CERTIFICATION TEST REPORT

Report Number. : R12663957L-E9

Applicant	:	Bose Corporation 100 The Mountain Framingham, MA 01701, USA
Model	:	BL2L
FCC ID	:	A94BL2L
IC	:	3232A-BL2L
EUT Description	:	Wireless Headset
Test Standard(s)	:	FCC 47 CFR PART 15 SUBPART C ISED RSS-247 ISSUE 2 ISED RSS-GEN ISSUE 5

Date Of Issue:
2019-04-17

Prepared by:
UL LLC
12 Laboratory Dr.
Research Triangle Park, NC 27709 U.S.A.
TEL: (919) 549-1400

NVLAP TESTING

NVLAP Lab code: 200246-0

REPORT REVISION HISTORY

Rev.	Issue Date	Revisions	Revised By
V1	2019-04-10	Initial Issue	Niklas Haydon
V2	2019-04-17	Adjusted duty cycle correction for radiated emissions	Niklas Haydon

UL LLC
12 Laboratory Dr., RTP, NC 27709; USA TEL:(919) 549-1400
This report shall not be reproduced except in full, without the written approval of UL LLC.

TABLE OF CONTENTS

REPORT REVISION HISTORY 2

TABLE OF CONTENTS 3

1. ATTESTATION OF TEST RESULTS 5

2. TEST METHODOLOGY 7

3. FACILITIES AND ACCREDITATION 7

4. CALIBRATION AND UNCERTAINTY 8

4.1. MEASURING INSTRUMENT CALIBRATION 8

4.2. SAMPLE CALCULATION 8

4.3. MEASUREMENT UNCERTAINTY 8

5. EQUIPMENT UNDER TEST 9

5.1. EUT DESCRIPTION 9

5.2. MAXIMUM OUTPUT POWER 9

5.3. DESCRIPTION OF AVAILABLE ANTENNAS 9

5.4. SOFTWARE AND FIRMWARE 9

5.5. WORST-CASE CONFIGURATION AND MODE 10

5.6. DESCRIPTION OF TEST SETUP 11

6. TEST AND MEASUREMENT EQUIPMENT 12

7. MEASUREMENT METHODS 15

8. ANTENNA PORT TEST RESULTS 16

8.1. ON TIME AND DUTY CYCLE 16

8.2. 20 dB AND 99% BANDWIDTH 17

8.2.1. BLUETOOTH BASIC DATA RATE GFSK MODULATION 18

8.2.2. BLUETOOTH ENHANCED DATA RATE 8PSK MODULATION 19

8.3. HOPPING FREQUENCY SEPARATION 20

8.3.1. BLUETOOTH BASIC DATA RATE GFSK MODULATION 21

8.3.2. BLUETOOTH ENHANCED DATA RATE 8PSK MODULATION 22

8.4. NUMBER OF HOPPING CHANNELS 23

8.4.1. BLUETOOTH BASIC DATA RATE GFSK MODULATION 24

8.4.2. BLUETOOTH ENHANCED DATA RATE 8PSK MODULATION 26

8.5. AVERAGE TIME OF OCCUPANCY 28

8.5.1. BLUETOOTH BASIC DATA RATE GFSK MODULATION 29

8.5.2. BLUETOOTH ENHANCED DATA RATE DQPSK MODULATION 31

8.5.3. BLUETOOTH ENHANCED DATA RATE 8PSK MODULATION 33

8.6. OUTPUT POWER 35

UL LLC
12 Laboratory Dr., RTP, NC 27709; USA TEL:(919) 549-1400

This report shall not be reproduced except in full, without the written approval of UL LLC.

8.6.1. BLUETOOTH BASIC DATA RATE GFSK MODULATION 36
8.6.2. BLUETOOTH ENHANCED DATA RATE DQPSK MODULATION 37
8.6.3. BLUETOOTH ENHANCED DATA RATE 8PSK MODULATION.....38

8.7. AVERAGE POWER 39
8.7.1. BLUETOOTH BASIC DATA RATE GFSK MODULATION 40
8.7.1. BLUETOOTH ENHANCED DATA RATE DQPSK MODULATION 41
8.7.2. BLUETOOTH ENHANCED DATA RATE 8PSK MODULATION.....42

8.8. CONDUCTED SPURIOUS EMISSIONS.....43
8.8.1. BLUETOOTH BASIC DATA RATE GFSK MODULATION 44
8.8.2. BLUETOOTH ENHANCED DATA RATE 8PSK MODULATION.....46

9. RADIATED TEST RESULTS.....48

9.1. TRANSMITTER ABOVE 1 GHz 50
9.1.1. BLUETOOTH BASIC DATA RATE GFSK MODULATION 50
9.1.2. BLUETOOTH ENHANCED DATA RATE 8PSK MODULATION.....60

9.2. WORST CASE BELOW 30MHZ 70

9.3. WORST CASE BELOW 1 GHZ.....71

9.4. WORST CASE 18-26 GHZ 73

10. SETUP PHOTOS 75

UL LLC
12 Laboratory Dr., RTP, NC 27709; USA TEL:(919) 549-1400

This report shall not be reproduced except in full, without the written approval of UL LLC.

1. ATTESTATION OF TEST RESULTS

COMPANY NAME: Bose Corporation
100 The Mountain
Framingham, MA 01701, USA

EUT DESCRIPTION: Wireless Headset

MODEL: BL2L

SERIAL NUMBER: L-3, L-4, L-5, L-6

DATE TESTED: 2019-03-06 to 2019-04-03

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 LLC 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 LLC and all revisions are duly noted in the revisions section. Any alteration of this document not carried out by UL LLC 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, or any agency of the U.S. government.

This report shall not be reproduced except in full, without the written approval of UL LLC.

Approved & Released For
UL LLC By:

Jeffrey Moser
Operations Leader
Consumer Technology Division
UL LLC

Prepared By:

Niklas Haydon
Engineer
Consumer Technology Division
UL LLC

UL LLC
12 Laboratory Dr., RTP, NC 27709; USA TEL:(919) 549-1400

This report shall not be reproduced except in full, without the written approval of UL LLC.

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 v05r02, 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 12 Laboratory Drive, Research Triangle Park, North Carolina, USA and 2800 Suite Perimeter Park Dr., Morrisville, North Carolina, USA. 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.

12 Laboratory Dr.	2800 Suite Perimeter Park Dr.
☐ Chamber A (ISED:2180C-1)	☒ Chamber North (ISED:2180C-3)
☐ Chamber C (ISED:2180C-2)	☒ Chamber South (ISED:2180C-4)

UL LLC (RTP) is accredited by NVLAP, Laboratory Code 200246-0

UL LLC
12 Laboratory Dr., RTP, NC 27709; USA TEL:(919) 549-1400
This report shall not be reproduced except in full, without the written approval of UL LLC.

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
Radio Frequency (Spectrum Analyzer)	141.2 Hz
Occupied Channel Bandwidth	2.00%
RF output power, conducted	1.3 dB (PK), 0.45 dB (AV)
RF output power, radiated (SAC)	4.52 dB
Power Spectral Density, conducted	2.47 dB
Unwanted Emissions, conducted	2.50 dB
All emissions, radiated	4.88 dB
Temperature	2.26°C
Humidity	6.79%
DC Supply voltages	1.70%
Time	3.39%

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

UL LLC
12 Laboratory Dr., RTP, NC 27709; USA TEL:(919) 549-1400
This report shall not be reproduced except in full, without the written approval of UL LLC.

5. EQUIPMENT UNDER TEST

5.1. EUT DESCRIPTION

The EUT is a left earbud of a wireless headset with a BT/BLE transceiver.

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	9.16	8.24
2402 - 2480	Enhanced DQPSK	8.68	7.38
2402 - 2480	Enhanced 8PSK	8.72	7.45

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

5.3. DESCRIPTION OF AVAILABLE ANTENNAS

The radio utilizes an LDS antenna, with a maximum gain of 0 dBi.

5.4. SOFTWARE AND FIRMWARE

The firmware installed in the EUT during testing was:

BT firmware version 13944.
Audio firmware version 5360.
Apps0 firmware version 1213.
Apps1 firmware version 1547165335.

The EUT driver software installed in the host equipment during testing was 97.0.0.0

The test utility software, BlueTest3, used during testing was 3.1.4

UL LLC
12 Laboratory Dr., RTP, NC 27709; USA TEL:(919) 549-1400
This report shall not be reproduced except in full, without the written approval of UL LLC.

5.5. WORST-CASE CONFIGURATION AND MODE

The EUT only transmits while battery powered therefore powerline conducted emissions were not performed.

Radiated emissions below 1GHz, above 18GHz 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 fundamental of the EUT was investigated in three orthogonal orientations X,Y,Z, it was determined that X orientation was worst-case orientation; therefore, all final radiated testing was performed with the EUT in X orientation.

All testing performed in GFSK and 8PSK modes. 8PSK mode represents DQPSK and is considered equivalent or worst-case. Note – Power and Average Time of Occupancy were performed in DQPSK mode.

Worst-case data rates/packet sizes were:

GFSK mode: DH5
DQPSK mode: 2-DH5
8PSK mode: 3-DH5

UL LLC
12 Laboratory Dr., RTP, NC 27709; USA TEL:(919) 549-1400
This report shall not be reproduced except in full, without the written approval of UL LLC.

5.6. DESCRIPTION OF TEST SETUP

SUPPORT EQUIPMENT

Support Equipment List				
Description	**Manufacturer**	**Model**	**Serial Number**	**FCC ID**
Laptop	Lenovo	T450	A2UQS	NA
Debugger	Qualcomm	TRBI 200	N171219	NA

I/O CABLES

I/O Cable List						
Cable No.	**Port**	**# of Identical Ports**	**Connector Type**	**Cable Type**	**Cable Length (m)**	**Remarks**
1	I/O	1	Hardwired	Single strand	<1m	For testing purposes only. Connects to laptop through debugger for configuration.
2	DC	1	hardwired	Single strand	<3m	For testing purposes only. Provides DC power.

SETUP DIAGRAMS

Please refer to R12663957L-EP9 for setup diagrams

UL LLC
12 Laboratory Dr., RTP, NC 27709; USA TEL:(919) 549-1400
This report shall not be reproduced except in full, without the written approval of UL LLC.

6. TEST AND MEASUREMENT EQUIPMENT

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

Test Equipment Used - Radiated Disturbance Emissions Test Equipment (Morrisville - North Chamber)

Equipment ID	Description	Manufacturer	Model Number	Last Cal.	Next Cal.
1-18 GHz					
AT0072	Double-Ridged Waveguide Horn Antenna, 1 to 18 GHz	ETS Lindgren	3117	2018-04-30	2019-04-30
Gain-Loss Chains					
N-SAC03	Gain-loss string: 1-18GHz	Various	Various	2019-03-15	2020-03-15
Receiver & Software					
SA0027	Spectrum Analyzer	Agilent	N9030A	2018-04-04	2019-04-04
SA0026	Spectrum Analyzer	Agilent	N9030A	2019-03-19	2020-03-19
SOFTEMI	EMI Software	UL	Version 9.5	NA	NA
Additional Equipment used					
SN 181562858	Environmental Meter	Fisher Scientific	14-650-118	2018-09-04	2020-09-04

UL LLC
12 Laboratory Dr., RTP, NC 27709; USA TEL:(919) 549-1400
This report shall not be reproduced except in full, without the written approval of UL LLC.

Test Equipment Used - Radiated Disturbance Emissions Test Equipment (Morrisville - South Chamber)

Equipment ID	Description	Manufacturer	Model Number	Last Cal.	Next Cal.
0.009-30MHz (Loop Ant.)					
AT0079	Active Loop Antenna	ETS-Lindgren	6502	2019-01-24	2020-01-31
30-1000 MHz					
AT0074	Hybrid Broadband Antenna	Sunol Sciences Corp.	JB3	2018-07-24	2019-07-24
1-18 GHz					
AT0069	Double-Ridged Waveguide Horn Antenna, 1 to 18 GHz	ETS Lindgren	3117	2018-04-30	2019-04-30
18-40 GHz					
AT0076	Horn Antenna, 18-26.5GHz	ARA	MWH-1826/B	2018-11-08	2019-11-08
Gain-Loss Chains					
S-SAC01	Gain-loss string: 0.009-30MHz	Various	Various	2018-09-06	2019-09-06
S-SAC02	Gain-loss string: 25-1000MHz	Various	Various	2018-05-20	2019-05-20
S-SAC03	Gain-loss string: 1-18GHz	Various	Various	2019-03-13	2020-03-13
S-SAC04	Gain-loss string: 18-40GHz	Various	Various	2018-09-30	2019-09-30
Receiver & Software					
SA0025	Spectrum Analyzer	Agilent	N9030A	2019-02-28	2020-02-28
SOFTEMI	EMI Software	UL	Version 9.5	NA	NA
Additional Equipment used					
s/n 181474409	Environmental Meter	Fisher Scientific	15-077-963	2018-07-27	2020-07-27

UL LLC
12 Laboratory Dr., RTP, NC 27709; USA TEL:(919) 549-1400
This report shall not be reproduced except in full, without the written approval of UL LLC.

Test Equipment Used - Wireless Conducted Measurement Equipment

Equipment ID	Description	Manufacturer	Model Number	Last Cal.	Next Cal.
81018	Spectrum Analyzer	Agilent Technologies	E4446A	2018-04-12	2019-04-12
SN 181474341	Environmental Meter	Fisher Scientific	15-077-963	2018-07-27	2020-07-27
76021	DC Regulated Power Supply	CircuitSpecialists.Com	CSI3005X5	N/A	N/A
76022	DC Regulated Power Supply	CircuitSpecialists.Com	CSI3005X5	N/A	N/A
1100504	Spectrum Analyzer	Agilent Technologies	E4446A	2018-11-19	2019-11-19
PWM005	RF Power Meter	Keysight Technologies	N1912A	2018-04-25	2019-04-25
PWS005	Peak and Avg Power Sensor, 50MHz to 18GHz	Keysight Technologies	N1921A	2018-04-26	2019-04-26
MM0165	True RMS Multimeter	Agilent	U1232A	2018-10-12	2019-10-31

UL LLC
12 Laboratory Dr., RTP, NC 27709; USA TEL:(919) 549-1400
This report shall not be reproduced except in full, without the written approval of UL LLC.

7. MEASUREMENT METHODS

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

Emissions 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

Out-of-Band Emissions in non-restricted band: ANSI C63.10-2013 Section 7.8.6, 7.8.8. & 6.10.4

Out-of-band emissions in restricted bands: ANSI C63.10-2013 Section 6.3-6.5 & 6.10.5

UL LLC
12 Laboratory Dr., RTP, NC 27709; USA TEL:(919) 549-1400
This report shall not be reproduced except in full, without the written approval of UL LLC.

8. ANTENNA PORT TEST RESULTS

8.1. ON TIME AND DUTY CYCLE

LIMITS

None; for reporting purposes only.

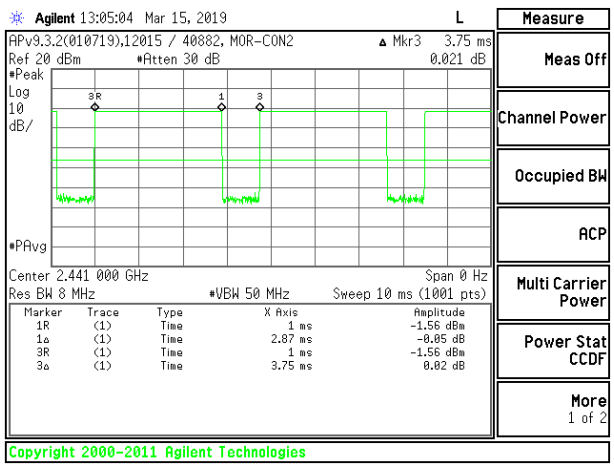
PROCEDURE

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

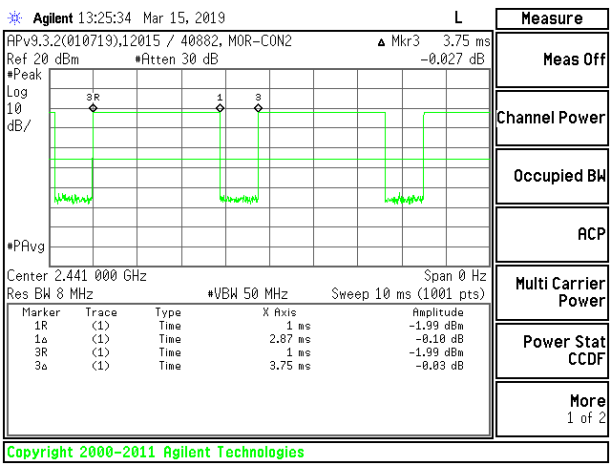
ON TIME AND DUTY CYCLE RESULTS

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	2.87	3.75	0.765	76.5%	1.16	0.348
Bluetooth 8PSK	2.87	3.75	0.765	76.5%	1.16	0.348

DUTY CYCLE PLOTS



BLUETOOTH GFSK



BLUETOOTH 8PSK

UL LLC
12 Laboratory Dr., RTP, NC 27709; USA TEL:(919) 549-1400
This report shall not be reproduced except in full, without the written approval of UL LLC.

8.2. 20 dB AND 99% BANDWIDTH

LIMITS

None; for reporting purposes only.

TEST PROCEDURE

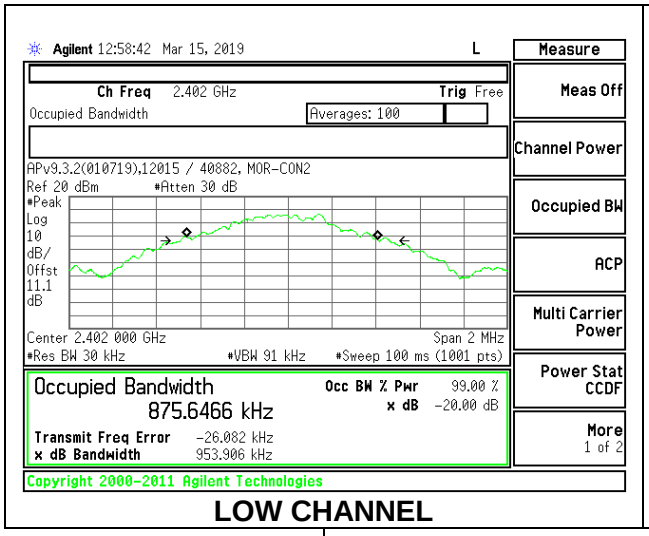
The transmitter output is connected to a spectrum analyzer. The RBW is set to 1-5% of the 20 dB bandwidth and 99% Occupied Bandwidth. The VBW is set to ≥ RBW. The sweep time is coupled.

RESULTS

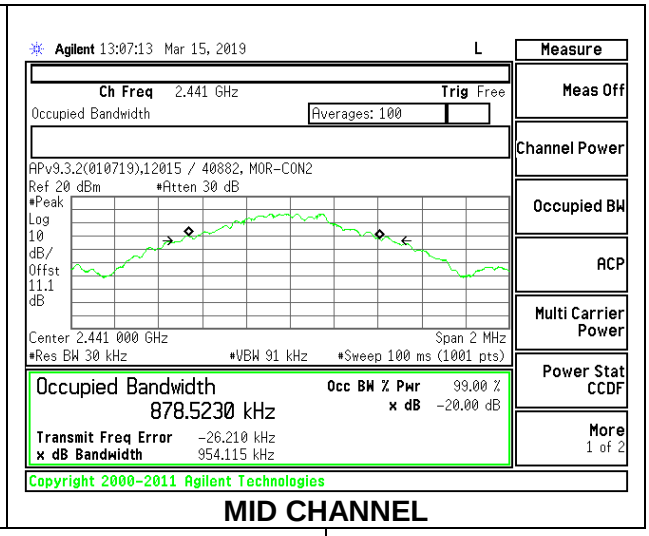
UL LLC
12 Laboratory Dr., RTP, NC 27709; USA TEL:(919) 549-1400
This report shall not be reproduced except in full, without the written approval of UL LLC.

8.2.1. BLUETOOTH BASIC DATA RATE GFSK MODULATION

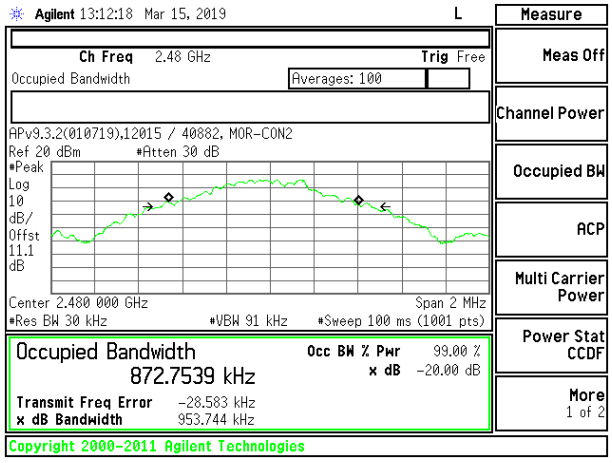
Channel	Frequency (MHz)	20dB Bandwidth (MHz)	99% Bandwidth (MHz)
Low	2402	0.954	0.876
Mid	2441	0.954	0.878
High	2480	0.954	0.873



LOW CHANNEL



MID CHANNEL



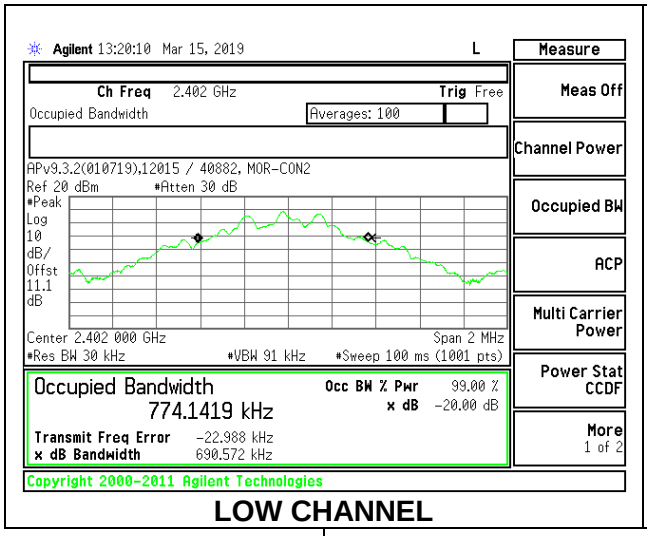
HIGH CHANNEL

UL LLC
12 Laboratory Dr., RTP, NC 27709; USA TEL:(919) 549-1400

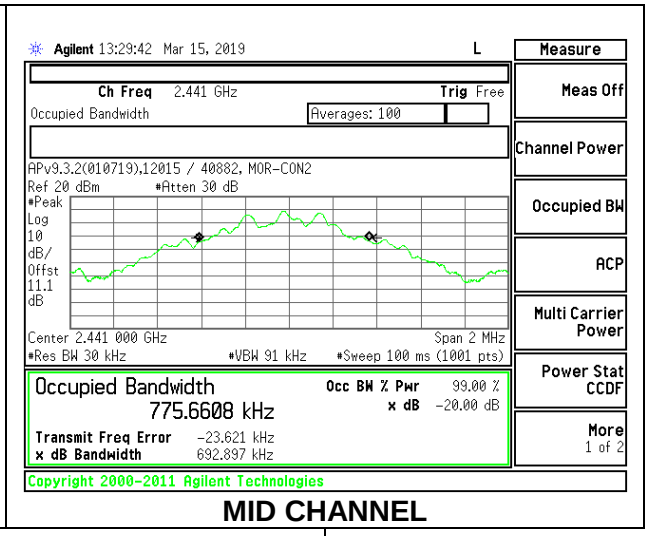
This report shall not be reproduced except in full, without the written approval of UL LLC.

8.2.2. BLUETOOTH ENHANCED DATA RATE 8PSK MODULATION

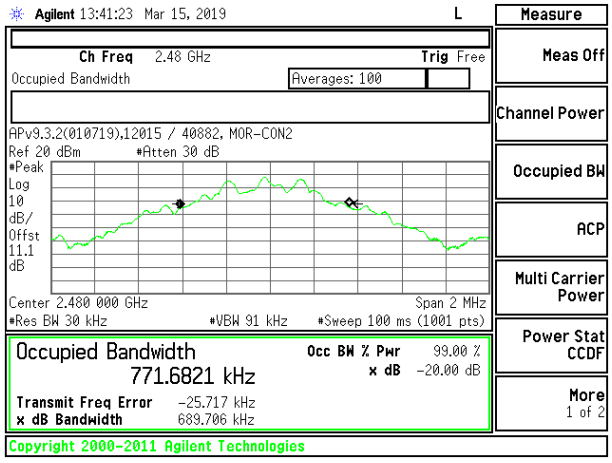
Channel	Frequency (MHz)	20dB Bandwidth (MHz)	99% Bandwidth (MHz)
Low	2402	0.691	0.774
Mid	2441	0.693	0.776
High	2480	0.69	0.772



LOW CHANNEL



MID CHANNEL



HIGH CHANNEL

UL LLC
12 Laboratory Dr., RTP, NC 27709; USA TEL:(919) 549-1400

This report shall not be reproduced except in full, without the written approval of UL LLC.

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.

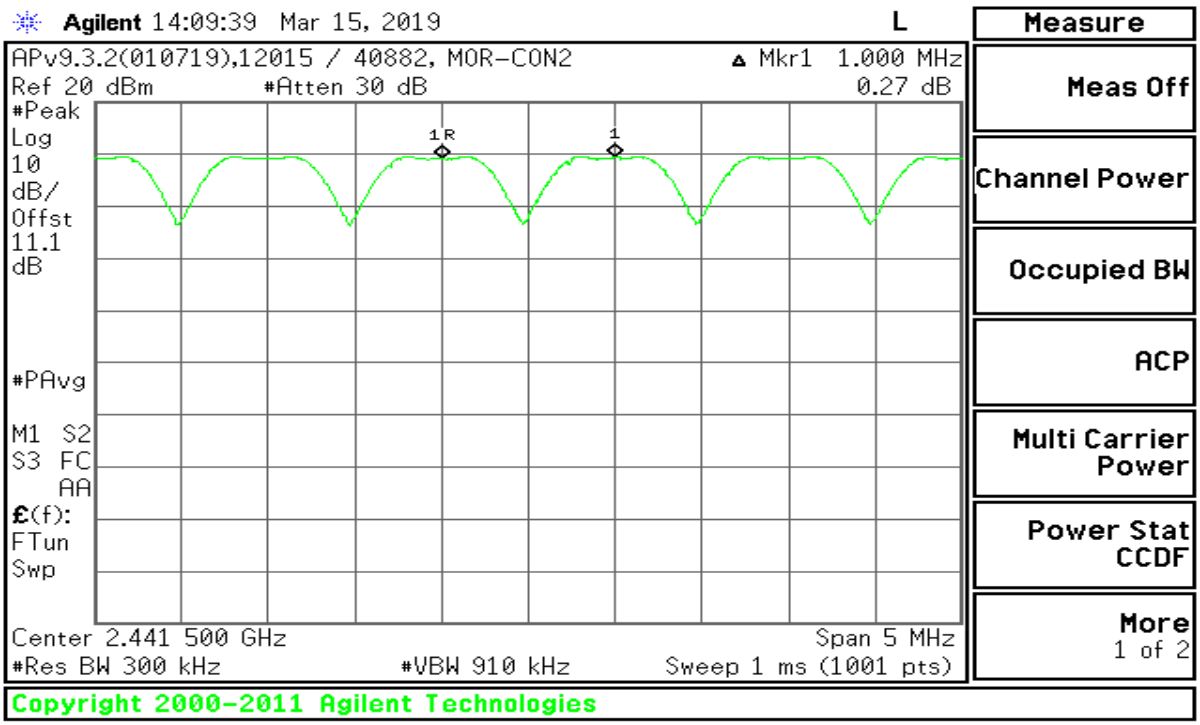
TEST PROCEDURE

The transmitter output is connected to a spectrum analyzer. The RBW is set to 300 kHz (approx. 30% of the channel spacing) and the VBW is set to 300 kHz. The sweep time is coupled.

RESULTS

UL LLC
12 Laboratory Dr., RTP, NC 27709; USA TEL:(919) 549-1400
This report shall not be reproduced except in full, without the written approval of UL LLC.

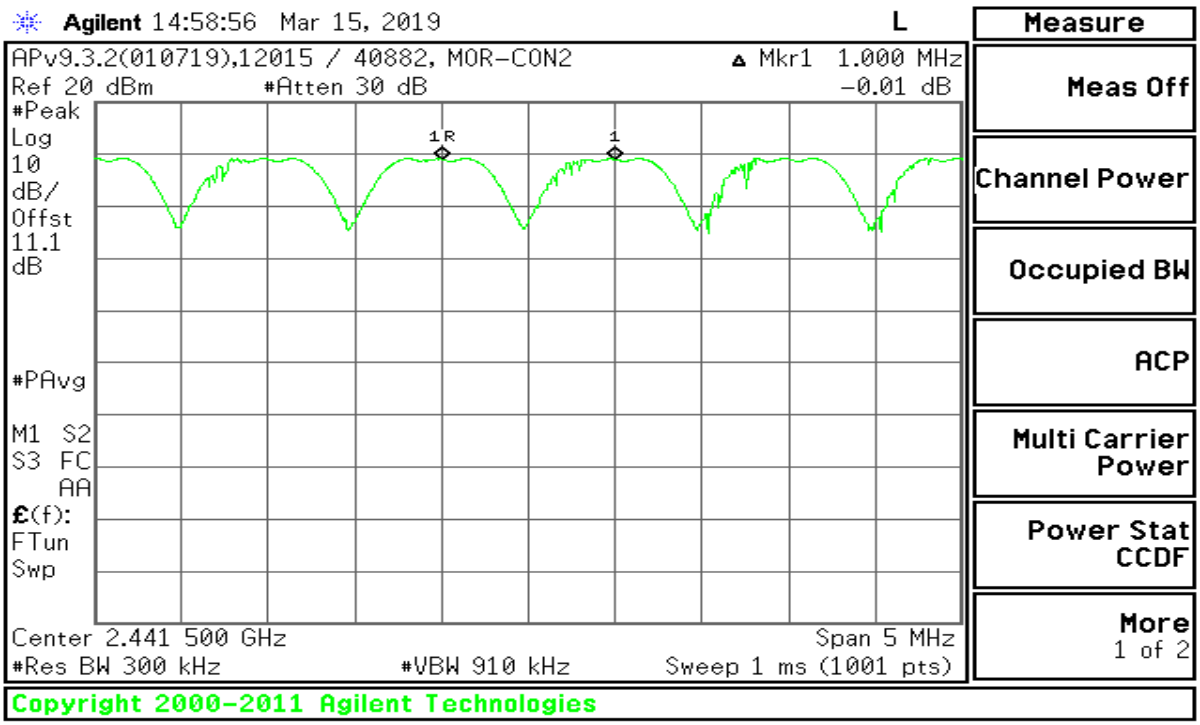
8.3.1. BLUETOOTH BASIC DATA RATE GFSK MODULATION



HOPPING FREQUENCY SEPARATION PLOT

UL LLC
12 Laboratory Dr., RTP, NC 27709; USA TEL:(919) 549-1400
This report shall not be reproduced except in full, without the written approval of UL LLC.

8.3.2. BLUETOOTH ENHANCED DATA RATE 8PSK MODULATION



HOPPING FREQUENCY SEPARATION PLOT

UL LLC
12 Laboratory Dr., RTP, NC 27709; USA TEL:(919) 549-1400
This report shall not be reproduced except in full, without the written approval of UL LLC.

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

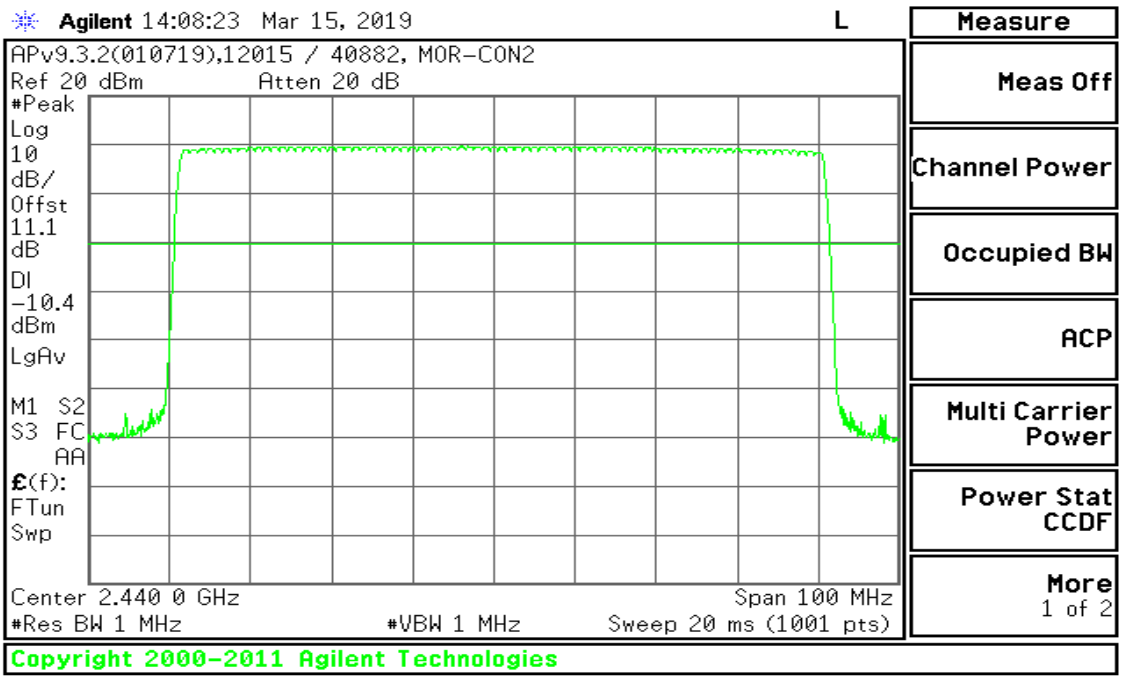
The transmitter output is connected to a spectrum analyzer. The span is set to cover the entire authorized band, in either a single sweep or in multiple contiguous sweeps for visibility of the entire span. Then, smaller spans are set to more clearly identify the channels. The RBW is set to 30% of the channel spacing (approx. 300kHz). The analyzer is set to Max Hold.

RESULTS

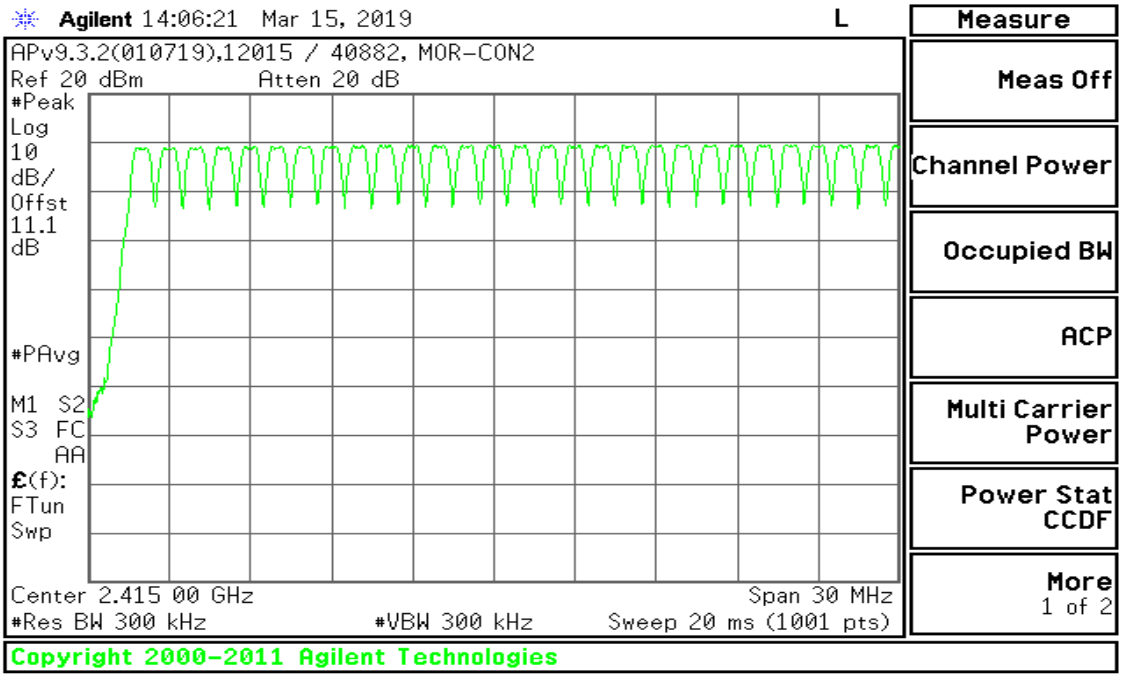
Normal Mode: All Channels Observed

UL LLC
12 Laboratory Dr., RTP, NC 27709; USA TEL:(919) 549-1400
This report shall not be reproduced except in full, without the written approval of UL LLC.

8.4.1. BLUETOOTH BASIC DATA RATE GFSK MODULATION

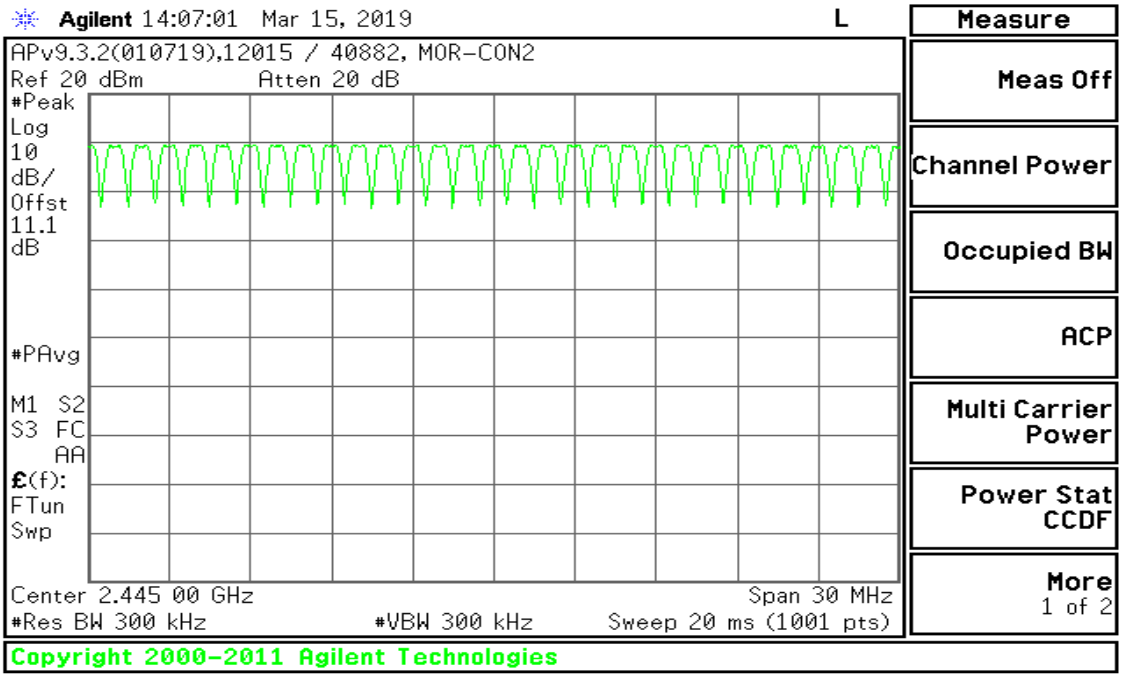


100MHz SPAN

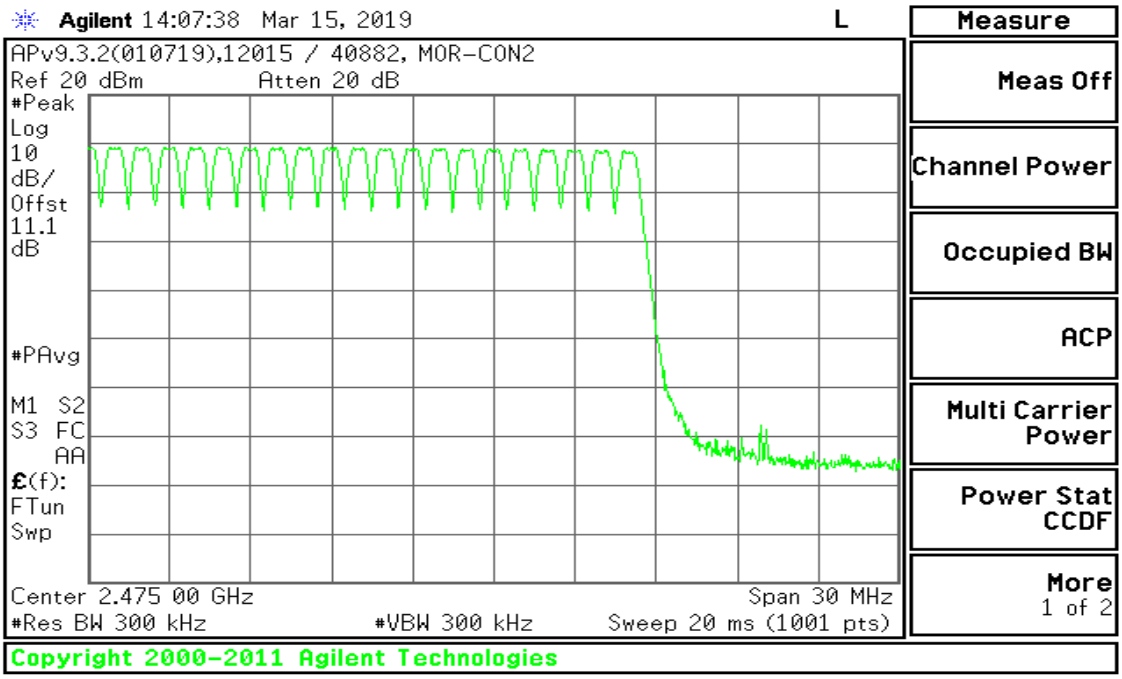


30MHz SPAN, SEGMENT 1 OF 3

UL LLC
12 Laboratory Dr., RTP, NC 27709; USA TEL:(919) 549-1400
This report shall not be reproduced except in full, without the written approval of UL LLC.



30MHz SPAN, SEGMENT 2 OF 3

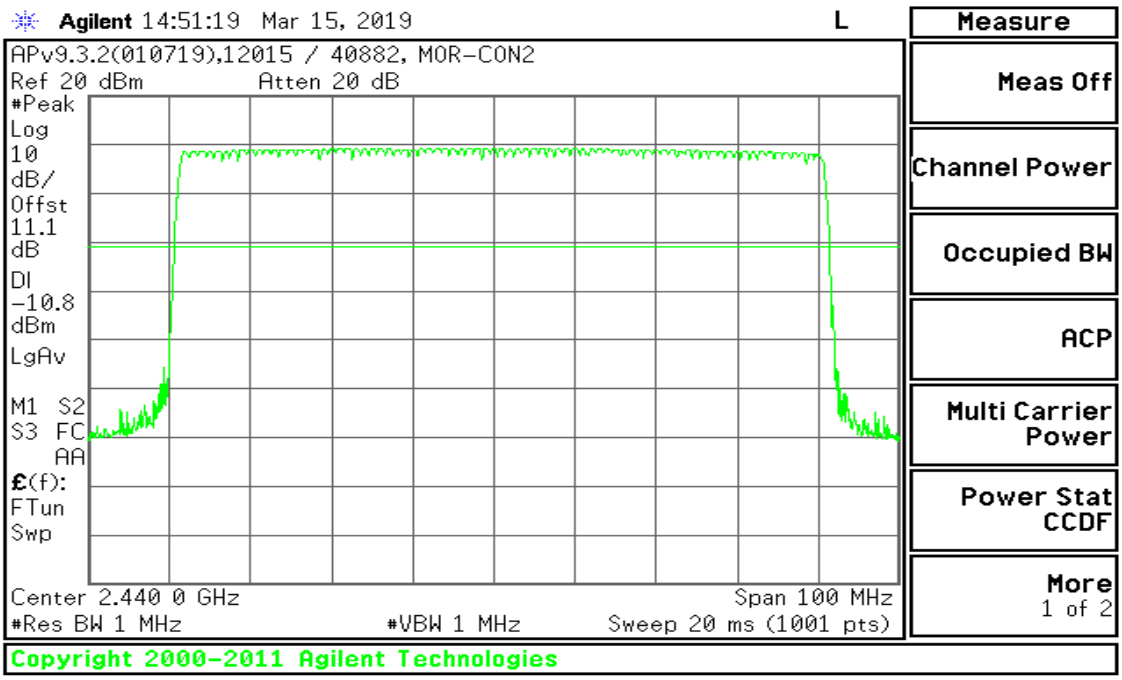


30MHz SPAN, SEGMENT 3 OF 3

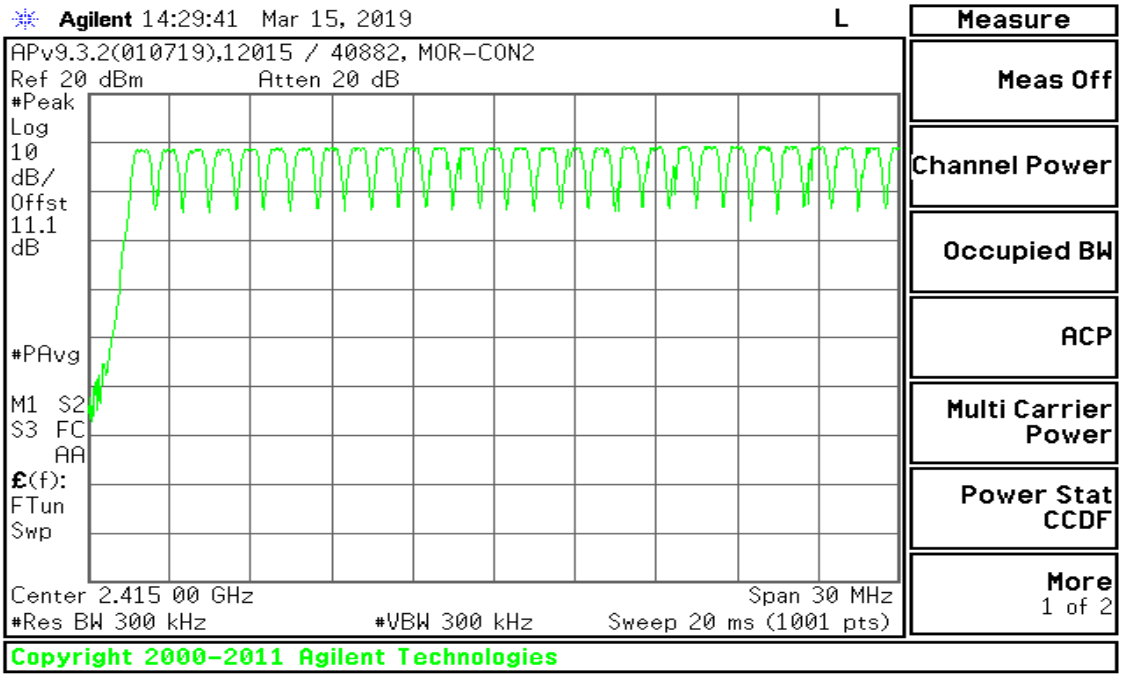
UL LLC
12 Laboratory Dr., RTP, NC 27709; USA TEL:(919) 549-1400

This report shall not be reproduced except in full, without the written approval of UL LLC.

8.4.2. BLUETOOTH ENHANCED DATA RATE 8PSK MODULATION

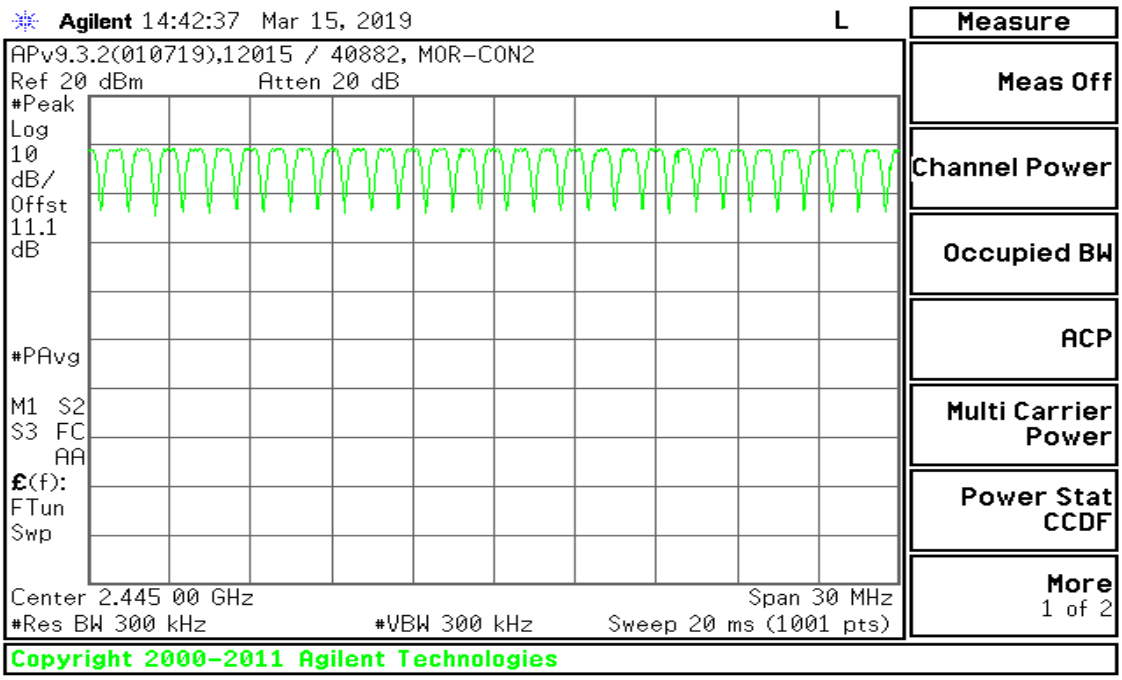


100MHz SPAN

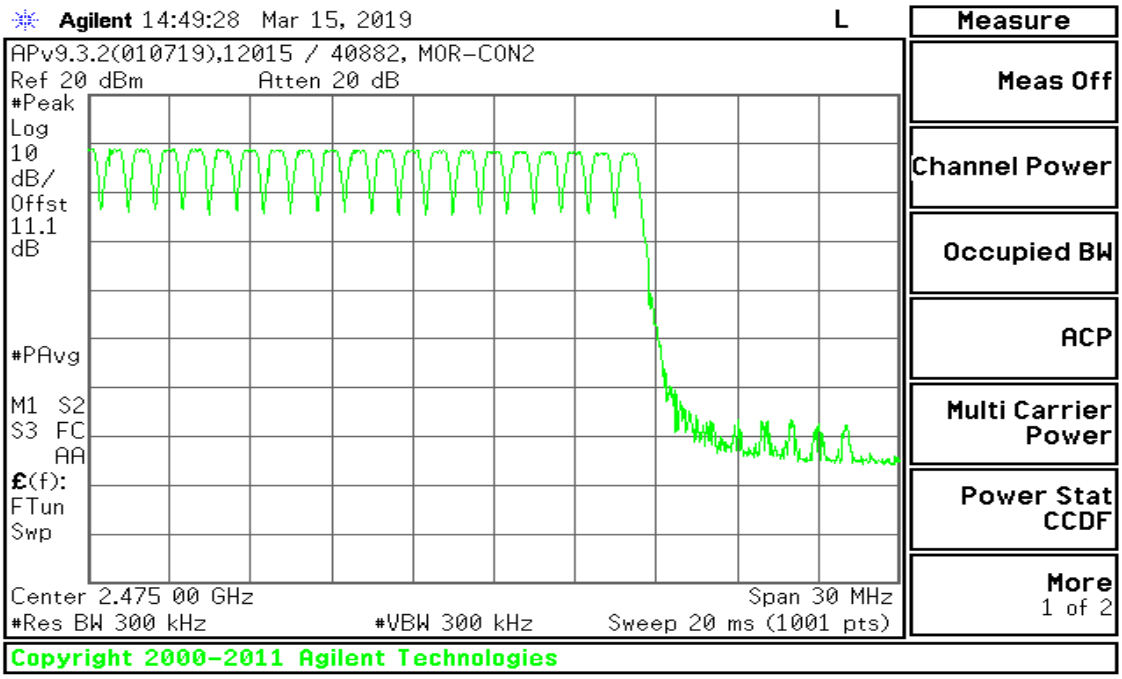


30MHz SPAN, SEGMENT 1 OF 3

UL LLC
12 Laboratory Dr., RTP, NC 27709; USA TEL:(919) 549-1400
This report shall not be reproduced except in full, without the written approval of UL LLC.



30MHz SPAN, SEGMENT 2 OF 3



30MHz SPAN, SEGMENT 3 OF 3

UL LLC
12 Laboratory Dr., RTP, NC 27709; USA
TEL:(919) 549-1400

This report shall not be reproduced except in full, without the written approval of UL LLC.

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.

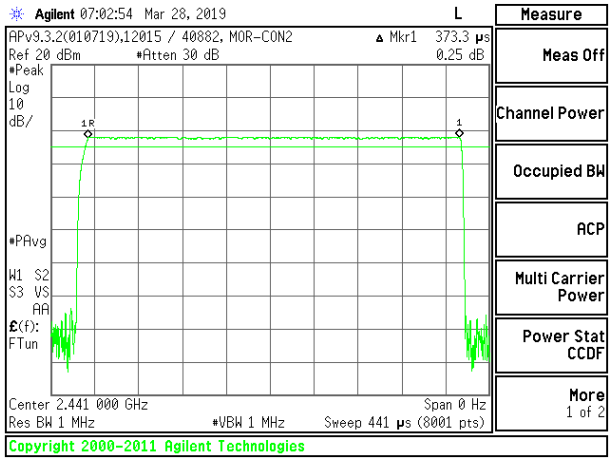
RESULTS

UL LLC
12 Laboratory Dr., RTP, NC 27709; USA TEL:(919) 549-1400
This report shall not be reproduced except in full, without the written approval of UL LLC.

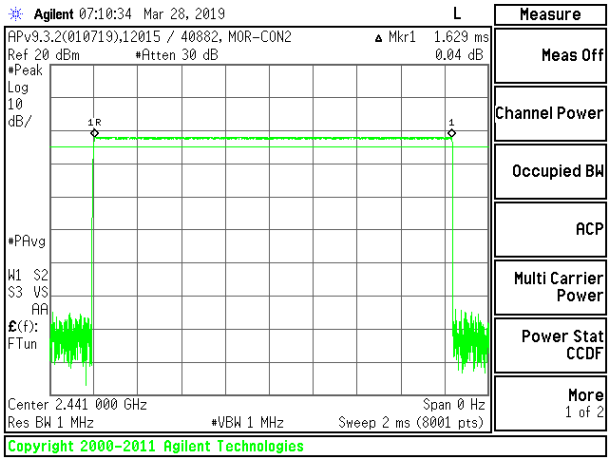
8.5.1. BLUETOOTH BASIC DATA RATE GFSK MODULATION

DH Packet	Pulse Width (msec)	Number of Pulses in 3.16 seconds	Average Time of Occupancy (sec)	Limit (sec)	Margin (sec)
GFSK Normal Mode					
DH1	0.373	32	0.1194	0.4	-0.2806
DH3	1.629	16	0.2606	0.4	-0.1394
DH5	2.878	11	0.3166	0.4	-0.0834
DH Packet	Pulse Width (sec)	Number of Pulses in 0.8 seconds	Average Time of Occupancy (sec)	Limit (sec)	Margin (sec)
GFSK AFH Mode					
DH1	0.373	8	0.02984	0.4	-0.3702
DH3	1.629	4	0.06516	0.4	-0.3348
DH5	2.878	2.75	0.07915	0.4	-0.3209

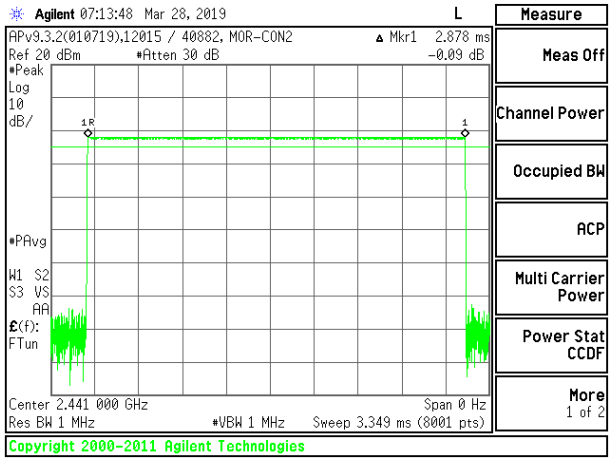
UL LLC
12 Laboratory Dr., RTP, NC 27709; USA TEL:(919) 549-1400
This report shall not be reproduced except in full, without the written approval of UL LLC.



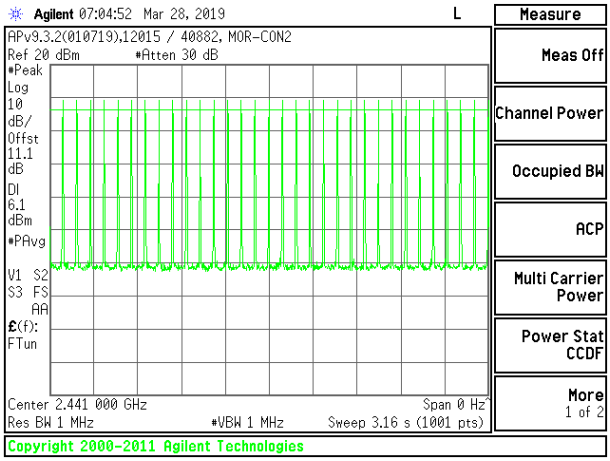
PULSE WIDTH – DH1



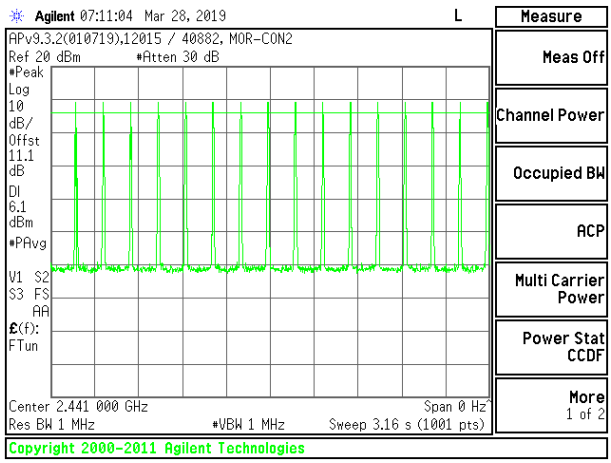
PULSE WIDTH – DH3



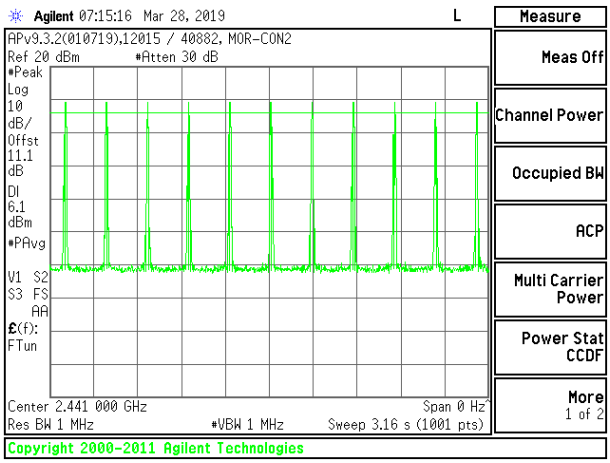
PULSE WIDTH – DH5



NUMBER OF PULSES IN 3.16 SECOND OBSERVATION PERIOD – DH1



NUMBER OF PULSES IN 3.16 SECOND OBSERVATION PERIOD – DH3



NUMBER OF PULSES IN 3.16 SECOND OBSERVATION PERIOD – DH5

UL LLC
12 Laboratory Dr., RTP, NC 27709; USA
TEL:(919) 549-1400

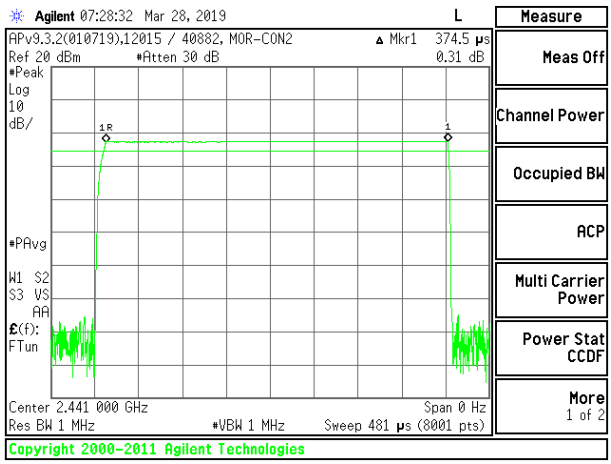
This report shall not be reproduced except in full, without the written approval of UL LLC.

8.5.2. BLUETOOTH ENHANCED DATA RATE DQPSK MODULATION

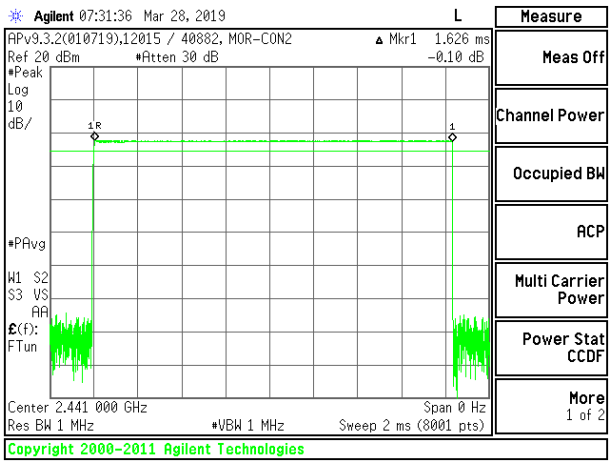
DH Packet	Pulse Width (msec)	Number of Pulses in 3.16 seconds	Average Time of Occupancy (sec)	Limit (sec)	Margin (sec)
DQPSK Normal Mode					
2DH1	0.3745	32	0.11984	0.4	-0.28016
2DH3	1.626	16	0.26016	0.4	-0.13984
2DH5	2.874	11	0.31614	0.4	-0.08386

Note: for AFH(DQPSK) 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.

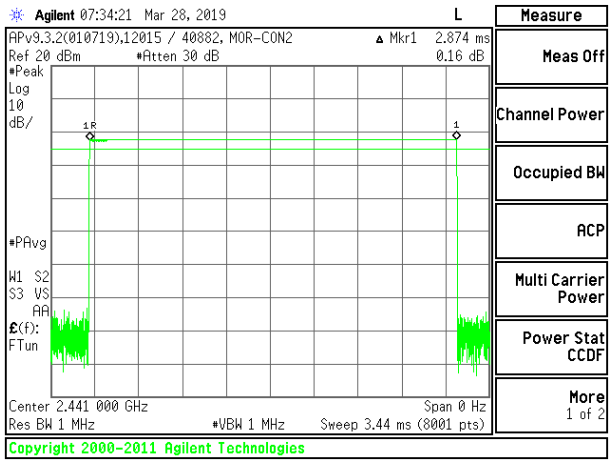
UL LLC
12 Laboratory Dr., RTP, NC 27709; USA TEL:(919) 549-1400
This report shall not be reproduced except in full, without the written approval of UL LLC.



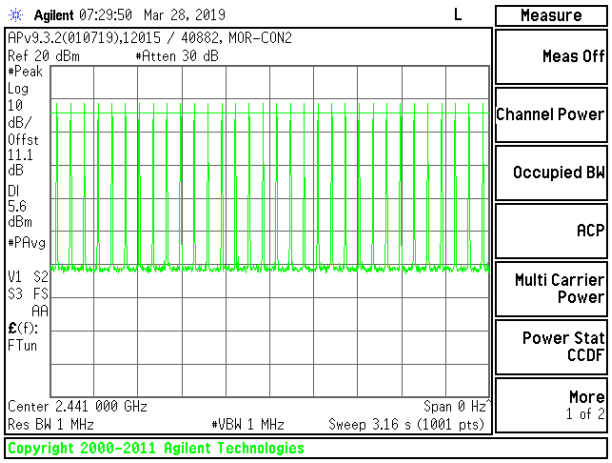
PULSE WIDTH – 2DH1



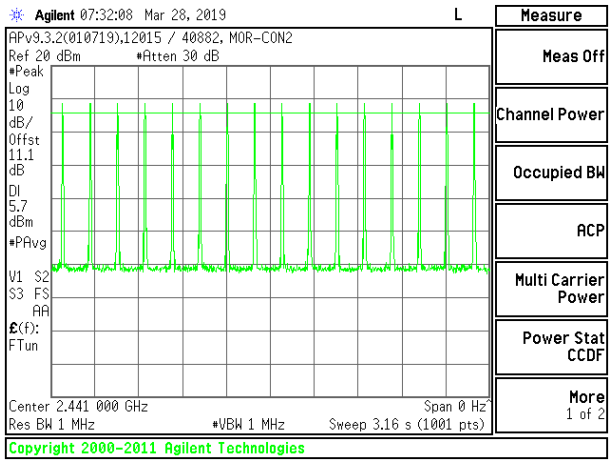
PULSE WIDTH – 2DH3



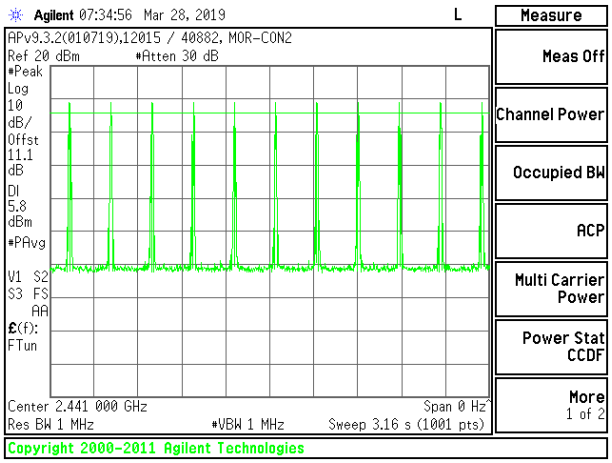
PULSE WIDTH – 2DH5



NUMBER OF PULSES IN 3.16 SECOND OBSERVATION PERIOD – 2DH1



NUMBER OF PULSES IN 3.16 SECOND OBSERVATION PERIOD – 2DH3



NUMBER OF PULSES IN 3.16 SECOND OBSERVATION PERIOD – 2DH5

UL LLC
12 Laboratory Dr., RTP, NC 27709; USA
TEL:(919) 549-1400

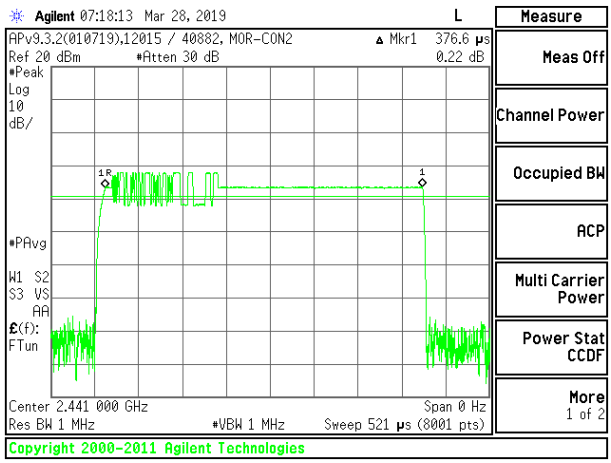
This report shall not be reproduced except in full, without the written approval of UL LLC.

8.5.3. BLUETOOTH ENHANCED DATA RATE 8PSK MODULATION

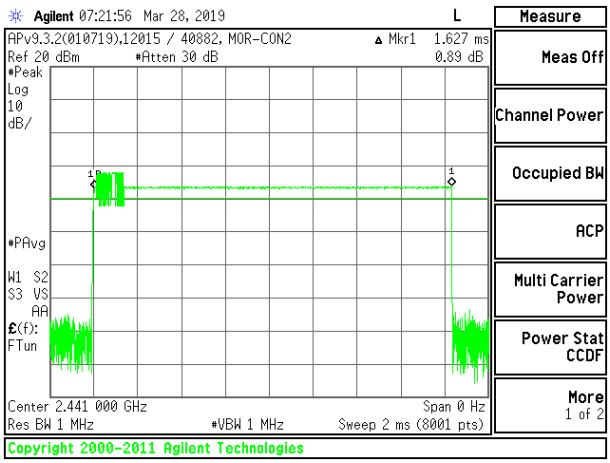
DH Packet	Pulse Width (msec)	Number of Pulses in 3.16 seconds	Average Time of Occupancy (sec)	Limit (sec)	Margin (sec)
8PSK Normal	Mode				
3DH1	0.377	32	0.12064	0.4	-0.2794
3DH3	1.627	16	0.26032	0.4	-0.1397
3DH5	2.874	11	0.31614	0.4	-0.0839

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.

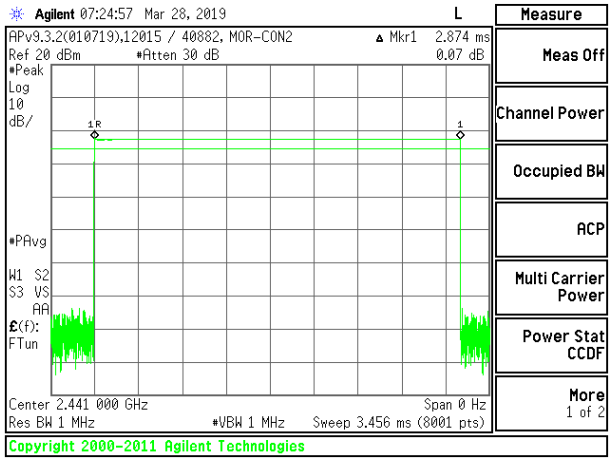
UL LLC
12 Laboratory Dr., RTP, NC 27709; USA TEL:(919) 549-1400
This report shall not be reproduced except in full, without the written approval of UL LLC.



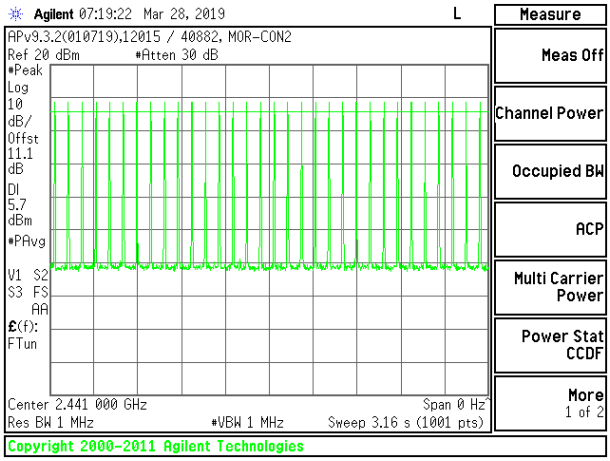
PULSE WIDTH – 3DH1



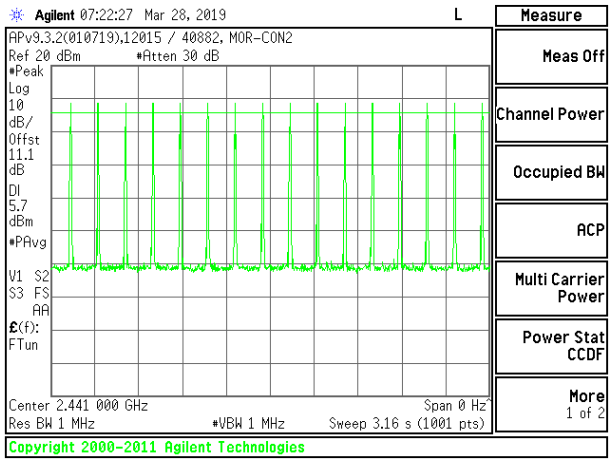
PULSE WIDTH – 3DH3



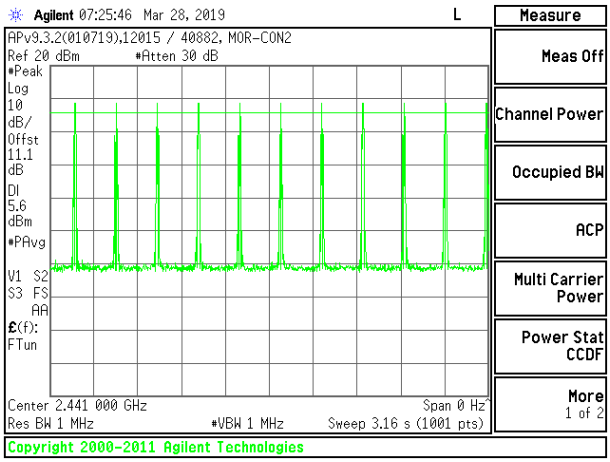
PULSE WIDTH – 3DH5



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

UL LLC
12 Laboratory Dr., RTP, NC 27709; USA TEL:(919) 549-1400

This report shall not be reproduced except in full, without the written approval of UL LLC.

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 of 10.5 dB (including 10 dB pad and 0.5 dB cable) was entered as an offset in the power meter to allow for a peak reading of power.

RESULTS

UL LLC
12 Laboratory Dr., RTP, NC 27709; USA TEL:(919) 549-1400
This report shall not be reproduced except in full, without the written approval of UL LLC.

8.6.1. BLUETOOTH BASIC DATA RATE GFSK MODULATION

Tested By:	12015/40882
Date:	2019-03-06

Channel	Frequency (MHz)	Output Power (dBm)	Limit (dBm)	Margin (dB)
Low	2402	8.73	30	-21.27
Middle	2441	9.16	30	-20.84
High	2480	8.63	30	-21.37

UL LLC
12 Laboratory Dr., RTP, NC 27709; USA TEL:(919) 549-1400
This report shall not be reproduced except in full, without the written approval of UL LLC.

8.6.2. BLUETOOTH ENHANCED DATA RATE DQPSK MODULATION

Tested By:	12015/40882
Date:	2019-03-06

Channel	Frequency (MHz)	Output Power (dBm)	Limit (dBm)	Margin (dB)
Low	2402	8.15	30	-21.85
Middle	2441	8.68	30	-21.32
High	2480	8.26	30	-21.74

UL LLC
12 Laboratory Dr., RTP, NC 27709; USA TEL:(919) 549-1400
This report shall not be reproduced except in full, without the written approval of UL LLC.

8.6.3. BLUETOOTH ENHANCED DATA RATE 8PSK MODULATION

Tested By:	12015/40882
Date:	2019-03-06

Channel	Frequency (MHz)	Output Power (dBm)	Limit (dBm)	Margin (dB)
Low	2402	8.21	30	-21.79
Middle	2441	8.72	30	-21.28
High	2480	8.11	30	-21.89

UL LLC
12 Laboratory Dr., RTP, NC 27709; USA TEL:(919) 549-1400
This report shall not be reproduced except in full, without the written approval of UL LLC.

8.7. AVERAGE POWER

LIMITS

None; for reporting purposes only

TEST PROCEDURE

Measurements perform using a wideband gated RF power meter.

The cable assembly insertion loss of 10.5 dB (including 10 dB pad and 0.5 dB cable) was entered as an offset in the power meter to allow for a gated average reading of power.

RESULTS

UL LLC
12 Laboratory Dr., RTP, NC 27709; USA TEL:(919) 549-1400
This report shall not be reproduced except in full, without the written approval of UL LLC.

8.7.1. BLUETOOTH BASIC DATA RATE GFSK MODULATION

Tested By:	12015/40882
Date	2019-03-06

Channel	Frequency (MHz)	Average Power (dBm)
Low	2402	8.65
Middle	2441	9.01
High	2480	8.54

UL LLC
12 Laboratory Dr., RTP, NC 27709; USA TEL:(919) 549-1400
This report shall not be reproduced except in full, without the written approval of UL LLC.

8.7.1. BLUETOOTH ENHANCED DATA RATE DQPSK MODULATION

Tested By:	12015/40882
Date	2019-03-06

Channel	Frequency (MHz)	Average Power (dBm)
Low	2402	7.95
Middle	2441	8.55
High	2480	8.05

UL LLC
12 Laboratory Dr., RTP, NC 27709; USA TEL:(919) 549-1400
This report shall not be reproduced except in full, without the written approval of UL LLC.

8.7.2. BLUETOOTH ENHANCED DATA RATE 8PSK MODULATION

Tested By:	12015/40882
Date	2019-03-06

Channel	Frequency (MHz)	Average Power (dBm)
Low	2402	7.99
Middle	2441	8.52
High	2480	7.95

UL LLC
12 Laboratory Dr., RTP, NC 27709; USA TEL:(919) 549-1400
This report shall not be reproduced except in full, without the written approval of UL LLC.

8.8. 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.

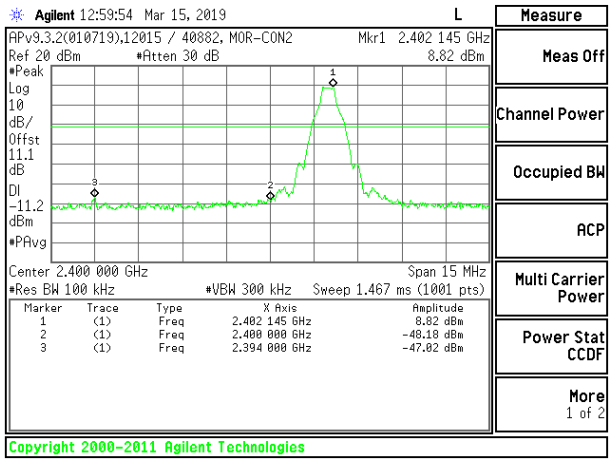
The bandedges at 2.4 and 2.4835 GHz are investigated with the transmitter set to the normal hopping mode.

RESULTS

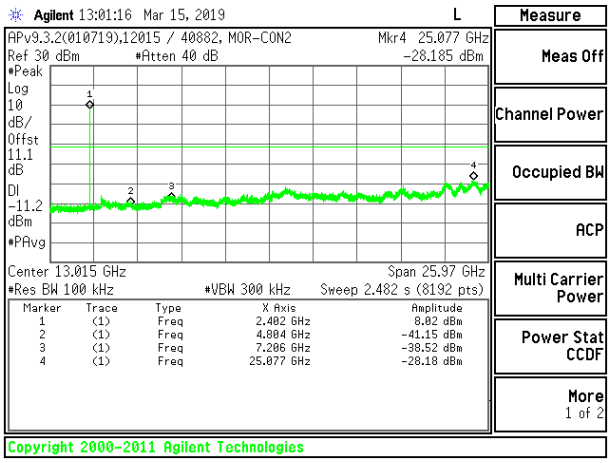
UL LLC
12 Laboratory Dr., RTP, NC 27709; USA TEL:(919) 549-1400
This report shall not be reproduced except in full, without the written approval of UL LLC.

8.8.1. BLUETOOTH BASIC DATA RATE GFSK MODULATION

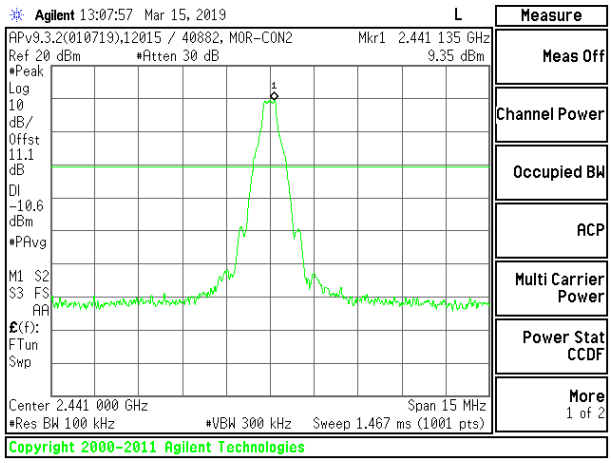
Antenna 1 SPURIOUS EMISSIONS, NON-HOPPING



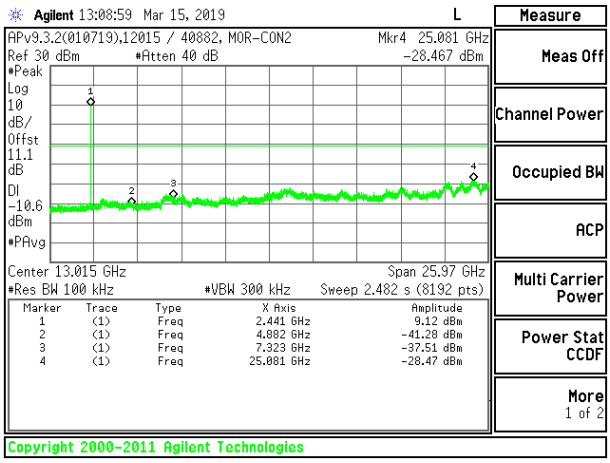
LOW CHANNEL BANDEDGE



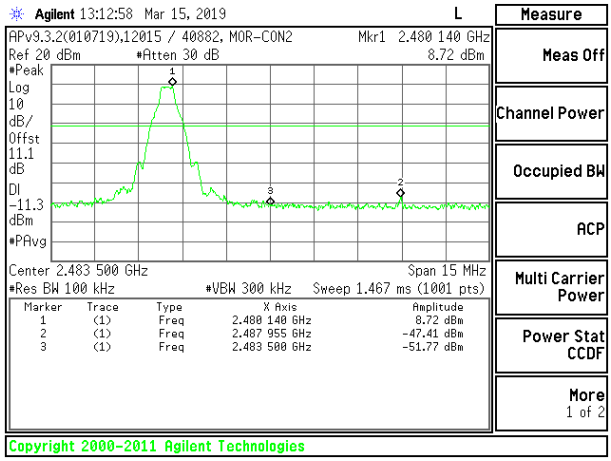
OUT-OF-BAND LOW CHANNEL



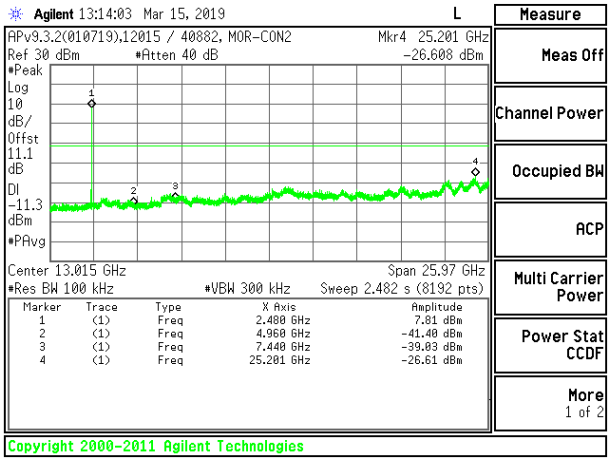
IN-BAND REFERENCE LEVEL



OUT-OF-BAND MID CHANNEL



HIGH CHANNEL BANDEDGE

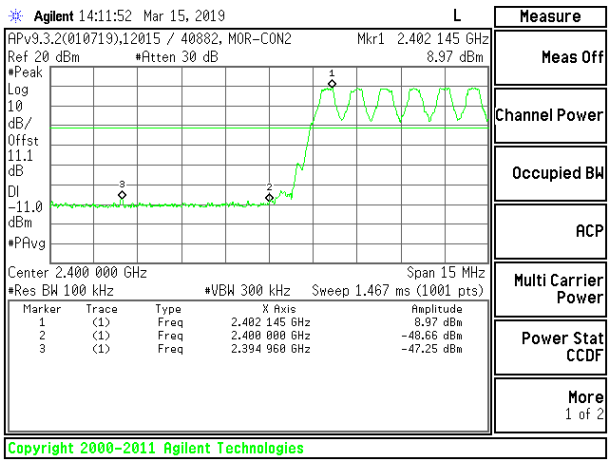


OUT-OF-BAND HIGH CHANNEL

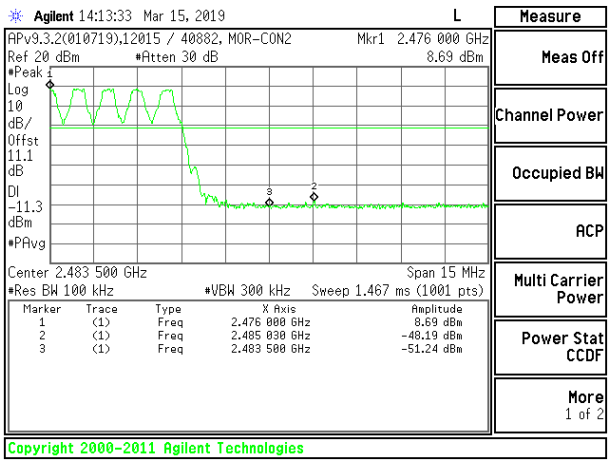
UL LLC
12 Laboratory Dr., RTP, NC 27709; USA TEL:(919) 549-1400

This report shall not be reproduced except in full, without the written approval of UL LLC.

Antenna 1 SPURIOUS BANDEDGE EMISSIONS WITH HOPPING ON



LOW BANDEDGE



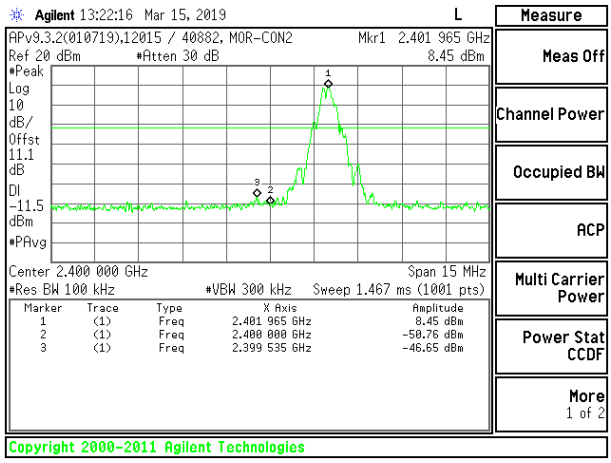
HIGH BANDEDGE

UL LLC
12 Laboratory Dr., RTP, NC 27709; USA TEL:(919) 549-1400

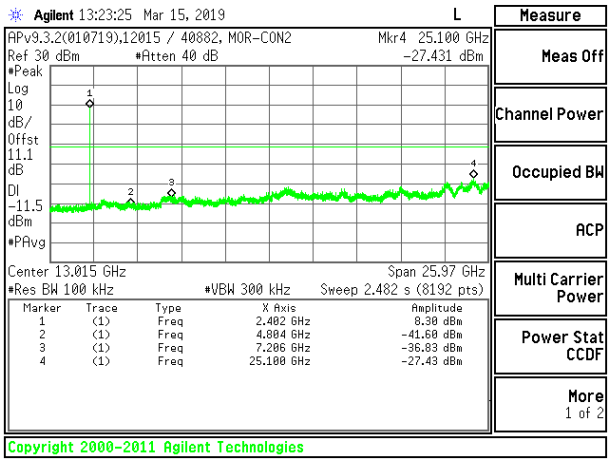
This report shall not be reproduced except in full, without the written approval of UL LLC.

8.8.2. BLUETOOTH ENHANCED DATA RATE 8PSK MODULATION

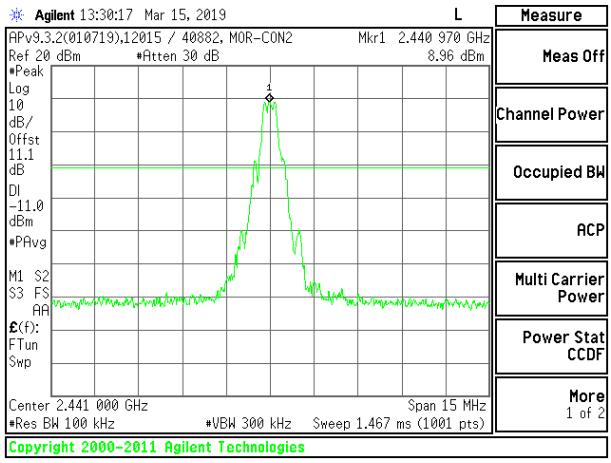
Antenna 1 SPURIOUS EMISSIONS, NON-HOPPING



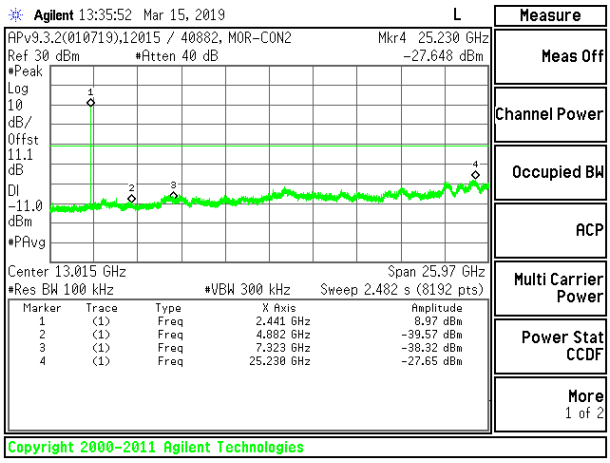
LOW CHANNEL BANDEDGE



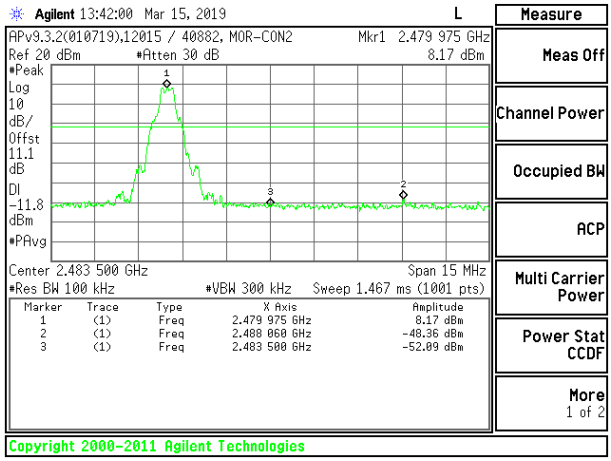
OUT-OF-BAND LOW CHANNEL



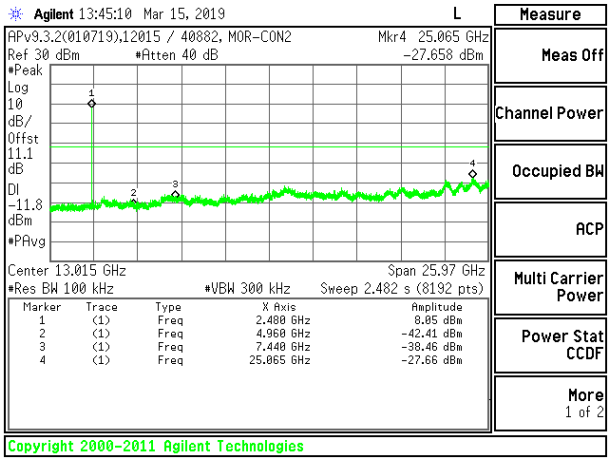
IN-BAND REFERENCE LEVEL



OUT-OF-BAND MID CHANNEL



HIGH CHANNEL BANDEDGE

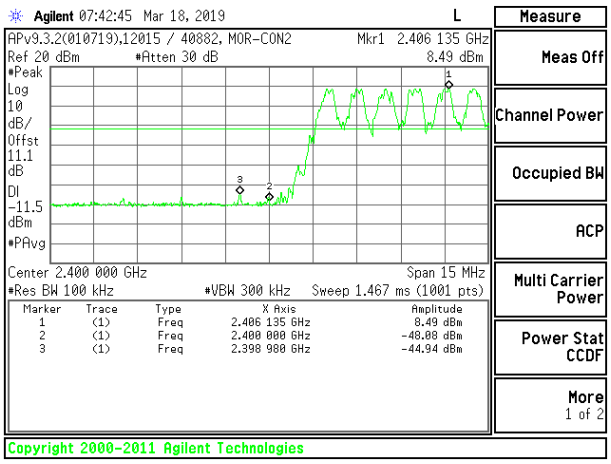


OUT-OF-BAND HIGH CHANNEL

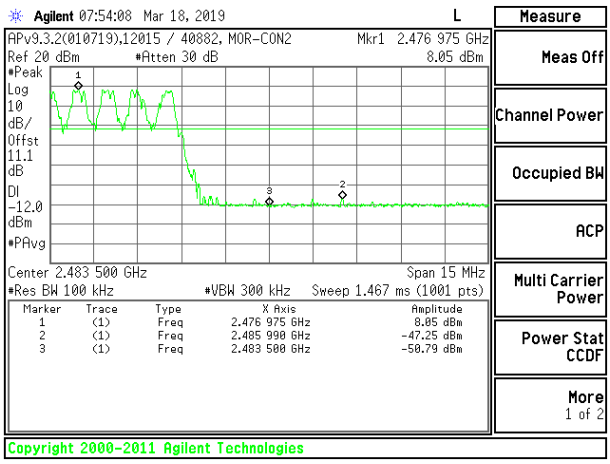
UL LLC
12 Laboratory Dr., RTP, NC 27709; USA TEL:(919) 549-1400

This report shall not be reproduced except in full, without the written approval of UL LLC.

Antenna 1 SPURIOUS BANDEDGE EMISSIONS WITH HOPPING ON



LOW BANDEDGE



HIGH BANDEDGE

UL LLC
12 Laboratory Dr., RTP, NC 27709; USA TEL:(919) 549-1400

This report shall not be reproduced except in full, without the written approval of UL LLC.

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 200 Hz for measurements from 9kHz to 150kHz, 9kHz for measurements from 150kHz to 30 MHz and 100 kHz for peak detection measurements or 120 kHz for quasi-peak detection measurements from 30-1000 MHz. Peak detection is used unless otherwise noted as quasi-peak.

For pre-scans from 1-18 GHz the resolution bandwidth is set to 1 MHz; the video bandwidth is set to 30 KHz for peak measurements.

For final measurements from 1-18 GHz the resolution bandwidth is set to 1 MHz; the video bandwidth is set to 3 MHz for peak measurements. For average measurements, a duty cycle correction was subtracted from the 4MH. Refer to the KDB 558074 D01 15.247 Meas Guidance v05r02 section below for further explanation.

For scans above 18 GHz the resolution bandwidth is set to 1 MHz; the video bandwidth is set to 3 MHz.

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.

UL LLC
12 Laboratory Dr., RTP, NC 27709; USA TEL:(919) 549-1400
This report shall not be reproduced except in full, without the written approval of UL LLC.

3D antenna use - For below 30MHz testing, investigation was done on three antenna orientations (parallel, perpendicular, and ground-parallel).

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.

KDB 558074 D01 15.247 Meas Guidance v05r02

Use of a duty cycle correction factor (DCCF) is permitted for calculating average radiated field strength emission levels for an FHSS device in 15.247. This DCCF can be applied when the field strength limit (e.g., within a Government Restricted band) and the conditions specified in Section 15.35(c) can be satisfied. The average radiated field strength is calculated by subtracting the DCCF from the maximum radiated field strength level as determined through measurement. The maximum radiated field strength level represents the worst-case (maximum amplitude) RMS measurement of the emission(s) during continuous transmission (i.e., not including any time intervals during which the transmitter is off or is transmitting at a reduced power level). It is also acceptable to apply the DCCF to a measurement performed with a peak detector instead of the specified RMS power averaging detector. Note that Section 15.35(c) specifies that the DCCF shall represent the worst-case (greatest duty cycle) over any 100 msec transmission period.

Note – For this test program, Peak detection was used. The DCCF was then subtracted from the peak value. The DCCF was calculated based on the worst case on-time when the device transmits DH5 packets and operates on 20 channels (5/1600 s per hop = 3.125 ms per channel). In this mode, the device will have a maximum of 2 hops on a channel in 100ms or 2x 3.125 ms = 6.25 ms on any channel. Therefore, 20log (6.25 / 100) = - 24dB.

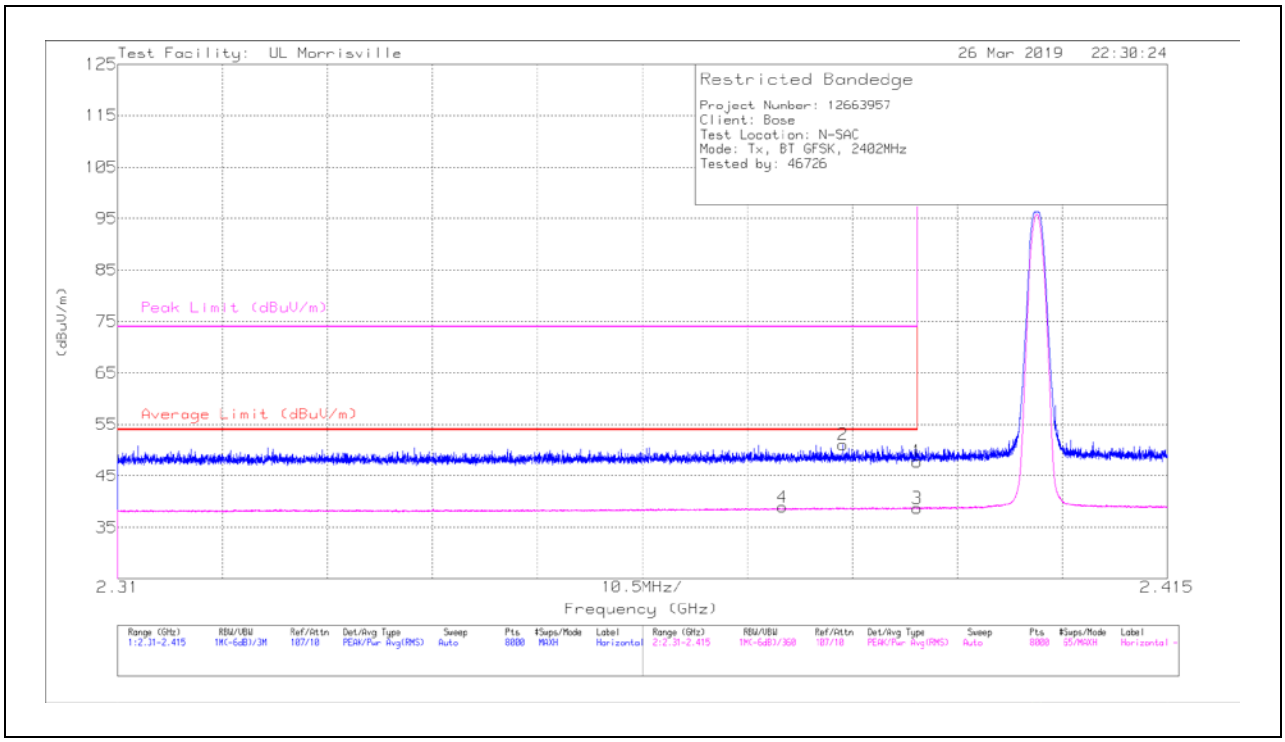
UL LLC
12 Laboratory Dr., RTP, NC 27709; USA TEL:(919) 549-1400
This report shall not be reproduced except in full, without the written approval of UL LLC.

9.1. TRANSMITTER ABOVE 1 GHz

9.1.1. BLUETOOTH BASIC DATA RATE GFSK MODULATION

BANDEDGE (LOW CHANNEL)

HORIZONTAL RESULT

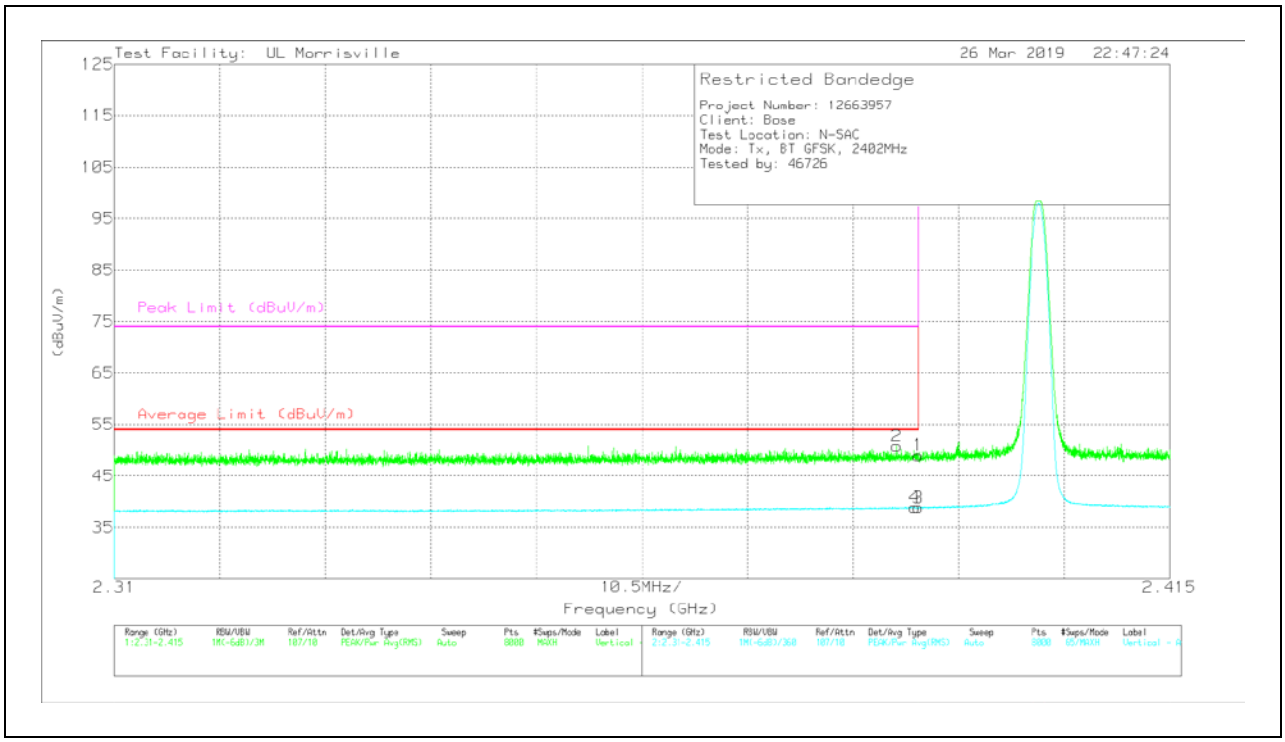


Marker	Frequency (GHz)	Meter Reading (dBuV)	Det	AT0072 AF (dB/m)	Amp/Cbl/Fltr/Pad (dB)	DC Corr (dB)	Corrected Reading (dBuV/m)	Average Limit (dBuV/m)	Avg Margin (dB)	Peak Limit (dBuV/m)	PK Margin (dB)	Azimuth (Degs)	Height (cm)	Polarity
1	* 2.39	40.32	Pk	32	-24.5	0	47.82	-	-	74	-26.18	194	153	H
	* 2.39	40.32	Pk	32	-24.5	-24	23.82	54	-30.18	-	-	194	153	H
2	* 2.383	43.57	Pk	32	-24.5	0	51.07	-	-	74	-22.93	194	153	H
	* 2.383	43.57	Pk	32	-24.5	-24	27.07	54	-26.93	-	-	194	153	H

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

UL LLC
12 Laboratory Dr., RTP, NC 27709; USA TEL:(919) 549-1400
This report shall not be reproduced except in full, without the written approval of UL LLC.

VERTICAL RESULT



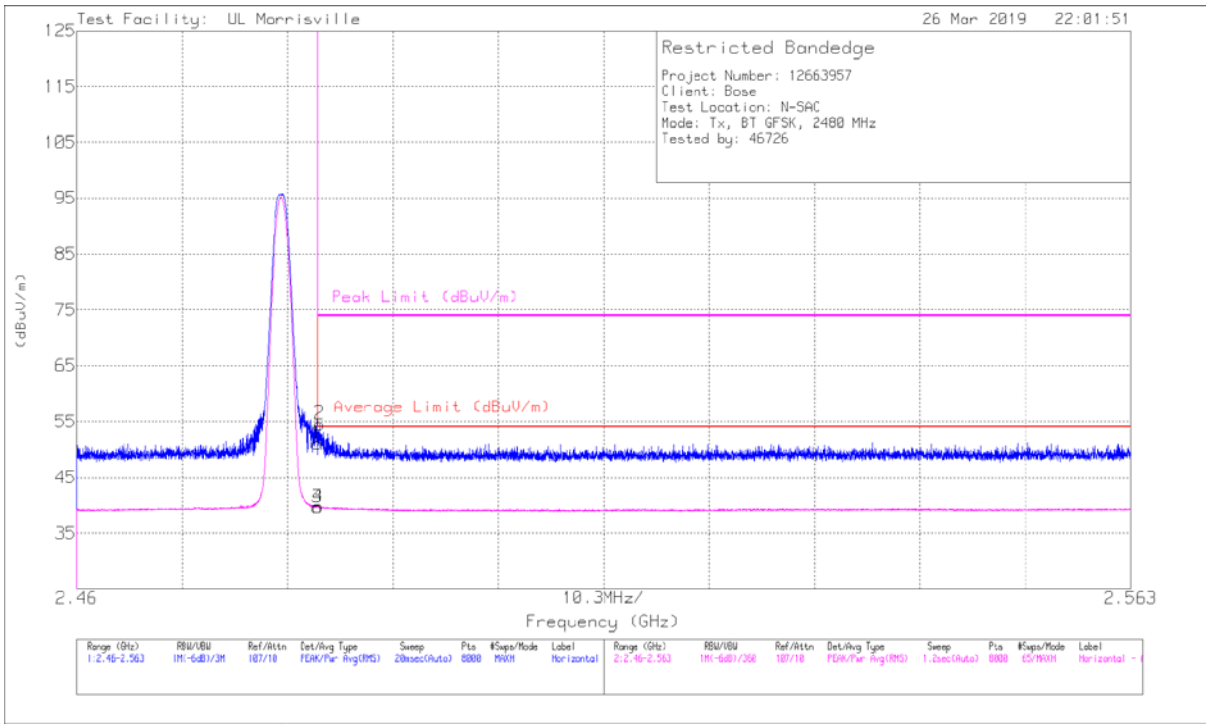
Marker	Frequency (GHz)	Meter Reading (dBuV)	Det	AT0072 AF (dB/m)	Amp/Cbl/Fltr/Pad (dB)	DC Corr (dB)	Corrected Reading (dBuV/m)	Average Limit (dBuV/m)	Avg Margin (dB)	Peak Limit (dBuV/m)	PK Margin (dB)	Azimuth (Degs)	Height (cm)	Polarity
1	* 2.39	41.5	Pk	32	-24.5	0	49	-	-	74	-25	93	107	V
	* 2.39	41.5	Pk	32	-24.5	-24	25	54	-29	-	-	93	107	V
2	* 2.388	43.27	Pk	32	-24.5	0	50.77	-	-	74	-23.23	93	107	V
	* 2.388	43.27	Pk	32	-24.5	-24	26.77	54	-27.23	-	-	93	107	V

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

UL LLC
12 Laboratory Dr., RTP, NC 27709; USA TEL:(919) 549-1400
This report shall not be reproduced except in full, without the written approval of UL LLC.

BANDEDGE (HIGH CHANNEL)

HORIZONTAL RESULT

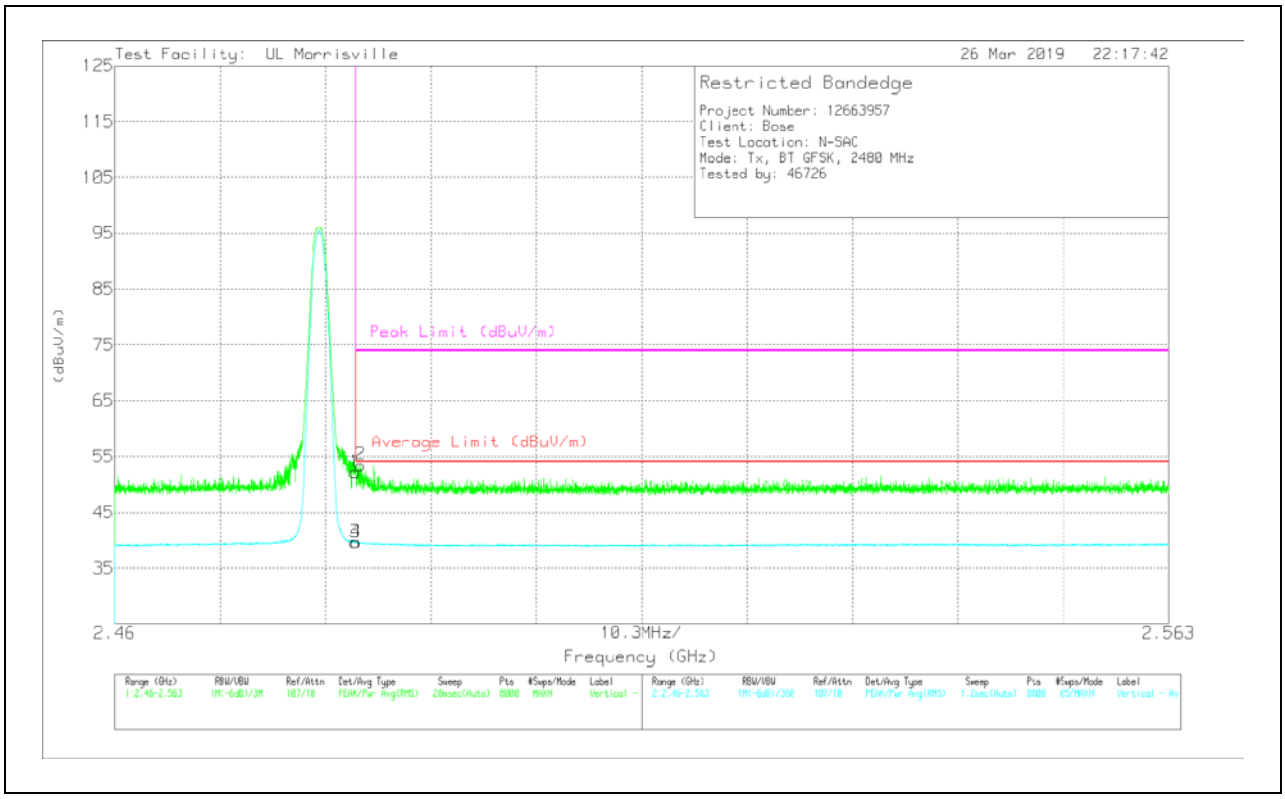


Marker	Frequency (GHz)	Meter Reading (dBuV)	Det	AT0072 AF (dB/m)	Amp/Cbl/Fltr/Pad (dB)	DC Corr (dB)	Corrected Reading (dBuV/m)	Average Limit (dBuV/m)	Avg Margin (dB)	Peak Limit (dBuV/m)	PK Margin (dB)	Azimuth (Degs)	Height (cm)	Polarity
1	* 2.484	42.97	Pk	32.4	-24.3	0	51.07	-	-	74	-22.93	191	274	H
	* 2.484	42.97	Pk	32.4	-24.3	-24	27.07	54	-26.93	-	-	191	274	H
2	* 2.484	46.47	Pk	32.4	-24.3	0	54.57	-	-	74	-19.43	191	274	H
	* 2.484	46.47	Pk	32.4	-24.3	-24	30.57	54	-23.43	-	-	191	274	H

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

UL LLC
12 Laboratory Dr., RTP, NC 27709; USA TEL:(919) 549-1400
This report shall not be reproduced except in full, without the written approval of UL LLC.

VERTICAL RESULT



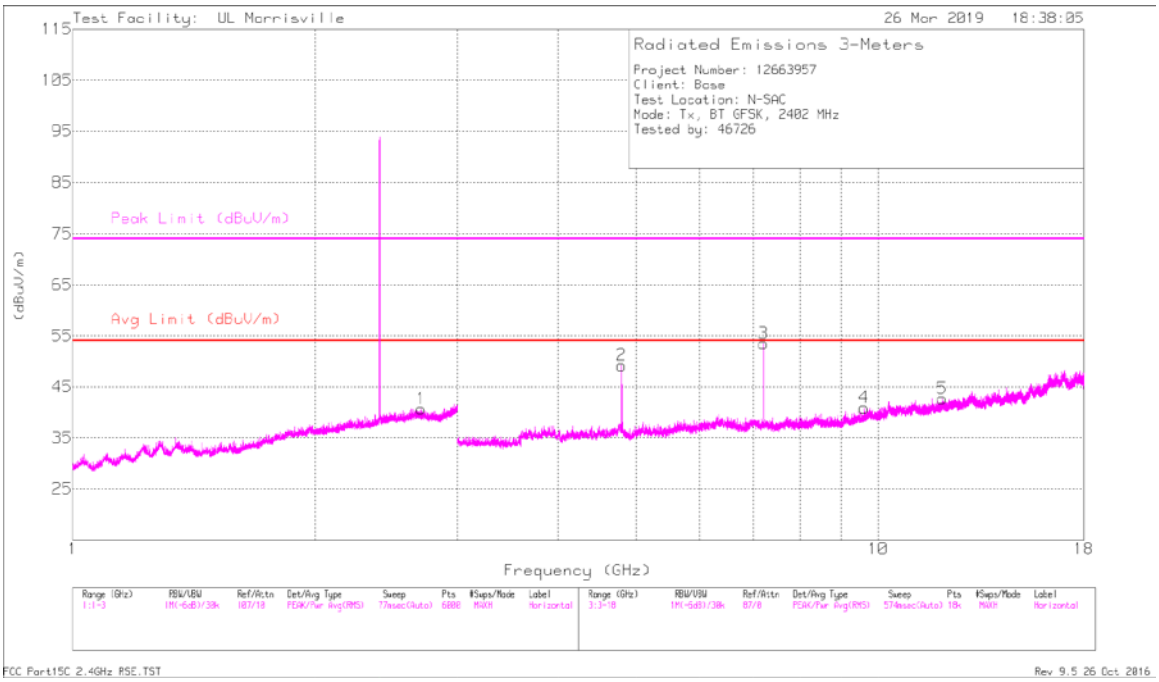
Marker	Frequency (GHz)	Meter Reading (dBuV)	Det	AT0072 AF (dB/m)	Amp/Cbl/Fltr/Pad (dB)	DC Corr (dB)	Corrected Reading (dBuV/m)	Average Limit (dBuV/m)	Avg Margin (dB)	Peak Limit (dBuV/m)	PK Margin (dB)	Azimuth (Degs)	Height (cm)	Polarity
1	* 2.484	44.1	Pk	32.4	-24.3	0	52.2	-	-	74	-21.8	150	132	V
	* 2.484	44.1	Pk	32.4	-24.3	-24	28.2	54	-25.8	-	-	150	132	V
2	* 2.484	45.38	Pk	32.4	-24.3	0	53.48	-	-	74	-20.52	150	132	V
	* 2.484	45.38	Pk	32.4	-24.3	-24	29.48	54	-24.52	-	-	150	132	V

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

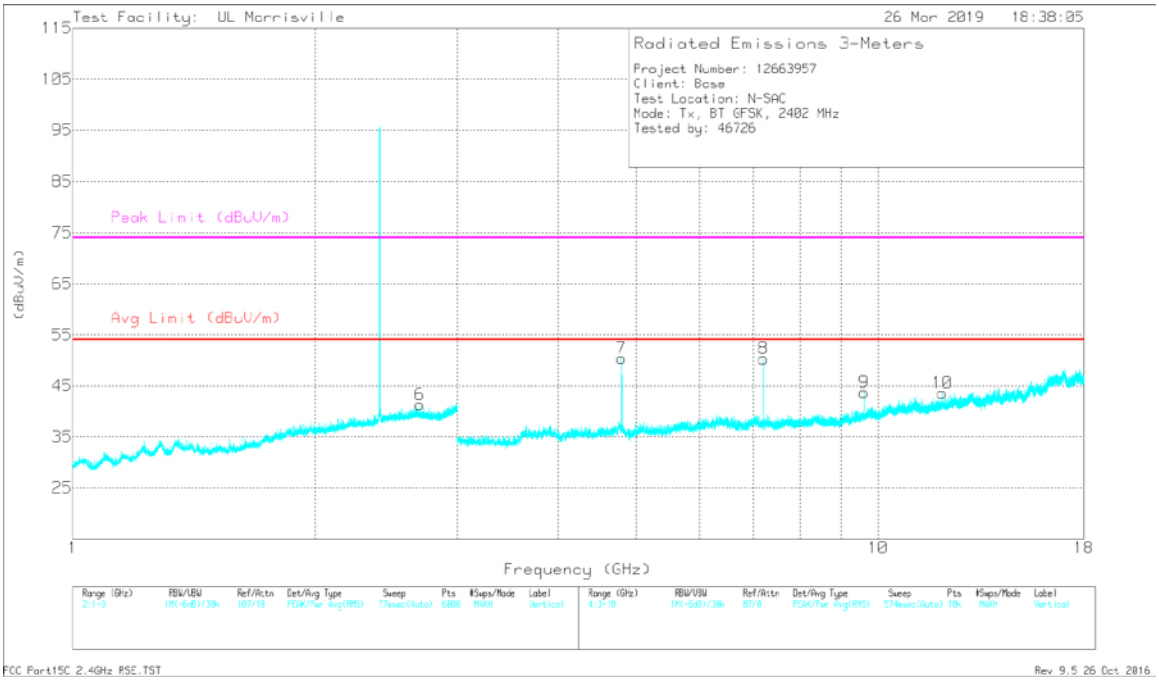
UL LLC
12 Laboratory Dr., RTP, NC 27709; USA TEL:(919) 549-1400
This report shall not be reproduced except in full, without the written approval of UL LLC.

HARMONICS AND SPURIOUS EMISSIONS

LOW CHANNEL RESULTS



HORIZONTAL



VERTICAL

UL LLC
12 Laboratory Dr., RTP, NC 27709; USA TEL:(919) 549-1400

This report shall not be reproduced except in full, without the written approval of UL LLC.

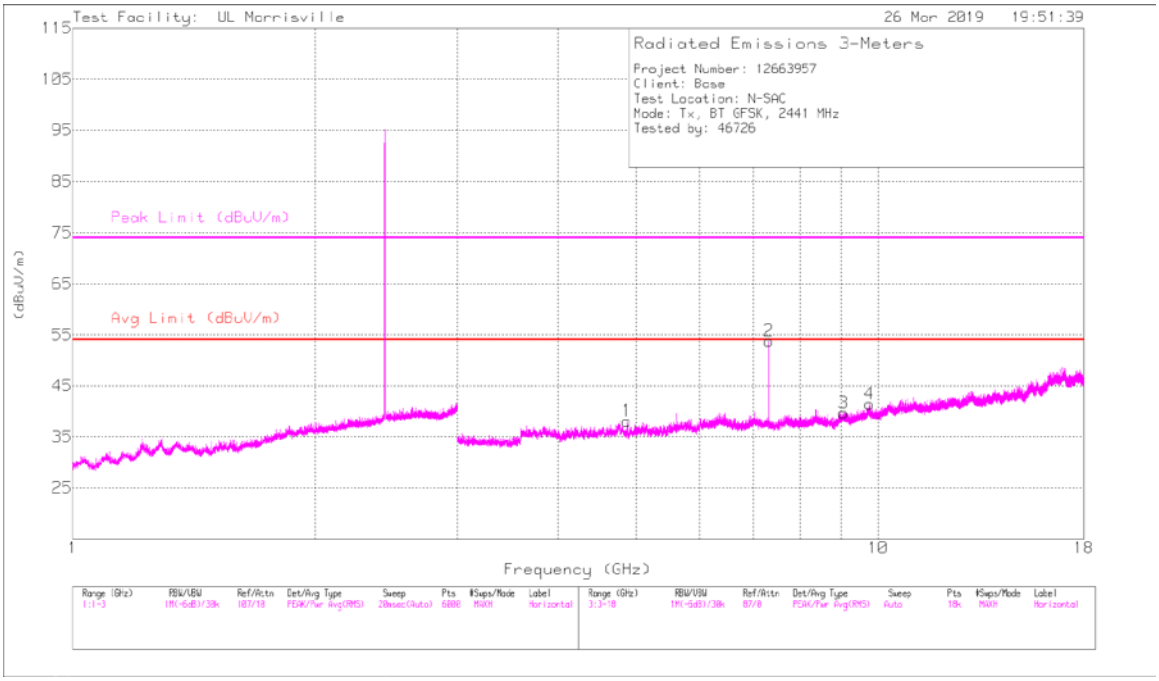
RADIATED EMISSIONS

Markers	Frequency (GHz)	Meter Reading (dBuV)	Det	AT0072 AF (dB/m)	Amp/Cbl/ Fltr/Pad (dB)	DC Corr (dB)	Corrected Reading (dBuV/m)	Avg Limit (dBuV/m)	Avg Margin (dB)	Peak Limit (dBuV/m)	PK Margin (dB)	Azimuth (Degs)	Height (cm)	Polarity
1	* 2.709	37	PK-U	32.4	-23.9	0	45.5	-	-	74	-28.5	262	227	H
	* 2.709	37	PK-U	32.4	-23.9	-24	21.5	54	-32.5	-	-	262	227	H
6	* 2.699	36.97	PK-U	32.5	-23.9	0	45.57	-	-	74	-28.43	152	390	V
	* 2.699	36.97	PK-U	32.5	-23.9	-24	21.57	54	-32.43	-	-	152	390	V
2	* 4.804	49.78	PK-U	34.1	-31.6	0	52.28	-	-	74	-21.72	250	314	H
	* 4.804	49.78	PK-U	34.1	-31.6	-24	28.28	54	-25.72	-	-	250	314	H
5	* 12.009	36.9	PK-U	38.7	-25.6	0	50	-	-	74	-24	105	133	H
	* 12.009	36.9	PK-U	38.7	-25.6	-24	26	54	-28	-	-	105	133	H
7	* 4.804	51.01	PK-U	34.1	-31.6	0	53.51	-	-	74	-20.49	149	400	V
	* 4.804	51.01	PK-U	34.1	-31.6	-24	29.51	54	-24.49	-	-	149	400	V
10	* 12.011	38.28	PK-U	38.7	-25.6	0	51.38	-	-	74	-22.62	335	227	V
	* 12.011	38.28	PK-U	38.7	-25.6	-24	27.38	54	-26.62	-	-	335	227	V
3	7.206	47.86	Pk	35.6	-30	0	53.46	-	-	-	-	0-360	102	H
8	7.206	44.71	Pk	35.6	-30	0	50.31	-	-	-	-	0-360	102	V
4	9.607	31.98	Pk	36.9	-28	0	40.88	-	-	-	-	0-360	102	H
9	9.608	34.78	Pk	36.9	-28	0	43.68	-	-	-	-	0-360	102	V

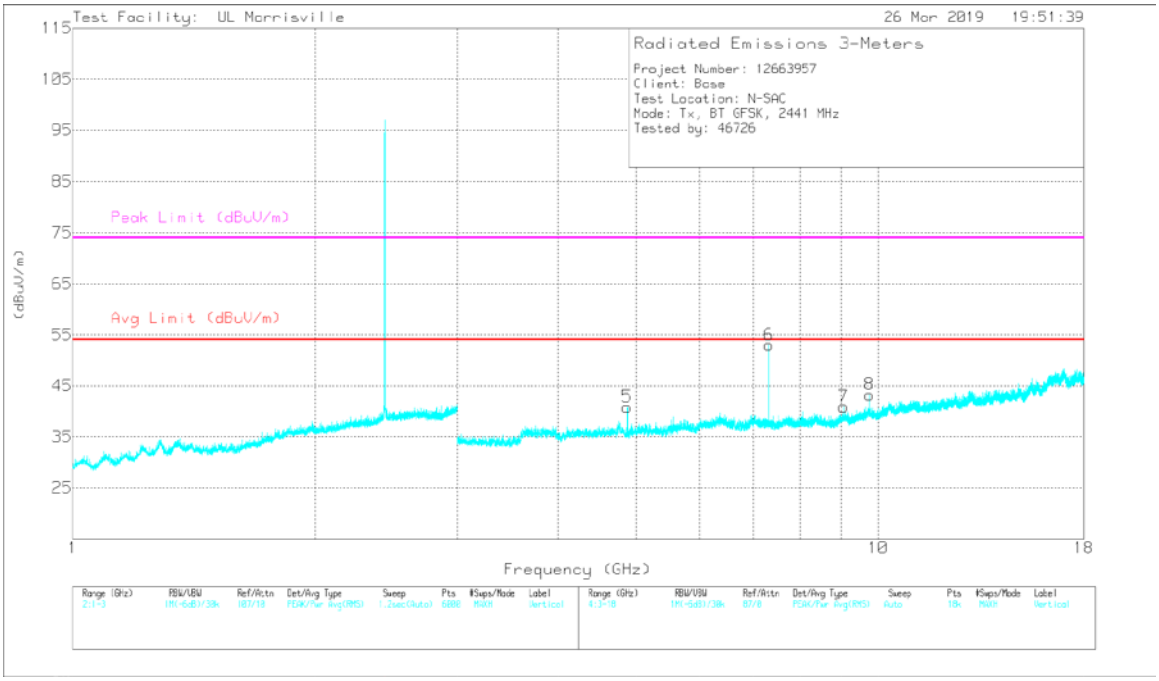
* - indicates frequency in CFR47 Pt 15 / IC RSS-Restricted Band
PK-U - Maximum Peak
Pk - Peak detector

UL LLC
12 Laboratory Dr., RTP, NC 27709; USA TEL:(919) 549-1400
This report shall not be reproduced except in full, without the written approval of UL LLC.

MID CHANNEL RESULTS



HORIZONTAL



VERTICAL

UL LLC
12 Laboratory Dr., RTP, NC 27709; USA
TEL:(919) 549-1400

This report shall not be reproduced except in full, without the written approval of UL LLC.

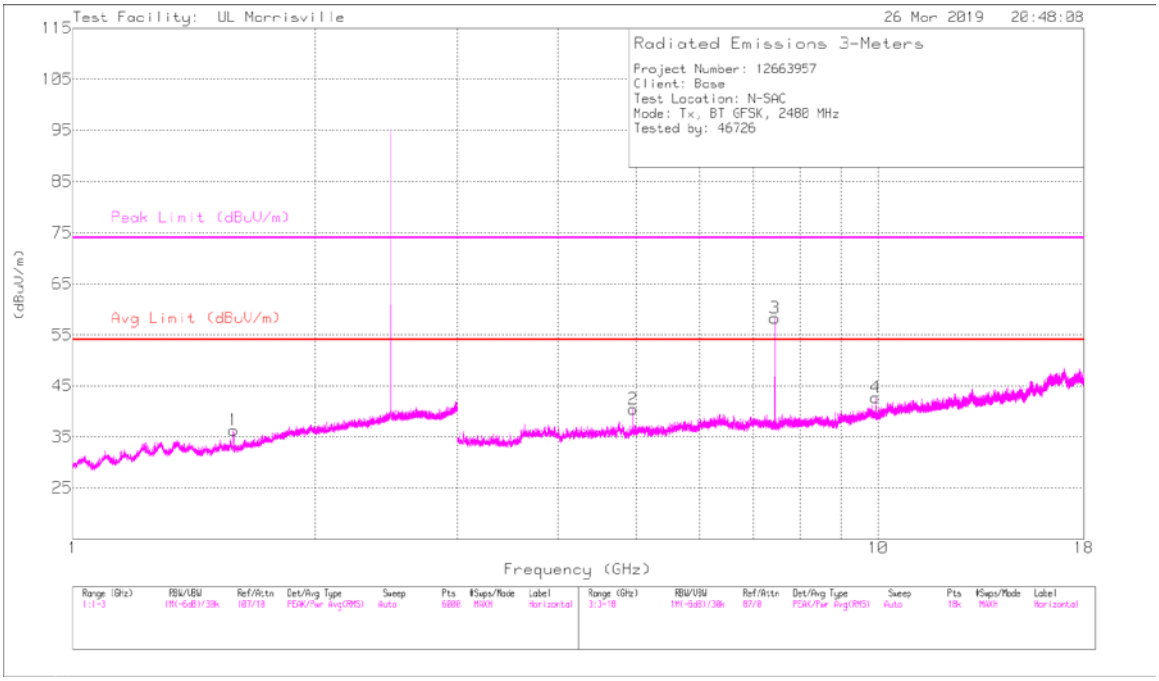
RADIATED EMISSIONS

Markers	Frequency (GHz)	Meter Reading (dBuV)	Det	AT0072 AF (dB/m)	Amp/Cbl/ Fltr/Pad (dB)	DC Corr (dB)	Corrected Reading (dBuV/m)	Avg Limit (dBuV/m)	Avg Margin (dB)	Peak Limit (dBuV/m)	PK Margin (dB)	Azimuth (Degs)	Height (cm)	Polarity
1	* ** 4.88	42.78	PK-U	34.1	-31.3	0	45.58	-	-	74	-28.42	326	106	H
	* ** 4.88	42.78	PK-U	34.1	-31.3	-24	21.58	54	-32.42	-	-	326	106	H
2	* ** 7.319	50.52	PK-U	35.6	-29.2	0	56.92	-	-	74	-17.08	211	115	H
	* ** 7.319	50.52	PK-U	35.6	-29.2	-24	32.92	54	-21.08	-	-	211	115	H
3	* ** 9.06	38.74	PK-U	36.3	-28.4	0	46.64	-	-	74	-27.36	359	291	H
	* ** 9.06	38.74	PK-U	36.3	-28.4	-24	22.64	54	-31.36	-	-	359	291	H
5	* ** 4.88	44.6	PK-U	34.1	-31.3	0	47.4	-	-	74	-26.6	355	384	V
	* ** 4.88	44.6	PK-U	34.1	-31.3	-24	23.4	54	-30.6	-	-	355	384	V
6	* ** 7.319	49.91	PK-U	35.6	-29.2	0	56.31	-	-	74	-17.69	249	104	V
	* ** 7.319	49.91	PK-U	35.6	-29.2	-24	32.31	54	-21.69	-	-	249	104	V
7	* ** 9.053	38.48	PK-U	36.3	-28.4	0	46.38	-	-	74	-27.62	358	337	V
	* ** 9.053	38.48	PK-U	36.3	-28.4	-24	22.38	54	-31.62	-	-	358	337	V
4	9.76	31.65	Pk	37	-27.2	0	41.45	-	-	-	-	0-360	103	H
8	9.76	33.46	Pk	37	-27.2	0	43.26	-	-	-	-	0-360	102	V

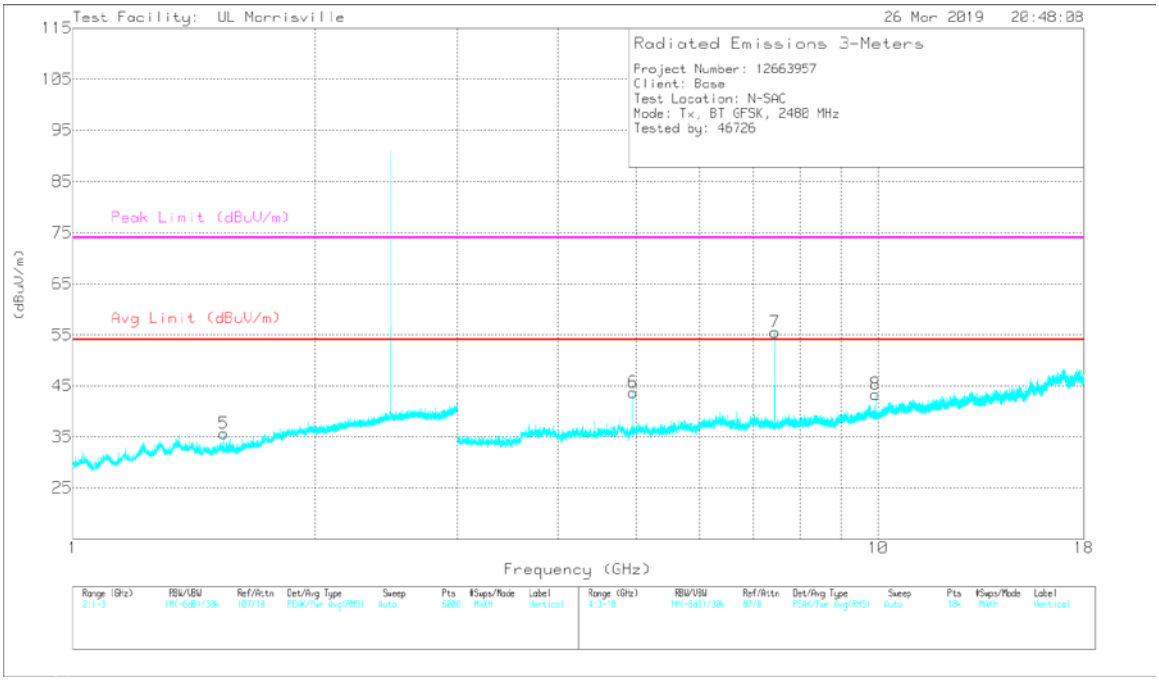
* - indicates frequency in CFR47 Pt 15 / IC RSS-Restricted Band
** - indicates frequency in Taiwan NCC LP0002 Restricted Band
PK-U - Maximum Peak
Pk - Peak detector

UL LLC
12 Laboratory Dr., RTP, NC 27709; USA TEL:(919) 549-1400
This report shall not be reproduced except in full, without the written approval of UL LLC.

HIGH CHANNEL RESULTS



HORIZONTAL



VERTICAL

UL LLC
12 Laboratory Dr., RTP, NC 27709; USA
TEL:(919) 549-1400

This report shall not be reproduced except in full, without the written approval of UL LLC.

RADIATED EMISSIONS

Markers	Frequency (GHz)	Meter Reading (dBuV)	Det	AT0072 AF (dB/m)	Amp/Cbl/Fltr/Pad (dB)	DC Corr (dB)	Corrected Reading (dBuV/m)	Avg Limit (dBuV/m)	Avg Margin (dB)	Peak Limit (dBuV/m)	PK Margin (dB)	Azimuth (Degs)	Height (cm)	Polarity
1	* ** 1.584	38	PK-U	27.8	-24.6	0	41.2	-	-	74	-32.8	10	135	H
	* ** 1.584	38	PK-U	27.8	-24.6	-24	17.2	54	-36.8	-	-	10	135	H
5	* ** 1.539	36.21	PK-U	28	-24.7	0	39.51	-	-	74	-34.49	49	186	V
	* ** 1.539	36.21	PK-U	28	-24.7	-24	15.15	54	-38.85	-	-	49	186	V
2	* ** 4.96	43.77	PK-U	34.1	-32.3	0	45.57	-	-	74	-28.43	278	391	H
	* ** 4.96	43.77	PK-U	34.1	-32.3	-24	21.57	54	-32.43	-	-	278	391	H
3	* ** 7.439	51.84	PK-U	35.6	-29.2	0	58.24	-	-	74	-15.76	34	103	H
	* ** 7.439	51.84	PK-U	35.6	-29.2	-24	34.24	54	-19.76	-	-	34	103	H
6	* ** 4.96	43.62	PK-U	34.1	-32.3	0	45.42	-	-	74	-28.58	99	283	V
	* ** 4.96	43.62	PK-U	34.1	-32.3	-24	21.42	54	-32.58	-	-	99	283	V
7	* ** 7.439	51.04	PK-U	35.6	-29.2	0	57.44	-	-	74	-16.56	207	120	V
	* ** 7.439	51.04	PK-U	35.6	-29.2	-24	33.44	54	-20.56	-	-	207	120	V
8	9.919	33.96	Pk	37.1	-27.7	0	43.36	-	-	-	-	0-360	199	V
4	9.92	33.27	Pk	37.1	-27.7	0	42.67	-	-	-	-	0-360	103	H

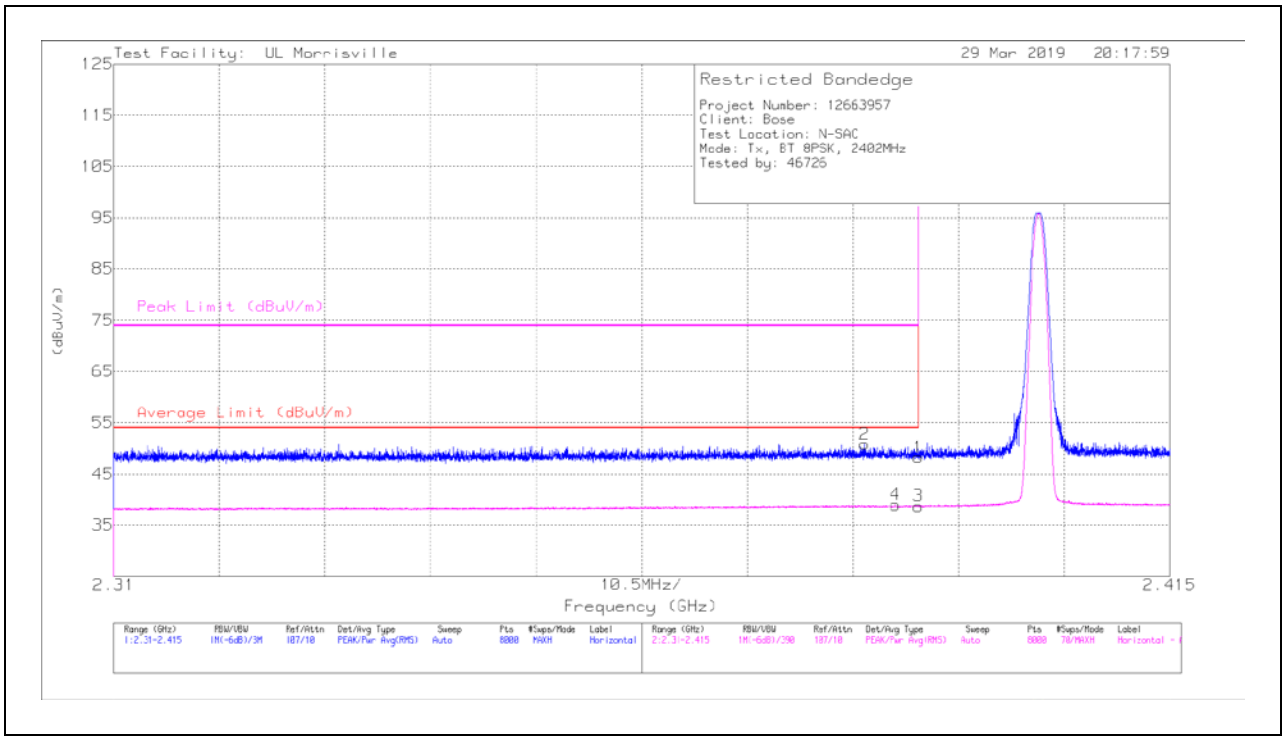
* - indicates frequency in CFR47 Pt 15 / IC RSS-Restricted Band
** - indicates frequency in Taiwan NCC LP0002 Restricted Band
PK-U - Maximum Peak
Pk - Peak detector

UL LLC
12 Laboratory Dr., RTP, NC 27709; USA TEL:(919) 549-1400
This report shall not be reproduced except in full, without the written approval of UL LLC.

9.1.2. BLUETOOTH ENHANCED DATA RATE 8PSK MODULATION

BANDEDGE (LOW CHANNEL)

HORIZONTAL RESULT

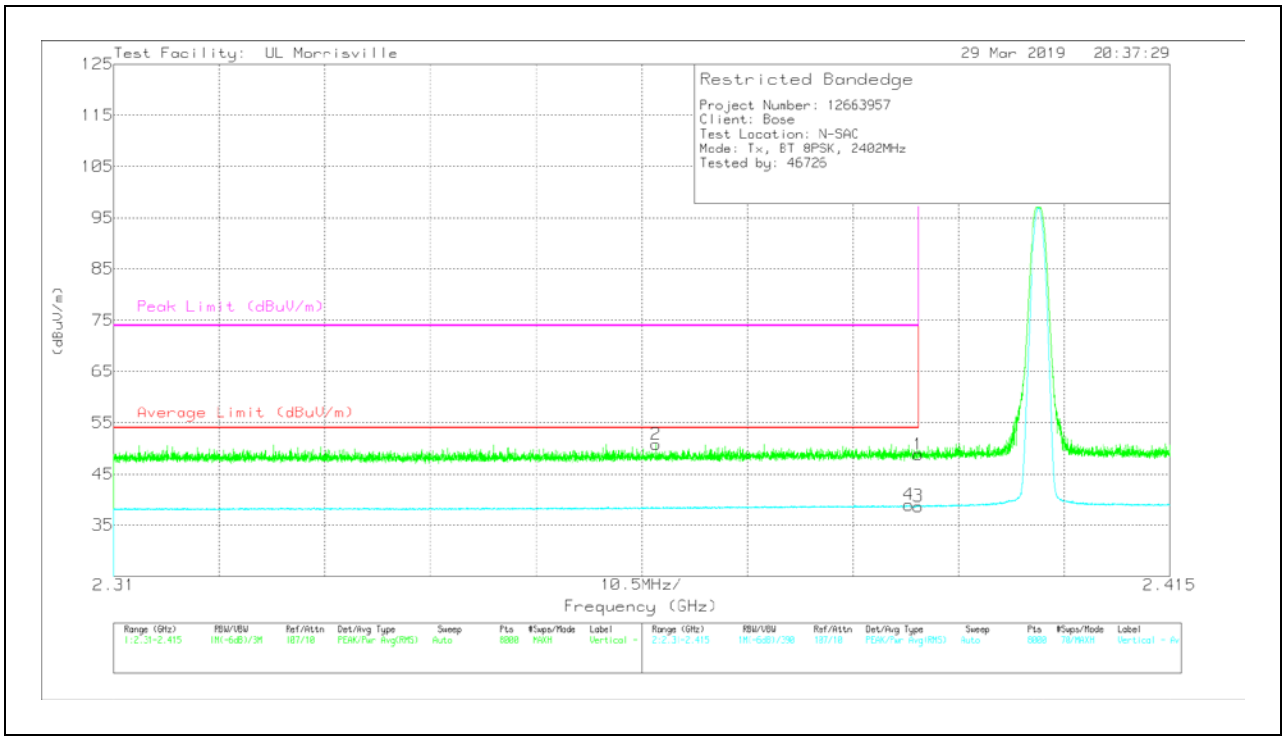


Marker	Frequency (GHz)	Meter Reading (dBuV)	Det	AT0072 AF (dB/m)	Amp/Cbl/Fltr/Pad (dB)	DC Corr (dB)	Corrected Reading (dBuV/m)	Average Limit (dBuV/m)	Avg Margin (dB)	Peak Limit (dBuV/m)	PK Margin (dB)	Azimuth (Degs)	Height (cm)	Polarity
1	* 2.39	40.72	Pk	32	-24.5	0	48.22	-	-	74	-25.78	13	189	H
	* 2.39	40.72	Pk	32	-24.5	-24	24.22	54	-29.78	-	-	13	189	H
2	* 2.385	43.36	Pk	32	-24.5	0	50.86	-	-	74	-23.14	13	189	H
	* 2.385	43.36	Pk	32	-24.5	-24	26.86	54	-27.14	-	-	13	189	H

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

UL LLC
12 Laboratory Dr., RTP, NC 27709; USA TEL:(919) 549-1400
This report shall not be reproduced except in full, without the written approval of UL LLC.

VERTICAL RESULT



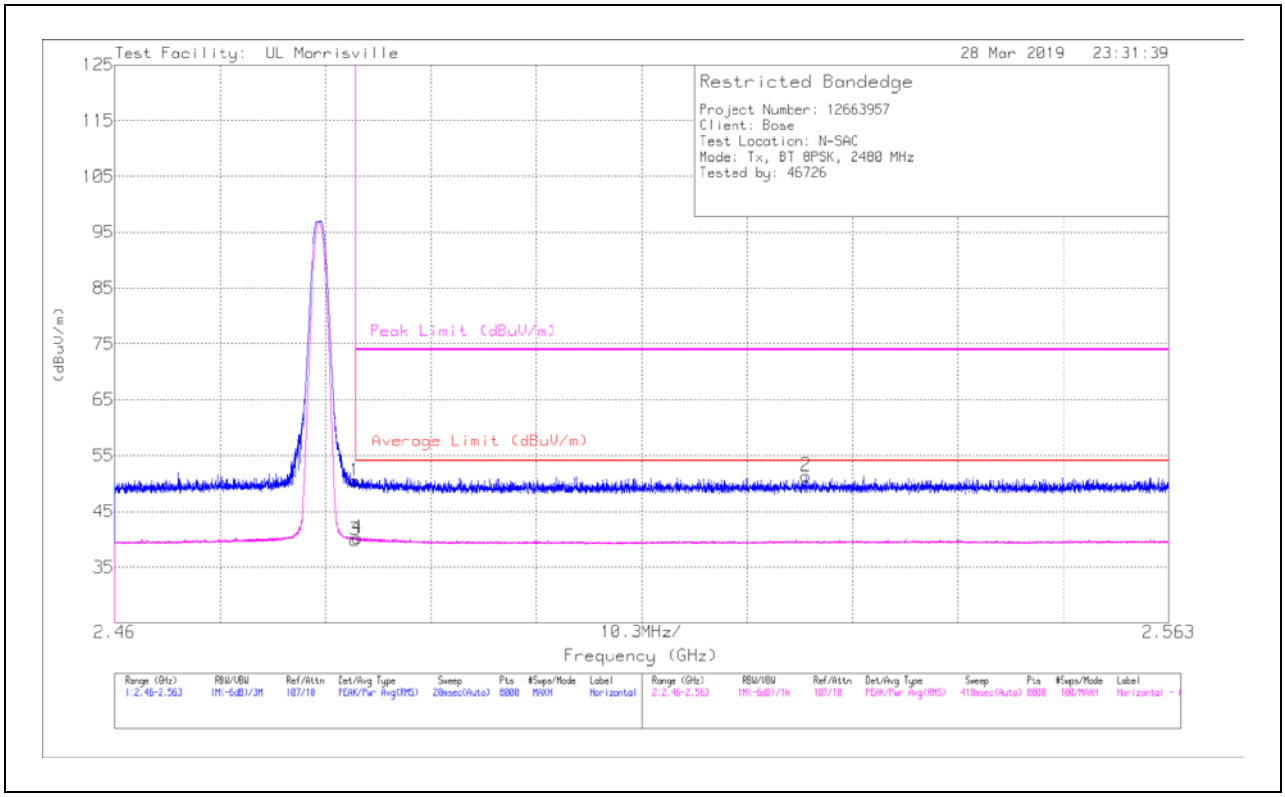
Marker	Frequency (GHz)	Meter Reading (dBuV)	Det	AT0072 AF (dB/m)	Amp/Cbl/Fltr/Pad (dB)	DC Corr (dB)	Corrected Reading (dBuV/m)	Average Limit (dBuV/m)	Avg Margin (dB)	Peak Limit (dBuV/m)	PK Margin (dB)	Azimuth (Degs)	Height (cm)	Polarity
1	* 2.39	41.32	Pk	32	-24.5	0	48.82	-	-	74	-25.18	196	121	V
	* 2.39	41.32	Pk	32	-24.5	-24	24.82	54	-29.18	-	-	196	121	V
2	* 2.364	43.59	Pk	31.8	-24.6	0	50.79	-	-	74	-23.21	196	121	V
	* 2.364	43.59	Pk	31.8	-24.6	-24	26.79	54	-27.21	-	-	196	121	V

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

UL LLC
12 Laboratory Dr., RTP, NC 27709; USA TEL:(919) 549-1400
This report shall not be reproduced except in full, without the written approval of UL LLC.

BANDEDGE (HIGH CHANNEL)

HORIZONTAL RESULT

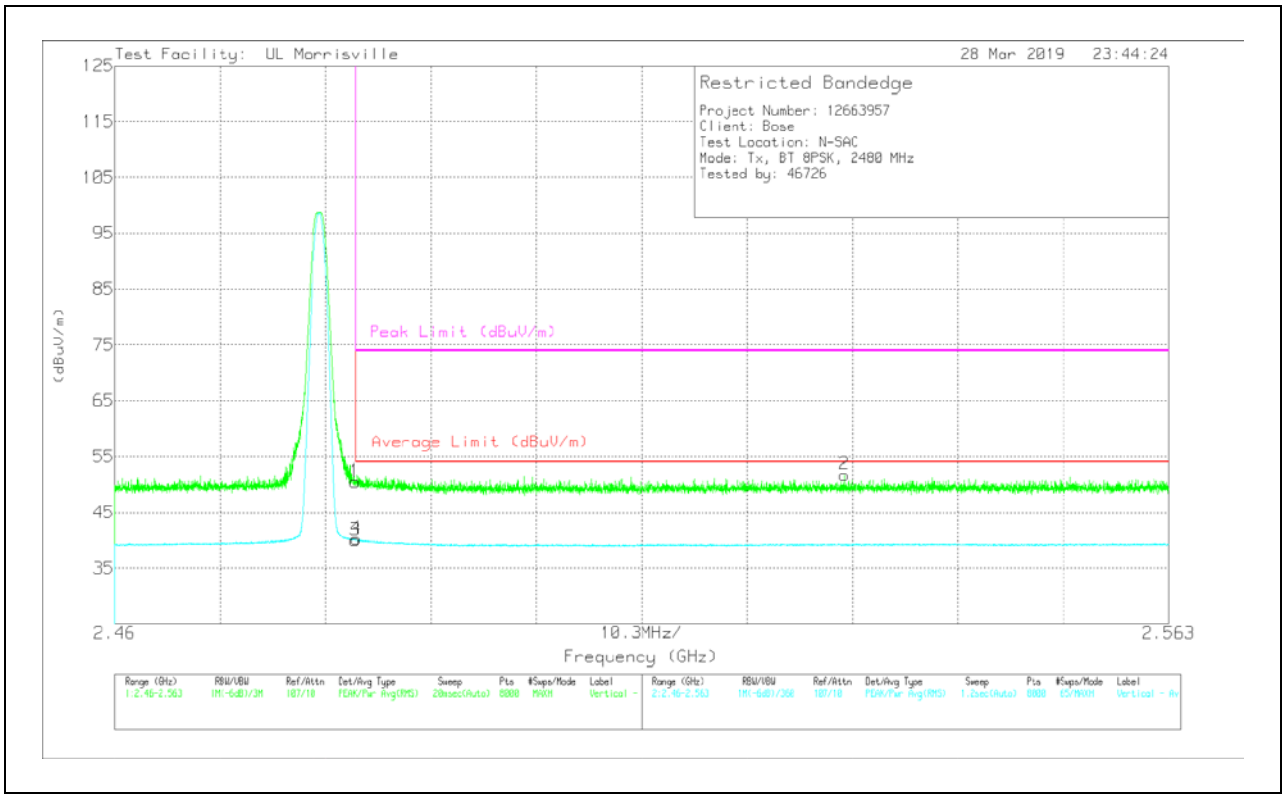


Marker	Frequency (GHz)	Meter Reading (dBuV)	Det	AT0072 AF (dB/m)	Amp/Cbl/Fltr/Pad (dB)	DC Corr (dB)	Corrected Reading (dBuV/m)	Average Limit (dBuV/m)	Avg Margin (dB)	Peak Limit (dBuV/m)	PK Margin (dB)	Azimuth (Degs)	Height (cm)	Polarity
1	* 2.484	42.34	Pk	32.4	-24.3	0	50.44	-	-	74	-23.56	6	278	H
	* 2.484	42.34	Pk	32.4	-24.3	-24	26.44	54	-27.56	-	-	6	278	H
2	2.528	43.27	Pk	32.4	-24.3	0	51.37	-	-	74	-22.63	6	278	H
	2.528	43.27	Pk	32.4	-24.3	-24	27.37	54	-26.63	-	-	6	278	H

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

UL LLC
12 Laboratory Dr., RTP, NC 27709; USA TEL:(919) 549-1400
This report shall not be reproduced except in full, without the written approval of UL LLC.

VERTICAL RESULT



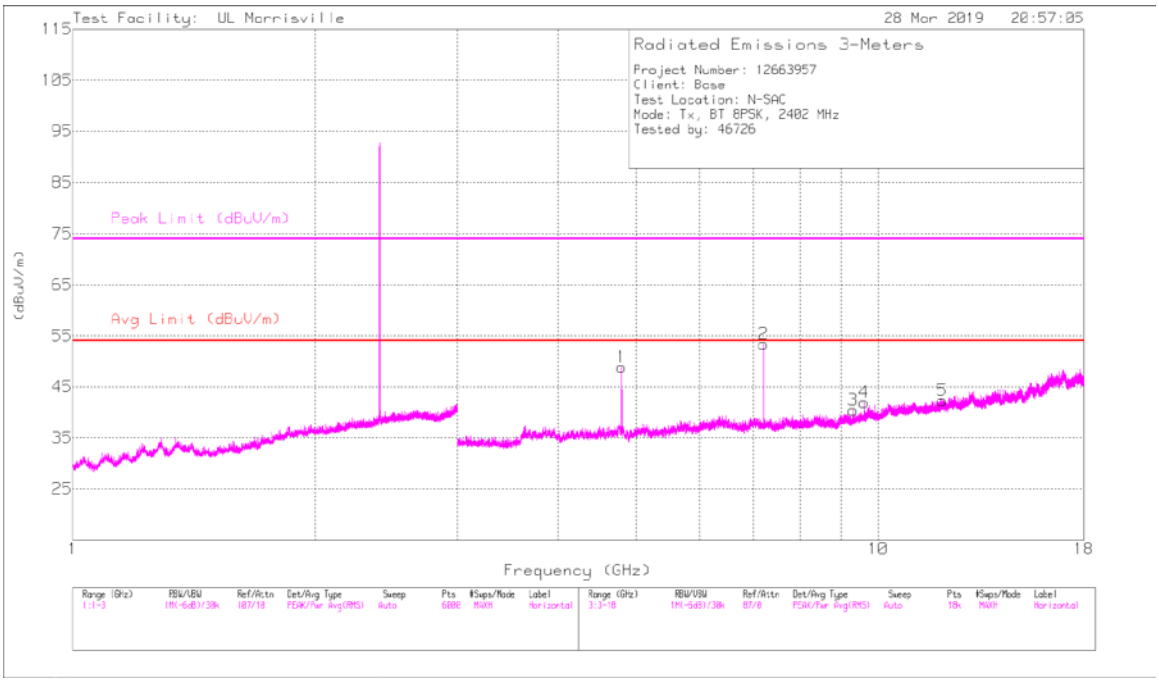
Marker	Frequency (GHz)	Meter Reading (dBuV)	Det	AT0072 AF (dB/m)	Amp/Cbl/Fltr/Pad (dB)	DC Corr (dB)	Corrected Reading (dBuV/m)	Average Limit (dBuV/m)	Avg Margin (dB)	Peak Limit (dBuV/m)	PK Margin (dB)	Azimuth (Degs)	Height (cm)	Polarity
1	* 2.484	42.4	Pk	32.4	-24.3	0	50.5	-	-	74	-23.5	81	299	V
	* 2.484	42.4	Pk	32.4	-24.3	-24	26.5	54	-27.5	-	-	81	299	V
2	2.531	43.76	Pk	32.4	-24.4	0	51.76	-	-	74	-22.24	81	299	V
	2.531	43.76	Pk	32.4	-24.4	-24	27.76	54	-26.24	-	-	81	299	V

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

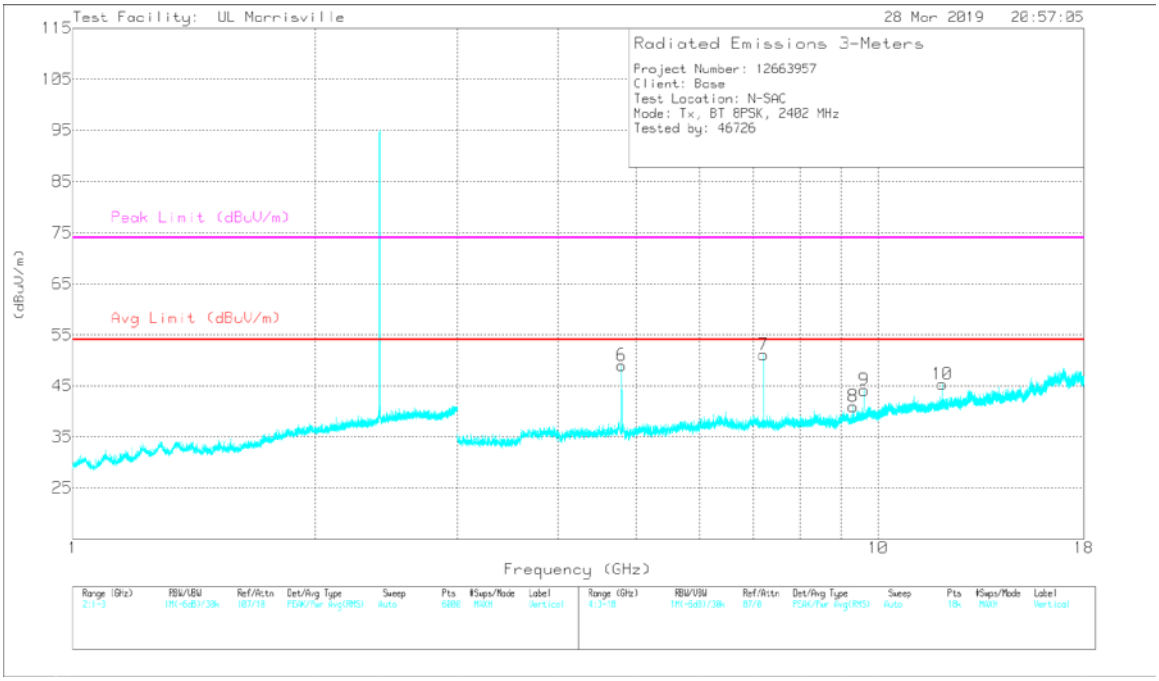
UL LLC
12 Laboratory Dr., RTP, NC 27709; USA TEL:(919) 549-1400
This report shall not be reproduced except in full, without the written approval of UL LLC.

HARMONICS AND SPURIOUS EMISSIONS

LOW CHANNEL RESULTS



HORIZONTAL



VERTICAL

UL LLC
12 Laboratory Dr., RTP, NC 27709; USA TEL:(919) 549-1400

This report shall not be reproduced except in full, without the written approval of UL LLC.

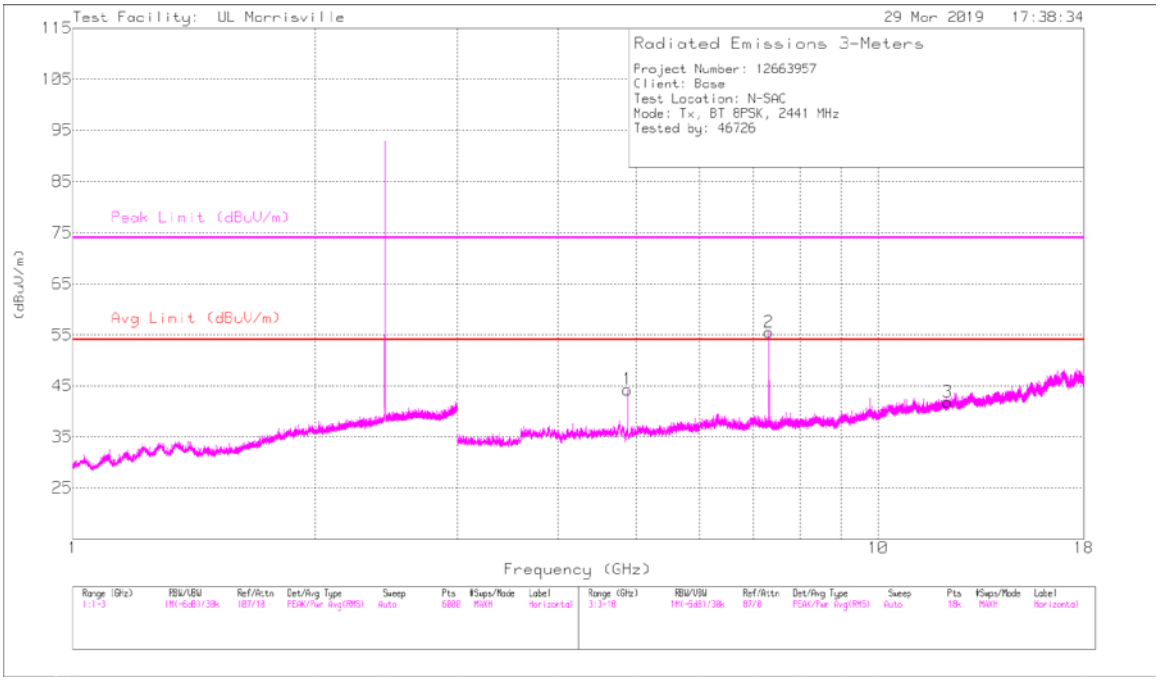
RADIATED EMISSIONS

Markers	Frequency (GHz)	Meter Reading (dBuV)	Det	AT0072 AF (dB/m)	Amp/Cbl/ Fltr/Pad (dB)	DC Corr (dB)	Corrected Reading (dBuV/m)	Avg Limit (dBuV/m)	Avg Margin (dB)	Peak Limit (dBuV/m)	PK Margin (dB)	Azimuth (Degs)	Height (cm)	Polarity
1	* 4.804	50.22	PK-U	34.1	-31.6	0	52.72	-	-	74	-21.28	70	334	H
	* 4.804	50.22	PK-U	34.1	-31.6	-24	28.72	54	-25.28	-	-	70	334	H
3	* 9.311	38.48	PK-U	36.4	-28.4	-	46.48	-	-	74	-27.52	229	142	H
	* 9.311	38.48	PK-U	36.4	-28.4	-24	22.48	54	-31.52	-	-	229	142	H
5	* 12.015	35.44	PK-U	38.7	-25.5	-	48.64	-	-	74	-25.36	355	314	H
	* 12.015	35.44	PK-U	38.7	-25.5	-24	24.64	54	-29.36	-	-	355	314	H
6	* 4.804	50.22	PK-U	34.1	-31.6	-	52.72	-	-	74	-21.28	264	253	V
	* 4.804	50.22	PK-U	34.1	-31.6	-24	28.72	54	-25.28	-	-	264	253	V
8	* 9.309	38.09	PK-U	36.4	-28.5	-	45.99	-	-	74	-28.01	330	258	V
	* 9.309	38.09	PK-U	36.4	-28.5	-24	21.99	54	-32.01	-	-	330	258	V
10	* 12.01	35.45	PK-U	38.7	-25.6	0	48.55	-	-	74	-25.45	352	145	V
	* 12.01	35.45	PK-U	38.7	-25.6	-24	24.55	54	-29.45	-	-	352	145	V
2	7.206	47.75	Pk	35.6	-30	0	53.35	-	-	-	-	0-360	103	H
7	7.206	45.52	Pk	35.6	-30	0	51.12	-	-	-	-	0-360	102	V
9	9.607	35.25	Pk	36.9	-28	0	44.15	-	-	-	-	0-360	102	V
4	9.608	33.03	Pk	36.9	-28	0	41.93	-	-	-	-	0-360	103	H

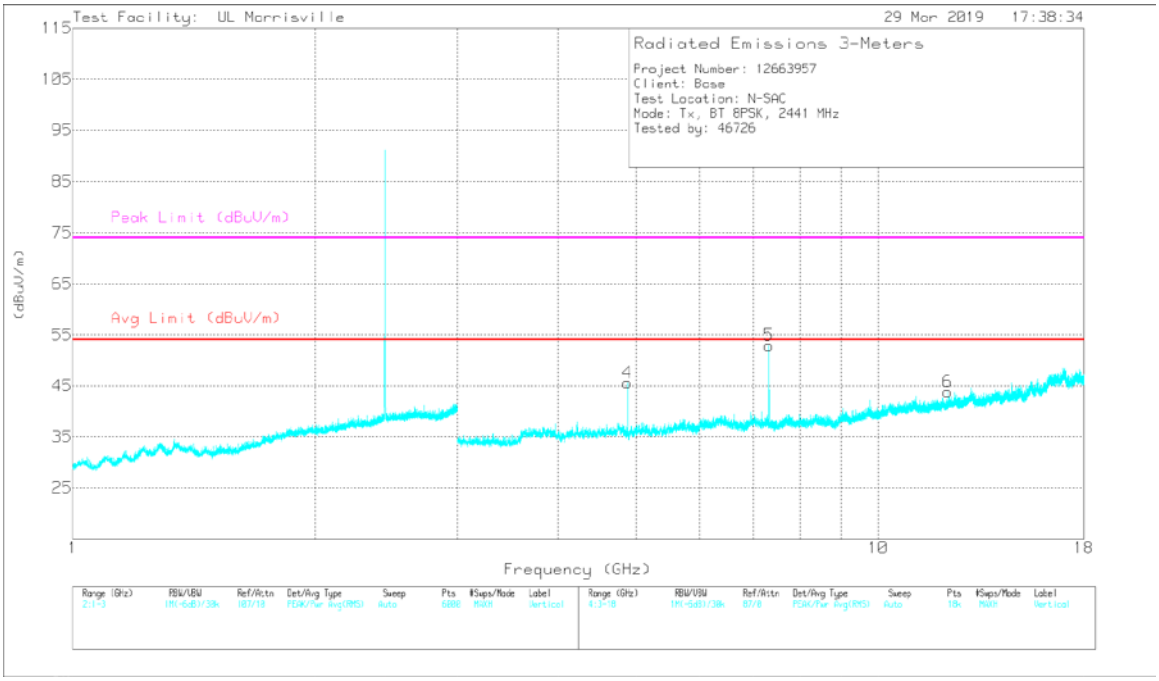
* - indicates frequency in CFR47 Pt 15 / IC RSS-Restricted Band
PK-U - Maximum Peak
Pk - Peak detector

UL LLC
12 Laboratory Dr., RTP, NC 27709; USA TEL:(919) 549-1400
This report shall not be reproduced except in full, without the written approval of UL LLC.

MID CHANNEL RESULTS



HORIZONTAL



VERTICAL

UL LLC
12 Laboratory Dr., RTP, NC 27709; USA
TEL:(919) 549-1400

This report shall not be reproduced except in full, without the written approval of UL LLC.

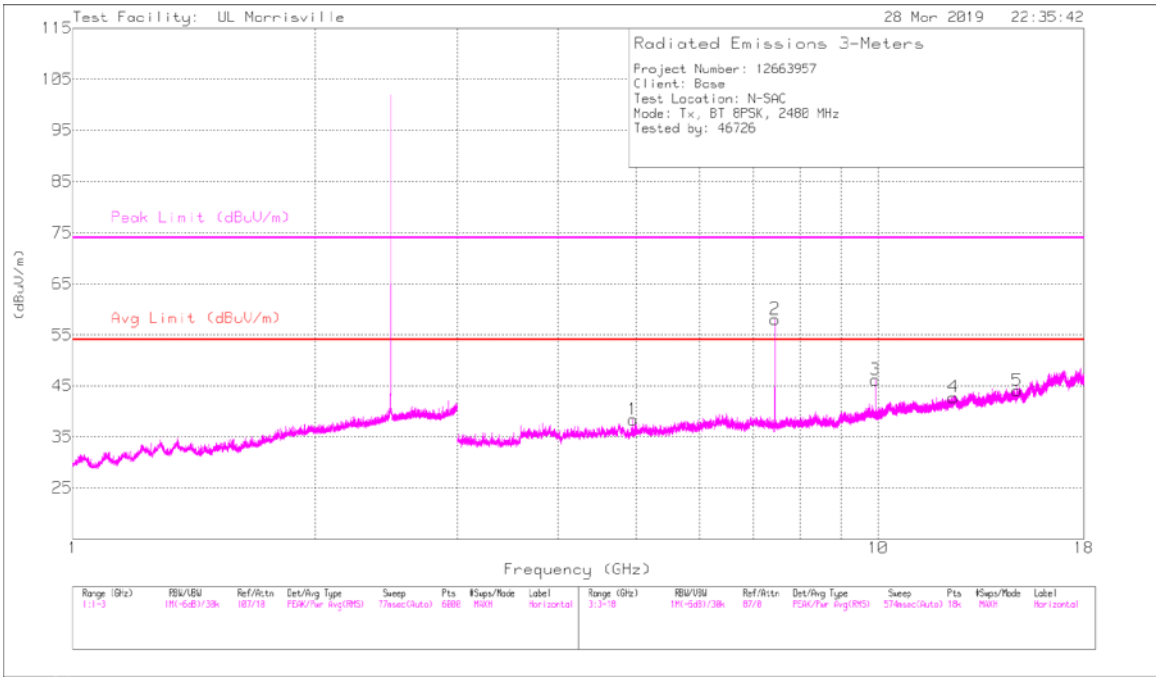
RADIATED EMISSIONS

Markers	Frequency (GHz)	Meter Reading (dBuV)	Det	AT0072 AF (dB/m)	Amp/Cbl/ Fltr/Pad (dB)	DC Corr (dB)	Corrected Reading (dBuV/m)	Avg Limit (dBuV/m)	Avg Margin (dB)	Peak Limit (dBuV/m)	PK Margin (dB)	Azimuth (Degs)	Height (cm)	Polarity
1	* ** 4.882	46.45	PK-U	34.1	-31.3	0	49.25	-	-	74	-24.75	35	108	H
	* ** 4.882	46.45	PK-U	34.1	-31.3	-24	25.25	54	-28.75	-	-	35	108	H
2	* ** 7.323	50.55	PK-U	35.6	-29.2	0	56.95	-	-	74	-17.05	225	103	H
	* ** 7.323	50.55	PK-U	35.6	-29.2	-24	32.95	54	-21.05	-	-	225	103	H
3	* ** 12.205	36.9	PK-U	38.9	-26.3	0	49.5	-	-	74	-24.5	207	127	H
	* ** 12.205	36.9	PK-U	38.9	-26.3	-24	25.5	54	-28.5	-	-	207	127	H
4	* ** 4.882	47.2	PK-U	34.1	-31.3	0	50	-	-	74	-24	252	270	V
	* ** 4.882	47.2	PK-U	34.1	-31.3	-24	26	54	-28	-	-	252	270	V
5	* ** 7.323	49.22	PK-U	35.6	-29.2	0	55.62	-	-	74	-18.38	250	387	V
	* ** 7.323	49.22	PK-U	35.6	-29.2	-24	31.62	54	-22.38	-	-	250	387	V
6	* ** 12.205	38.48	PK-U	38.9	-26.3	0	51.08	-	-	74	-22.92	192	103	V
	* ** 12.205	38.48	PK-U	38.9	-26.3	-24	27.08	54	-26.92	-	-	192	103	V

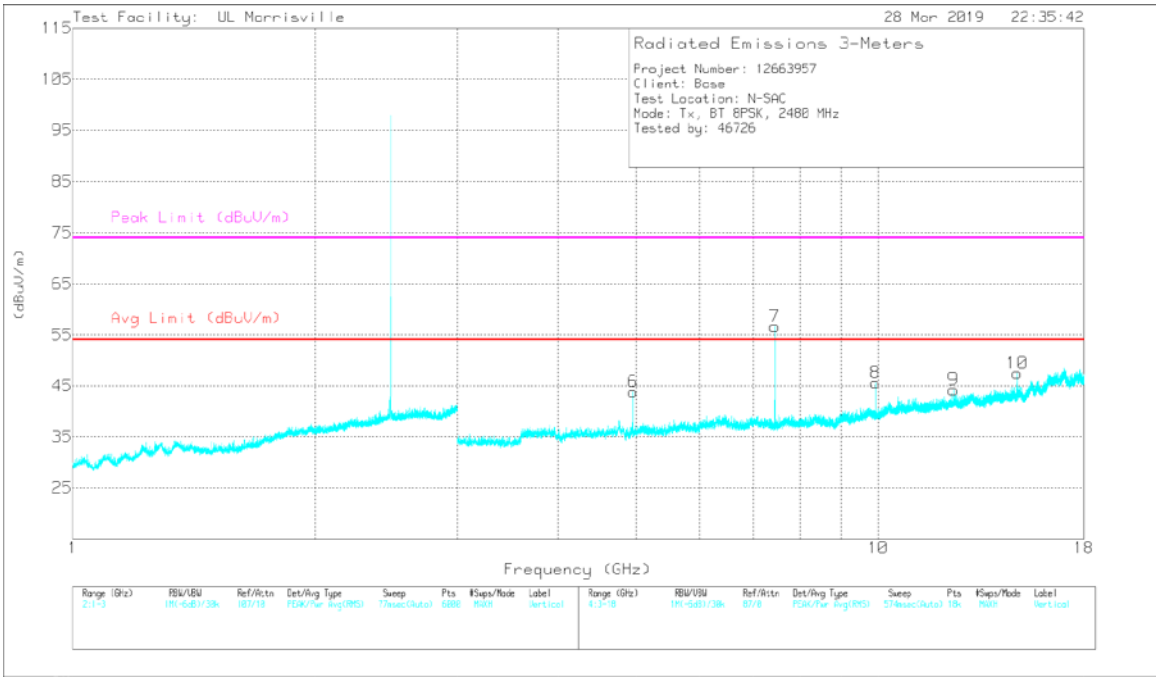
* - indicates frequency in CFR47 Pt 15 / IC RSS-Restricted Band
** - indicates frequency in Taiwan NCC LP0002 Restricted Band
PK-U - Maximum Peak

UL LLC
12 Laboratory Dr., RTP, NC 27709; USA TEL:(919) 549-1400
This report shall not be reproduced except in full, without the written approval of UL LLC.

HIGH CHANNEL RESULTS



HORIZONTAL



VERTICAL

UL LLC
12 Laboratory Dr., RTP, NC 27709; USA
TEL:(919) 549-1400

This report shall not be reproduced except in full, without the written approval of UL LLC.

RADIATED EMISSIONS

Markers	Frequency (GHz)	Meter Reading (dBuV)	Det	AT0072 AF (dB/m)	Amp/Cbl/ Fltr/Pad (dB)	DC Corr (dB)	Corrected Reading (dBuV/m)	Avg Limit (dBuV/m)	Avg Margin (dB)	Peak Limit (dBuV/m)	PK Margin (dB)	Azimuth (Degs)	Height (cm)	Polarity
1	* 4.96	45.69	PK-U	34.1	-32.3	0	47.49	-	-	74	-26.51	228	371	H
	* 4.96	45.69	PK-U	34.1	-32.3	-24	23.49	54	-30.51	-	-	228	371	H
2	* 7.44	53	PK-U	35.6	-29.2	-	59.4	-	-	74	-14.6	202	104	H
	* 7.44	53	PK-U	35.6	-29.2	-24	35.4	54	-18.6	-	-	202	104	H
4	* 12.4	38.16	PK-U	38.9	-26.3	-	50.76	-	-	74	-23.24	240	216	H
	* 12.4	38.16	PK-U	38.9	-26.3	-24	26.76	54	-27.24	-	-	240	216	H
6	* 4.96	46.62	PK-U	34.1	-32.3	-	48.42	-	-	74	-25.58	351	352	V
	* 4.96	46.62	PK-U	34.1	-32.3	-24	24.42	54	-29.58	-	-	351	352	V
7	* 7.44	51.59	PK-U	35.6	-29.2	-	57.99	-	-	74	-16.01	16	102	V
	* 7.44	51.59	PK-U	35.6	-29.2	-24	33.99	54	-20.01	-	-	16	102	V
9	* 12.4	38.81	PK-U	38.9	-26.3	0	51.41	-	-	74	-22.59	186	115	V
	* 12.4	38.81	PK-U	38.9	-26.3	-24	27.41	54	-26.59	-	-	186	115	V
3	9.92	36.76	Pk	37.1	-27.7	0	46.16	-	-	-	-	0-360	103	H
8	9.92	36.17	Pk	37.1	-27.7	0	45.57	-	-	-	-	0-360	102	V
5	14.88	31.28	Pk	39.5	-26.7	0	44.08	-	-	-	-	0-360	103	H
10	14.88	34.63	Pk	39.5	-26.7	0	47.43	-	-	-	-	0-360	102	V

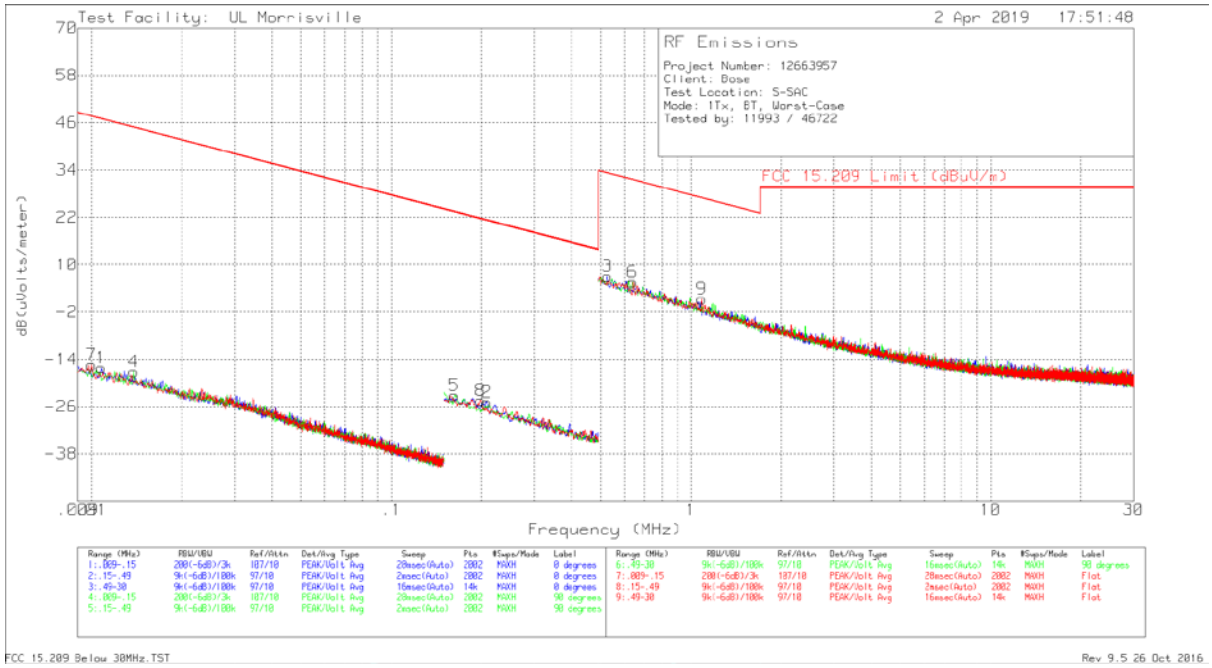
* - indicates frequency in CFR47 Pt 15 / IC RSS-Restricted Band
PK-U - Maximum Peak
Pk - Peak detector

UL LLC
12 Laboratory Dr., RTP, NC 27709; USA TEL:(919) 549-1400
This report shall not be reproduced except in full, without the written approval of UL LLC.

9.2. WORST CASE BELOW 30MHZ

SPURIOUS EMISSIONS BELOW 30 MHz (WORST-CASE CONFIGURATION)

Note: All measurements were made at a test distance of 3 m. The measured data was extrapolated from the test distance (3m) to the specification distance (300 m from 9-490 kHz and 30 m from 490 kHz – 30 MHz) to clearly show the relative levels of fundamental and spurious emissions and demonstrate compliance with the requirement that the level of any spurious emissions be below the level of the intentionally transmitted signal. The extrapolation factor for the limits were 40*Log (test distance / specification distance).



ANTENNA- THREE ORIENTATIONS

BELOW 30MHz DATA

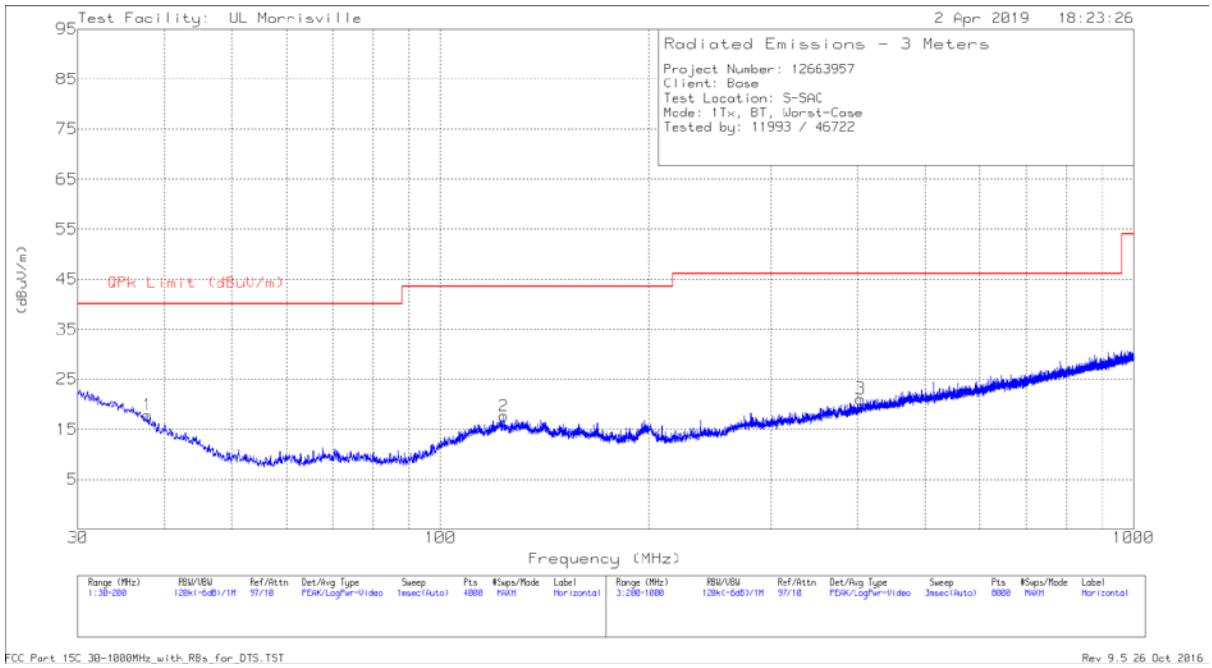
Marker	Frequency (MHz)	Meter Reading (dBuV)	Det	AT0079 AF (dB/m)	Cbl (dB)	Dist. Corr. Factor (dB)	Corrected Reading dB(uV/m)	FCC 15.209 QP Limit (dBuV/m)	FCC 15.209 AV Limit (dBuV/m)	FCC 15.209 PK Limit (dBuV/m)	Worst-Case Margin (dB)	Azimuth (Degs)	Antenna Face
7	.00998	46.18	Pk	18.3	.1	-80	-15.42	-	47.62	67.62	-63.04	0-360	Flat
1	.01075	45.74	Pk	18	.1	-80	-16.16	-	46.98	66.98	-63.14	0-360	On
4	.01383	46.03	Pk	16.7	.1	-80	-17.17	-	44.79	64.79	-61.96	0-360	Off
5	.16241	45.96	Pk	10.7	.1	-80	-23.24	-	23.39	43.39	-46.63	0-360	Off
8	.19871	44.75	Pk	10.7	.1	-80	-24.45	-	21.64	41.64	-46.09	0-360	Flat
2	.20831	44.32	Pk	10.7	.1	-80	-24.88	-	21.23	41.23	-46.11	0-360	On
3	.52584	36.17	Pk	10.8	.1	-40	7.07	33.19	-	-	-26.12	0-360	On
6	.63756	34.63	Pk	10.8	.1	-40	5.53	31.51	-	-	-25.98	0-360	Off
9	1.08656	30.12	Pk	11	.2	-40	1.32	26.88	-	-	-25.56	0-360	Flat

Pk - Peak detector

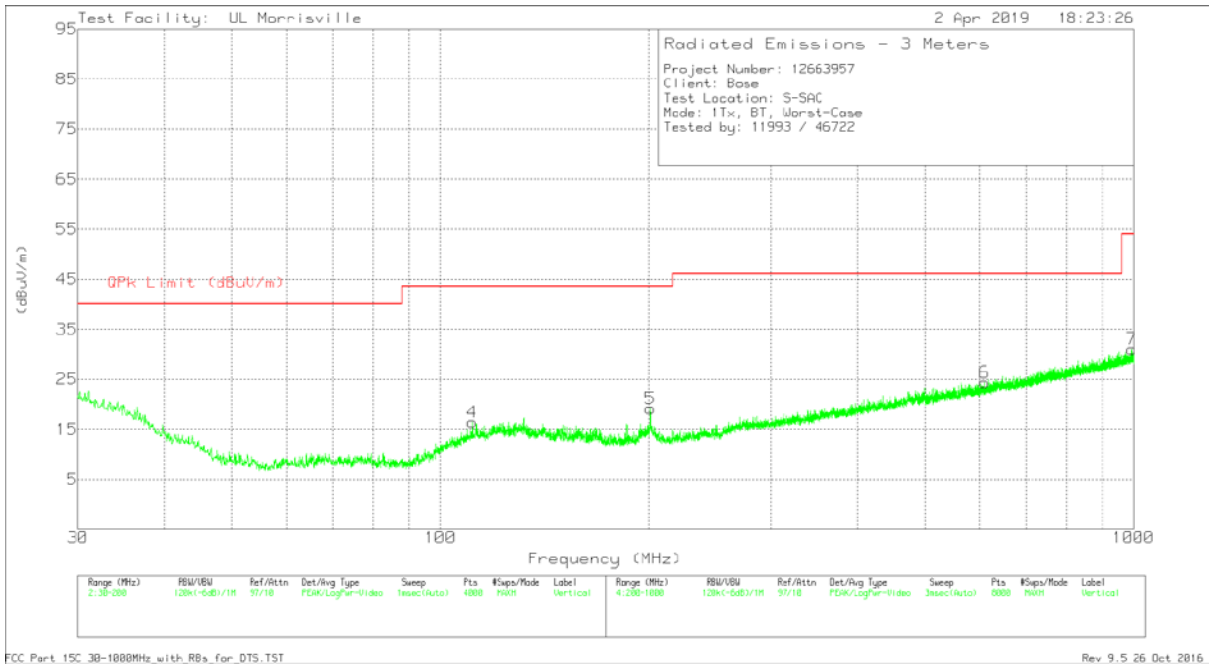
UL LLC
12 Laboratory Dr., RTP, NC 27709; USA TEL:(919) 549-1400
This report shall not be reproduced except in full, without the written approval of UL LLC.

9.3. WORST CASE BELOW 1 GHZ

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



HORIZONTAL



VERTICAL

UL LLC
12 Laboratory Dr., RTP, NC 27709; USA TEL:(919) 549-1400

This report shall not be reproduced except in full, without the written approval of UL LLC.

BELOW 1GHz DATA

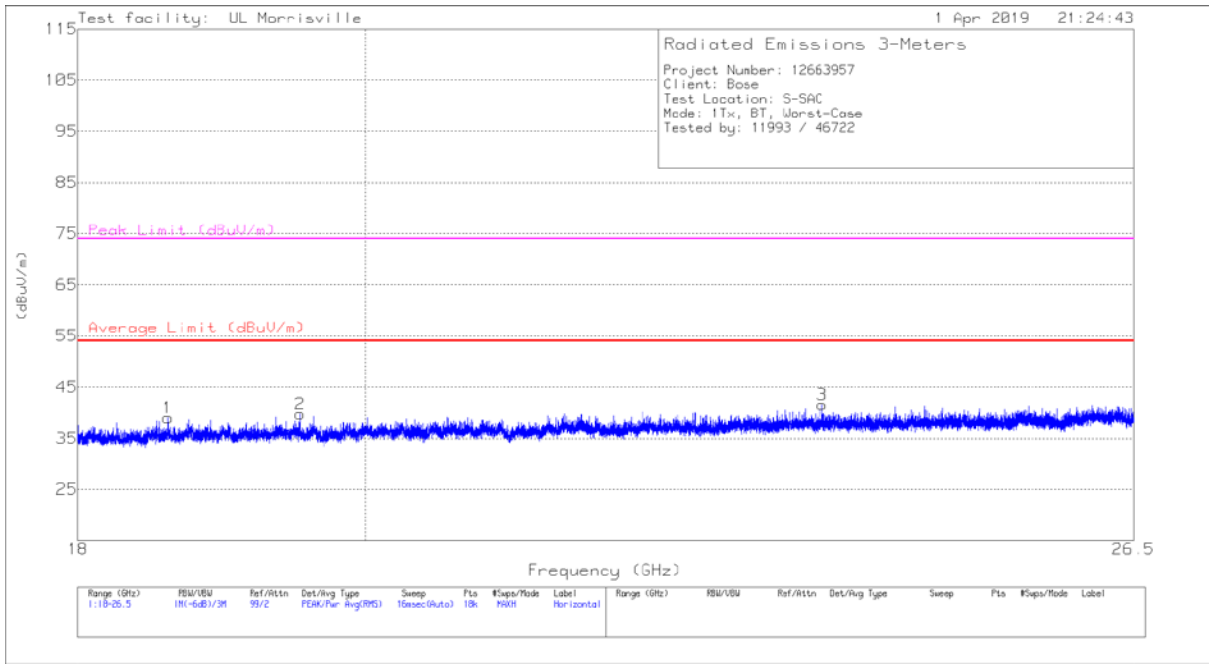
Marker	Frequency (MHz)	Meter Reading (dBuV)	Det	AT0074 AF (dB/m)	Cbl/Amp	Corrected Reading (dBuV/m)	QPk Limit (dBuV/m)	Margin (dB)	Azimuth (Degs)	Height (cm)	Polarity
1	* 37.7795	29.34	Pk	20.2	-31.7	17.84	40	-22.16	0-360	398	H
2	* 123.5242	30.23	Pk	18.2	-30.8	17.63	43.52	-25.89	0-360	99	H
4	* 111.281	30.13	Pk	17.2	-30.9	16.43	43.52	-27.09	0-360	101	V
3	* 403.7265	29.61	Pk	20.5	-29	21.11	46.02	-24.91	0-360	399	H
6	* 609.9533	29.47	Pk	23.6	-28.7	24.37	46.02	-21.65	0-360	102	V
7	* 993.2031	28.92	Pk	28	-25.9	31.02	53.97	-22.95	0-360	299	V
5	201.0001	31.79	Pk	17.6	-30.2	19.19	43.52	-24.33	0-360	102	V

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

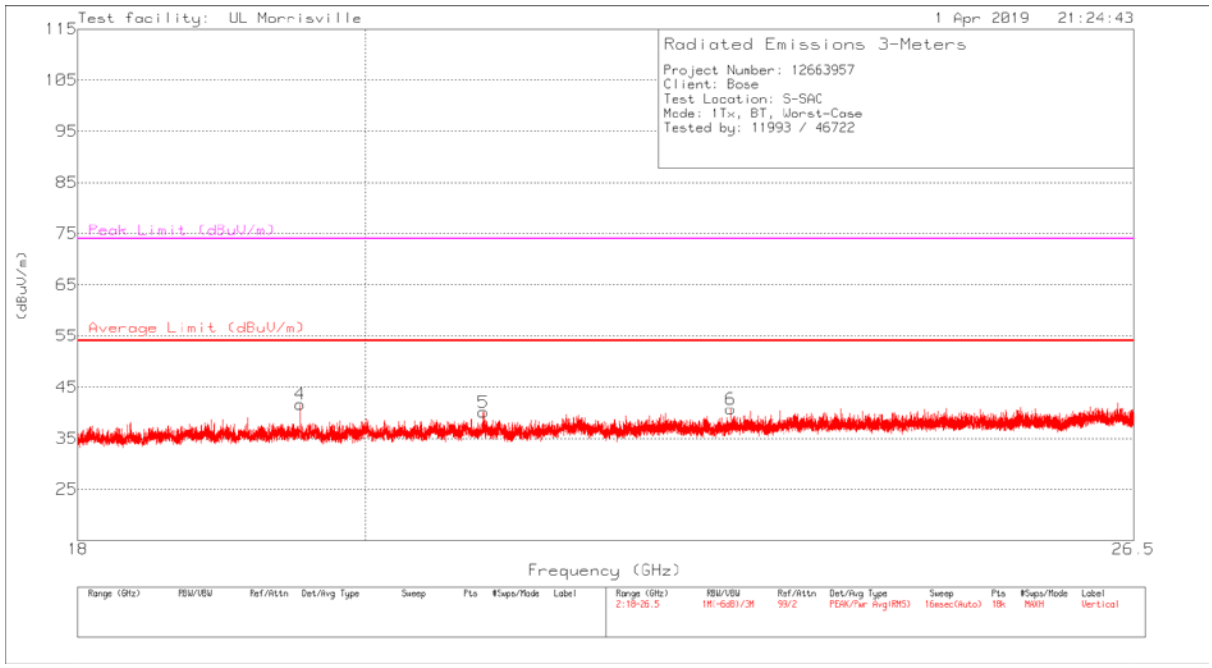
UL LLC
12 Laboratory Dr., RTP, NC 27709; USA TEL:(919) 549-1400
This report shall not be reproduced except in full, without the written approval of UL LLC.

9.4. WORST CASE 18-26 GHZ

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



HORIZONTAL



VERTICAL

UL LLC
12 Laboratory Dr., RTP, NC 27709; USA TEL:(919) 549-1400

This report shall not be reproduced except in full, without the written approval of UL LLC.

18 – 26GHz DATA

Marker	Frequency (GHz)	Meter Reading (dBuV)	Det	AT0076 AF (dB/m)	Cbl/Amp (dB)	Corrected Reading (dBuV/m)	Average Limit (dBuV/m)	Margin (dB)	Peak Limit (dBuV/m)	Margin (dB)	Azimuth (Degs)	Height (cm)	Polarity
1	* 18.604	45.18	Pk	32.7	-38.9	38.98	54	-15.02	74	-35.02	0-360	149	H
2	* 19.529	45.7	Pk	32.8	-38.8	39.7	54	-14.3	74	-34.3	0-360	199	H
3	* 23.642	45.07	Pk	33.9	-37.4	41.57	54	-12.43	74	-32.43	0-360	199	H
4	* 19.529	47.64	Pk	32.8	-38.8	41.64	54	-12.36	74	-32.36	0-360	101	V
5	* 20.883	45.07	Pk	33.1	-38.1	40.07	54	-13.93	74	-33.93	0-360	300	V
6	* 22.865	44.89	Pk	33.6	-37.8	40.69	54	-13.31	74	-33.31	0-360	251	V

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

UL LLC
12 Laboratory Dr., RTP, NC 27709; USA TEL:(919) 549-1400
This report shall not be reproduced except in full, without the written approval of UL LLC.

10. SETUP PHOTOS

Please refer to R12663957L-EP9 for setup photos

END OF TEST REPORT

UL LLC
12 Laboratory Dr., RTP, NC 27709; USA TEL:(919) 549-1400
This report shall not be reproduced except in full, without the written approval of UL LLC.