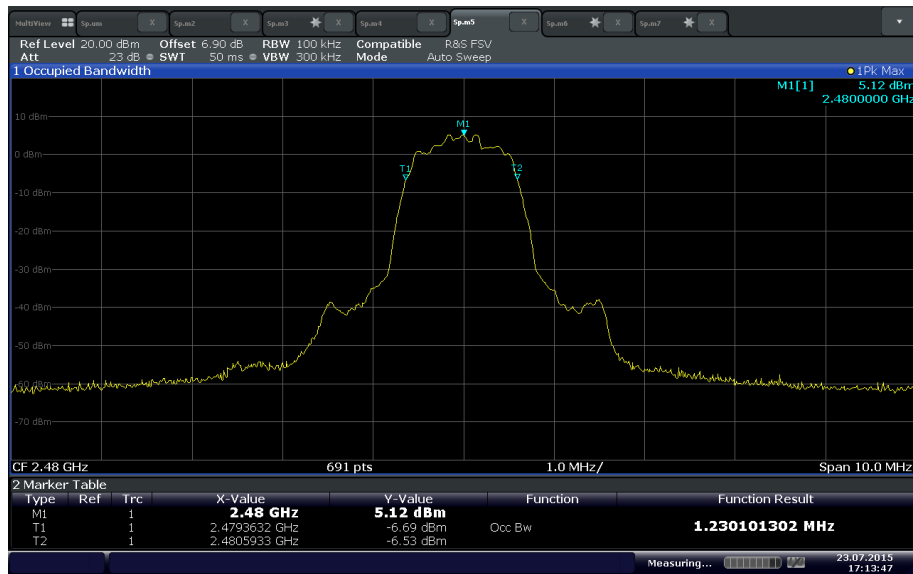
Date: 23.JUL.2015 17:05:29

8DPSK Low Channel



Date: 23.JUL.2015 17:10:28

8DPSK Mid Channel



Date: 23 JUL 2015 17:13:47

8DPSK High Channel

2.6 PEAK OUTPUT POWER

2.6.1 Specification Reference

Part 15 Subpart C §15.247(b)(1)

2.6.2 Standard Applicable

(1) For frequency hopping systems operating in the 2400–2483.5 MHz band employing at least 75 non-overlapping hopping channels, and all frequency hopping systems in the 5725–5850 MHz band: 1 watt. For all other frequency hopping systems in the 2400–2483.5 MHz band: 0.125 watts.

2.6.3 Equipment Under Test and Modification State

Serial No: C20015440005 /Test Configuration B

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

July 16, 2015 / NS

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	24.8 °C
Relative Humidity	64.1 %
ATM Pressure	99.1 kPa

2.6.7 Additional Observations

This is a conducted test using a Peak Power Meter.

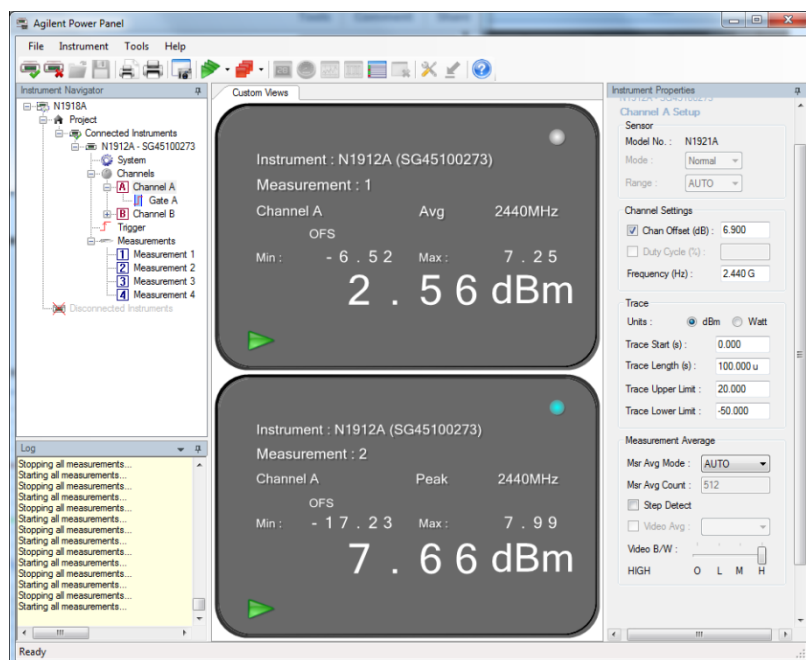
2.6.8 Test Results (Conducted)

Modulation	Channel	Frequency (MHz)	Measured Average Output Power (dBm)	Measured Peak Output Power (dBm)	Measured Peak Output Power (mW)	Limit (mW)
GFSK	0	2402	6.60	7.26	5.32	1000.0
	38	2440	7.25	7.99	6.30	1000.0
	78	2480	7.11	7.86	6.11	1000.0
$\pi/4$ -DQPSK	0	2402	4.46	7.19	5.24	1000.0
	38	2440	5.06	7.76	5.97	1000.0
	78	2480	4.89	7.68	5.86	1000.0
8DPSK	0	2402	4.46	7.65	5.82	1000.0
	38	2440	5.06	8.20	6.61	1000.0
	78	2480	4.90	8.14	6.52	1000.0

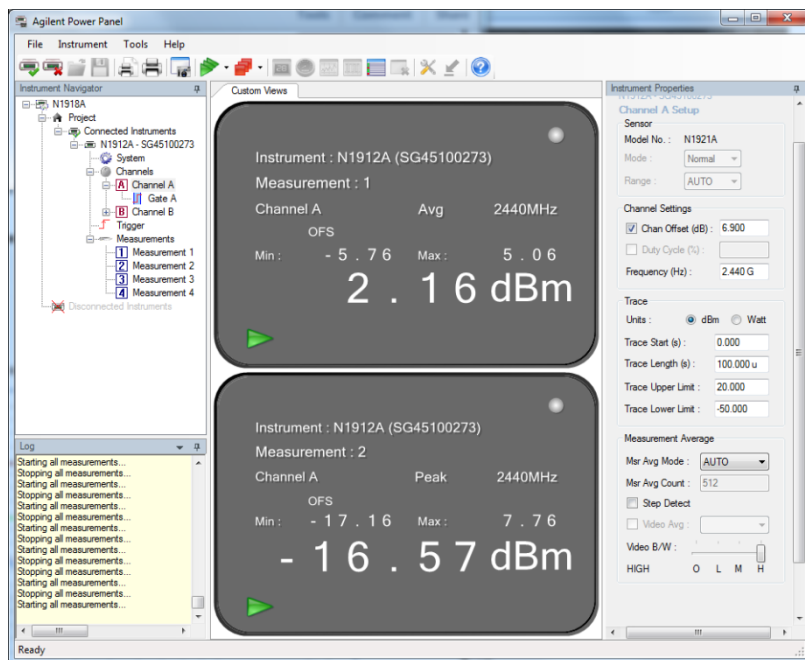
2.6.9 Test Results (De Facto EIRP Limit)

Modulation	Channel	Frequency (MHz)	Measured Peak Output Power (dBm)	Antenna Gain (dBi)	Calculated Peak Output Power EIRP (dBm)	Limit (dBm)
GFSK	38	2440	7.99	-6.01	1.98	30
$\pi/4$ -DQPSK	38	2440	7.76	-6.01	1.75	30
8DPSK	38	2440	8.20	-6.01	2.19	30

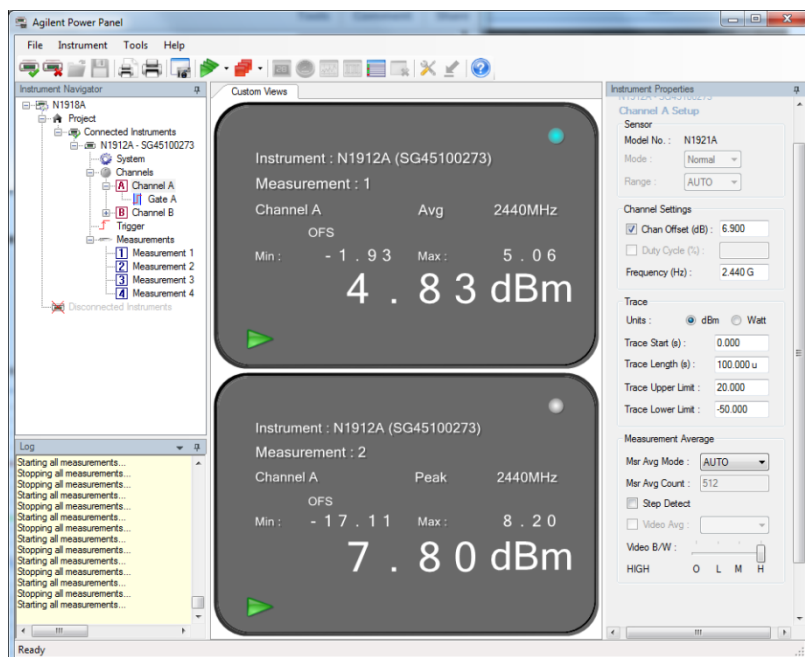
2.6.10 Sample Test Display



GFSK mid channel (Channel 38 2440 MHz)



$\pi/4$ -DQPSK mid channel (Channel 38 2440 MHz)



8DPSK mid channel (Channel 38 2440 MHz)

2.7 BAND-EDGE COMPLIANCE OF RF CONDUCTED EMISSIONS

2.7.1 Specification Reference

Part 15 Subpart C §15.247(d)

2.7.2 Standard Applicable

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

2.7.3 Equipment Under Test and Modification State

Serial No: C20015440005 /Test Configuration B

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

July 23, 2015 / NS

2.7.5 Test Equipment Used

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

2.7.6 Environmental Conditions

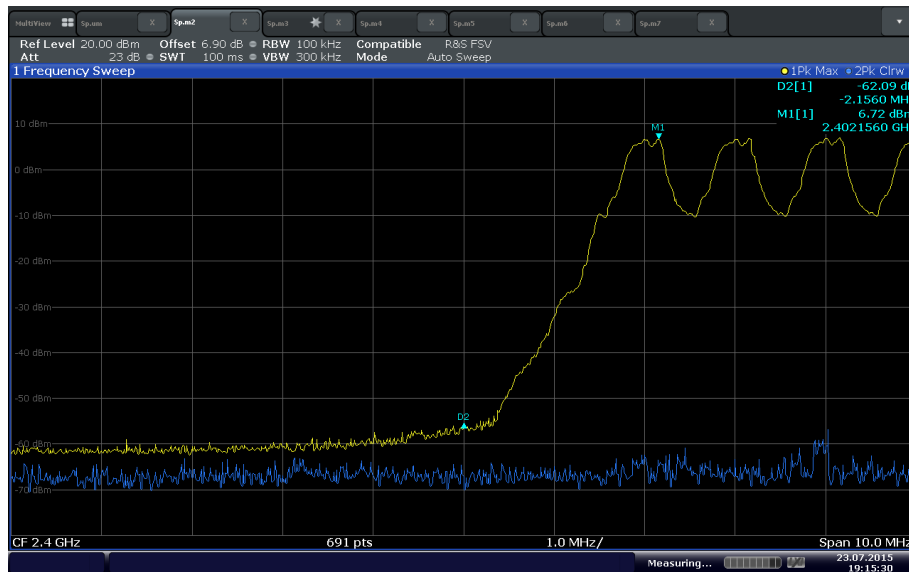
Test performed at TÜV SÜD America Inc. Rancho Bernardo facility.

Ambient Temperature	24.8 °C
Relative Humidity	64.1 %
ATM Pressure	99.1 kPa

2.7.7 Additional Observations

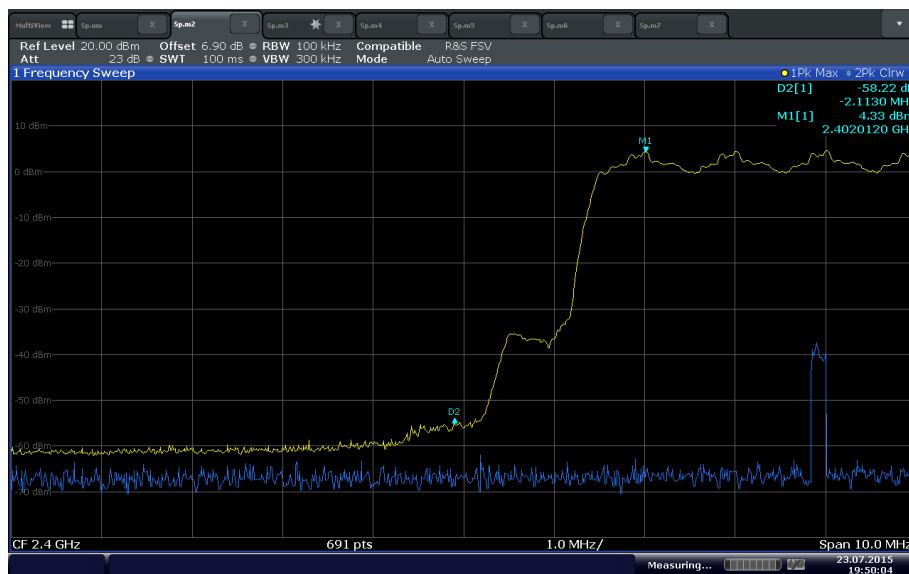
- This is a conducted test.
- An offset of 6.9 dB was added to compensate the power splitter and coaxial cable attenuation.
- Span is wide enough to capture the peak level of the emission operating on the channel closest to the band edge.
- RBW is $\geq 1\%$ of the span, VBW is $\geq$ RBW.
- Sweep is auto, detector is peak, trace is max hold.
- Trace allowed to stabilize. Marker-delta function used to verify compliance.
- Limit is 20dBc.
- Both Hopping and Non-Hopping mode verified.

2.7.8 Test Results



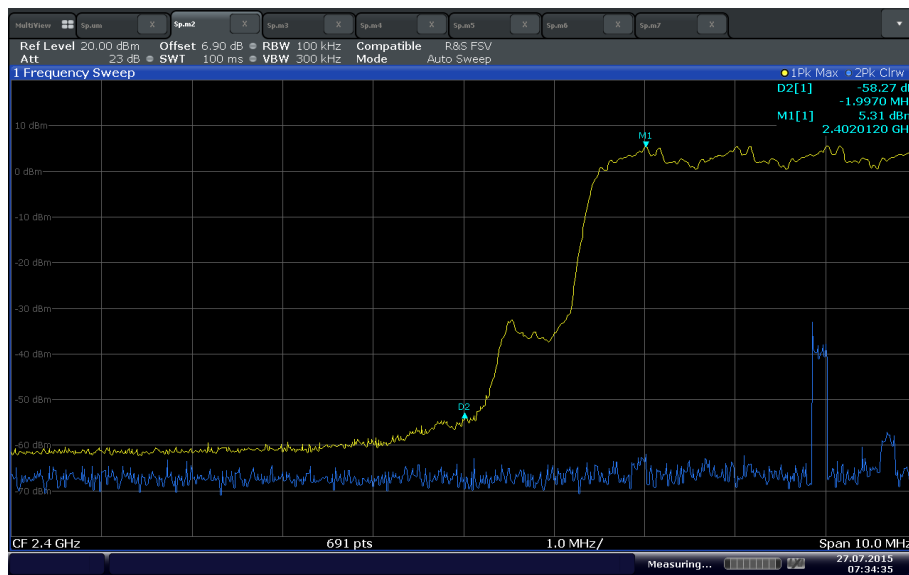
Date: 23 JUL 2015 19:15:30

Hopping lower bandedge (GFSK)



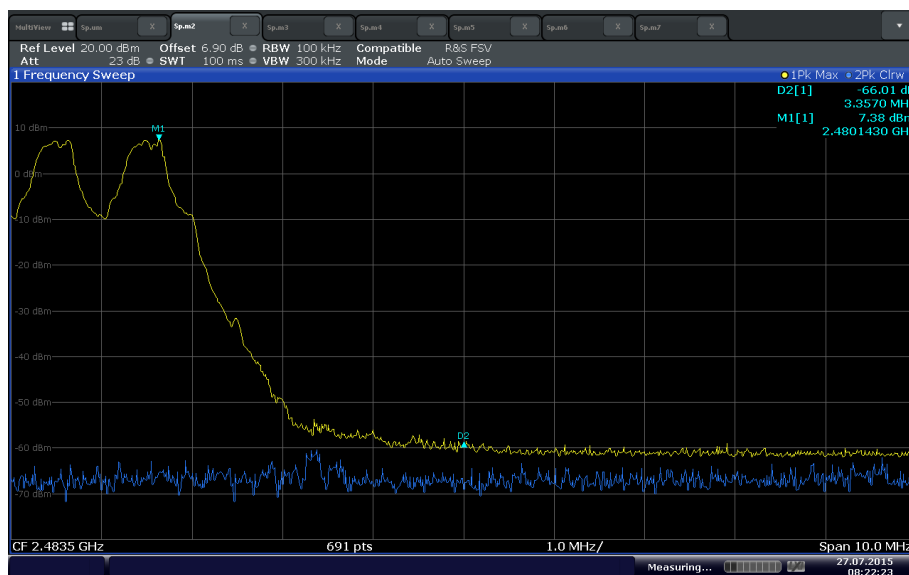
Date: 23 JUL 2015 19:50:04

Hopping lower bandedge ($\pi/4$ -DQPSK)



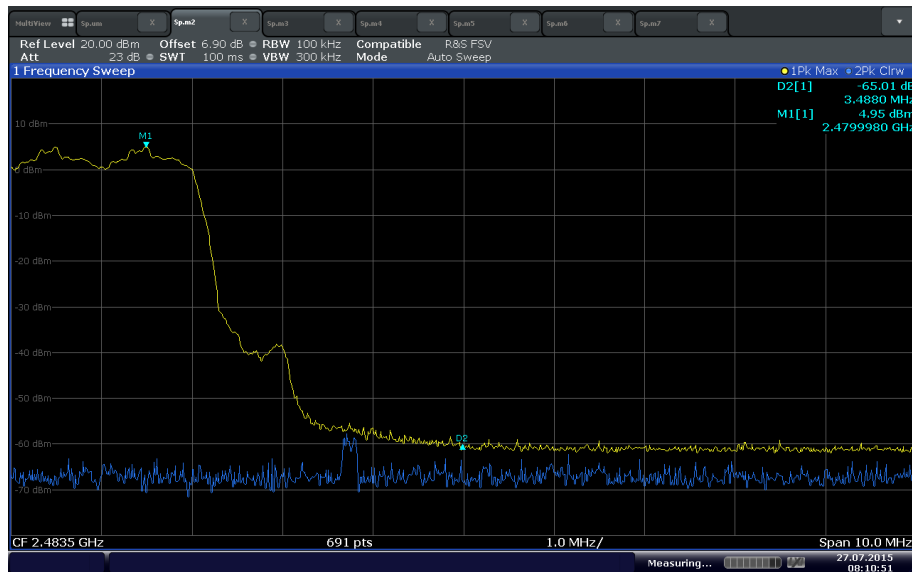
Date: 27 JUL 2015 07:34:35

Hopping lower bandedge (8DPSK)



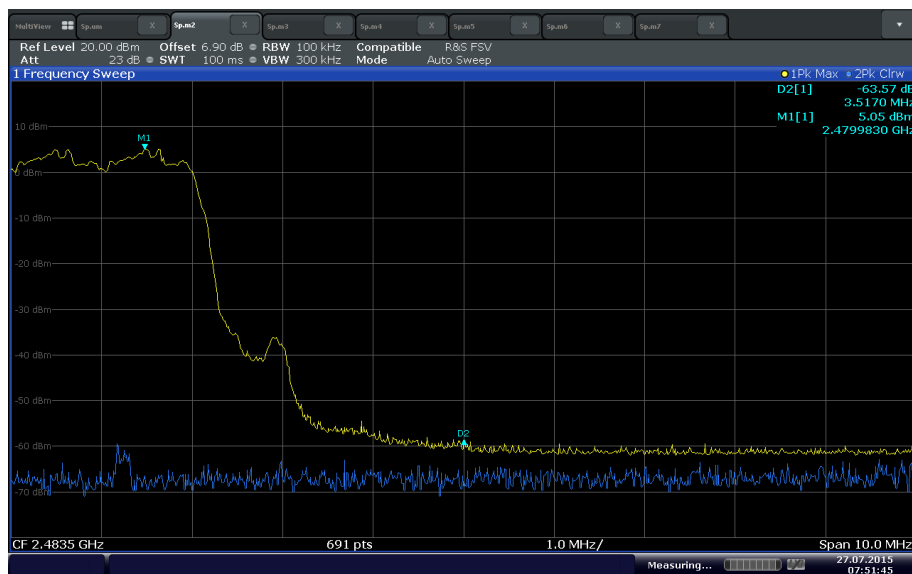
Date: 27 JUL 2015 08:22:23

Hopping upper bandedge (GFSK)



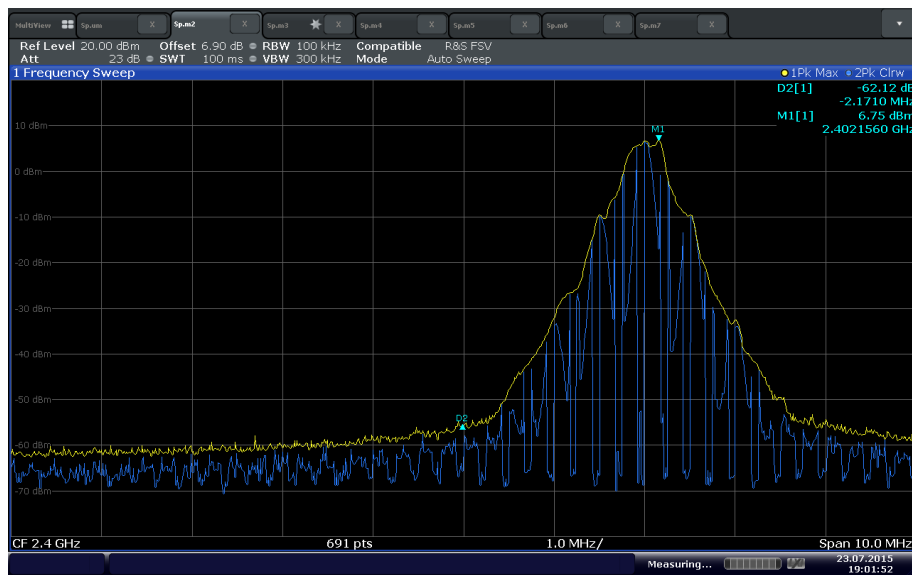
Date: 27 JUL 2015 08:10:51

Hopping upper bandedge ($\pi/4$ -DQPSK)



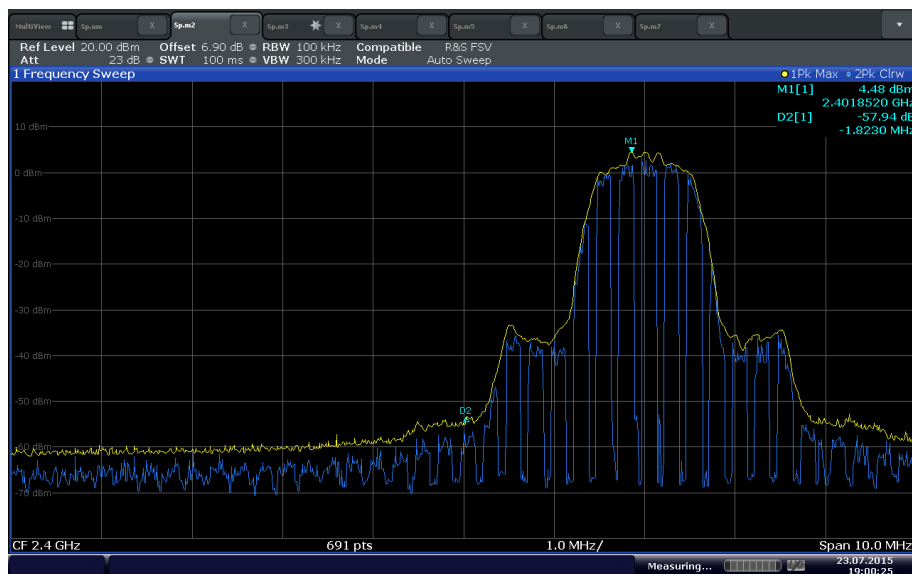
Date: 27 JUL 2015 07:51:46

Hopping upper bandedge (8DPSK)



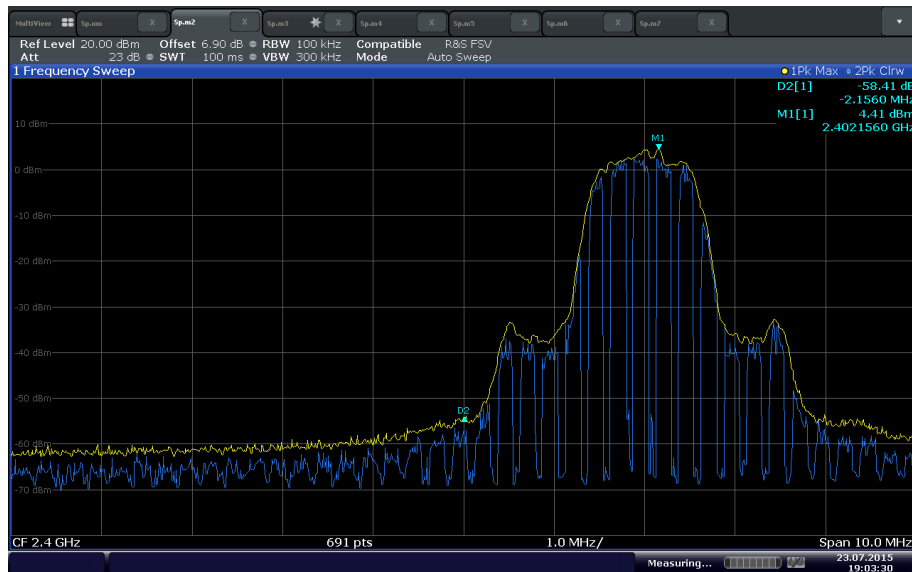
Date: 23 JUL 2015 19:01:51

Non-hopping lower bandedge (GFSK)



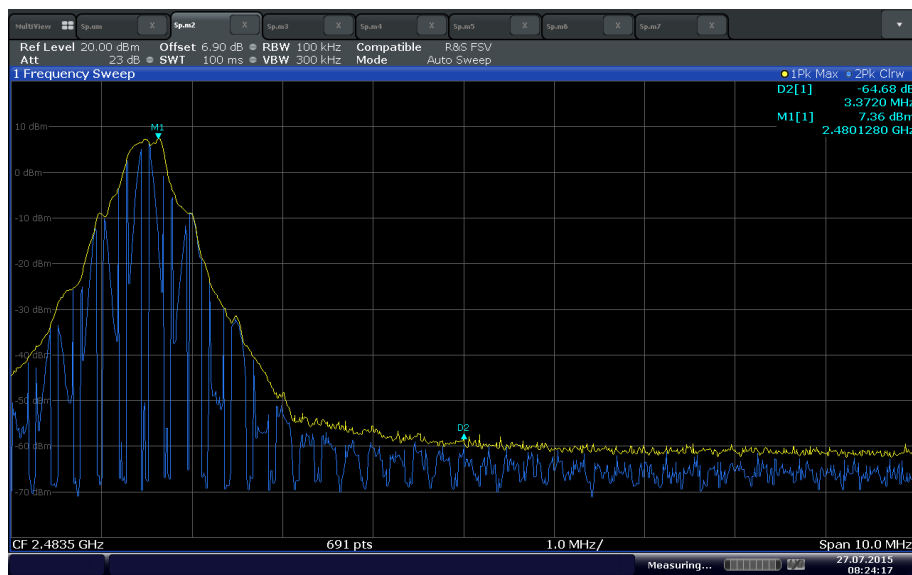
Date: 23 JUL 2015 19:00:25

Non-hopping lower bandedge ($\pi/4$ -DQPSK)



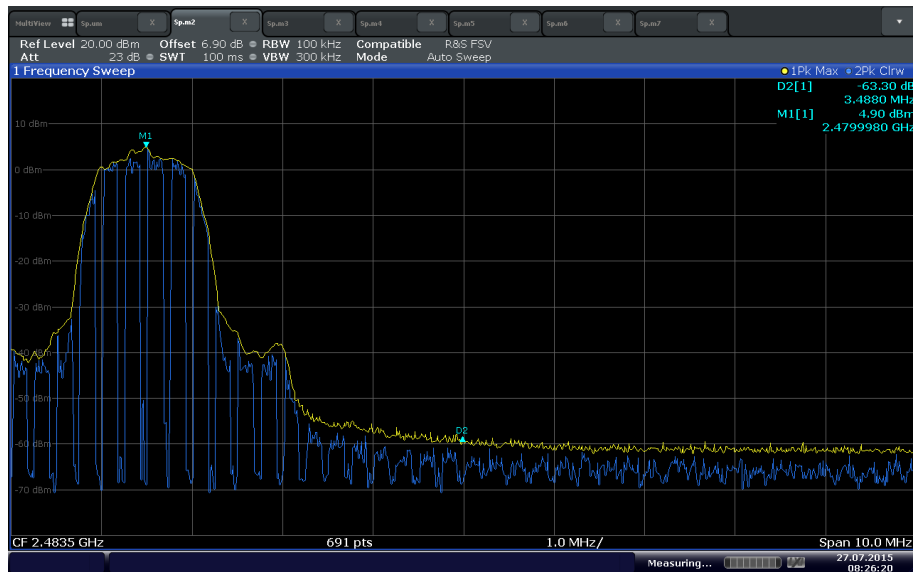
Date: 23 JUL 2015 19:03:30

Non-hopping lower bandedge (8DPSK)



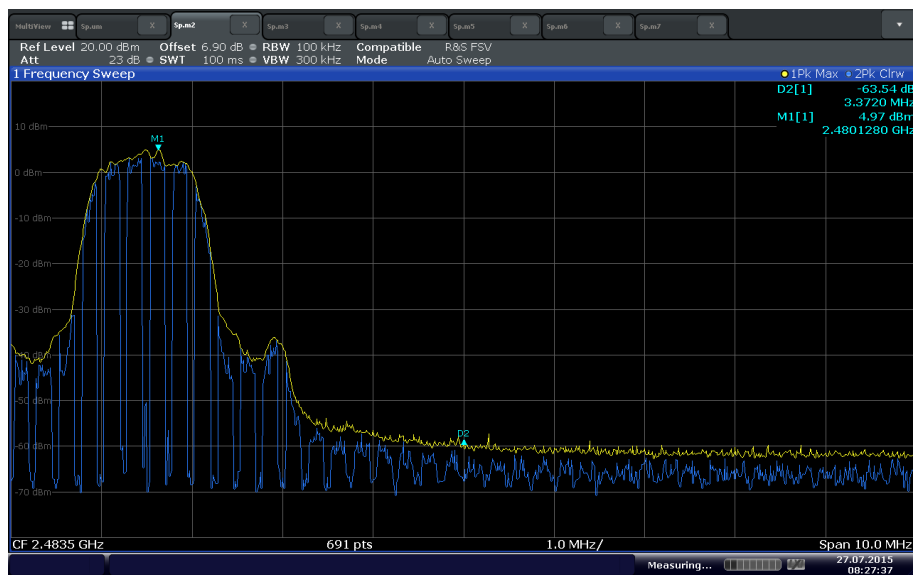
Date: 27 JUL 2015 08:24:18

Non-hopping upper bandedge (GFSK)



Date: 27 JUL 2015 08:26:20

Non-hopping upper bandedge ($\pi/4$ -DQPSK)



Date: 27 JUL 2015 08:27:37

Non-hopping upper bandedge (8DPSK)

2.8 SPURIOUS RF CONDUCTED EMISSIONS

2.8.1 Specification Reference

Part 15 Subpart C §15.247(d)

2.8.2 Standard Applicable

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

2.8.3 Equipment Under Test and Modification State

Serial No: C20015440005 /Test Configuration B

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

August 4, 2015 / NS

2.8.5 Test Equipment Used

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

2.8.6 Environmental Conditions

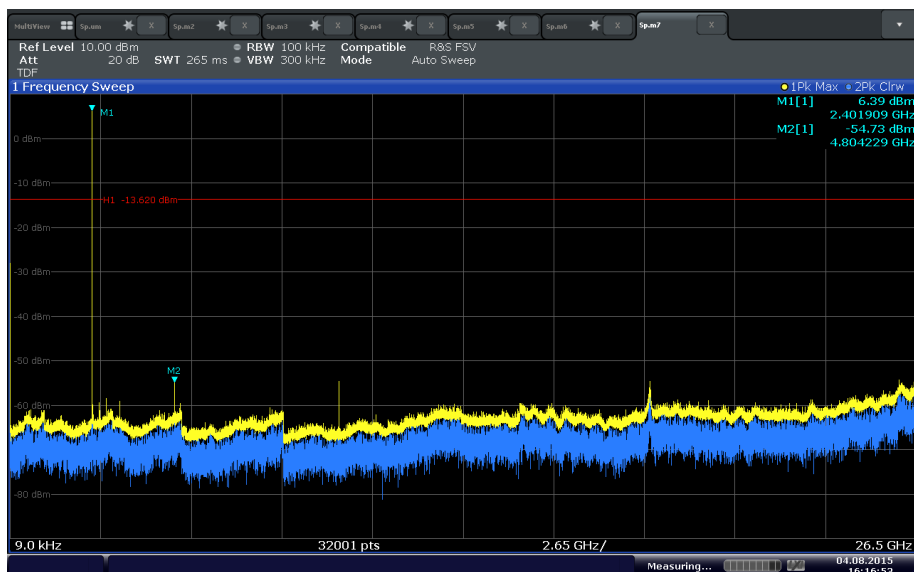
Test performed at TÜV SÜD America Inc. Rancho Bernardo facility.

Ambient Temperature	24.8 °C
Relative Humidity	57.1 %
ATM Pressure	99.1 kPa

2.8.7 Additional Observations

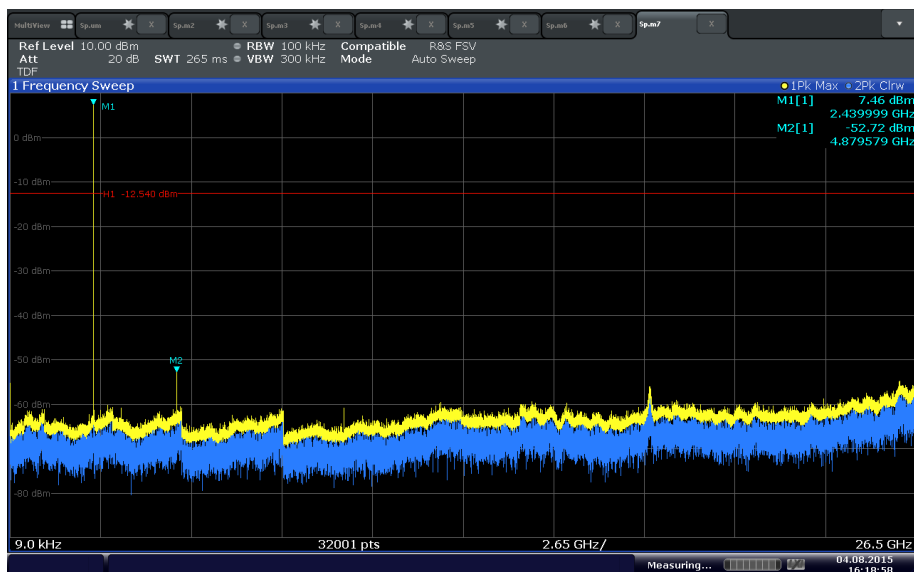
- This is a conducted test.
- A TDF factor was used to compensate the power splitter and coaxial cable attenuation.
- Span is from 9 kHz up to 26.5GHz (to cover 1^{0th} harmonic of the High Channel).
- Sweep point setting of the spectrum analyzer is set to maximum (32001).
- RBW is 100 kHz, VBW is ≥ RBW.
- Sweep is auto, detector is peak.
- Trace is max hold.
- Trace allowed to stabilize. Maximum spurious emission compared to limit.
- Limit is 20dBc.

2.8.8 Test Results Plots



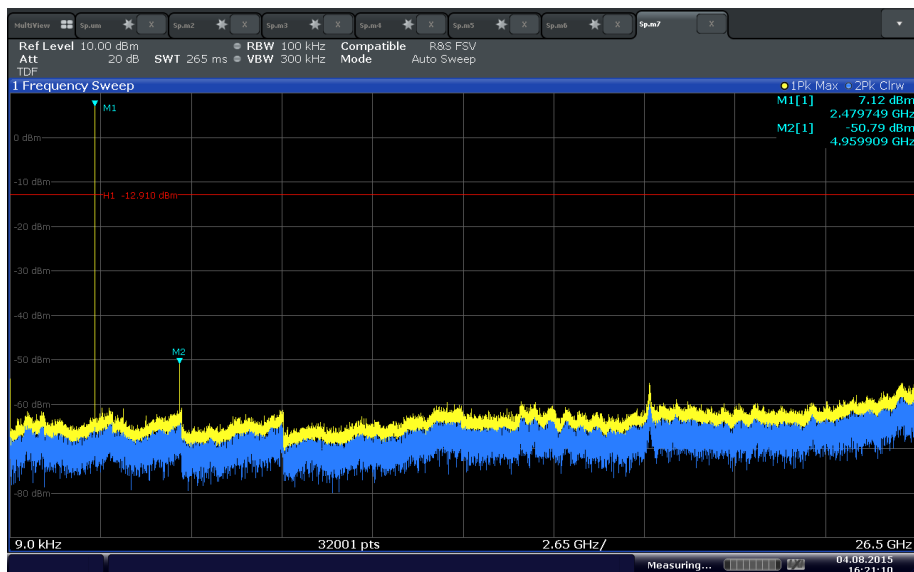
Date: 4 AUG 2015 16:16:54

Low Channel (GFSK)



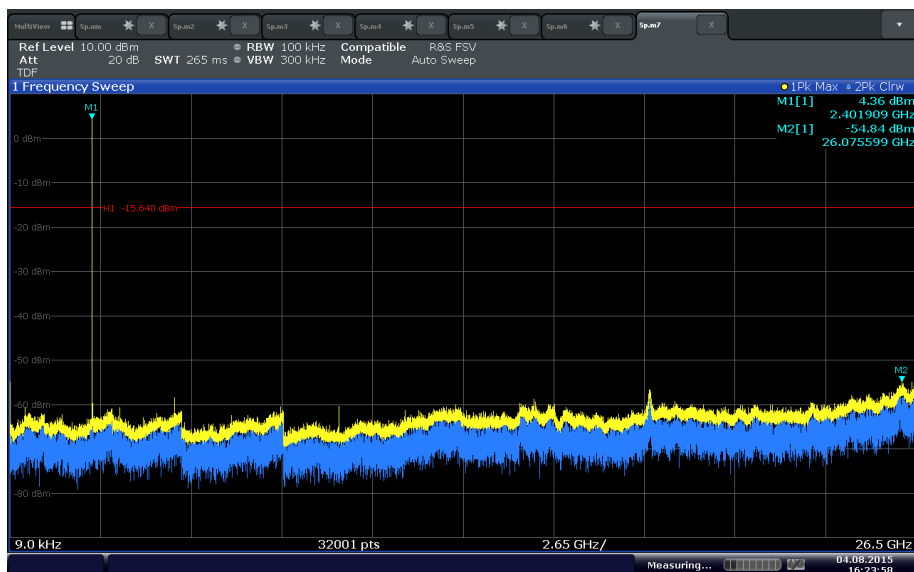
Date: 4 AUG 2015 16:18:58

Mid Channel (GFSK)



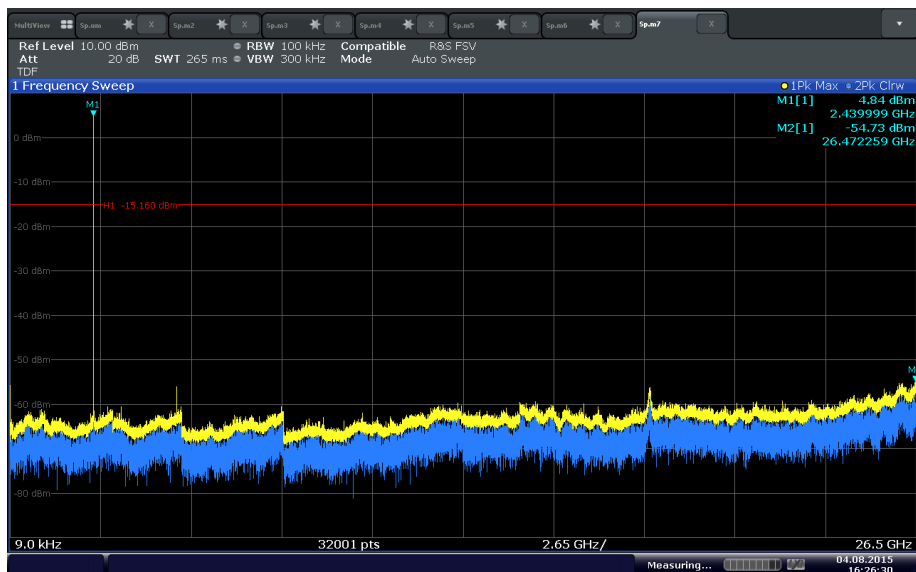
Date: 4 AUG 2015 16:21:10

High Channel (GFSK)



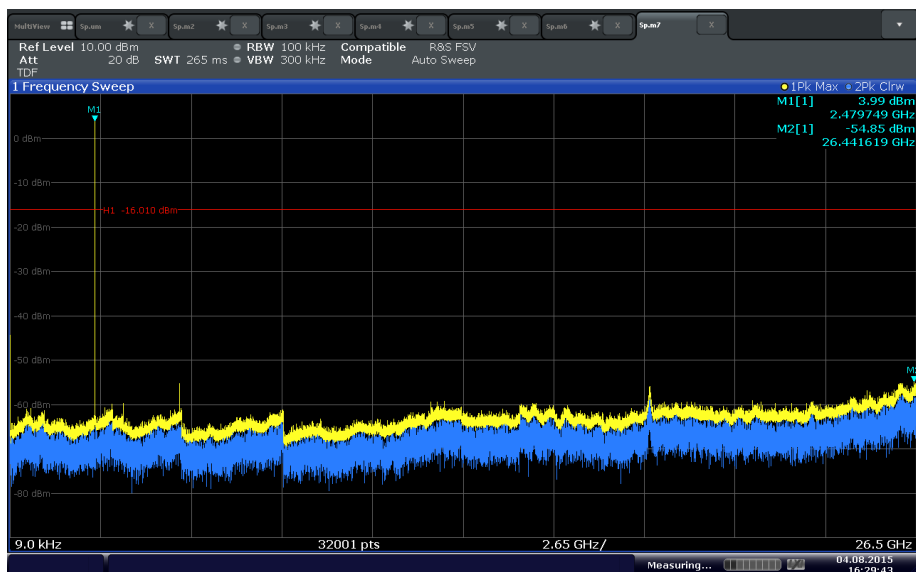
Date: 4 AUG 2015 16:23:58

Low Channel ($\pi/4$ -DQPSK)



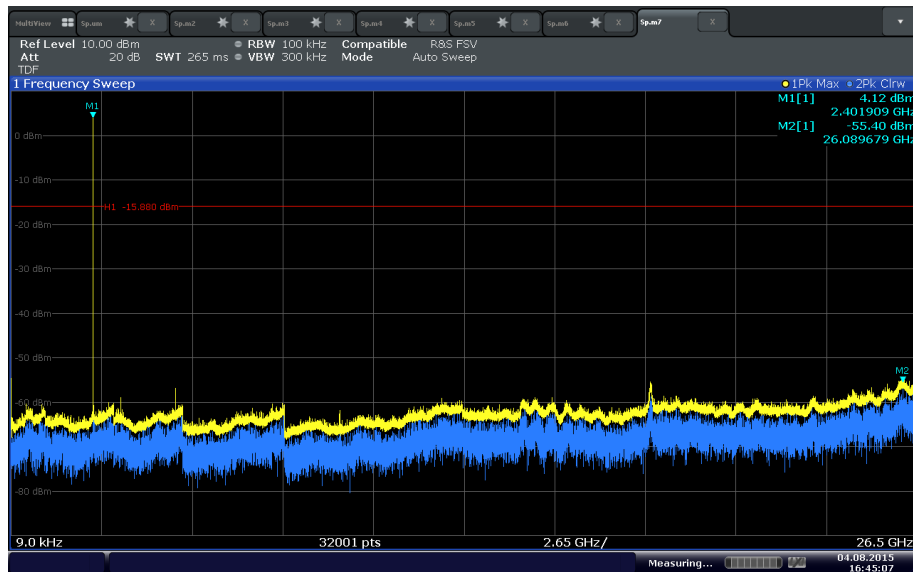
Date: 4 AUG 2015 16:26:30

Mid Channel ($\pi/4$ -DQPSK)



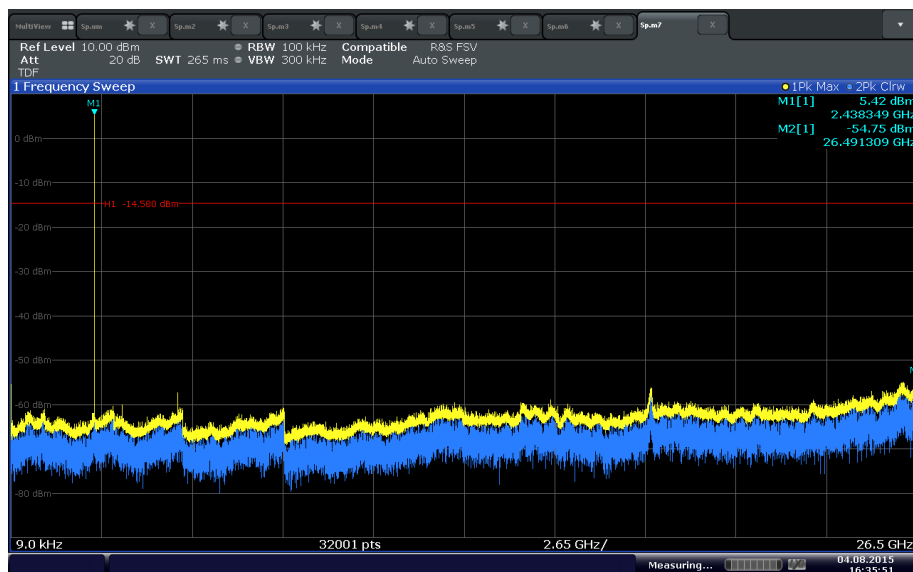
Date: 4 AUG 2015 16:29:44

High Channel ($\pi/4$ -DQPSK)



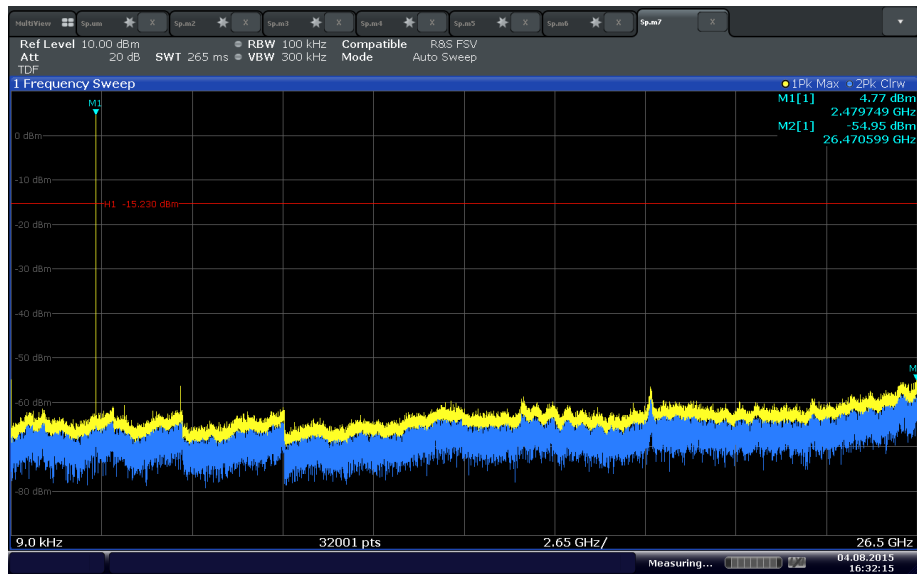
Date: 4 AUG 2015 16:45:07

Low Channel (8DPSK)



Date: 4 AUG 2015 16:35:51

Mid Channel (8DPSK)



Date: 4 AUG 2015 16:32:16

High Channel (8DPSK)

2.9 SPURIOUS RADIATED EMISSIONS

2.9.1 Specification Reference

Part 15 Subpart C §15.247(d)

2.9.2 Standard Applicable

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

2.9.3 Equipment Under Test and Modification State

Serial No: C20015440005 / Test Configuration B

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

December 15 and 16, 2015 / AC

2.9.5 Test Equipment Used

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

2.9.6 Environmental Conditions

Test performed at TÜV SÜD America Inc. Rancho Bernardo facility

Ambient Temperature	21.6 °C
Relative Humidity	35.1 %
ATM Pressure	99.1 kPa

2.9.7 Additional Observations

- This is a radiated test. The spectrum was searched from 30MHz to the 10th harmonic.
- There are no emissions found that do not comply to the restricted bands defined in FCC Part 15 Subpart C, 15.205 or Part 15.247(d).
- Only the considered worst case configuration (mid channel GFSK) presented for radiated emissions when not hopping. There are no significant differences in radiated emissions between the three modulation types.



- Only noise floor measurements observed above 18GHz.
- Measurement was done using EMC32 automated software. Reported level is the actual level with all the correction factors factored in. Correction Factor column is for informational purposes only. See Section 2.9.8 for sample computation.

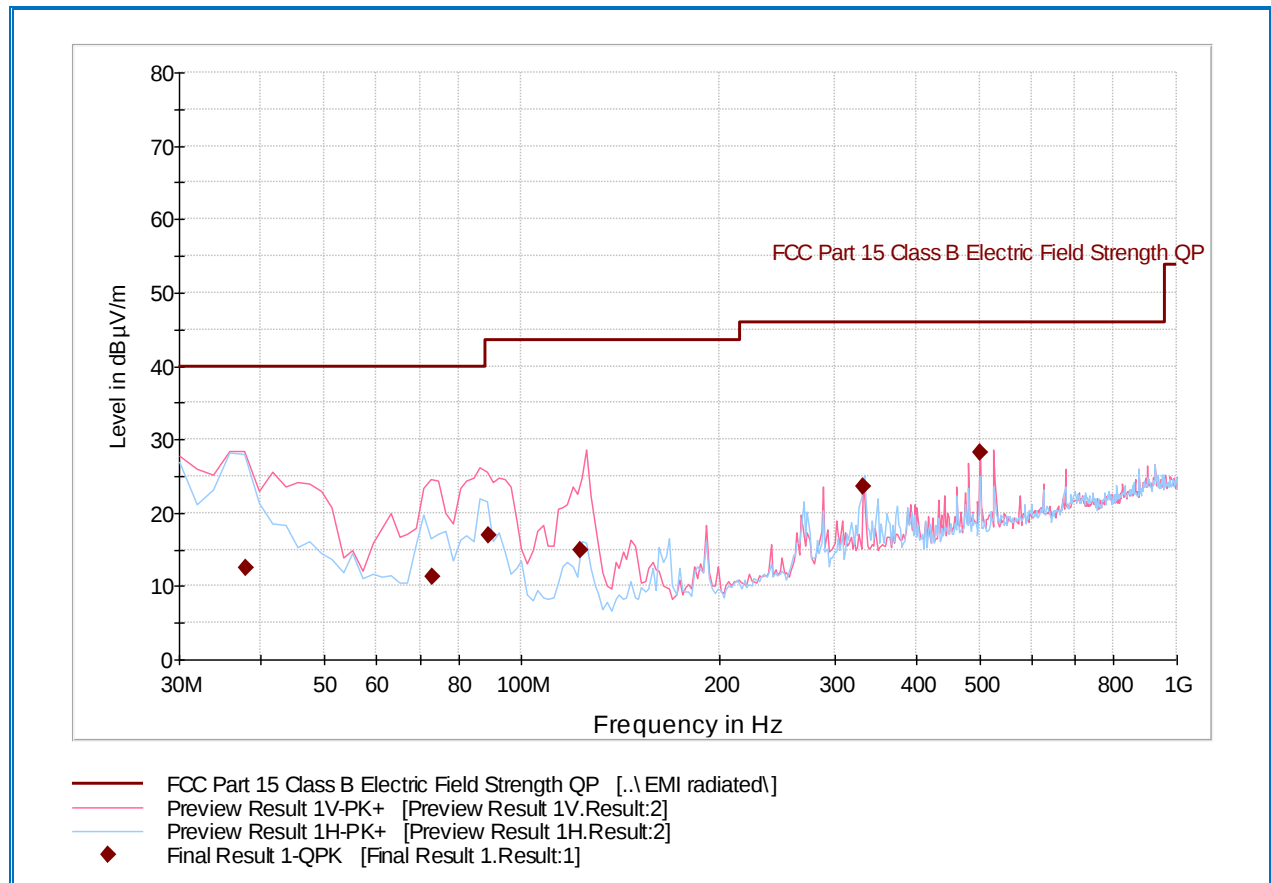
2.9.8 Sample Computation (Radiated Emission)

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

2.9.9 Test Results

See attached plots.

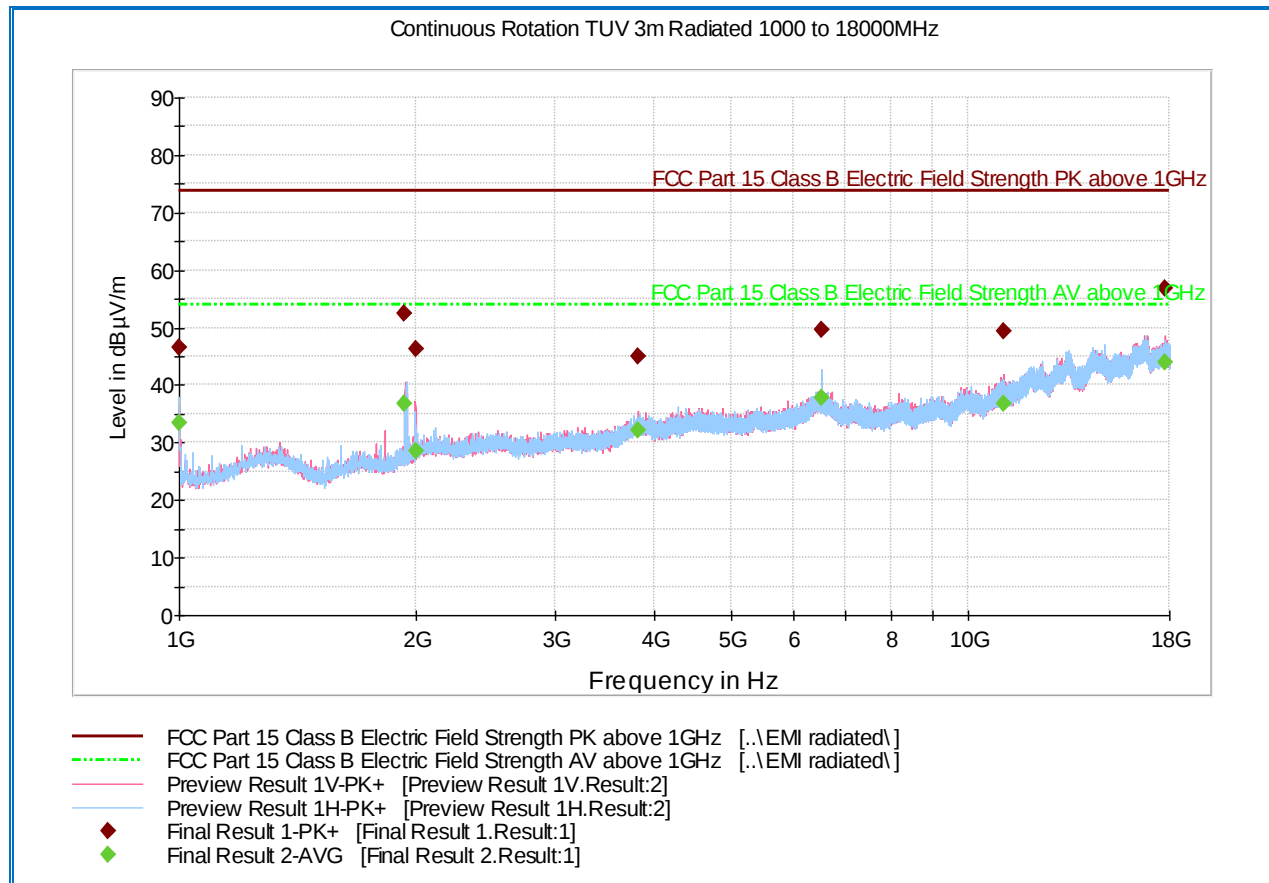
2.9.10 Test Results Below 1GHz (Receive Mode)



Quasi Peak Data

Frequency (MHz)	QuasiPeak (dBµV/m)	Meas. Time (ms)	Bandwidth (kHz)	Height (cm)	Polarization	Azimuth (deg)	Corr. (dB)	Margin (dB)	Limit (dBµV/m)
37.935551	12.5	1000.0	120.000	400.0	V	15.0	-15.7	27.5	40.0
73.189419	11.3	1000.0	120.000	106.0	V	315.0	-22.4	28.7	40.0
88.932745	17.0	1000.0	120.000	100.0	V	-2.0	-21.0	26.5	43.5
123.130501	15.0	1000.0	120.000	100.0	V	15.0	-20.6	28.5	43.5
332.086493	23.6	1000.0	120.000	100.0	H	22.0	-11.6	22.4	46.0
500.020842	28.2	1000.0	120.000	100.0	V	313.0	-7.1	17.8	46.0

2.9.11 Test Results Above 1GHz (Receive Mode)



Peak Data

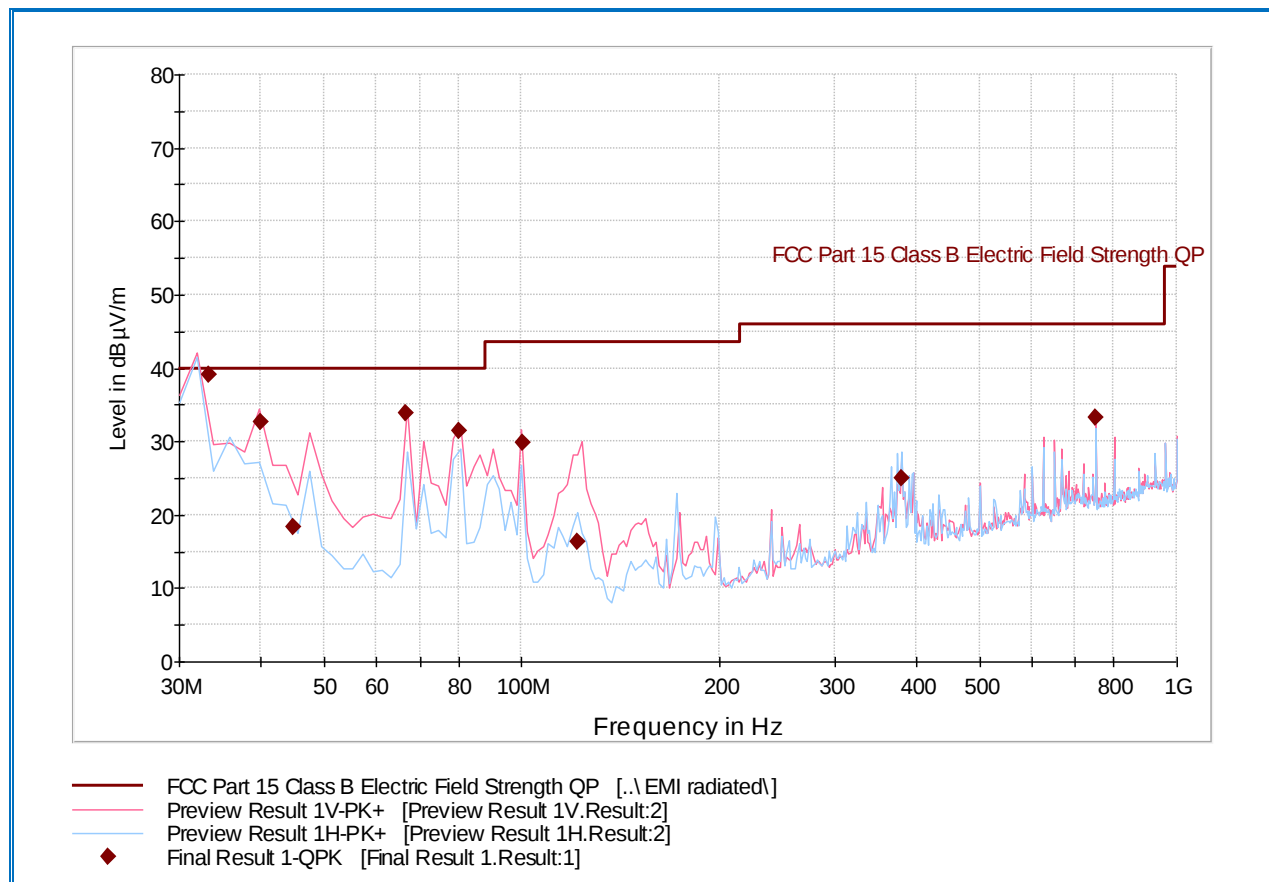
Frequency (MHz)	MaxPeak (dBµV/m)	Meas. Time (ms)	Bandwidth (kHz)	Height (cm)	Polarization	Azimuth (deg)	Corr. (dB)	Margin (dB)	Limit (dBµV/m)
1000.000000	46.5	1000.0	1000.000	237.4	H	0.0	-7.2	27.4	73.9
1932.533333	52.5	1000.0	1000.000	256.3	V	98.0	-2.3	21.4	73.9
1992.466667	46.2	1000.0	1000.000	218.4	V	20.0	-1.8	27.7	73.9
3815.400000	44.9	1000.0	1000.000	275.3	V	101.0	5.1	29.0	73.9
6527.633333	49.7	1000.0	1000.000	202.5	H	56.0	11.5	24.2	73.9
11085.333333	49.4	1000.0	1000.000	139.7	V	177.0	15.0	24.5	73.9
17745.566666	56.8	1000.0	1000.000	148.7	V	47.0	23.9	17.1	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)
1000.000000	33.5	1000.0	1000.000	237.4	H	0.0	-7.2	20.4	53.9
1932.533333	36.9	1000.0	1000.000	256.3	V	98.0	-2.3	17.0	53.9
1992.466667	28.7	1000.0	1000.000	218.4	V	20.0	-1.8	25.2	53.9
3815.400000	32.2	1000.0	1000.000	275.3	V	101.0	5.1	21.7	53.9
6527.633333	37.9	1000.0	1000.000	202.5	H	56.0	11.5	16.0	53.9
11085.333333	36.8	1000.0	1000.000	139.7	V	177.0	15.0	17.1	53.9
17745.566666	44.0	1000.0	1000.000	148.7	V	47.0	23.9	9.9	53.9

Test Notes: No significant emissions observed above 18GHz.

2.9.12 Test Results Below 1GHz (Bluetooth TX Worst Case – Non-hopping)

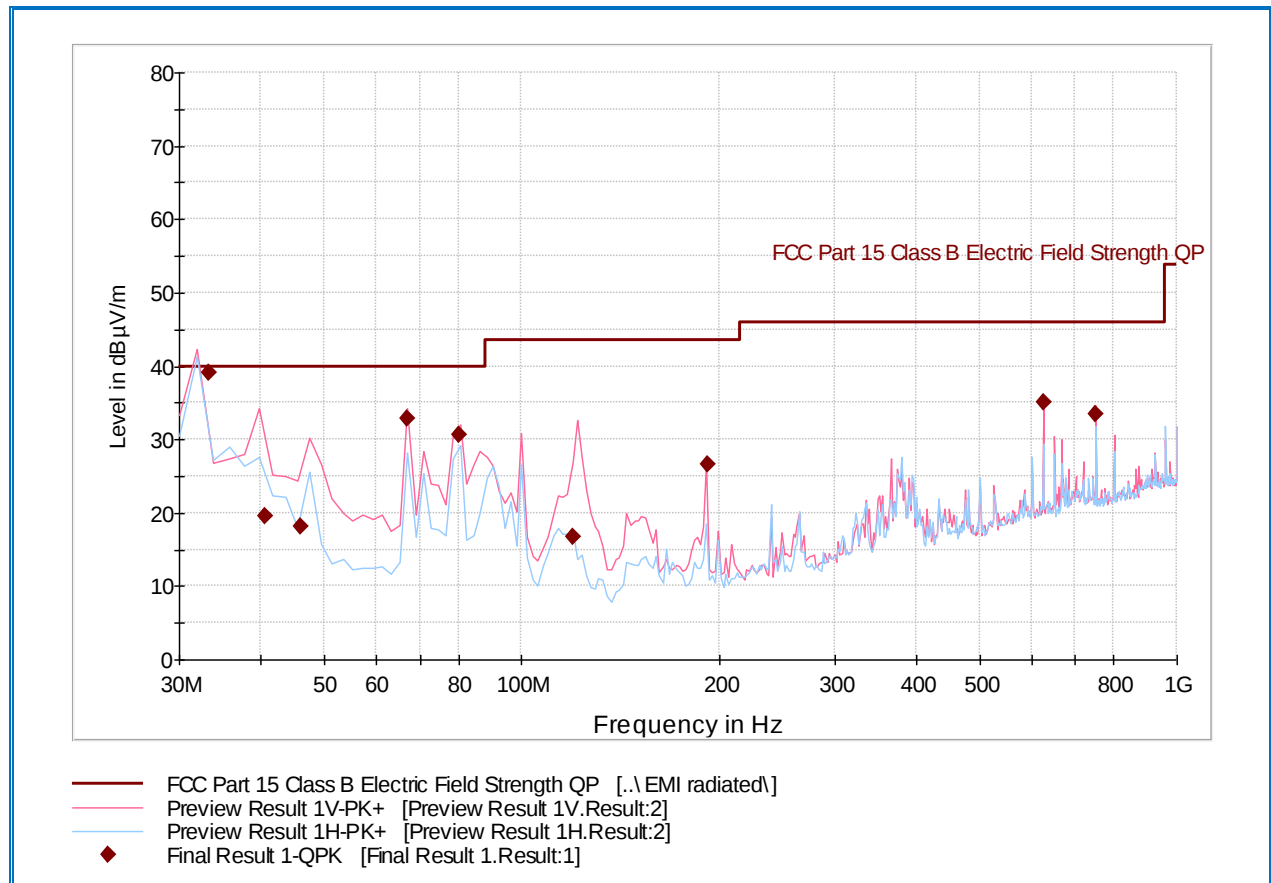


Quasi Peak Data

Frequency (MHz)	QuasiPeak (dBμV/m)	Meas. Time (ms)	Bandwidth (kHz)	Height (cm)	Polarization	Azimuth (deg)	Corr. (dB)	Margin (dB)	Limit (dBμV/m)
33.320000	39.1	1000.0	120.000	100.0	V	97.0	-13.2	0.9	40.0
40.039439	32.7	1000.0	120.000	100.0	V	175.0	-16.7	7.3	40.0
44.734990	18.3	1000.0	120.000	108.0	V	266.0	-18.5	21.7	40.0
66.573868	33.8	1000.0	120.000	100.0	V	142.0	-22.3	6.2	40.0
80.021082	31.4	1000.0	120.000	119.0	V	-14.0	-22.0	8.6	40.0
100.219960	29.9	1000.0	120.000	100.0	V	114.0	-19.8	13.6	43.5
121.666613	16.3	1000.0	120.000	200.0	V	11.0	-20.5	27.2	43.5
379.339800	24.9	1000.0	120.000	106.0	H	343.0	-9.7	21.1	46.0
750.022365	33.2	1000.0	120.000	100.0	V	342.0	-2.0	12.8	46.0

Test Notes: Only worst case channel presented for spurious emissions below 1GHz.

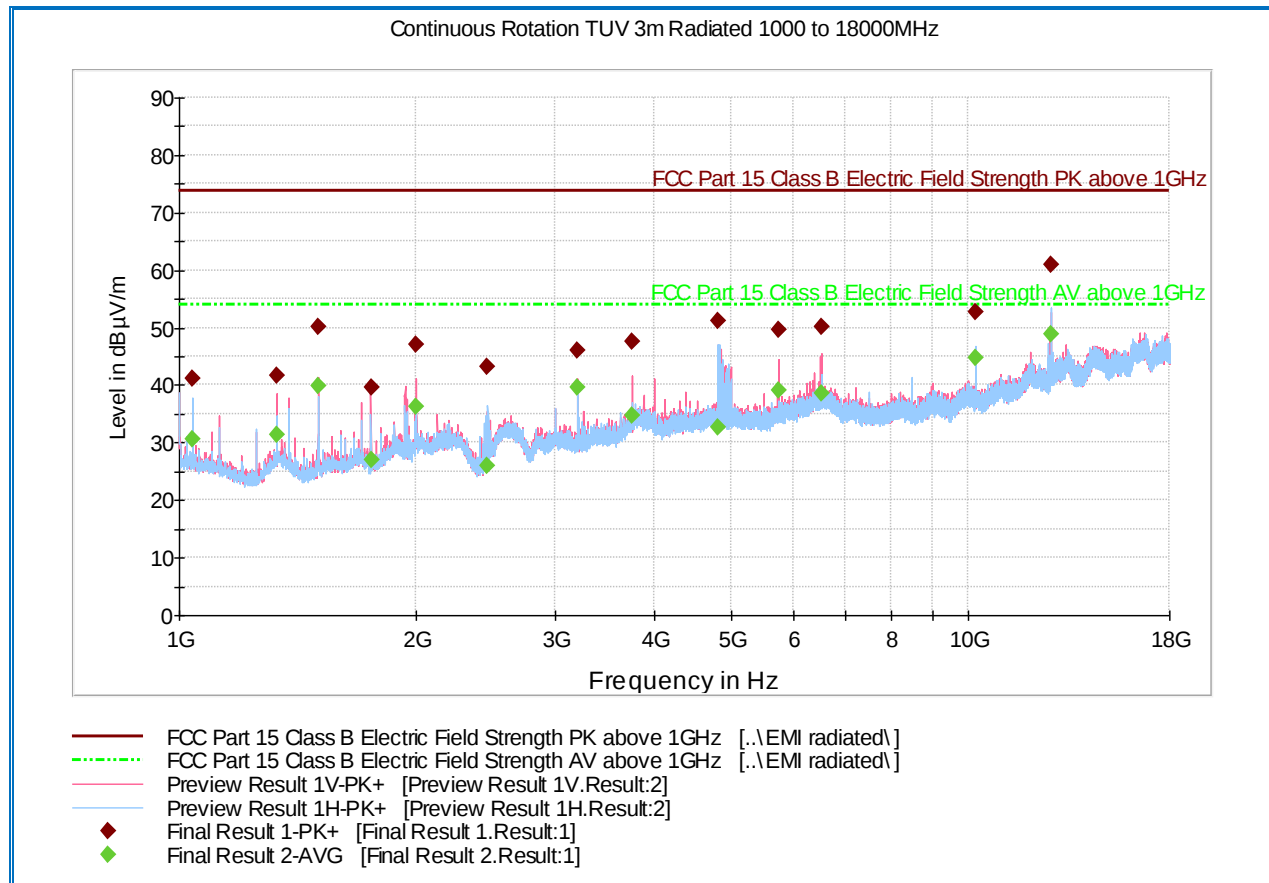
2.9.13 Test Results Below 1GHz (Bluetooth TX Worst Case – Hopping)



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)
33.320000	39.1	1000.0	120.000	100.0	V	102.0	-13.2	0.9	40.0
40.639439	19.5	1000.0	120.000	102.0	V	174.0	-17.0	20.5	40.0
45.934990	18.0	1000.0	120.000	100.0	V	94.0	-18.8	22.0	40.0
66.813868	32.8	1000.0	120.000	105.0	V	209.0	-22.3	7.2	40.0
80.021082	30.7	1000.0	120.000	127.0	V	24.0	-22.0	9.3	40.0
120.002725	16.7	1000.0	120.000	100.0	V	15.0	-20.4	26.8	43.5
192.022685	26.6	1000.0	120.000	100.0	V	212.0	-16.6	16.9	43.5
625.029659	35.0	1000.0	120.000	111.0	V	91.0	-3.5	11.0	46.0
750.062365	33.4	1000.0	120.000	100.0	V	-8.0	-2.0	12.6	46.0

2.9.14 Test Results Above 1GHz (Bluetooth TX Worst Case – Hopping)



Peak Data

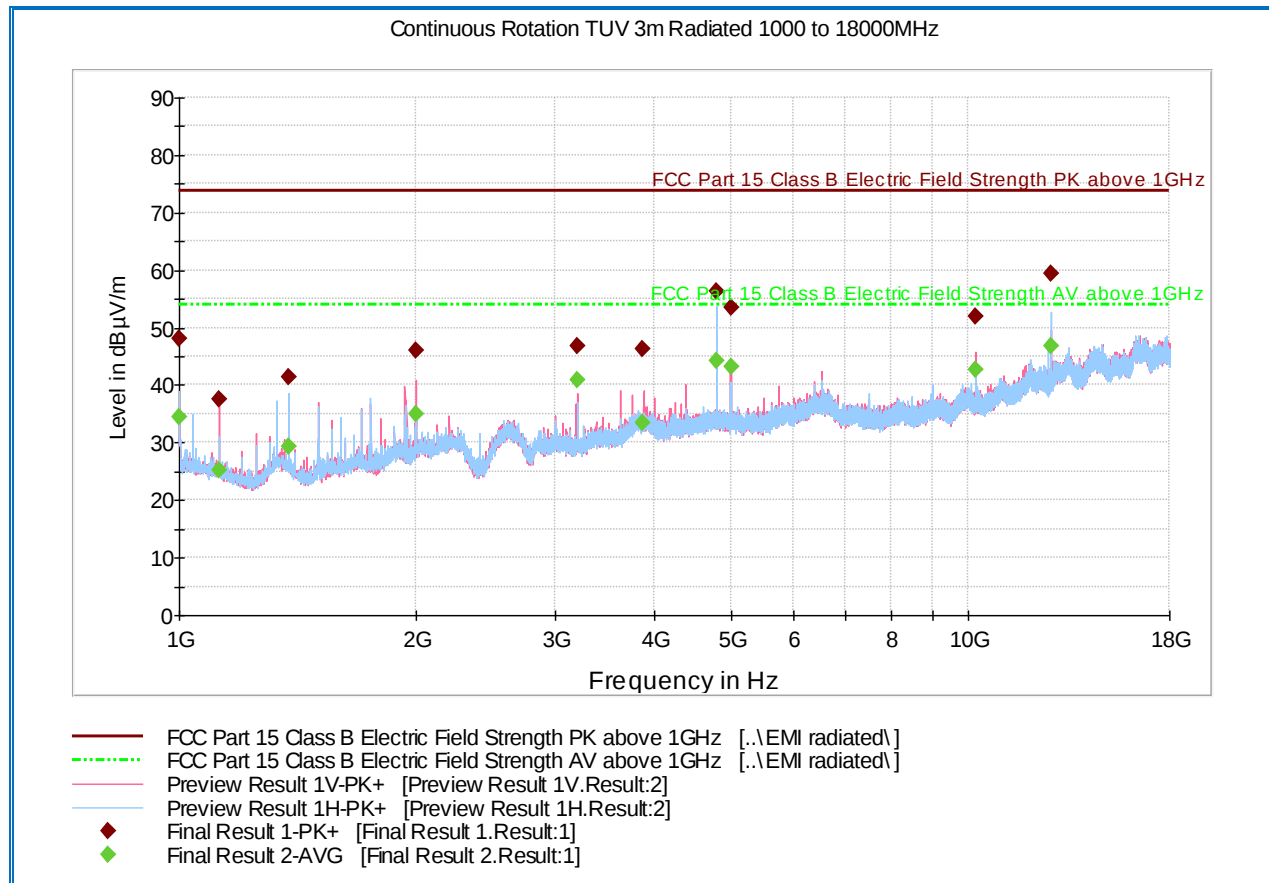
Frequency (MHz)	MaxPeak (dB μ V/m)	Meas. Time (ms)	Bandwidth (kHz)	Height (cm)	Polarization	Azimuth (deg)	Corr. (dB)	Margin (dB)	Limit (dB μ V/m)
1040.266667	41.2	1000.0	1000.000	172.6	H	46.0	-7.7	32.7	73.9
1331.700000	41.6	1000.0	1000.000	157.6	V	108.0	-5.3	32.3	73.9
1500.000000	50.3	1000.0	1000.000	236.4	V	-9.0	-6.0	23.6	73.9
1749.900000	39.5	1000.0	1000.000	156.7	V	68.0	-3.9	34.4	73.9
2000.200000	47.0	1000.0	1000.000	237.4	V	0.0	-1.8	26.9	73.9
2460.833333	43.1	1000.0	1000.000	171.6	H	20.0	-0.2	30.8	73.9
3200.000000	46.0	1000.0	1000.000	132.7	V	39.0	1.4	27.9	73.9
3750.233333	47.7	1000.0	1000.000	256.4	V	0.0	4.5	26.2	73.9
4823.866667	51.2	1000.0	1000.000	248.4	H	-20.0	5.8	22.7	73.9
5750.000000	49.7	1000.0	1000.000	155.6	V	1.0	8.6	24.2	73.9
6527.633333	50.3	1000.0	1000.000	163.6	V	118.0	11.5	23.6	73.9
10200.033333	52.7	1000.0	1000.000	206.5	H	3.0	13.2	21.2	73.9
12762.100000	60.8	1000.0	1000.000	302.2	H	341.0	18.1	13.1	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)
1040.266667	30.5	1000.0	1000.000	172.6	H	46.0	-7.7	23.4	53.9
1331.700000	31.3	1000.0	1000.000	157.6	V	108.0	-5.3	22.6	53.9
1500.000000	39.9	1000.0	1000.000	236.4	V	-9.0	-6.0	14.0	53.9
1749.900000	27.0	1000.0	1000.000	156.7	V	68.0	-3.9	26.9	53.9
2000.200000	36.2	1000.0	1000.000	237.4	V	0.0	-1.8	17.7	53.9
2460.833333	26.0	1000.0	1000.000	171.6	H	20.0	-0.2	27.9	53.9
3200.000000	39.5	1000.0	1000.000	132.7	V	39.0	1.4	14.4	53.9
3750.233333	34.7	1000.0	1000.000	256.4	V	0.0	4.5	19.2	53.9
4823.866667	32.6	1000.0	1000.000	248.4	H	-20.0	5.8	21.3	53.9
5750.000000	39.0	1000.0	1000.000	155.6	V	1.0	8.6	14.9	53.9
6527.633333	38.5	1000.0	1000.000	163.6	V	118.0	11.5	15.4	53.9
10200.033333	44.7	1000.0	1000.000	206.5	H	3.0	13.2	9.2	53.9
12762.100000	48.9	1000.0	1000.000	302.2	H	341.0	18.1	5.0	53.9

Test Notes: Measurement was performed with a 2.4GHz notch filter.

2.9.15 Test Results Above 1GHz Low Channel (Bluetooth TX Worst Case)



Peak Data

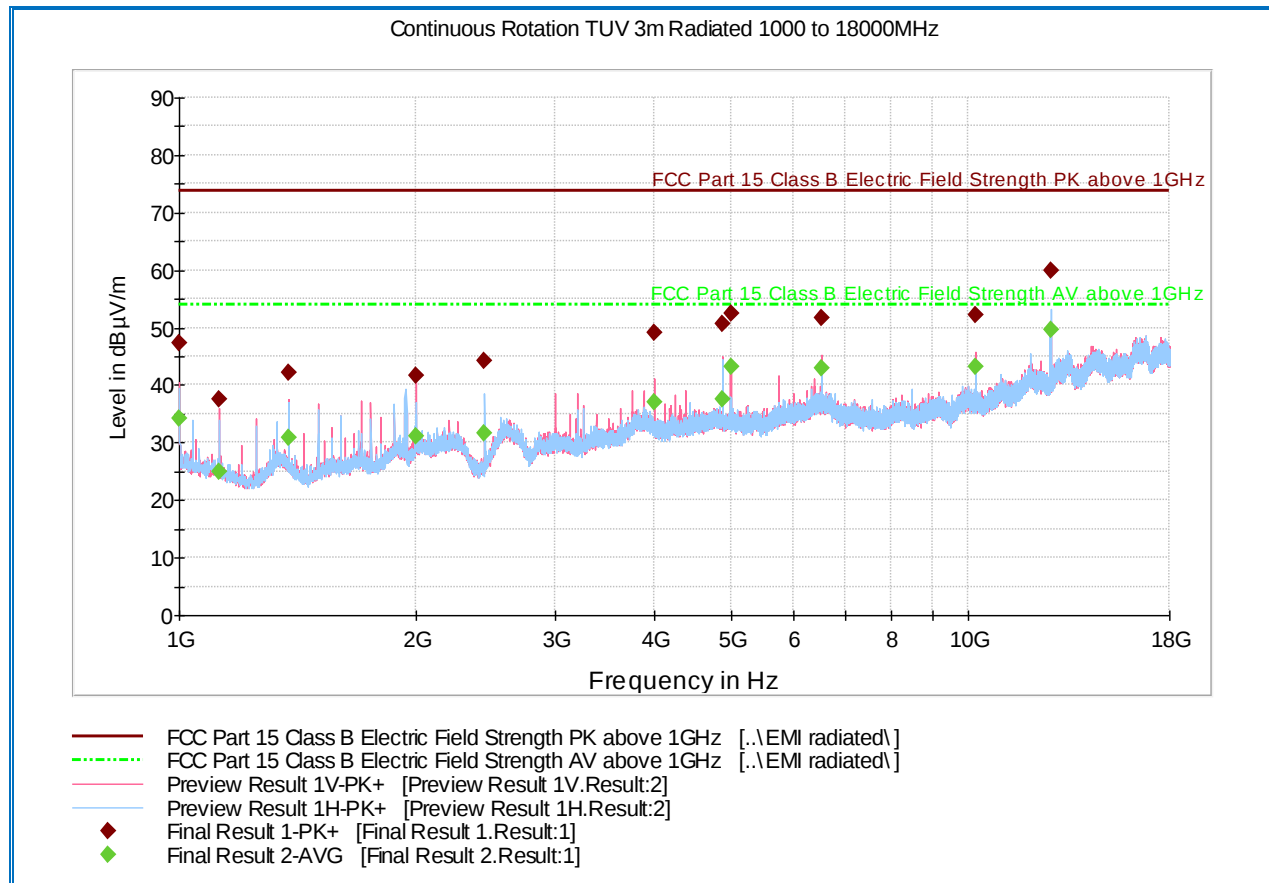
Frequency (MHz)	MaxPeak (dBµV/m)	Meas. Time (ms)	Bandwidth (kHz)	Height (cm)	Polarization	Azimuth (deg)	Corr. (dB)	Margin (dB)	Limit (dBµV/m)
1000.000000	48.0	1000.0	1000.000	257.3	H	187.0	-7.2	25.9	73.9
1124.866667	37.7	1000.0	1000.000	156.7	V	-3.0	-7.1	36.2	73.9
1375.166667	41.3	1000.0	1000.000	173.6	H	111.0	-5.3	32.6	73.9
2000.000000	45.9	1000.0	1000.000	295.3	V	4.0	-1.8	28.0	73.9
3200.000000	46.7	1000.0	1000.000	165.6	V	-3.0	1.4	27.2	73.9
3874.500000	46.4	1000.0	1000.000	162.6	V	-9.0	5.1	27.5	73.9
4804.033333	56.3	1000.0	1000.000	202.3	H	358.0	5.8	17.6	73.9
4999.900000	53.6	1000.0	1000.000	170.6	V	-10.0	6.6	20.3	73.9
10200.233333	52.0	1000.0	1000.000	299.2	V	171.0	13.2	21.9	73.9
12762.100000	59.4	1000.0	1000.000	276.3	H	-3.0	18.1	14.5	73.9

Average Data

Frequency (MHz)	Average (dBµV/m)	Meas. Time (ms)	Bandwidth (kHz)	Height (cm)	Polarization	Azimuth (deg)	Corr. (dB)	Margin (dB)	Limit (dBµV/m)
1000.000000	34.3	1000.0	1000.000	257.3	H	187.0	-7.2	19.6	53.9
1124.866667	25.2	1000.0	1000.000	156.7	V	-3.0	-7.1	28.7	53.9
1375.166667	29.2	1000.0	1000.000	173.6	H	111.0	-5.3	24.7	53.9
2000.000000	34.9	1000.0	1000.000	295.3	V	4.0	-1.8	19.0	53.9
3200.000000	40.9	1000.0	1000.000	165.6	V	-3.0	1.4	13.0	53.9
3874.500000	33.4	1000.0	1000.000	162.6	V	-9.0	5.1	20.5	53.9
4804.033333	44.3	1000.0	1000.000	202.3	H	358.0	5.8	9.6	53.9
4999.900000	43.1	1000.0	1000.000	170.6	V	-10.0	6.6	10.8	53.9
10200.233333	42.7	1000.0	1000.000	299.2	V	171.0	13.2	11.2	53.9
12762.100000	46.8	1000.0	1000.000	276.3	H	-3.0	18.1	7.1	53.9

Test Notes: Measurement was performed with a 2.4GHz notch filter.

2.9.16 Test Results Above 1GHz Mid Channel (Bluetooth TX Worst Case)



Peak Data

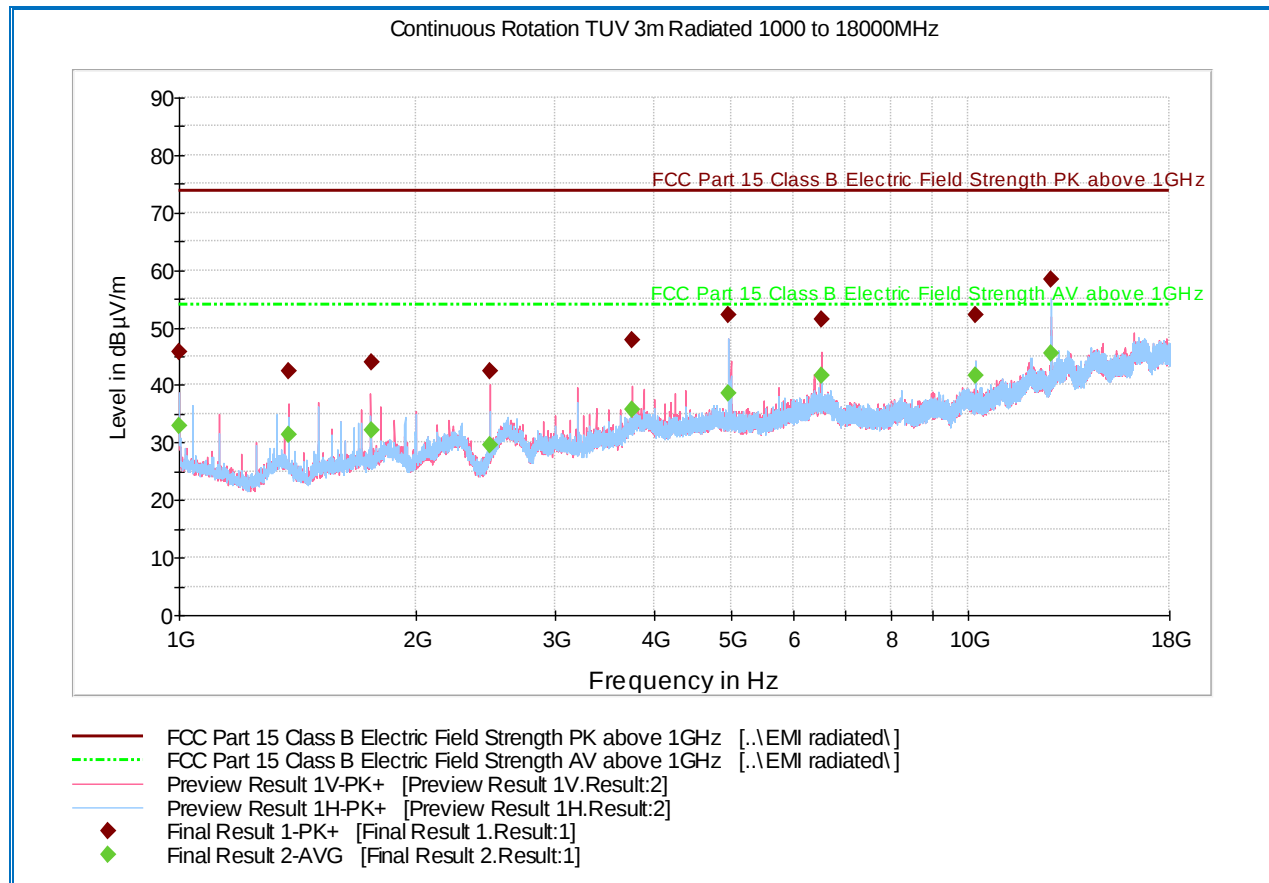
Frequency (MHz)	MaxPeak (dBµV/m)	Meas. Time (ms)	Bandwidth (kHz)	Height (cm)	Polarization	Azimuth (deg)	Corr. (dB)	Margin (dB)	Limit (dBµV/m)
1000.000000	47.2	1000.0	1000.000	276.3	V	248.0	-7.2	26.7	73.9
1124.866667	37.4	1000.0	1000.000	155.6	V	0.0	-7.1	36.5	73.9
1374.766667	42.3	1000.0	1000.000	219.4	V	16.0	-5.3	31.6	73.9
1999.600000	41.7	1000.0	1000.000	198.5	V	-3.0	-1.8	32.2	73.9
2439.733333	44.3	1000.0	1000.000	173.6	H	57.0	-0.3	29.6	73.9
3999.733333	49.0	1000.0	1000.000	132.7	V	9.0	5.0	24.9	73.9
4879.966667	50.6	1000.0	1000.000	116.7	V	-3.0	6.1	23.3	73.9
4999.900000	52.4	1000.0	1000.000	182.6	V	72.0	6.6	21.5	73.9
6528.033333	51.7	1000.0	1000.000	202.3	V	291.0	11.5	22.2	73.9
10200.033333	52.3	1000.0	1000.000	248.3	V	170.0	13.2	21.6	73.9
12762.100000	59.8	1000.0	1000.000	164.6	H	353.0	18.1	14.1	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)
1000.000000	34.2	1000.0	1000.000	276.3	V	248.0	-7.2	19.7	53.9
1124.866667	25.0	1000.0	1000.000	155.6	V	0.0	-7.1	28.9	53.9
1374.766667	30.9	1000.0	1000.000	219.4	V	16.0	-5.3	23.0	53.9
1999.600000	31.1	1000.0	1000.000	198.5	V	-3.0	-1.8	22.8	53.9
2439.733333	31.7	1000.0	1000.000	173.6	H	57.0	-0.3	22.2	53.9
3999.733333	37.0	1000.0	1000.000	132.7	V	9.0	5.0	16.9	53.9
4879.966667	37.5	1000.0	1000.000	116.7	V	-3.0	6.1	16.4	53.9
4999.900000	43.1	1000.0	1000.000	182.6	V	72.0	6.6	10.8	53.9
6528.033333	42.9	1000.0	1000.000	202.3	V	291.0	11.5	11.0	53.9
10200.033333	43.2	1000.0	1000.000	248.3	V	170.0	13.2	10.7	53.9
12762.100000	49.6	1000.0	1000.000	164.6	H	353.0	18.1	4.3	53.9

Test Notes: Measurement was performed with a 2.4GHz notch filter.

2.9.17 Test Results Above 1GHz High Channel (Bluetooth TX Worst Case)



Peak Data

Frequency (MHz)	MaxPeak (dBμV/m)	Meas. Time (ms)	Bandwidth (kHz)	Height (cm)	Polarization	Azimuth (deg)	Corr. (dB)	Margin (dB)	Limit (dBμV/m)
1000.000000	45.8	1000.0	1000.000	256.3	V	248.0	-7.2	28.1	73.9
1374.966667	42.3	1000.0	1000.000	219.4	V	16.0	-5.3	31.6	73.9
1749.900000	43.9	1000.0	1000.000	250.3	V	-1.0	-3.9	30.0	73.9
2479.933333	42.5	1000.0	1000.000	144.7	V	135.0	-0.1	31.4	73.9
3749.833333	47.9	1000.0	1000.000	103.7	V	45.0	4.5	26.0	73.9
4960.266667	52.3	1000.0	1000.000	132.7	H	16.0	6.5	21.6	73.9
6527.633333	51.4	1000.0	1000.000	202.3	V	292.0	11.5	22.5	73.9
10200.033333	52.1	1000.0	1000.000	246.3	H	187.0	13.2	21.8	73.9
12762.100000	58.3	1000.0	1000.000	278.3	H	-3.0	18.1	15.6	73.9

Average Data

Frequency (MHz)	Average (dBμV/m)	Meas. Time (ms)	Bandwidth (kHz)	Height (cm)	Polarization	Azimuth (deg)	Corr. (dB)	Margin (dB)	Limit (dBμV/m)
1000.000000	32.8	1000.0	1000.000	256.3	V	248.0	-7.2	21.1	53.9
1374.966667	31.4	1000.0	1000.000	219.4	V	16.0	-5.3	22.5	53.9
1749.900000	32.1	1000.0	1000.000	250.3	V	-1.0	-3.9	21.8	53.9
2479.933333	29.5	1000.0	1000.000	144.7	V	135.0	-0.1	24.4	53.9
3749.833333	35.8	1000.0	1000.000	103.7	V	45.0	4.5	18.1	53.9
4960.266667	38.6	1000.0	1000.000	132.7	H	16.0	6.5	15.3	53.9
6527.633333	41.5	1000.0	1000.000	202.3	V	292.0	11.5	12.4	53.9
10200.033333	41.7	1000.0	1000.000	246.3	H	187.0	13.2	12.2	53.9
12762.100000	45.6	1000.0	1000.000	278.3	H	-3.0	18.1	8.3	53.9

Test Notes: Measurement was performed with a 2.4GHz notch filter.

2.10 RADIATED IMMEDIATE RESTRICTED BANDS

2.10.1 Specification Reference

Part 15 Subpart C §15.247(d)

2.10.2 Standard Applicable

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

2.10.3 Equipment Under Test and Modification State

Serial No: C20015440005 / Test Configuration B

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

December 16, 2015 / AC

2.10.5 Test Equipment Used

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

2.10.6 Environmental Conditions

Test performed at TÜV SÜD America Inc. Rancho Bernardo facility

Ambient Temperature	24.6 °C
Relative Humidity	35.1 %
ATM Pressure	99.1 kPa

2.10.7 Additional Observations

- This is a radiated test. The spectrum was searched from 2310MHz to 2390MHz for lower immediate restricted band and 2483.5MHz to 2500MHz for the upper immediate restricted band.
- There are no emissions found that do not comply with the restricted bands defined in FCC Part 15 Subpart C, 15.205.
- Both Non-hopping and Hopping modes were verified.



- 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 2.10.8 for sample computation.

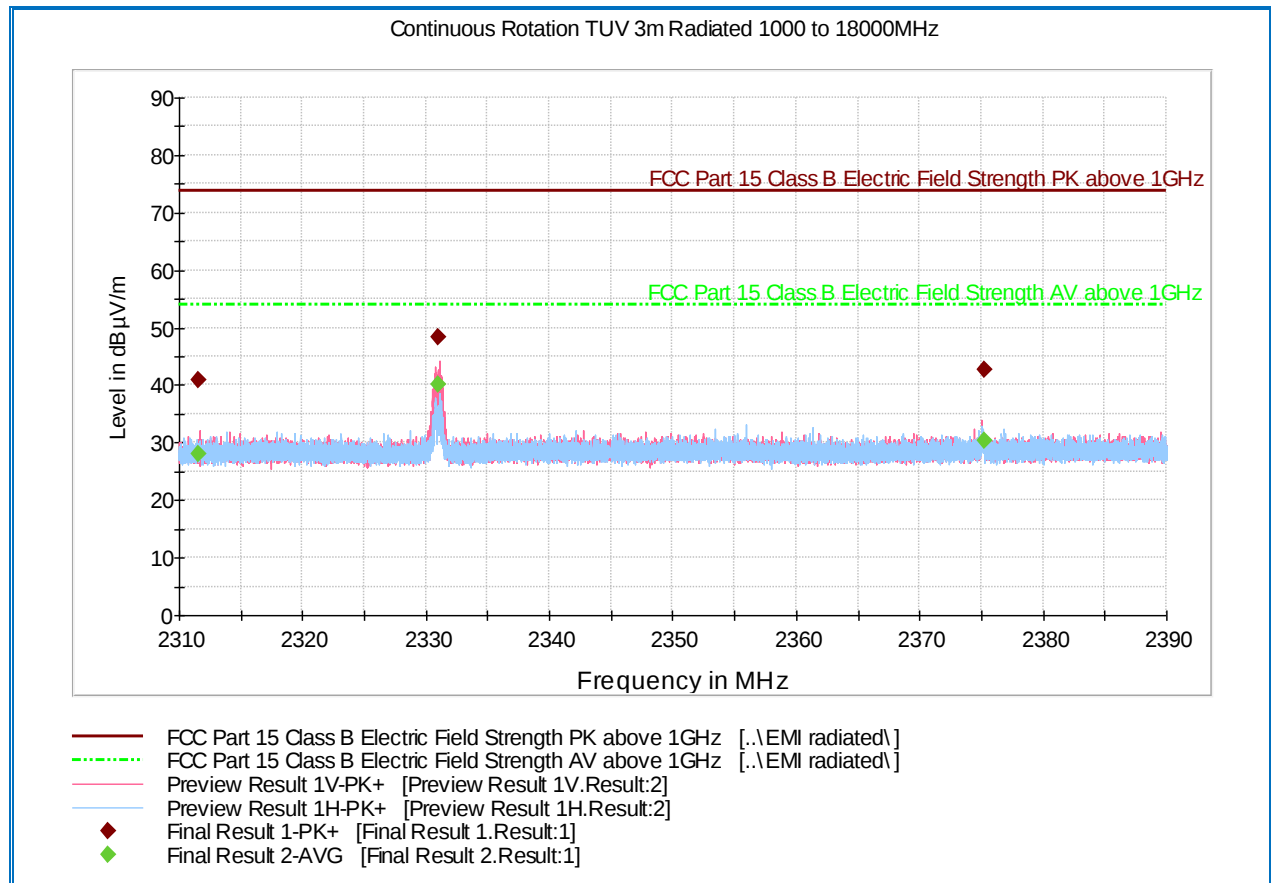
2.10.8 Sample Computation (Radiated Emission)

Measuring equipment raw measurement (dB μ V) @ 2400 MHz			53.9
Correction Factor (dB)	Asset# 1153 (cable)	3.4	-0.4
	Asset# 8628(preamplifier)	-36.5	
	Asset#7575 (antenna)	32.7	
Reported Max Peak Final Measurement (dB μ V/m) @ 2400 MHz			53.5

2.10.9 Test Results

See attached plots.

2.10.10 Test Results Restricted Band 2310MHz to 2390MHz (Hopping)



Peak Data

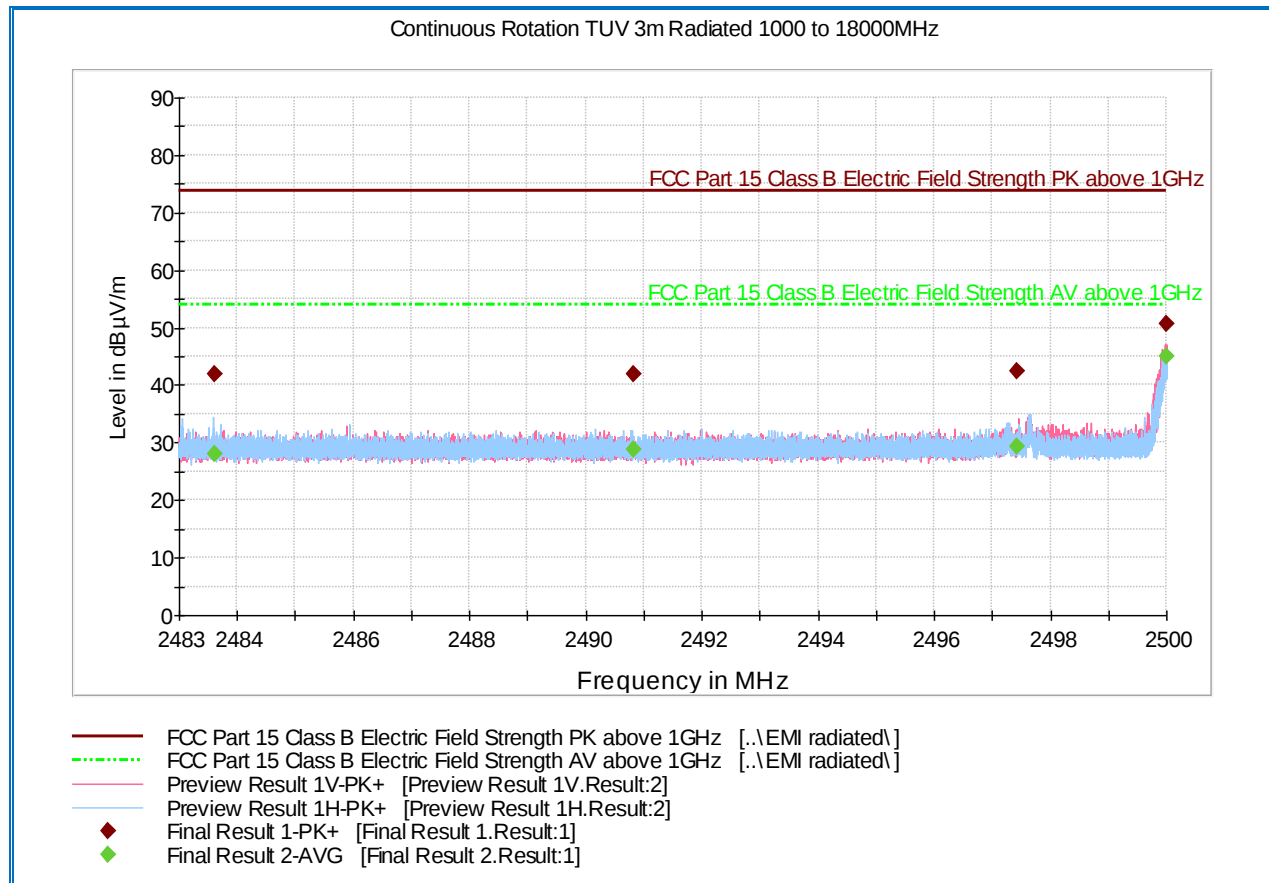
Frequency (MHz)	MaxPeak (dBµV/m)	Meas. Time (ms)	Bandwidth (kHz)	Height (cm)	Polarization	Azimuth (deg)	Corr. (dB)	Margin (dB)	Limit (dBµV/m)
2311.517333	41.0	1000.0	1000.000	219.4	V	257.0	-0.7	32.9	73.9
2330.952000	48.2	1000.0	1000.000	163.6	V	24.0	-0.6	25.7	73.9
2375.240000	42.7	1000.0	1000.000	171.6	V	36.0	-0.6	31.2	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)
2311.517333	28.1	1000.0	1000.000	219.4	V	257.0	-0.7	25.8	53.9
2330.952000	40.0	1000.0	1000.000	163.6	V	24.0	-0.6	13.9	53.9
2375.240000	30.3	1000.0	1000.000	171.6	V	36.0	-0.6	23.6	53.9

Test Notes: 2.4GHz notch filter removed for this test.

2.10.11 Test Results Restricted Band 2483.5MHz to 2500MHz (Hopping)



Peak Data

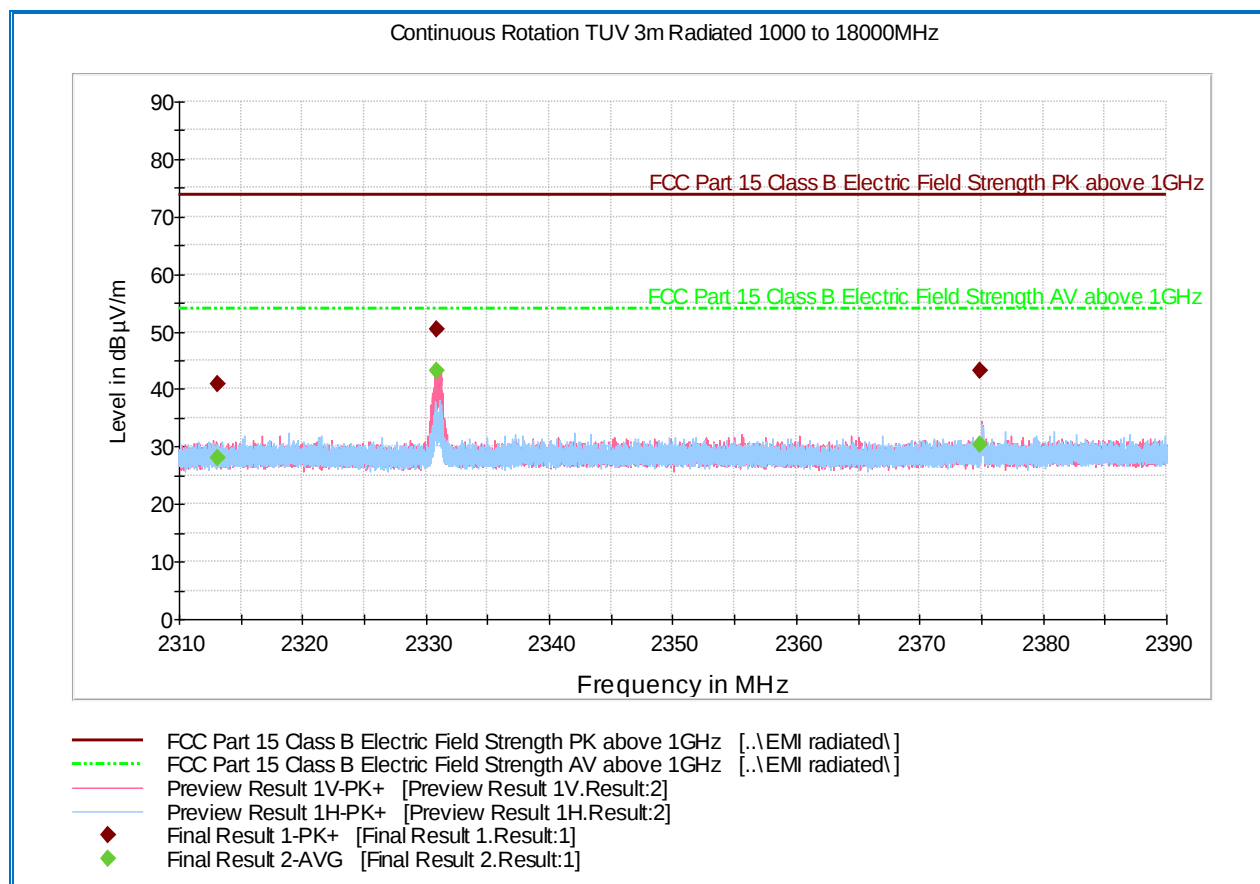
Frequency (MHz)	MaxPeak (dBµV/m)	Meas. Time (ms)	Bandwidth (kHz)	Height (cm)	Polarization	Azimuth (deg)	Corr. (dB)	Margin (dB)	Limit (dBµV/m)
2483.600000	42.0	1000.0	1000.000	163.6	V	41.0	0.0	25.7	73.9
2490.821733	42.0	1000.0	1000.000	115.8	H	221.0	0.0	31.9	73.9
2497.427367	42.5	1000.0	1000.000	154.7	H	38.0	0.0	31.4	73.9
2500.000000	50.8	1000.0	1000.000	155.7	H	324.0	0.0	23.1	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)
2483.600000	28.0	1000.0	1000.000	163.6	V	41.0	0.0	15.3	53.9
2490.821733	28.8	1000.0	1000.000	115.8	H	221.0	0.0	25.1	53.9
2497.427367	29.3	1000.0	1000.000	154.7	H	38.0	0.0	24.6	53.9
2500.000000	45.0	1000.0	1000.000	155.7	H	324.0	0.0	8.9	53.9

Test Notes: 2.4GHz notch filter removed for this test.

2.10.12 Test Results Restricted Band 2310MHz to 2390MHz (Non Hopping)



Peak Data

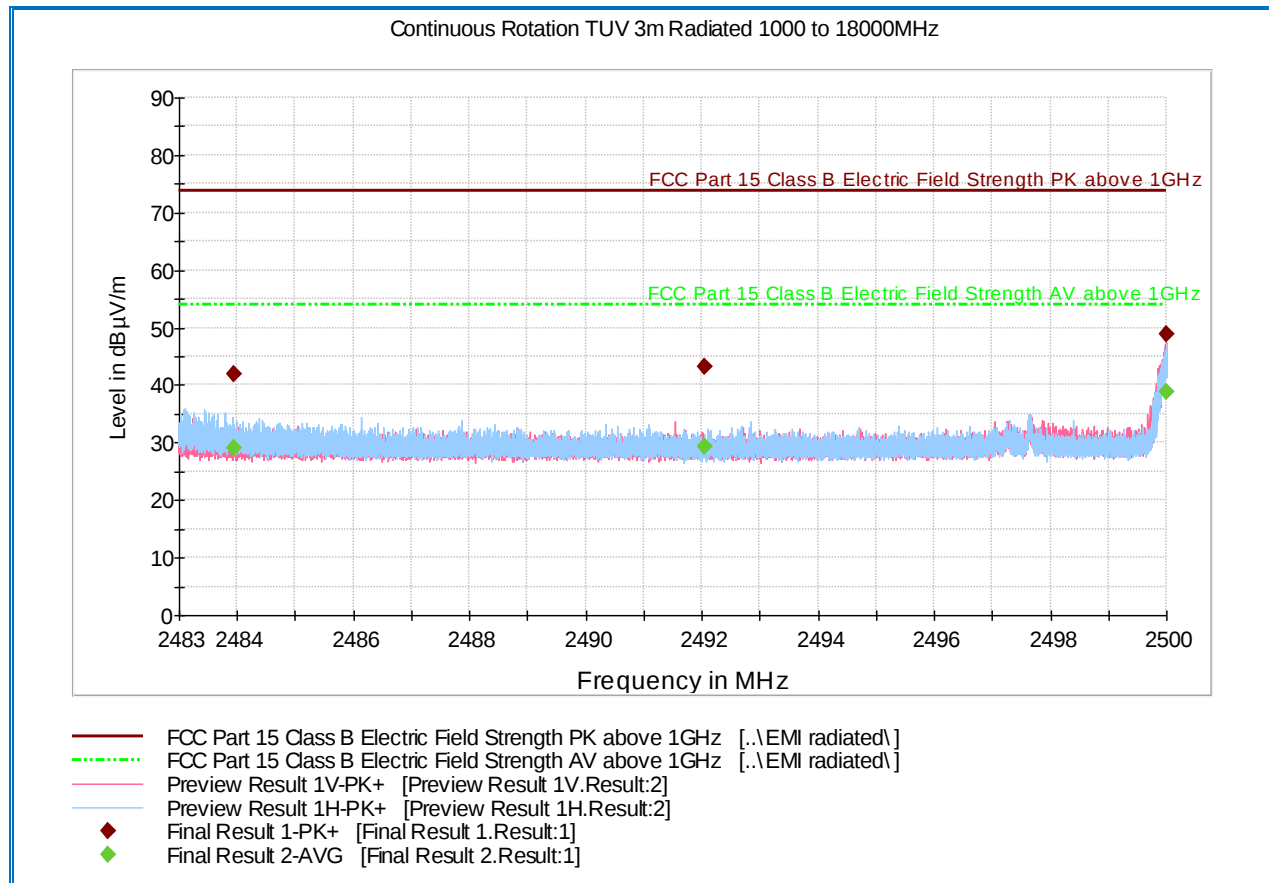
Frequency (MHz)	MaxPeak (dBµV/m)	Meas. Time (ms)	Bandwidth (kHz)	Height (cm)	Polarization	Azimuth (deg)	Corr. (dB)	Margin (dB)	Limit (dBµV/m)
2313.162667	41.0	1000.0	1000.000	379.1	V	137.0	-0.7	32.9	73.9
2330.906667	50.5	1000.0	1000.000	156.6	V	20.0	-0.6	23.4	73.9
2374.829333	43.1	1000.0	1000.000	157.6	V	3.0	-0.6	30.8	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)
2313.162667	28.1	1000.0	1000.000	379.1	V	137.0	-0.7	25.8	53.9
2330.906667	43.2	1000.0	1000.000	156.6	V	20.0	-0.6	10.7	53.9
2374.829333	30.4	1000.0	1000.000	157.6	V	3.0	-0.6	23.5	53.9

Test Notes: 2.4GHz notch filter removed for this test.

2.10.13 Test Results Restricted Band 2483.5MHz to 2500MHz (Non Hopping)



Peak Data

Frequency (MHz)	MaxPeak (dBµV/m)	Meas. Time (ms)	Bandwidth (kHz)	Height (cm)	Polarization	Azimuth (deg)	Corr. (dB)	Margin (dB)	Limit (dBµV/m)
2483.937967	41.9	1000.0	1000.000	162.6	V	86.0	0.0	32.0	73.9
2492.037967	43.3	1000.0	1000.000	131.7	H	19.0	0.0	30.6	73.9
2500.000000	48.8	1000.0	1000.000	174.6	V	347.0	0.0	25.1	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)
2483.937967	29.1	1000.0	1000.000	162.6	V	86.0	0.0	24.8	53.9
2492.037967	29.4	1000.0	1000.000	131.7	H	19.0	0.0	24.5	53.9
2500.000000	38.9	1000.0	1000.000	174.6	V	347.0	0.0	15.0	53.9

Test Notes: 2.4GHz notch filter removed for this test.

2.11 RECEIVER SPURIOUS EMISSIONS

2.11.1 Specification Reference

RSS-Gen 7.1

2.11.2 Standard Applicable

Spurious emissions from receivers shall not exceed the radiated limits shown in Table 2 below:

Table 2: Receiver Radiated Limits

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

*Measurements for compliance with limits in the above table may be performed at distances other than 3 metres, in accordance with Section 6.5 of RSS-Gen.

2.11.3 Equipment Under Test and Modification State

Serial No: C20015440005 / Test Configuration B

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

December 15, 2015 / AC

2.11.5 Test Equipment Used

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

2.11.6 Environmental Conditions

Test performed at TÜV SÜD America Inc. Rancho Bernardo facility

Ambient Temperature 21.6 °C
Relative Humidity 35.1 %
ATM Pressure 99.1 kPa

2.11.7 Additional Observations

- This is a radiated test. The spectrum was searched from 30MHz to the 3rd harmonic (up to 10th performed).
- Result identical to Section 2.9.10 and 2.9.11 of this test report.
- EUT in RX (Receive) mode configuration.

SECTION 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
Antenna Conducted Port Setup						
7604	P-Series Power Meter	N1912A	SG45100273	Agilent	05/27/15	05/27/16
7605	50MHz-18GHz Wideband Power Sensor	N1921A	MY51100054	Agilent	04/10/15	04/10/16
7582	Signal/Spectrum Analyzer	FSW26	101614	Rhode & Schwarz	12/22/14	12/22/15
1189	Signal Generator	8648C	3623A03059	Hewlett Packard	10/14/14	10/14/15
7608	Vector Signal Generator	SMBV100A	259021	Rhode & Schwarz	07/29/15	07/29/16
8825	20dB Attenuator	46-20-34	BK5773	Weinschel Corp.	Verified by 7582 and 7608	
Radiated Test Setup						
7575	Double-ridged waveguide horn antenna	3117	00155511	EMCO	04/27/15	04/27/16
8628	Pre-amplifier	QLJ 01182835-JO	8986002	QuinStar Technologies Inc.	03/20/15	03/20/16
1002	Bilog Antenna	3142C	00058717	ETS-Lindgren	01/30/14	01/30/16
1040	EMI Test Receiver	ESIB40	100292	Rhode & Schwarz	09/29/15	09/29/16
1049	EMI Test Receiver	ESU	100133	Rhode & Schwarz	03/11/15	03/11/16
6815	2.4GHz Band Notch Filter	BRM50702	008	Micro-Tronics	Verified by 1049	
1016	Pre-amplifier	PAM-0202	187	PAM	12/10/14	12/10/15
Miscellaneous						
6792	Multimeter	3478A	2911A70964	Hewlett Packard	08/14/15	08/14/16
7560	Barometer/Temperature/Hu midity Transmitter	iBTHX-W	1240476	Omega	10/19/15	10/19/16
1123	DC Power Supply	E3631A	N/A	Hewlett Packard	Verified by 6792	
	Test Software	EMC32	V8.53	Rhode & Schwarz	N/A	

3.2 MEASUREMENT UNCERTAINTY

For a 95% confidence level, the measurement uncertainties for defined systems are:

3.2.1 Radiated Emission Measurements (Below 1GHz)

Contribution		Probability Distribution Type	Probability Distribution x_i	Standard Uncertainty $u(x_i)$	$[u(x_i)]^2$
1	Receiver/Spectrum Analyzer	Rectangular	0.45	0.26	0.07
2	Cables	Rectangular	0.50	0.29	0.08
3	Preamplifier	Rectangular	0.50	0.29	0.08
4	Antenna	Rectangular	0.75	0.43	0.19
5	Site	Rectangular	2.70	1.56	2.43
6	EUT Setup	Rectangular	1.00	0.58	0.33
Combined Uncertainty (u_c):					1.78
Coverage Factor (k):					2
Expanded Uncertainty:					3.57

3.2.2 Radiated Emission Measurements (Above 1GHz)

Contribution		Probability Distribution Type	Probability Distribution x_i	Standard Uncertainty $u(x_i)$	$[u(x_i)]^2$
1	Receiver/Spectrum Analyzer	Rectangular	0.57	0.33	0.11
2	Cables	Rectangular	0.70	0.40	0.16
3	Preamplifier	Rectangular	0.50	0.29	0.08
4	Antenna	Rectangular	0.37	0.21	0.05
5	Site	Rectangular	2.70	1.56	2.43
6	EUT Setup	Rectangular	1.00	0.58	0.33
Combined Uncertainty (u_c):					1.78
Coverage Factor (k):					2
Expanded Uncertainty:					3.56

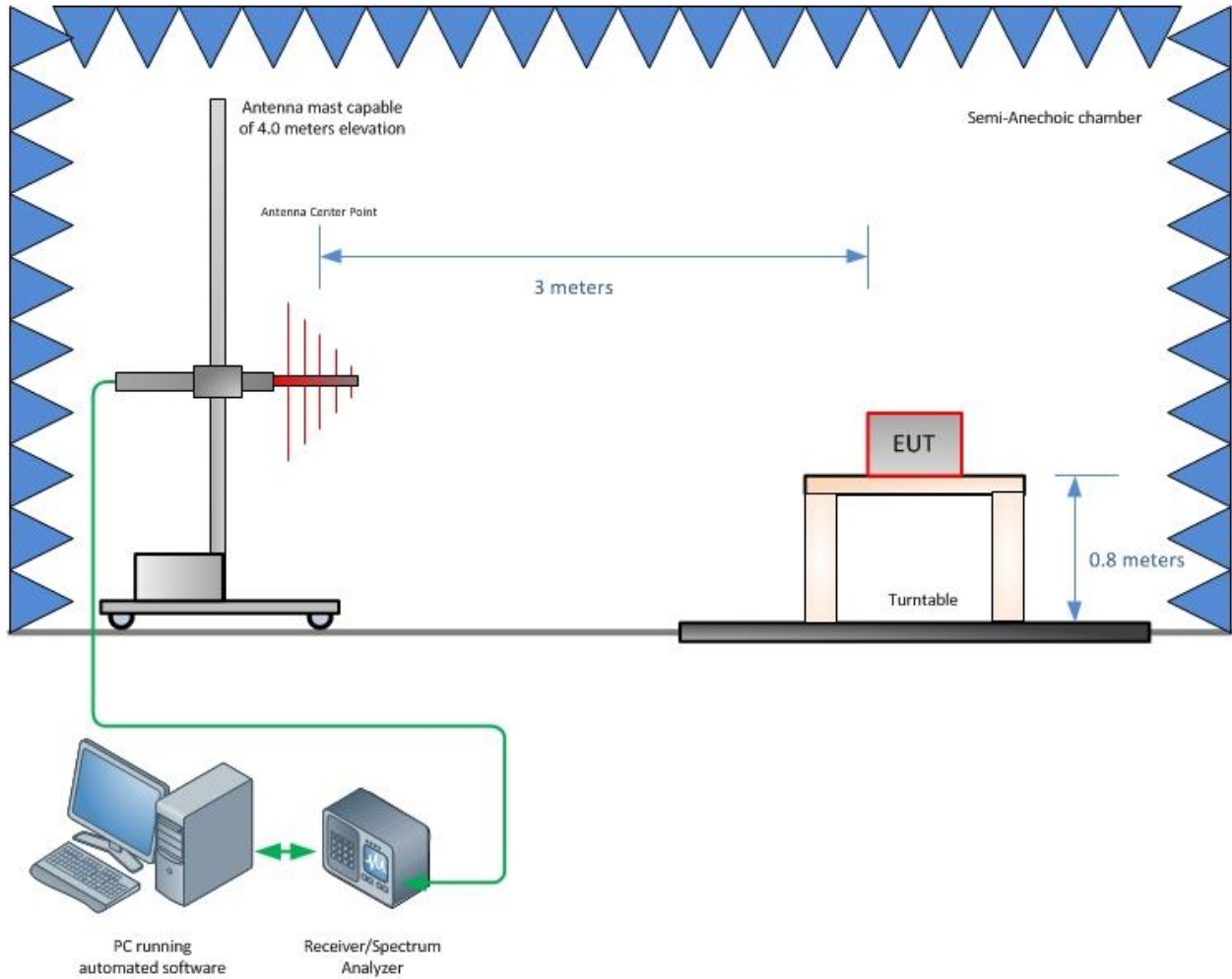
3.2.3 Conducted Antenna Port Measurement

Contribution		Probability Distribution Type	Probability Distribution x_i	Standard Uncertainty $u(x_i)$	$[u(x_i)]^2$
1	Receiver/Spectrum Analyzer	Rectangular	0.34	0.20	0.04
2	Cables	Rectangular	1.00	0.58	0.33
3	EUT Setup	Rectangular	0.50	0.29	0.08
Combined Uncertainty (u_c):					0.67
Coverage Factor (k):					1.96
Expanded Uncertainty:					1.32

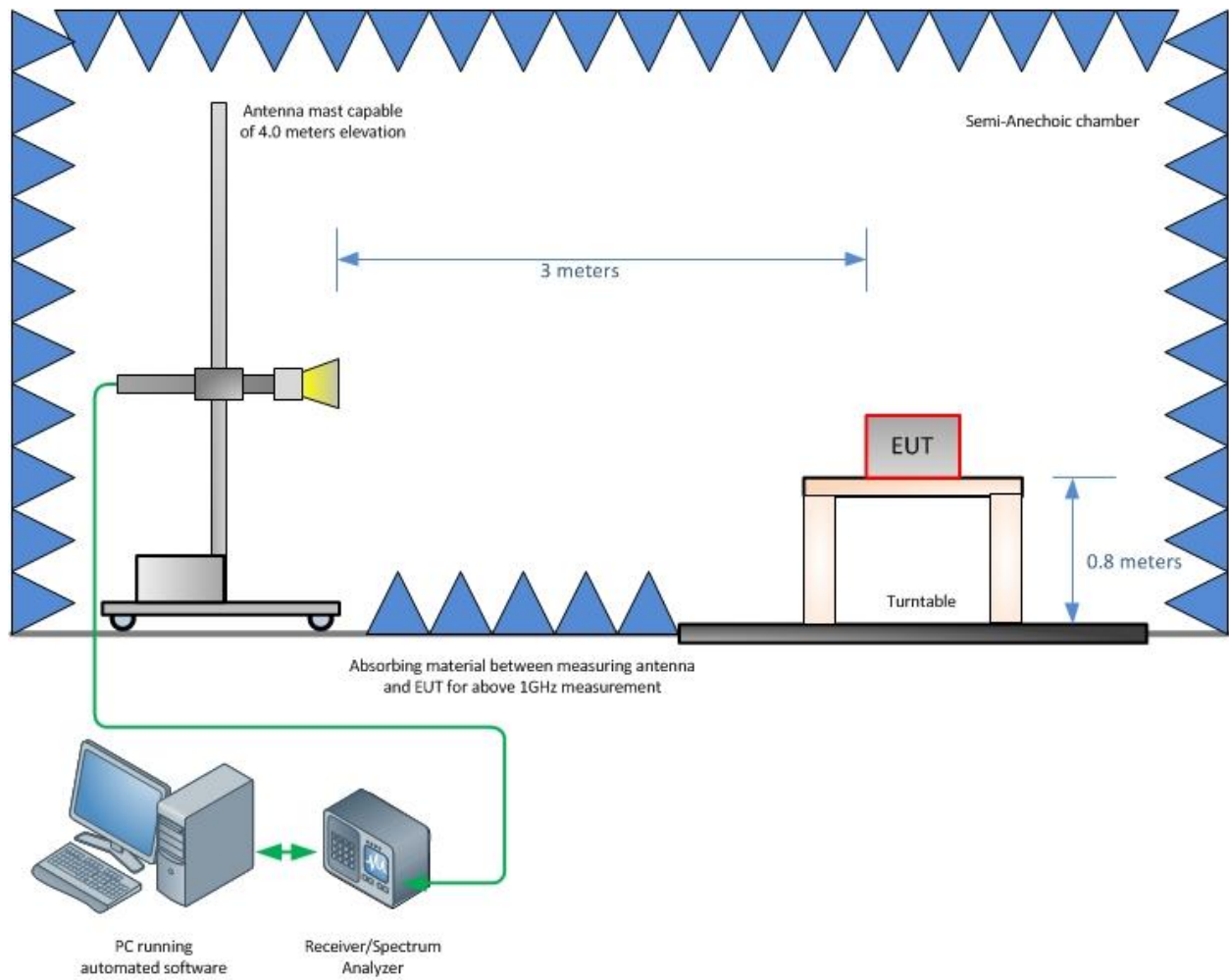
SECTION 4

DIAGRAM OF TEST SETUP

4.1 TEST SETUP DIAGRAM



Radiated Emission Test Setup (Below 1GHz)



Radiated Emission Test Setup (Above 1GHz)



SECTION 5

ACCREDITATION, DISCLAIMERS AND COPYRIGHT

5.1 ACCREDITATION, DISCLAIMERS AND COPYRIGHT

TÜV SÜD America Inc.'s reports apply only to the specific sample tested under stated test conditions. It is the manufacturer's responsibility to assure the continued compliance of production units of this model. TÜV SÜD America, Inc. shall have no liability for any deductions, inferences or generalizations drawn by the client or others from TÜV SÜD America, Inc.'s issued reports.

This report is the confidential property of the client. As a mutual protection to our clients, the public and TÜV SÜD America, Inc., extracts from the test report shall not be reproduced, except in full without TÜV SÜD America, Inc.'s written approval.

This report must not be used to claim product certification, approval, or endorsement by A2LA, NIST, or any agency of the federal government.

TÜV SÜD America, Inc. and its professional staff hold government and professional organization certifications for AAMI, ACIL, AEA, ANSI, IEEE, A2LA, NIST and VCCI.

