CERTIFICATION TEST REPORT

Report Number. : 12148309-E1V3

Applicant	:	SONOS, INC. 614 CHAPALA STREET SANTA BARBARA, CA 93101, U.S.A
Model	:	S17
FCC ID	:	SBVRM017
IC	:	5373A-RM017
EUT Description	:	802.11 a/b/g/n 4x4 (HT20) Client Device
Test Standard(s)	:	FCC 47 CFR PART 15 SUBPART C ISED RSS-247 ISSUE 2 ISED RSS-GEN ISSUE 5

Date Of Issue:
July 30, 2019

Prepared by:
UL Verification Services Inc.
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NVLAP TESTING

NVLAP Lab code: 200065-0

REPORT REVISION HISTORY

Rev.	Issue Date	Revisions	Revised By
V1	6/13/2019	Initial Issue	
V2	6/20/2019	Updated Section 5.5 & 7	K.Kedida
V3	7/30/2019	Updated Section 5.5	K.Kedida

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1. ATTESTATION OF TEST RESULTS

COMPANY NAME: SONOS, INC.
614 CHAPALA STREET
SANTA BARBARA, CA 93101, U.S.A

EUT DESCRIPTION: 802.11 a/b/g/n 4x4 (HT20) Client Device

MODEL: S17

SERIAL NUMBER: 5C-AA-FD-D0-08-14(Radiated)
5C-FF-DD-00-03-69 (Conducted)

DATE TESTED: February 27 to March 11, 2019

APPLICABLE STANDARDS	
STANDARD	**TEST RESULTS**
CFR 47 Part 15 Subpart C	Complies
ISED RSS-247 Issue 2	Complies
ISED RSS-GEN Issue 5	Complies

UL Verification Services Inc. tested the above equipment in accordance with the requirements set forth in the above standards. The test results show that the equipment tested is capable of demonstrating compliance with the requirements as documented in this report.

The results documented in this report apply only to the tested sample, under the conditions and modes of operation as described herein. It is the manufacturer's responsibility to assure that additional production units of this model are manufactured with identical electrical and mechanical components. All samples tested were in good operating condition throughout the entire test program. Measurement Uncertainties are published for informational purposes only and were not taken into account unless noted otherwise.

This document may not be altered or revised in any way unless done so by UL Verification Services Inc. and all revisions are duly noted in the revisions section. Any alteration of this document not carried out by UL Verification Services Inc. will constitute fraud and shall nullify the document. This report must not be used by the client to claim product certification, approval, or endorsement by NVLAP, NIST, any agency of the Federal Government, or any agency of the U.S. government.

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2. TEST METHODOLOGY

The tests documented in this report were performed in accordance with FCC CFR 47 Part 2, FCC CFR 47 Part 15, ANSI C63.10-2013, KDB 558074 D01 15.247 Meas Guidance v05r01, RSS-GEN Issue 5, and RSS-247 Issue 2.

3. FACILITIES AND ACCREDITATION

The test sites and measurement facilities used to collect data are located at 47173 and 47266 Benicia Street, and 47658 Kato Road, Fremont, California, USA. Line conducted emissions are measured only at the 47173 address. The following table identifies which facilities were utilized for radiated emission measurements documented in this report. Specific facilities are also identified in the test results sections.

47173 Benicia Street	47266 Benicia Street	47658 Kato Rd.
☐ Chamber A	☐ Chamber D	☐ Chamber I
☐ Chamber B	☐ Chamber E	☒ Chamber J
☐ Chamber C	☐ Chamber F	☒ Chamber K
	☐ Chamber G	☐ Chamber L
	☐ Chamber H	

The above test sites and facilities are covered under FCC Test Firm Registration # 208313. Chambers above are covered under Industry Canada company address and respective code: 2324A.

UL Verification Services Inc. is accredited by NVLAP, Laboratory Code 200065-0

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4. CALIBRATION AND UNCERTAINTY

4.1. MEASURING INSTRUMENT CALIBRATION

The measuring equipment utilized to perform the tests documented in this report has been calibrated in accordance with the manufacturer's recommendations, and is traceable to recognized national standards.

4.2. SAMPLE CALCULATION

RADIATED EMISSIONS
Where relevant, the following sample calculation is provided:
Field Strength (dBuV/m) = Measured Voltage (dBuV) + Antenna Factor (dB/m) + Cable Loss (dB) – Preamp Gain (dB)
36.5 dBuV + 18.7 dB/m + 0.6 dB – 26.9 dB = 28.9 dBuV/m

MAINS CONDUCTED EMISSIONS
Where relevant, the following sample calculation is provided:
Final Voltage (dBuV) = Measured Voltage (dBuV) + Cable Loss (dB) + Limiter Factor (dB) + LISN Insertion Loss.
36.5 dBuV + 0 dB +10.1 dB+ 0 dB = 46.6 dBuV

4.3. MEASUREMENT UNCERTAINTY

Where relevant, the following measurement uncertainty levels have been estimated for tests performed on the apparatus:

PARAMETER	UNCERTAINTY
Worst Case Conducted Disturbance, 9KHz to 0.15 MHz	3.84 dB
Worst Case Conducted Disturbance, 0.15 to 30 MHz	3.65 dB
Worst Case Radiated Disturbance, 9KHz to 30 MHz	2.52 dB
Worst Case Radiated Disturbance, 30 to 1000 MHz	4.88 dB
Worst Case Radiated Disturbance, 1000 to 18000 MHz	4.24 dB
Worst Case Radiated Disturbance, 18000 to 26000 MHz	4.37 dB
Worst Case Radiated Disturbance, 26000 to 40000 MHz	5.17 dB

Uncertainty figures are valid to a confidence level of 95%.

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5. EQUIPMENT UNDER TEST

5.1. EUT DESCRIPTION

The EUT is an 802.11 4x4 a/b/g/n (HT20) Client Device. Product model S17 is a high-performance wireless speaker and part of the Sonos sound system. The device's primary function will be for streaming via WiFi, but also features Bluetooth audio streaming and Bluetooth Low Energy, used for simplified set-up.

5.2. MAXIMUM OUTPUT POWER

The transmitter has a maximum peak conducted output power as follows:

Frequency Range (MHz)	Mode	Output Power (dBm)	Output Power (mW)
2402 - 2480	Basic GFSK	16.23	41.98
2402 - 2480	Enhanced DQPSK	15.12	32.51
2402 - 2480	Enhanced 8PSK	13.92	24.66

Note: GFSK, DQPSK, 8PSK average Power are all investigated, The GFSK & 8PSK Power are the worst case. Testing is based on these modes to showing compliance.

5.3. DESCRIPTION OF AVAILABLE ANTENNAS

The radio utilizes an FPC antenna, with a maximum gain of 2.2 dBi.

5.4. SOFTWARE AND FIRMWARE

The test utility software used during testing was Sonos Compliance GUI 4.0.

5.5. WORST-CASE CONFIGURATION AND MODE

Radiated emissions below 1GHz, above 18GHz, and power line conducted emission were performed with the EUT set to transmit at the channel with highest output power as worst-case scenario.

Band edge and radiated emissions between 1GHz and 18GHz were performed with the EUT set to transmit at the highest power on low, middle and high channels.

The EUT can only be setup in desktop orientation; therefore, all radiated testing was performed with the EUT in desktop orientation. The test set-up includes the power supply and USB-C Cord. Note that the USB-C Cord is not supplied with the product, it is used as support equipment for testing purposes only.

Worst-case data rates as provided by the client were:

GFSK mode: DH5
8PSK mode: 3-DH5

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5.6. DESCRIPTION OF TEST SETUP

SUPPORT EQUIPMENT

Support Equipment List				
Description	**Manufacturer**	**Model**	**Serial Number**	**FCC ID**
Laptop	Lenovo	X230	SON-00002240	N/A
AC Adapter	Lenovo	42T4418	11S42T4418Z1ZGWG0B5776	N/A

I/O CABLES

I/O Cable List						
Cable No	**Port**	**# of identica**	**Connector Type**	**Cable Type**	**Cable Length (m)**	**Remarks**
1	AC Power	1	AC	Unshielded	2	AC Mains to EUT
2	Ethernet	1	RJ45	Unshielded	10	Ethernet to Ethernet converter
3	Ethernet to USB	1	RJ45 to USB	Unshielded	0.2	USB to USB adapter
4	USB adapter to USB C	1	USB to USB C	Unshielded	0.12	USB C to EUT
5	DC Power	1	DC	Shielded	1.2	AC/DC Adapter to Laptop
6	AC Power	1	AC	Unshielded	1	AC Mains to AC/DC Adapter

TEST SETUP

The EUT connected to support laptop via the ethernet cable during testing.
The test utility software on support laptop exercised the radio card.
For radiated testing, the support laptop was set up outside the chamber.

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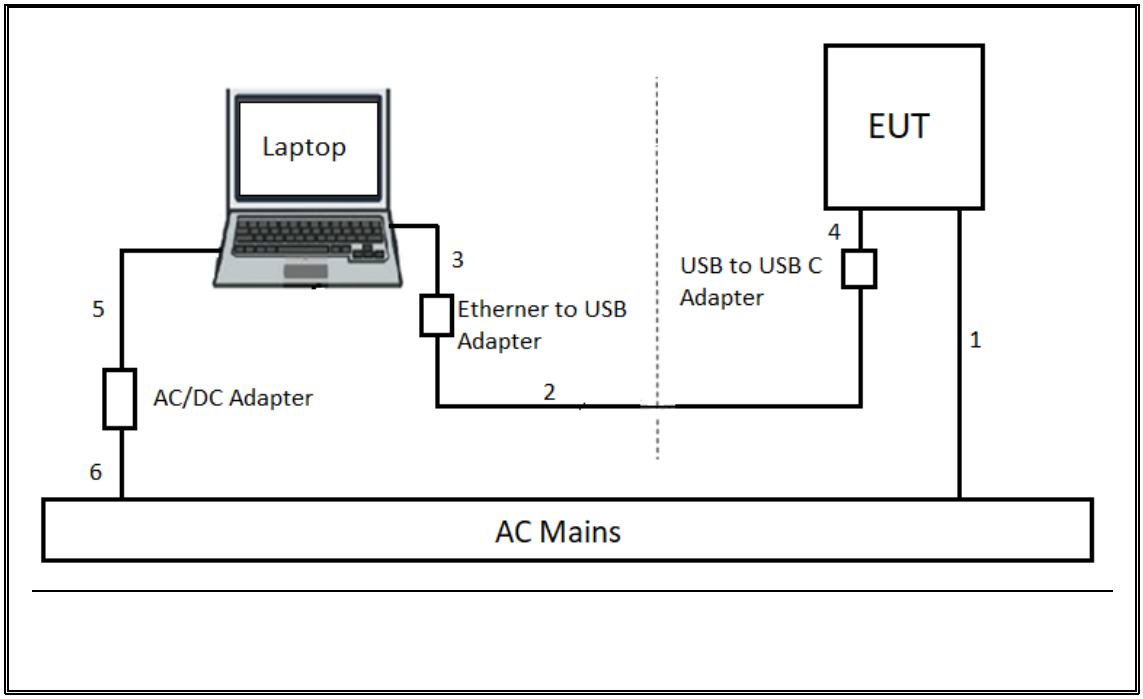
SETUP DIAGRAM



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6. TEST AND MEASUREMENT EQUIPMENT

The following test and measurement equipment was utilized for the tests documented in this report:

TEST EQUIPMENT LIST					
Description	**Manufacturer**	**Model**	**ID Num**	**Cal Due**	**Last Cal**
Amplifier, 9KHz to 1GHz, 32dB	SONOMA INSTRUMENT	310	PRE0180174	05/31/2019	05/31/2018
Antenna, Horn 1-18GHz	ETS-Lindgren	3117	AT0067	03/26/2019	03/26/2018
Antenna, Horn 1-18GHz	AR	AMPL-ATH1G18	PRE0189055	4/20/2019	4/20/2018
Amplifier, 1-7GHz, 24dB	AMPLICAL	AMP1G7-24-27	T1608	07/30/2019	07/30/2018
EMI TEST RECEIVER	Rohde & Schwarz	ESW44	PRE0179372	05/04/2019	05/04/2018
Spectrum Analyzer, PXA, 3Hz to 44GHz	Agilent (Keysight) Technologies	N9030A	T1450	01/23/2020	01/23/2019
Power Meter, P-series single channel	Agilent (Keysight) Technologies	N1911A	T1264	01/31/2020	01/31/2019
Hybrid Antenna, 30MHz to 3GHz	SunAR rf motion	JB3	PRE0181575	08/01/2019	08/01/2018
18 - 26.5 GHz Horn Antenna	ARA	MWH-1826/B	T448	03/13/2019	03/13/2018
Pre-Amp 1-26.5 GHz	Agilent	8449B	T404	03/09/2020	03/09/2019
Antenna, Passive Loop 30Hz to 1MHz	ELETRO METRICS	EM-6871	PRE0179465	05/22/2019	05/22/2018
Antenna, Passive Loop 100kHz to 30MHz	ELETRO METRICS	EM-6872	PRE0179467	05/22/2019	05/22/2018
AC Line Conducted					
EMI Receiver	Rohde & Schwarz	ESR	T1436	02/14/2020	02/14/2019
LISN for Conducted Emissions CISPR-16	FCC INC.	FCC LISN 50/250	T1310	06/15/2019	06/15/2018

Description	Manufacturer	Model	Version
Radiated Software	UL	UL EMC	Ver. 9.5, June 22, 2018
Antenna Port Software	UL	UL RF	Ver. 9.3.2, Jan 07, 2019
AC Line Conducted Software	UL	UL EMC	Ver. 9.5, May 26, 2015

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7. MEASUREMENT METHODS

On Time and Duty Cycle: ANSI C63.10-2013 Section 11.6

Occupied BW (20dB): ANSI C63.10-2013 Section 6.9.2

Occupied BW (99%): ANSI C63.10-2013 Section 6.9.3

Carrier Frequency Separation: ANSI C63.10-2013 Section 7.8.2

Number of Hopping Frequencies: ANSI C63.10-2013 Section 7.8.3

Time of Occupancy (Dwell Time): ANSI C63.10-2013 Section 7.8.4

Peak Output Power: ANSI C63.10-2013 Section 7.8.5

Conducted Spurious Emissions: ANSI C63.10-2013 Section 7.8.8

Conducted Band-Edge: ANSI C63.10-2013 Section 6.10.4

Radiated Spurious Emissions Below 30MHz: ANSI C63.10-2013 Section 6.4

Radiated Spurious Emissions 30-1000MHz: ANSI C63.10-2013 Section 6.3 and 6.5

Radiated Spurious Emissions above 1GHz: ANSI C63.10-2013 Section 6.3 and 6.6

Radiated Band-edge: ANSI C63.10-2013 Section 6.10.5

AC Power-line conducted emissions: ANSI C63.10-2013, Section 6.2.

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8. ANTENNA PORT TEST RESULTS

8.1. ON TIME AND DUTY CYCLE

LIMITS

None; for reporting purposes only.

PROCEDURE

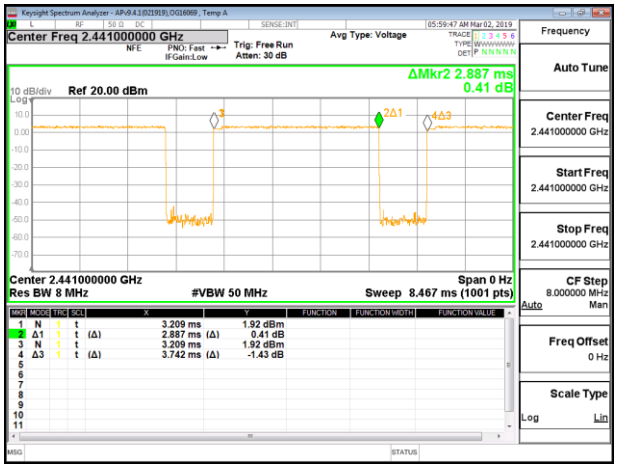
ANSI C63.10, Section 11.6 : Zero-Span Spectrum Analyzer Method.

ON TIME AND DUTY CYCLE RESULTS

Mode	ON Time B (msec)	Period (msec)	Duty Cycle x (linear)	Duty Cycle (%)	Duty Cycle Correction Factor (dB)	1/T Minimum VBW (kHz)
Bluetooth GFSK	2.89	3.75	0.77	0.77	1.13	0.35
Bluetooth 8PSK	2.89	3.74	0.77	0.77	1.13	0.35

DUTY CYCLE PLOTS

BLUETOOTH GFSK



BLUETOOTH 8PSK

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8.2. 20 dB AND 99% BANDWIDTH

LIMITS

None; for reporting purposes only.

TEST PROCEDURE

The transmitter output is connected to a spectrum analyzer. The RBW is set to ≥ 1% of the 20 dB bandwidth. The VBW is set to ≥ RBW. The sweep time is coupled.

RESULTS

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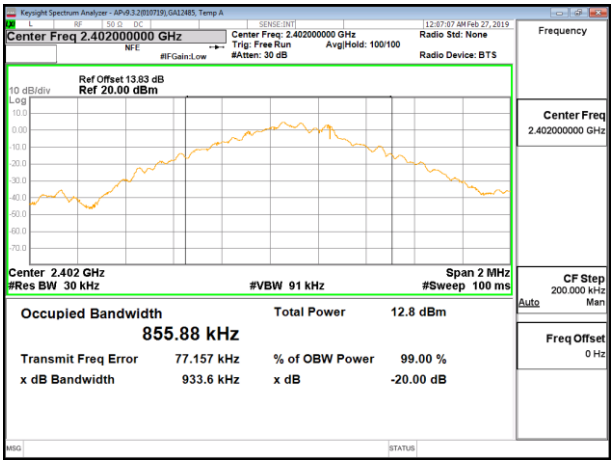
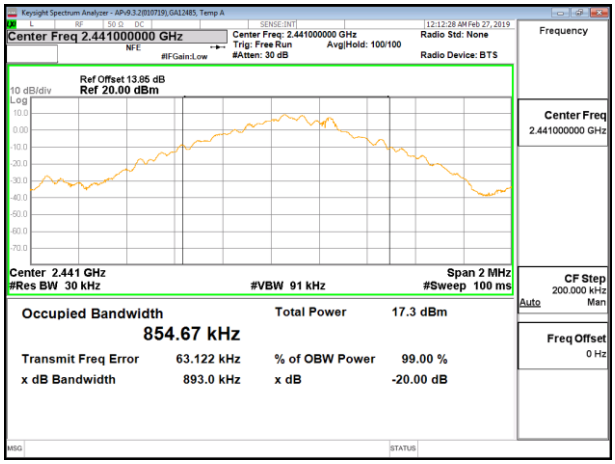
8.2.1. BLUETOOTH BASIC DATA RATE GFSK MODULATION

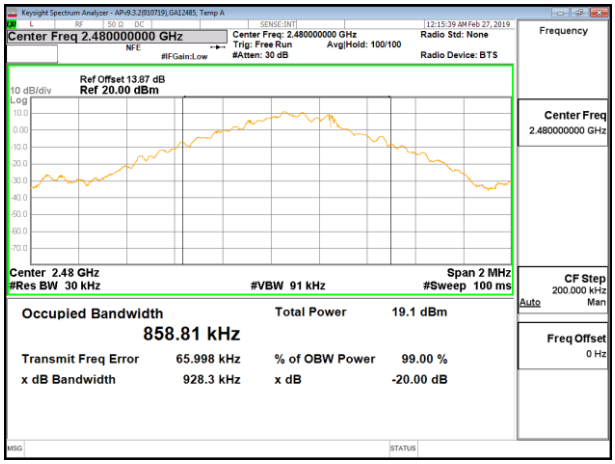
Channel	Frequency (MHz)	20dB Bandwidth (MHz)	99% Bandwidth (MHz)
Low	2402	0.934	0.856
Mid	2441	0.893	0.855
High	2480	0.928	0.859



LOW CHANNEL



MID CHANNEL



HIGH CHANNEL

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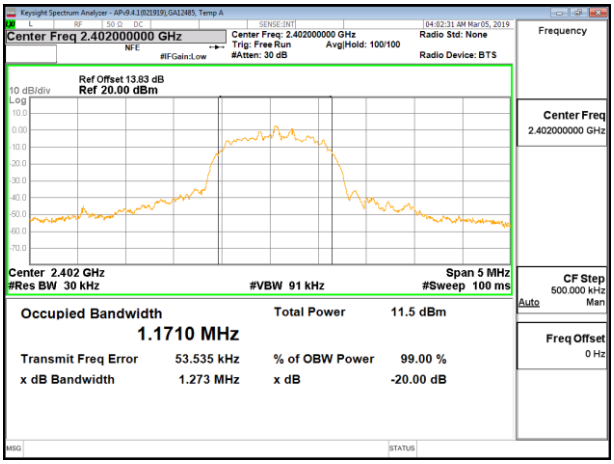
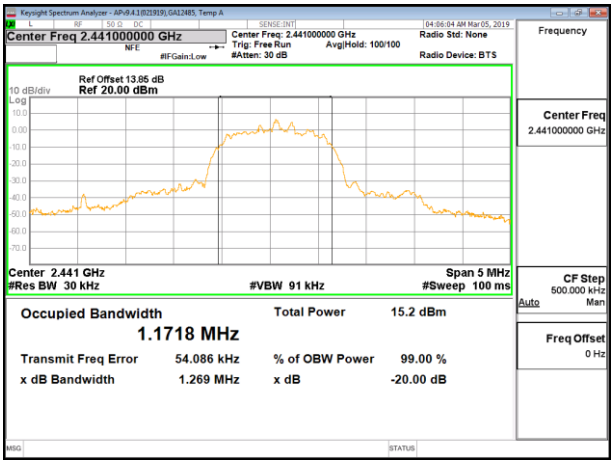
8.2.2. BLUETOOTH ENHANCED DATA RATE 8PSK MODULATION

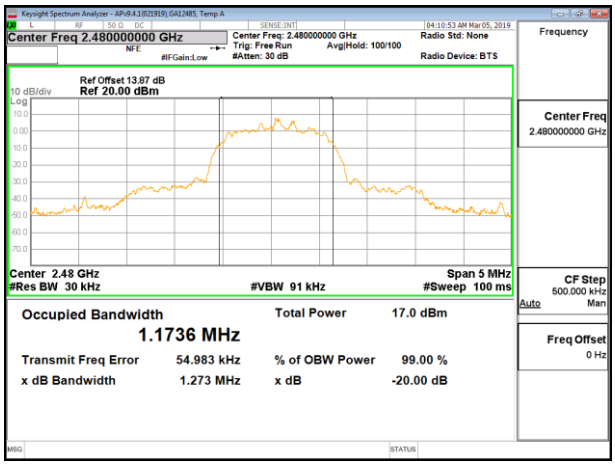
Channel	Frequency (MHz)	20dB Bandwidth (MHz)	99% Bandwidth (MHz)
Low	2402	1.273	1.171
Mid	2441	1.269	1.172
High	2480	1.273	1.174



LOW CHANNEL



MID CHANNEL



HIGH CHANNEL

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8.3. HOPPING FREQUENCY SEPARATION

LIMITS

FCC §15.247 (a) (1)

RSS-247 (5.1) (b)

Frequency hopping systems shall have hopping channel carrier frequencies separated by a minimum of 25 kHz or the 20 dB bandwidth of the hoping 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.

TEST PROCEDURE

The transmitter output is connected to a spectrum analyzer. The RBW is set to 300 kHz and the VBW is set to 300 kHz. The sweep time is coupled.

RESULTS

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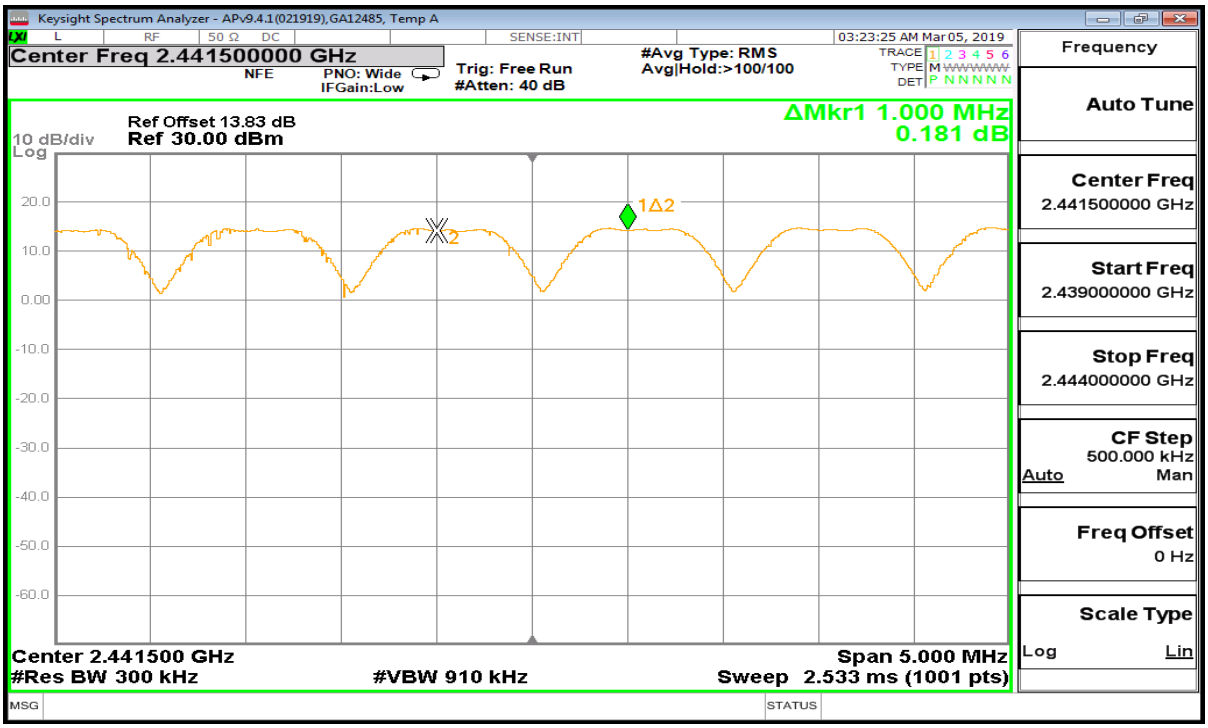
8.3.1. BLUETOOTH BASIC DATA RATE GFSK MODULATION



HOPPING FREQUENCY SEPARATION PLOT

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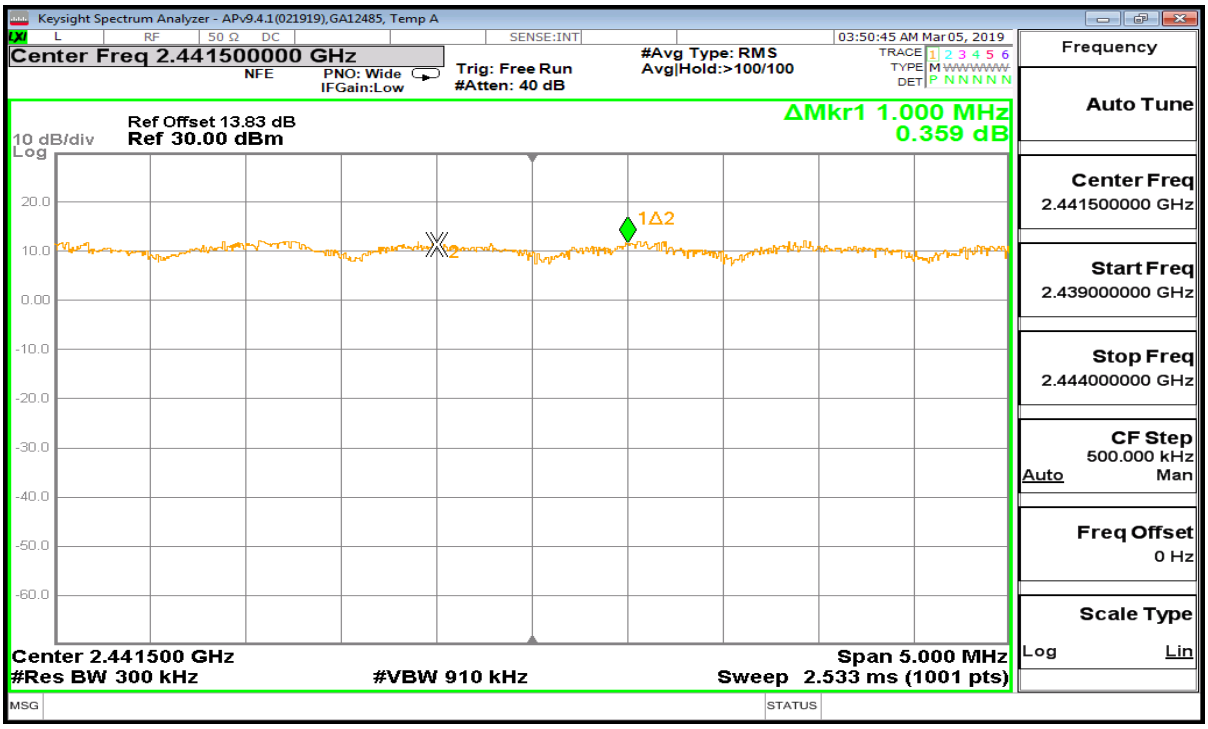
8.3.2. BLUETOOTH ENHANCED DATA RATE 8PSK MODULATION



HOPPING FREQUENCY SEPARATION PLOT

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8.4. NUMBER OF HOPPING CHANNELS

LIMITS

FCC §15.247 (a) (1) (iii)

RSS-247 (5.1) (d)

Frequency hopping systems in the 2400 – 2483.5 MHz band shall use at least 15 non-overlapping channels.

TEST PROCEDURE

The transmitter output is connected to a spectrum analyzer. The span is set to cover the entire authorized band, in either a single sweep or in multiple contiguous sweeps. The RBW is set to a maximum of 1 % of the span. The analyzer is set to Max Hold.

RESULTS

Normal Mode: 79 Channels Observed

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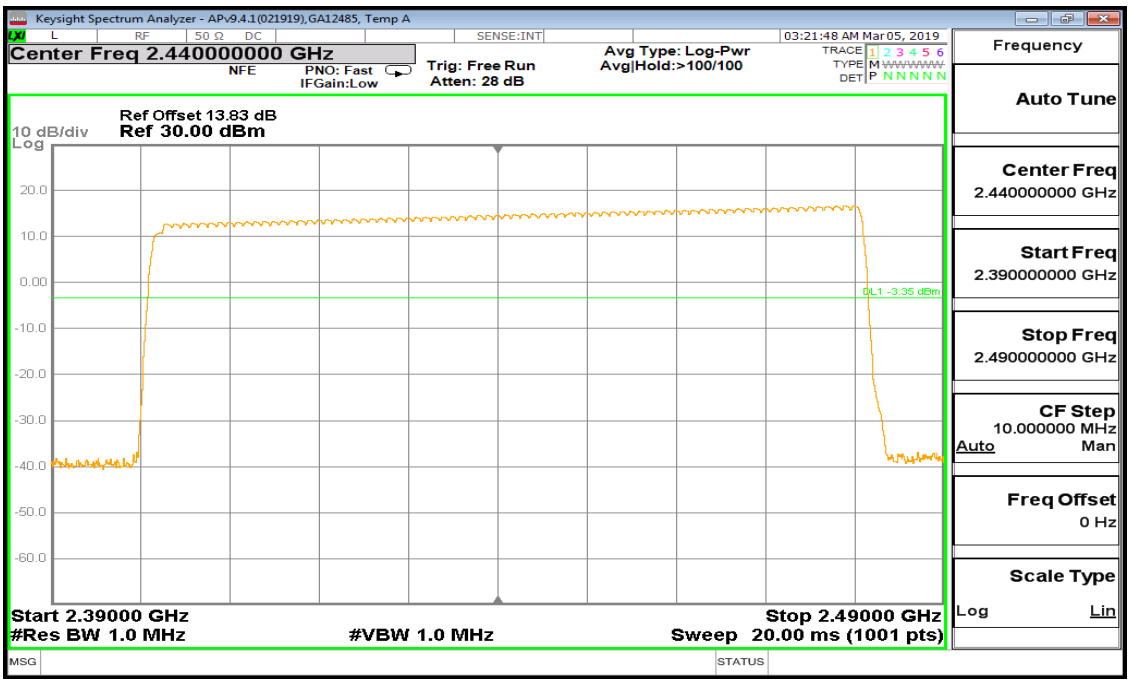
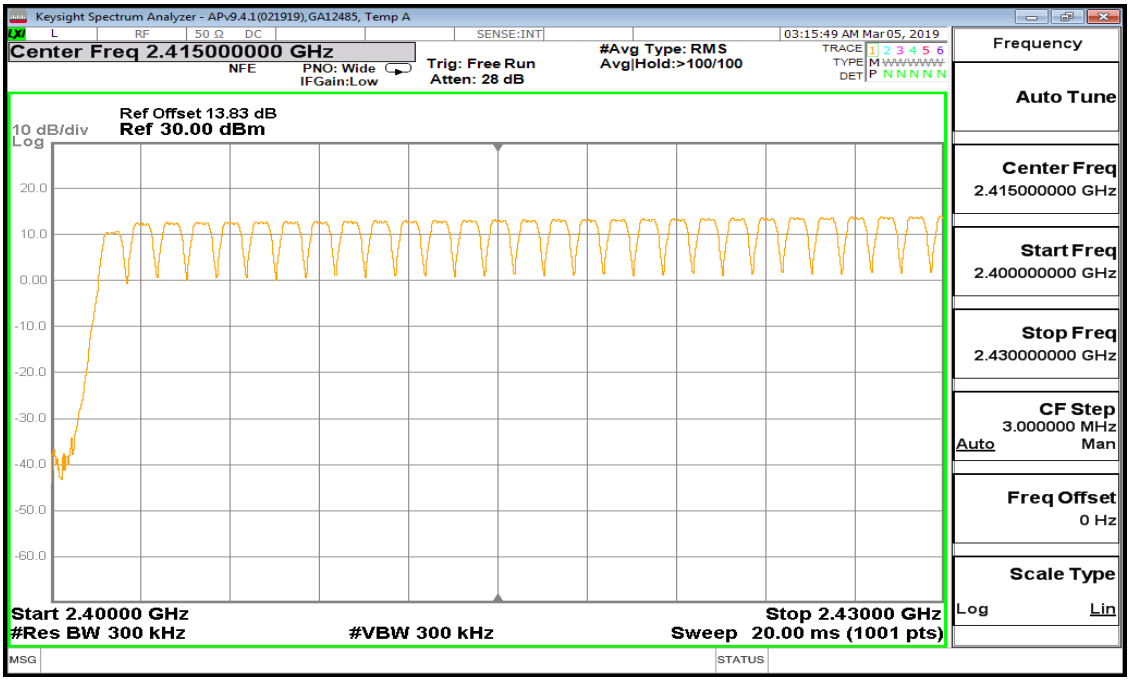
8.4.1. BLUETOOTH BASIC DATA RATE GFSK MODULATION



100MHz SPAN



30MHz SPAN, SEGMENT 1 OF 3

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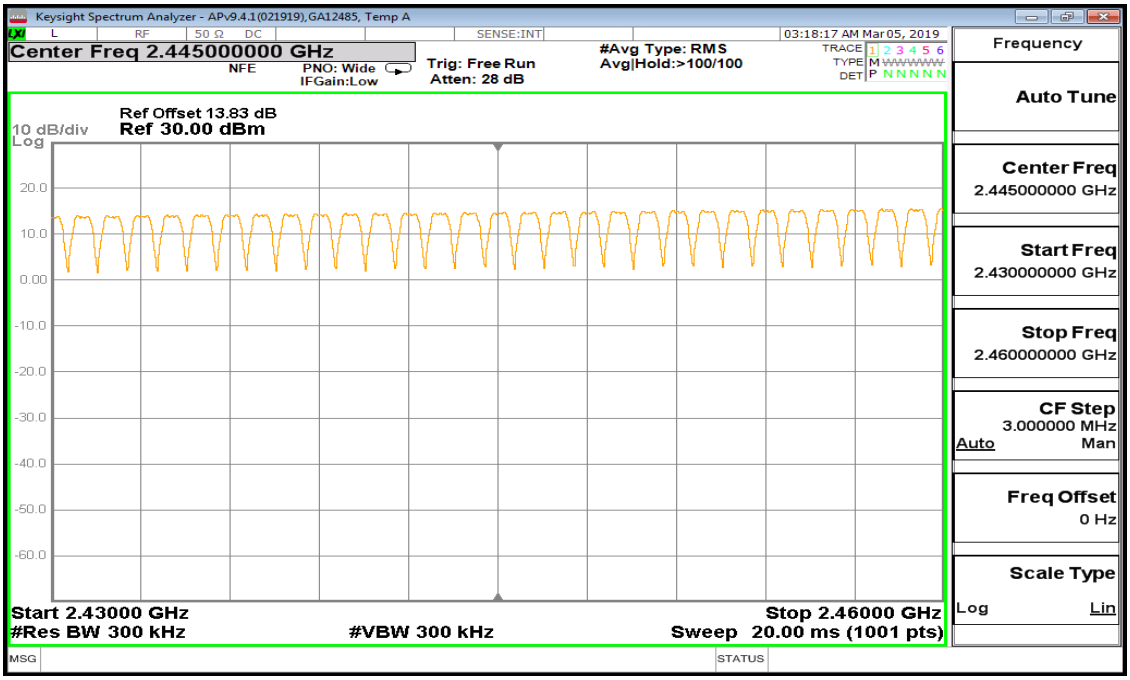
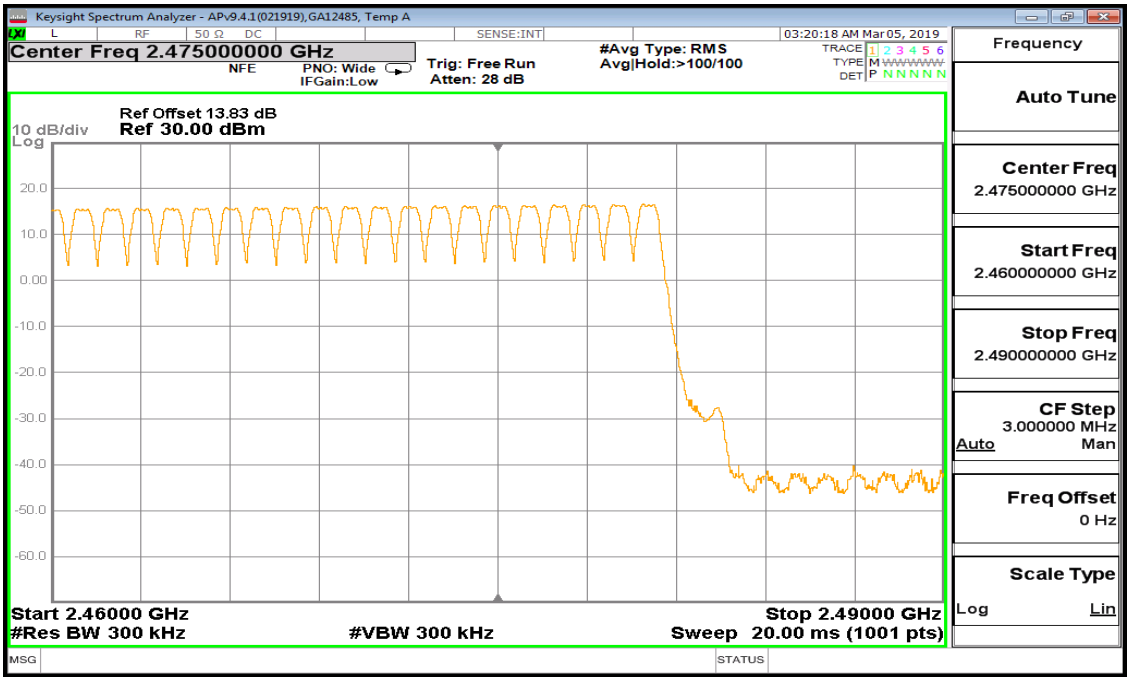


30MHz SPAN, SEGMENT 2 OF 3



30MHz SPAN, SEGMENT 3 OF 3

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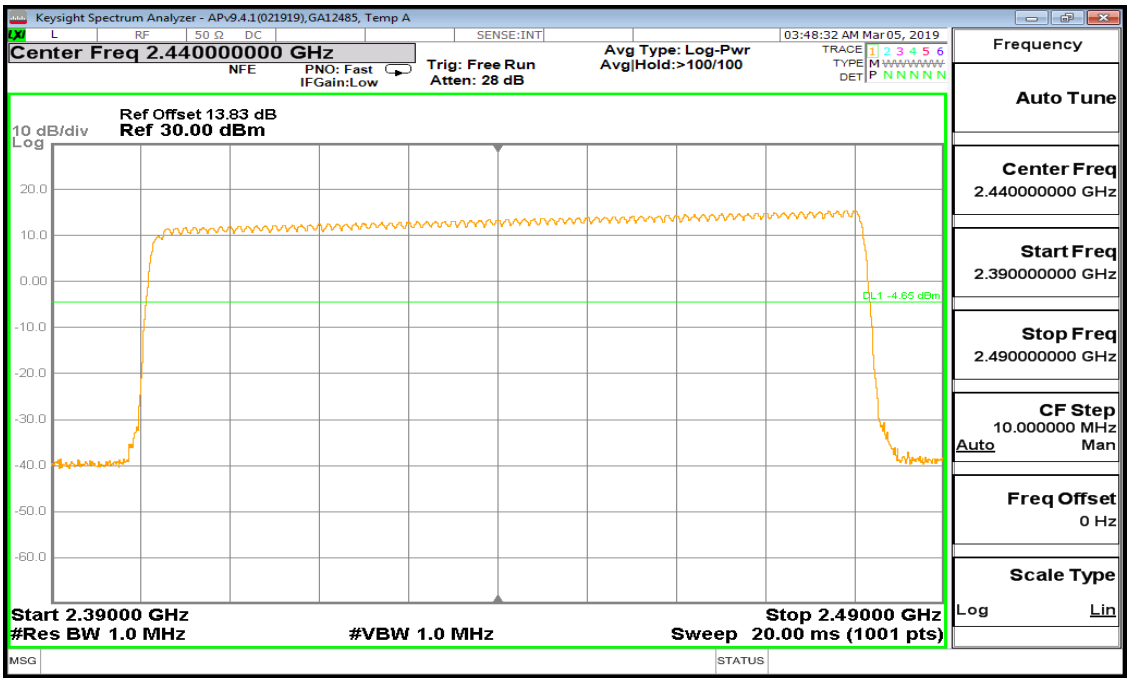
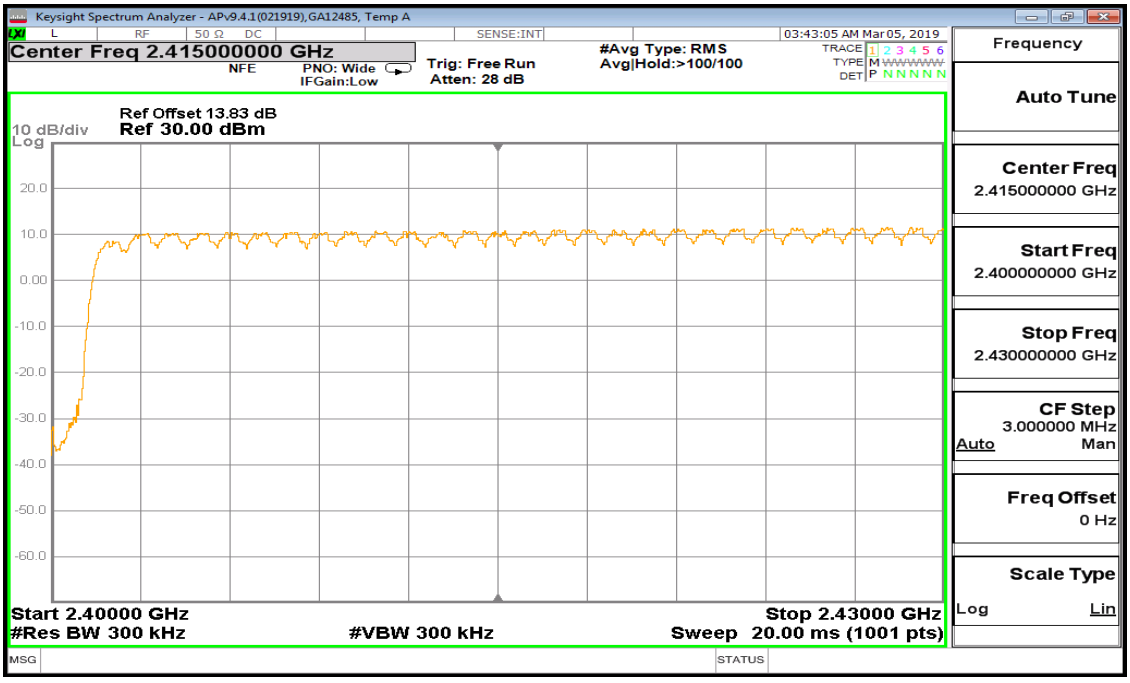
8.4.2. BLUETOOTH ENHANCED DATA RATE 8PSK MODULATION



100MHz SPAN



30MHz SPAN, SEGMENT 1 OF 3

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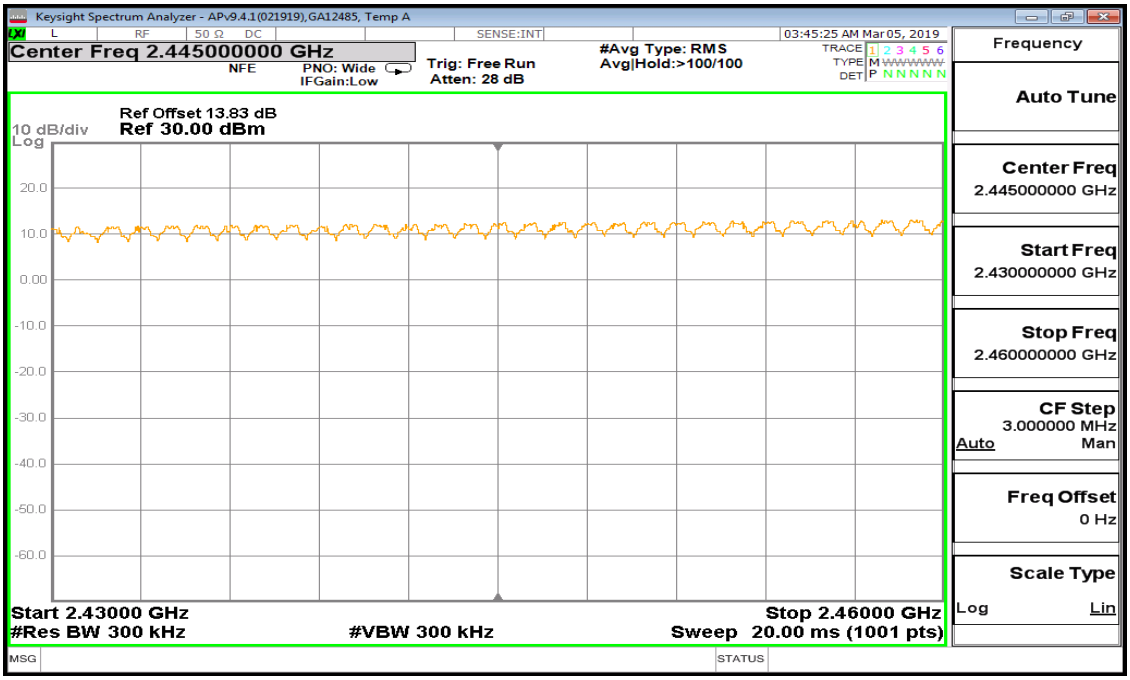
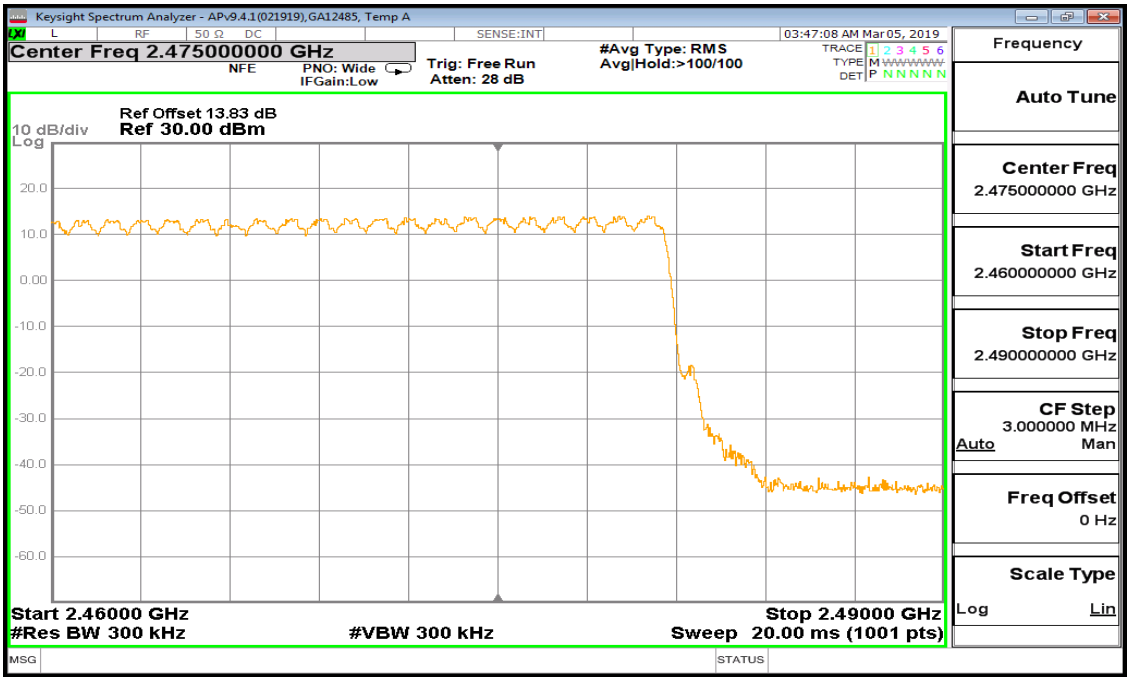


30MHz SPAN, SEGMENT 2 OF 3



30MHz SPAN, SEGMENT 3 OF 3

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8.5. AVERAGE TIME OF OCCUPANCY

LIMITS

FCC §15.247 (a) (1) (iii)

RSS-247 (5.1) (d)

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.

TEST PROCEDURE

The transmitter output is connected to a spectrum analyzer. The span is set to 0 Hz, centered on a single, selected hopping channel. The width of a single pulse is measured in a fast scan. The number of pulses is measured in a 3.16 second scan, to enable resolution of each occurrence.

The average time of occupancy in the specified 3.16 second period (79 channels * 0.4 s) is equal to 10 * (# of pulses in 3.16 s) * pulse width.

For AFH mode, the average time of occupancy in the specified 8 second period (20 channels * 0.4 seconds) is equal to 10 * (# of pulses in 0.8 s) * pulse width.

RESULTS

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8.5.1. BLUETOOTH BASIC DATA RATE GFSK MODULATION

DH Packet	Pulse Width (msec)	Number of Pulses in 3.16 seconds	Average Time of Occupancy (sec)	Limit (sec)	Margin (sec)
GFSK Normal Mode					
3DH1	0.392	32	0.1254	0.4	-0.2746
3DH3	1.648	16	0.2637	0.4	-0.1363
3DH5	2.896	10	0.2896	0.4	-0.1104
DH Packet	Pulse Width (sec)	Number of Pulses in 0.8 seconds	Average Time of Occupancy (sec)	Limit (sec)	Margin (sec)
GFSK AFH Mode					
3DH1	0.392	8	0.03136	0.4	-0.3686
3DH3	1.648	4	0.06592	0.4	-0.3341
3DH5	2.896	2.5	0.07240	0.4	-0.3276

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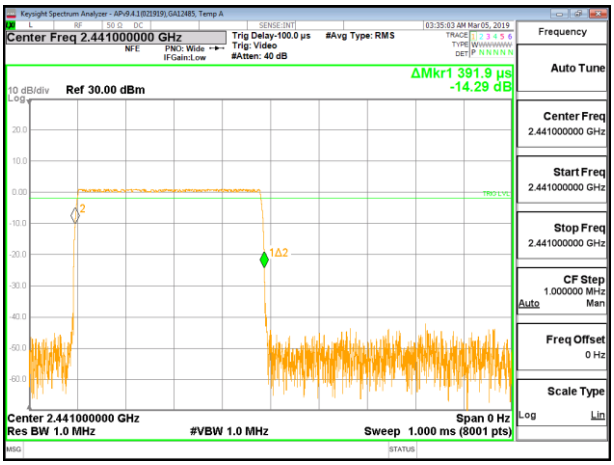
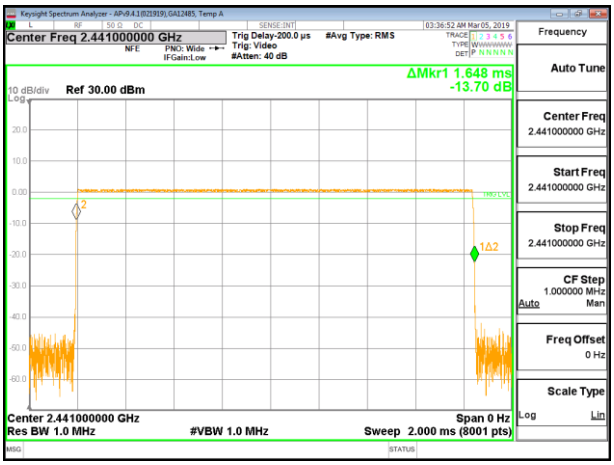
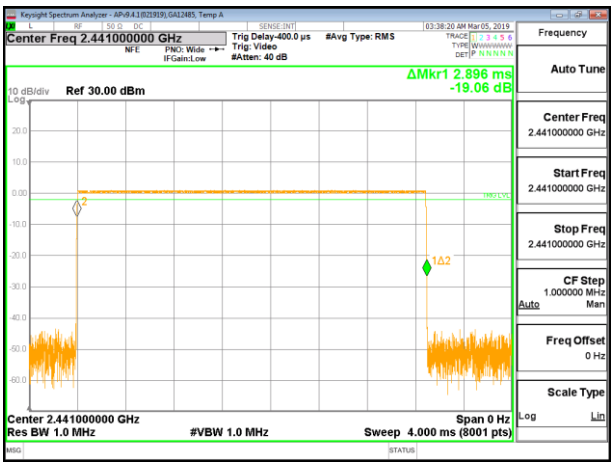


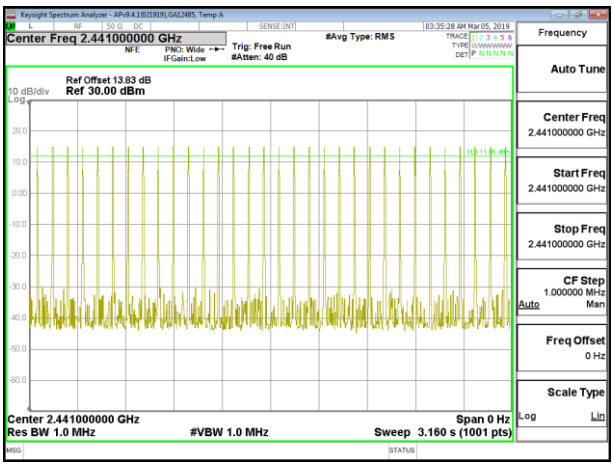
PULSE WIDTH – 3DH1



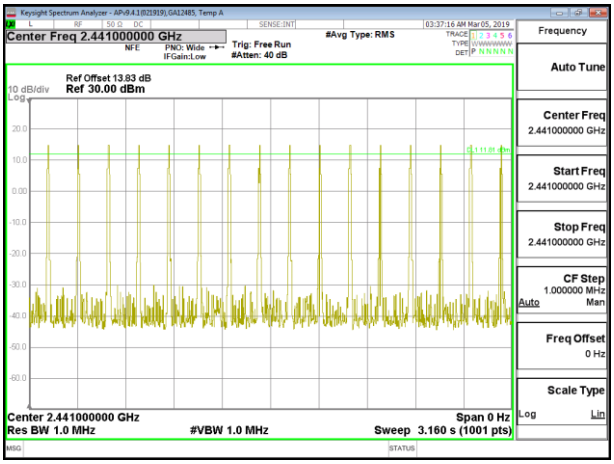
PULSE WIDTH – 3DH3



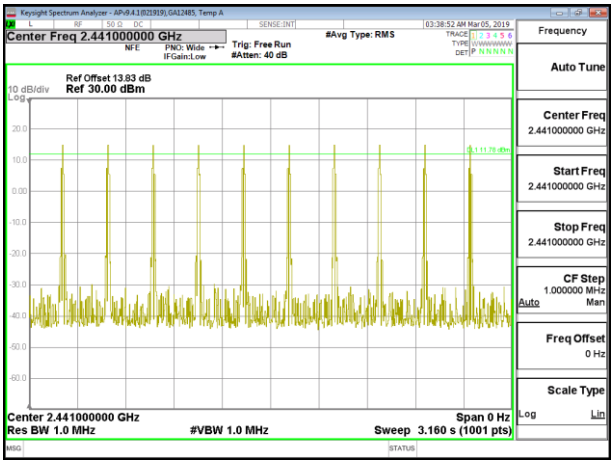
PULSE WIDTH – 3DH5



NUMBER OF PULSES IN 3.16 SECOND OBSERVATION PERIOD – 3DH1



NUMBER OF PULSES IN 3.16 SECOND OBSERVATION PERIOD – 3DH3



NUMBER OF PULSES IN 3.16 SECOND OBSERVATION PERIOD – 3DH5

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8.5.2. BLUETOOTH ENHANCED DATA RATE 8PSK MODULATION

DH Packet	Pulse Width (msec)	Number of Pulses in 3.16 seconds	Average Time of Occupancy (sec)	Limit (sec)	Margin (sec)
8PSK Normal Mode					
3DH1	0.405	32	0.12944	0.4	-0.27056
3DH3	1.655	16	0.2648	0.4	-0.1352
3DH5	2.907	10	0.2907	0.4	-0.1093

Note: for AFH(8PSK) mode, please refer to the results of AFH(GFSK) mode; the channel selection and hopping rate are the same for both EDR and Basic Rate operation, data for Basic Rate demonstrates compliance with channel occupancy when AFH is employed.

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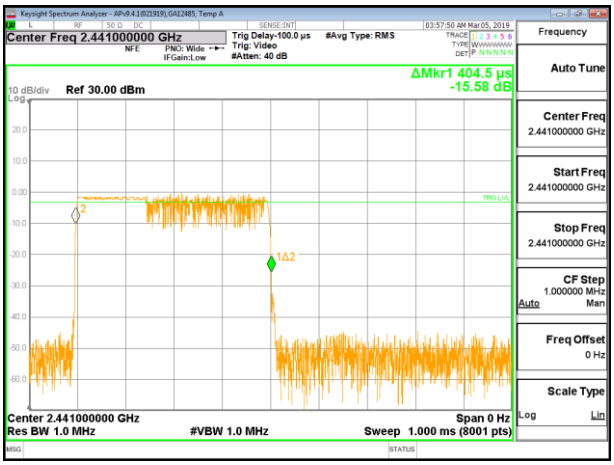
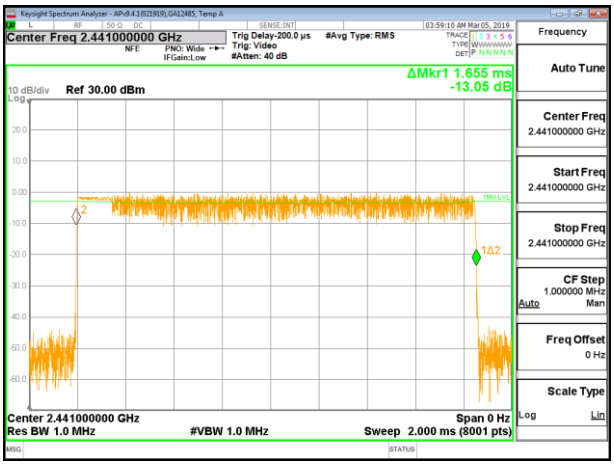
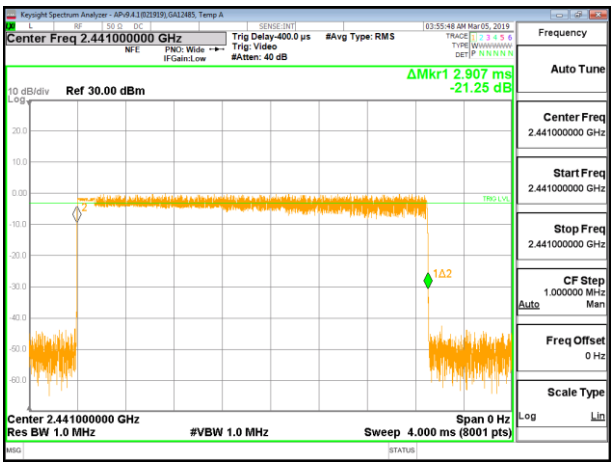


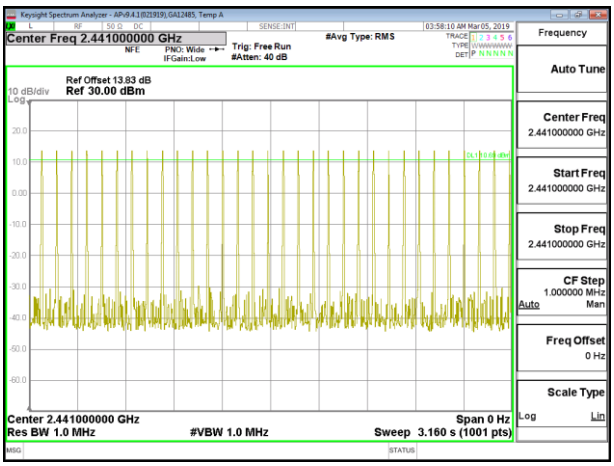
PULSE WIDTH – 3DH1



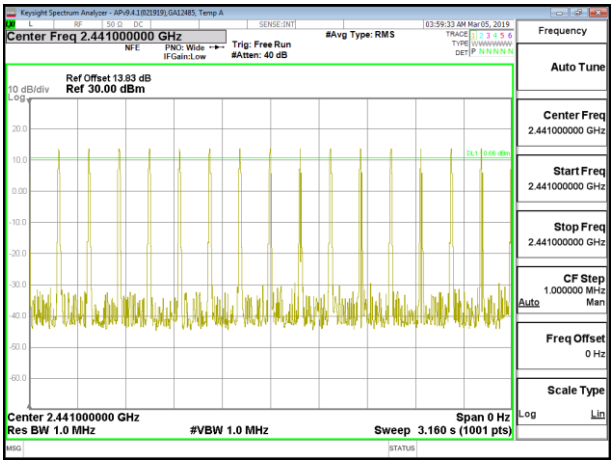
PULSE WIDTH – 3DH3



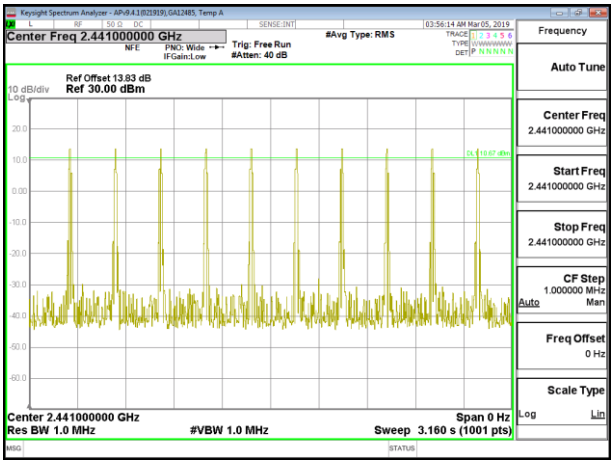
PULSE WIDTH – 3DH5



NUMBER OF PULSES IN 3.16 SECOND OBSERVATION PERIOD – 3DH1



NUMBER OF PULSES IN 3.16 SECOND OBSERVATION PERIOD – 3DH3



NUMBER OF PULSES IN 3.16 SECOND OBSERVATION PERIOD – 3DH5

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8.6. OUTPUT POWER

LIMITS

§15.247 (b) (1)

RSS-247 (5.4) (b)

The maximum antenna gain is less than 6 dBi, therefore the limit is 30 dBm. 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.

TEST PROCEDURE

Measurements perform using a wideband gated RF power meter.

The cable assembly insertion loss was entered as an offset in the power meter to allow for a peak reading of power.

RESULTS

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8.6.1. BLUETOOTH BASIC DATA RATE GFSK MODULATION

Tested By:	GA 12485
Date:	3/14/2019

Channel	Frequency (MHz)	Output Power (dBm)	Limit (dBm)	Margin (dB)
Low	2402	10.50	30	-19.5
Middle	2441	14.26	30	-15.74
High	2480	16.23	30	-13.77

8.6.2. BLUETOOTH ENHANCED DATA RATE 8PSK MODULATION

Tested By:	GA 12485
Date:	3/14/2019

Channel	Frequency (MHz)	Output Power (dBm)	Limit (dBm)	Margin (dB)
Low	2402	9.42	21	-11.58
Middle	2441	13.12	21	-7.88
High	2480	15.12	21	-5.88

8.6.3. BLUETOOTH ENHANCED DATA RATE DQPSK MODULATION

Tested By:	GA 12485
Date:	3/14/2019

Channel	Frequency (MHz)	Output Power (dBm)	Limit (dBm)	Margin (dB)
Low	2402	8.49	21	-12.51
Middle	2441	11.7	21	-9.3
High	2480	13.92	21	-7.08

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8.7. CONDUCTED SPURIOUS EMISSIONS

LIMITS

FCC §15.247 (d)

RSS-247 5.5

Limit = -20 dBc

TEST PROCEDURE

The transmitter output is connected to a spectrum analyzer. The resolution bandwidth is set to 100 kHz. The video bandwidth is set to 300 kHz.

The spectrum from 30 MHz to 26 GHz is investigated with the transmitter set to the lowest, middle, and highest channels.

The band edges at 2.4 and 2.4835 GHz are investigated with the transmitter set to the normal hopping mode.

RESULTS

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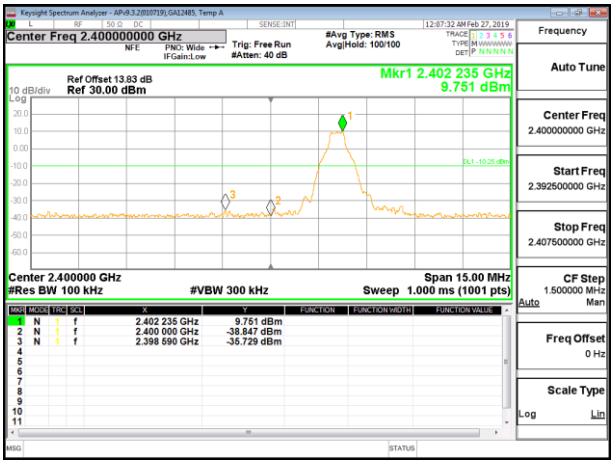
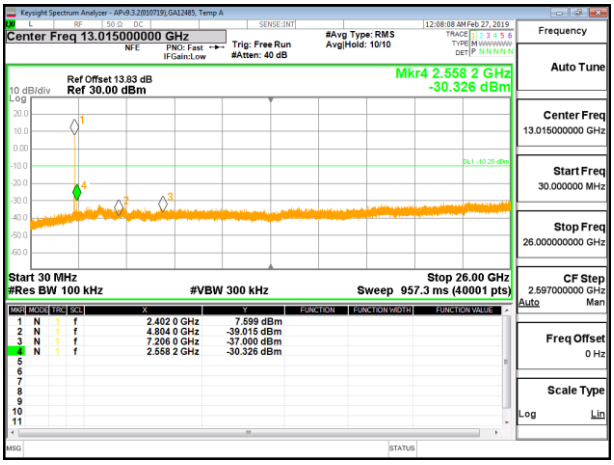
8.7.1. BLUETOOTH BASIC DATA RATE GFSK MODULATION

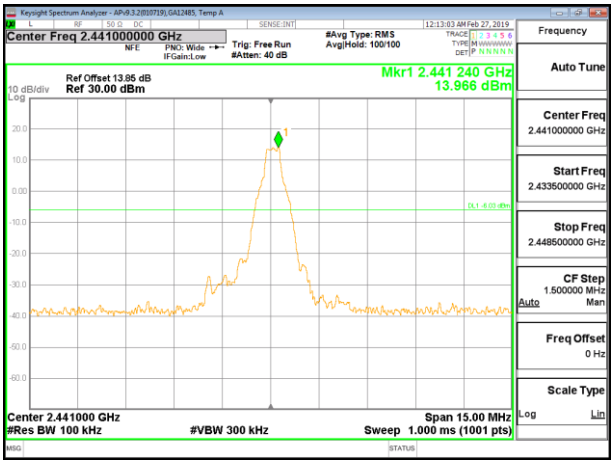
Antenna 1 SPURIOUS EMISSIONS, NON-HOPPING



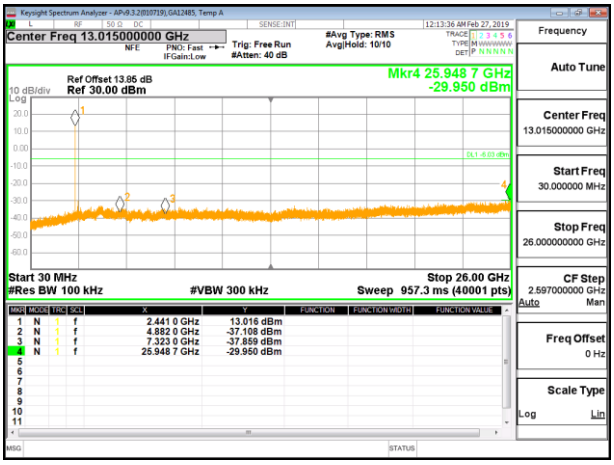
LOW CHANNEL BANDEDGE



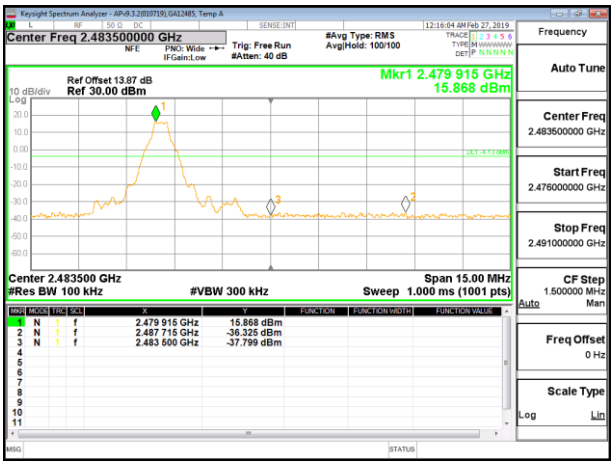
OUT-OF-BAND LOW CHANNEL



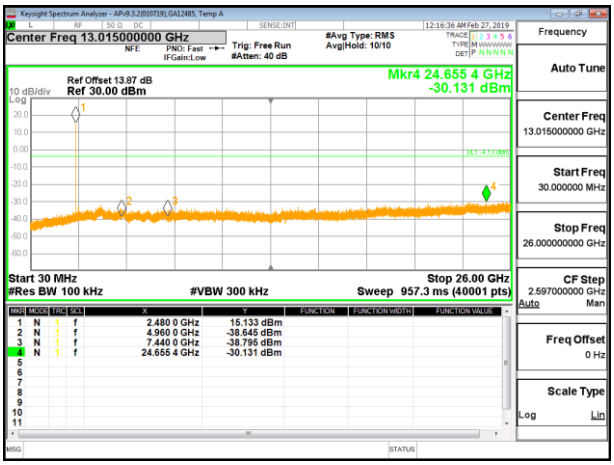
IN-BAND REFERENCE LEVEL



OUT-OF-BAND MID CHANNEL



HIGH CHANNEL BANDEDGE



OUT-OF-BAND HIGH CHANNEL

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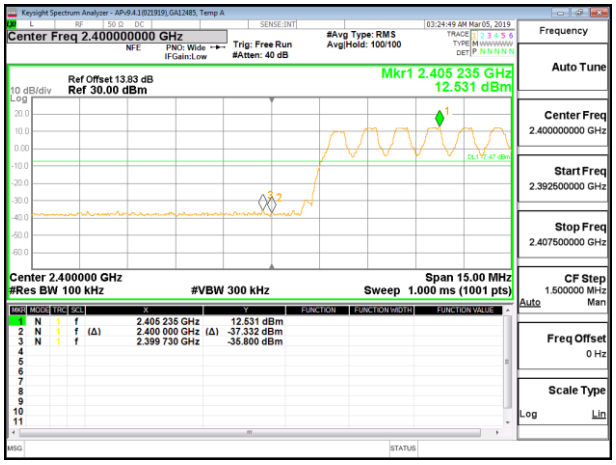
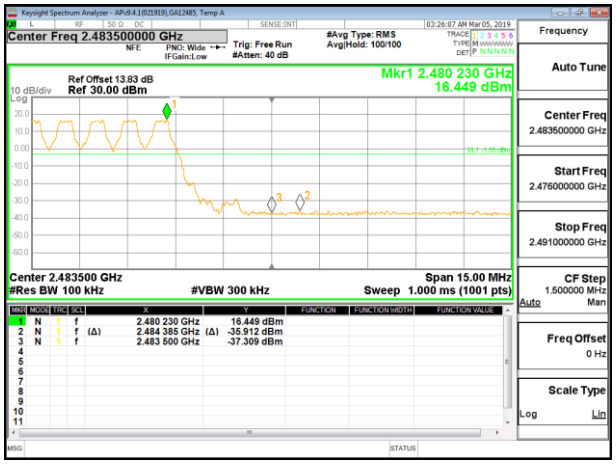
Antenna 1 SPURIOUS BANDEDGE EMISSIONS WITH HOPPING ON



LOW BANDEDGE



HIGH BANDEDGE

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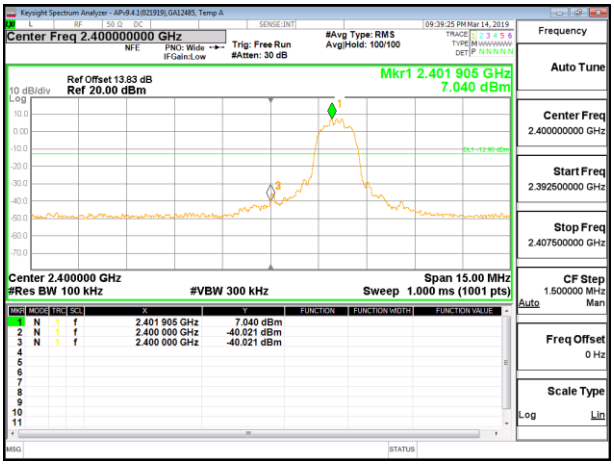
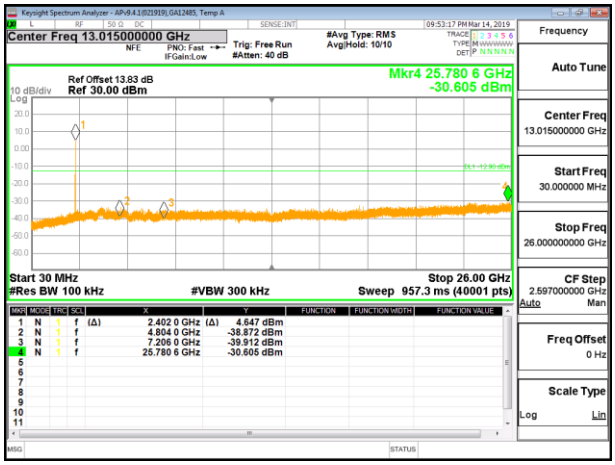
8.7.2. BLUETOOTH ENHANCED DATA RATE 8PSK MODULATION

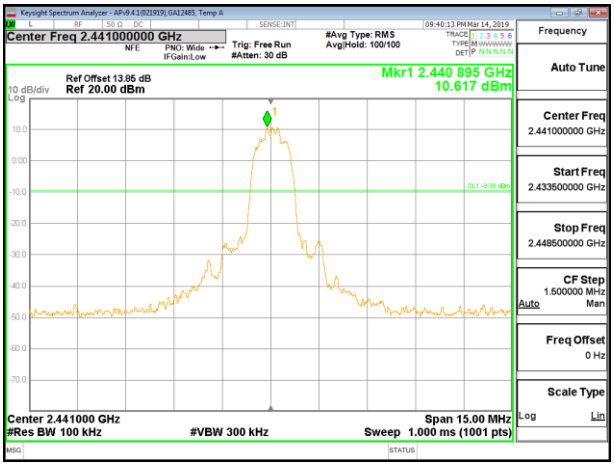
Antenna 1 SPURIOUS EMISSIONS, NON-HOPPING



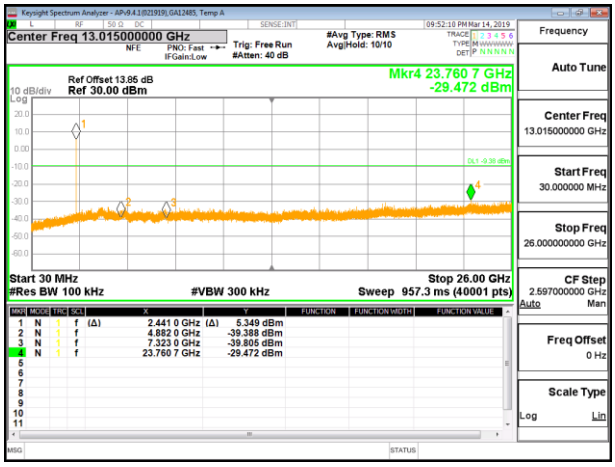
LOW CHANNEL BANDEDGE



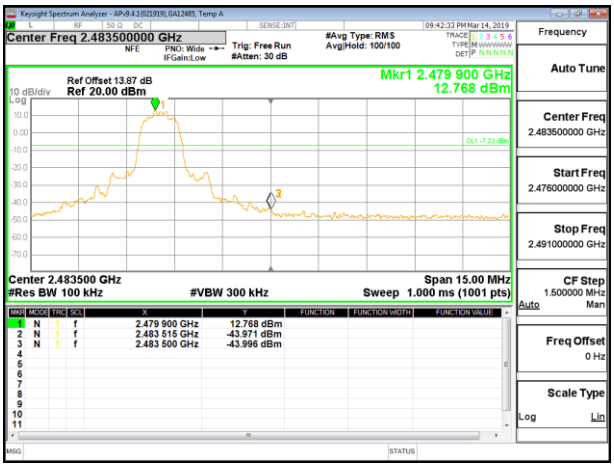
OUT-OF-BAND LOW CHANNEL



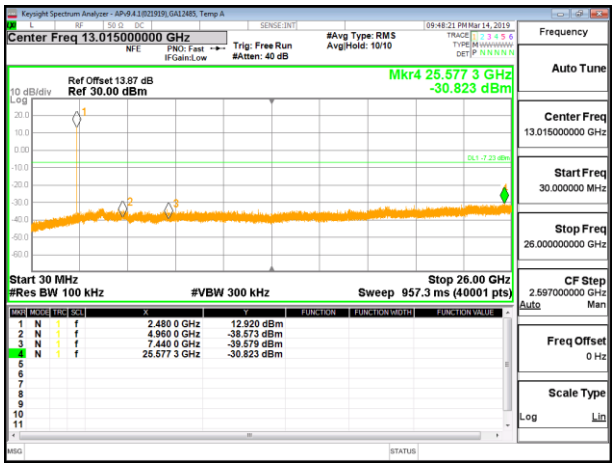
IN-BAND REFERENCE LEVEL



OUT-OF-BAND MID CHANNEL



HIGH CHANNEL BANDEDGE



OUT-OF-BAND HIGH CHANNEL

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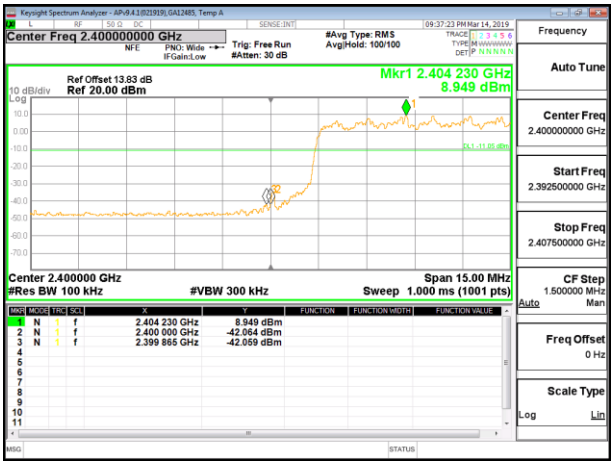
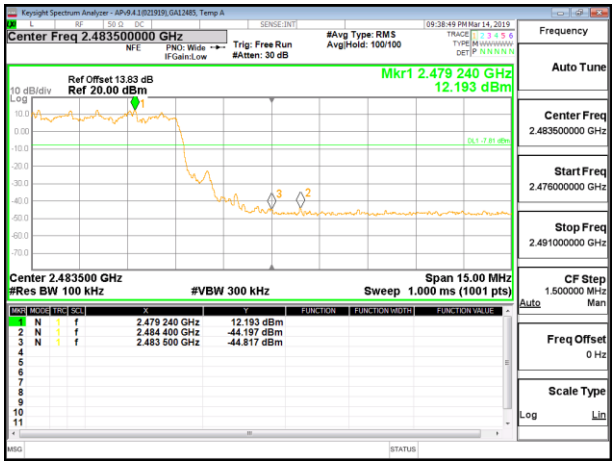
Antenna 1 SPURIOUS BANDEDGE EMISSIONS WITH HOPPING ON



LOW BANDEDGE



HIGH BANDEDGE

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9. RADIATED TEST RESULTS

LIMITS

FCC §15.205 and §15.209

RSS-GEN, Section 8.9 and 8.10.

Frequency Range (MHz)	Field Strength Limit (uV/m) at 3 m	Field Strength Limit (dBuV/m) at 3 m
0.009-0.490	2400/F(kHz) @ 300 m	-
0.490-1.705	24000/F(kHz) @ 30 m	-
1.705 - 30	30 @ 30m	-
30 - 88	100	40
88 - 216	150	43.5
216 - 960	200	46
Above 960	500	54

TEST PROCEDURE

The EUT is placed on a non-conducting table 80 cm above the ground plane for measurement below 1GHz; 1.5 m above the ground plane for measurement above 1GHz. The antenna to EUT distance is 3 meters. The EUT is configured in accordance with ANSI C63.10. The EUT is set to transmit in a continuous mode.

For measurements below 1 GHz the resolution bandwidth is set to 100 kHz for peak detection measurements or 120 kHz for quasi-peak detection measurements. Peak detection is used unless otherwise noted as quasi-peak.

For pre-scans above 1 GHz the resolution bandwidth is set to 1 MHz; the video bandwidth is set to 30 KHz for peak measurements.

For final measurements above 1 GHz the resolution bandwidth is set to 1 MHz; the video bandwidth is set to 3 MHz for peak measurements and 1 MHz resolution bandwidth with 1/T video bandwidth with peak detector for average measurements.

The spectrum from 1 GHz to 18 GHz is investigated with the transmitter set to the lowest, middle, and highest channels in each applicable band. Below 1GHz and above 18GHz emissions, the channel with the highest output power was tested.

The frequency range of interest is monitored at a fixed antenna height and EUT azimuth. The EUT is rotated through 360 degrees to maximize emissions received. The antenna is scanned from 1 to 4 meters above the ground plane to further maximize the emission. Measurements are made with the antenna polarized in both the vertical and the horizontal positions.

2D antenna use - For below 30MHz testing, investigation was done on three antenna orientations (parallel, perpendicular, and ground-parallel), parallel and perpendicular are the worst orientations, therefore testing was performed on these two orientations only.

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KDB 414788 Open Field Site(OFS) and Chamber Correlation Justification

Base on FCC 15.31 (f) (2): measurements may be performed at a distance closer than that specified in the regulations; however, an attempt should be made to avoid making measurements in the near field.

OFS and chamber correlation testing had been performed and chamber measured test result is the worst case test result.

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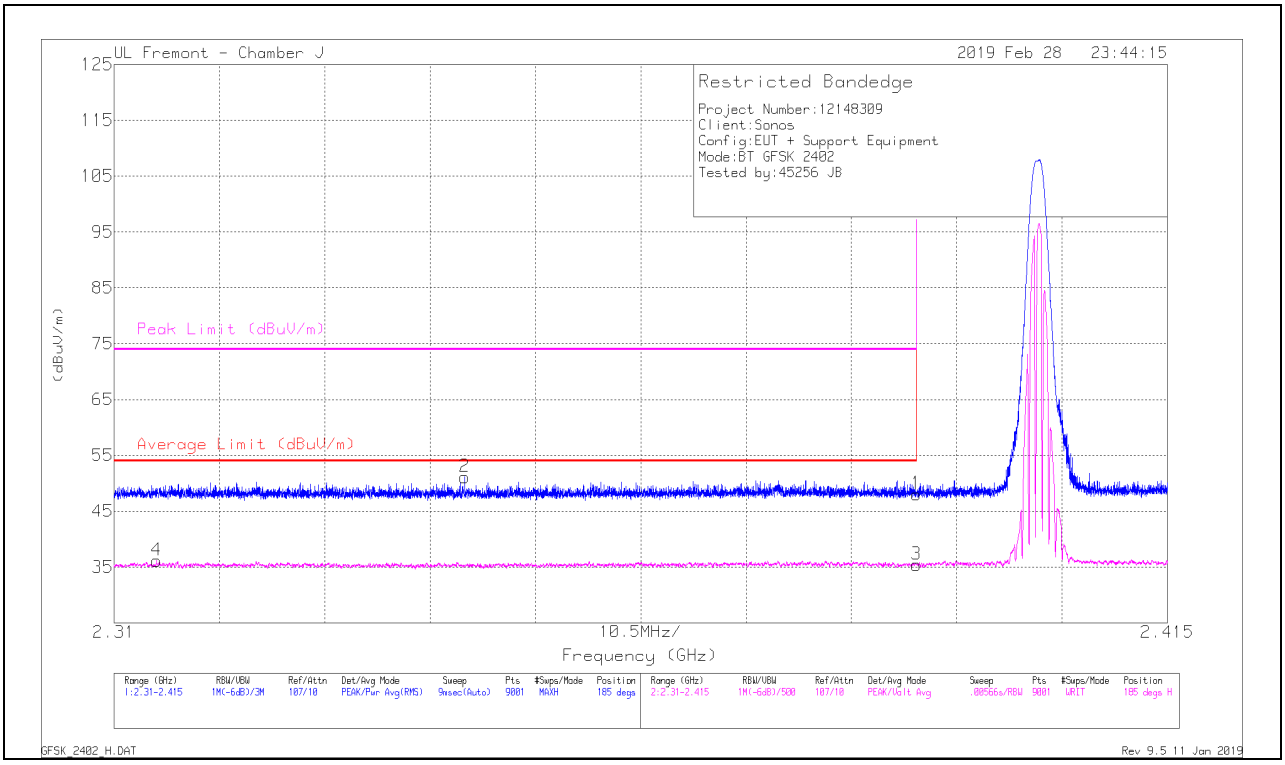
9.1. TRANSMITTER ABOVE 1 GHz

9.1.1. BLUETOOTH BASIC DATA RATE GFSK MODULATION

BANDEDGE (LOW CHANNEL)

HORIZONTAL RESULT



Marker	Frequency (GHz)	Meter Reading (dBuV)	Det	AF AT0067 (dB/m)	Amp/Cbl/Fltr/Pad (dB)	Corrected Reading (dBuV/m)	Average Limit (dBuV/m)	Margin (dB)	Peak Limit (dBuV/m)	PK Margin (dB)	Azimuth (Degs)	Height (cm)	Polarity
1	* 2.39	41.83	Pk	32	-25.8	48.03	-	-	74	-25.97	185	137	H
2	* 2.345	45.02	Pk	31.9	-25.8	51.12	-	-	74	-22.88	185	137	H
3	* 2.39	29.21	VA1T	32	-25.8	35.41	54	-18.59	-	-	185	137	H
4	* 2.314	30.05	VA1T	31.9	-25.8	36.15	54	-17.85	-	-	185	137	H

* - indicates frequency in CFR47 Pt 15 / IC RSS-Restricted Band
Pk - Peak detector
VA1T - FHSS: Linear Voltage Average VB=1/Ton where: Ton is transmit duration

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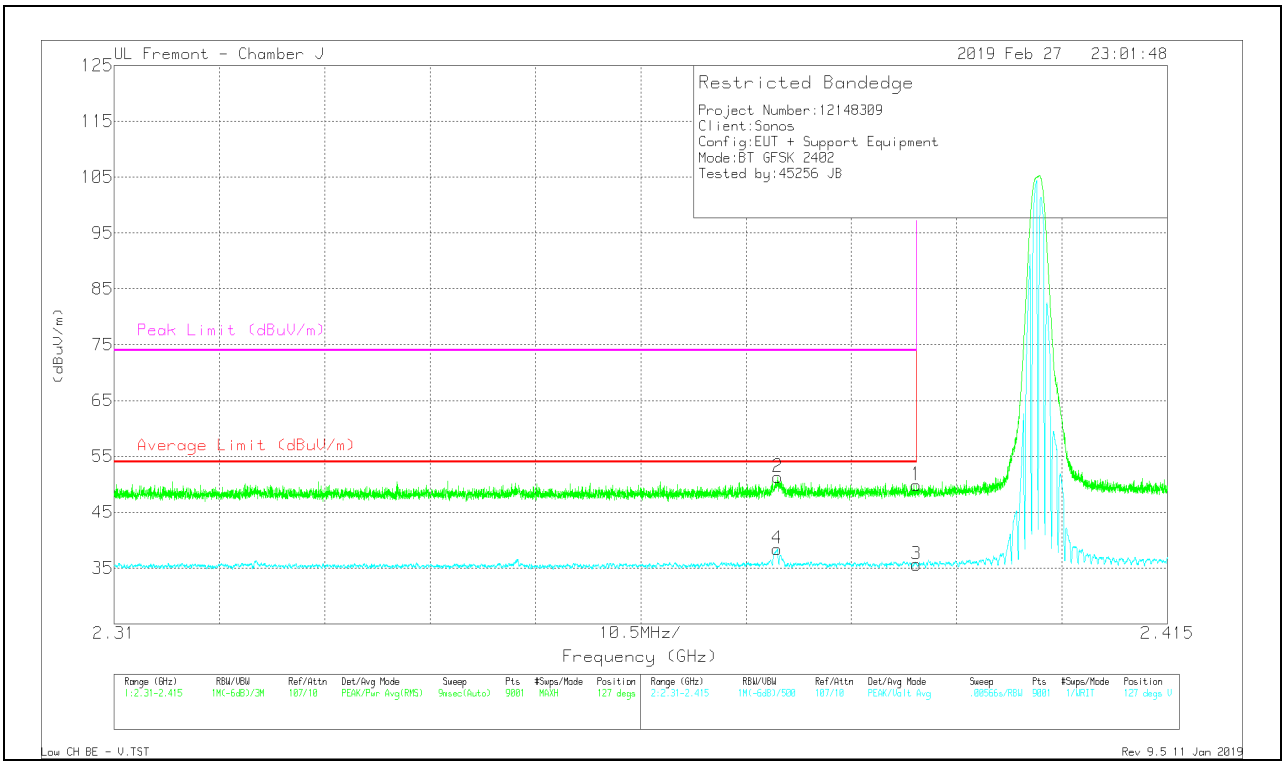
VERTICAL RESULT



Marker	Frequency (GHz)	Meter Reading (dBuV)	Det	AF AT0067 (dB/m)	Amp/Cbl/Flt r/Pad (dB)	Corrected Reading (dBuV/m)	Average Limit (dBuV/m)	Margin (dB)	Peak Limit (dBuV/m)	PK Margin (dB)	Azimuth (Degs)	Height (cm)	Polarity
1	* 2.39	43.65	Pk	32	-25.8	49.85	-	-	74	-24.15	127	175	V
2	* 2.376	45.1	Pk	32	-25.8	51.3	-	-	74	-22.7	127	175	V
3	* 2.39	29.45	VA1T	32	-25.8	35.65	54	-18.35	-	-	127	174	V
4	* 2.376	32.24	VA1T	32	-25.8	38.44	54	-15.56	-	-	127	174	V

* - indicates frequency in CFR47 Pt 15 / IC RSS-Restricted Band
Pk - Peak detector
VA1T - FHSS: Linear Voltage Average VB=1/Ton where: Ton is transmit duration

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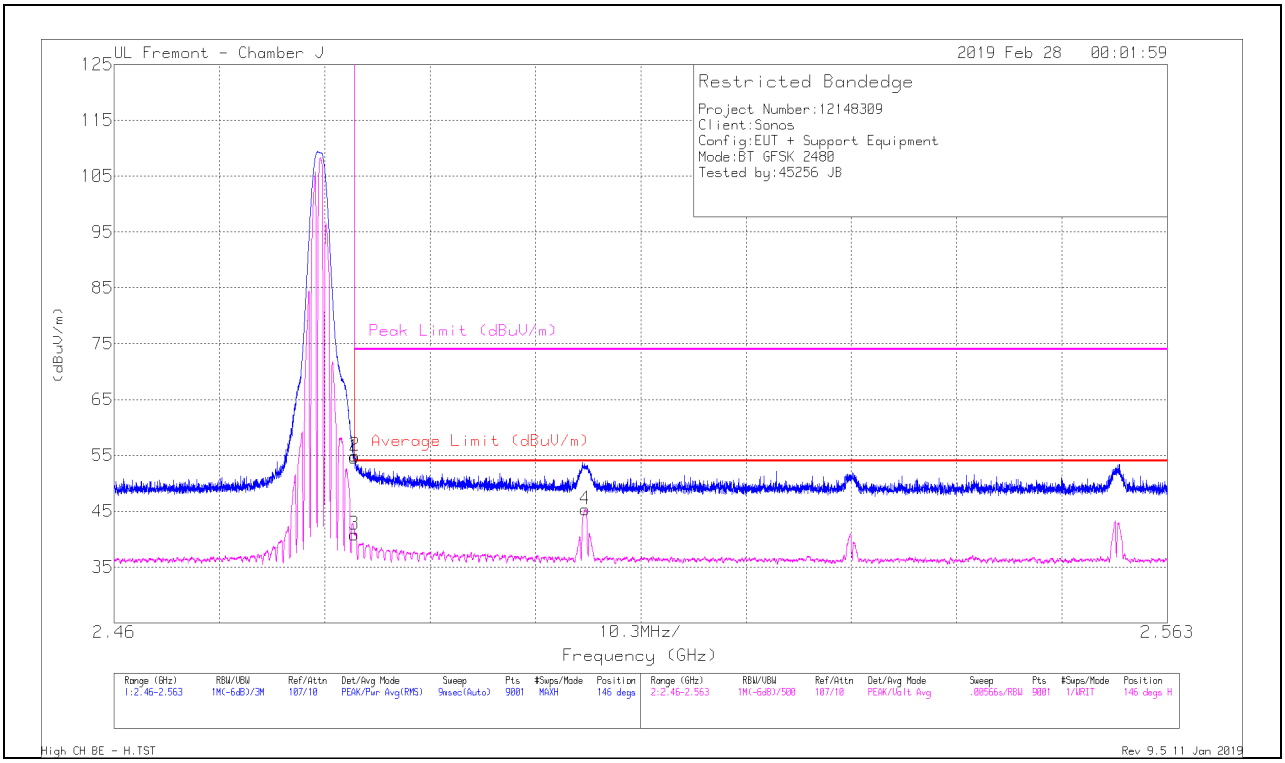
BANDEDGE (HIGH CHANNEL)

HORIZONTAL RESULT



Marker	Frequency (GHz)	Meter Reading (dBuV)	Det	AF AT0067 (dB/m)	Amp/Cbl/Fltr/Pad (dB)	Corrected Reading (dBuV/m)	Average Limit (dBuV/m)	Margin (dB)	Peak Limit (dBuV/m)	PK Margin (dB)	Azimuth (Degs)	Height (cm)	Polarity
1	* 2.484	47.97	Pk	32.5	-25.8	54.67	-	-	74	-19.33	146	271	H
2	* 2.484	48.26	Pk	32.5	-25.8	54.96	-	-	74	-19.04	146	271	H
3	* 2.484	34.16	VA1T	32.5	-25.8	40.86	54	-13.14	-	-	146	271	H
4	2.506	38.54	VA1T	32.5	-25.7	45.34	54	-8.66	-	-	146	271	H

* - indicates frequency in CFR47 Pt 15 / IC RSS-Restricted Band
Pk - Peak detector
VA1T - FHSS: Linear Voltage Average VB=1/Ton where: Ton is transmit duration

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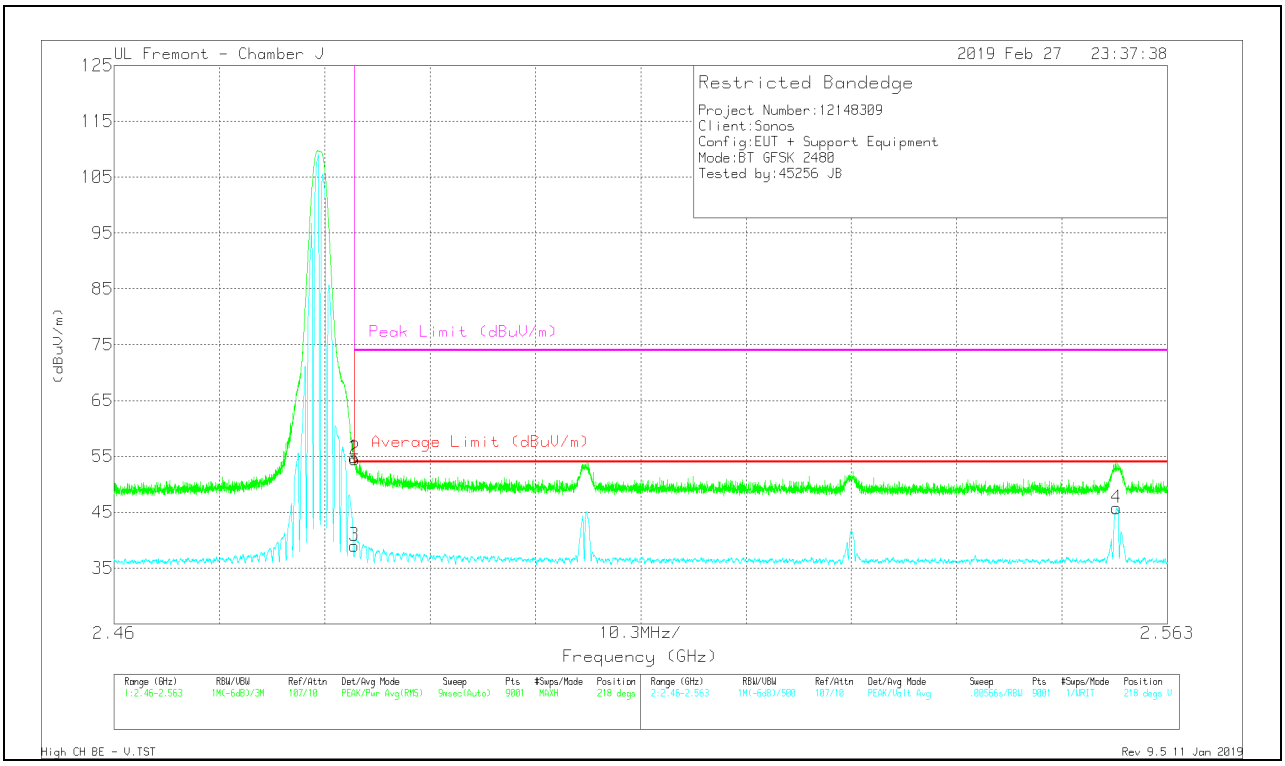
VERTICAL RESULT



Marker	Frequency (GHz)	Meter Reading (dBuV)	Det	AF AT0067 (dB/m)	Amp/Cbl/Flt r/Pad (dB)	Corrected Reading (dBuV/m)	Average Limit (dBuV/m)	Margin (dB)	Peak Limit (dBuV/m)	PK Margin (dB)	Azimuth (Degs)	Height (cm)	Polarity
1	* 2.484	48.1	Pk	32.5	-25.8	54.8	-	-	74	-19.2	218	252	V
2	* 2.484	47.77	Pk	32.5	-25.8	54.47	-	-	74	-19.53	218	252	V
3	* 2.484	32.34	VA1T	32.5	-25.8	39.04	54	-14.96	-	-	218	252	V
4	2.558	38.87	VA1T	32.5	-25.6	45.77	54	-8.23	-	-	218	252	V

* - indicates frequency in CFR47 Pt 15 / IC RSS-Restricted Band
Pk - Peak detector
VA1T - FHSS: Linear Voltage Average VB=1/Ton where: Ton is transmit duration

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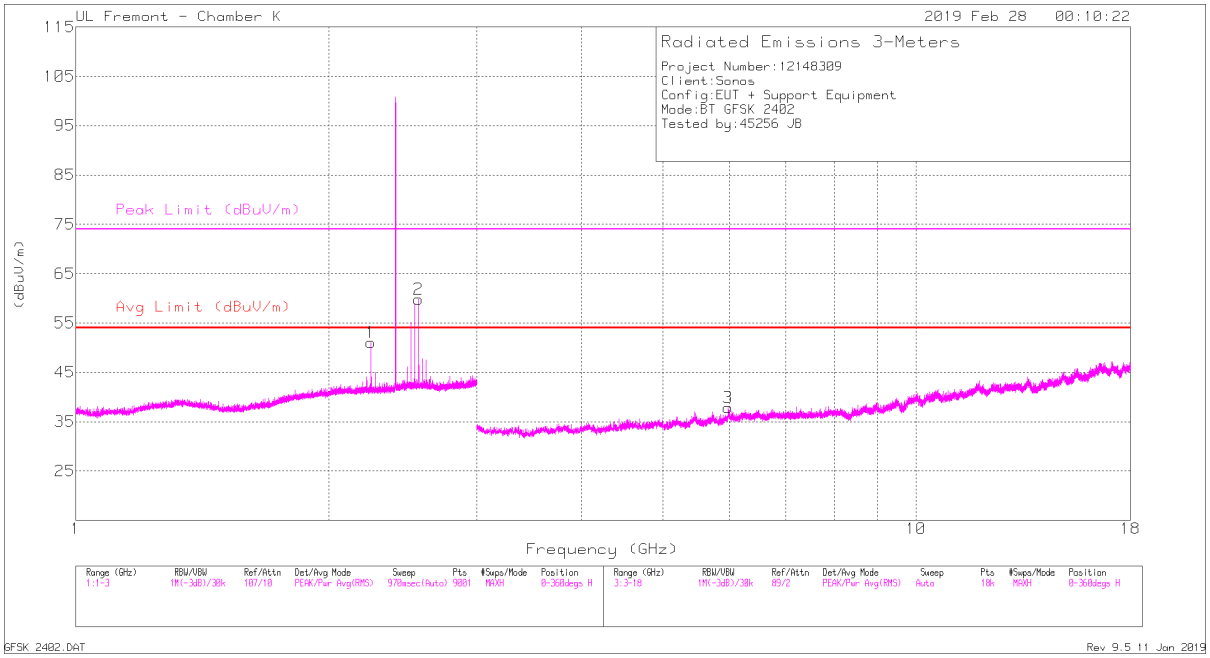
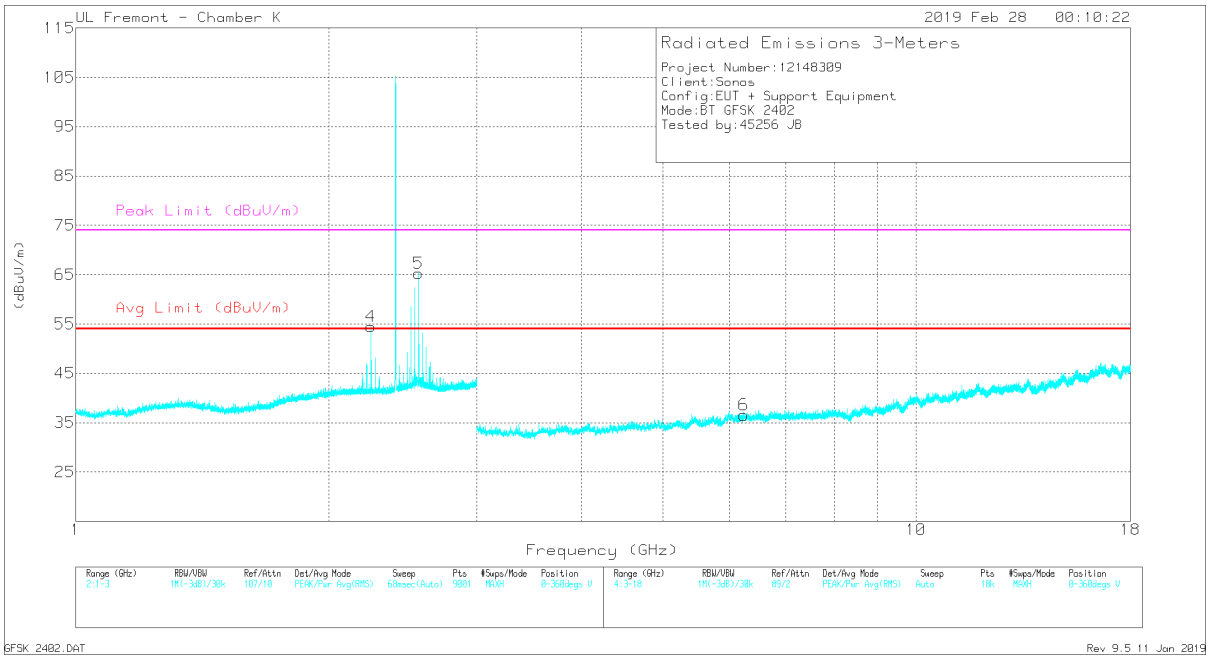
HARMONICS AND SPURIOUS EMISSIONS

LOW CHANNEL RESULTS



HORIZONTAL



VERTICAL

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RADIATED EMISSIONS

Frequency (GHz)	Meter Reading (dBuV)	Det	AF AT0067 (dB/m)	Amp/Cbl/Fltr/Pad (dB)	Corrected Reading (dBuV/m)	Avg Limit (dBuV/m)	Margin (dB)	Peak Limit (dBuV/m)	PK Margin (dB)	Azimuth (Degs)	Height (cm)	Polarity
* 2.246	48.26	PKFH	31.9	-25.9	54.26	-	-	74	-19.74	168	226	H
* 2.246	44.64	VA1T	31.9	-25.9	50.64	54	-3.36	-	-	168	226	H
* 2.246	51.69	PKFH	31.9	-25.9	57.69	-	-	74	-16.31	49	246	V
* 2.246	47.98	VA1T	31.9	-25.9	53.98	54	-.02	-	-	49	246	V

* - indicates frequency in CFR47 Pt 15 / IC RSS-Restricted Band
VA1T - FHSS: Linear Voltage Average VB=1/Ton where: Ton is transmit duration

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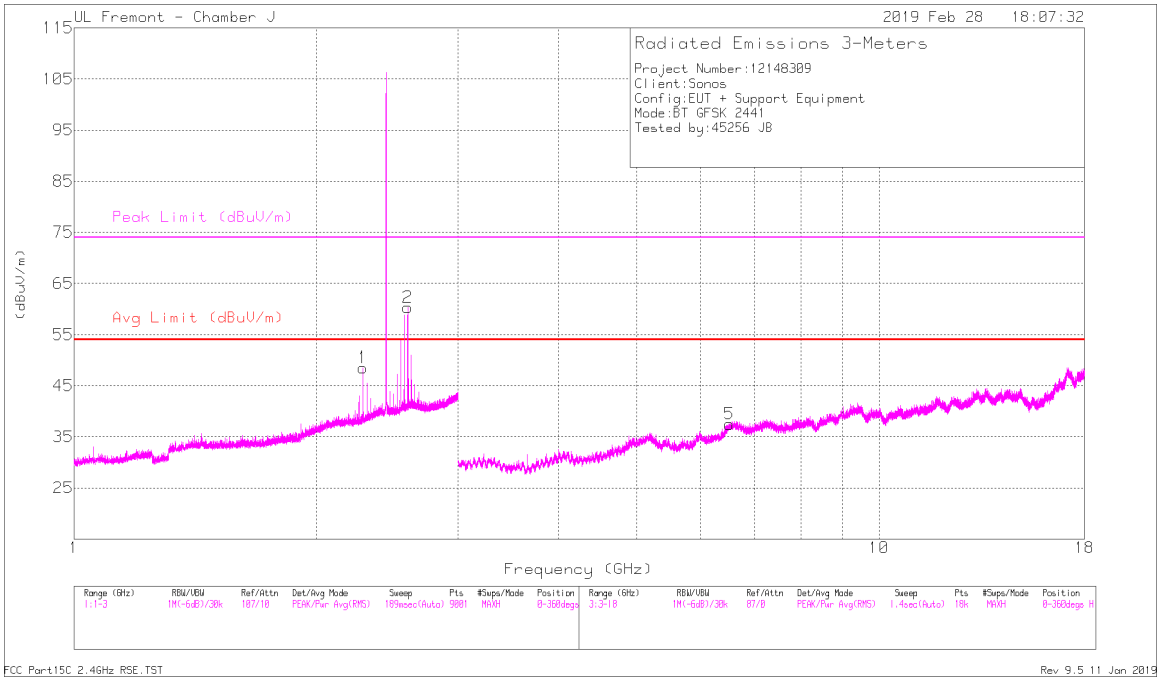
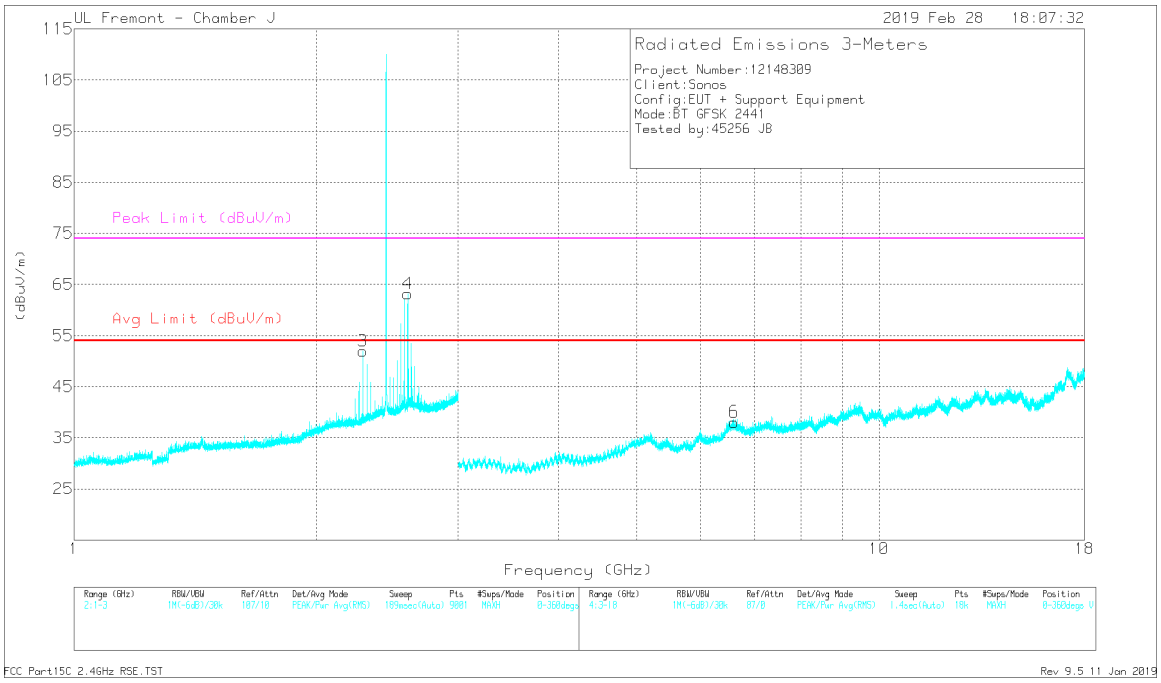
MID CHANNEL RESULTS



HORIZONTAL



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RADIATED EMISSIONS

Frequency (GHz)	Meter Reading (dBuV)	Det	AF PRE0189055 (dB/m)	Amp/Cbl/Fltr/Pad (dB)	Corrected Reading (dBuV/m)	Avg Limit (dBuV/m)	Margin (dB)	Peak Limit (dBuV/m)	PK Margin (dB)	Azimuth (Degs)	Height (cm)	Polarity
* 2.285	38.6	PKFH	28.5	-15.2	51.9	-	-	74	-22.1	3	195	H
* 2.285	33.68	VA1T	28.5	-15.2	46.98	54	-7.02	-	-	3	195	H
* 2.285	41.92	PKFH	28.5	-15.2	55.22	-	-	74	-18.78	23	147	V
* 2.285	38.29	VA1T	28.5	-15.2	51.59	54	-2.41	-	-	23	147	V

* - indicates frequency in CFR47 Pt 15 / IC RSS-Restricted Band
VA1T - FHSS: Linear Voltage Average VB=1/Ton where: Ton is transmit duration

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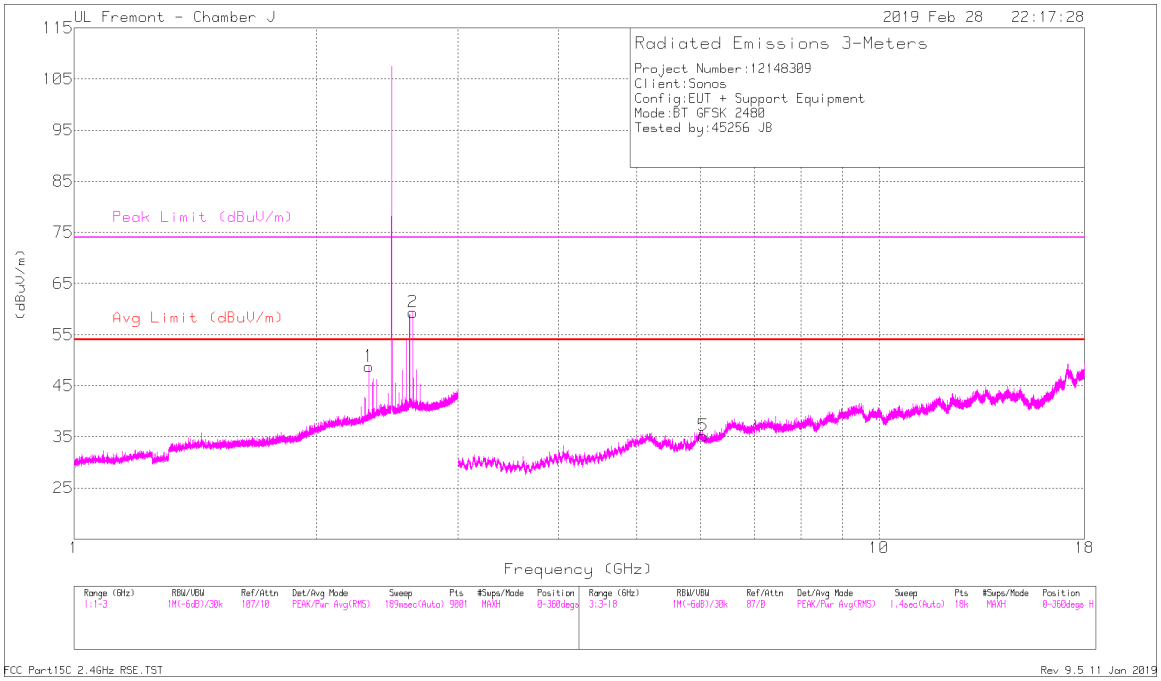
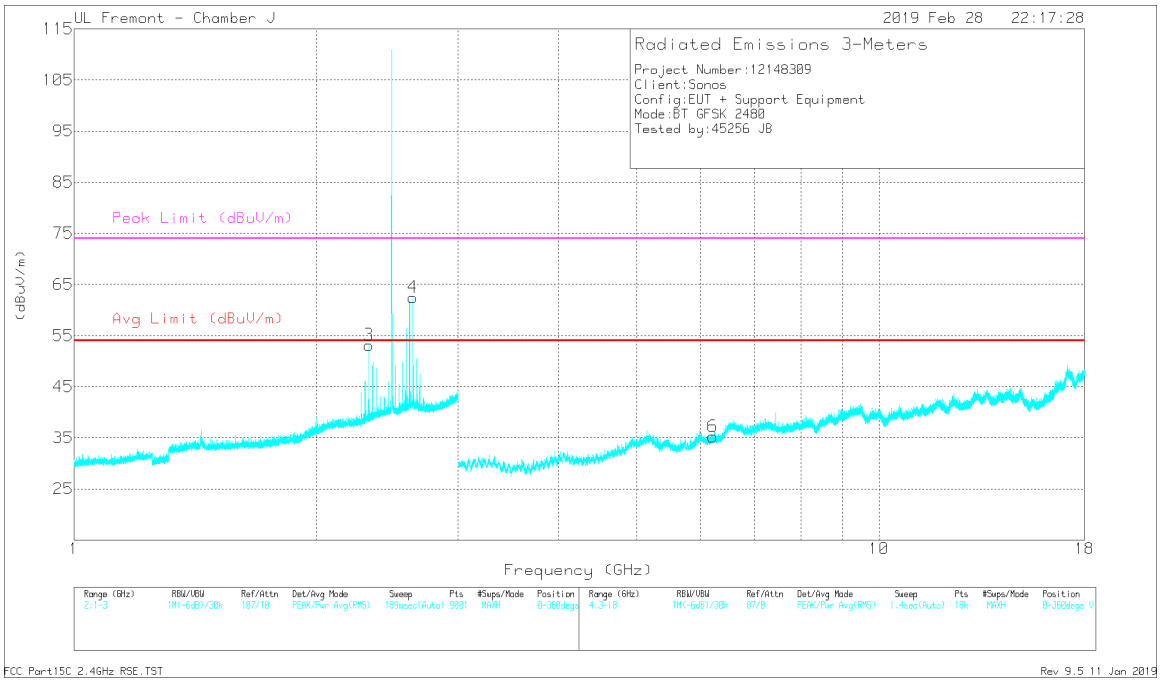
HIGH CHANNEL RESULTS



HORIZONTAL



VERTICAL

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RADIATED EMISSIONS

Frequency (GHz)	Meter Reading (dBuV)	Det	AF PRE0189055 (dB/m)	Amp/Cbl/Fltr/Pad (dB)	Corrected Reading (dBuV/m)	Avg Limit (dBuV/m)	Margin (dB)	Peak Limit (dBuV/m)	PK Margin (dB)	Azimuth (Degs)	Height (cm)	Polarity
* 2.324	39.16	PKFH	28.8	-15.1	52.86	-	-	74	-21.14	106	111	H
* 2.324	34.75	VA1T	28.8	-15.1	48.45	54	-5.55	-	-	106	111	H
* 2.324	42.23	PKFH	28.8	-15.1	55.93	-	-	74	-18.07	185	137	V
* 2.324	39.22	VA1T	28.8	-15.1	52.92	54	-1.08	-	-	185	137	V

* - indicates frequency in CFR47 Pt 15 / IC RSS-Restricted Band
VA1T - FHSS: Linear Voltage Average VB=1/Ton where: Ton is transmit duration

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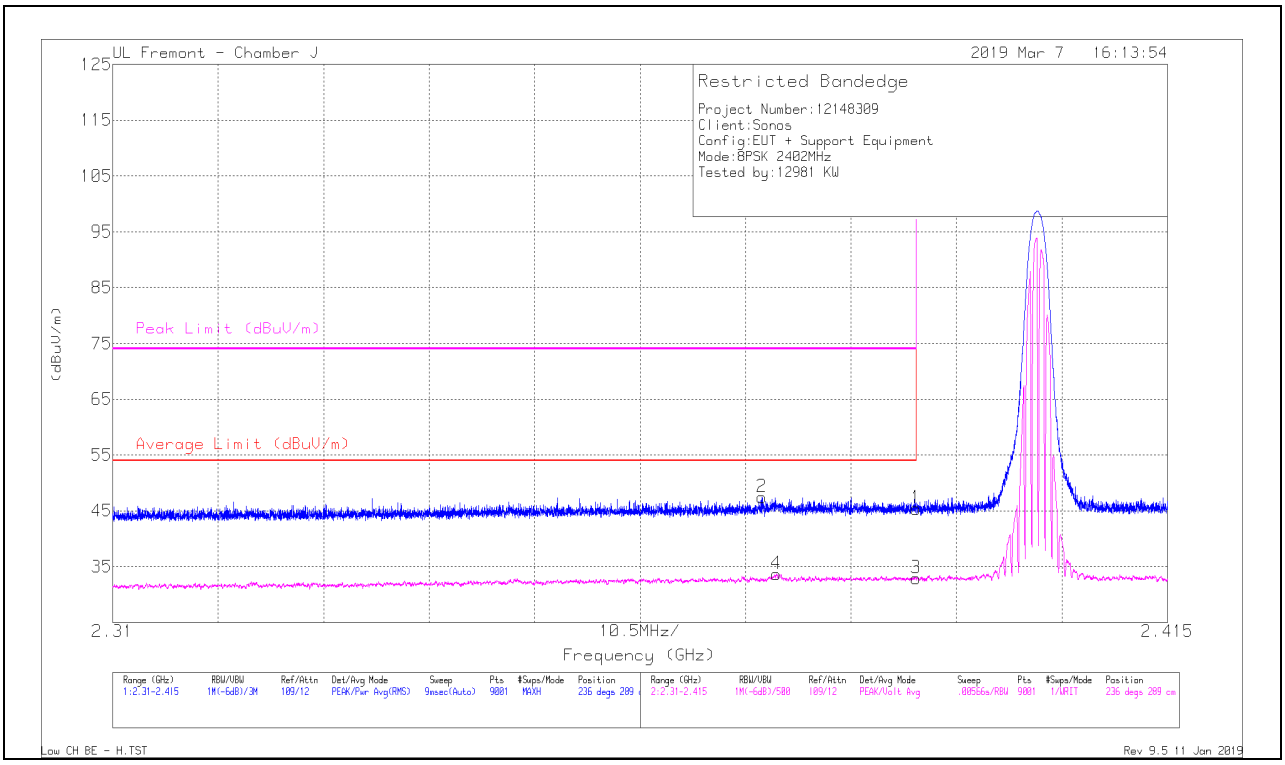
9.1.2. BLUETOOTH ENHANCED DATA RATE 8PSK MODULATION

BANDEDGE (LOW CHANNEL)

HORIZONTAL RESULT



Marker	Frequency (GHz)	Meter Reading (dBuV)	Det	AF PRE018905 5 (dB/m)	Amp/Cbl/Flt r/Pad (dB)	Corrected Reading (dBuV/m)	Average Limit (dBuV/m)	Margin (dB)	Peak Limit (dBuV/m)	PK Margin (dB)	Azimuth (Degs)	Height (cm)	Polarity
1	* 2.39	30.69	Pk	29.5	-14.8	45.39	-	-	74	-28.61	236	289	H
2	* 2.375	32.81	Pk	29.4	-14.8	47.41	-	-	74	-26.59	236	289	H
3	* 2.39	18.19	VA1T	29.5	-14.8	32.89	54	-21.11	-	-	236	289	H
4	* 2.376	19.11	VA1T	29.4	-14.8	33.71	54	-20.29	-	-	236	289	H

* - indicates frequency in CFR47 Pt 15 / IC RSS-Restricted Band
Pk - Peak detector
VA1T - FHSS: Linear Voltage Average VB=1/Ton where: Ton is transmit duration

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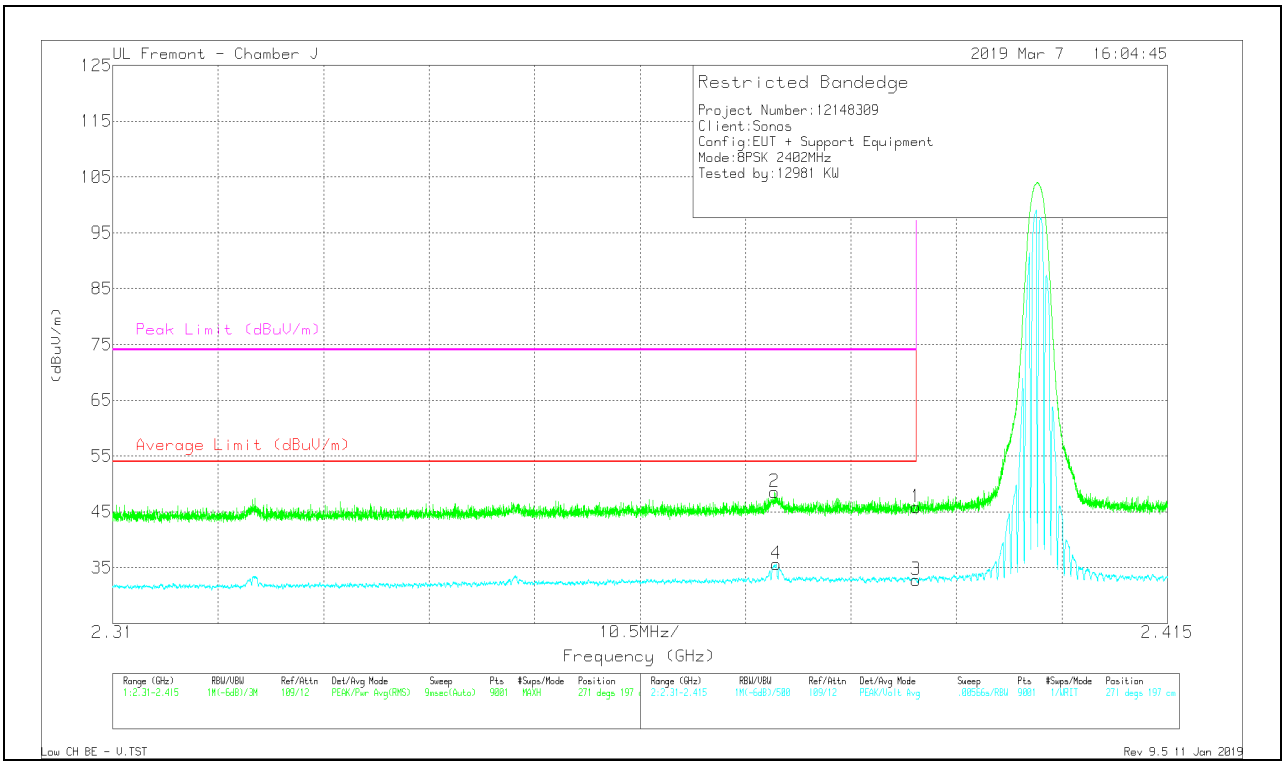
VERTICAL RESULT



Marker	Frequency (GHz)	Meter Reading (dBuV)	Det	AF PRE0189055 (dB/m)	Amp/Cbl/Flt r/Pad (dB)	Corrected Reading (dBuV/m)	Average Limit (dBuV/m)	Margin (dB)	Peak Limit (dBuV/m)	PK Margin (dB)	Azimuth (Degs)	Height (cm)	Polarity
1	* 2.39	31.1	Pk	29.5	-14.8	45.8	-	-	74	-28.2	271	197	V
2	* 2.376	33.9	Pk	29.4	-14.8	48.5	-	-	74	-25.5	271	197	V
3	* 2.39	18.04	VA1T	29.5	-14.8	32.74	54	-21.26	-	-	271	197	V
4	* 2.376	21.03	VA1T	29.4	-14.8	35.63	54	-18.37	-	-	271	197	V

* - indicates frequency in CFR47 Pt 15 / IC RSS-Restricted Band
Pk - Peak detector
VA1T - FHSS: Linear Voltage Average VB=1/Ton where: Ton is transmit duration

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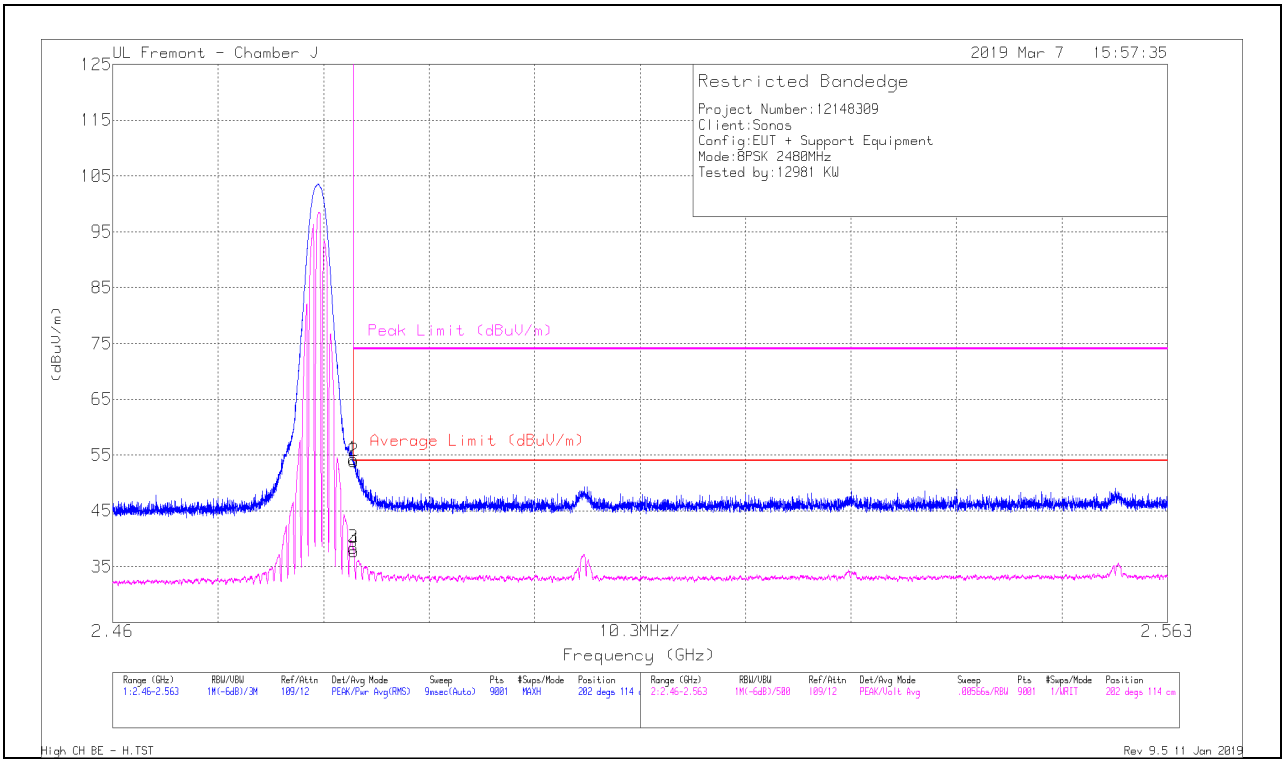
BANDEDGE (HIGH CHANNEL)

HORIZONTAL RESULT



Marker	Frequency (GHz)	Meter Reading (dBuV)	Det	AF PRE0189055 (dB/m)	Amp/Cbl/Fltr/Pad (dB)	Corrected Reading (dBuV/m)	Average Limit (dBuV/m)	Margin (dB)	Peak Limit (dBuV/m)	PK Margin (dB)	Azimuth (Degs)	Height (cm)	Polarity
1	* 2.484	39.06	Pk	29.9	-14.7	54.26	-	-	74	-19.74	202	114	H
2	* 2.484	38.68	Pk	29.9	-14.7	53.88	-	-	74	-20.12	202	114	H
3	* 2.484	23.2	VA1T	29.9	-14.7	38.4	54	-15.6	-	-	202	114	H
4	* 2.484	22.59	VA1T	29.9	-14.7	37.79	54	-16.21	-	-	202	114	H

* - indicates frequency in CFR47 Pt 15 / IC RSS-Restricted Band
Pk - Peak detector
VA1T - FHSS: Linear Voltage Average VB=1/Ton where: Ton is transmit duration

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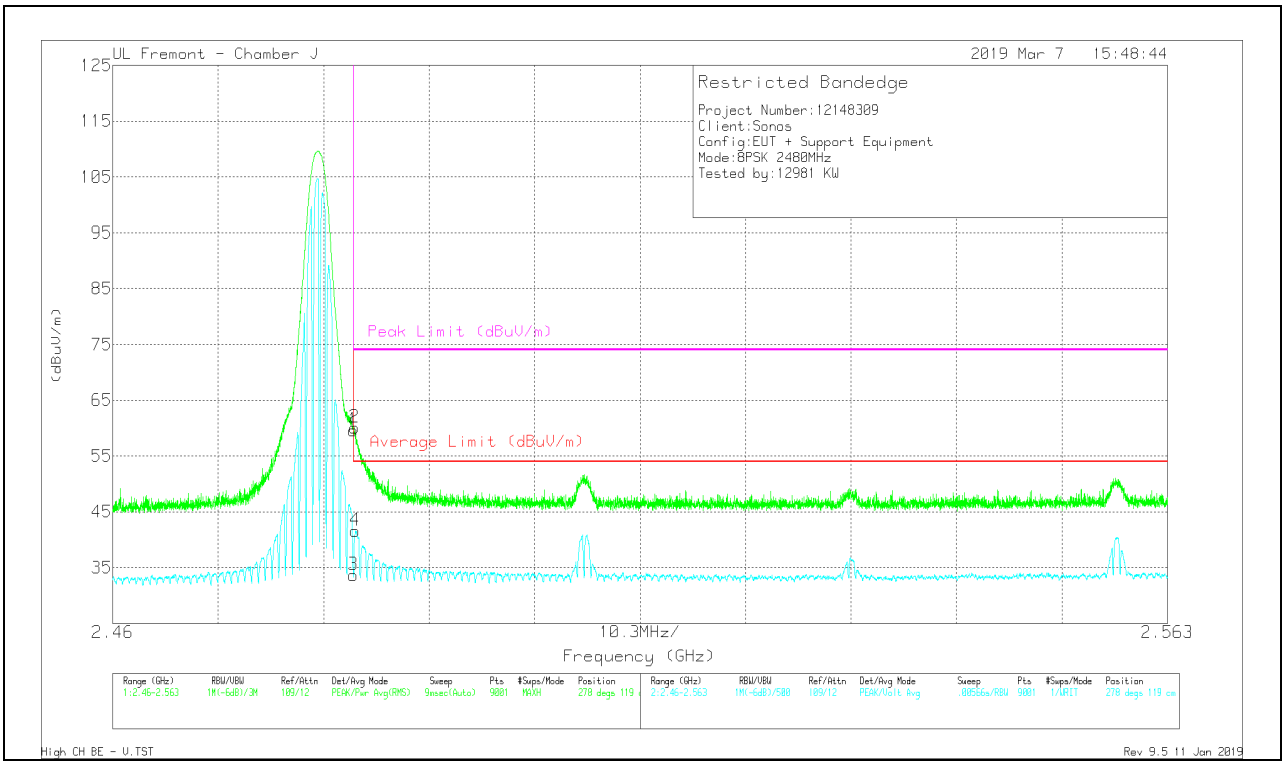
VERTICAL RESULT



Marker	Frequency (GHz)	Meter Reading (dBuV)	Det	AF PRE018905 5 (dB/m)	Amp/Cbl/Flt r/Pad (dB)	Corrected Reading (dBuV/m)	Average Limit (dBuV/m)	Margin (dB)	Peak Limit (dBuV/m)	PK Margin (dB)	Azimuth (Degs)	Height (cm)	Polarity
1	* 2.484	44.44	Pk	29.9	-14.7	59.64	-	-	74	-14.36	278	119	V
2	* 2.484	44.85	Pk	29.9	-14.7	60.05	-	-	74	-13.95	278	119	V
3	* 2.484	18.47	VA1T	29.9	-14.7	33.67	54	-20.33	-	-	278	119	V
4	* 2.484	26.38	VA1T	29.9	-14.7	41.58	54	-12.42	-	-	278	119	V

* - indicates frequency in CFR47 Pt 15 / IC RSS-Restricted Band
Pk - Peak detector
VA1T - FHSS: Linear Voltage Average VB=1/Ton where: Ton is transmit duration

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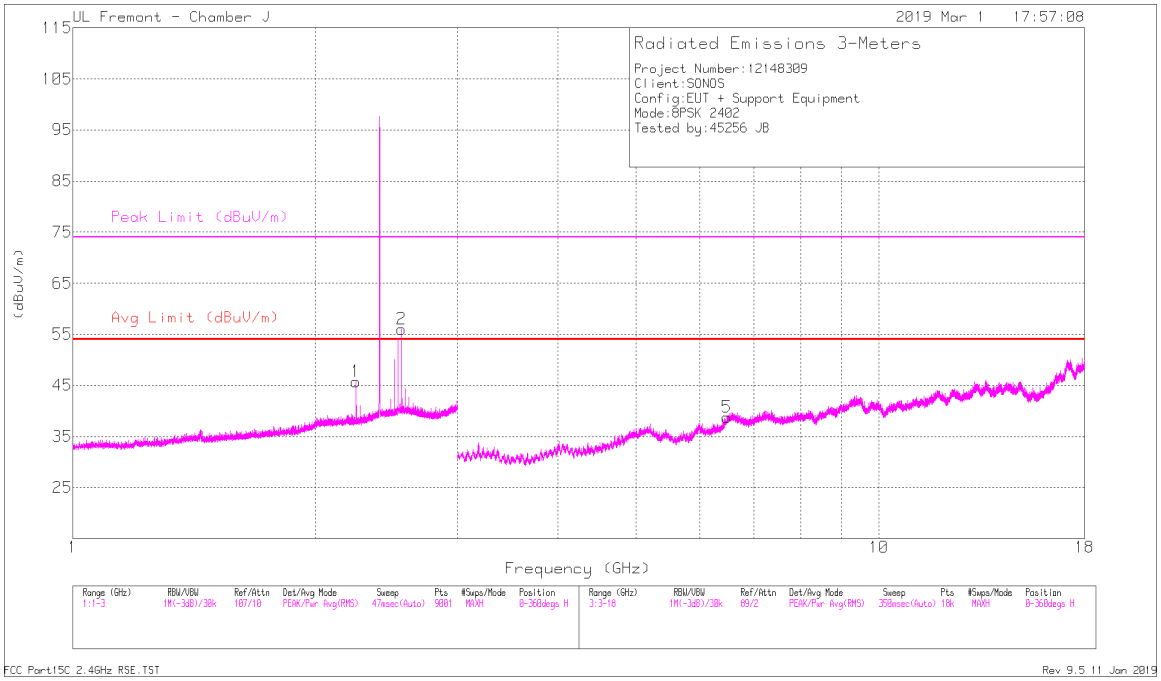
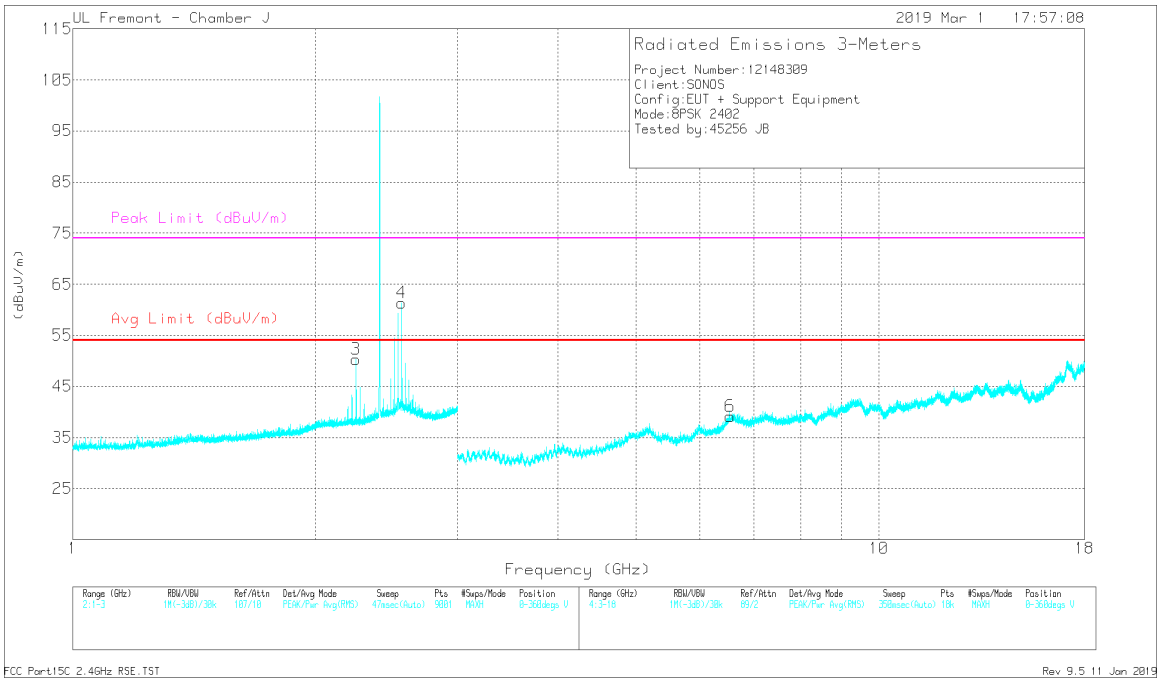
HARMONICS AND SPURIOUS EMISSIONS

LOW CHANNEL RESULTS



HORIZONTAL



VERTICAL

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RADIATED EMISSIONS

Frequency (GHz)	Meter Reading (dBuV)	Det	AF PRE0189055 (dB/m)	Amp/Cbl/Fltr/Pad (dB)	Corrected Reading (dBuV/m)	Avg Limit (dBuV/m)	Margin (dB)	Peak Limit (dBuV/m)	PK Margin (dB)	Azimuth (Degs)	Height (cm)	Polarity
* 2.246	50.22	PKFH	28.4	-25.9	52.72	-	-	74	-21.28	119	283	H
* 2.246	42.87	VA1T	28.4	-25.9	45.37	54	-8.63	-	-	119	283	H
* 2.246	51	PKFH	28.4	-25.9	53.5	-	-	74	-20.5	355	105	V
* 2.246	44.76	VA1T	28.4	-25.9	47.26	54	-6.74	-	-	355	105	V

* - indicates frequency in CFR47 Pt 15 / IC RSS-Restricted Band
VA1T - FHSS: Linear Voltage Average VB=1/Ton where: Ton is transmit duration

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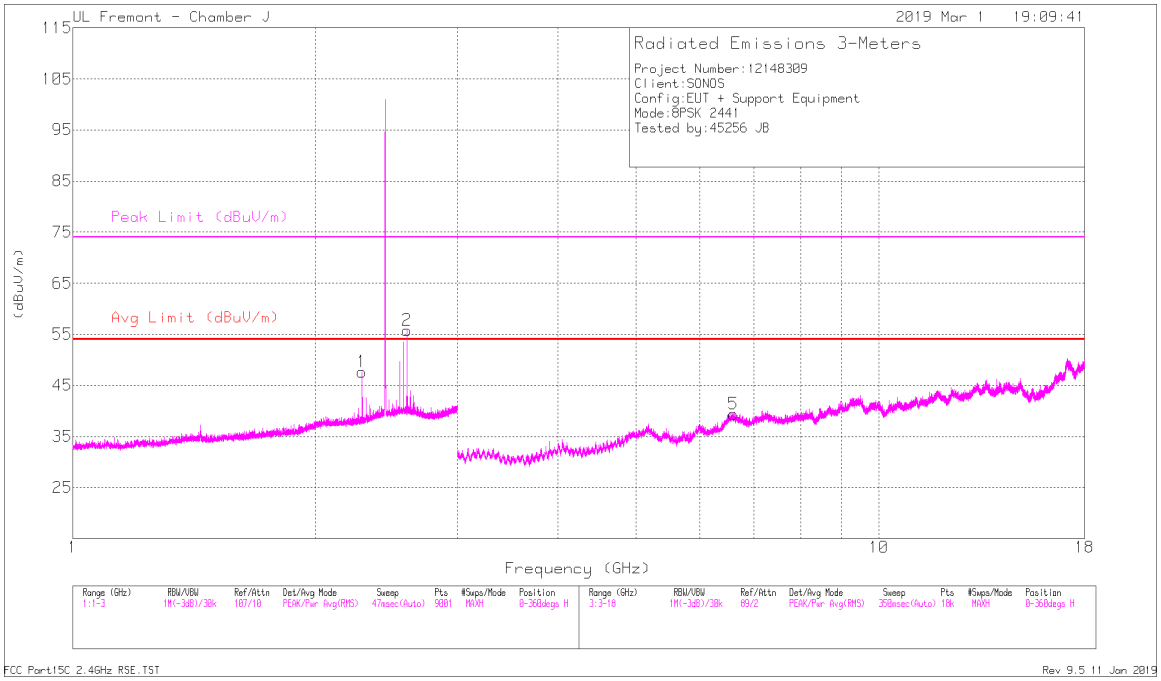
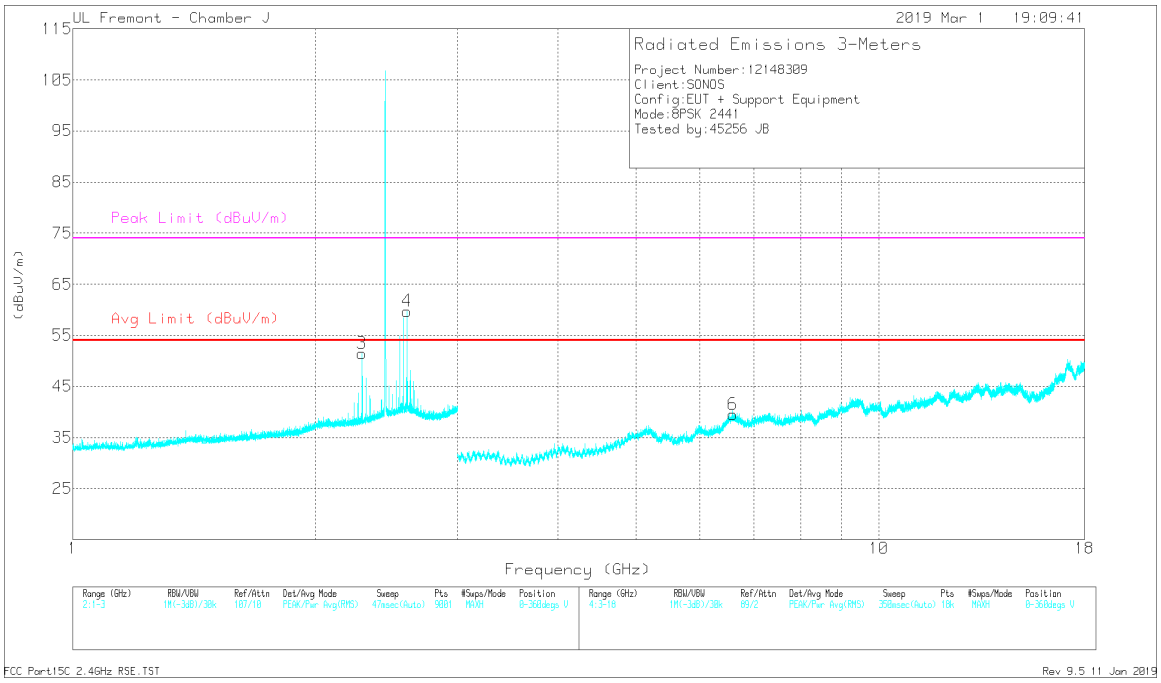
MID CHANNEL RESULTS



HORIZONTAL



VERTICAL

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RADIATED EMISSIONS

Frequency (GHz)	Meter Reading (dBuV)	Det	AF PRE0189055 (dB/m)	Amp/Cbl/Fltr/Pad (dB)	Corrected Reading (dBuV/m)	Avg Limit (dBuV/m)	Margin (dB)	Peak Limit (dBuV/m)	PK Margin (dB)	Azimuth (Degs)	Height (cm)	Polarity
* 2.285	48.18	PKFH	28.5	-25.8	50.88	-	-	74	-23.12	309	359	H
* 2.285	40.35	VA1T	28.5	-25.8	43.05	54	-10.95	-	-	309	359	H
* 2.285	52.63	PKFH	28.5	-25.8	55.33	-	-	74	-18.67	263	134	V
* 2.285	46.4	VA1T	28.5	-25.8	49.1	54	-4.9	-	-	263	134	V

* - indicates frequency in CFR47 Pt 15 / IC RSS-Restricted Band
VA1T - FHSS: Linear Voltage Average VB=1/Ton where: Ton is transmit duration

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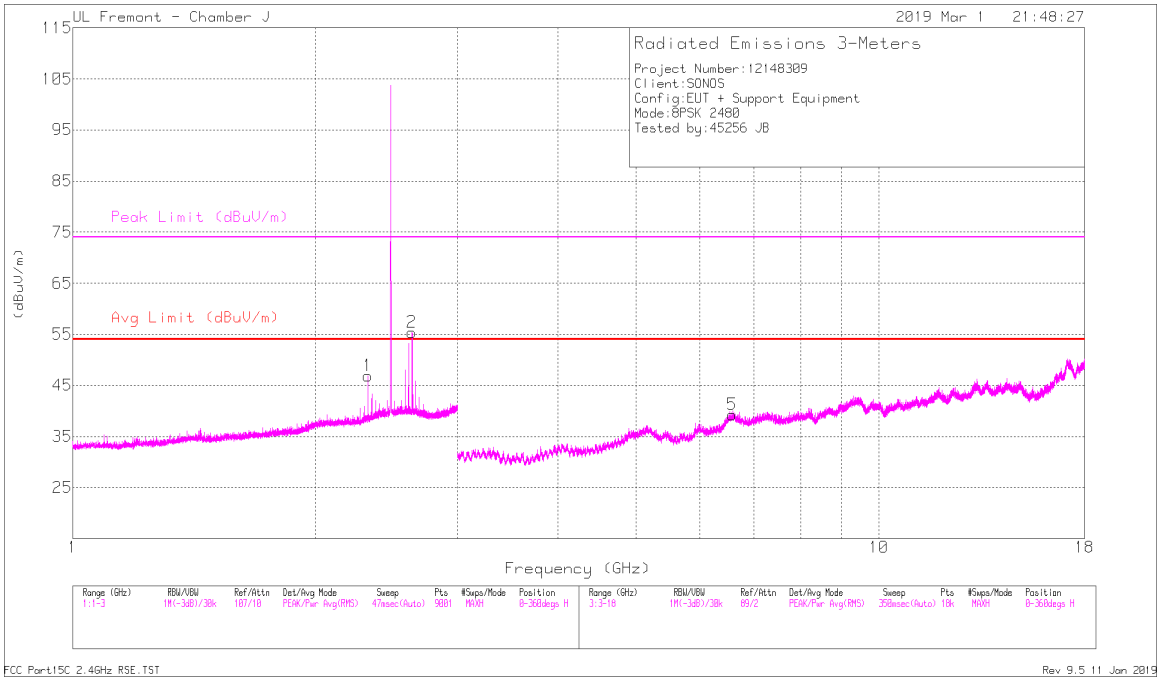
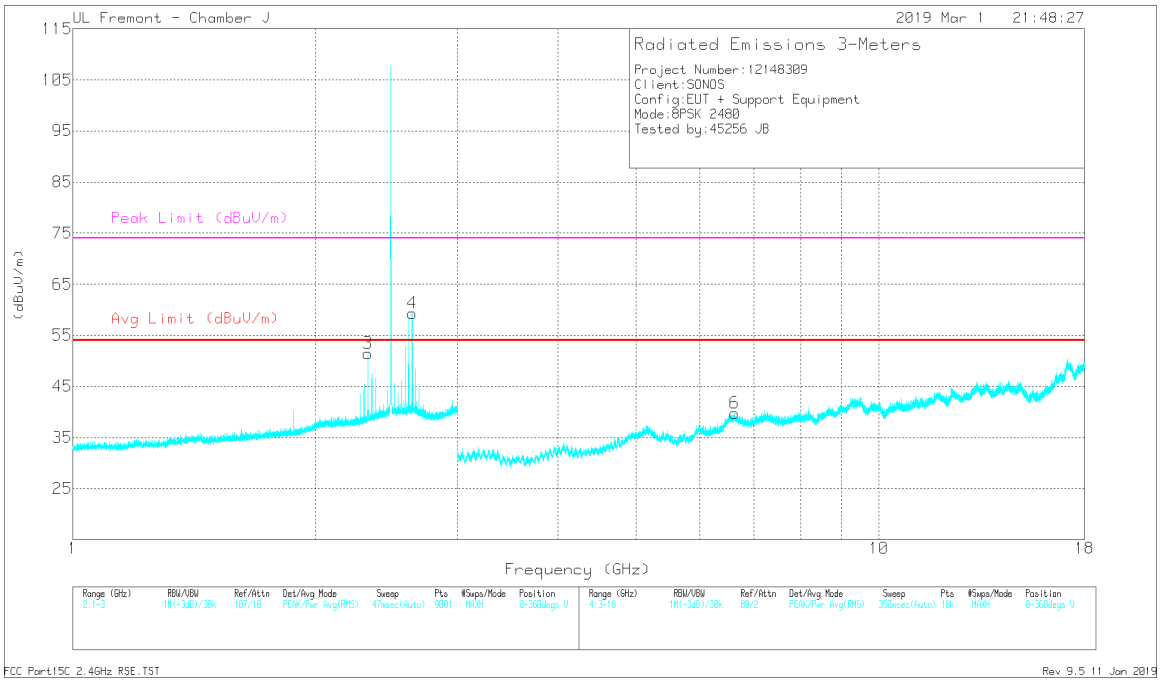
HIGH CHANNEL RESULTS



HORIZONTAL



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RADIATED EMISSIONS

Frequency (GHz)	Meter Reading (dBuV)	Det	AF PRE0189055 (dB/m)	Amp/Cbl/Fltr/Pad (dB)	Corrected Reading (dBuV/m)	Avg Limit (dBuV/m)	Margin (dB)	Peak Limit (dBuV/m)	PK Margin (dB)	Azimuth (Degs)	Height (cm)	Polarity
* 2.324	51.38	PKFH	28.8	-25.8	54.38	-	-	74	-19.62	111	304	H
* 2.324	43.65	VA1T	28.8	-25.8	46.65	54	-7.35	-	-	111	304	H
* 2.324	53.62	PKFH	28.8	-25.8	56.62	-	-	74	-17.38	269	206	V
* 2.324	47.49	VA1T	28.8	-25.8	50.49	54	-3.51	-	-	269	206	V

* - indicates frequency in CFR47 Pt 15 / IC RSS-Restricted Band
VA1T - FHSS: Linear Voltage Average VB=1/Ton where: Ton is transmit duration

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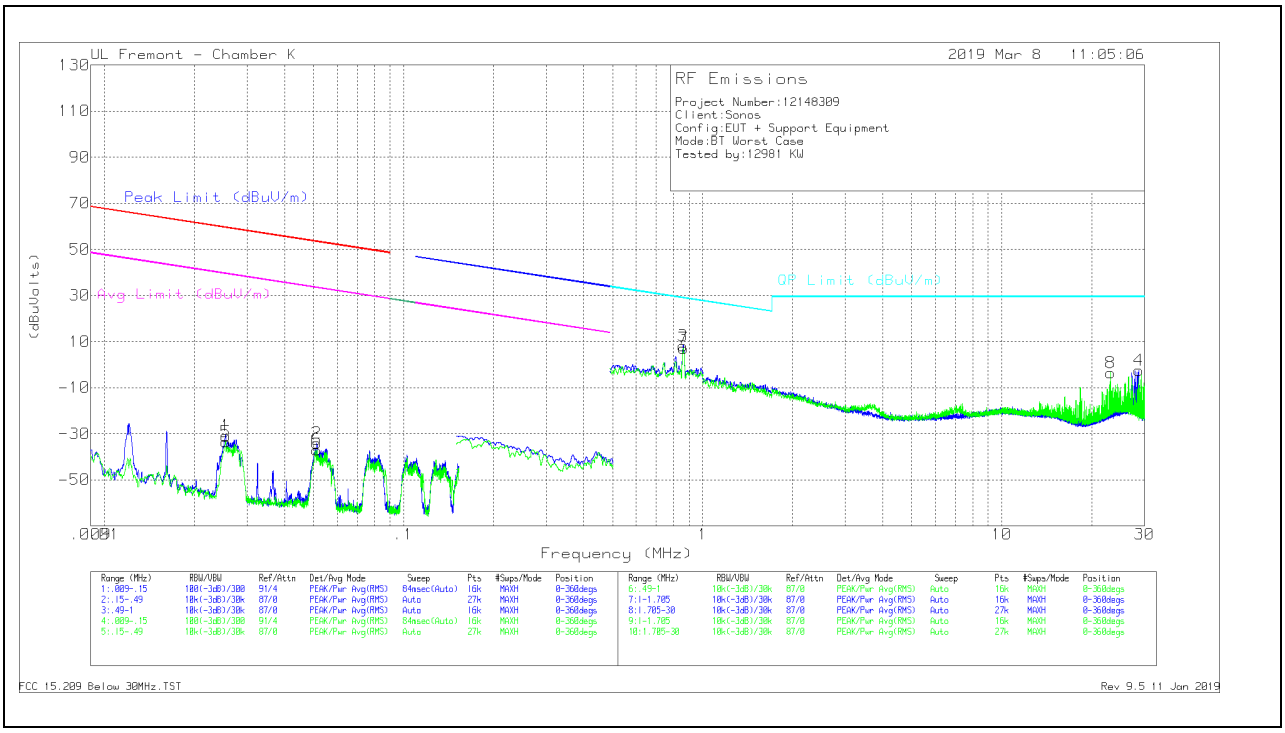
9.2. WORST CASE BELOW 30MHZ

SPURIOUS EMISSIONS BELOW 30 MHz (WORST-CASE CONFIGURATION)



Below 30MHz Data

Marker	Frequency (MHz)	Meter Reading (dBuV)	Det	Loop Antenna (ACF)	Cables w/ PRE0186650	Dist Corr 300m	Corrected Reading (dBuVolts)	Peak Limit (dBuV/m)	Margin (dB)	Avg Limit (dBuV/m)	Margin (dB)	Azimuth (Degs)
1	.02543	22.91	Pk	58.4	-32.2	-80	-30.89	59.48	-90.37	39.48	-70.37	0-360
2	.05134	21.12	Pk	57	-32.2	-80	-34.08	53.38	-87.46	33.38	-67.46	0-360
5	.02543	20.29	Pk	58.4	-32.2	-80	-33.51	59.48	-92.99	39.48	-72.99	0-360
6	.05135	18.32	Pk	57	-32.2	-80	-36.88	53.37	-90.25	33.37	-70.25	0-360

Marker	Frequency (MHz)	Meter Reading (dBuV)	Det	Loop Antenna (ACF)	Cables w/ PRE0186650	Dist Corr 30m (dB) 40Log	Corrected Reading (dBuVolts)	QP Limit (dBuV/m)	Margin (dB)	Azimuth (Degs)
3	.85979	23.92	Pk	56.3	-32.1	-40	8.12	28.93	-20.81	0-360
7	.86182	22.82	Pk	56.3	-32.1	-40	7.02	28.91	-21.89	0-360
4	28.68471	36.48	Pk	32.6	-31.6	-40	-2.52	29.5	-32.02	0-360
8	23.12612	34.08	Pk	34	-31.6	-40	-3.52	29.5	-33.02	0-360

Pk - Peak detector

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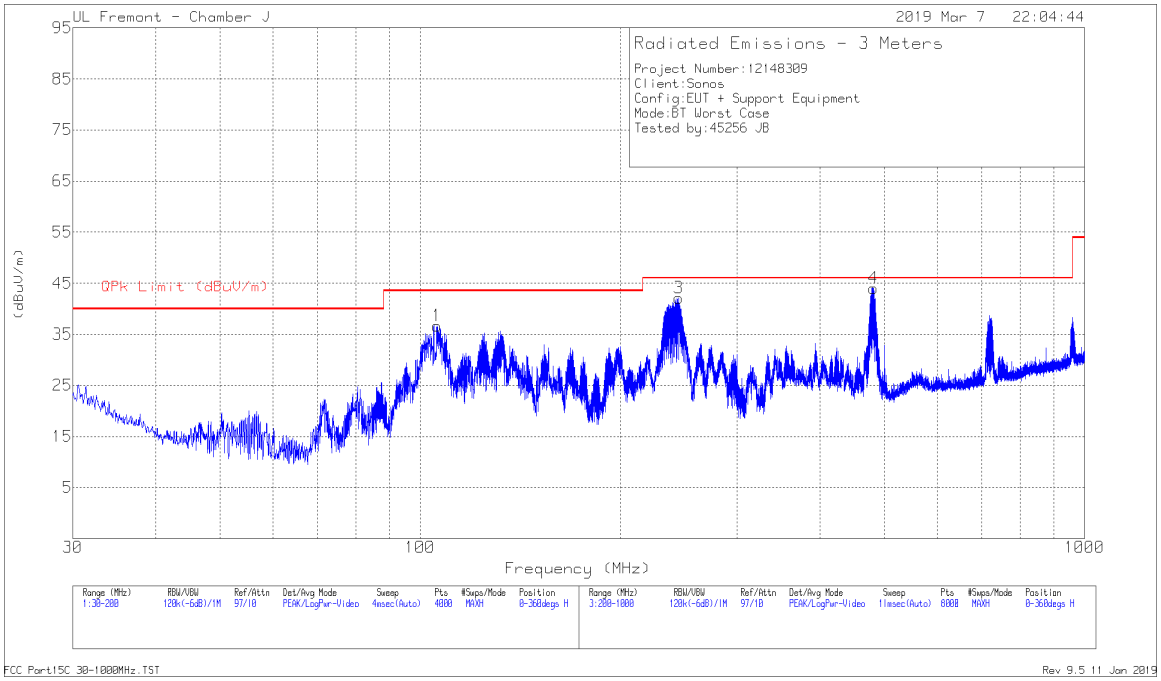
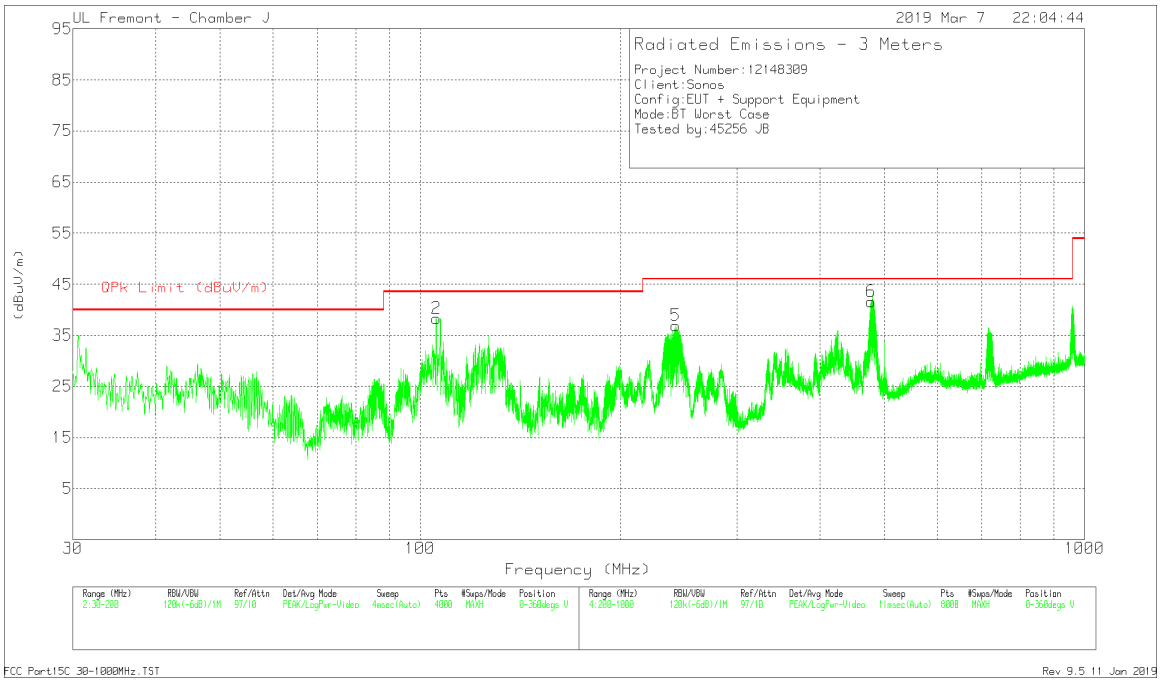
9.3. WORST CASE BELOW 1 GHZ

SPURIOUS EMISSIONS 30 TO 1000 MHz (WORST-CASE CONFIGURATION)



HORIZONTAL



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Below 1GHz Data

Marker	Frequency (MHz)	Meter Reading (dBuV)	Det	AF PRE0181575 (dB/m)	Amp Cbl (dB)	Corrected Reading (dBuV/m)	QPk Limit (dBuV/m)	Margin (dB)	Azimuth (Degs)	Height (cm)	Polarity
1	105.9246	49.7	Pk	17.9	-30.9	36.7	43.52	-6.82	0-360	198	H
2	105.7121	51.44	Pk	17.8	-30.9	38.34	43.52	-5.18	0-360	101	V
3	* 245.0059	54.78	Pk	17.5	-30.2	42.08	46.02	-3.94	0-360	101	H
	* 245.0548	53.3	Qp	17.5	-30.2	40.6	46.02	-5.42	88	115	H
4	481.0365	49.82	Pk	23.6	-29.4	44.02	46.02	-2	0-360	198	H
	481.107	46.55	Qp	23.6	-29.4	40.75	46.02	-5.27	108	172	H
5	* 242.4055	49.57	Pk	17.5	-30.2	36.87	46.02	-9.15	0-360	101	V
6	477.036	47.55	Pk	23.6	-29.5	41.65	46.02	-4.37	0-360	198	V
	477.094	46.03	Qp	23.6	-29.5	40.13	46.02	-5.89	196	192	V

* - indicates frequency in CFR47 Pt 15 / IC RSS-Restricted Band
Pk - Peak detector
Qp - Quasi-Peak detector

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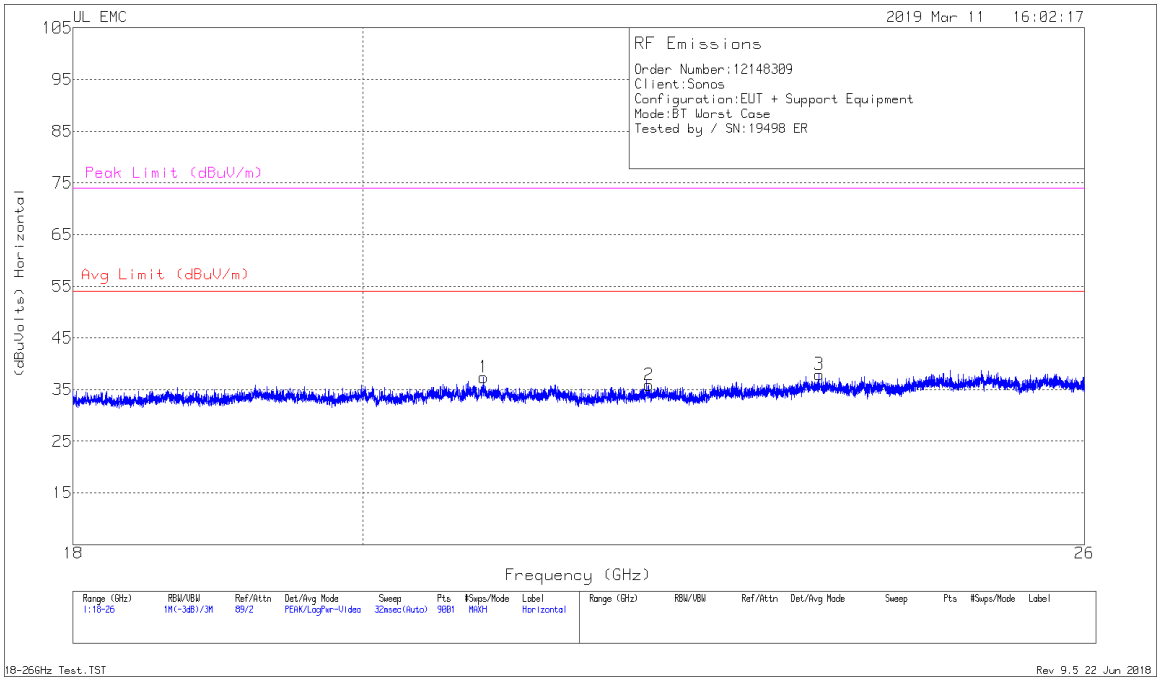
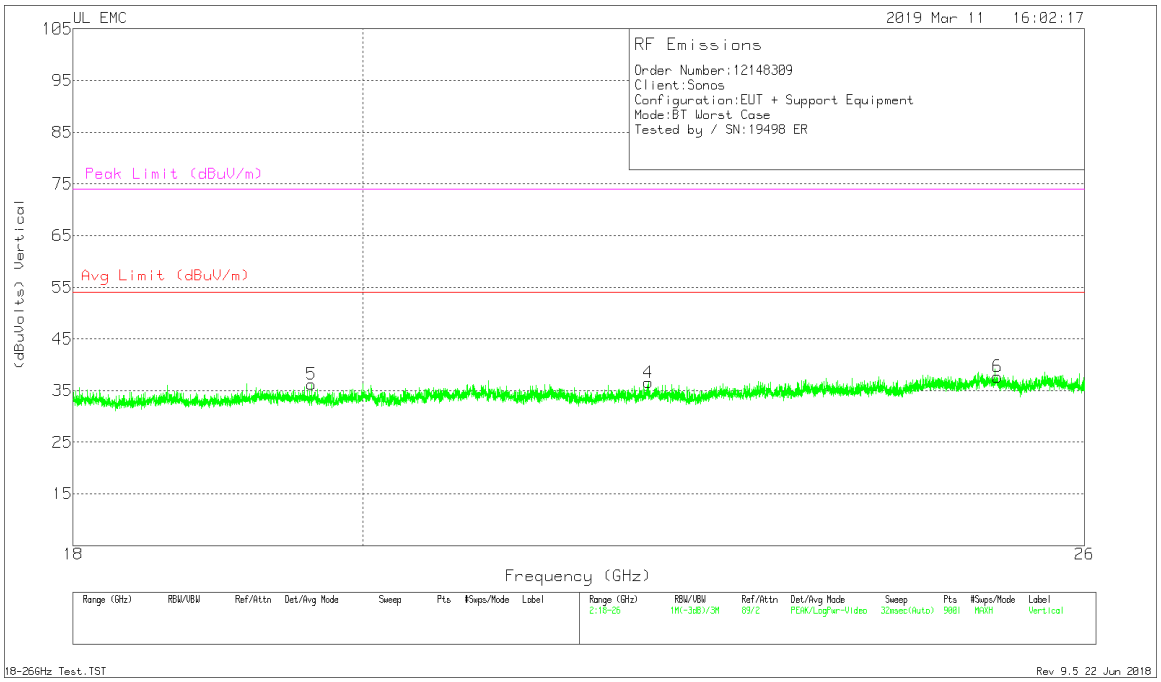
9.4. WORST CASE 18-26 GHZ

SPURIOUS EMISSIONS 18-26 GHz (WORST-CASE CONFIGURATION)



HORIZONTAL



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18 – 26GHz DATA

Marker	Frequency (GHz)	Meter Reading (dBuV)	Det	T448 AF (dB/m)	Amp/Cbl (dB)	Dist Corr (dB)	Corrected Reading (dBuVolts)	Avg Limit (dBuV/m)	Margin (dB)	Peak Limit (dBuV/m)	PK Margin (dB)
1	20.897	70.79	Pk	33.2	-57.1	-9.5	37.39	54	-16.61	74	-36.61
2	22.191	69.29	Pk	33.4	-57.3	-9.5	35.89	54	-18.11	74	-38.11
3	23.608	70.13	Pk	33.9	-56.6	-9.5	37.93	54	-16.07	74	-36.07
4	22.187	69.76	Pk	33.5	-57.2	-9.5	36.56	54	-17.44	74	-37.44
5	19.629	69.72	Pk	32.6	-56.6	-9.5	36.22	54	-17.78	74	-37.78
6	25.189	67.66	Pk	34.7	-55.2	-9.5	37.66	54	-16.34	74	-36.34

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10. AC POWER LINE CONDUCTED EMISSIONS

LIMITS

FCC §15.207 (a)

RSS-Gen 8.8

Frequency of Emission (MHz)	Conducted Limit (dBuV)	
	Quasi-peak	Average
0.15-0.5	66 to 56 *	56 to 46 *
0.5-5	56	46
5-30	60	50

* Decreases with the logarithm of the frequency.

TEST PROCEDURE

The EUT is placed on a non-conducting table 40 cm from the vertical ground plane and 80 cm above the horizontal ground plane. The EUT is configured in accordance with ANSI C63.4.

The receiver is set to a resolution bandwidth of 9 kHz. Peak detection is used unless otherwise noted as quasi-peak or average.

Line conducted data is recorded for both NEUTRAL and HOT lines.

RESULTS

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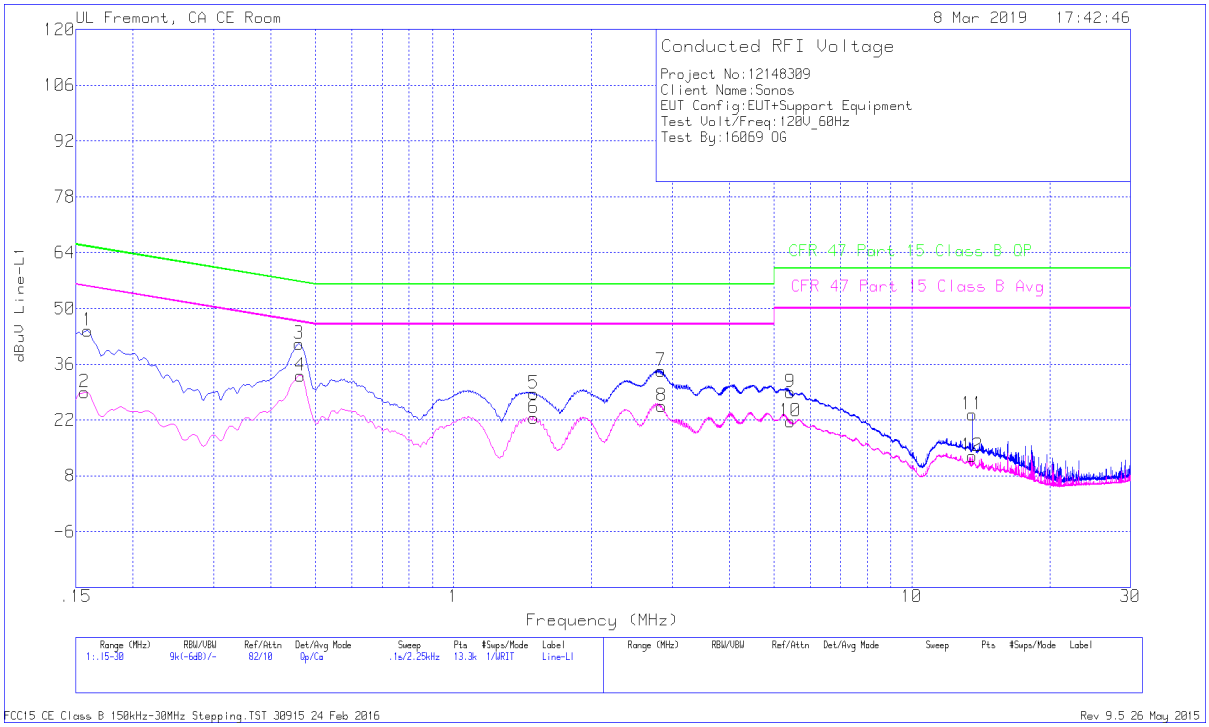
AC Power Line Norm

LINE 1 RESULTS



Range 1: Line-L1 .15 - 30MHz

Marker	Frequency (MHz)	Meter Reading (dBuV)	Det	LISN L1	LC Cables C1&C3	Limiter (dB)	Corrected Reading dBuV	CFR 47 Part 15 Class B QP	QP Margin (dB)	CFR 47 Part 15 Class B Avg	Av(CISPR)Margin (dB)
1	.159	34.3	Qp	.1	0	10.1	44.5	65.52	-21.02	-	-
2	.15675	18.81	Ca	.1	0	10.1	29.01	-	-	55.63	-26.62
3	.4605	30.96	Qp	0	0	10.1	41.06	56.68	-15.62	-	-
4	.46275	23.11	Ca	0	0	10.1	33.21	-	-	46.64	-13.43
5	1.4955	18.44	Qp	0	.1	10.1	28.64	56	-27.36	-	-
6	1.4955	12.35	Ca	0	.1	10.1	22.55	-	-	46	-23.45
7	2.841	24.13	Qp	0	.1	10.1	34.33	56	-21.67	-	-
8	2.84325	15.32	Ca	0	.1	10.1	25.52	-	-	46	-20.48
9	5.43525	18.78	Qp	0	.1	10.1	28.98	60	-31.02	-	-
10	5.4375	11.47	Ca	0	.1	10.1	21.67	-	-	50	-28.33
11	13.56	12.86	Qp	.1	.2	10.2	23.36	60	-36.64	-	-
12	13.56	2.41	Ca	.1	.2	10.2	12.91	-	-	50	-37.09

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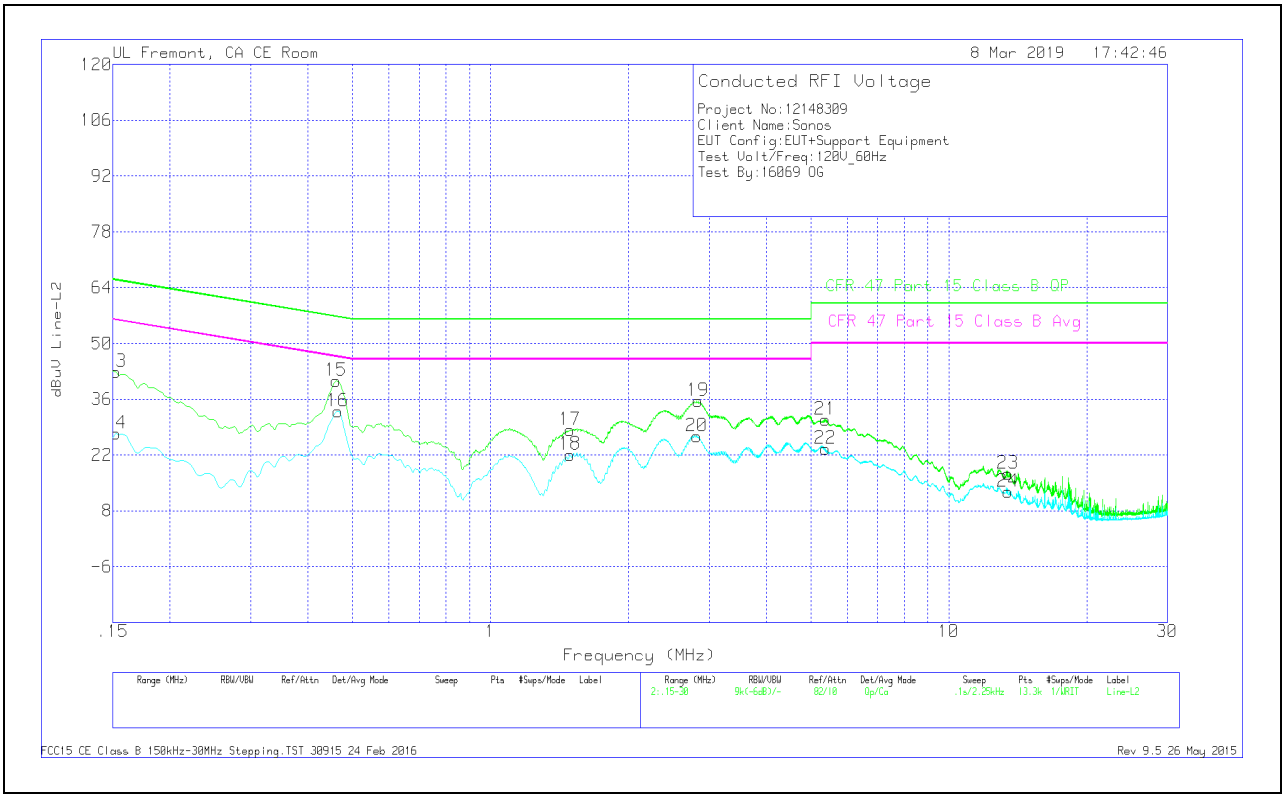
LINE 2 RESULTS



Range 2: Line-L2 .15 - 30MHz

Marker	Frequency (MHz)	Meter Reading (dBuV)	Det	LISN L2	LC Cables C2&C3	Limiter (dB)	Corrected Reading dBuV	CFR 47 Part 15 Class B QP	QP Margin (dB)	CFR 47 Part 15 Class B Avg	Av(CISPR)Margin (dB)
13	.15225	32.7	Qp	.1	0	10.1	42.9	65.88	-22.98	-	-
14	.15225	17.22	Ca	.1	0	10.1	27.42	-	-	55.88	-28.46
15	.4605	30.45	Qp	0	0	10.1	40.55	56.68	-16.13	-	-
16	.465	22.88	Ca	0	0	10.1	32.98	-	-	46.6	-13.62
17	1.49325	18.12	Qp	0	.1	10.1	28.32	56	-27.68	-	-
18	1.491	11.9	Ca	0	.1	10.1	22.1	-	-	46	-23.9
19	2.8365	25.39	Qp	0	.1	10.1	35.59	56	-20.41	-	-
20	2.8185	16.47	Ca	0	.1	10.1	26.67	-	-	46	-19.33
21	5.3835	20.66	Qp	0	.1	10.1	30.86	60	-29.14	-	-
22	5.37675	13.31	Ca	0	.1	10.1	23.51	-	-	50	-26.49
23	13.47675	6.86	Qp	.1	.2	10.2	17.36	60	-42.64	-	-
24	13.47675	2.3	Ca	.1	.2	10.2	12.8	-	-	50	-37.2

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