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Report On

Application for Grant of Equipment Authorization of the
NX35-C200 Vehicle Tracking System

FCC Part 15 Subpart C §15.247 (FHSS)
ISED RSS-247

Report No. JT72130952-0817A **October 2017**

REPORT ON	Radio Testing of the NX35-C200 Vehicle Tracking System
TEST REPORT NUMBER	JT72130952-0817A
PREPARED FOR	Novatel Wireless Inc 9605 Scranton Rd. Ste 300 San Diego, CA 92121 USA
CONTACT PERSON	Roman Olmos Senior Regulatory Engineer (858) 812-3400 rolmos@nvtl.com
PREPARED BY	Ivan Retana **Name** Authorized Signatory Title: EMC Engineer
APPROVED BY	Ferdinand S. Custodio Name Authorized Signatory Title: EMC/Senior Wireless Test Engineer
DATED	October 17, 2017

Revision History

JT72130952-0817A NX35-C200 Vehicle Tracking System					
DATE	OLD REVISION	NEW REVISION	REASON	PAGES AFFECTED	APPROVED BY
10/17/2017		Initial Release			Ferdinand S. Custodio

CONTENTS

TÜV SÜD AMERICA INC 10040 Mesa Rim Road San Diego, CA 92121-2912 Phone: 858 678 1400 FAX: 858 546 0364

SECTION 1

REPORT SUMMARY

Radio Testing of the
NX35-C200 Vehicle Tracking System

1.1 INTRODUCTION

The information contained in this report is intended to show verification of the NX35-C200 Vehicle Tracking System to the following requirements:

- FCC Part 15 Subpart C §15.247 (FHSS)
- ISED RSS-247

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	Ctrak
Model Number(s)	NX35-C200
FCC ID Number	PKRNVWNX35C200
IC Number	3229A-NX35C200
Serial Number(s)	EMC Sample 1
Number of Samples Tested	1
Test Specification/Issue/Date	• FCC Part 15 Subpart C §15.247 (October 1, 2016). • IC RSS-247 Issue 2 February 2017 Digital Transmission Systems (DTSs), Frequency Hopping Systems (FHSs) and Licence-Exempt Local Area Network (LE-LAN) Devices. • IC RSS-Gen Issue 4, November 2014 - General Requirements for Compliance of Radio Apparatus (Issue 4, November 2014). • ANSI C63.10-2013. American National Standard of Procedures for Compliance Testing of Unlicensed Wireless Devices
Start of Test	September 15, 2017
Finish of Test	September 20, 2017
Name of Engineer(s)	Ivan Retana
Related Document(s)	Supporting documents for EUT certification are separate exhibits.

1.2 BRIEF SUMMARY OF RESULTS

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

Section	§15.247 Spec Clause	RSS	Test Description	Result
-	§15.207 (a)	RSS-Gen 8.8	Conducted Emissions	**N/A[1]**
2.1	§15.247(a)(1)	RSS-247 5.1 (2)	Carrier Frequency Separation	**Compliant**
2.2	§15.247(a)(1)(iii)	RSS-247 5.1 (4)	Number of Hopping Frequencies	**Compliant**
2.3	§15.247(a)(1)(iii)	RSS-247 5.1 (4)	Time of Occupancy (Dwell Time)	**Compliant**
2.4	§15.215(c)	RSS-247 5.1 (1)	20 dB Bandwidth	**Compliant**
2.5		RSS-Gen 6.6	99% Emission Bandwidth	**Compliant**
2.6	§15.247(b)(3)	RSS-247 5.4 (2)	Maximum Conducted Output Power	**Compliant**
2.7	§15.247(d)	RSS-247 5.5	Band-edge Compliance of RF Conducted Emissions	**Compliant**
2.8			Spurious RF Conducted Emissions	**Compliant**
2.9	ANSI C63.10-2013 Clause 11.12.2.1	RSS-Gen 8.9 and 8.10	Cabinet/Case Radiated Emissions	**Compliant**

Test Notes:

1 *Test Not Applicable. EUT is a battery-operated device.*

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1.1 PRODUCT INFORMATION

1.1.1 Technical Description

The Equipment Under Test (EUT) was an NX35-C200 Vehicle Tracking System. The NX35 device is designed to accurately track position and other data of vehicles or assets and report this data to a data centre. The NX35 is used to gather information relevant to fleet management services, to plot a vehicle position on a map and to follow the route taken by a vehicle during a journey. The position and speed of the vehicle is sampled using GNSS (Global Navigation Satellite System) and reported through a GSM modem data link with industry standard communication protocols.

1.1.2 EUT General Description

EUT Description	Vehicle Tracking System
Model Number(s)	NX35-C200
Rated Voltage	6.0 – 32.0VDC
Mode Verified	Bluetooth Classic
Capability	CDMA 1xRTT 800/1900MHz, GPS/GNSS, and Bluetooth/BLE
Modulation	GFSK, π/4-DQPSK, 8DPSK
Primary Unit (EUT)	☒ Production
	☐ Pre-Production
	☐ Engineering
Antenna Gain	2.3 dBi

1.1.3 Maximum Conducted Output Power

Modulation	Mode	Frequency Range (MHz)	Average Output Power (dBm)
GFSK	FHSS	2402-2480	8.0

1.2 EUT TEST CONFIGURATION

1.2.1 Test Configuration Description

Test Configuration	Description
Default	EUT connected to a support laptop via a USB to RS232 cable to enable BL transmit mode. Tools and software were provided by the manufacturer and was used to configure RF parameter of the EUT.

1.2.2 EUT Exercise Software

The EUT Bluetooth capability is enabled throughout a support laptop via a serial terminal connection.

1.2.3 Support Equipment and I/O cables

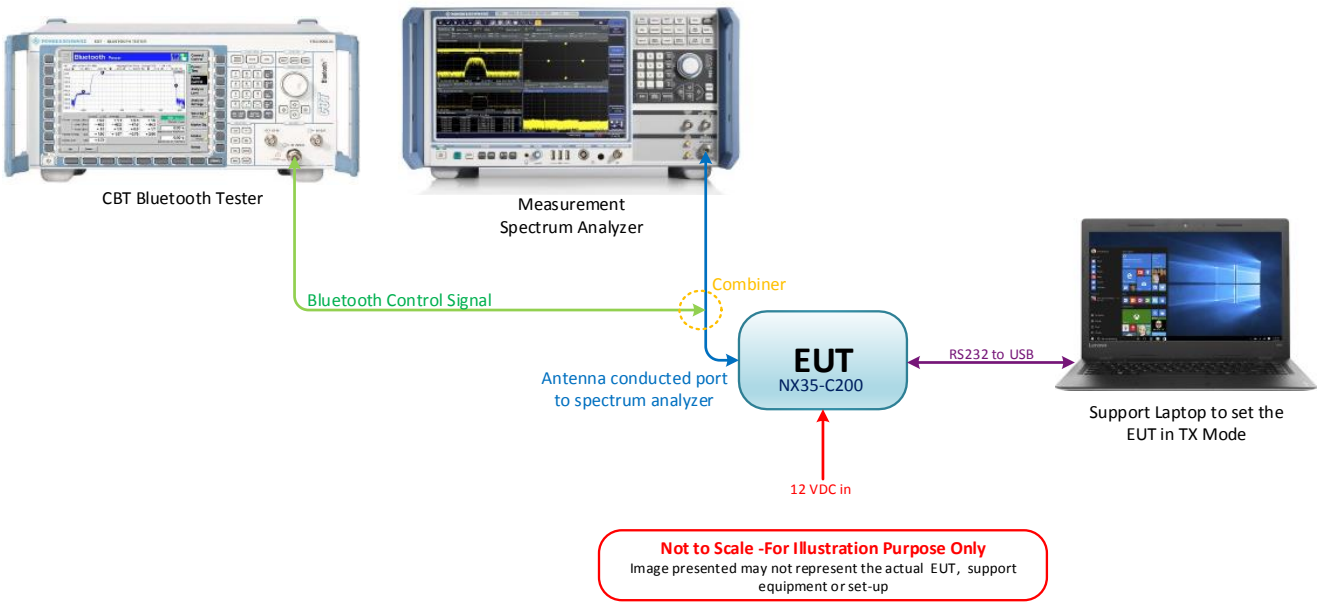
Manufacturer	Equipment/Cable	Description
Sony	Support Laptop	Model: PCG-31311L

1.2.4 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) /DH3	Non-hopping
GFSK	DH3	Hopping

1.2.5 Simplified Test Configuration Diagram



1.3 DEVIATIONS FROM THE STANDARD

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

1.4 MODIFICATION RECORD

Description of Modification	Modification Fitted By	Date Modification Fitted
Serial Number: EMC Sample 1		
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.

1.5 TEST METHODOLOGY

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

For conducted and radiated emissions the equipment under test (EUT) was configured to measure its highest possible emission level. This level was based on the maximized cable configuration from exploratory testing per ANSI C63.10-2014. The test modes were adapted according to the Operating Instructions provided by the manufacturer/client.

1.6 TEST FACILITY LOCATION

1.6.1 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.

1.6.2 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.

1.7 TEST FACILITY REGISTRATION

1.7.1 FCC – Designation 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 Designation is US1146.

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

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

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

SECTION 2

TEST DETAILS

Radio Testing of the
NX35-C200 Vehicle Tracking System

TÜV SÜD AMERICA INC 10040 Mesa Rim Road San Diego, CA 92121-2912 Phone: 858 678 1400 FAX: 858 546 0364

2.1 CARRIER FREQUENCY SEPARATION

2.1.1 Specification Reference

Part 15 Subpart C §15.247(a)(1) and RSS-247 5.1 (2)

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: EMC Sample 1 / Default Test Configuration

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

September 15, 2017 /IR

2.1.5 Test Equipment Used

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

2.1.6 Environmental Conditions

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

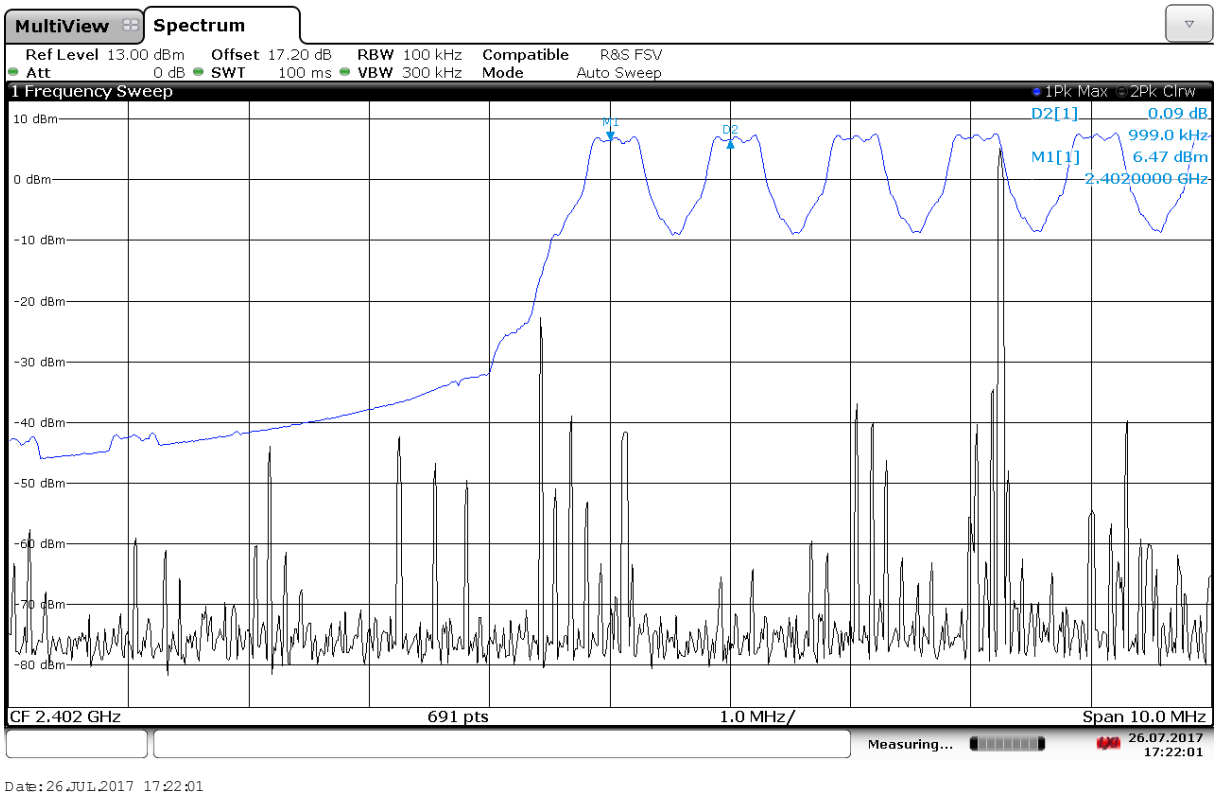
Ambient Temperature	26.1 °C
Relative Humidity	49.1 %
ATM Pressure	98.7 kPa

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 17.2dB was added to compensate for the external attenuator and cable used.
- Marker-delta function is used between the peaks of the adjacent channels.
- Limit used is >953.33 kHz (2/3 of worst case 20dB BW).

2.1.8 Test Results



Observed carrier frequency separation between Channel 0 and Channel 1 = 999.0 KHz
Complies. (Greater than 953.33 kHz , this is 2/3 of 1.43 MHz 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: EMC Sample 1 / Default Test Configuration

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

September 15, 2017 /IR

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

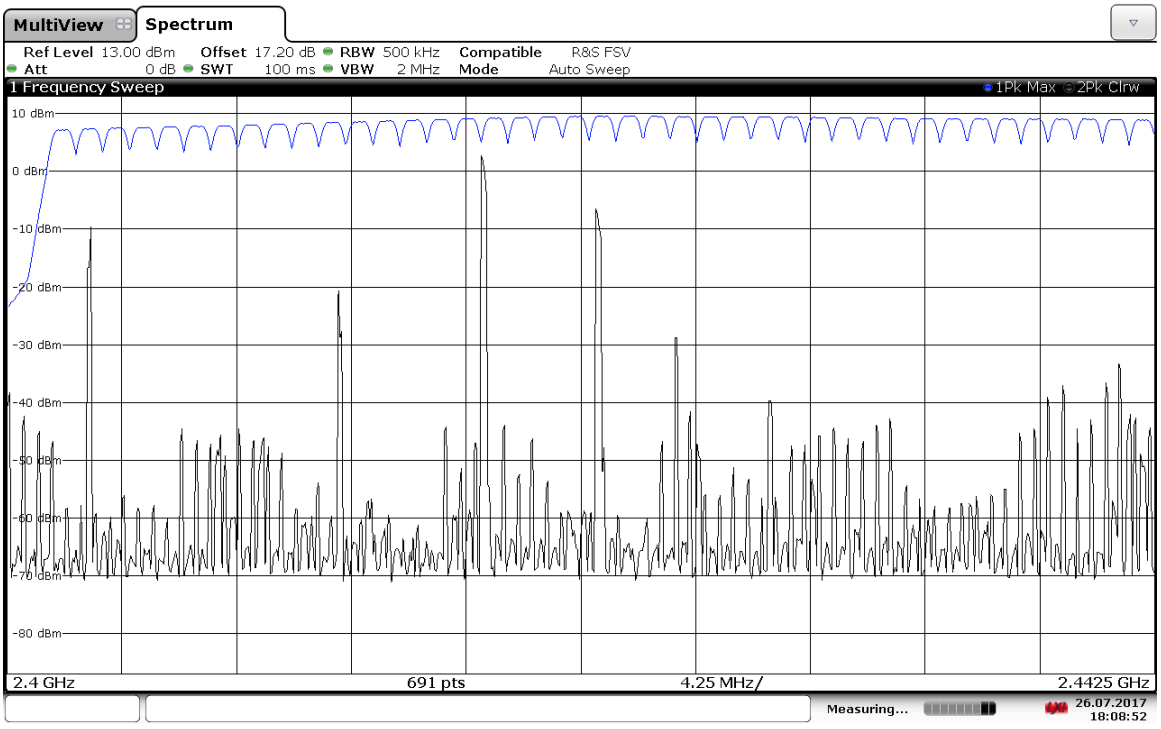
Ambient Temperature	26.1 °C
Relative Humidity	49.1 %
ATM Pressure	98.7 kPa

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.
- RBW is 1% of the span, VBW is 3x RBW
- Sweep is auto
- Detector is peak, trace is max hold.
- An offset of 17.2dB was added to compensate for the external attenuator, power divider/combiner and cable used.

2.2.8 Test Results

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



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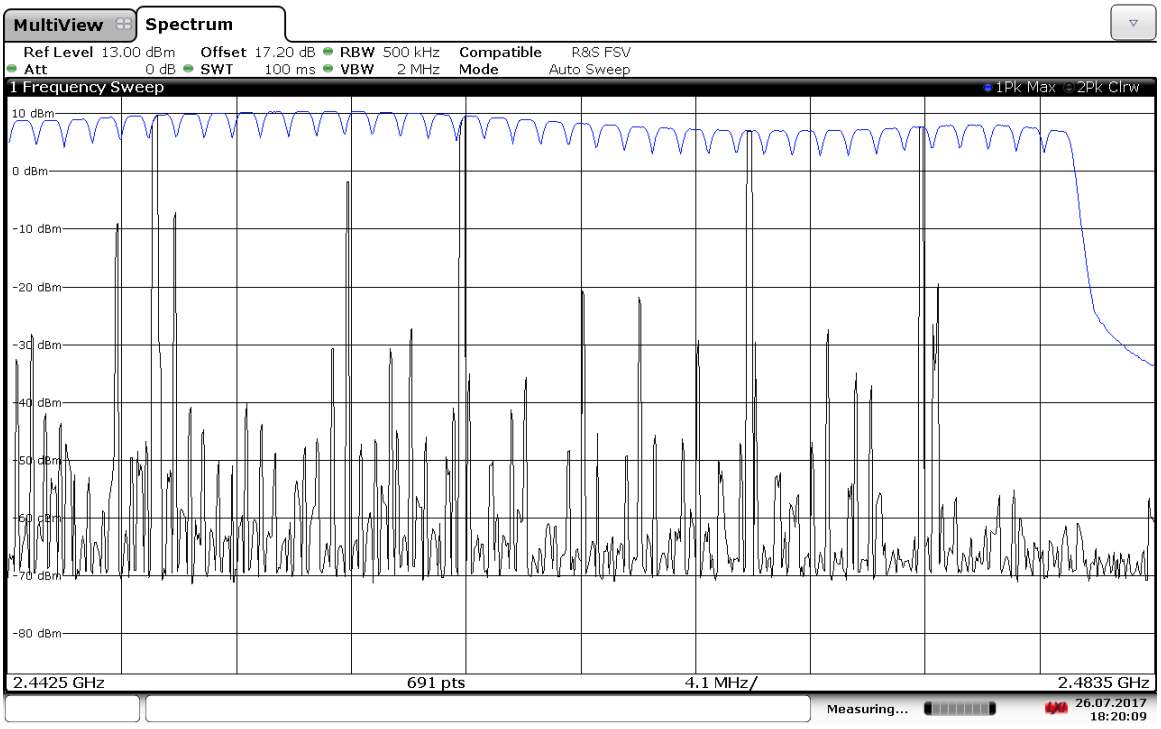
Plot #1



Date: 26.JUL.2017 18:20:10

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: EMC Sample 1 / Default Test Configuration

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

September 15, 2017 /IR

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

Ambient Temperature	26.1 °C
Relative Humidity	49.1 %
ATM Pressure	98.7 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).
- All packet types verified.

2.3.8 Test Results

Modulation	Packet Type	Measured time of occupancy	Requirement
GFSK	DH1	123.13 ms	<400 ms
	DH3	312.72 ms	<400 ms
	DH5	289.04 ms	<400 ms
π/4-DQPSK	2-DH1	121.63 ms	<400 ms
	2-DH3	264.05 ms	<400 ms
	2-DH5	289.79 ms	<400 ms
8DPSK	3-DH1	127.87 ms	<400 ms
	3-DH3	280.19 ms	<400 ms
	3-DH5	198.13 ms	<400 ms

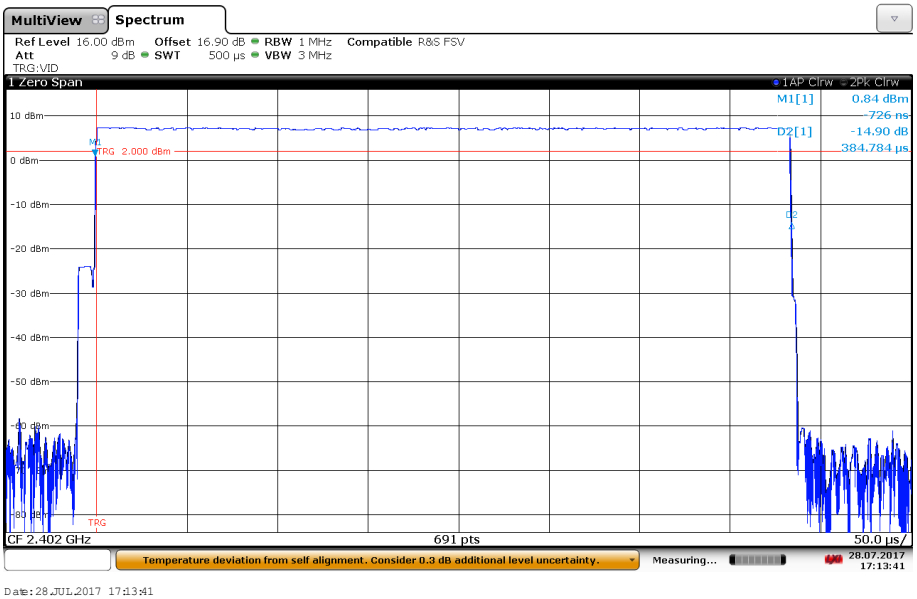
2.3.9 Sample Computation (GFSK DH3)

Width of single pulse = 0.0016459 second
Observed occurrence = 19 pulses/3.16 seconds
Required period = 79 channels x 0.4 second
= 31.6 seconds

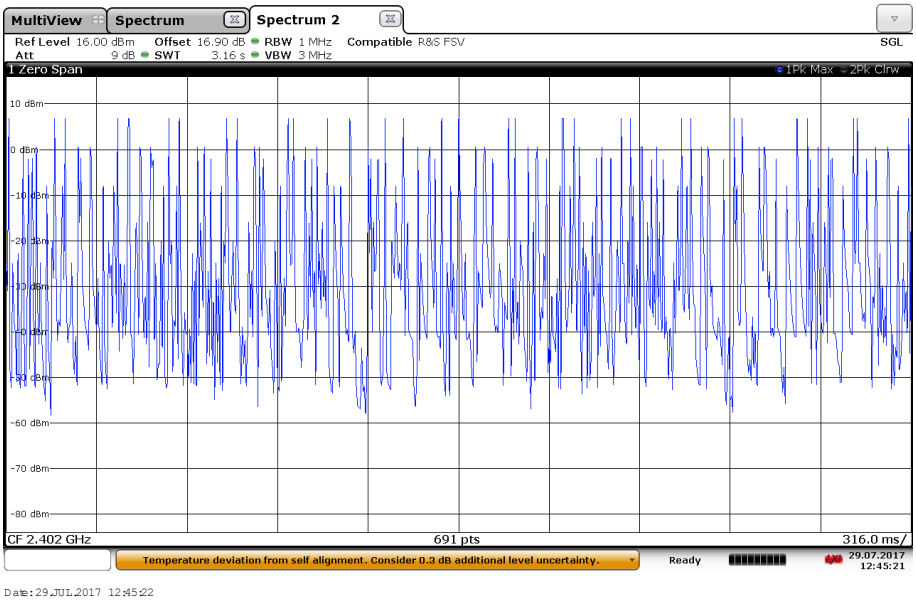
Average time of occupancy = Pulse width x #pulses in 3.16 seconds x 10
= 0.0016459 second x 19x 10
= 0.31272 second

Compliance = **Complies.** 0.31272 second < 0.4 second

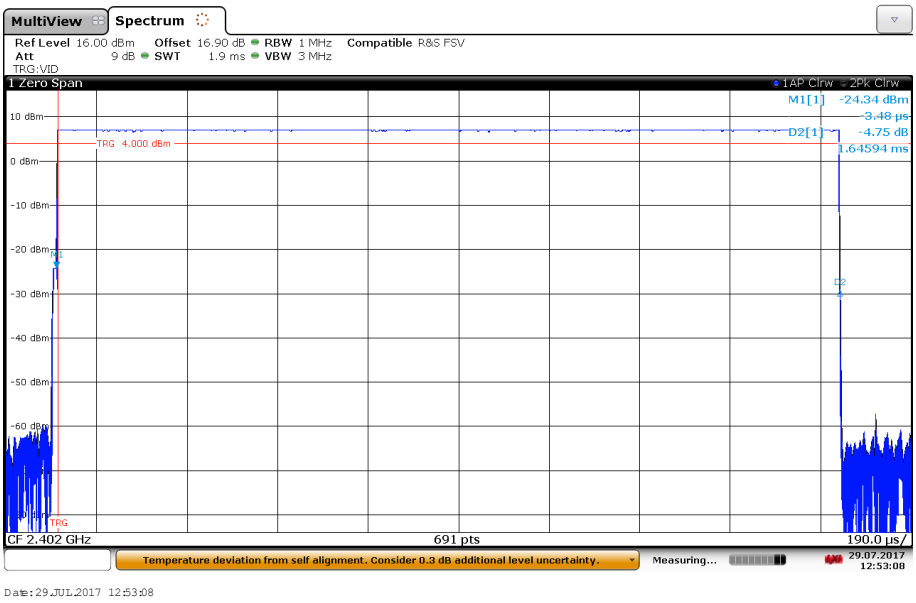
2.3.10 Test Results Plots



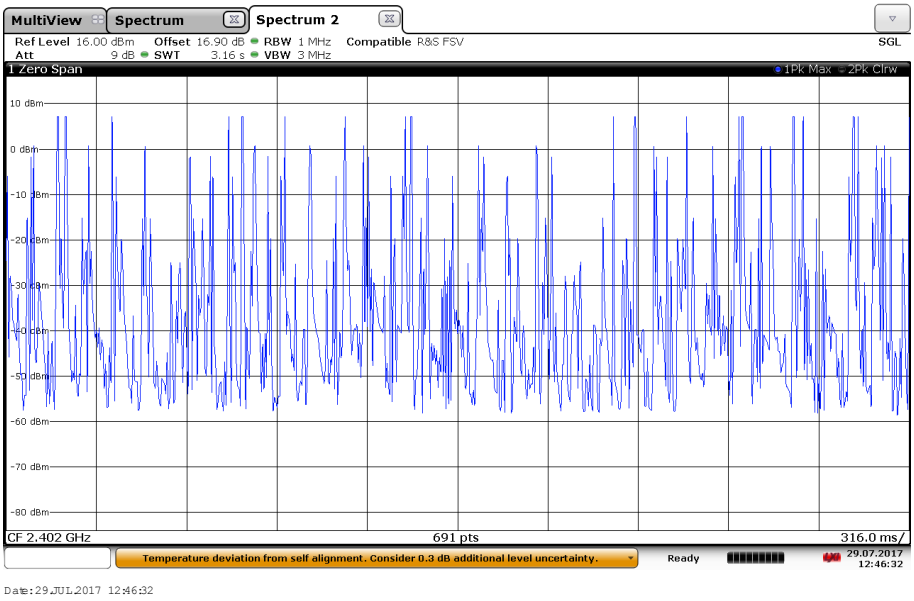
GFSK DH1 width of single pulse (0.384784ms)



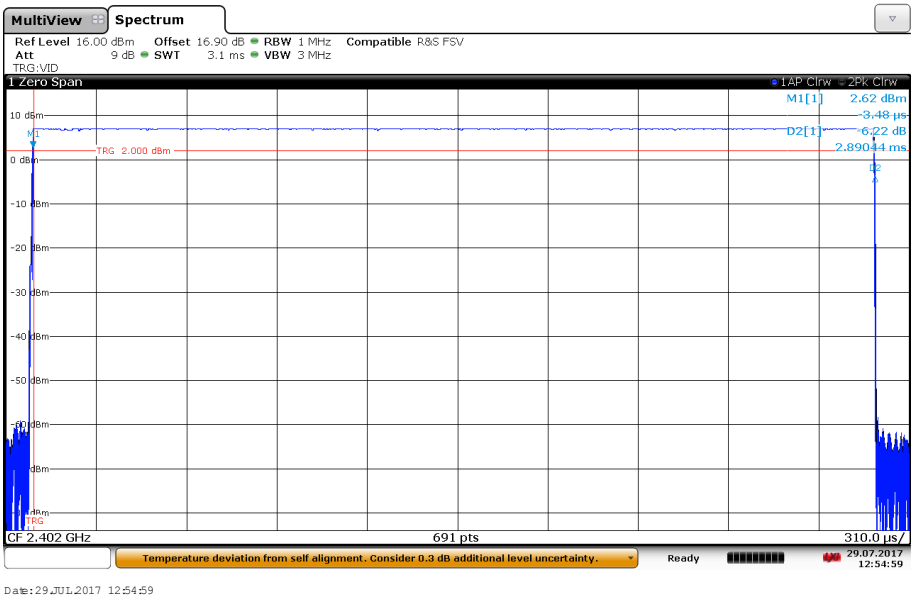
32 pulses/3.16 seconds (DH1)



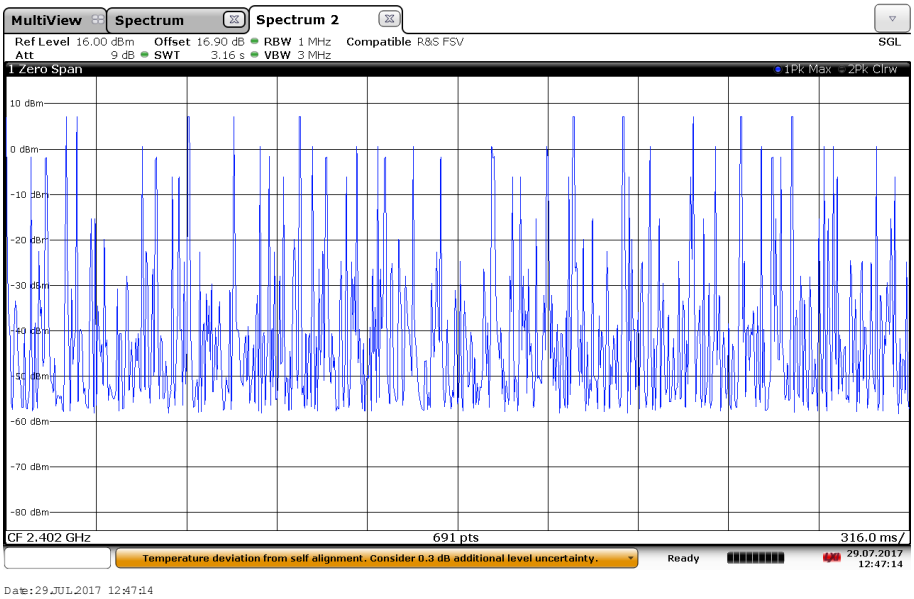
GFSK DH3 width of single pulse (1.64594ms)



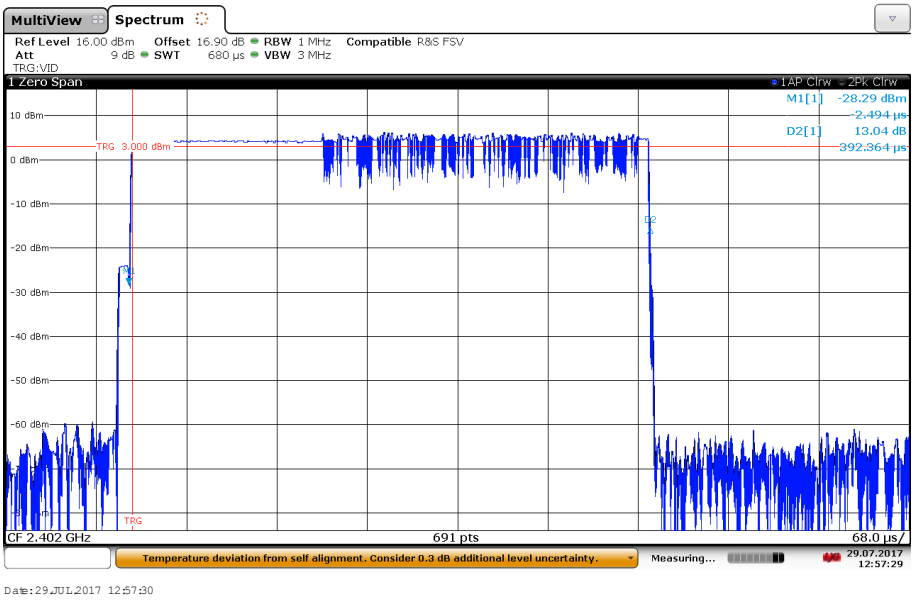
19 pulses/3.16 seconds (DH3)



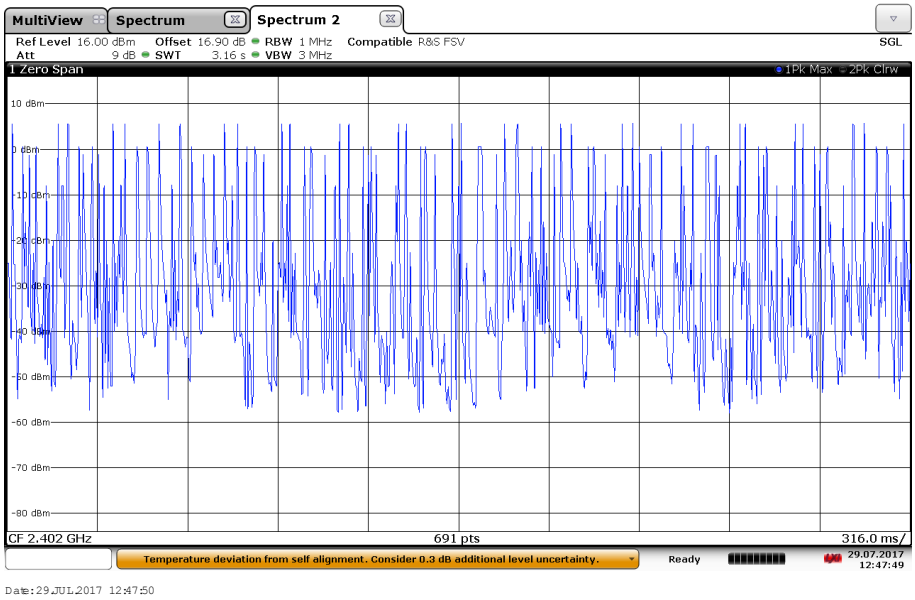
GFSK DH5 width of single pulse (2.89044ms)



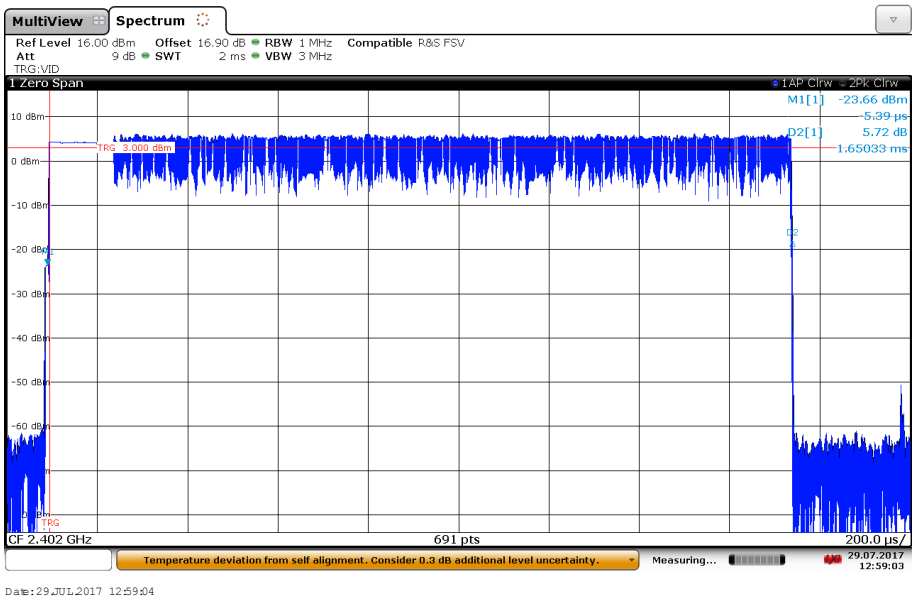
10 pulses/3.16 seconds (DH5)



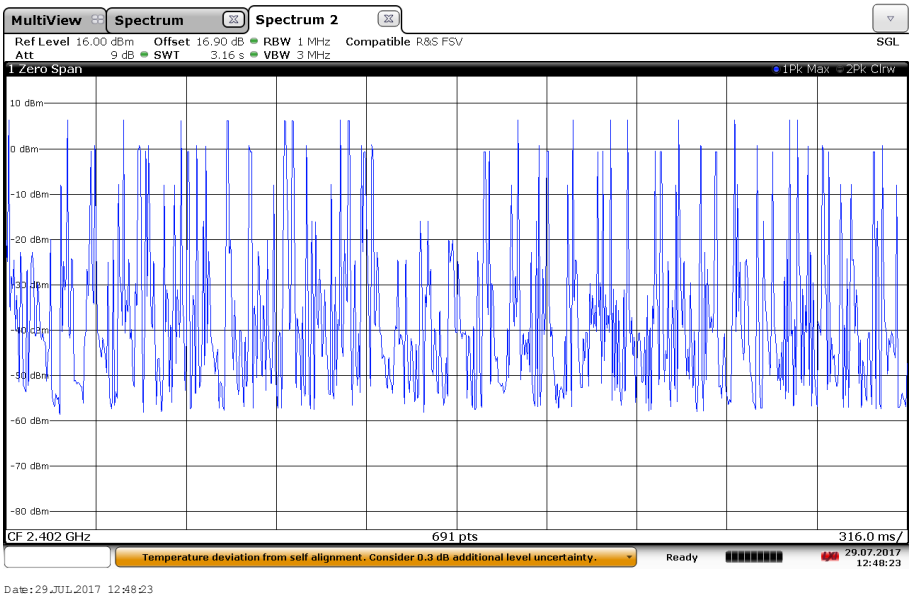
π/4-DQPSK 2-DH1 width of single pulse (0.392364ms)



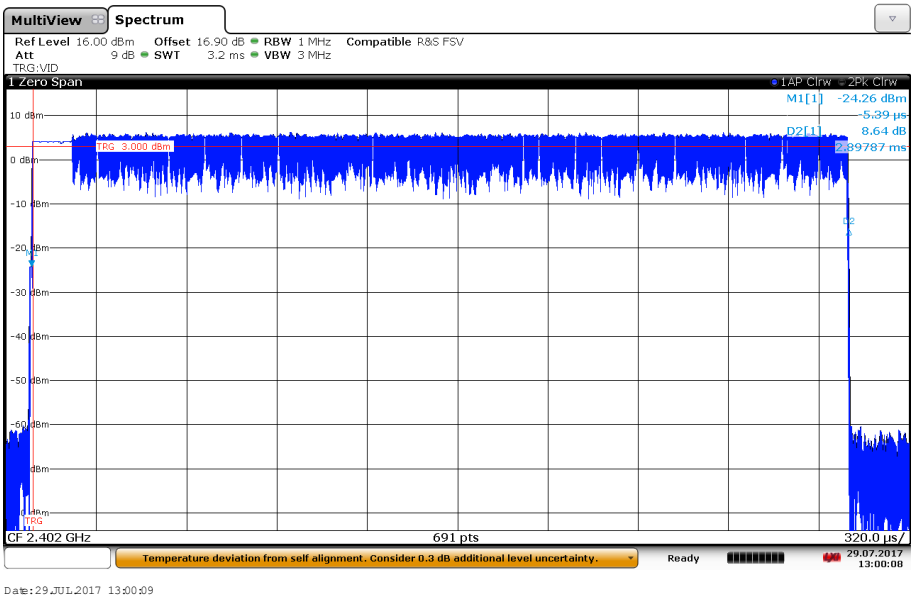
31 pulses/3.16 seconds (2-DH1)



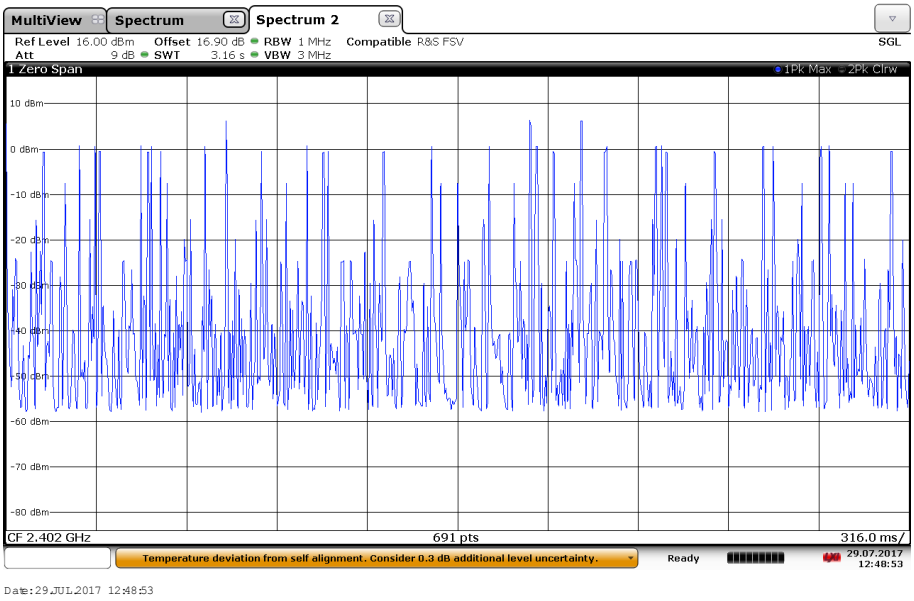
π/4-DQPSK 2-DH3 width of single pulse (1.65093ms)



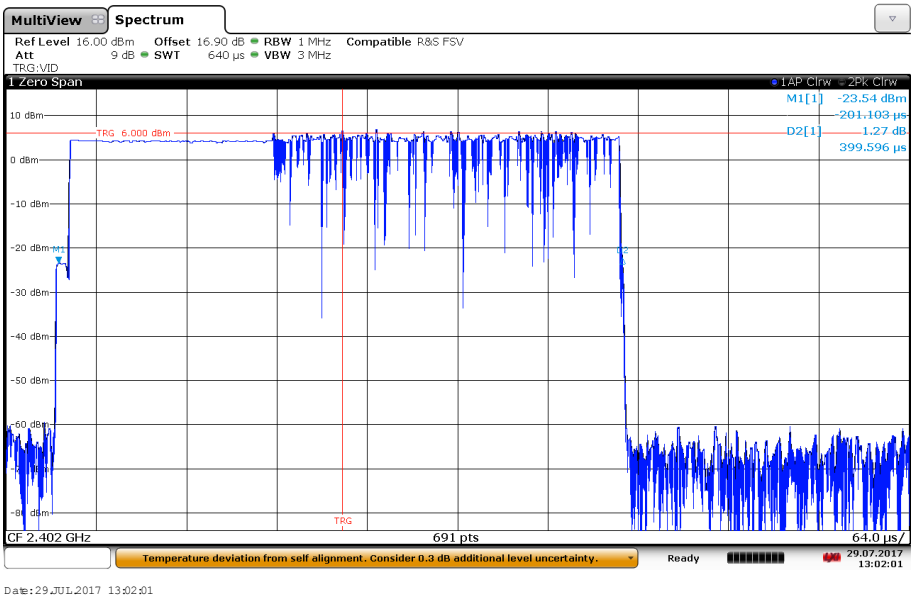
16 pulses/3.16 seconds (2-DH3)



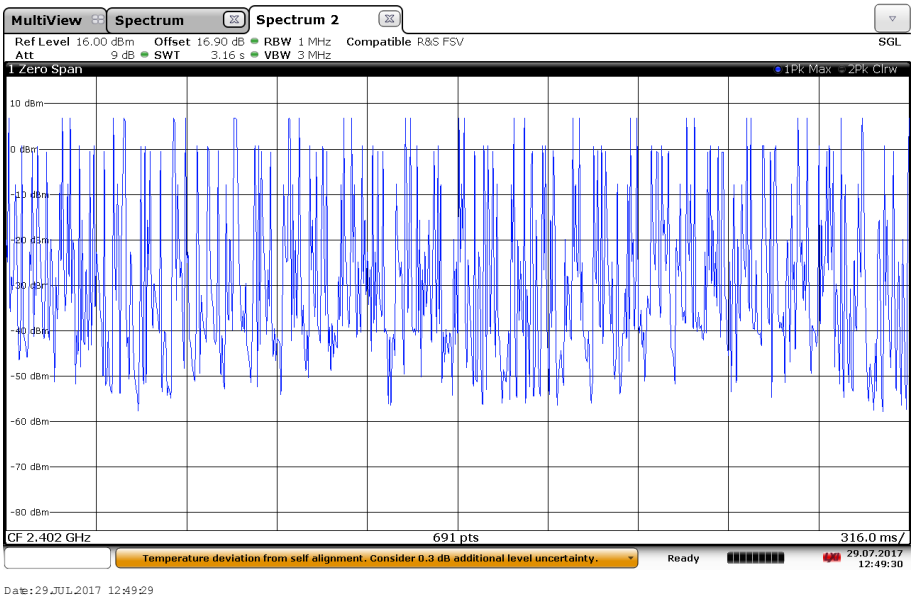
π/4-DQPSK 2-DH5 width of single pulse (2.89787ms)



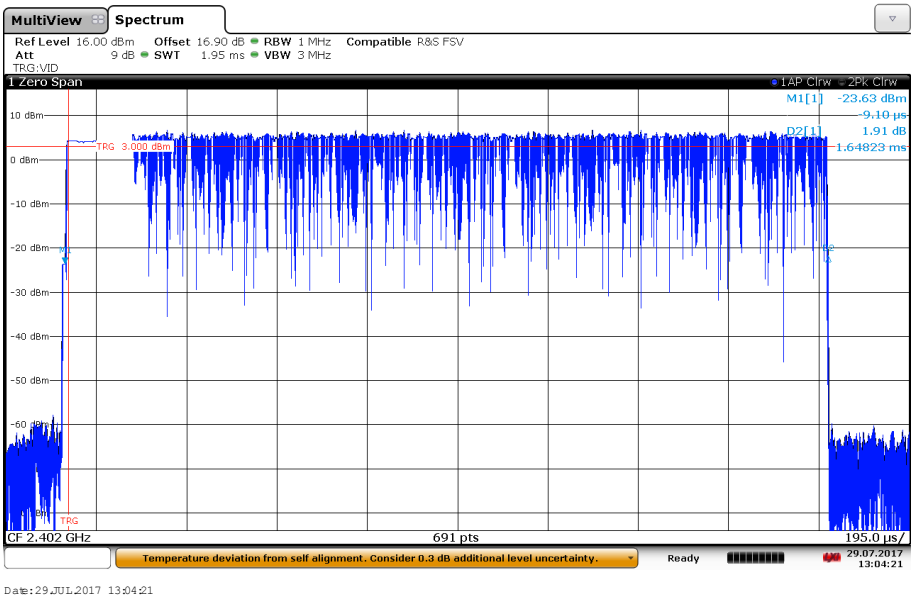
10 pulses/3.16 seconds (2-DH5)



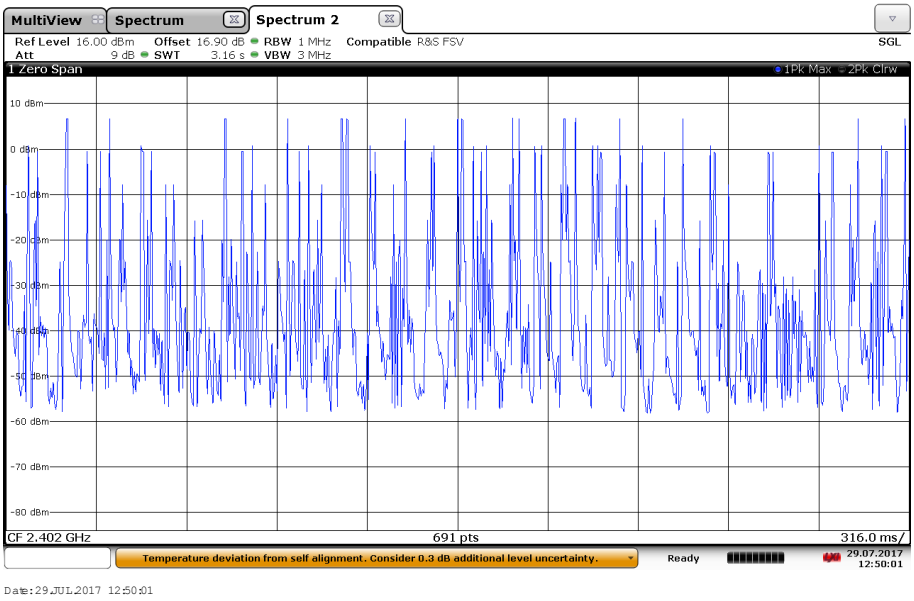
8DPSK 3-DH1 width of single pulse (0.399596ms)



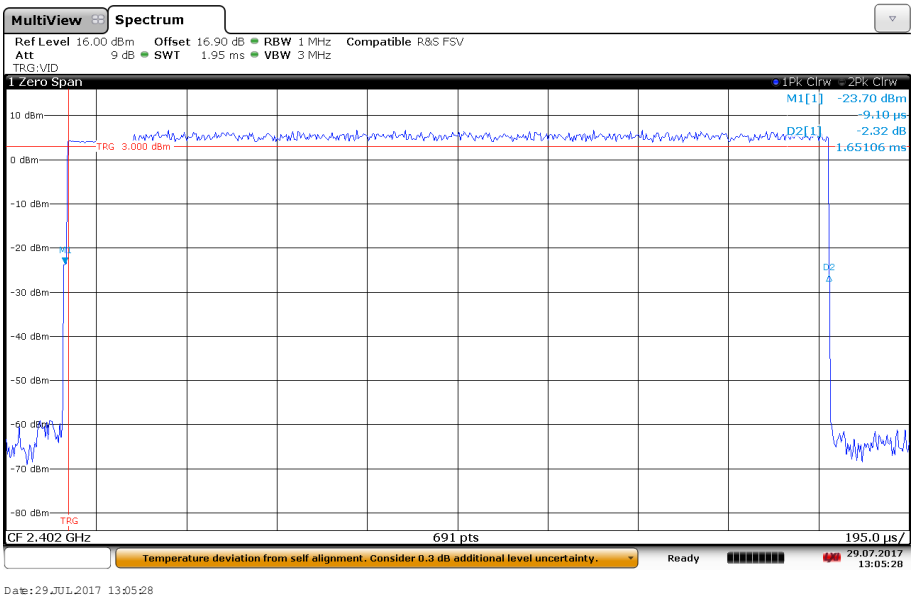
32 pulses/3.16 seconds (3-DH1)



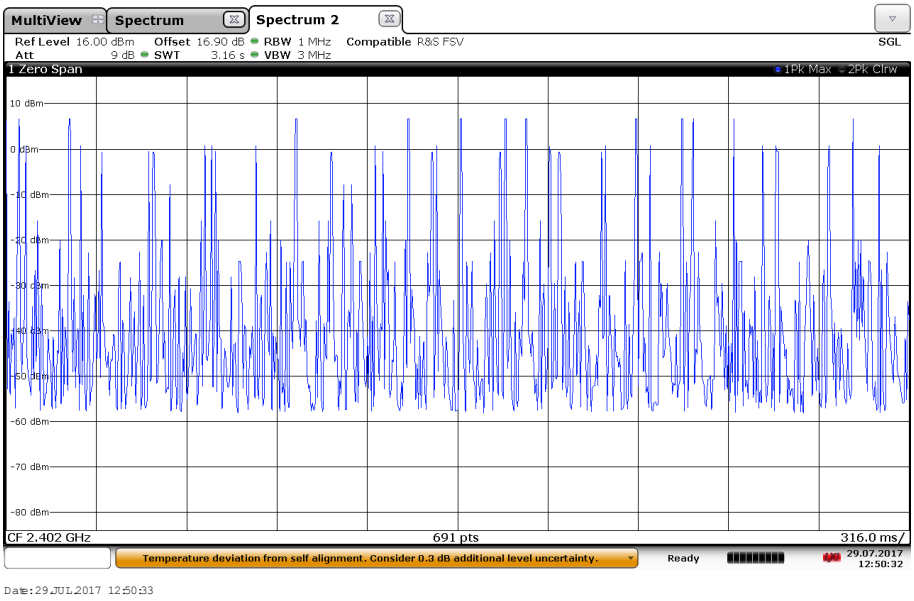
8DPSK 3-DH3 width of single pulse (1.64823ms)



17 pulses/3.16 seconds (3-DH3)



8DPSK 3-DH5 width of single pulse (1.65106ms)



12 pulses/3.16 seconds (3-DH5)

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: EMC Sample 1 / Default Test Configuration

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

September 15, 2017/IR

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

Ambient Temperature	26.1 °C
Relative Humidity	49.1 %
ATM Pressure	98.7 kPa

2.4.7 Additional Observations

- This is a conducted test.
- An offset of 17.20dB was added to compensate for the external attenuator, power divider/splitter and cable used.
- Span is approximately 2 to 3 times the expected 20dB bandwidth.
- RBW is ≥ 1% of the expected 20dB bandwidth while VBW is ≥ 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.

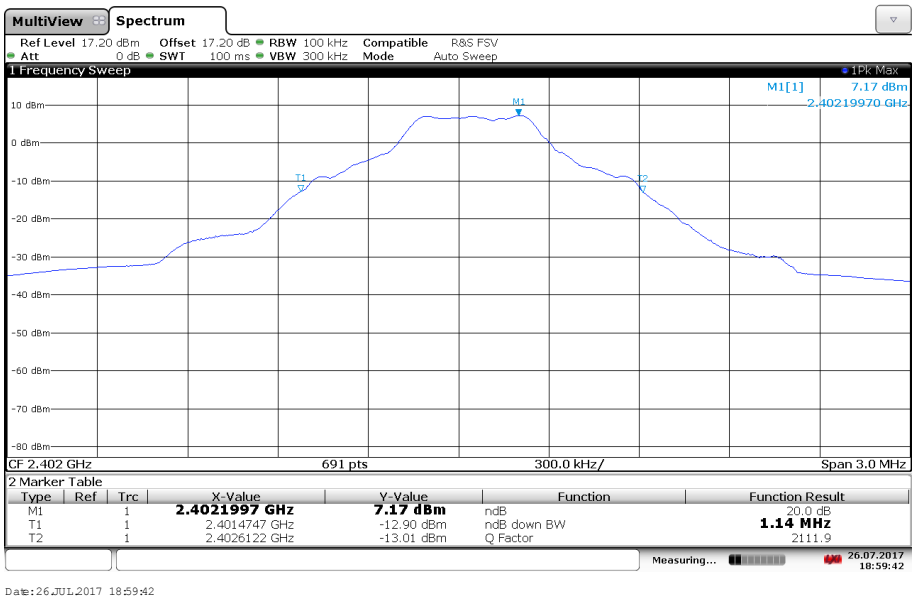
2.4.8 Test Results

Modulation	Channel	Frequency (MHz)	Measured 20dB Bandwidth (MHz)
GFSK	0	2402	1.14
	38	2440	1.15
	78	2480	1.15
π/4-DQPSK	0	2402	1.42
	38	2440	1.43
	78	2480	1.43
8DPSK	0	2402	1.40
	38	2440	1.41
	78	2480	1.41

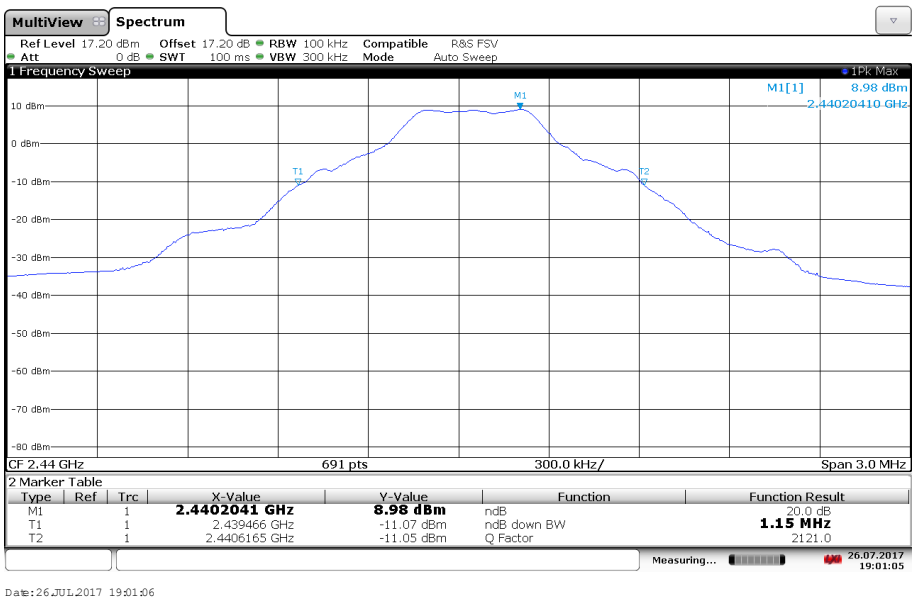
Worst case configuration (Mid/High Channel π/4-DQPSK)
2402 MHz – (20dB BW/2) = 2401.28 MHz (within the frequency band - **Compliant**)

Worst case configuration (Mid/High Channel π/4-DQPSK)
2480 MHz + (20dB BW/2) = 2480.715MHz (within the frequency band - **Compliant**)

2.4.9 Test Results Plots



GFSK Low Channel



GFSK Mid Channel

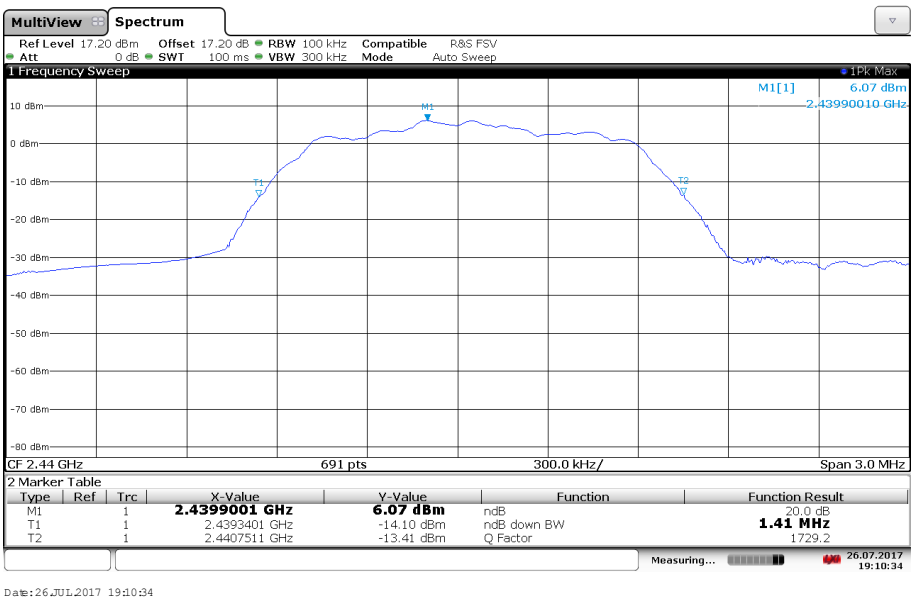
GFSK High Channel

π/4-DQPSK Low Channel

π/4-DQPSK Mid Channel

π/4-DQPSK High Channel

8DPSK Low Channel



8DPSK Mid Channel

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: EMC Sample 1 / Default Test Configuration

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

September 15, 2017/IR

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	26.1 °C
Relative Humidity	49.1 %
ATM Pressure	98.7 kPa

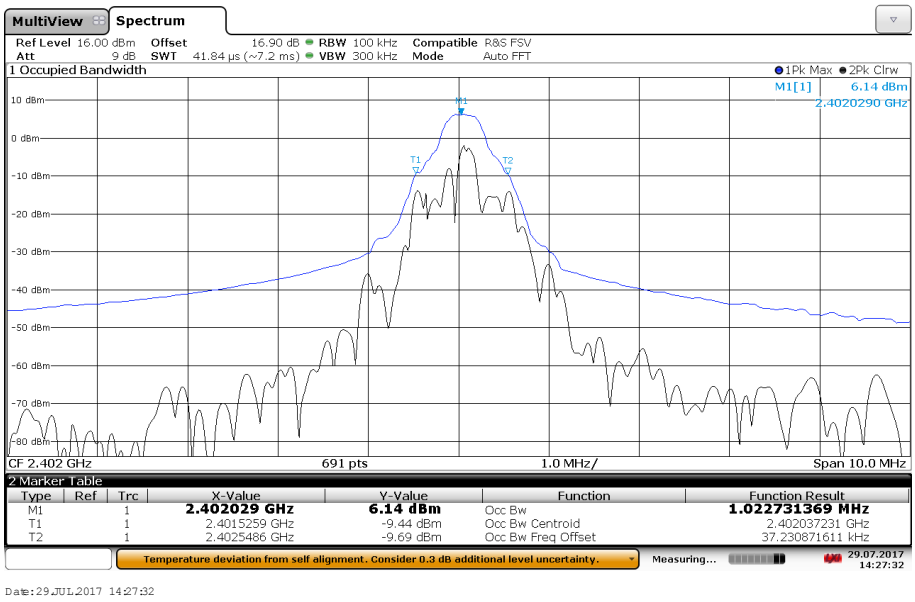
2.5.7 Additional Observations

- This is a conducted test.
- An offset of 16.90dB was added to compensate for the external attenuator, power divider/splitter and cable used.
- 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.

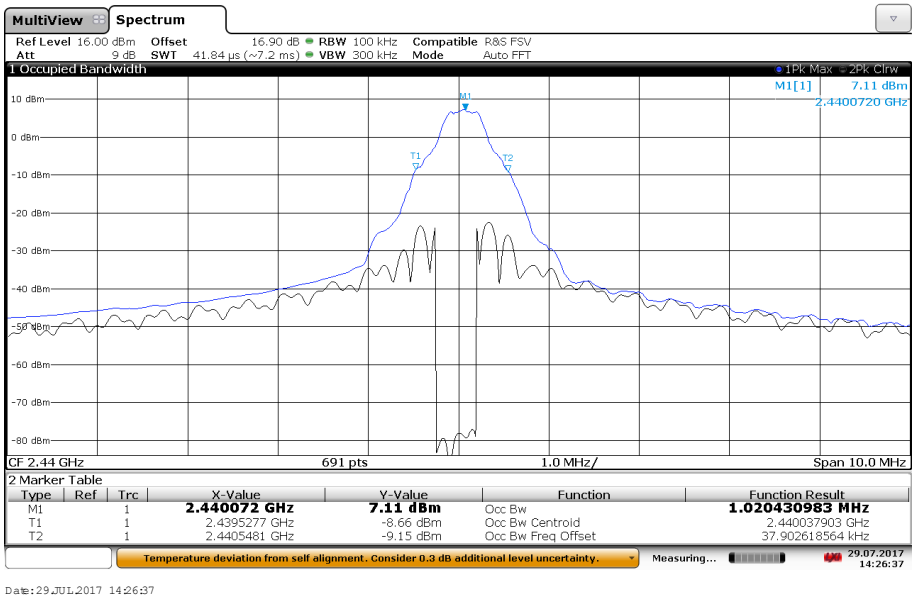
2.5.8 Test Results (For reporting purposes only)

Modulation	Channel	Frequency (MHz)	Measured 20dB Bandwidth (MHz)
GFSK	0	2402	1.022
	38	2440	1.020
	78	2480	1.017
π/4-DQPSK	0	2402	1.262
	38	2440	1.263
	78	2480	1.273
8DPSK	0	2402	1.274
	38	2440	1.276
	78	2480	1.279

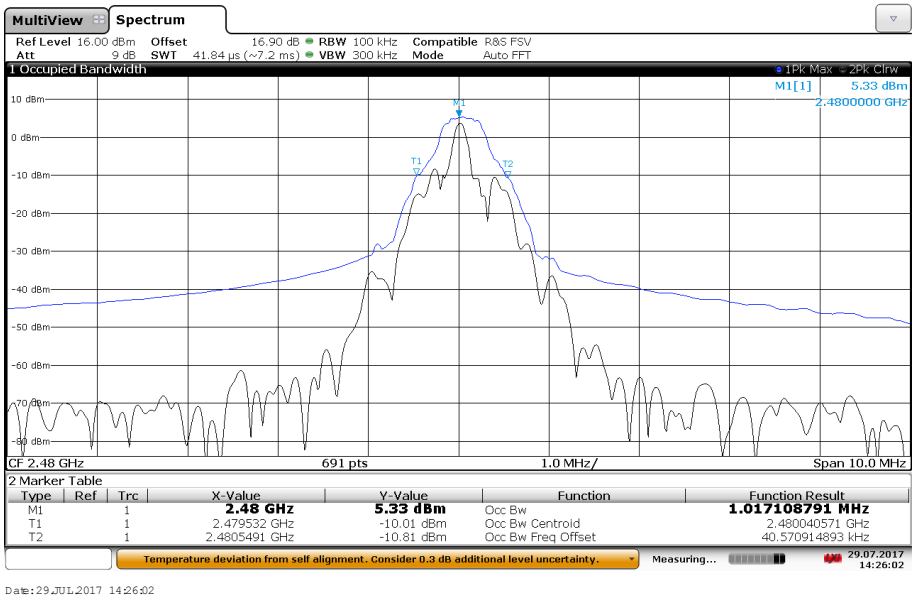
2.5.9 Test Results Plots



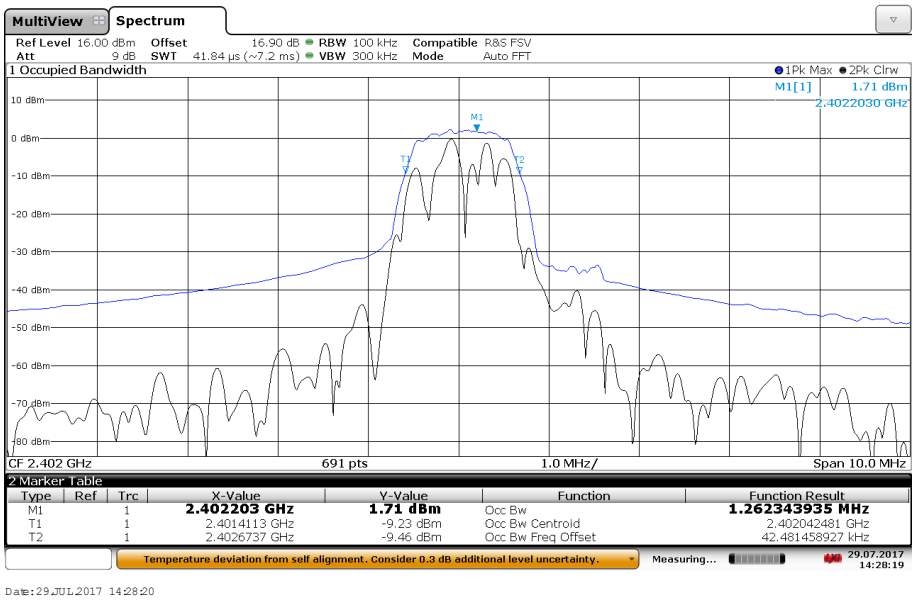
GFSK Low Channel (2404 MHz)



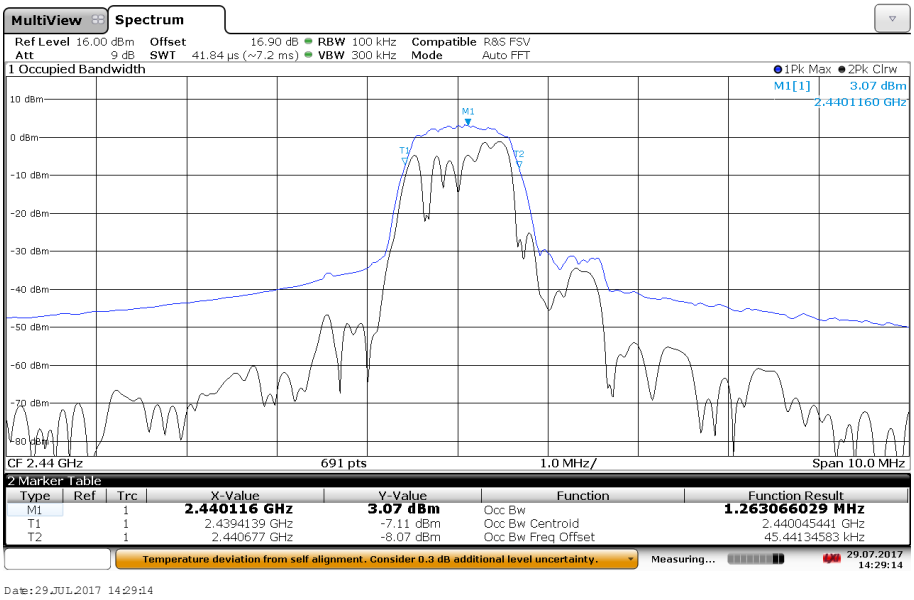
GFSK Mid Channel (2440 MHz)



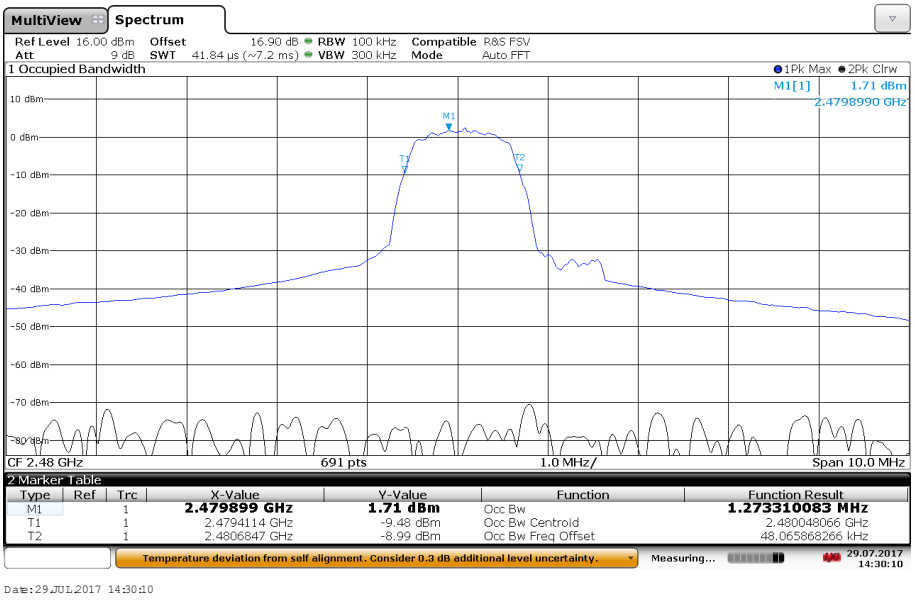
GFSK High Channel (2478 MHz)



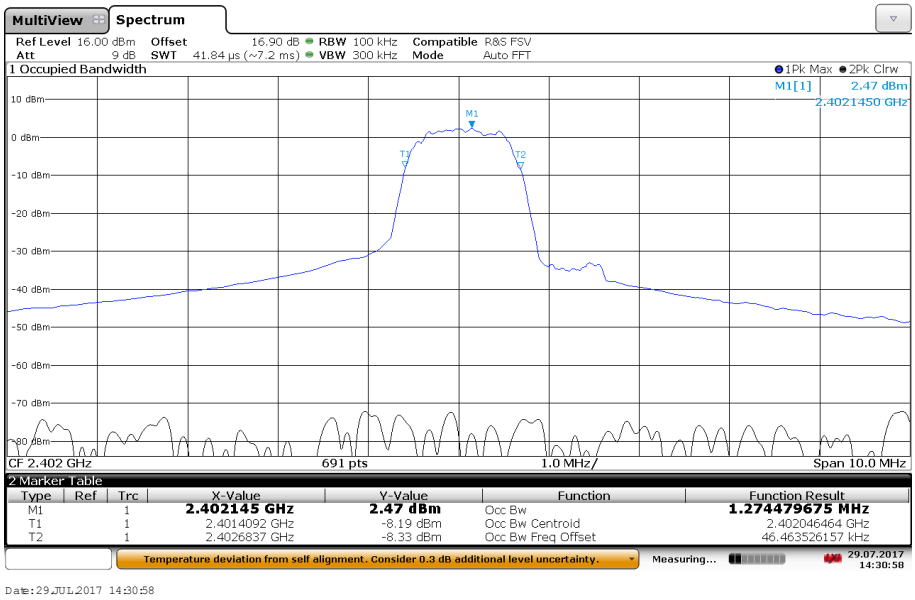
π/4-DQPSK Low Channel (2404 MHz)



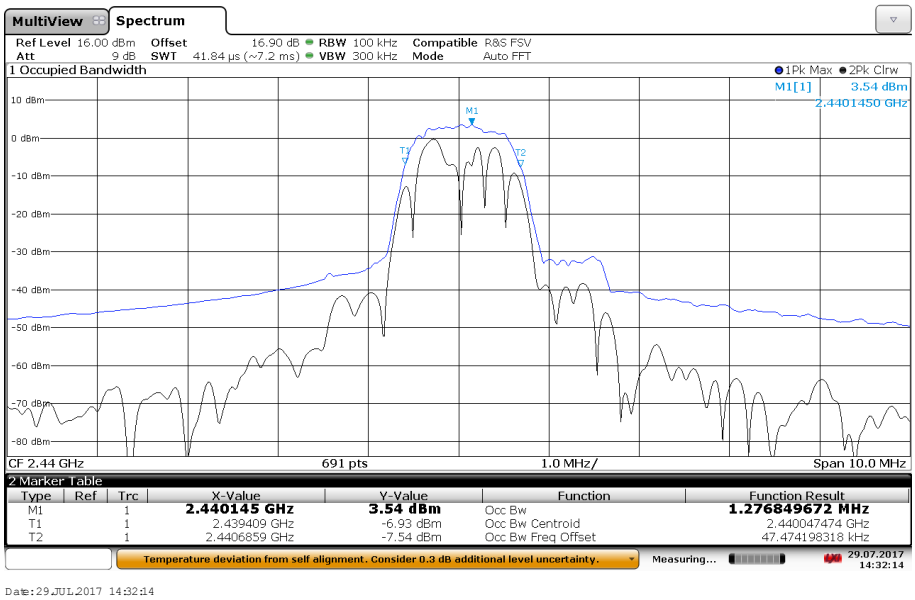
π/4-DQPSK Mid Channel (2440 MHz)



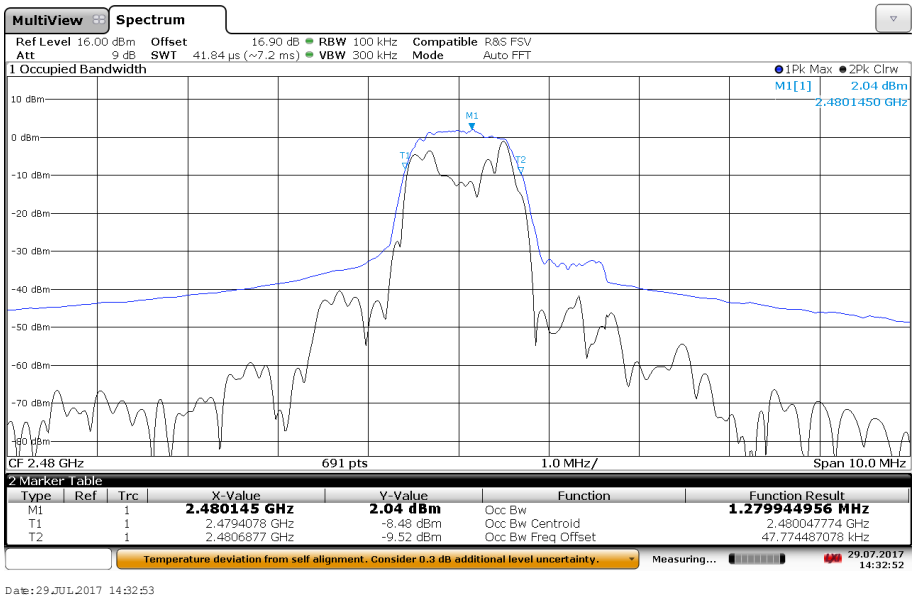
π/4-DQPSK High Channel (2478 MHz)



8DPSK Low Channel (2404 MHz)



8DPSK Mid Channel (2440 MHz)



8DPSK High Channel (2478 MHz)

2.6 MAXIMUM CONDUCTED OUTPUT POWER

2.6.1 Specification Reference

Part 15 Subpart C §15.247(b)(3)

2.6.2 Standard Applicable

(3) For systems using digital modulation in the 902-928 MHz, 2400-2483.5 MHz, and 5725-5850 MHz bands: 1 Watt. As an alternative to a peak power measurement, compliance with the one Watt limit can be based on a measurement of the maximum conducted output power. Maximum Conducted Output Power is defined as the total transmit power delivered to all antennas and antenna elements averaged across all symbols in the signaling alphabet when the transmitter is operating at its maximum power control level. Power must be summed across all antennas and antenna elements. The average must not include any time intervals during which the transmitter is off or is transmitting at a reduced power level. If multiple modes of operation are possible (e.g., alternative modulation methods), the maximum conducted output power is the highest total transmit power occurring in any mode.

2.6.3 Equipment Under Test and Modification State

Serial No: EMC Sample 1 / Test Configuration A

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

September 15, 2017/IR

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

Ambient Temperature	26.1 °C
Relative Humidity	49.1 %
ATM Pressure	98.7 kPa

2.6.7 Additional Observations

- This is a conducted test using a RMS Power Meter.
- An offset of 16.90dB was added to compensate for the external attenuator and cable used.
- The EUT was verified while in single carrier test mode.

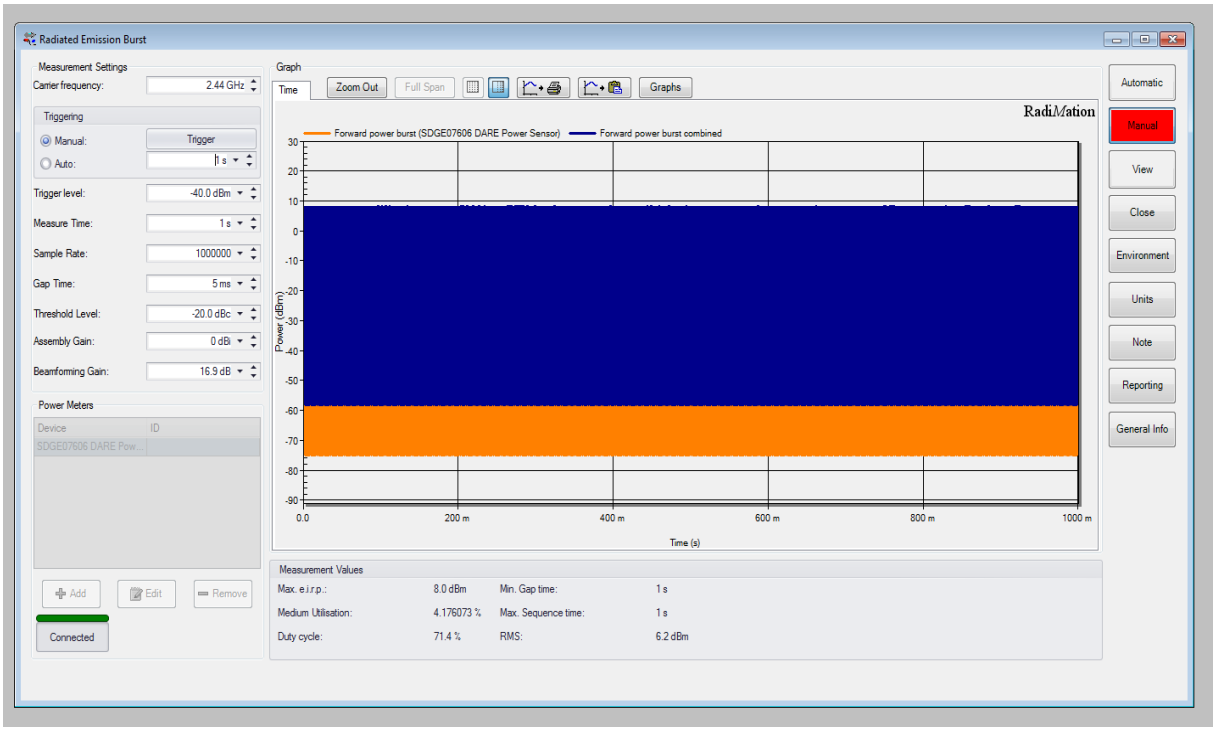
2.6.8 Test Results (Conducted)

Modulation	Channel	Frequency (MHz)	Measured Average Output Power (dBm)	Measured Average Output Power (mW)	Limit (mW)
GFSK	0	2402	7.1	5.1286	1000
	38	2440	8.0	6.3096	1000
	78	2480	6.3	4.2658	1000
π/4-DQPSK	0	2402	4.7	2.9512	1000
	38	2440	5.7	3.7154	1000
	78	2480	4.3	2.6915	1000
8DPSK	0	2402	4.7	2.9512	1000
	38	2440	5.7	3.7154	1000
	78	2480	4.3	2.6915	1000

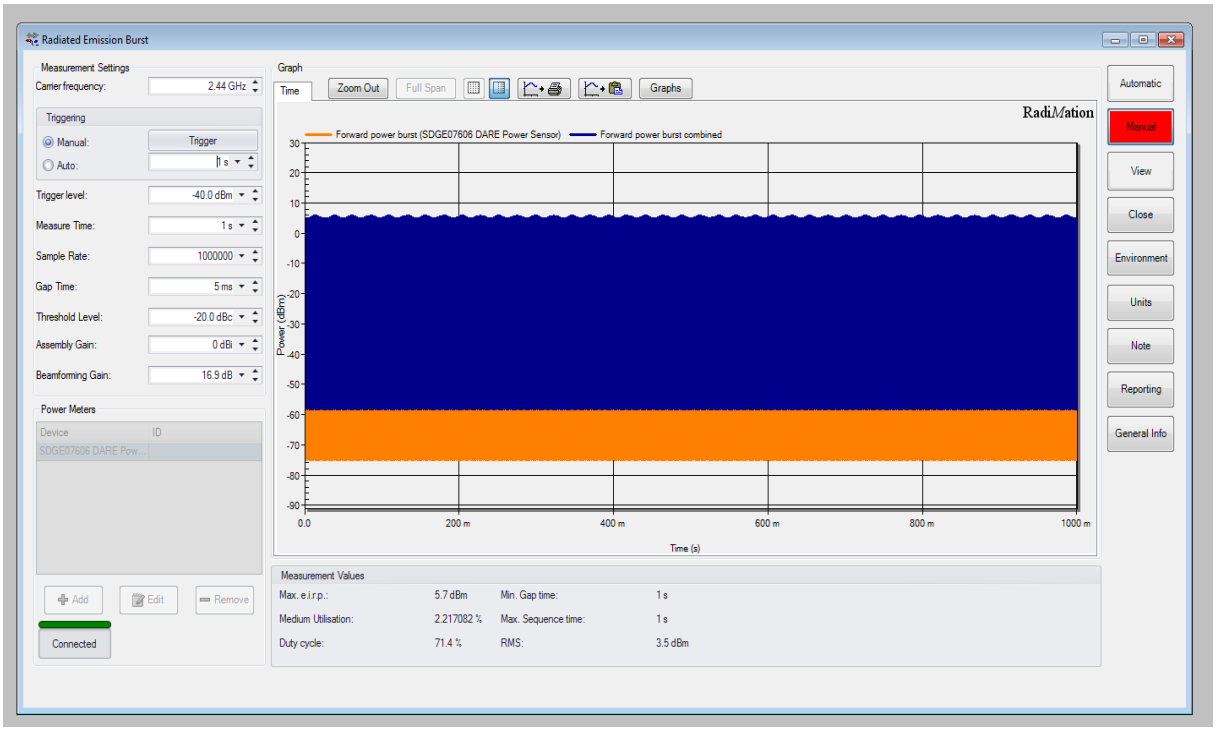
2.6.9 Test Results (*De Facto* EIRP Limit)

Modulation	Channel	Frequency (MHz)	Measured Average Output Power (dBm))	Antenna Gain (dBi)	Calculated Peak Output Power EIRP (dBm))	Limit (dBm))
GFSK	38	2440	8.0	2.3	10.3	30
π/4-DQPSK	38	2440	5.7	2.3	8.0	30
8DPSK	38	2440	5.7	2.3	8.0	30

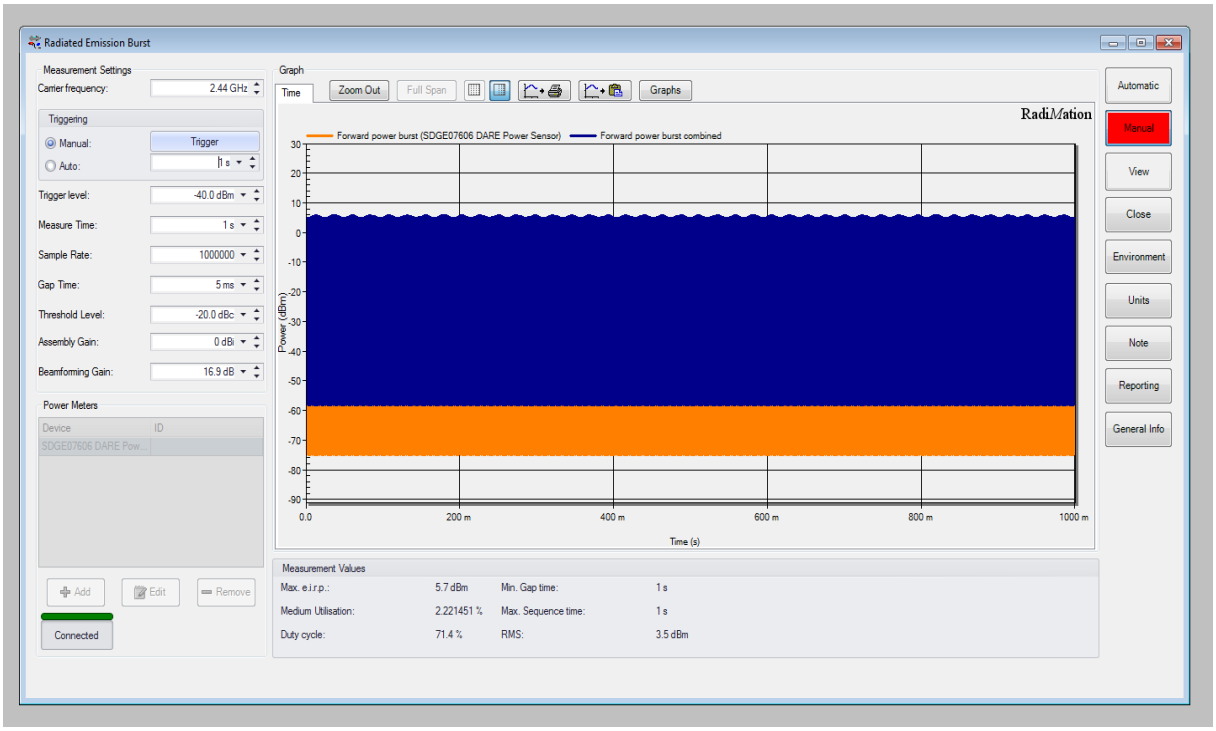
2.6.10 Sample Test Display



GFSK mid channel (Channel 38 2440 MHz)



π/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) and RSS-247 5.5

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: EMC Sample 1 / Default Test Configuration

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

September 15, 2017/IR

2.7.5 Test Equipment Used

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

2.7.6 Environmental Conditions

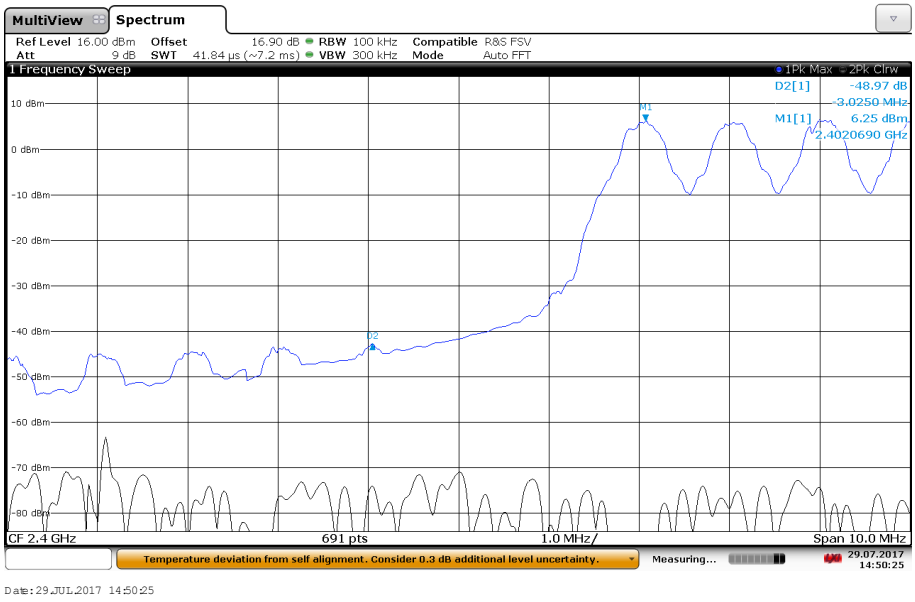
Test performed at TÜV SÜD America Inc. Rancho Bernardo facility.

Ambient Temperature	26.1 °C
Relative Humidity	49.1 %
ATM Pressure	98.7 kPa

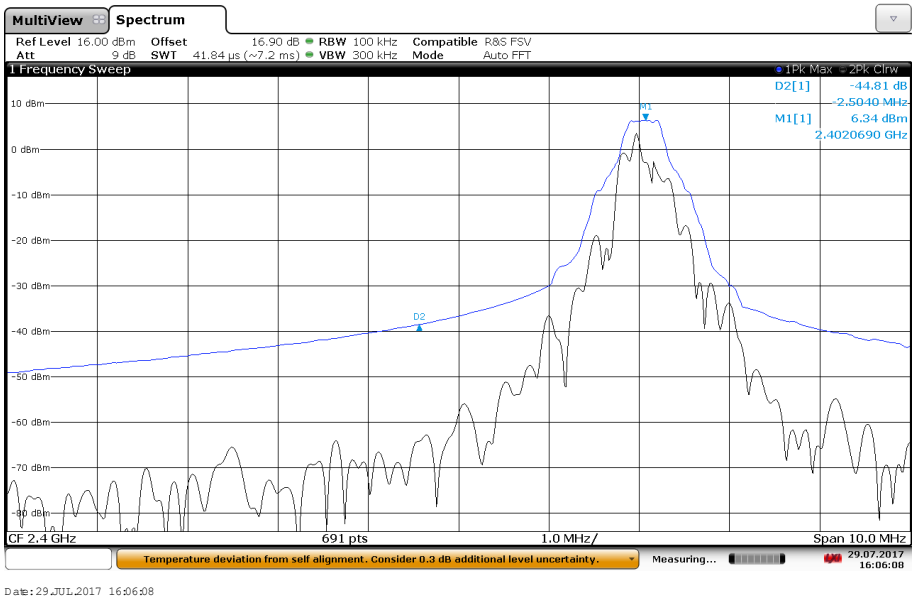
2.7.7 Additional Observations

- This is a conducted test.
- A 16.90dbm correction factor was used to compensate for the external attenuator, connector and cable used within the frequency band.
- Procedure is per Clause 12.2.4, 12.2.5.1, 12.2.5.2 and 13.3.2 of KDB558074.

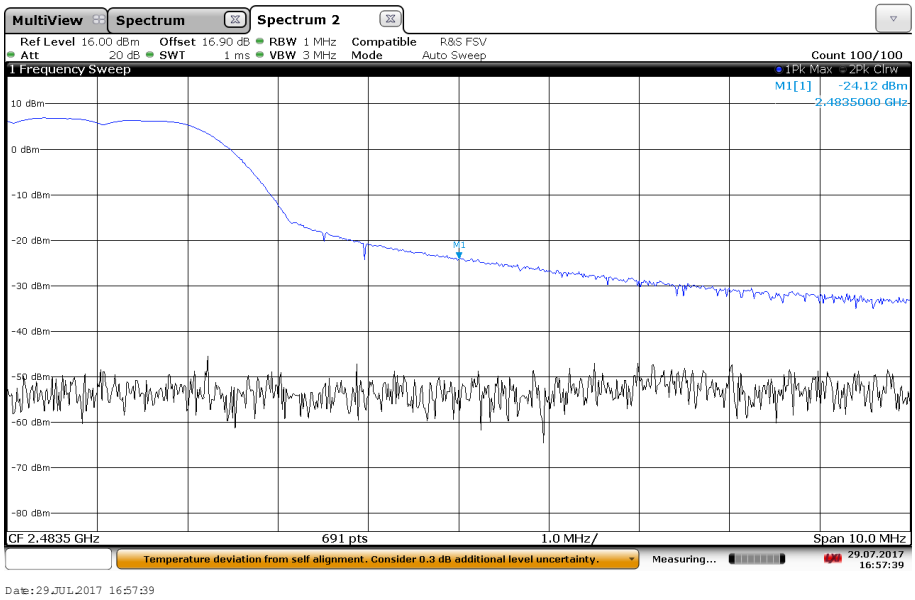
2.7.8 Test Results



GFSK Hopping lower band edge (2402 MHz)



GFSK Non-Hopping lower band edge (2402 MHz)



GFSK Hopping High Channel (2480 MHz Peak)

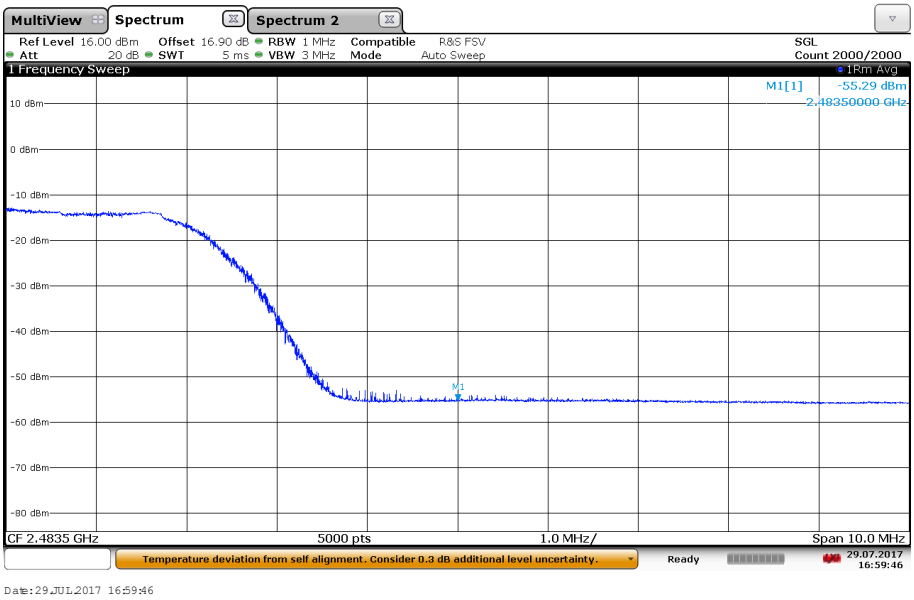
Upper Band Edge (in Restricted Band) measurement using Peak Power measurement procedure as per Clause 12.2.4 of KDB558074

Measured Peak = -24.12 dBm, since antenna gain is 2.0 dBi then EIRP is -21.82 dBm. Electric field strength in dBµV/m is then calculated using the formula:

$$E = EIRP - 20\log D + 104.8$$

Where: E = electric field strength in dBµV/m
EIRP = equivalent isotropic radiated power in dBm
D = specific measurement distance in meters

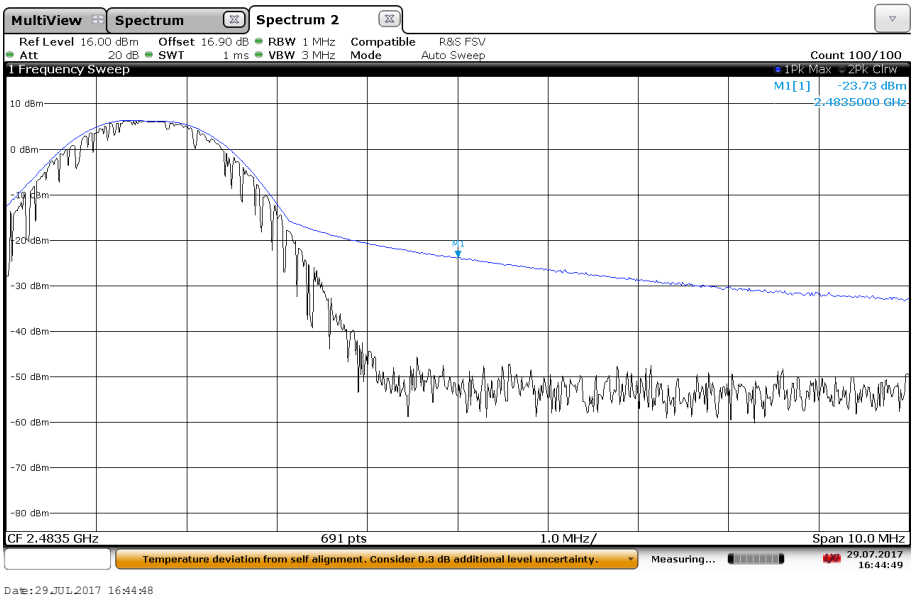
E is therefore =(-24.12 + 2.0 dbi) dBm – (20log 3 meters) + 104.8
= 73.43 dBµV/m @ 3 meters (**Complies** with 74 dBµV/m Peak limits)



GFSK Hopping High Channel (2480 MHz Average)

Upper Band Edge (in Restricted Band) measurement using Trace averaging across on and off times of the EUT transmissions followed by duty cycle correction as per Clause 12.2.5.2 of KDB558074

E is therefore =(-55.29 + 2.3 dbi) dBm – (20log 3 meters) + 104.8
= 42.26dBµV/m @ 3 meters (**Complies** with 54 dBµV/m Average limits)



GFSK Non-Hopping High Channel (2480 MHz Peak)

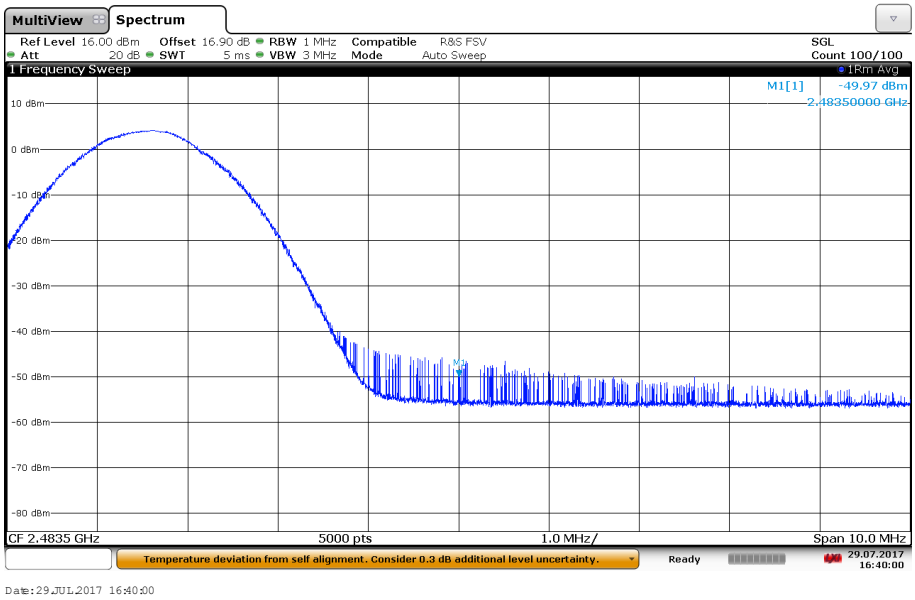
Upper Band Edge (in Restricted Band) measurement using Peak Power measurement procedure as per Clause 12.2.4 of KDB558074

Measured Peak = -23.73 dBm, since antenna gain is 2.0 dBi then EIRP is -21.43 dBm. Electric field strength in dBµV/m is then calculated using the formula:

$$E = EIRP - 20\log D + 104.8$$

Where:	E	= electric field strength in dBµV/m
	EIRP	= equivalent isotropic radiated power in dBm
	D	= specific measurement distance in meters

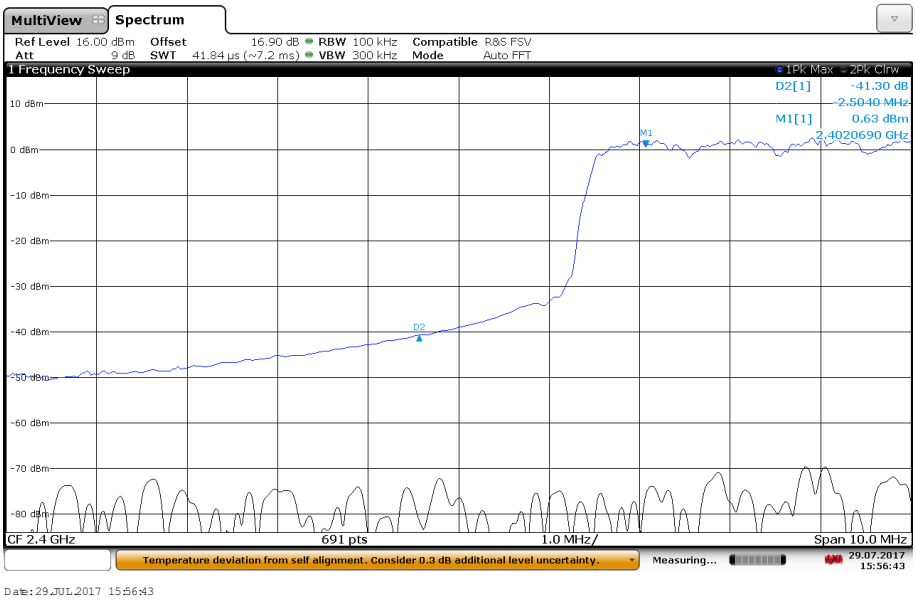
E is therefore =(-23.73 + 2.3 dbi) dBm – (20log 3 meters) + 104.8
= 73.82 dBµV/m @ 3 meters (**Complies** with 74 dBµV/m Peak limits)



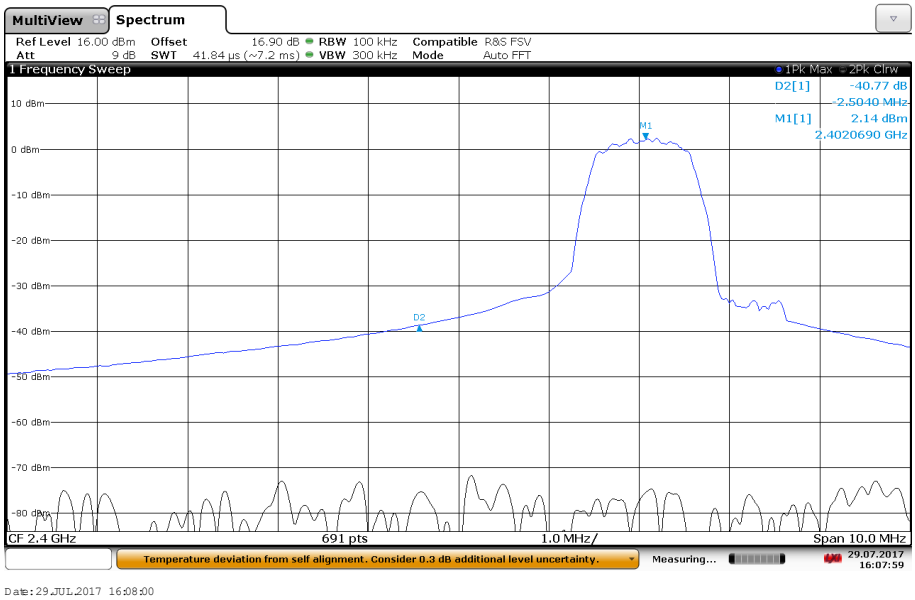
GFSK Non-Hopping High Channel (2480 MHz Average)

Upper Band Edge (in Restricted Band) measurement using Trace averaging across on and off times of the EUT transmissions followed by duty cycle correction as per Clause 12.2.5.2 of KDB558074

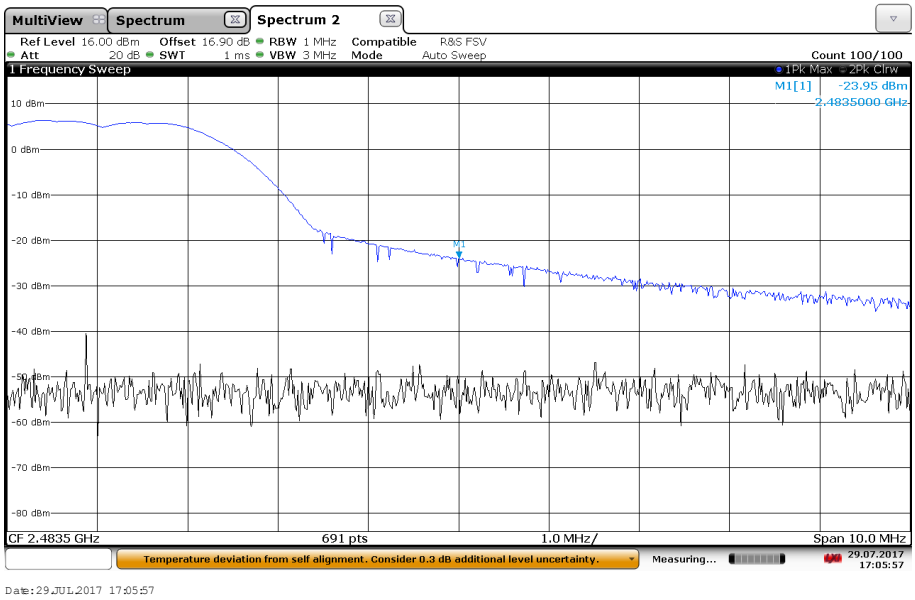
E is therefore =(-49.97 + 2.3 dbi) dBm – (20log 3 meters) + 104.8
= 47.58dBµV/m @ 3 meters (**Complies** with 54 dBµV/m Average limits)



π/4-DQPSK Hopping lower band edge (2402 MHz)



π/4-DQPSK Non-Hopping lower band edge (2402 MHz)



π/4-DQPSK Hopping High Channel (2480 MHz Peak)

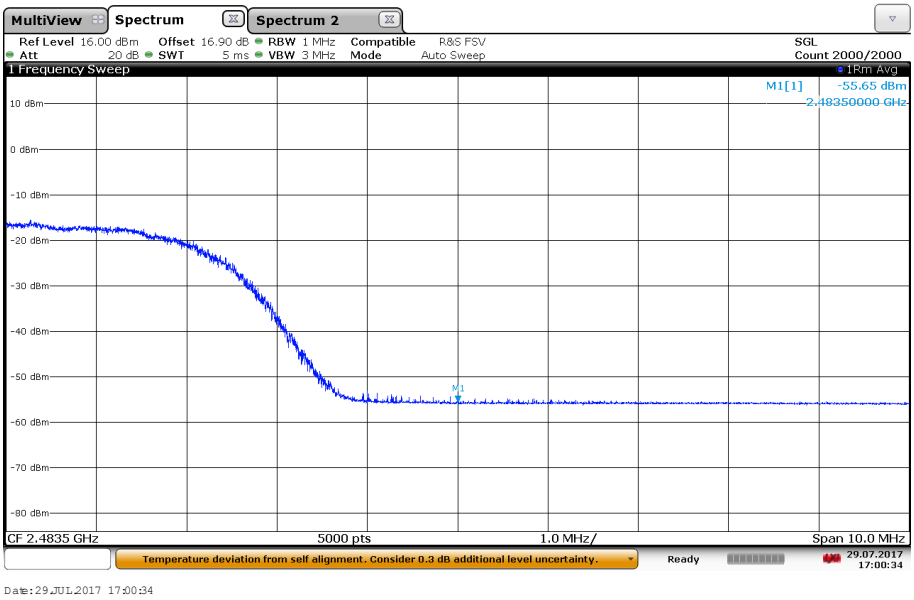
Upper Band Edge (in Restricted Band) measurement using Peak Power measurement procedure as per Clause 12.2.4 of KDB558074

Measured Peak = -23.95 dBm, since antenna gain is 2.0 dBi then EIRP is -21.65 dBm. Electric field strength in dBµV/m is then calculated using the formula:

$$E = EIRP - 20\log D + 104.8$$

Where: E = electric field strength in dBµV/m
EIRP = equivalent isotropic radiated power in dBm
D = specific measurement distance in meters

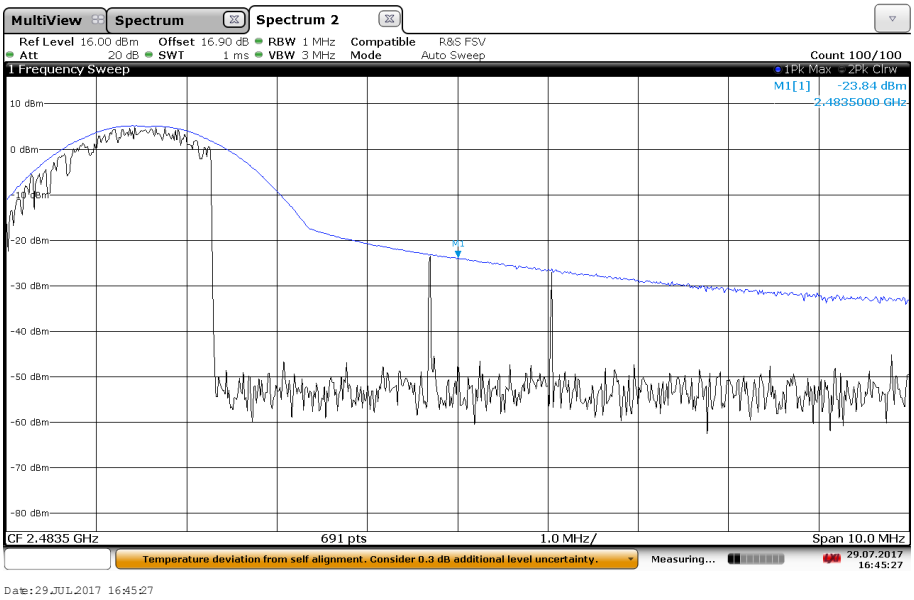
E is therefore =(-23.95 + 2.3 dbi) dBm – (20log 3 meters) + 104.8
= 73.60dBµV/m @ 3 meters (**Complies** with 74 dBµV/m Peak limits)



π/4-DQPSK Hopping High Channel (2480 MHz Average)

Upper Band Edge (in Restricted Band) measurement using Trace averaging across on and off times of the EUT transmissions followed by duty cycle correction as per Clause 12.2.5.2 of KDB558074

E is therefore =(-55.65 + 2.3 dbi) dBm – (20log 3 meters) + 104.8
= 41.90dBµV/m @ 3 meters (**Complies** with 54 dBµV/m Average limits)



π/4-DQPSK Non-Hopping High Channel (2480 MHz Peak)

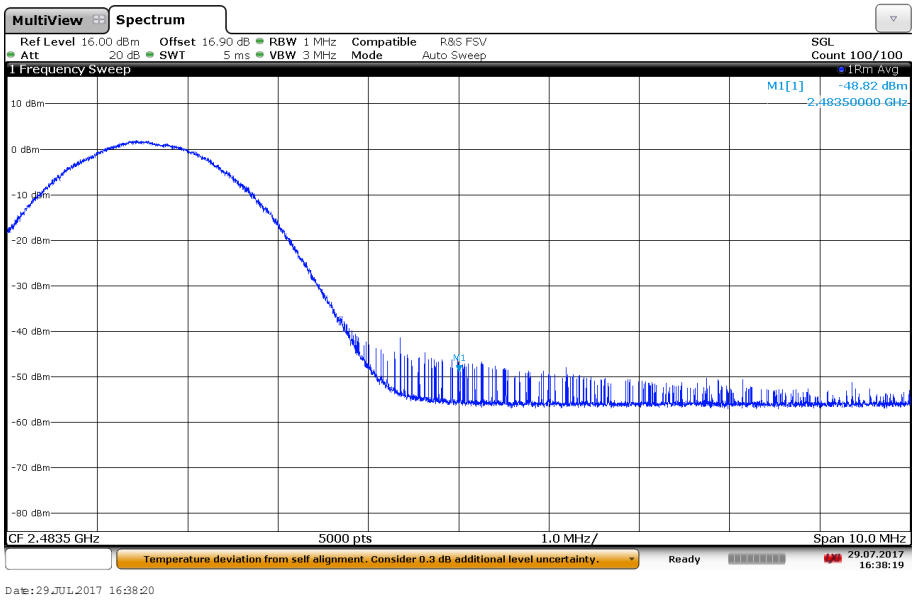
Upper Band Edge (in Restricted Band) measurement using Peak Power measurement procedure as per Clause 12.2.4 of KDB558074

Measured Peak = -23.84 dBm, since antenna gain is 2.3 dBi then EIRP is -21.54 dBm. Electric field strength in dBµV/m is then calculated using the formula:

$$E = EIRP - 20\log D + 104.8$$

Where: E = electric field strength in dBµV/m
EIRP = equivalent isotropic radiated power in dBm
D = specific measurement distance in meters

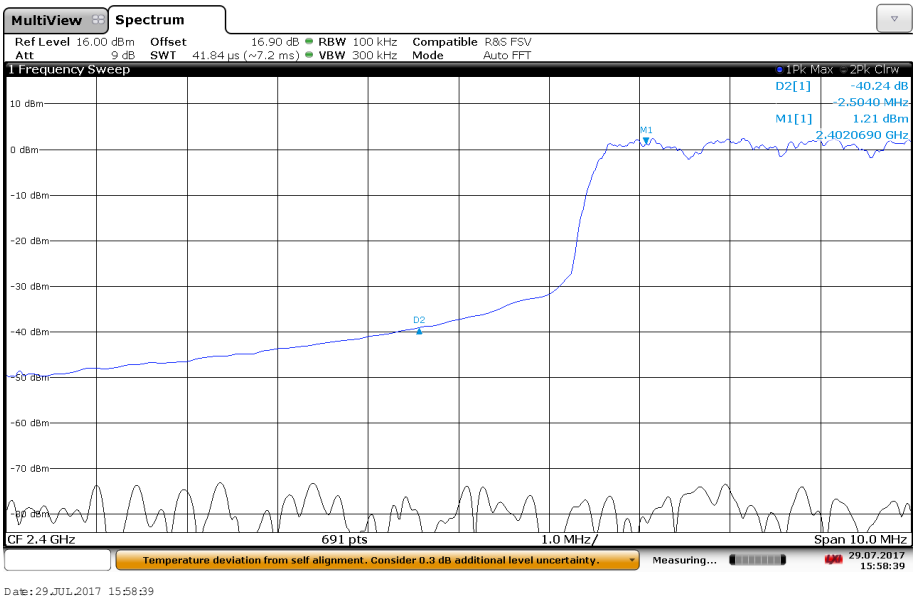
E is therefore =(-23.84 + 2.3 dbi) dBm – (20log 3 meters) + 104.8
= 73.71 dBµV/m @ 3 meters (**Complies** with 74 dBµV/m Peak limits)



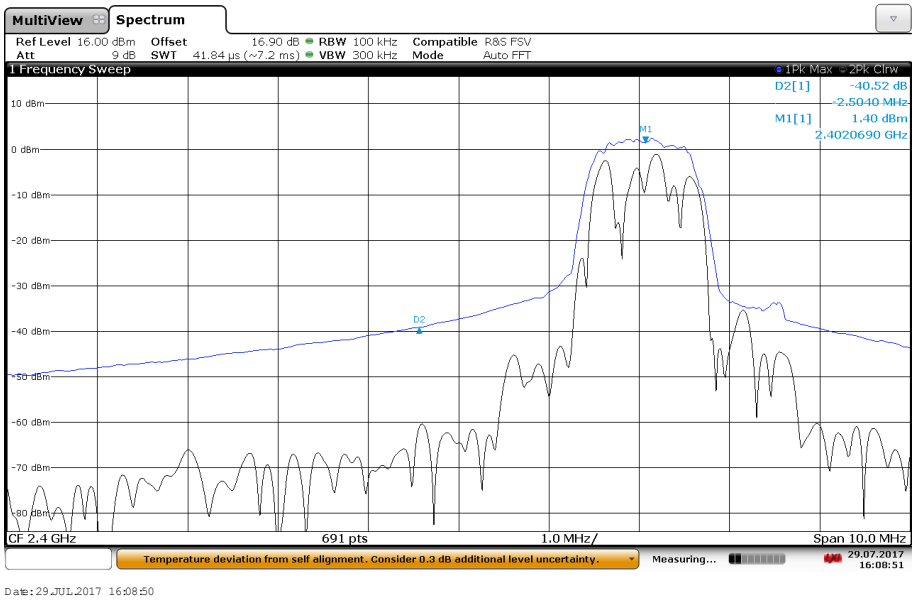
π/4-DQPSK Non-Hopping High Channel (2480 MHz Average)

Upper Band Edge (in Restricted Band) measurement using Trace averaging across on and off times of the EUT transmissions followed by duty cycle correction as per Clause 12.2.5.2 of KDB558074

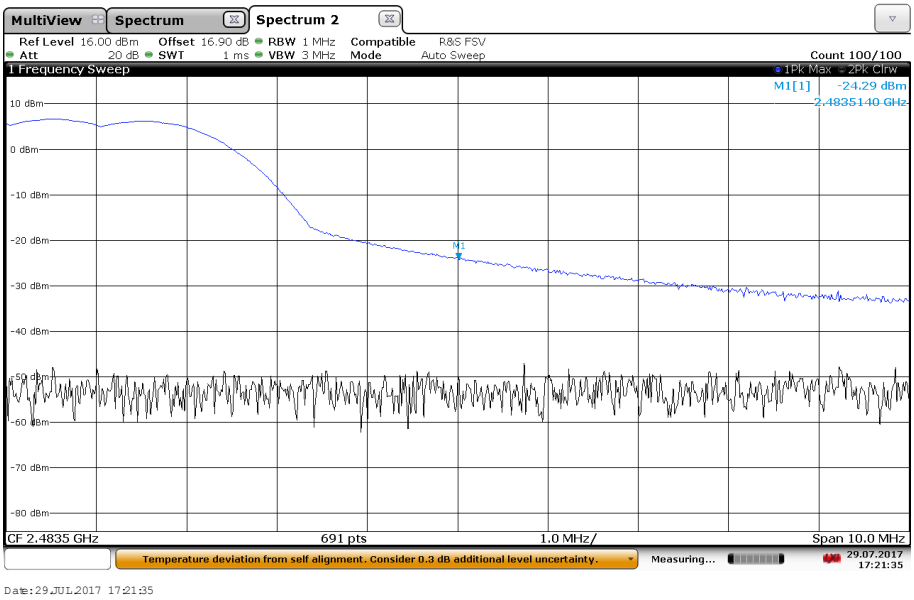
E is therefore =(-49.97 + 2.3 dbi) dBm – (20log 3 meters) + 104.8
= 47.58dBµV/m @ 3 meters (**Complies** with 54 dBµV/m Average limits)



8DPSK Hopping lower band edge (2402 MHz)



8DPSK Non-Hopping lower band edge (2402 MHz)



8DPSK Hopping High Channel (2480 MHz Peak)

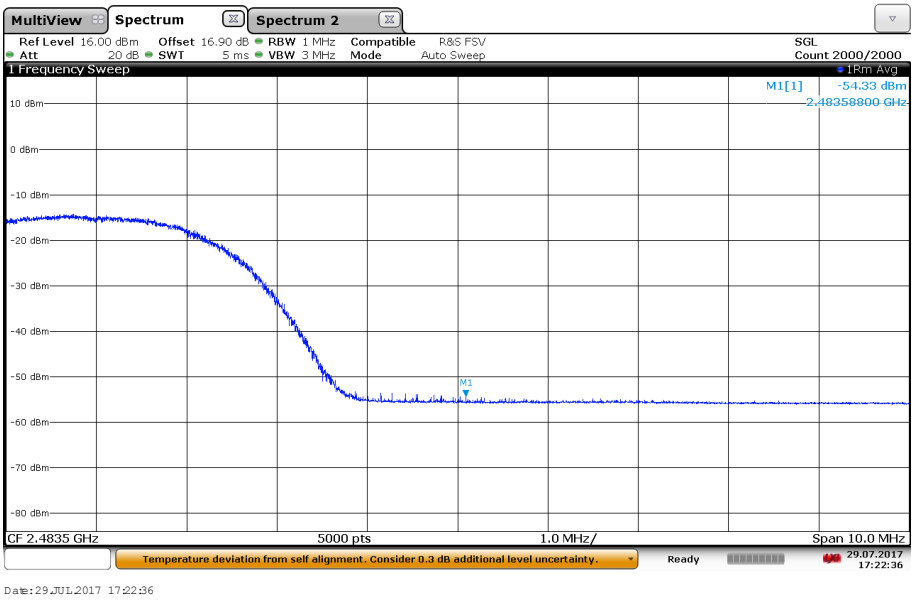
Upper Band Edge (in Restricted Band) measurement using Peak Power measurement procedure as per Clause 12.2.4 of KDB558074

Measured Peak = -24.29 dBm, since antenna gain is 2.3 dBi then EIRP is -21.99 dBm. Electric field strength in dBµV/m is then calculated using the formula:

$$E = EIRP - 20\log D + 104.8$$

Where: E = electric field strength in dBµV/m
EIRP = equivalent isotropic radiated power in dBm
D = specific measurement distance in meters

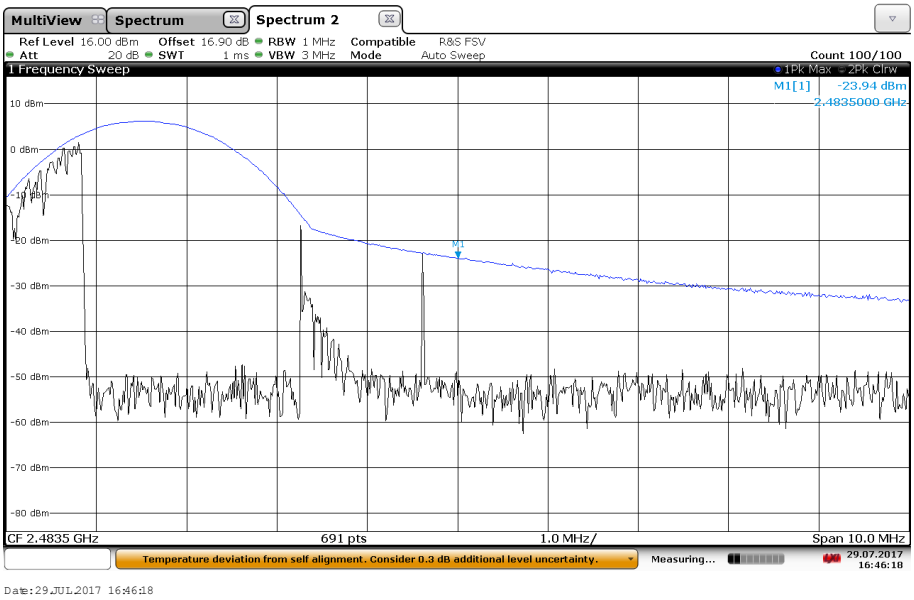
E is therefore =(-24.29 + 2.3 dbi) dBm – (20log 3 meters) + 104.8
= 73.26dBµV/m @ 3 meters (**Complies** with 74 dBµV/m Peak limits)



8DPSK Hopping High Channel (2480 MHz Average)

Upper Band Edge (in Restricted Band) measurement using Trace averaging across on and off times of the EUT transmissions followed by duty cycle correction as per Clause 12.2.5.2 of KDB558074

E is therefore =(-54.33 + 2.0 dbi) dBm – (20log 3 meters) + 104.8
= 43.22dBµV/m @ 3 meters (**Complies** with 54 dBµV/m Average limits)



8DPSK Non-Hopping High Channel (2480 MHz Peak)

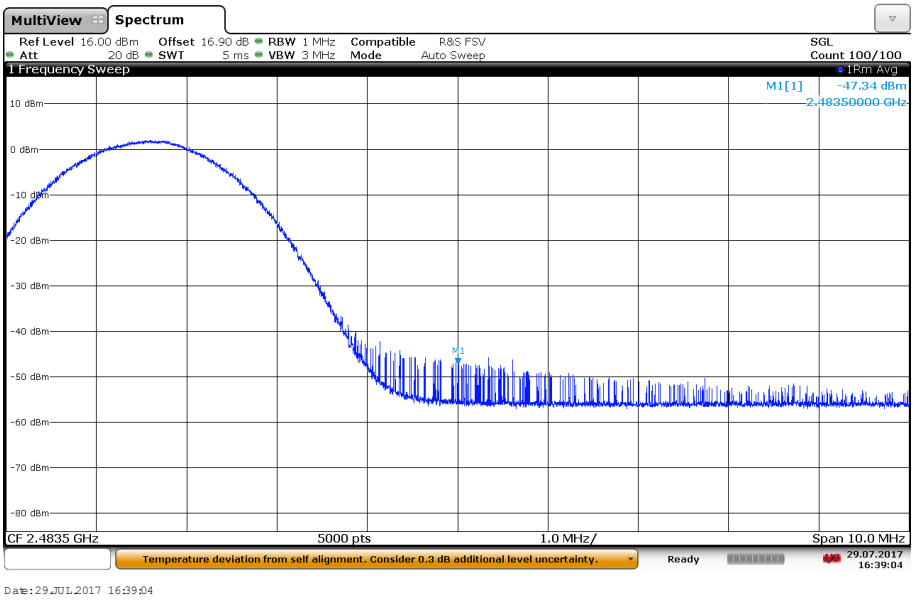
Upper Band Edge (in Restricted Band) measurement using Peak Power measurement procedure as per Clause 12.2.4 of KDB558074

Measured Peak = -23.94 dBm, since antenna gain is 2.3 dBi then EIRP is -21.64 dBm. Electric field strength in dBµV/m is then calculated using the formula:

$$E = EIRP - 20\log D + 104.8$$

Where: E = electric field strength in dBµV/m
EIRP = equivalent isotropic radiated power in dBm
D = specific measurement distance in meters

E is therefore =(-23.94 + 2.3 dbi) dBm – (20log 3 meters) + 104.8
= 73.61 dBµV/m @ 3 meters (**Complies** with 74 dBµV/m Peak limits)



8DPSK Non-Hopping High Channel (2480 MHz Average)

Upper Band Edge (in Restricted Band) measurement using Trace averaging across on and off times of the EUT transmissions followed by duty cycle correction as per Clause 12.2.5.2 of KDB558074

E is therefore =(-47.34 + 2.0 dbi) dBm – (20log 3 meters) + 104.8
= 50.21dBµV/m @ 3 meters (**Complies** with 54 dBµV/m Average limits)

2.8 SPURIOUS RF CONDUCTED EMISSIONS

2.8.1 Specification Reference

Part 15 Subpart C §15.247(d) and RSS-247 5.5

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: EMC Sample 1 / Default Test Configuration

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

September 15, 2017 / IR

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	26.1 °C
Relative Humidity	49.1 %
ATM Pressure	98.7 kPa

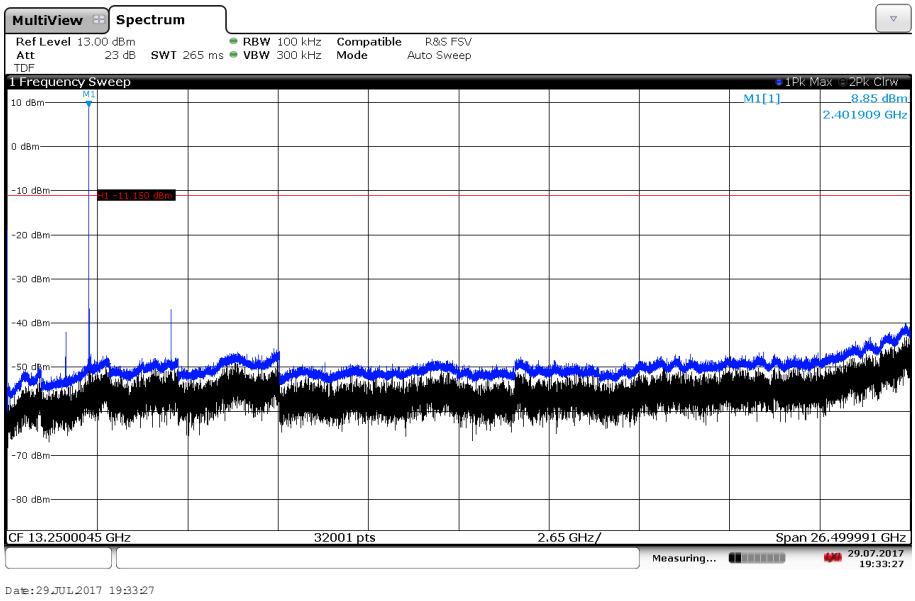
2.8.7 Additional Observations

- This is a conducted test.
- A TDF factor was used to compensate for the external attenuator, connector and cable used within the frequency band.
- Span is from 9 kHz up to 26.5GHz (to cover 10th 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.

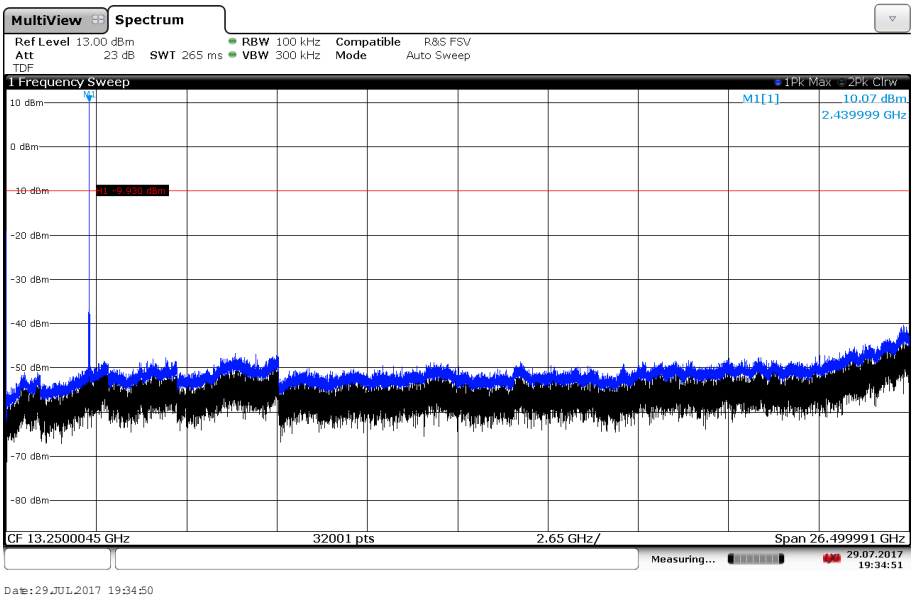
- Trace is max hold.
- Trace allowed to stabilize. Maximum spurious emission compared to limit.
- Limit is 20dBc.

2.8.8 Test Results

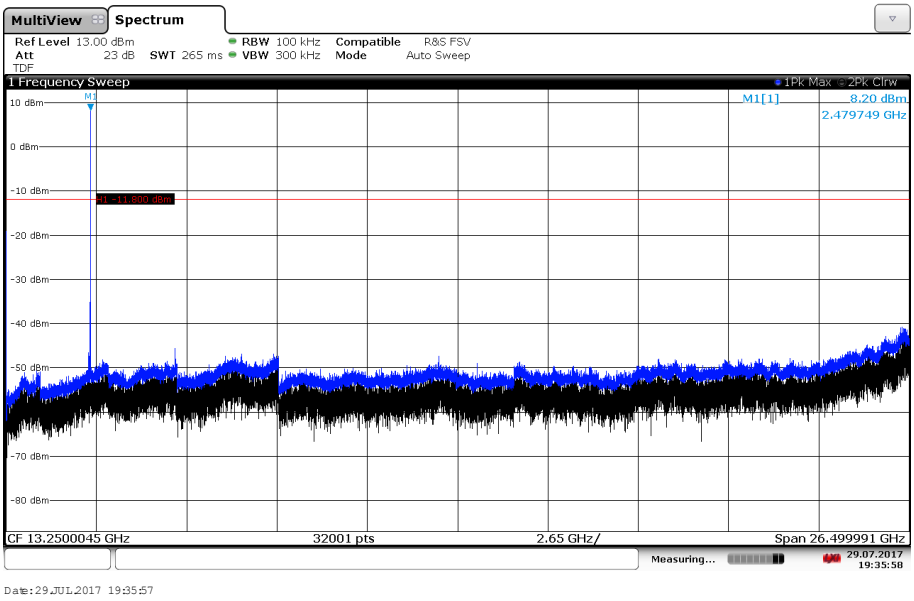
See attached tables and plots.



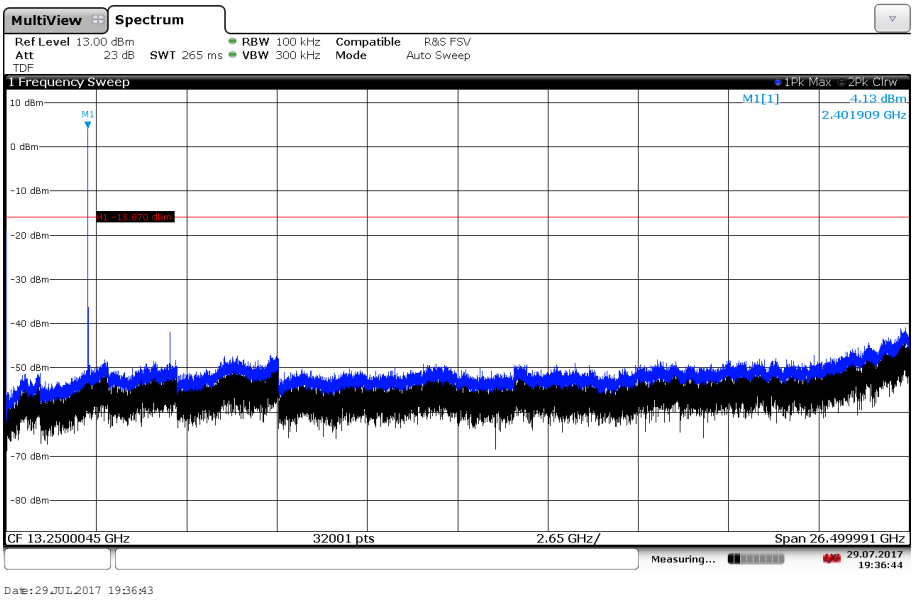
GFSK Low Channel (2402MHz)



GFSK Mid Channel (2440MHz)

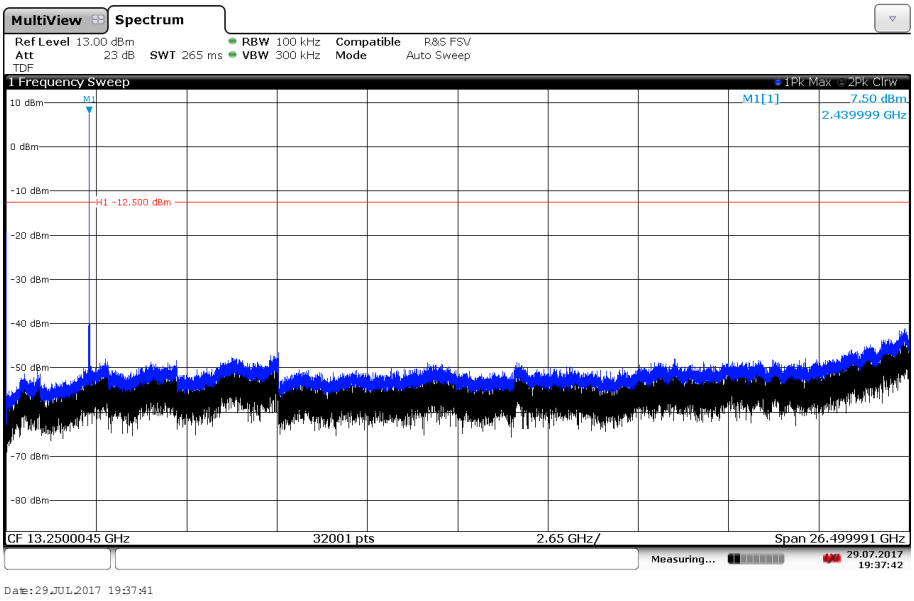


GFSK High Channel (2480MHz)



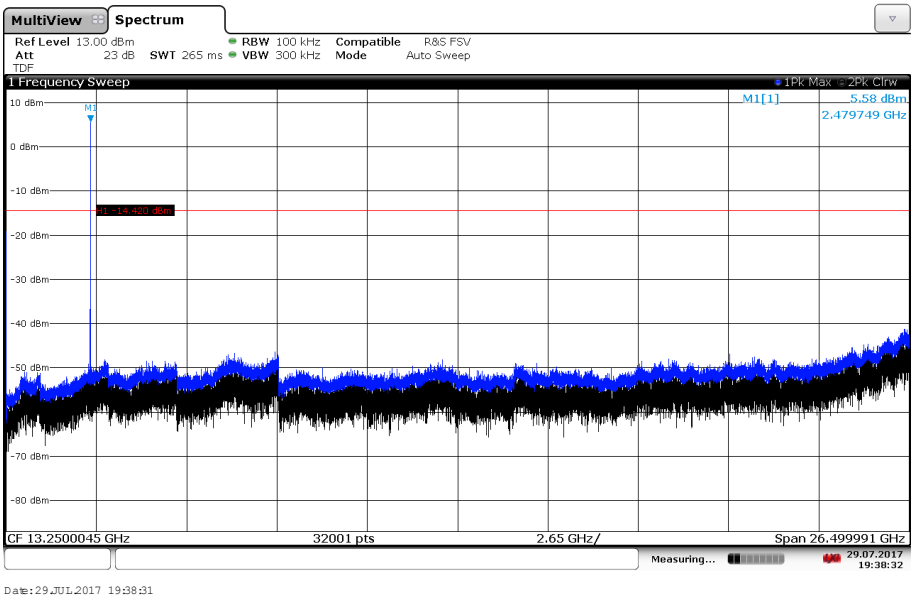
Date: 29.JUL.2017 19:36:43

π/4-DQPSK Low Channel (2402MHz)

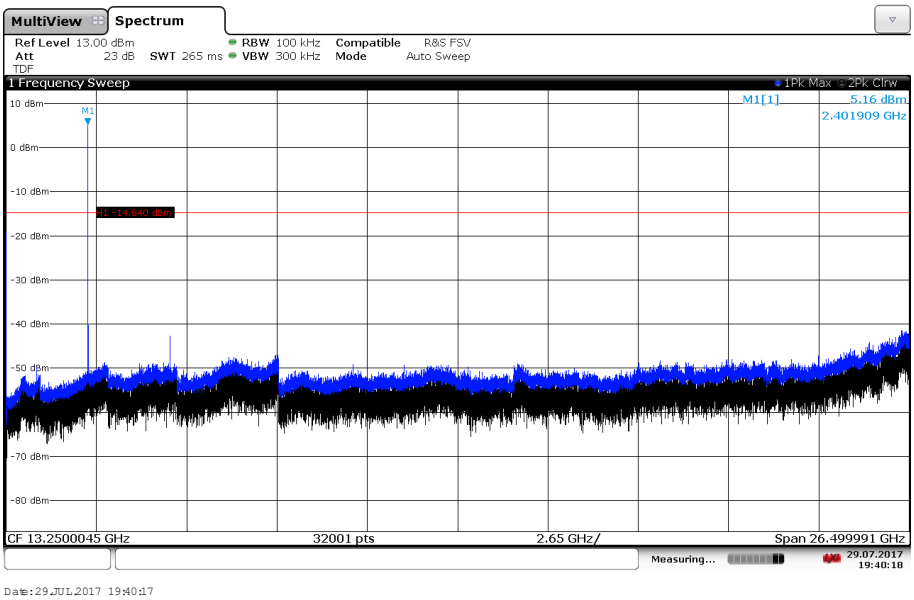


Date: 29.JUL.2017 19:37:41

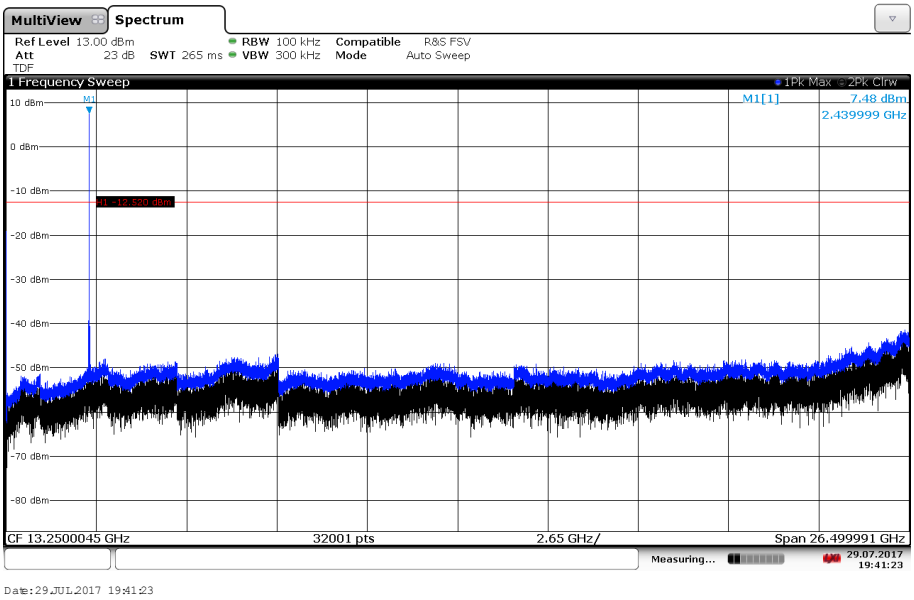
π/4-DQPSK Mid Channel (2440MHz)



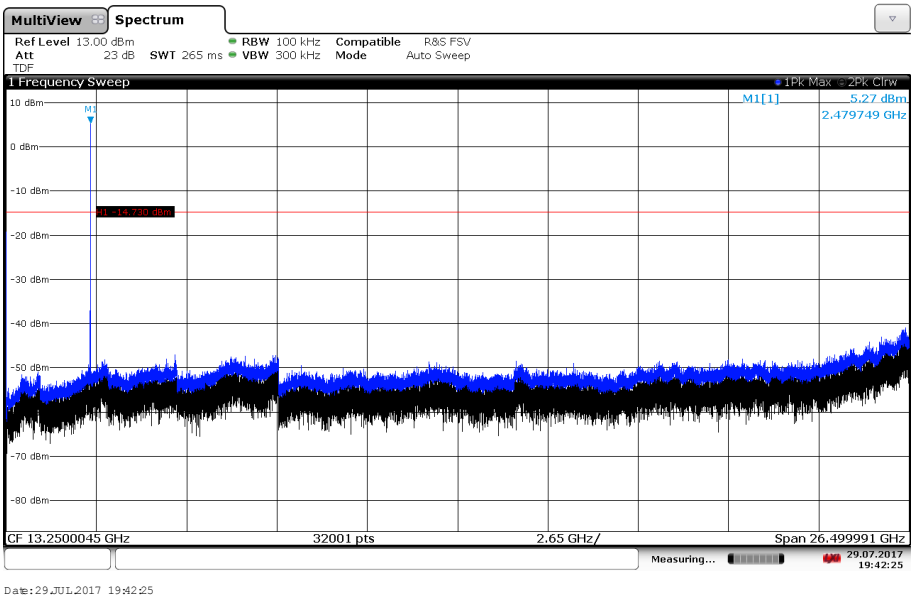
π/4-DQPSK High Channel (2480MHz)



8DPSK Low Channel (2402MHz)



8DPSK Mid Channel (2440MHz)



8DPSK High Channel (2480MHz)

2.9 CABINET/CASE RADIATED EMISSIONS

2.9.1 Specification Reference

ANSI C63.10-2013 Clause 11.12.2.1 and RSS-Gen 8.9 / 8.10

2.9.2 Standard Applicable

Antenna-port conducted measurements may also be used as an alternative to radiated measurements for determining compliance in the restricted frequency bands requirements. If conducted measurements are performed, then proper impedance matching must be ensured and an additional radiated test for cabinet/case emissions is required.

2.9.3 Equipment Under Test and Modification State

Serial No: EMC Sample 1 /Test Configuration C

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

September 20, 2017/IR

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	26.5 °C
Relative Humidity	43.5 %
ATM Pressure	98.6 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 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.

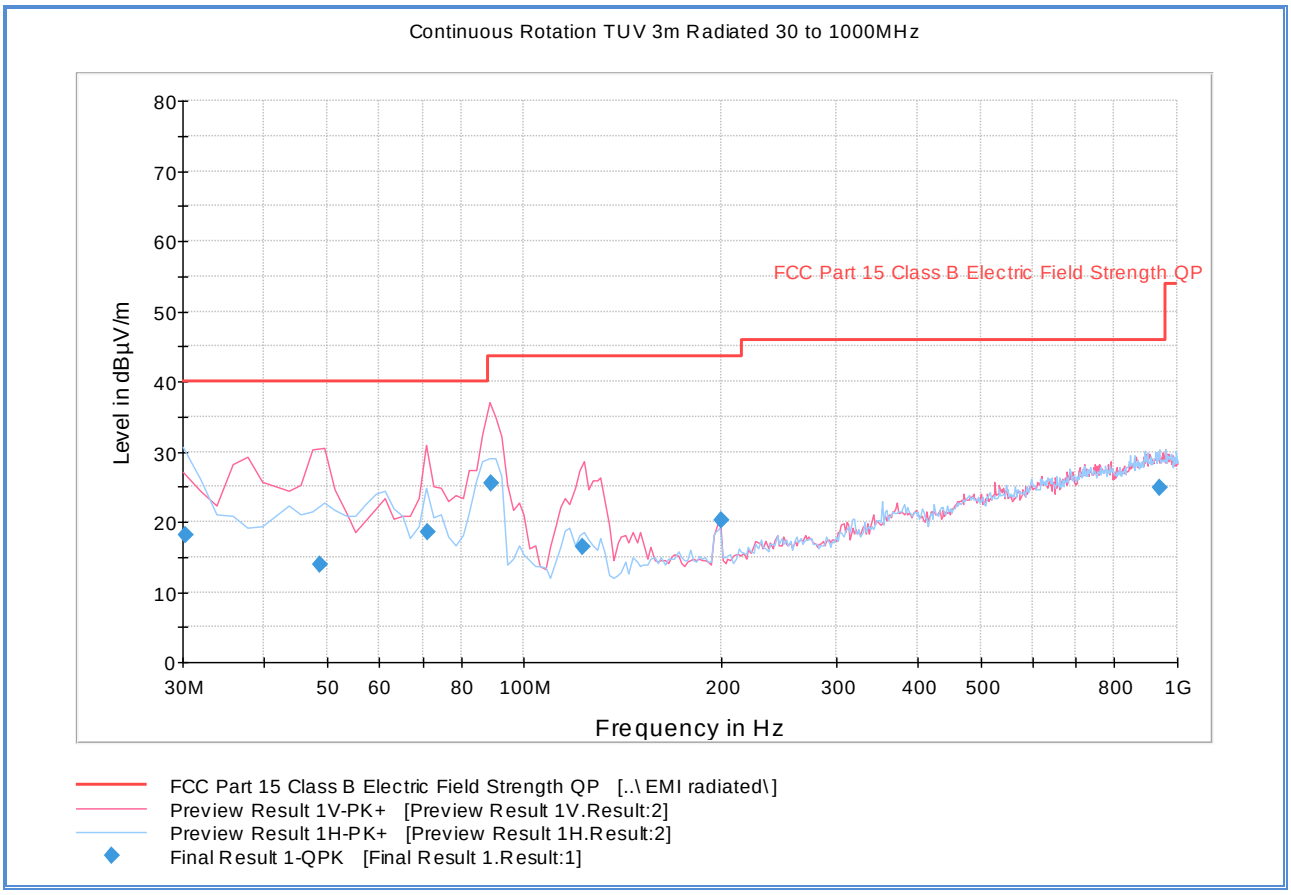
2.9.8 Sample Computation (Radiated Emission)

Measuring equipment raw measurement (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**

2.9.9 Test Results

See attached plots.

2.9.10 Test Results Below 1GHz (Worst Case: Mid Channel)

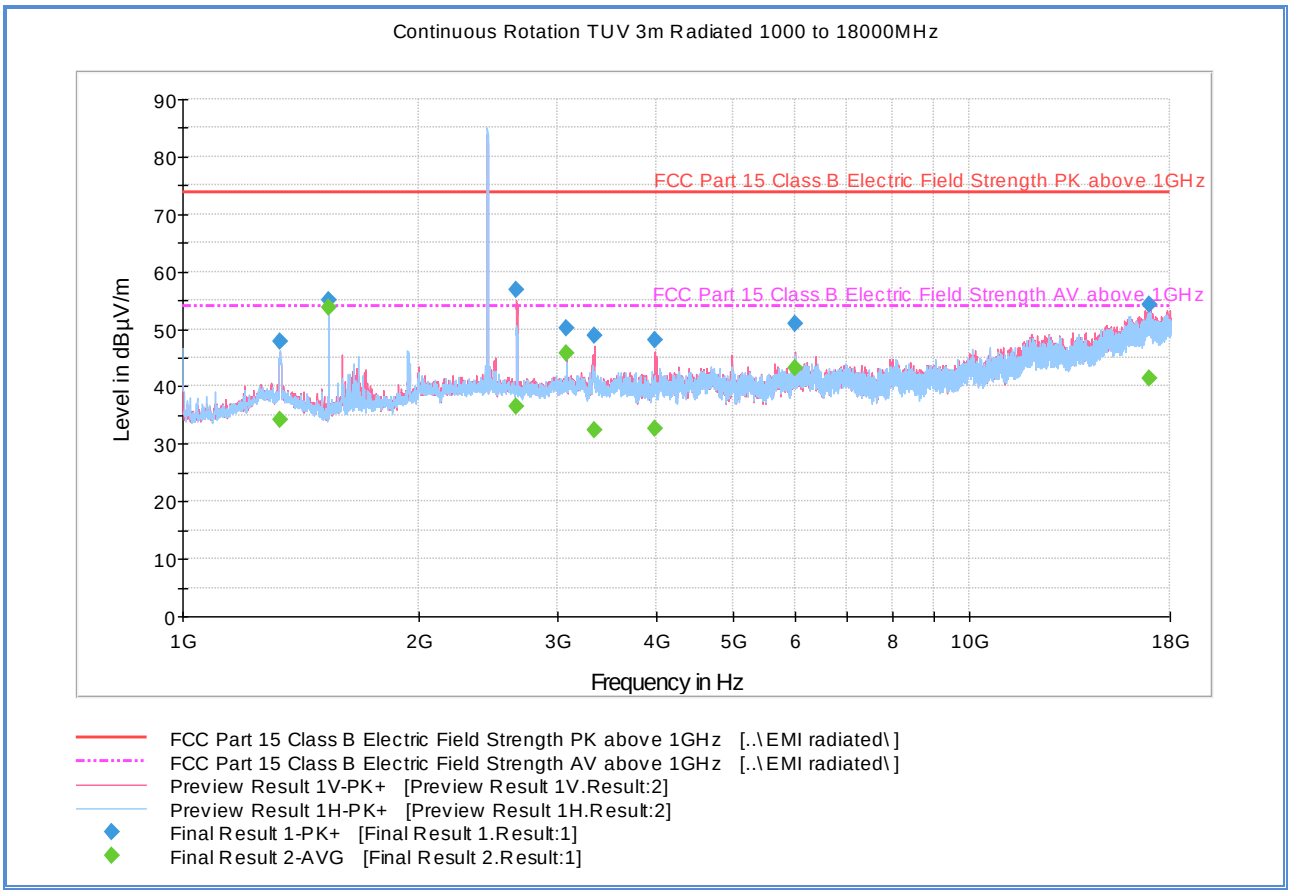


Quasi Peak Data

Frequency (MHz)	QuasiPeak (dBµV/m)	Meas. Time (ms)	Bandwidth (kHz)	Height (cm)	Polarization	Azimuth (deg)	Corr. (dB)	Margin (dB)	Limit (dBµV/m)
30.320000	18.0	1000.0	120.000	365.0	H	62.0	-6.1	22.0	40.0
48.558878	13.8	1000.0	120.000	100.0	V	238.0	-14.2	26.2	40.0
70.981643	18.4	1000.0	120.000	400.0	V	160.0	-17.0	21.6	40.0
89.156633	25.4	1000.0	120.000	100.0	V	1.0	-16.1	18.1	43.5
122.586613	16.4	1000.0	120.000	100.0	V	250.0	-15.9	27.1	43.5
199.998236	20.3	1000.0	120.000	100.0	V	95.0	-12.0	23.2	43.5

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

2.9.11 Test Results Above 1GHz (Worst Case: Mid Channel)



Peak Data

Frequency (MHz)	MaxPeak (dBµV/m)	Meas. Time (ms)	Bandwidth (kHz)	Height (cm)	Polarization	Azimuth (deg)	Corr. (dB)	Margin (dB)	Limit (dBµV/m)
1330.966667	47.8	1000.0	1000.000	343.1	V	13.0	-5.1	26.1	73.9
1535.333333	55.1	1000.0	1000.000	103.7	H	200.0	-5.5	18.8	73.9
2653.366667	56.8	1000.0	1000.000	156.6	V	206.0	-0.6	17.1	73.9
3070.800000	50.2	1000.0	1000.000	122.7	V	278.0	0.8	23.7	73.9
3332.933333	49.0	1000.0	1000.000	103.7	V	71.0	1.1	24.9	73.9
3988.066667	48.0	1000.0	1000.000	99.7	V	136.0	2.7	25.9	73.9
6000.500000	51.0	1000.0	1000.000	341.1	V	170.0	6.4	22.9	73.9
16943.733333	54.2	1000.0	1000.000	302.2	H	88.0	23.0	19.7	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)
1330.966667	34.2	1000.0	1000.000	343.1	V	13.0	-5.1	19.7	53.9
1535.333333	53.7	1000.0	1000.000	103.7	H	200.0	-5.5	0.2	53.9
2653.366667	36.6	1000.0	1000.000	156.6	V	206.0	-0.6	17.3	53.9
3070.800000	45.8	1000.0	1000.000	122.7	V	278.0	0.8	8.1	53.9
3332.933333	32.4	1000.0	1000.000	103.7	V	71.0	1.1	21.5	53.9
3988.066667	32.6	1000.0	1000.000	99.7	V	136.0	2.7	21.3	53.9
6000.500000	43.2	1000.0	1000.000	341.1	V	170.0	6.4	10.7	53.9
16943.733333	41.4	1000.0	1000.000	302.2	H	88.0	23.0	12.5	53.9

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

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						
7606	USB RF Power Sensor	RadiPower RPR3006W	14I00048SNO048	DARE!! Instruments	11/30/16	11/30/17
7582	Signal/Spectrum Analyzer	FSW26*	101614	Rhode & Schwarz	10/26/16	10/26/17
8871	20dB Attenuator	CAT-20	N/A	MCL HAT-20	04/26/17	04/26/18
Radiated Test Setup						
1002	Bilog Antenna	3142C	00058717	ETS-Lindgren	11/06/15	11/06/17
1040	EMI Test Receiver	ESIB40	100292	Rhode & Schwarz	10/07/16	10/07/17
1016	Pre-amplifier	PAM-0202	187	PAM	02/09/17	02/09/18
1051	Double-ridged waveguide horn antenna	3115	9408-4329	EMCO	07/17/17	07/17/18
1049	EMI Test Receiver	ESU	100133	Rhode & Schwarz	07/13/17	07/13/18
8628	Pre-amplifier	QLJ 01182835-JO	8986002	QuinStar Technologies Inc.	02/09/17	02/09/18
Miscellaneous						
6708	Multimeter	34401A	US36086974	Hewlett Packard	07/05/17	07/05/18
7554	Barometer/Temperature/Humidity Transmitter	iBTHX-W	0400706	Omega	01/17/17	01/17/18
-	Test Software	EMC32	V8.53	Rhode & Schwarz	N/A	
-	Test Software	RadiMotion	V2014.2.3	Dare Instruments	N/A	

*Note: Date was not set-up in FSW26

3.2 MEASUREMENT UNCERTAINTY

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

3.2.1 Radiated Measurements (Below 1GHz)

	Contribution	Probability Distribution Type	Probability Distribution x_i	Standard Uncertainty $u(x_i)$	$[u(x_i)]^2$
1	Receiver/Spectrum Analyser	Rectangular	0.45	0.26	0.07
2	Cables	Rectangular	0.50	0.29	0.08
3	Preamp	Rectangular	0.50	0.29	0.08
4	Antenna	Rectangular	0.75	0.43	0.19
5	Site	Triangular	3.52	1.44	2.07
6	EUT Setup	Rectangular	1.00	0.58	0.33
				Combined Uncertainty (u_c):	1.68
				Coverage Factor (k):	2
				Expanded Uncertainty:	3.36

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	Preamp	Rectangular	0.50	0.29	0.08
4	Antenna	Rectangular	0.37	0.21	0.05
5	Site	Triangular	3.00	1.22	1.50
6	EUT Setup	Rectangular	1.00	0.58	0.33
				Combined Uncertainty (u_c):	1.49
				Coverage Factor (k):	2
				Expanded Uncertainty:	2.99

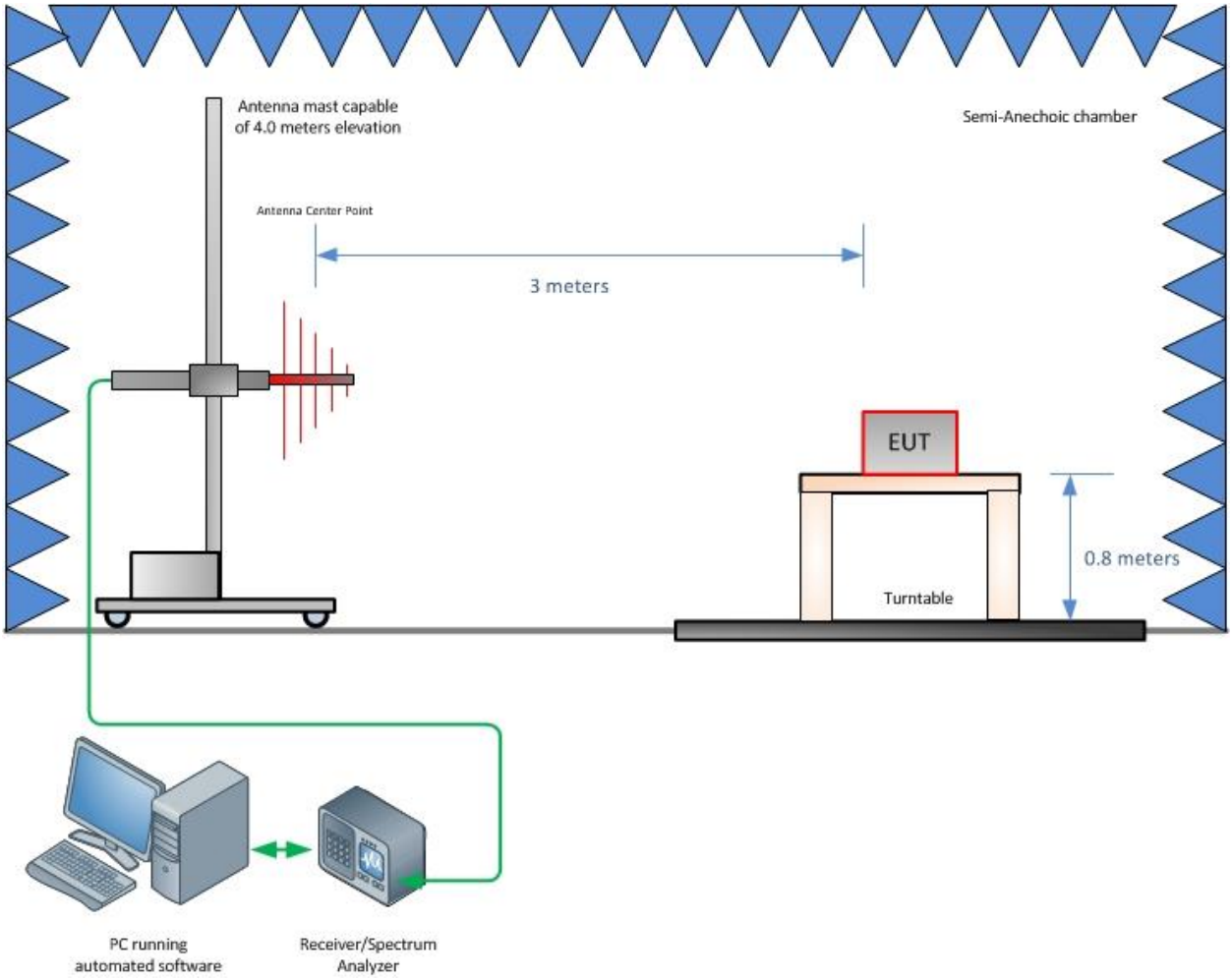
3.2.3 Conducted Antenna Port Measurement

	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	0.30	0.17	0.03
3	EUT Setup	Rectangular	0.50	0.29	0.08
				Combined Uncertainty (u_c):	0.39
				Coverage Factor (k):	1.96
				Expanded Uncertainty:	0.76

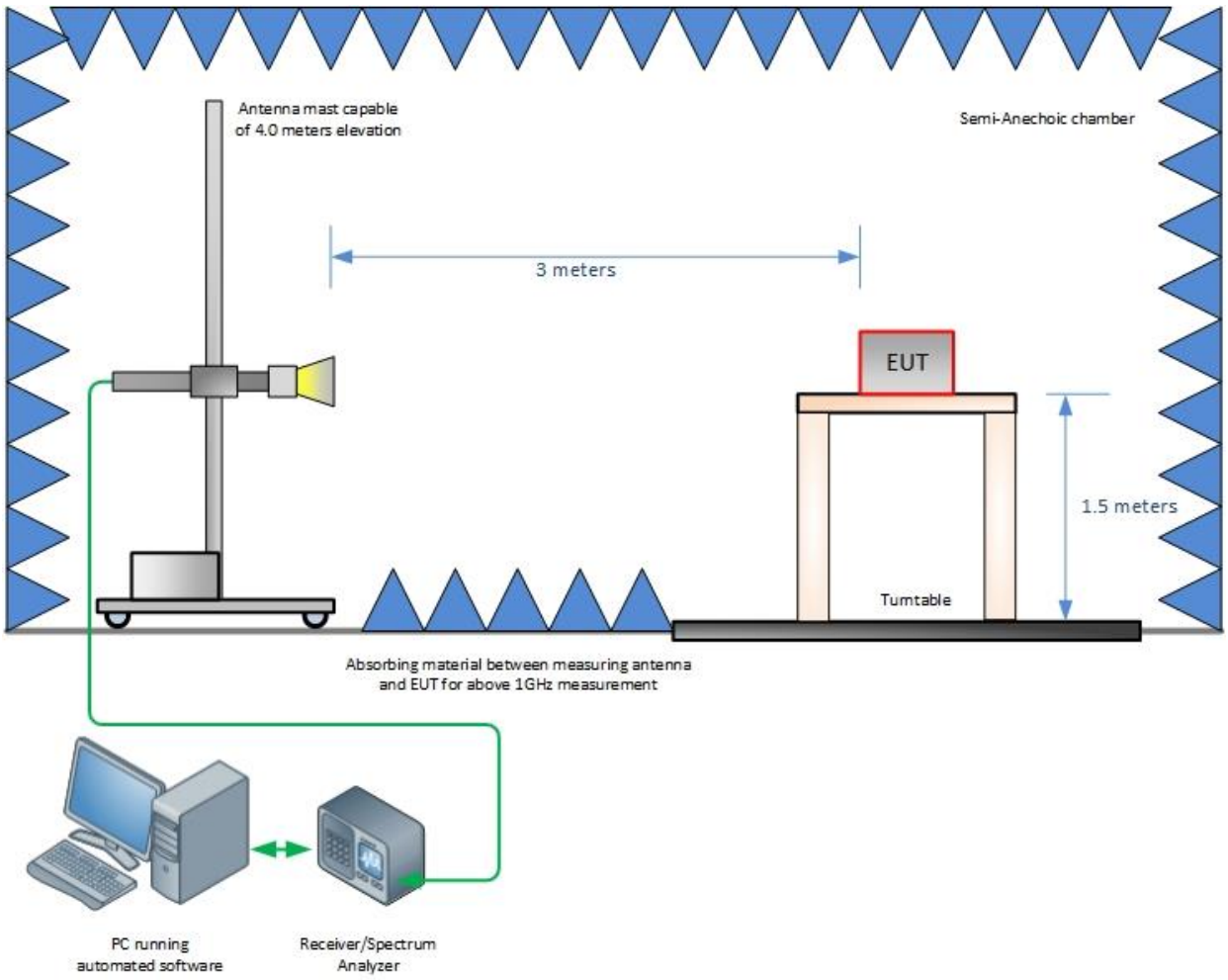
SECTION 4

DIAGRAM OF TEST SETUP

4.1 TEST SETUP DIAGRAM



Radiated Emission Test Setup (Below 1GHz)



Radiated Emission Test Setup (Above 1GHz)

SECTION 5

ACCREDITATION, DISCLAIMERS AND COPYRIGHT

5.1 ACCREDITATION, DISCLAIMERS AND COPYRIGHT

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