



TEST REPORT

Report Number : R13274094-E6

Applicant : Raspberry Pi Limited
Maurice Wilkes Building
St. Johns Innovation Park, Crowley Road
Cambridge, CB4 0DS
United Kingdom

Model : Pi Zero 2

FCC ID : 2ABCB-RPIZ2

IC : 20953-RPIZ2

EUT Description : Radio Module with BT/BLE/2.4GHz WLAN

Test Standard(s) : FCC 47 CFR PART 15 SUBPART C
ISED RSS-247 ISSUE 2
ISED RSS-GEN ISSUE 5+A2

Date Of Issue:

2021-08-19

Prepared by:

UL LLC

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REPORT REVISION HISTORY

Ver.	Issue Date	Revisions	Revised By
1	2021-03-26	Initial Issue	Brian T. Kiewra
2	2021-07-16	Editorial revisions	Brian T. Kiewra
3	2021-08-19	Further editorial revisions	Brian T. Kiewra

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1. ATTESTATION OF TEST RESULTS

COMPANY NAME: Raspberry Pi Limited
Maurice Wilkes Building
St. Johns Innovation Park, Crowley Road
Cambridge, CB4 0DS
United Kingdom

EUT DESCRIPTION: Radio Module with BT/BLE/2.4GHz WLAN.

MODEL: Pi Zero 2

BRAND: Raspberry Pi

SERIAL NUMBER: DVT2 #72, DVT2 #42

SAMPLE RECEIPT DATE: 2020-11-09

DATE TESTED: 2020-10-22 to 2021-01-22

APPLICABLE STANDARDS	
STANDARD	TEST RESULTS
CFR 47 Part 15 Subpart C	Complies
ISED RSS-247 Issue 2 / ISED RSS-GEN Issue 5+A2	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.

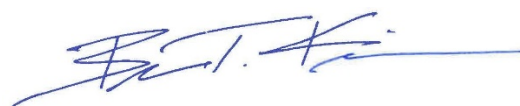
This document may not be altered or revised in any way unless done so by UL LLC and all revisions are duly noted in the revisions section. Any alteration of this document not carried out by UL LLC will constitute fraud and shall nullify the document.

Approved & Released
For UL LLC By:



Jeff Moser
Operations Manager
Consumer Technology Division
UL LLC

Prepared By:



Brian T. Kiewra
Project Engineer
Consumer Technology Division
UL LLC

2. TEST RESULTS SUMMARY

This report contains data provided by the customer which can impact the validity of results. UL LLC is only responsible for the validity of results after the integration of the data provided by the customer.

FCC Clause	ISED Clause	Requirement	Result	Comment
See Comment		Duty Cycle	Reporting purposes only	Per ANSI C63.10, Section 11.6.
See Comment	RSS-GEN 6.7	20dB BW/99% OBW	Reporting purposes only	ANSI C63.10 Sections 6.9.2 and 6.9.3
15.247 (a)(1)	RSS-247 (5.1) (b)	Hopping Frequency Separation	Compliant	None.
15.247 (a)(1)(iii)	RSS-247 (5.1) (d)	Number of Hopping Channels	Compliant	None.
15.247 (a)(1)(iii)	RSS-247 (5.1) (d)	Average Time of Occupancy	Compliant	None.
15.247 (b)(1)	RSS-247 (5.4) (b)	Output Power	Compliant	None.
See Comment		Average Power	Reporting purposes only	Per ANSI C63.10, Section 11.9.2.3.2.
15.247 (d)	RSS-247 (5.5)	Conducted Spurious Emissions	Compliant	None.
15.209, 15.205	RSS-GEN 8.9, 8.10	Radiated Emissions	Compliant	None.
15.207	RSS-Gen 8.8	AC Mains Conducted Emissions	Compliant	None.

3. 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, KDB 414788 D01 Radiated Test Site V01r01, RSS-GEN Issue 5+A2, and RSS-247 Issue 2.

4. FACILITIES AND ACCREDITATION

UL LLC is accredited by A2LA, certification #0751.06, for all testing performed within the scope of this report. Testing was performed at the locations noted below.

	Address	ISED CABID	ISED Company Number	FCC Registration
<input type="checkbox"/>	Building: 12 Laboratory Dr RTP, NC 27709, U.S.A	US0067	2180C	703469
<input checked="" type="checkbox"/>	Building: 2800 Perimeter Park Dr Morrisville, NC 27560, U.S.A		27265	

5. DECISION RULES AND MEASUREMENT UNCERTAINTY

5.1. METROLOGICAL TRACEABILITY

All test and measuring equipment utilized to perform the tests documented in this report are calibrated on a regular basis, with a maximum time between calibrations of one year or the manufacturers' recommendation, whichever is less, and where applicable is traceable to recognized national standards.

5.2. DECISION RULES

The Decision Rule is based on Simple Acceptance in accordance with ISO Guide 98-4:2012 Clause 8.2. (Measurement uncertainty is not taken into account when stating conformity with a specified requirement.)

5.3. 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	1.22%
RF output power, conducted	1.3 dB (PK) 0.45 dB (AV)
RF output power, radiated (SAC) < 180 MHz	6.18 dB
RF output power, radiated (SAC) >=180 MHz	3.23 dB
Power Spectral Density, conducted	2.47 dB
Unwanted Emissions, conducted	1.94 dB
All emissions, radiated	6.01 dB
Conducted Emissions (0.150-30MHz) - LISN	3.40 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%.

5.4. 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)

$$36.5 \text{ dBuV} + 18.7 \text{ dB/m} + 0.6 \text{ dB} - 26.9 \text{ dB} = 28.9 \text{ dBuV/m}$$

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.

$$36.5 \text{ dBuV} + 0 \text{ dB} + 10.1 \text{ dB} + 0 \text{ dB} = 46.6 \text{ dBuV}$$

6. EQUIPMENT UNDER TEST

6.1. EUT DESCRIPTION

The EUT is a BT/BLE/2.4GHz WLAN radio module. This report only covers the BT testing. The PMN is Raspberry Pi Zero 2 and HVIN is 1.0.

6.2. 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	6.22	4.19
2402 - 2480	Enhanced DQPSK	6.69	4.67
2402 - 2480	Enhanced 8PSK	7.13	5.16

Note: GFSK, DQPSK, 8PSK Peak Power were all investigated, The GFSK & 8PSK Power are the worst case. Testing is based on these modes to showing compliance. For Peak power data please refer to section 9.6.

6.3. DESCRIPTION OF AVAILABLE ANTENNAS

The antenna(s) gain, as provided by the manufacturer are as follows:
The radio utilizes an antenna, with a maximum gain of 2.5 dBi.

6.4. SOFTWARE AND FIRMWARE

The EUT firmware installed during testing was v1.0.

The test utility software used during testing was v1.0.

6.5. 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 fundamental of the EUT was investigated in three orthogonal orientations X,Y,Z, it was determined that Z orientation was worst-case orientation; therefore, all final radiated testing was performed with the EUT in Z orientation.

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

GFSK mode: DH5
8PSK mode: 3-DH5

6.6. DESCRIPTION OF TEST SETUP

SUPPORT EQUIPMENT

Support Equipment List				
Description	Manufacturer	Model	Serial Number	FCC ID
Monitor	Viewsonic	VX2452MH	TVT171081663	N/A
Power Supply	Stontronics	DSA-12CA-05	4314HB	V100236

I/O CABLES

I/O Cable List						
Cable No.	Port	# of Identical Ports	Connector Type	Cable Type	Cable Length (m)	Remarks
1	Micro USB	1	USB	USB	1	To AC/DC power supply with USB

SETUP DIAGRAM

Please refer to R13274094-EP1 for setup diagrams.

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 6.3-6.4

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.

8. TEST AND MEASUREMENT EQUIPMENT

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

Test Equipment Used - Wireless Conducted Measurement Equipment

Equipment ID	Description	Manufacturer	Model Number	Last Cal.	Next Cal.
72822	Spectrum Analyzer	Agilent Technologies	E4446A	2020-01-02	2021-01-21
T177	Spectrum Analyzer	Agilent Technologies	E4446A	2020-04-30	2021-04-30
PWM005	RF Power Meter	Keysight Technologies	N1912A	2020-07-14	2021-07-14
PWS005	Peak and Avg Power Sensor, 50MHz to 6GHz	Keysight Technologies	E1921A	2020-05-26	2021-05-26
HI0090	Environmental Meter	Fisher Scientific	15-077-963	2020-06-26	2021-06-26
SOFTEMI	Antenna Port Software	UL	Version 2020.10.22, 2020.12.3	NA	NA
MM0167	True RMS Multimeter	Agilent	U1232A	2020-08-05	2021-08-05

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	2020-08-20	2021-08-20
30-1000 MHz					
AT0075	Hybrid Broadband Antenna	Sunol Sciences Corp.	JB3	2020-10-27	2021-10-27
1-18 GHz					
AT0067	Double-Ridged Waveguide Horn Antenna, 1 to 18 GHz	ETS Lindgren	3117	2020-04-28	2021-04-28
Gain-Loss Chains					
S-SAC01	Gain-loss string: 0.009-30MHz	Various	Various	2020-07-10	2021-07-10
S-SAC02	Gain-loss string: 25-1000MHz	Various	Various	2020-07-10	2021-07-10
S-SAC03	Gain-loss string: 1-18GHz	Various	Various	2020-07-06	2021-07-06
Receiver & Software					
SA0025	Spectrum Analyzer	Agilent	N9030A	2020-03-17	2021-03-17
SOFTEMI	EMI Software	UL	Version 9.5 (2020-08-18)		
Additional Equipment used					
s/n 200037635	Environmental Meter	Fisher Scientific	06-662-4	2020-01-22	2022-01-22

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

Equipment ID	Description	Manufacturer	Model Number	Last Cal.	Next Cal.
18-40 GHz					
AT0063	Horn Antenna, 18-26.5GHz	ARA	MWH-1826/B	2020-10-30	2021-10-30
Gain-Loss Chains					
N-SAC04	Gain-loss string: 18-40GHz	Various	Various	2020-07-31	2021-07-31
Receiver & Software					
SA0026	Spectrum Analyzer	Agilent	N9030A	2020-07-16	2021-07-16
SA0027	Spectrum Analyzer	Agilent	N9030A	2020-06-10	2021-06-10
SOFTEMI	EMI Software	UL	Version 9.5 (2020-08-18)		
Additional Equipment used					
s/n 200037610	Environmental Meter	Fisher Scientific	06-662-4	2020-01-22	2022-01-22

Test Equipment Used - Line-Conducted Emissions – Voltage (Morrisville – Conducted 1)

Equipment ID	Description	Manufacturer	Model Number	Last Cal.	Next Cal.
CBL087	Coax cable, RG223, N-male to BNC-male, 20-ft.	Pasternack	PE3W06143-240	2020-03-26	2021-03-26
HI0091	Environmental Meter	Fisher Scientific	14-650-118	2020-06-26	2021-06-26
LISN003	LISN, 50-ohm/50-uH, 2-conductor, 25A	Fischer Custom Com.	FCC-LISN-50-25-2-01-550V	2020-08-18	2021-08-18
75141	EMI Test Receiver 9kHz-7GHz	Rohde & Schwarz	ESCI 7	2020-08-18	2021-08-18
ATA222	Transient Limiter, 0.009-100MHz	Electro-Metrics	EM-7600	2020-03-26	2021-03-26
PS214	AC Power Source	Elgar	CW2501M (s/n 1523A02396)	NA	NA
SOFTEMI	EMI Software	UL	Version 9.5 (2018-08-18)		

9. ANTENNA PORT TEST RESULTS

9.1. ON TIME AND DUTY CYCLE

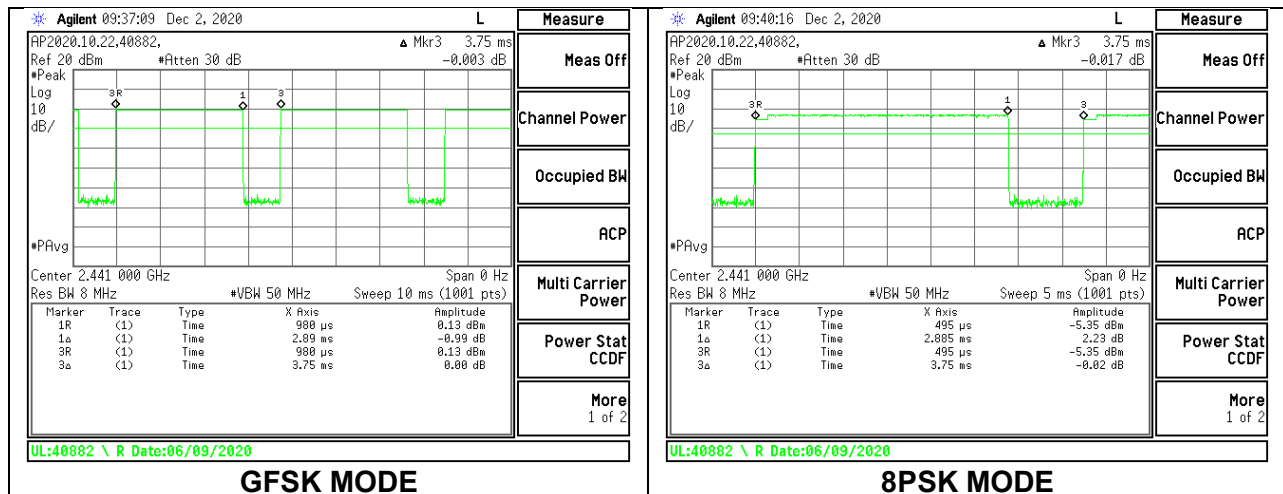
LIMITS

None; for reporting purposes only.

PROCEDURE

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

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	0.771	77.1%	1.13	0.346
Bluetooth 8PSK	2.885	3.75	0.769	76.9%	1.14	0.347



Note: The normal mode DCCF that will be used in the market was calculated based on the worst case 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 100 ms or 2x 3.125 ms = 6.25 ms on any channel. Therefore, 20log (6.25 / 100) = -24dB.

9.2. 20 dB AND 99% BANDWIDTH

LIMITS

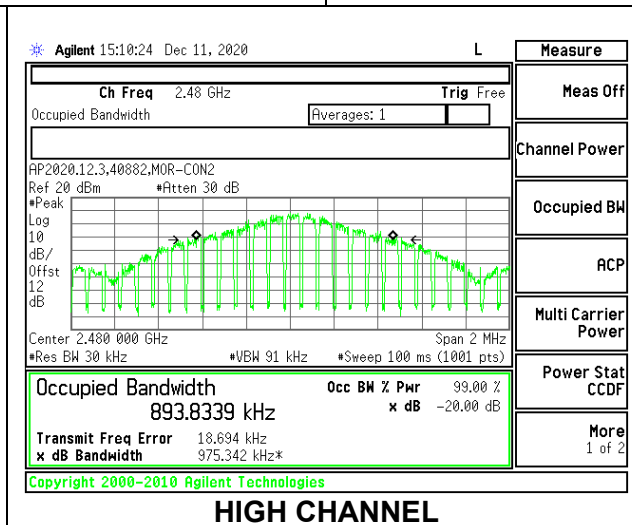
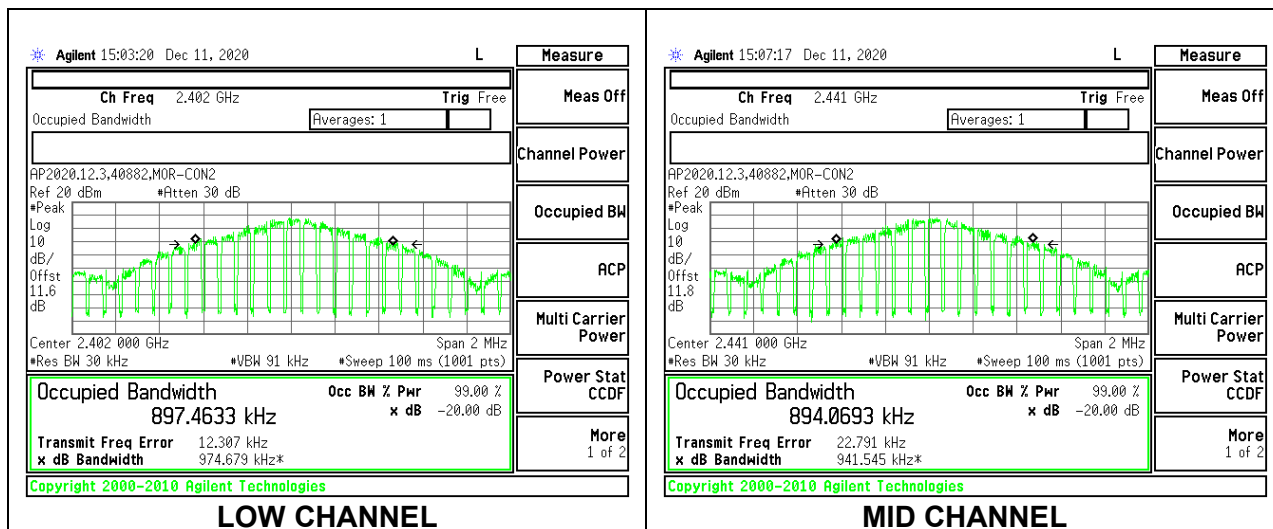
None; for reporting purposes only.

TEST PROCEDURE

The transmitter output is connected to a spectrum analyzer. The RBW is set to $\geq 1\%$ of the 20 dB bandwidth. The VBW is set to $\geq 3x$ RBW. The sweep time is coupled.

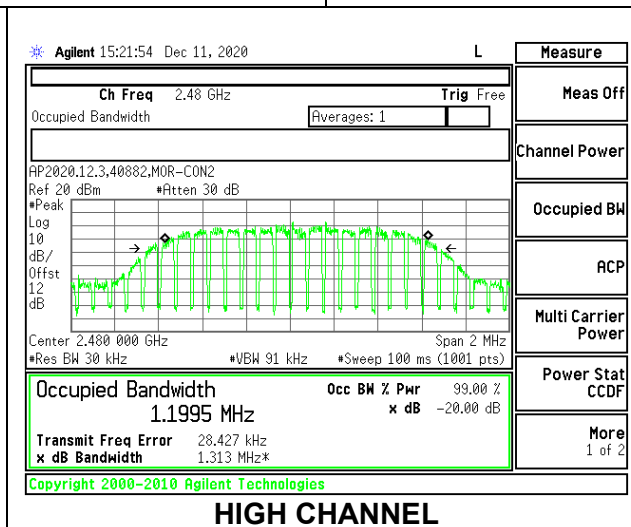
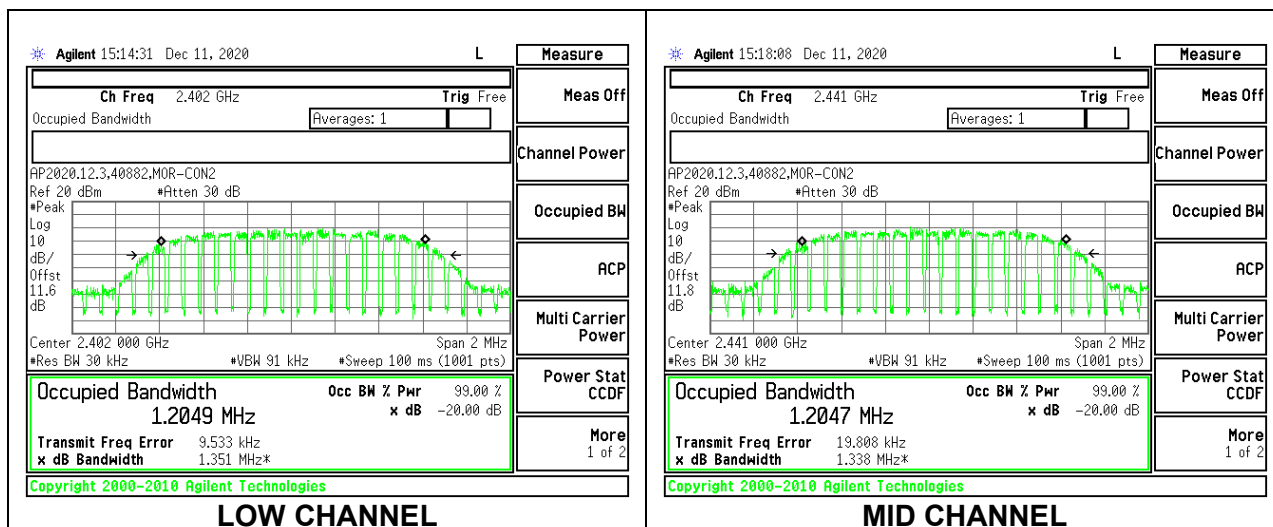
9.2.1. BLUETOOTH BASIC DATA RATE GFSK MODULATION

Channel	Frequency (MHz)	20dB Bandwidth (MHz)	99% Bandwidth (MHz)
Low	2402	0.975	0.897
Mid	2441	0.942	0.894
High	2480	0.975	0.894



9.2.2. BLUETOOTH ENHANCED DATA RATE 8PSK MODULATION

Channel	Frequency (MHz)	20dB Bandwidth (MHz)	99% Bandwidth (MHz)
Low	2402	1.351	1.205
Mid	2441	1.338	1.205
High	2480	1.313	1.2



9.3. 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 hopping channel, whichever is greater.

Alternatively, frequency hopping systems operating in the 2400-2483.5 MHz band may have hopping channel carrier frequencies that are separated by 25 kHz or two-thirds of the 20 dB bandwidth of the hopping channel, whichever is greater, provided the systems operate with an output power no greater than 125 mW.

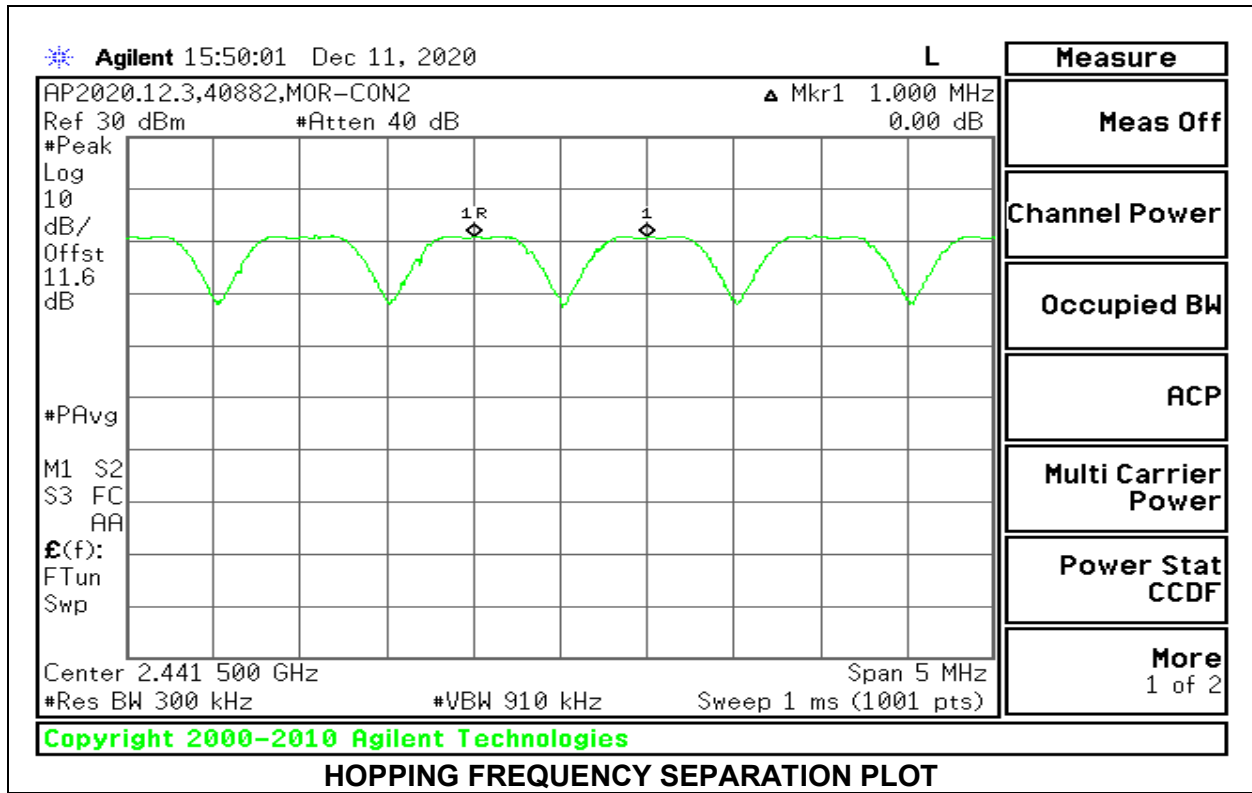
TEST PROCEDURE

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

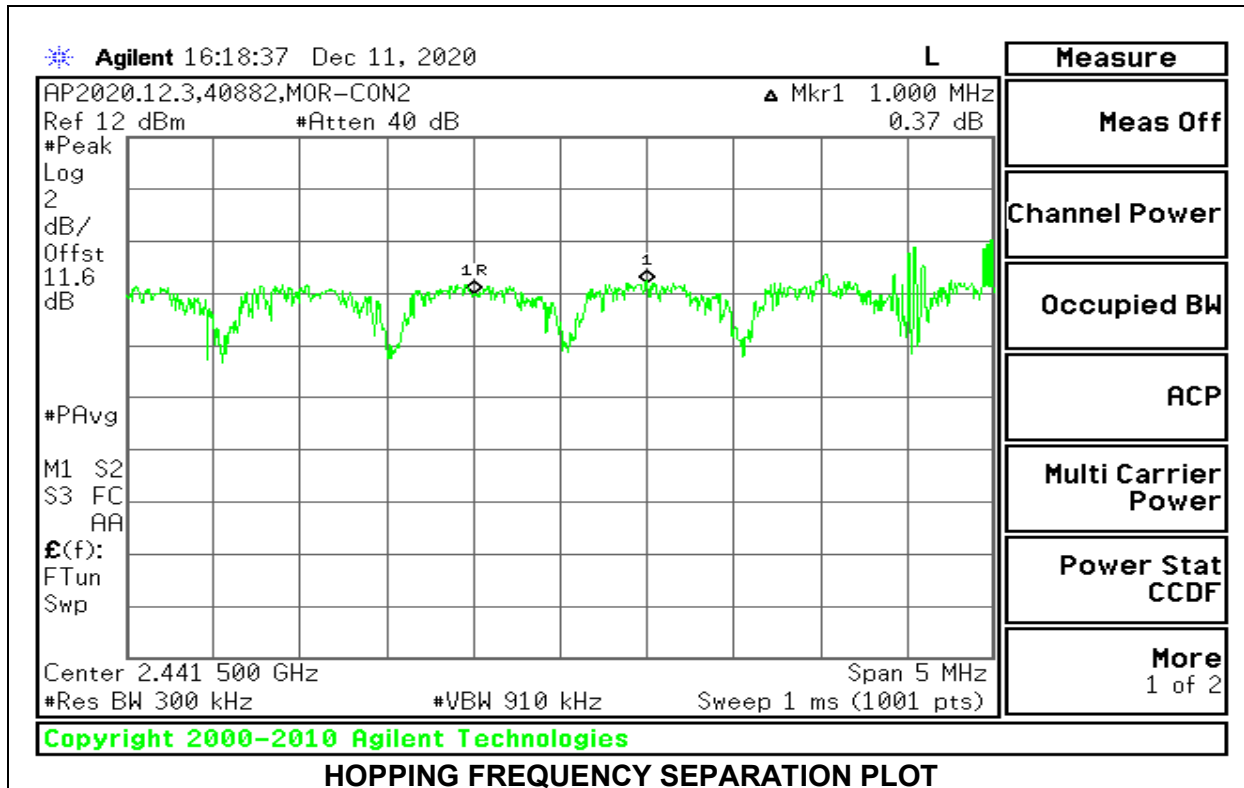
RESULTS

Only High Power GFSK mode result is reported since EDR (QPSK/8PSK) has exact same channel plan.

9.3.1. BLUETOOTH BASIC DATA RATE GFSK MODULATION



9.3.2. BLUETOOTH ENHANCED DATA RATE 8PSK MODULATION



Note – The channel hopping separation of 1MHz is less than the 20 dB bandwidth (approx. 1.35MHz). However, the output power is less than 125 mW and the channel separation is greater than 2/3 the 20 dB bandwidth (approx. 901 kHz).

Ch. A (MHz)	Ch. B (MHz)	Ch. 1 to Ch. 2 Sep. (MHz)	Max. 20 dB BW (MHz)	2/3 20 dB BW (MHz)	Margin (MHz)
2441	2442	1.000	1.351	0.901	-0.099

9.4. 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.

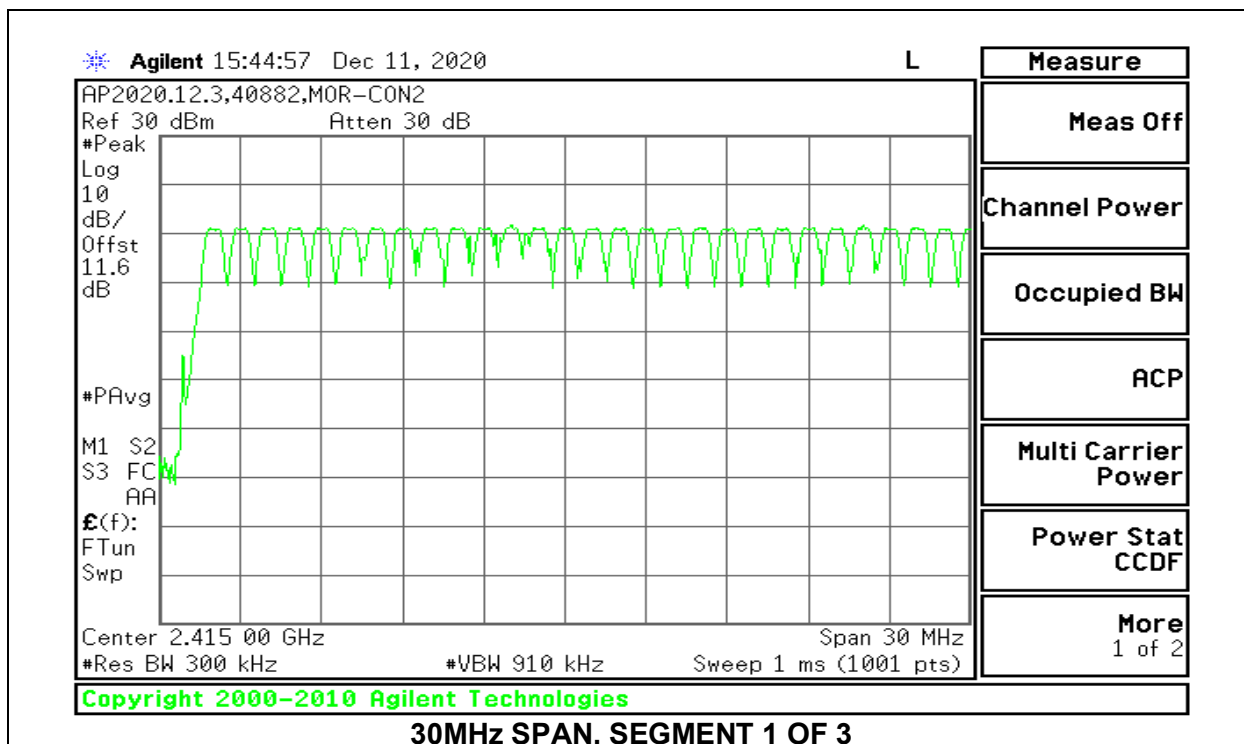
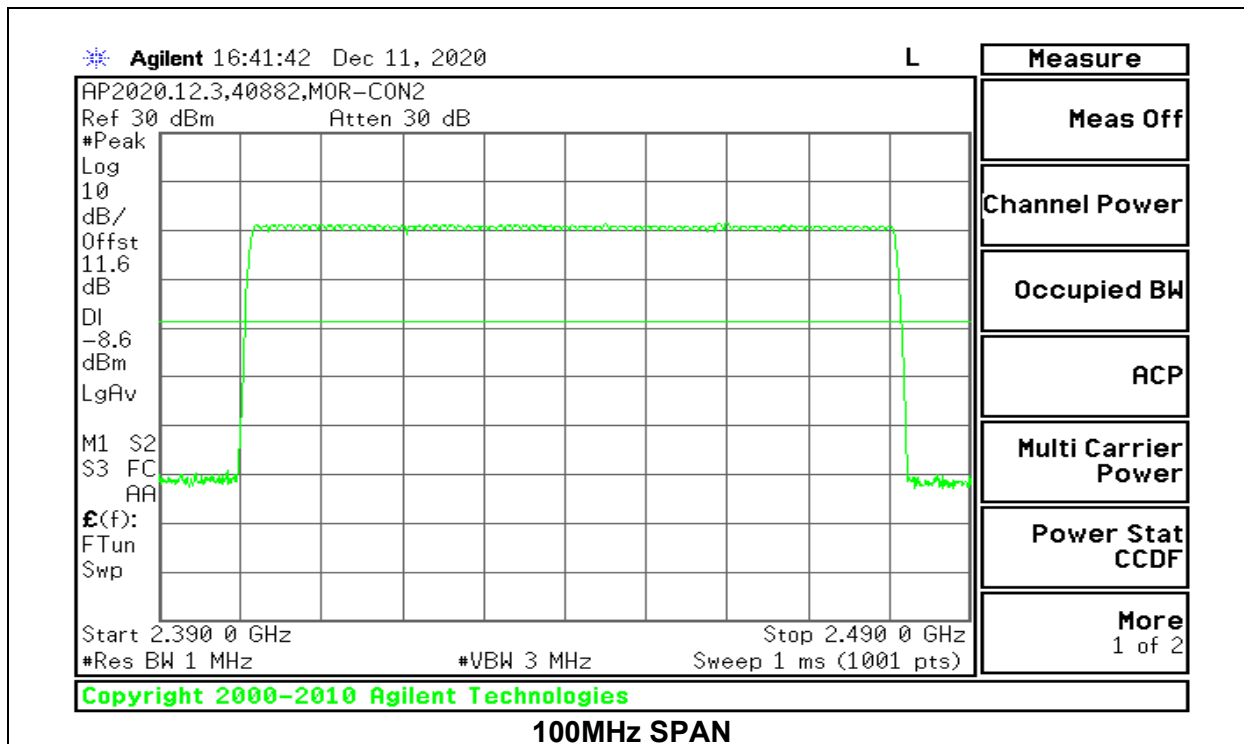
TEST PROCEDURE

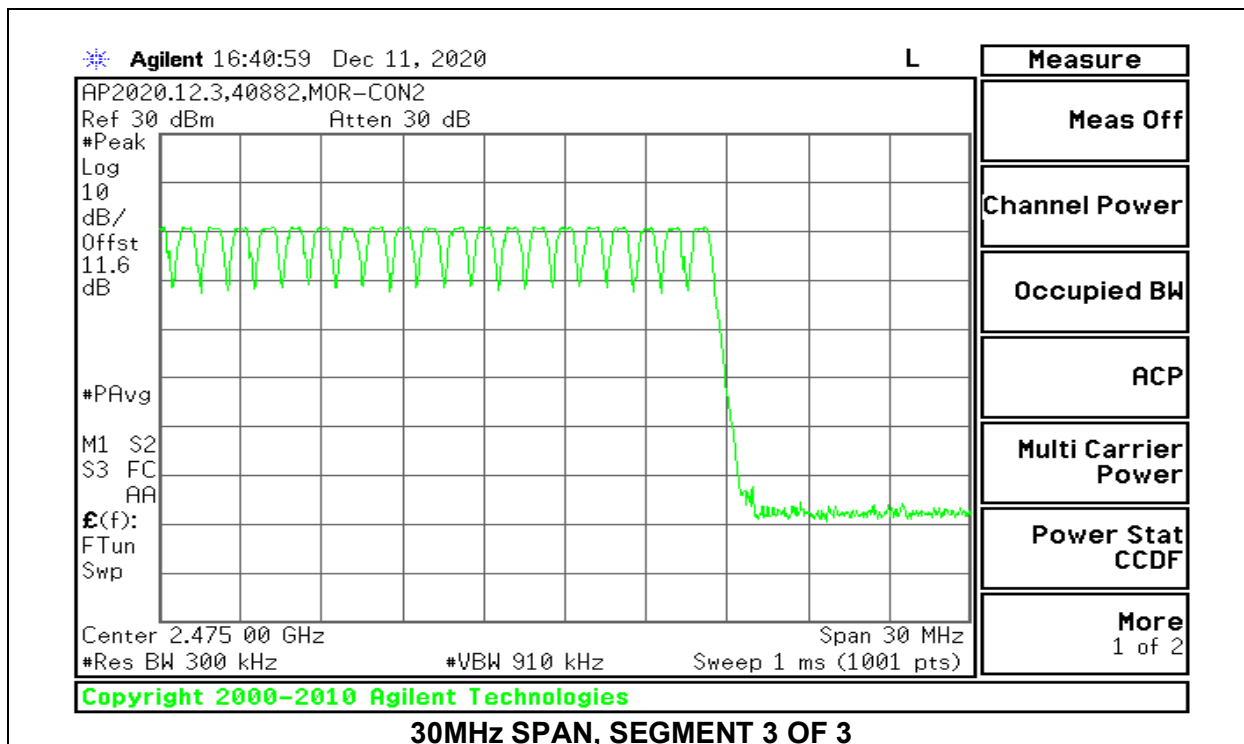
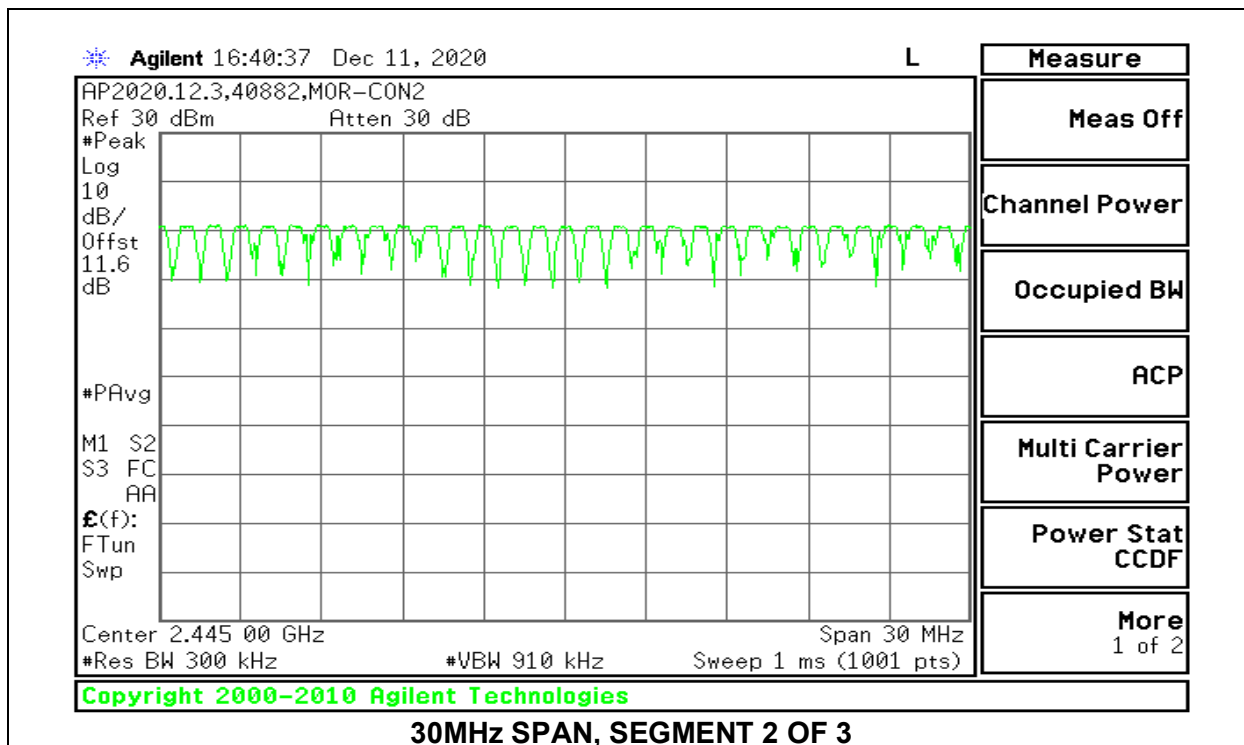
The transmitter output is connected to a spectrum analyzer. The span is set to cover the entire authorized band, in either a single sweep or in multiple contiguous sweeps. The RBW is set to a maximum of 30% of the channel spacing. The analyzer is set to Max Hold.

RESULTS

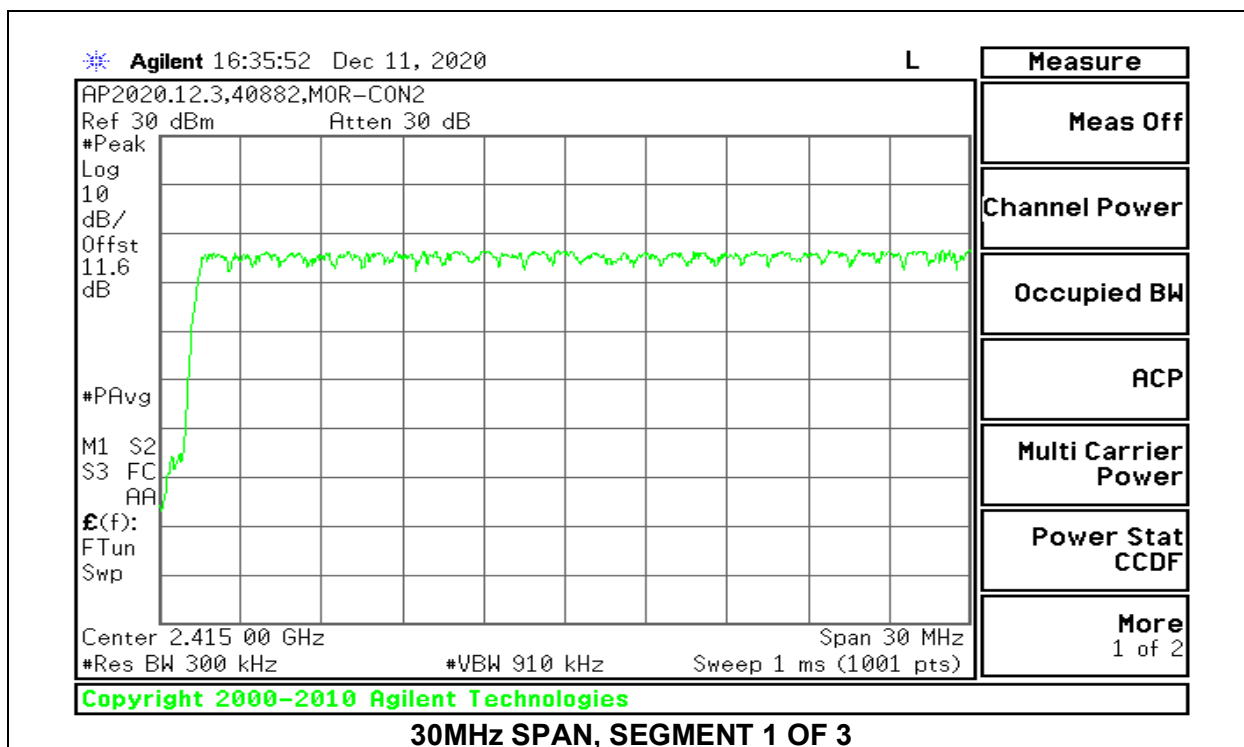
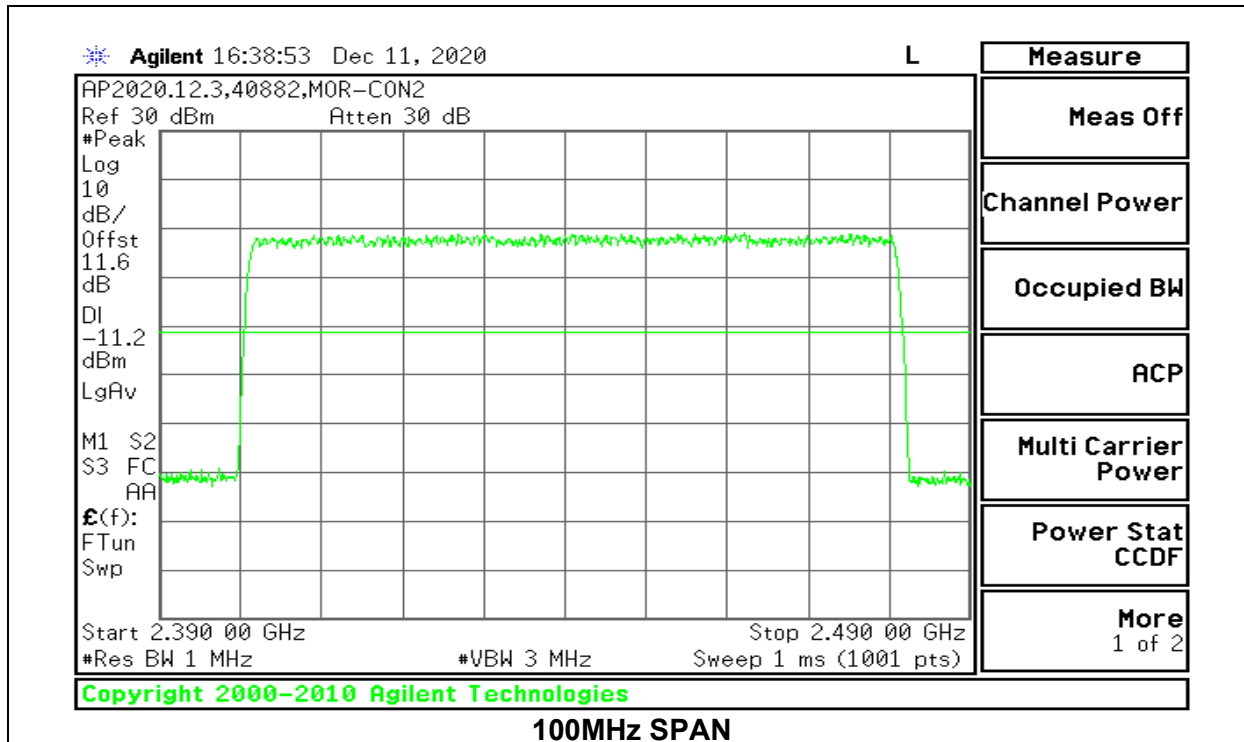
Normal Mode: All Channels Observed

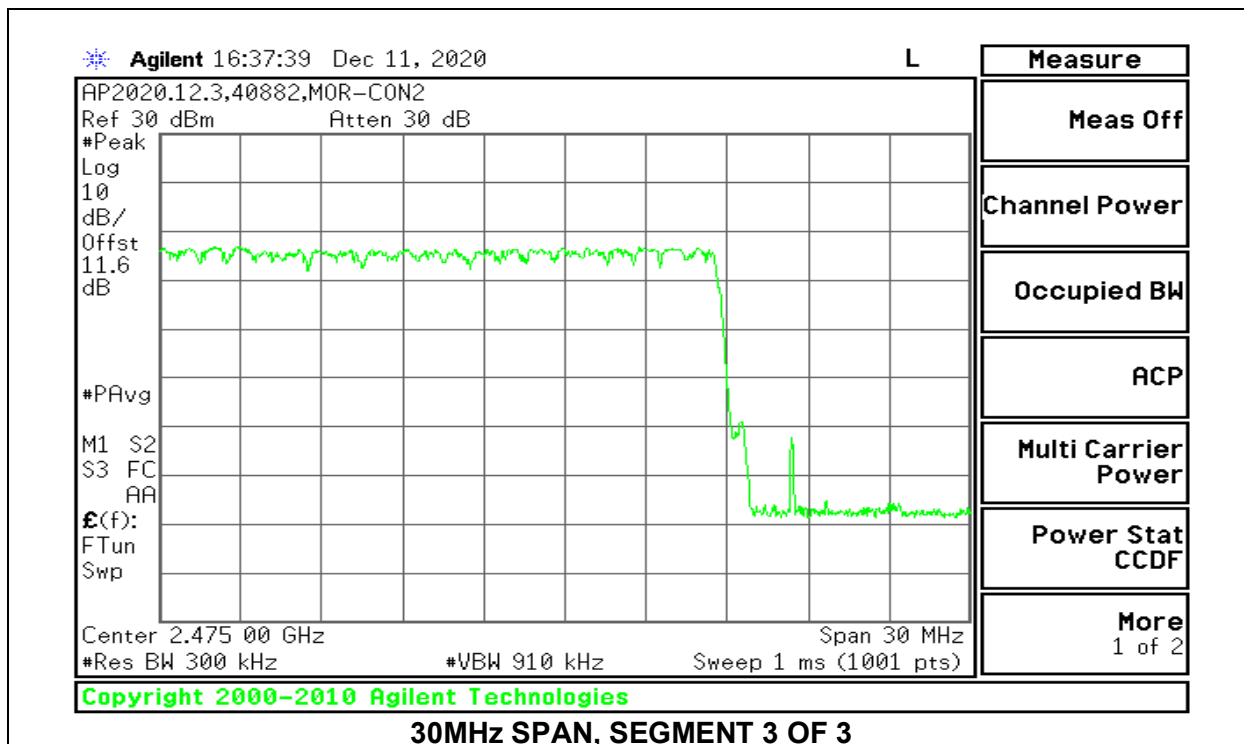
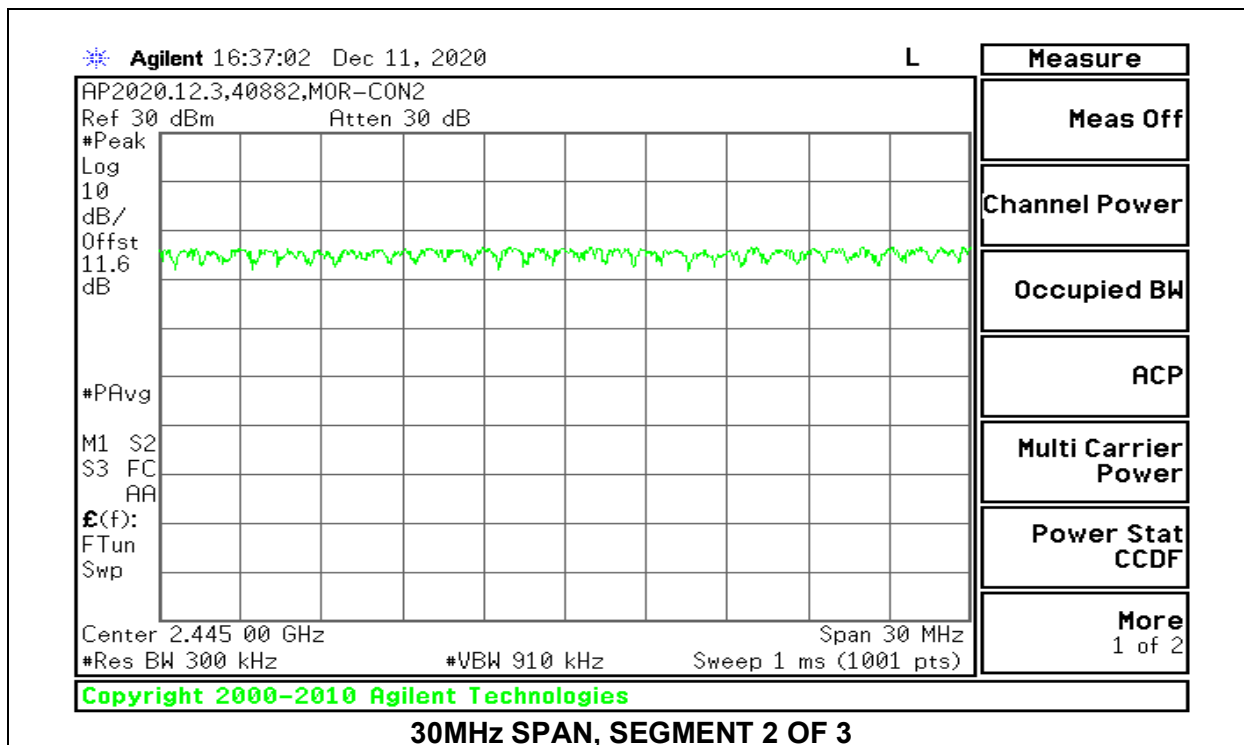
9.4.1. BLUETOOTH BASIC DATA RATE GFSK MODULATION





9.4.2. BLUETOOTH ENHANCED DATA RATE 8PSK MODULATION





9.5. 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

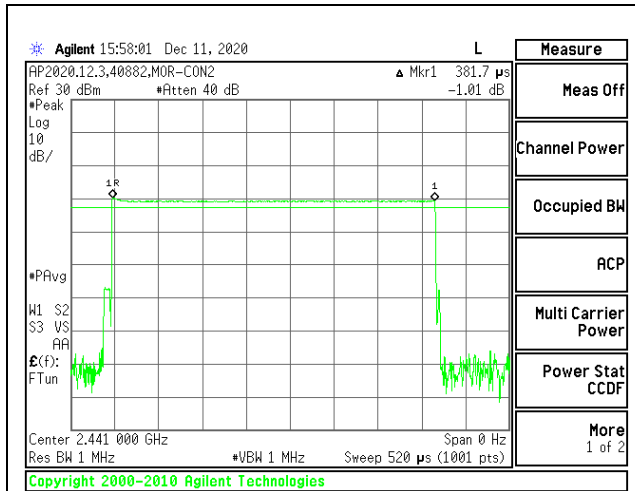
The transmitter output is connected to a spectrum analyzer. The span is set to 0 Hz, centered on a single, selected hopping channel. The width of a single pulse is measured in a fast scan. The number of pulses is measured in a 3.16 second scan, to enable resolution of each occurrence.

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

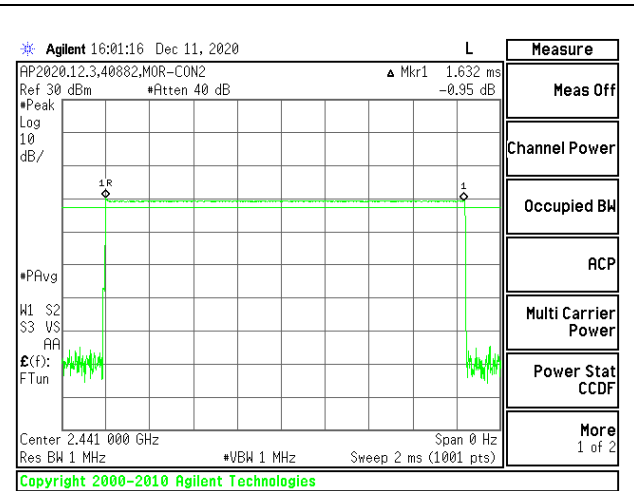
For AFH mode, the average time of occupancy in the specified 8 second period (20 channels * 0.4 seconds) is equal to $10 * (\# \text{ of pulses in } 0.8 \text{ s}) * \text{ pulse width}$.

9.5.1. BLUETOOTH BASIC DATA RATE GFSK MODULATION

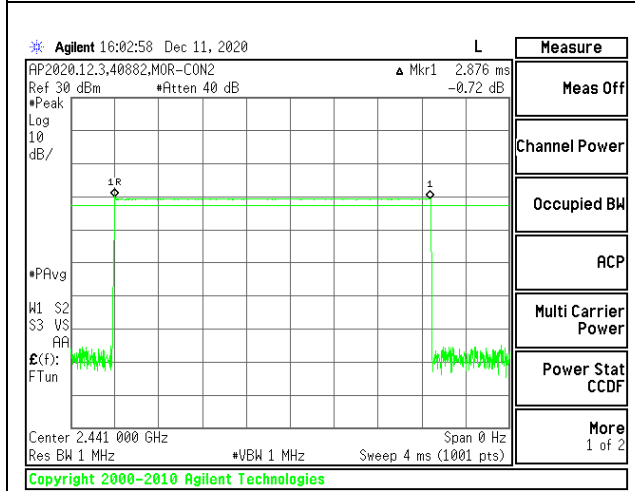
DH Packet	Pulse Width (msec)	Number of Pulses in 3.16 seconds	Average Time of Occupancy (sec)	Limit (sec)	Margin (sec)
GFSK Normal Mode					
DH1	0.3817	32	0.1221	0.4	-0.2779
DH3	1.632	20	0.3264	0.4	-0.0736
DH5	2.876	13	0.3739	0.4	-0.0261
GFSK AFH Mode					
DH Packet	Pulse Width (sec)	Number of Pulses in 0.8 seconds	Average Time of Occupancy (sec)	Limit (sec)	Margin (sec)
DH1	0.3817	8	0.03054	0.4	-0.3695
DH3	1.632	5	0.08160	0.4	-0.3184
DH5	2.876	3.25	0.09347	0.4	-0.3065



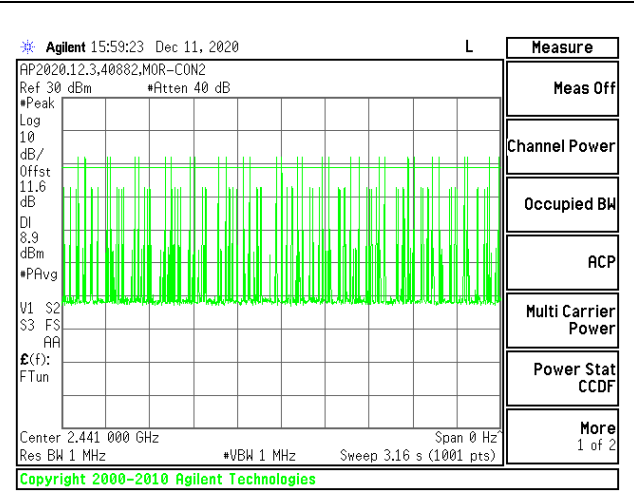
PULSE WIDTH – DH1



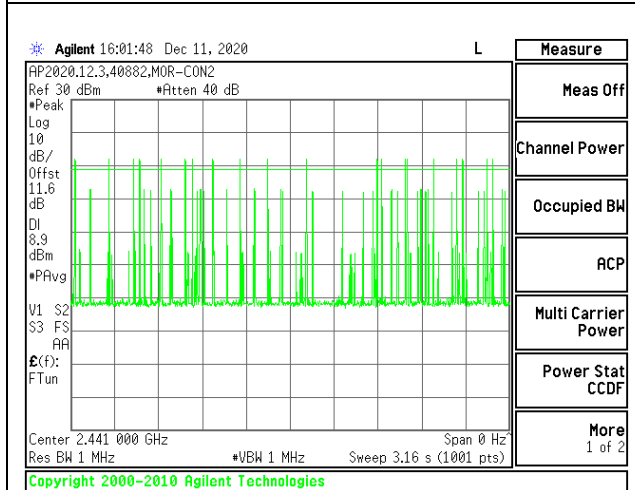
PULSE WIDTH – DH3



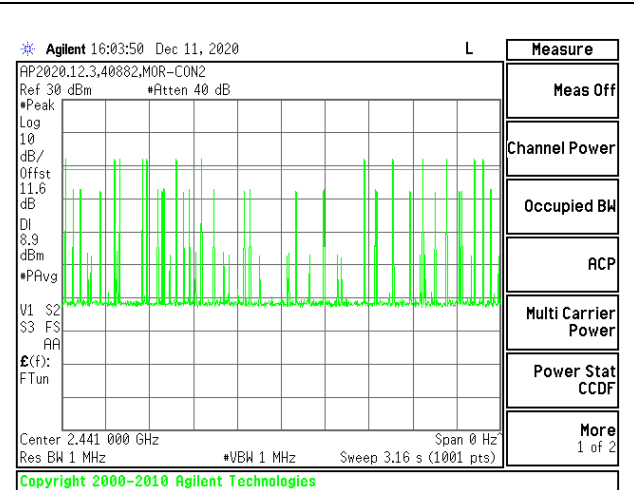
PULSE WIDTH – DH5



NUMBER OF PULSES IN 3.16 SECOND OBSERVATION PERIOD – DH1



NUMBER OF PULSES IN 3.16 SECOND OBSERVATION PERIOD – DH3



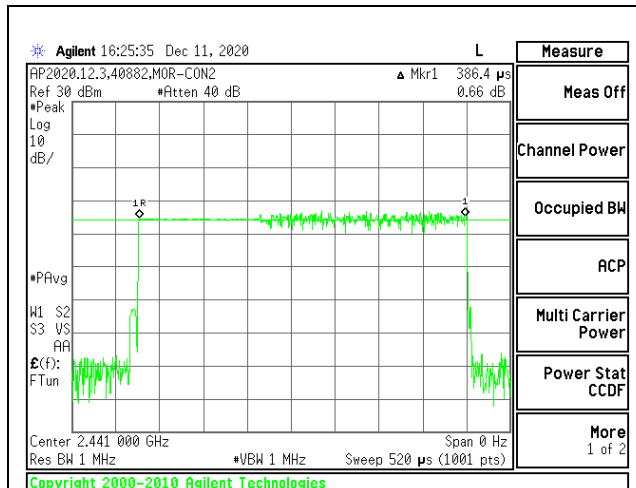
NUMBER OF PULSES IN 3.16 SECOND OBSERVATION PERIOD – DH5

9.5.2. BLUETOOTH ENHANCED DATA RATE 8PSK MODULATION

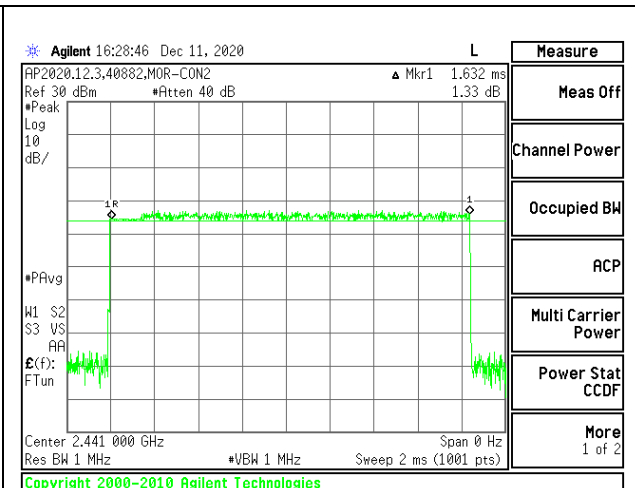
DH Packet	Pulse Width (msec)	Number of Pulses in 3.16 seconds	Average Time of Occupancy (sec)	Limit (sec)	Margin (sec)
8PSK Normal Mode					
3DH1	0.386	32	0.12352	0.4	-0.27648
3DH3	1.632	14	0.22848	0.4	-0.17152
3DH5	2.88	11	0.3168	0.4	-0.0832

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.

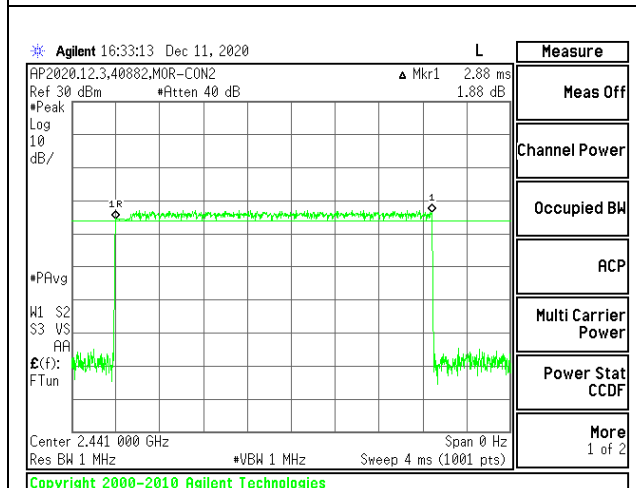
Additionally, 8PSK represents DQPSK since both are Phased Shift Keying Modulation, Enhanced Data Rate and 8PSK has higher power.



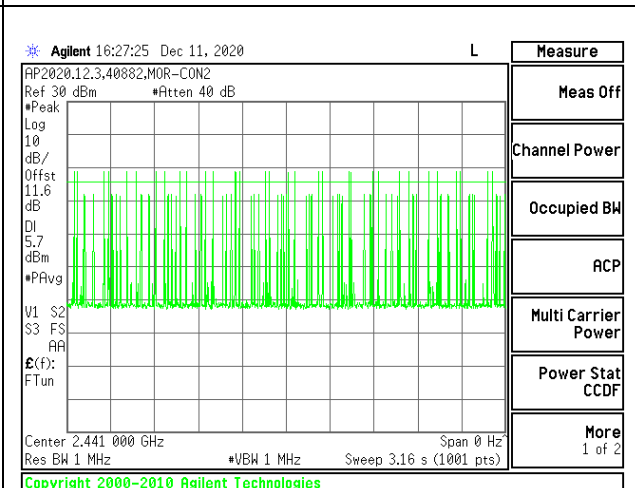
PULSE WIDTH - 3DH1



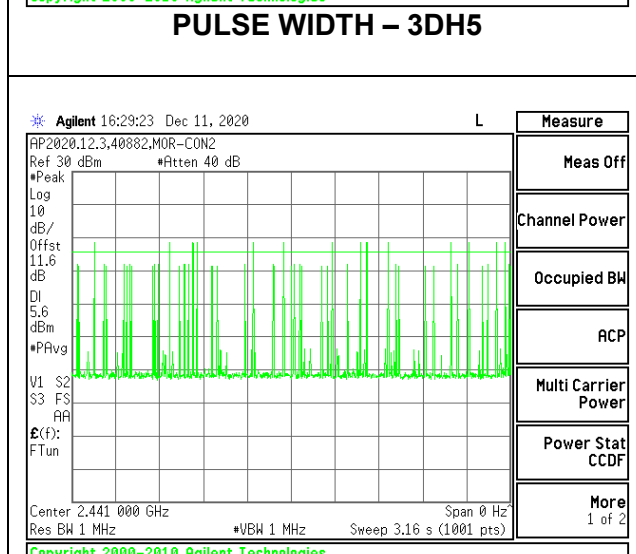
PULSE WIDTH - 3DH3



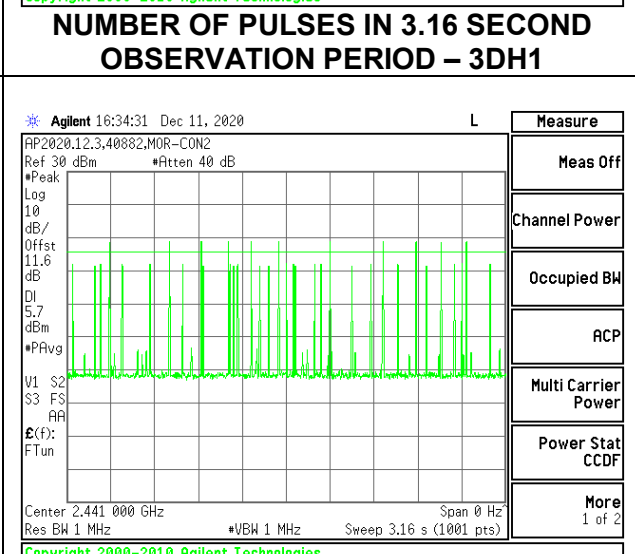
PULSE WIDTH - 3DH5



**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**

9.6. 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.

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

TEST PROCEDURE

Measurements perform using a wideband gated RF power meter.

The cable assembly insertion loss of 11.61 dB (including 10.13 dB pad and 1.48 dB cable) was entered as an offset in the power meter.

9.6.1. BLUETOOTH BASIC DATA RATE GFSK MODULATION

Tested By:	40882
Date:	2021-01-22

Channel	Frequency (MHz)	Output Power (dBm)	Limit (dBm)	Margin (dB)
Low	2402	5.55	30	-24.45
Middle	2441	5.79	30	-24.21
High	2480	6.22	30	-23.78

9.6.2. BLUETOOTH ENHANCED DATA RATE 8PSK MODULATION

Tested By:	40882
Date:	2021-01-22

Channel	Frequency (MHz)	Output Power (dBm)	Limit (dBm)	Margin (dB)
Low	2402	7.13	21	-13.87
Middle	2441	7.07	21	-13.93
High	2480	7.13	21	-13.87

9.6.3. BLUETOOTH ENHANCED DATA RATE DQPSK MODULATION

Tested By:	40882
Date:	2021-01-22

Channel	Frequency (MHz)	Output Power (dBm)	Limit (dBm)	Margin (dB)
Low	2402	6.69	21	-14.31
Middle	2441	6.58	21	-14.42
High	2480	6.67	21	-14.33

9.7. AVERAGE POWER

LIMITS

None; for reporting purposes only

TEST PROCEDURE

Gated average power measurements performed using a wideband gated RF power meter.

The cable assembly insertion loss of 11.61 dB (including 10.13 dB pad and 1.48 dB cable) was entered as an offset in the power meter.

9.7.1. BLUETOOTH BASIC DATA RATE GFSK MODULATION

Tested By:	40882
Date	2021-01-22

Channel	Frequency (MHz)	Average Power (dBm)
Low	2402	5.35
Middle	2441	5.59
High	2480	6.05

9.7.2. BLUETOOTH ENHANCED DATA RATE 8PSK MODULATION

Tested By:	40882
Date	2021-01-22

Channel	Frequency (MHz)	Average Power (dBm)
Low	2402	4.01
Middle	2441	3.97
High	2480	4.09

9.7.3. BLUETOOTH ENHANCED DATA RATE DQPSK MODULATION

Tested By:	40882
Date	2021-01-22

Channel	Frequency (MHz)	Average Power (dBm)
Low	2402	4.08
Middle	2441	3.97
High	2480	4.09

9.8. CONDUCTED SPURIOUS EMISSIONS

LIMITS

FCC §15.247 (d)

RSS-247 5.5

Limit = -20 dBc

TEST PROCEDURE

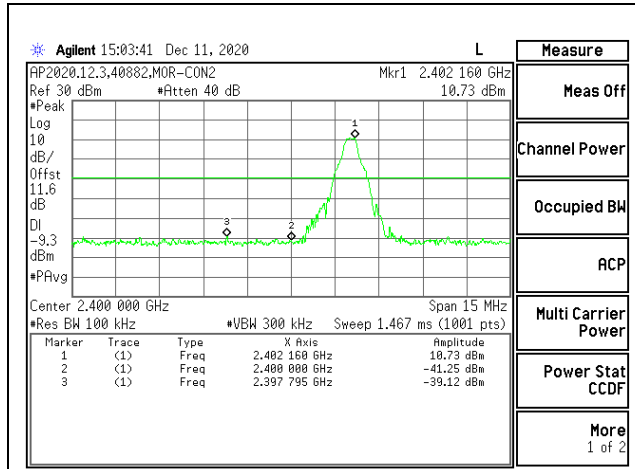
The transmitter output is connected to a spectrum analyzer. The resolution bandwidth is set to 100 kHz. The video bandwidth is set to 300 kHz.

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

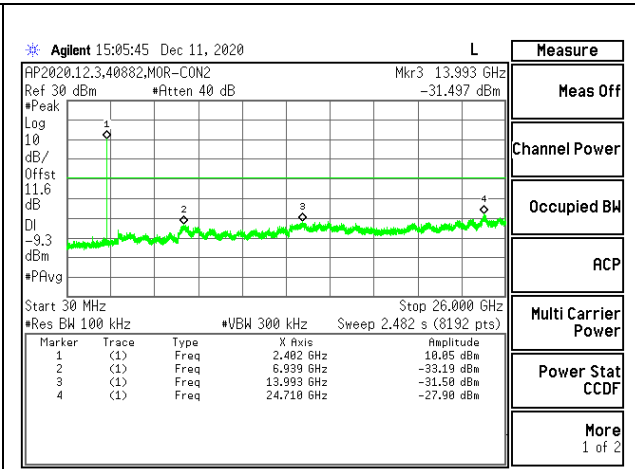
The bandedges at 2.4 and 2.4835 GHz are investigated with the transmitter set to the normal hopping mode.

9.8.1. BLUETOOTH BASIC DATA RATE GFSK MODULATION

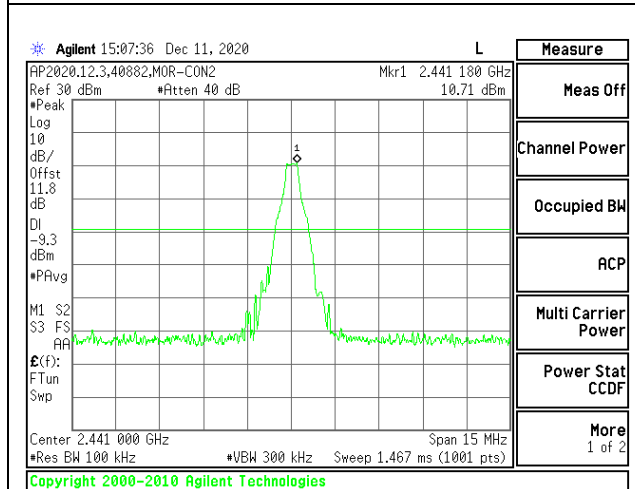
SPURIOUS EMISSIONS, NON-HOPPING



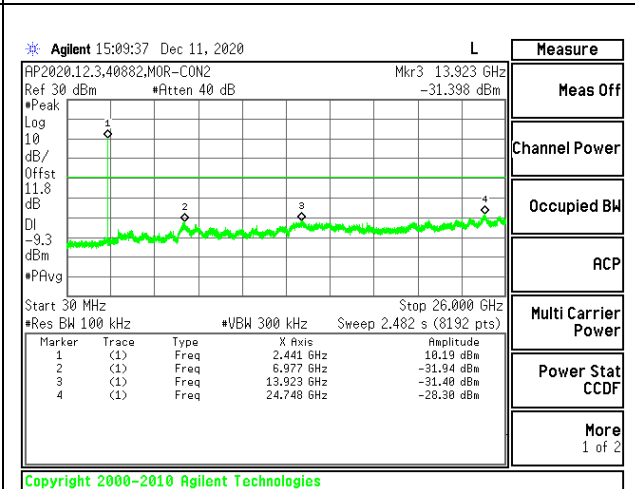
LOW CHANNEL BANDEDGE



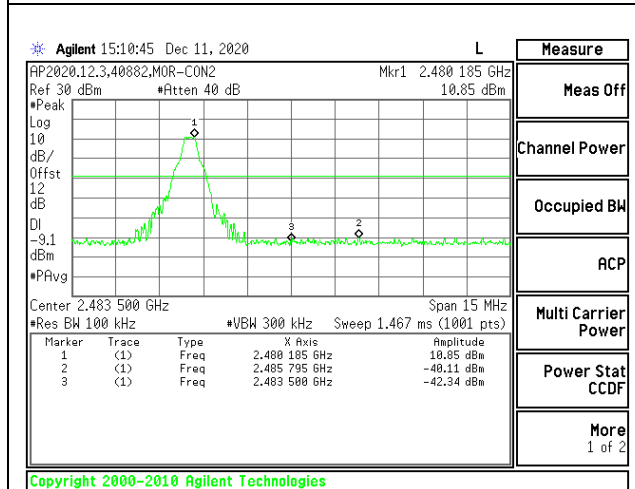
OUT-OF-BAND LOW CHANNEL



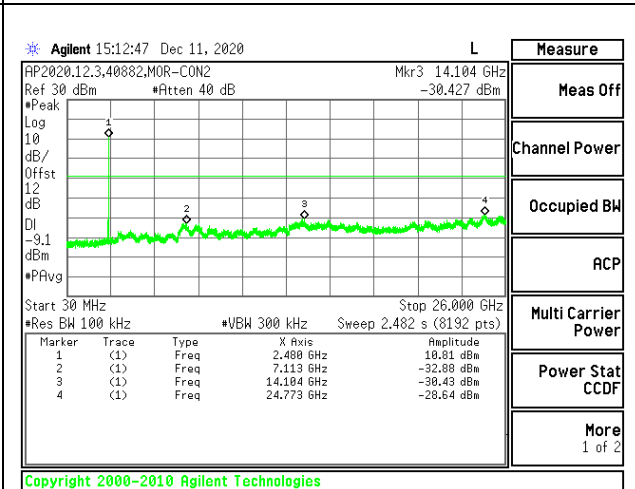
IN-BAND REFERENCE LEVEL



OUT-OF-BAND MID CHANNEL

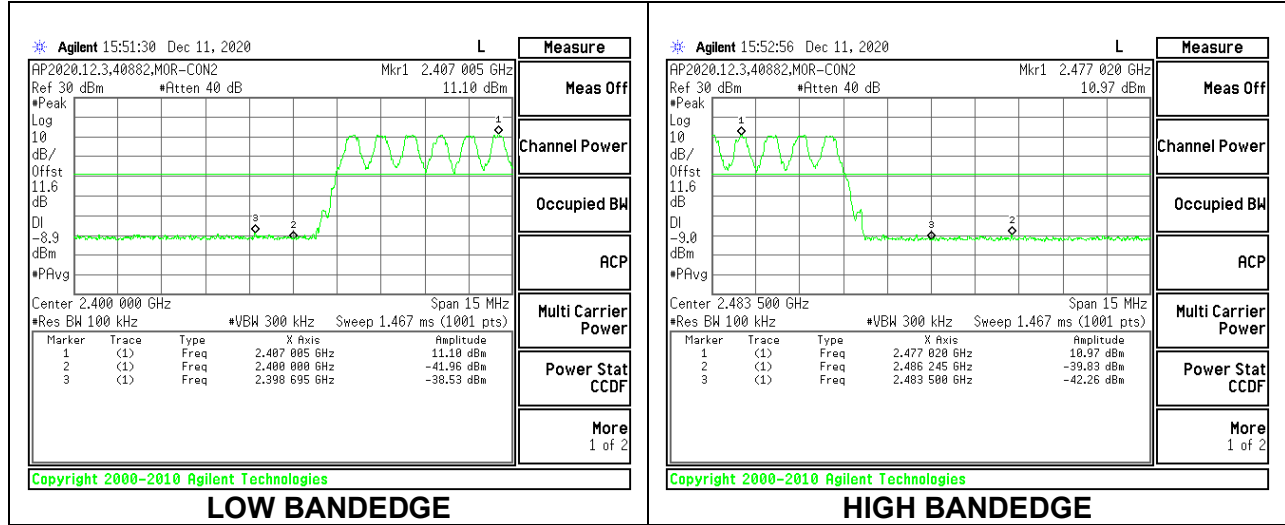


HIGH CHANNEL BANDEDGE



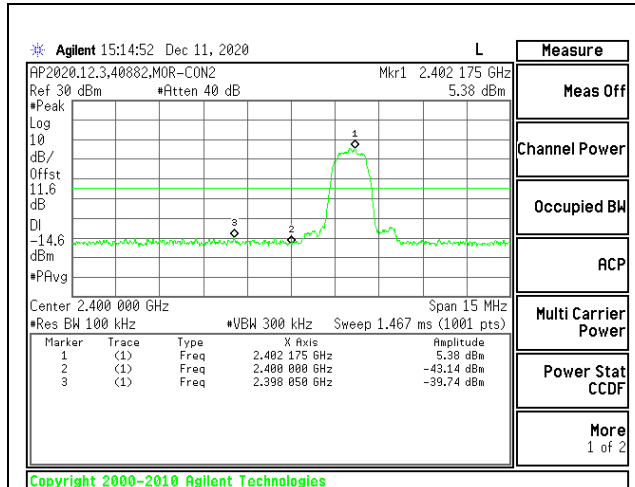
OUT-OF-BAND HIGH CHANNEL

SPURIOUS BANDEGE EMISSIONS WITH HOPPING ON

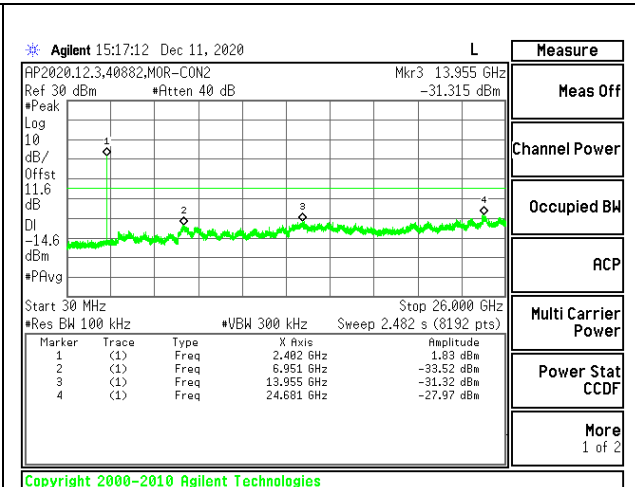


9.8.2. BLUETOOTH ENHANCED DATA RATE 8PSK MODULATION

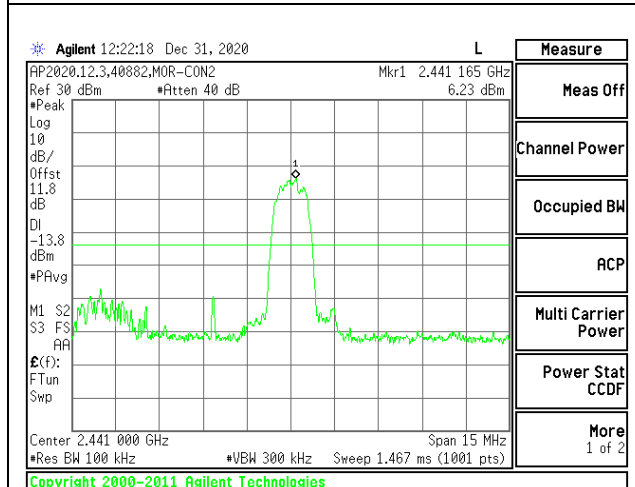
SPURIOUS EMISSIONS, NON-HOPPING



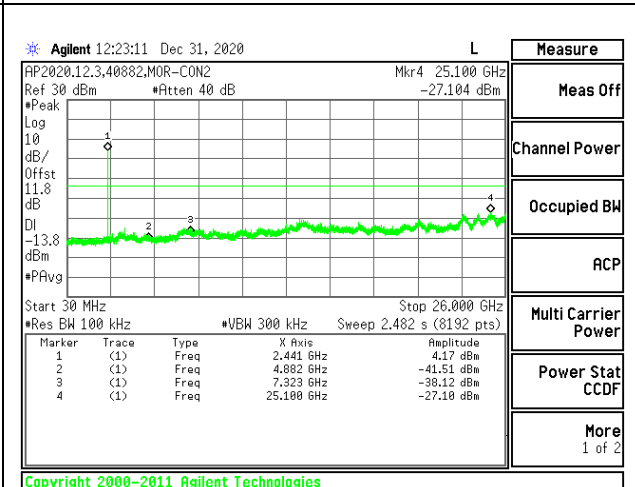
LOW CHANNEL BANDEDGE



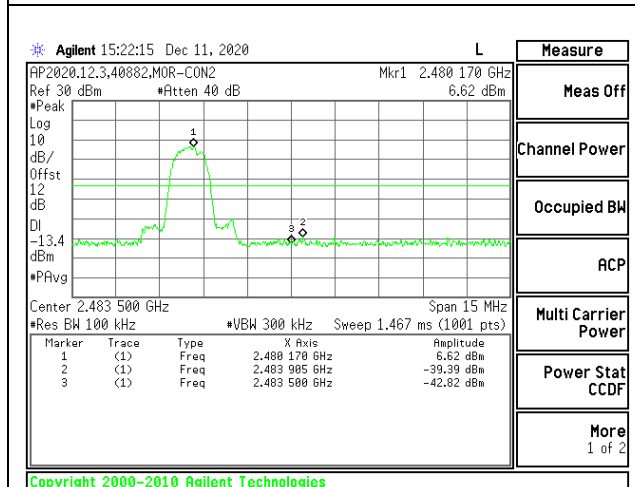
OUT-OF-BAND LOW CHANNEL



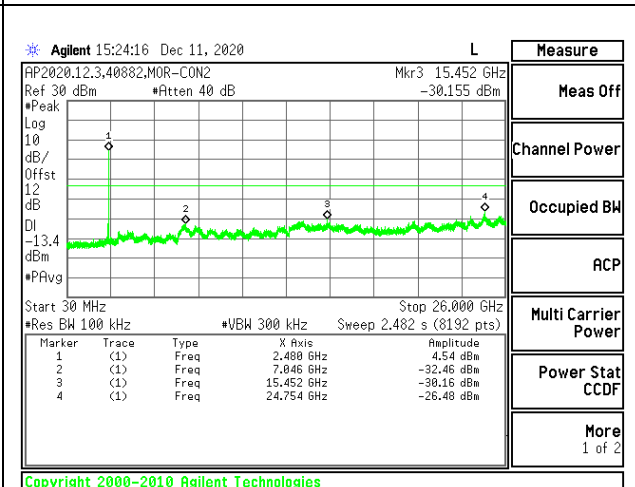
IN-BAND REFERENCE LEVEL



OUT-OF-BAND MID CHANNEL

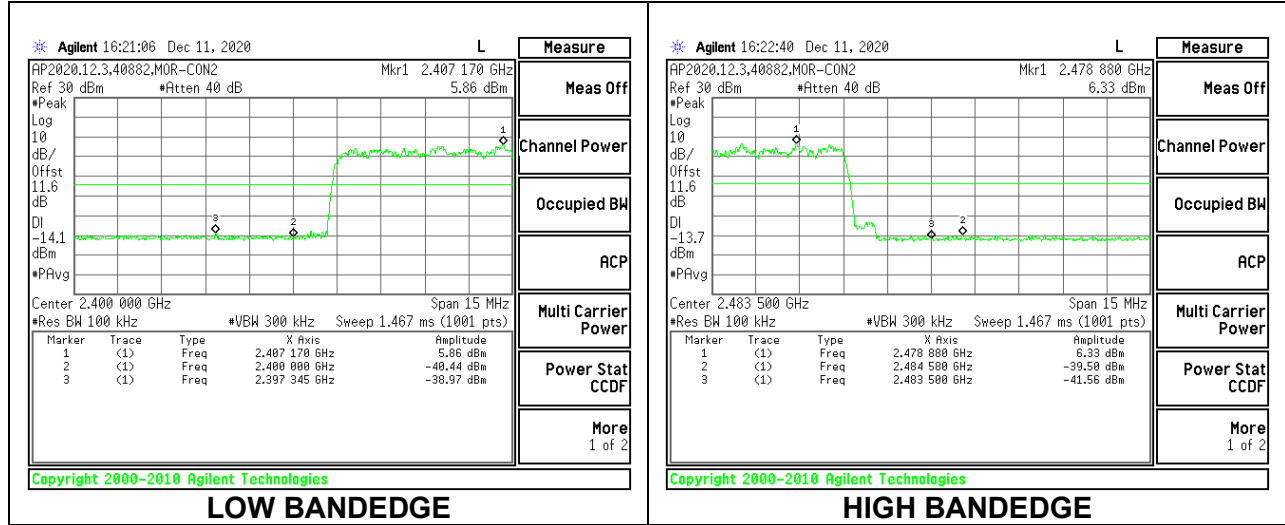


HIGH CHANNEL BANDEDGE



OUT-OF-BAND HIGH CHANNEL

SPURIOUS BANDEGE EMISSIONS WITH HOPPING ON



10. 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 in the 30-1000MHz range, 9kHz for peak and/or quasi-peak detection measurements in the 0.15-30MHz range and 200Hz for peak and/or quasi-peak detection measurements in the 9 to 150kHz range. 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, where T = on time.

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.

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

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.

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

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 v05r01

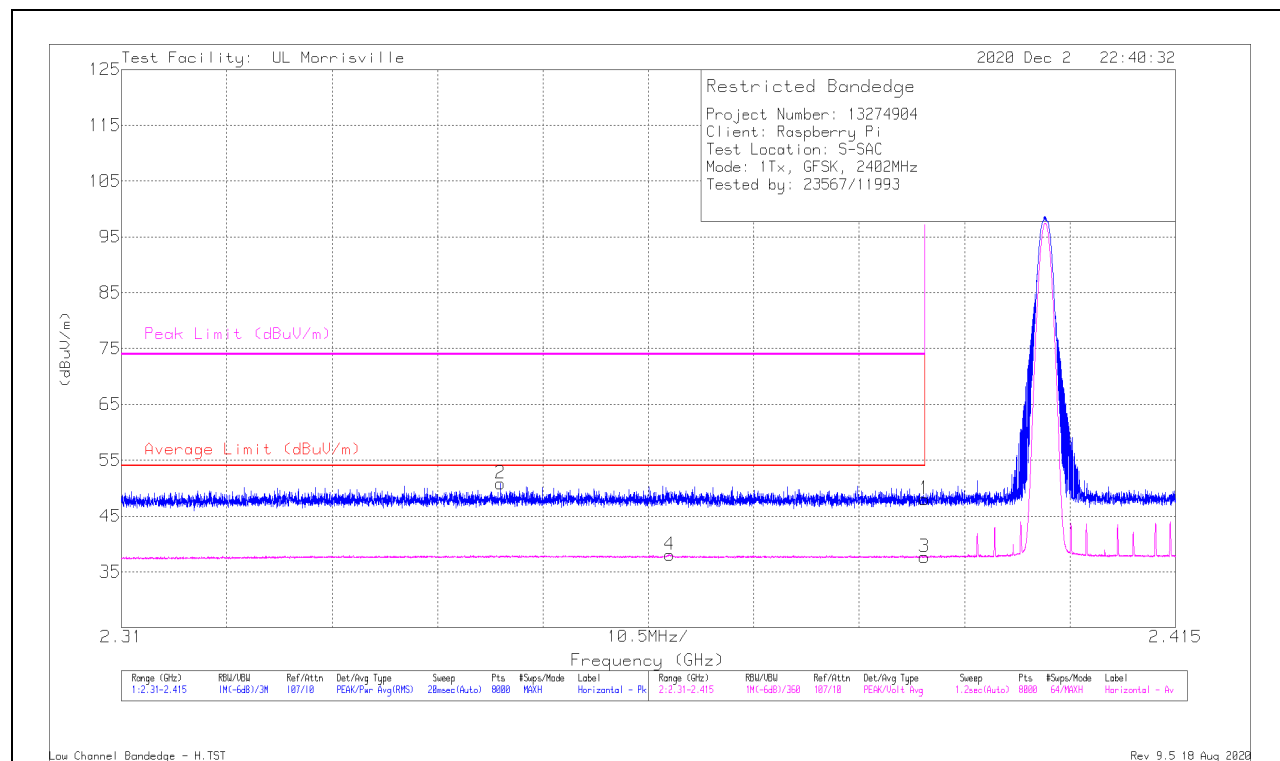
Use of a duty cycle correction factor (DCCF) is permitted for calculating average radiated field strength emission levels for an FHSS device in 15.247. This DCCF can be applied when the field strength limit (e.g., within a Government Restricted band) and the conditions specified in Section 15.35(c) can 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.

10.1. TRANSMITTER ABOVE 1 GHz

10.1.1. BLUETOOTH BASIC DATA RATE GFSK MODULATION

BANDEDGE (LOW CHANNEL)

HORIZONTAL RESULT



Marker	Frequency (GHz)	Meter Reading (dBuV)	Det	AT0067 (dB/m)	Amp/Cbl/Filtr/Pad (dB)	DC Corr (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	40.14	Pk	32.1	-24.2	0	48.04	-	-	74	-25.96	135	245	H
2	*** 2.34775	42.96	Pk	32.2	-24.3	0	50.86	-	-	74	-23.14	135	245	H
3	*** 2.39	29.75	V1TV	32.1	-24.2	-24	13.65	54	-40.35	-	-	135	245	H
4	*** 2.3646	30.14	V1TV	32.2	-24.3	-24	14.04	54	-39.96	-	-	135	245	H

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

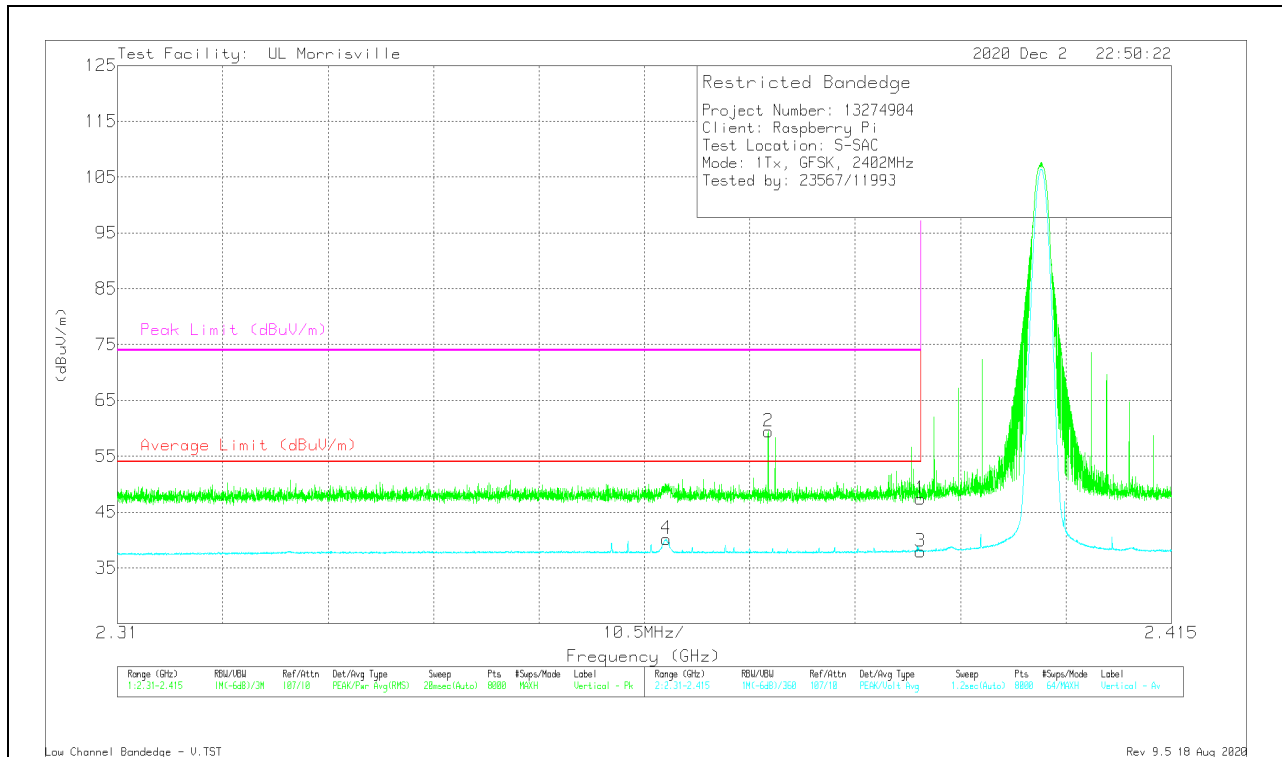
** - indicates frequency in Taiwan NCC LP0002 Restricted Band

Pk - Peak detector

V1TV: VB=1/Ton, Linear Voltage Average where: Ton is packet duration

Note: The DCCF was calculated based on the worst case 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 100 ms or 2x 3.125 ms = 6.25 ms on any channel. Therefore, $20\log(6.25 / 100) = -24\text{dB}$.

VERTICAL RESULT



Marker	Frequency (GHz)	Meter Reading (dBuV)	Det	AT0067 (dB/m)	Amp/Cbl/Filtr/Pad (dB)	DC Corr (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	39.51	Pk	32.1	-24.2	0	47.41	-	-	74	-26.59	44	101	V
2	*** 2.37483	51.51	Pk	32.2	-24.3	0	59.41	-	-	74	-14.59	44	101	V
3	*** 2.39	30.02	V1TV	32.1	-24.2	-24	13.92	54	-40.08	-	-	44	101	V
4	*** 2.36466	32.29	V1TV	32.2	-24.3	-24	16.19	54	-37.81	-	-	44	101	V

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

** - indicates frequency in Taiwan NCC LP0002 Restricted Band

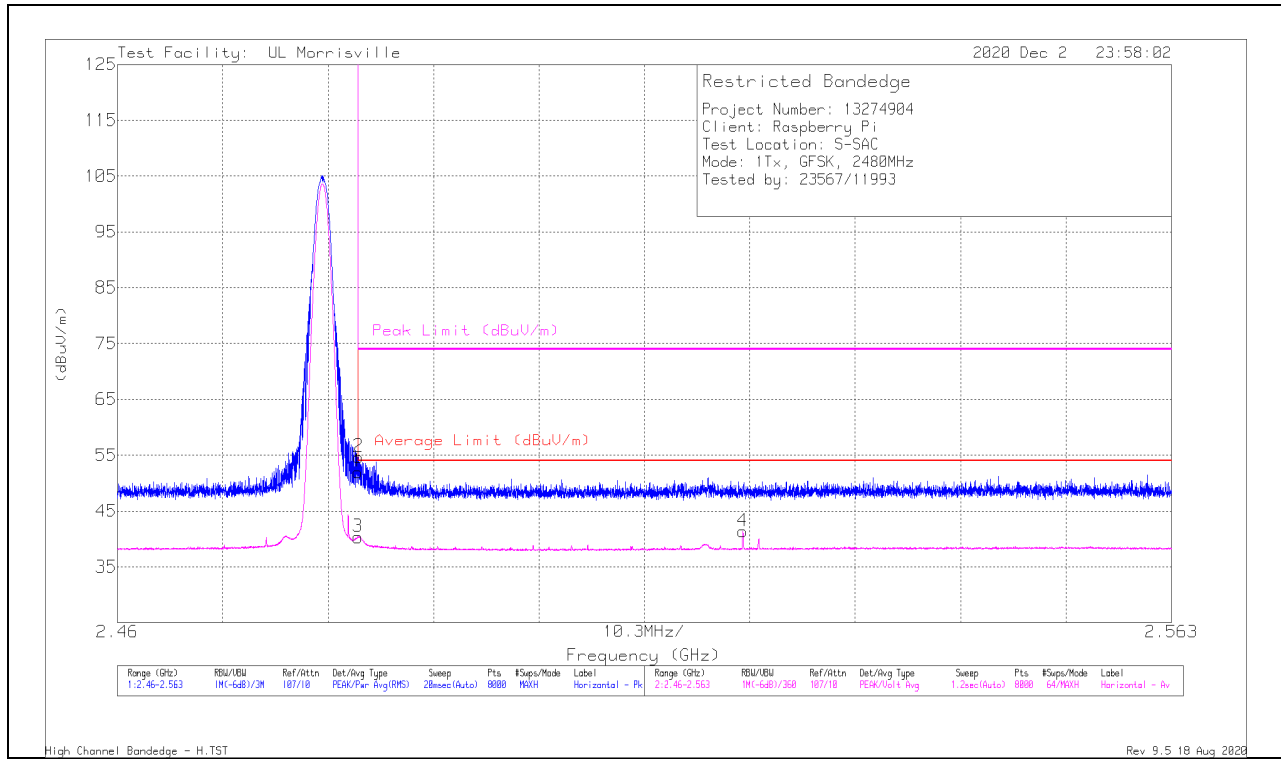
Pk - Peak detector

V1TV: VB=1/Ton, Linear Voltage Average where: Ton is packet duration

Note: The DCCF was calculated based on the worst case 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 100 ms or 2x 3.125 ms = 6.25 ms on any channel. Therefore, 20log (6.25 / 100) = - 24dB.

BANDEDGE (HIGH CHANNEL)

HORIZONTAL RESULT



Marker	Frequency (GHz)	Meter Reading (dBuV)	Det	AT0067 (dB/m)	Amp/Cbl/Filtr/Pad (dB)	DC Corr (dB)	Corrected Reading (dBuV/m)	Average Limit (dBuV/m)	Margin (dB)	Peak Limit (dBuV/m)	PK Margin (dB)	Azimuth (Degs)	Height (cm)	Polarity
1	* ** 2.4835	43.7	Pk	32.4	-24.1	0	52	-	-	74	-22	75	132	H
2	* ** 2.48359	46.39	Pk	32.4	-24.1	0	54.69	-	-	74	-19.31	75	132	H
3	* ** 2.4835	32.04	V1TV	32.4	-24.1	-24	16.34	54	-37.66	-	-	75	132	H
4	** 2.52111	32.94	V1TV	32.5	-24.1	-24	17.34	54	-36.66	-	-	75	132	H

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

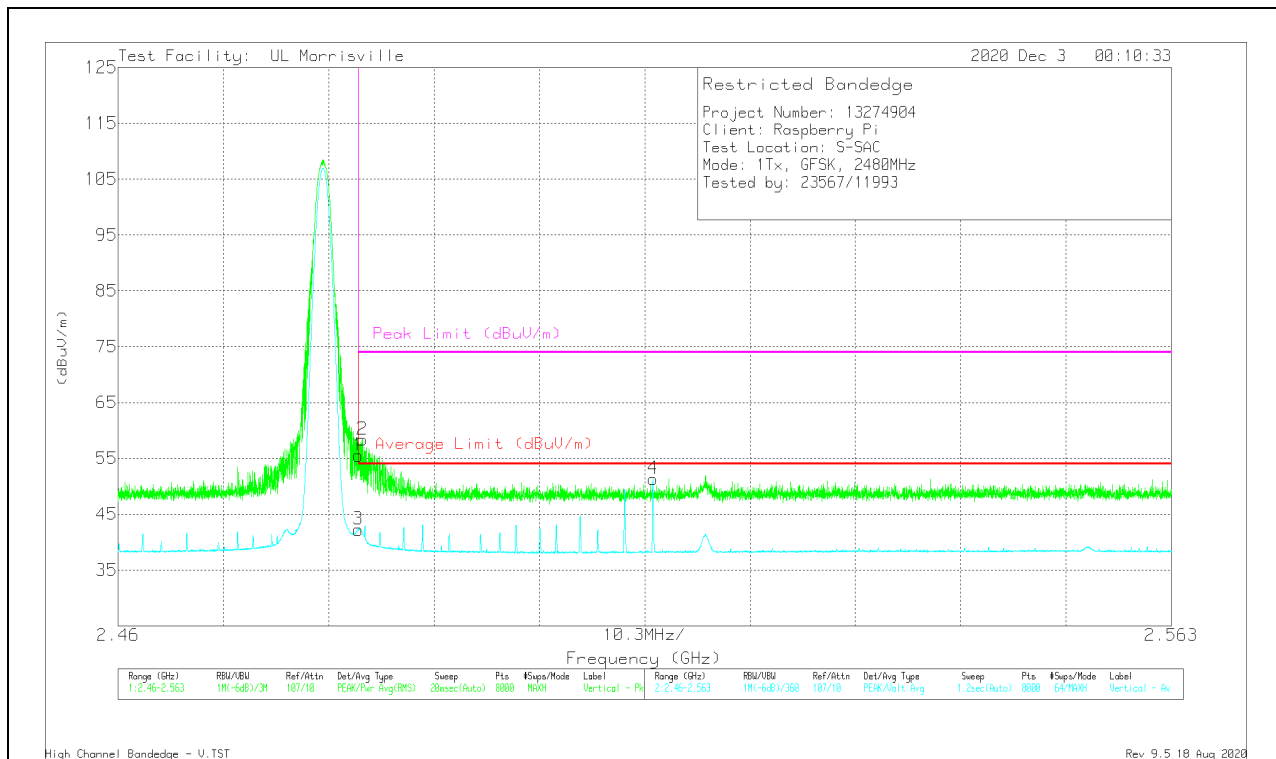
** - indicates frequency in Taiwan NCC LP0002 Restricted Band

Pk - Peak detector

V1TV: VB=1/Ton, Linear Voltage Average where: Ton is packet duration

Note: The DCCF was calculated based on the worst case 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 100 ms or 2x 3.125 ms = 6.25 ms on any channel. Therefore, 20log (6.25 / 100) = - 24dB.

VERTICAL RESULT



Marker	Frequency (GHz)	Meter Reading (dBuV)	Det	AT0067 (dB/m)	Amp/Cbl/Filtr/Pad (dB)	DC Corr (dB)	Corrected Reading (dBuV/m)	Average Limit (dBuV/m)	Margin (dB)	Peak Limit (dBuV/m)	PK Margin (dB)	Azimuth (Degs)	Height (cm)	Polarity
1	*** 2.4835	47.22	Pk	32.4	-24.1	0	55.52	-	-	74	-18.48	106	113	V
2	*** 2.48389	50.06	Pk	32.4	-24.1	0	58.36	-	-	74	-15.64	106	113	V
3	* ** 2.4835	33.93	V1TV	32.4	-24.1	-24	18.23	54	-35.77	-	-	106	113	V
4	** 2.51231	42.94	V1TV	32.5	-24.1	-24	27.34	54	-26.66	-	-	106	113	V

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

** - indicates frequency in Taiwan NCC LP0002 Restricted Band

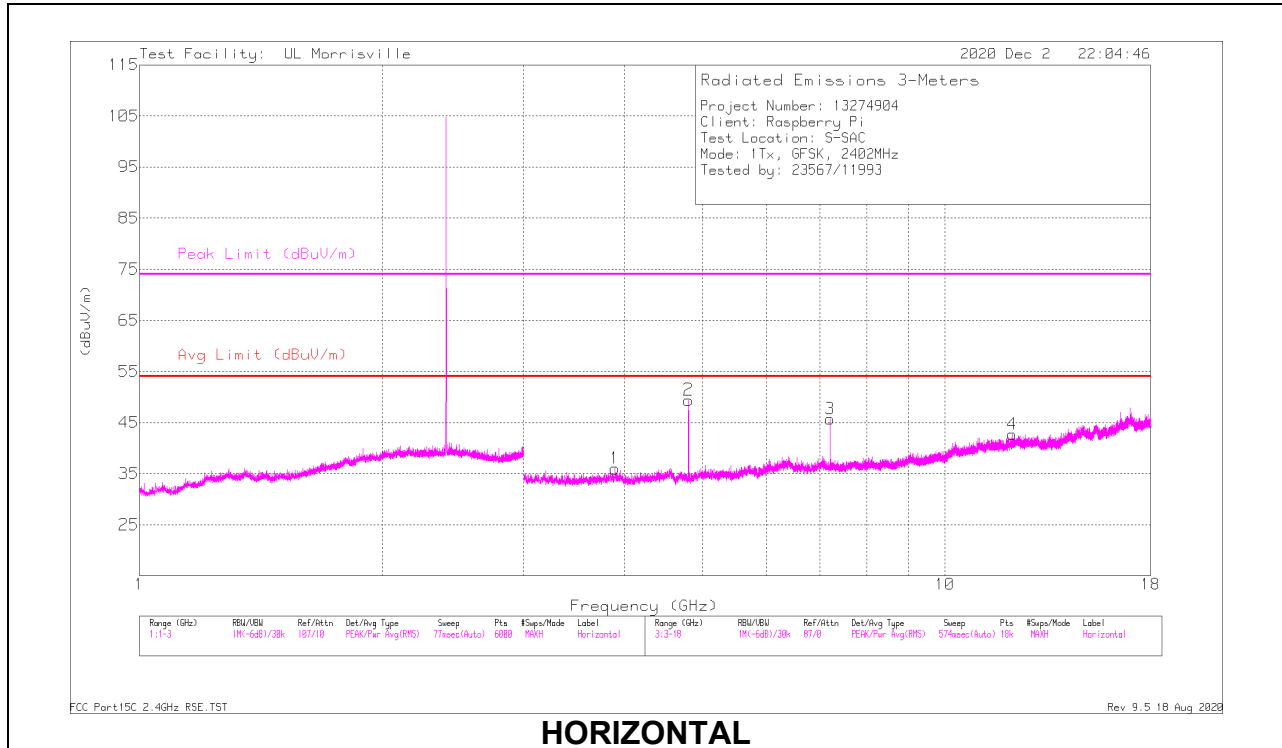
Pk - Peak detector

V1TV: VB=1/Ton, Linear Voltage Average where: Ton is packet duration

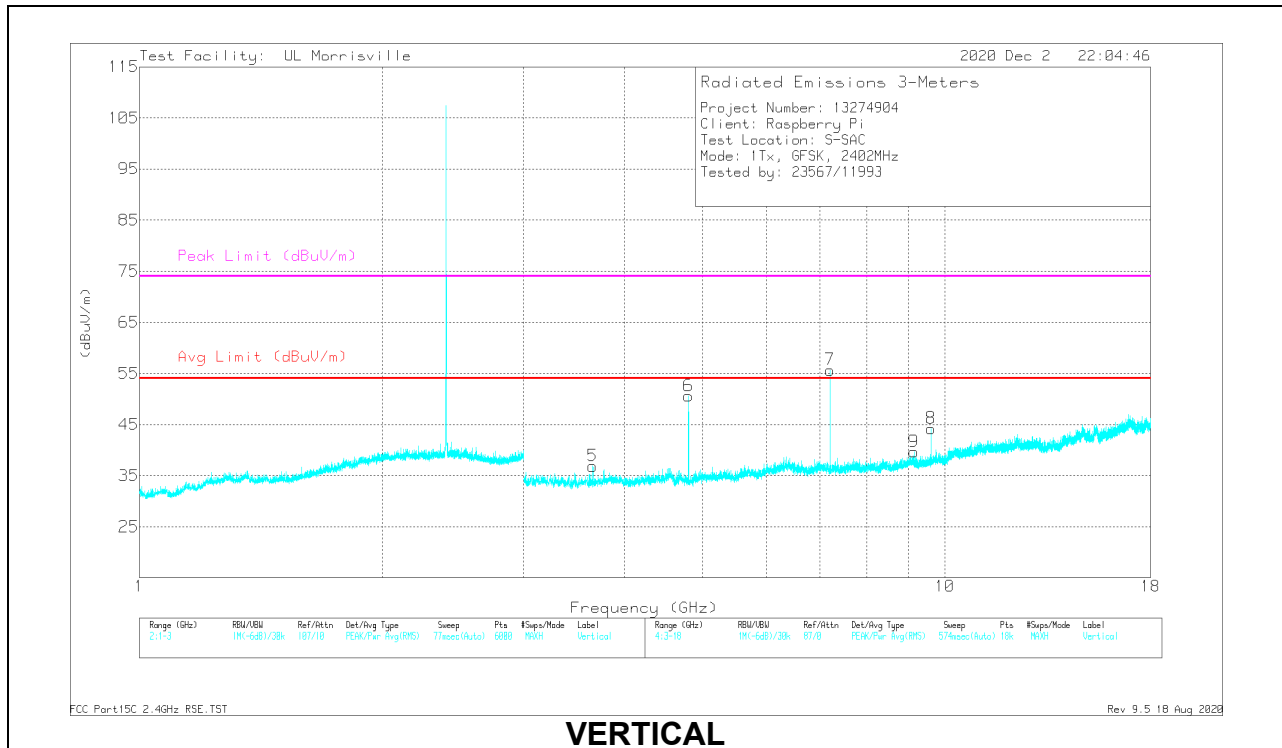
Note: The DCCF was calculated based on the worst case time when the device transmits DH5 packets and operates on 20 channels (5/1600 s per hop = 3.125 ms per channel). In this mode, the device will have a maximum of 2 hops on a channel in 100 ms or 2x 3.125 ms = 6.25 ms on any channel. Therefore, 20log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

HARMONICS AND SPURIOUS EMISSIONS

LOW CHANNEL RESULTS



HORIZONTAL



VERTICAL

RADIATED EMISSIONS

Marker	Frequency (GHz)	Meter Reading (dBuV)	Det	AT0067 (dB/m)	Amp/Cbl/Filtr/Pad (dB)	DC Corr (dB)	Corrected Reading (dBuV/m)	Avg Limit (dBuV/m)	Margin (dB)	Peak Limit (dBuV/m)	PK Margin (dB)	Azimuth (Degs)	Height (cm)	Polarity
1	*** 3.89218	40.03	PK2	33.4	-32.1	0	41.33	-	-	74	-32.67	347	107	H
	*** 3.89207	27.67	V1TV	33.4	-32.1	-24	4.97	54	-49.03	-	-	347	107	H
2	*** 4.80408	48.15	PK2	34	-30.9	0	51.25	-	-	74	-22.75	238	152	H
	*** 4.80405	44.07	V1TV	34	-30.9	-24	23.17	54	-30.83	-	-	238	152	H
4	*** 12.11627	33.69	PK2	38.8	-24.2	0	48.29	-	-	74	-25.71	292	242	H
	*** 12.11686	21.24	V1TV	38.8	-24.2	-24	11.84	54	-42.16	-	-	292	242	H
5	*** 3.65556	40.11	PK2	33.1	-32.2	0	41.01	-	-	74	-32.99	15	186	V
	*** 3.65555	28.21	V1TV	33.1	-32.2	-24	5.11	54	-48.89	-	-	15	186	V
6	*** 4.804	51.68	PK2	34	-30.9	0	54.78	-	-	74	-19.22	221	190	V
	*** 4.80403	48.04	V1TV	34	-30.9	-24	27.14	54	-26.86	-	-	221	190	V
9	*** 9.15188	34.99	PK2	36.3	-26.1	0	45.19	-	-	74	-28.81	80	328	V
	*** 9.15126	22.22	V1TV	36.3	-26.1	-24	8.42	54	-45.58	-	-	80	328	V
3	7.20607	38.02	Pk	35.6	-27.9	0	45.72	-	-	-	-	0-360	199	H
7	7.20607	48	Pk	35.6	-27.9	0	55.7	-	-	-	-	0-360	199	V
8	9.60704	33.94	Pk	36.6	-26.3	0	44.24	-	-	-	-	0-360	199	V

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

** - indicates frequency in Taiwan NCC LP0002 Restricted Band

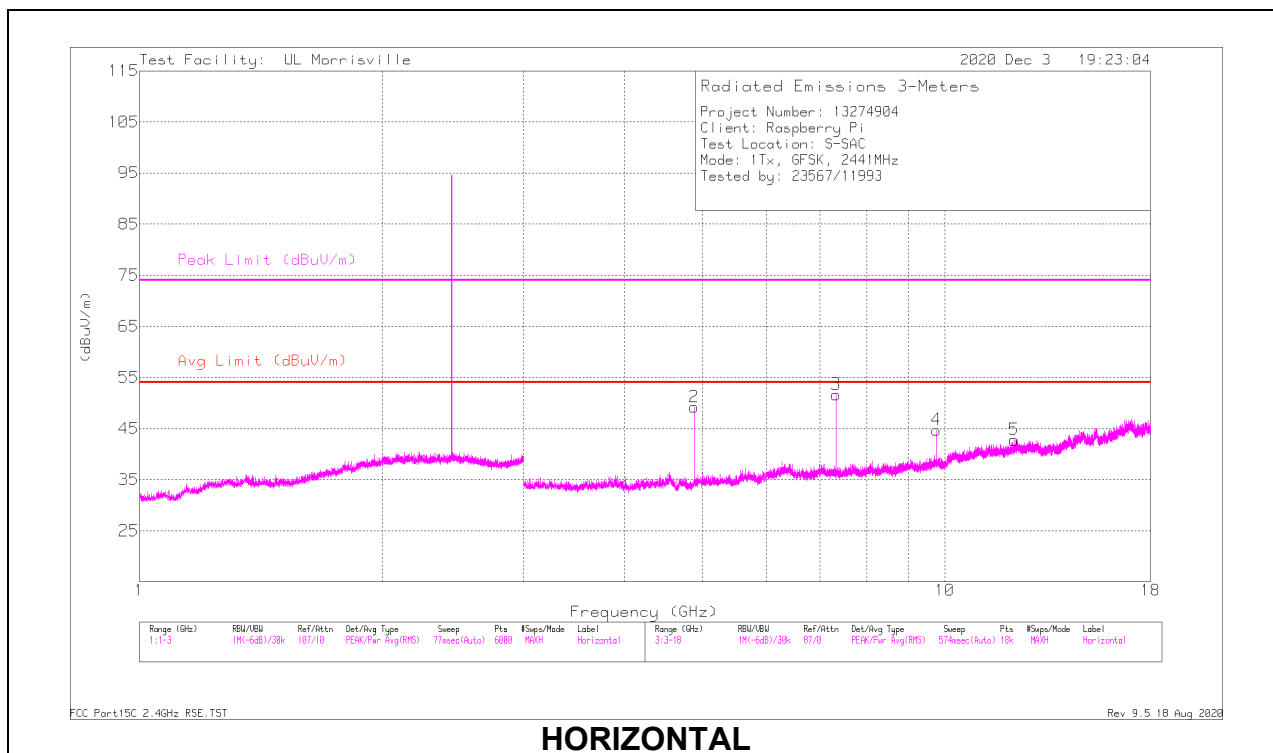
PK2: Maximum Peak

V1TV: VB=1/Ton, Linear Voltage Average where: Ton is packet duration

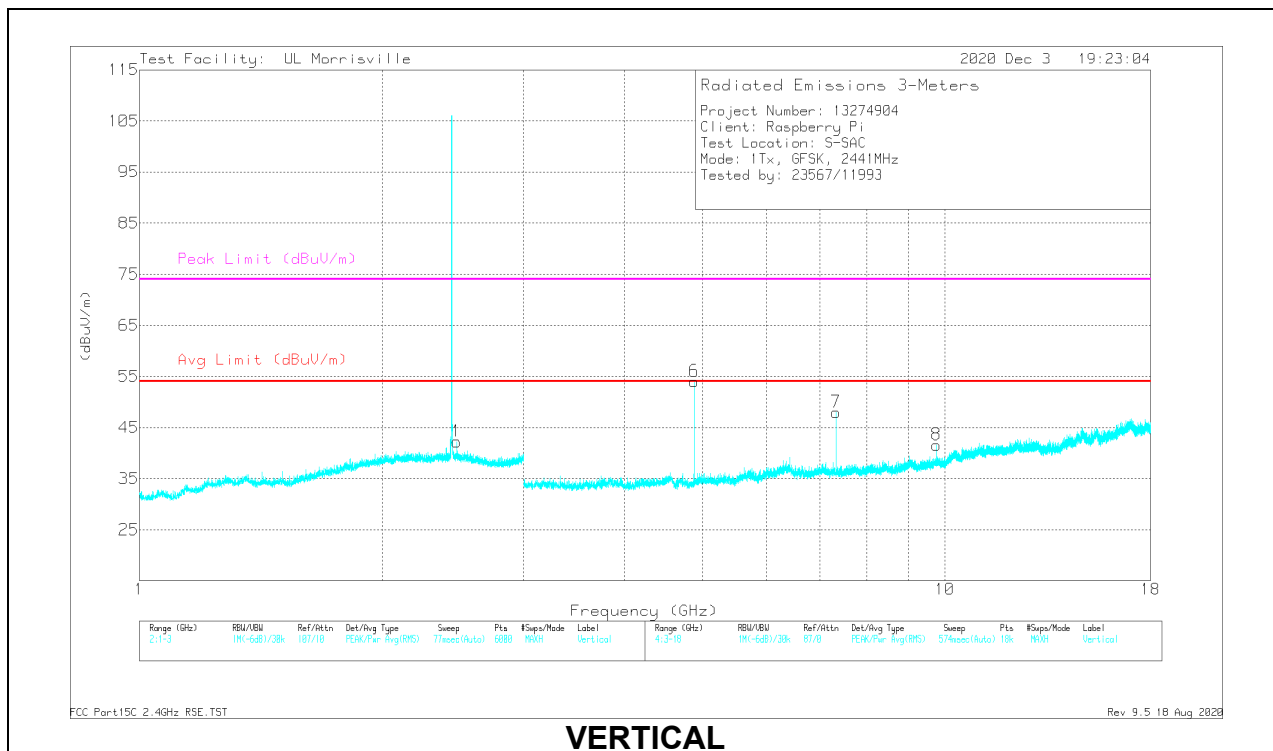
Pk - Peak detector

Note: The DCCF was calculated based on the worst case 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 100 ms or 2x 3.125 ms = 6.25 ms on any channel. Therefore, 20log (6.25 / 100) = - 24dB.

MID CHANNEL RESULTS



HORIZONTAL



VERTICAL

RADIATED EMISSIONS

Marker	Frequency (GHz)	Meter Reading (dBuV)	Det	AT0067 (dB/m)	Amp/Cbl/Filtr/Pad (dB)	DC Corr (dB)	Corrected Reading (dBuV/m)	Avg Limit (dBuV/m)	Margin (dB)	Peak Limit (dBuV/m)	PK Margin (dB)	Azimuth (Degs)	Height (cm)	Polarity
2	*** 4.88206	49.77	PK2	34	-30.8	0	52.97	-	-	74	-21.03	240	101	H
	*** 4.88204	45.43	V1TV	34	-30.8	-24	24.63	54	-29.37	-	-	240	101	H
3	*** 7.32313	53.98	PK2	35.6	-27.4	0	62.18	-	-	74	-11.82	256	105	H
	*** 7.32309	49.03	V1TV	35.6	-27.4	-24	33.23	54	-20.77	-	-	256	105	H
5	** 12.19213	34.67	PK2	38.8	-24.3	0	49.17	-	-	74	-24.83	76	308	H
	** 12.19176	21.41	V1TV	38.8	-24.3	-24	11.91	54	-42.09	-	-	76	308	H
6	*** 4.88198	52.03	PK2	34	-30.8	0	55.23	-	-	74	-18.77	197	102	V
	*** 4.88202	48.29	V1TV	34	-30.8	-24	27.49	54	-26.51	-	-	197	102	V
7	*** 7.32313	52.82	PK2	35.6	-27.4	0	61.02	-	-	74	-12.98	257	158	V
	*** 7.3231	47.61	V1TV	35.6	-27.4	-24	31.81	54	-22.19	-	-	257	158	V
1	2.47858	34.36	Pk	32.4	-24.5	0	42.26	-	-	-	-	0-360	101	V
4	9.76288	33.84	Pk	36.7	-25.8	0	44.74	-	-	-	-	0-360	101	H
8	9.76288	30.72	Pk	36.7	-25.8	0	41.62	-	-	-	-	0-360	200	V

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

** - indicates frequency in Taiwan NCC LP0002 Restricted Band

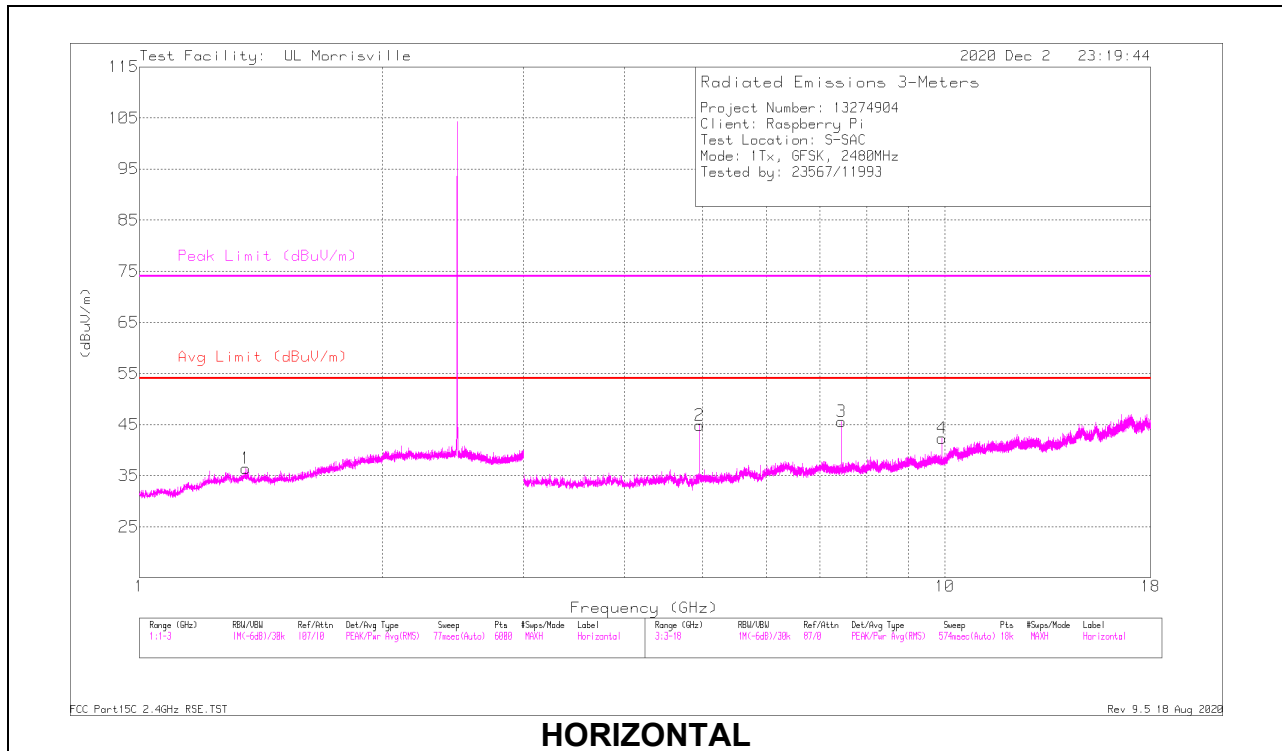
PK2: Maximum Peak

V1TV: VB=1/Ton, Linear Voltage Average where: Ton is packet duration

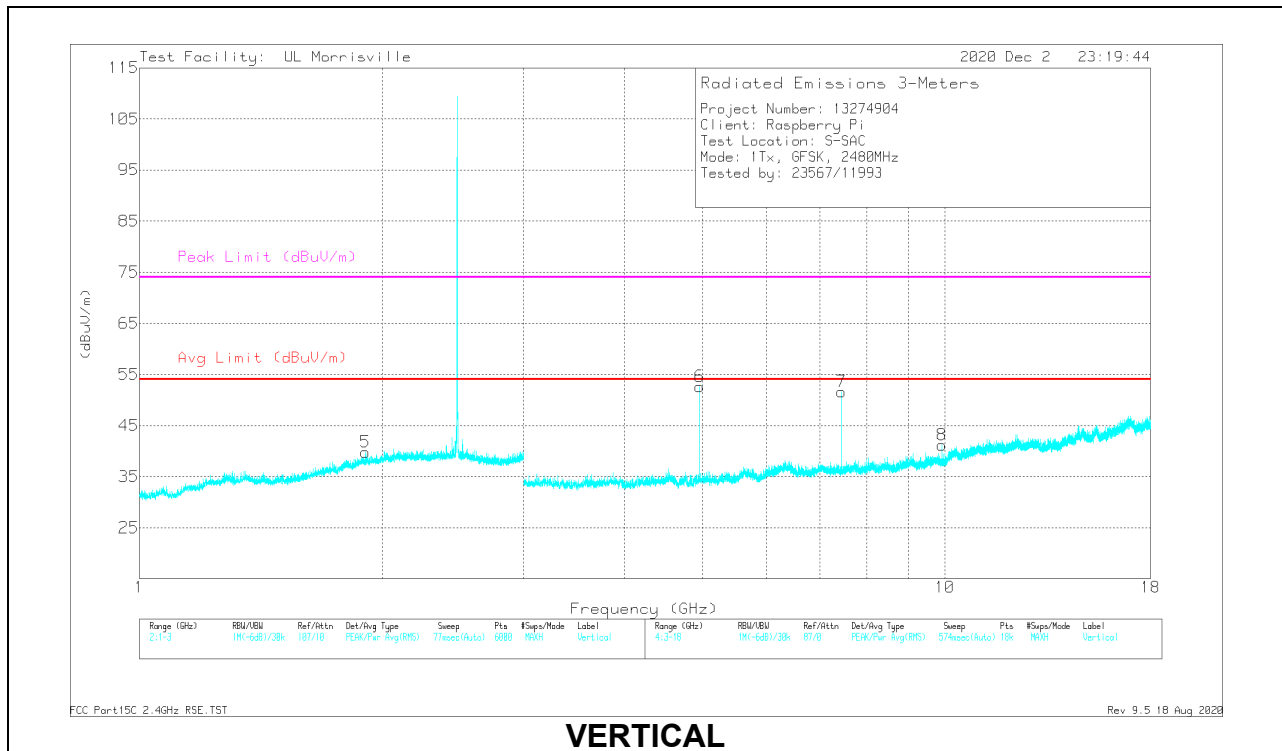
Pk - Peak detector

Note: The DCCF was calculated based on the worst case 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 100 ms or 2x 3.125 ms = 6.25 ms on any channel. Therefore, $20\log(6.25 / 100) = -24\text{dB}$.

HIGH CHANNEL RESULTS



HORIZONTAL



VERTICAL

RADIATED EMISSIONS

Marker	Frequency (GHz)	Meter Reading (dBuV)	Det	AT0067 (dB/m)	Amp/Cbl/Filtr/Pad (dB)	DC Corr (dB)	Corrected Reading (dBuV/m)	Avg Limit (dBuV/m)	Margin (dB)	Peak Limit (dBuV/m)	PK Margin (dB)	Azimuth (Degs)	Height (cm)	Polarity
1	*** 1.35463	35.85	PK2	29	-22.9	0	41.95	-	-	74	-32.05	171	317	H
	** 1.35666	23.24	V1TV	28.9	-22.9	-24	5.24	54	-48.76	-	-	171	317	H
5	** 1.90644	35.97	PK2	31.3	-22.4	0	44.87	-	-	74	-29.13	224	261	V
	** 1.90706	23.03	V1TV	31.3	-22.4	-24	7.93	54	-46.07	-	-	224	261	V
2	*** 4.95977	46.59	PK2	33.9	-31	0	49.49	-	-	74	-24.51	67	110	H
	*** 4.9601	41.15	V1TV	33.9	-31	-24	20.05	54	-33.95	-	-	67	110	H
3	*** 7.44054	43.31	PK2	35.6	-27.7	0	51.21	-	-	74	-22.79	215	119	H
	*** 7.4401	36.68	V1TV	35.6	-27.7	-24	20.58	54	-33.42	-	-	215	119	H
6	*** 4.96006	52.61	PK2	33.9	-31	0	55.51	-	-	74	-18.49	193	101	V
	*** 4.96008	48.69	V1TV	33.9	-31	-24	27.59	54	-26.41	-	-	193	101	V
7	*** 7.44009	47.25	PK2	35.6	-27.7	0	55.15	-	-	74	-18.85	225	122	V
	*** 7.44008	41.91	V1TV	35.6	-27.7	-24	25.81	54	-28.19	-	-	225	122	V
4	9.91955	31.08	Pk	37	-25.8	0	42.28	-	-	-	-	0-360	101	H
8	9.92039	30	Pk	37	-25.8	0	41.2	-	-	-	-	0-360	200	V

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

** - indicates frequency in Taiwan NCC LP0002 Restricted Band

PK2: Maximum Peak

V1TV: $V_B=1/T_{on}$, Linear Voltage Average where: T_{on} is packet duration

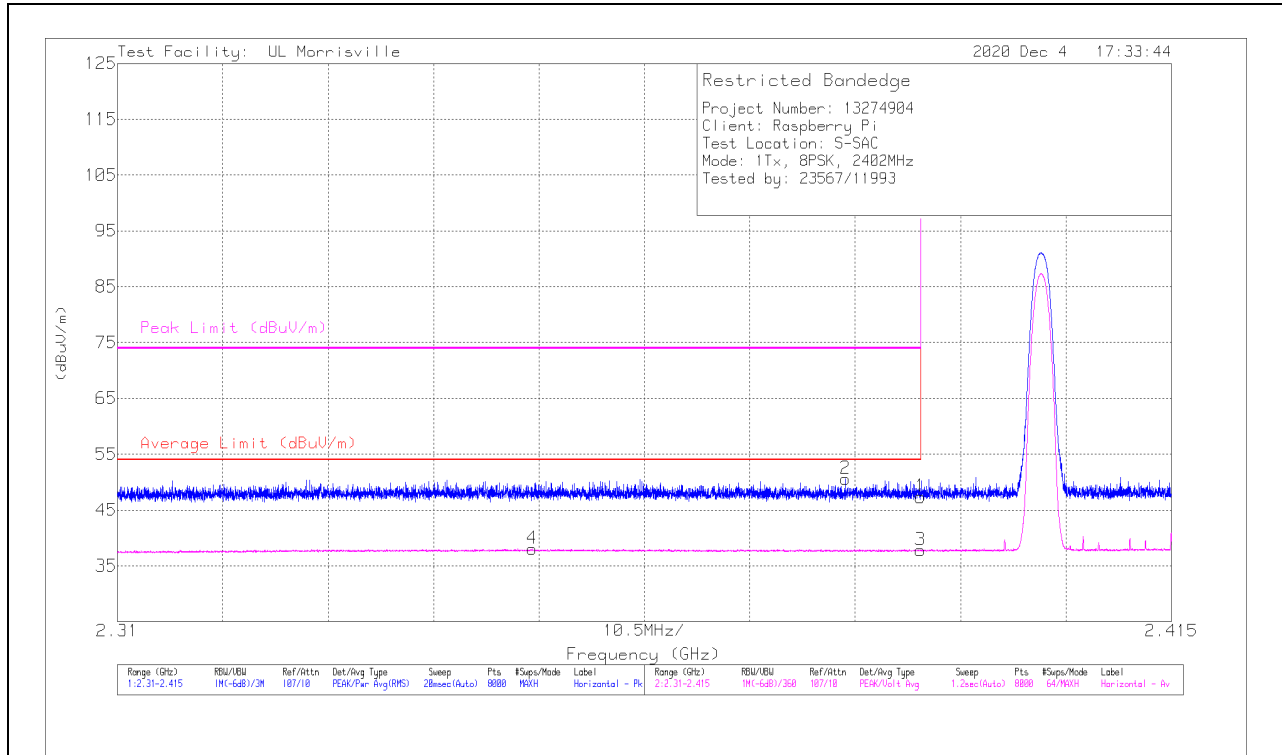
Pk - Peak detector

Note: The DCCF was calculated based on the worst case 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 100 ms or 2×3.125 ms = 6.25 ms on any channel. Therefore, $20 \log(6.25 / 100) = -24$ dB.

10.1.2. BLUETOOTH ENHANCED DATA RATE 8PSK MODULATION

BANDEDGE (LOW CHANNEL)

HORIZONTAL RESULT



Marker	Frequency (GHz)	Meter Reading (dBuV)	Det	AT0067 (dB/m)	Amp/Cbl/Filtr/Pad (dB)	DC Corr (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	39.45	Pk	32.1	-24.2	0	47.35	-	-	74	-26.65	48	358	H
2	* ** 2.38253	42.65	Pk	32.2	-24.3	0	50.55	-	-	74	-23.45	48	358	H
3	* ** 2.39	29.88	V1TV	32.1	-24.2	-24	13.78	54	-40.22	-	-	48	358	H
4	* ** 2.35132	30.15	V1TV	32.2	-24.3	-24	14.05	54	-39.95	-	-	48	358	H

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

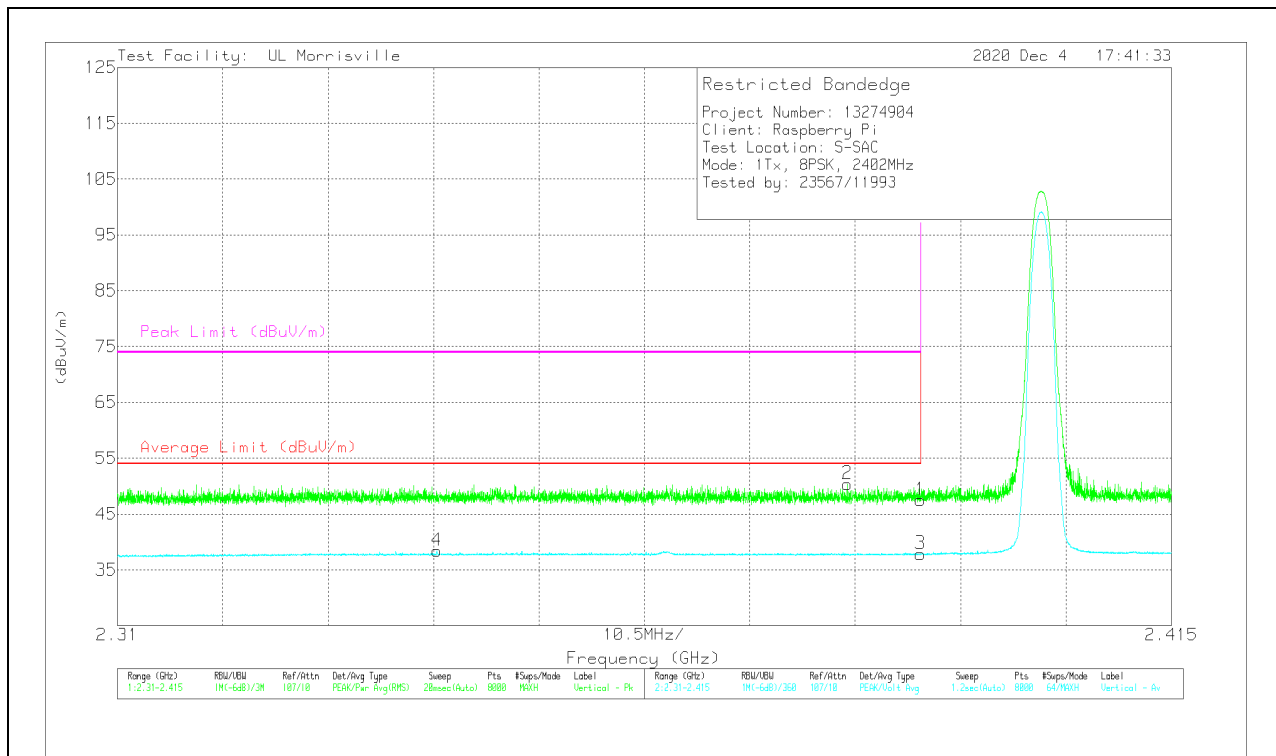
** - indicates frequency in Taiwan NCC LP0002 Restricted Band

Pk - Peak detector

V1TV: VB=1/Ton, Linear Voltage Average where: Ton is packet duration

Note: The DCCF was calculated based on the worst case 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 100 ms or 2x 3.125 ms = 6.25 ms on any channel. Therefore, $20\log(6.25 / 100) = -24\text{dB}$.

VERTICAL RESULT



Marker	Frequency (GHz)	Meter Reading (dBuV)	Det	AT0067 (dB/m)	Amp/Cbl/Filtr/Pad (dB)	DC Corr (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	39.61	Pk	32.1	-24.2	0	47.51	-	-	74	-26.49	113	135	V
2	** 2.3827	42.5	Pk	32.2	-24.3	0	50.4	-	-	74	-23.6	113	135	V
3	*** 2.39	29.95	V1TV	32.1	-24.2	-24	14.85	54	-39.15	-	-	113	135	V
4	*** 2.34183	30.54	V1TV	32.2	-24.3	-24	14.44	54	-39.56	-	-	113	135	V

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

** - indicates frequency in Taiwan NCC LP0002 Restricted Band

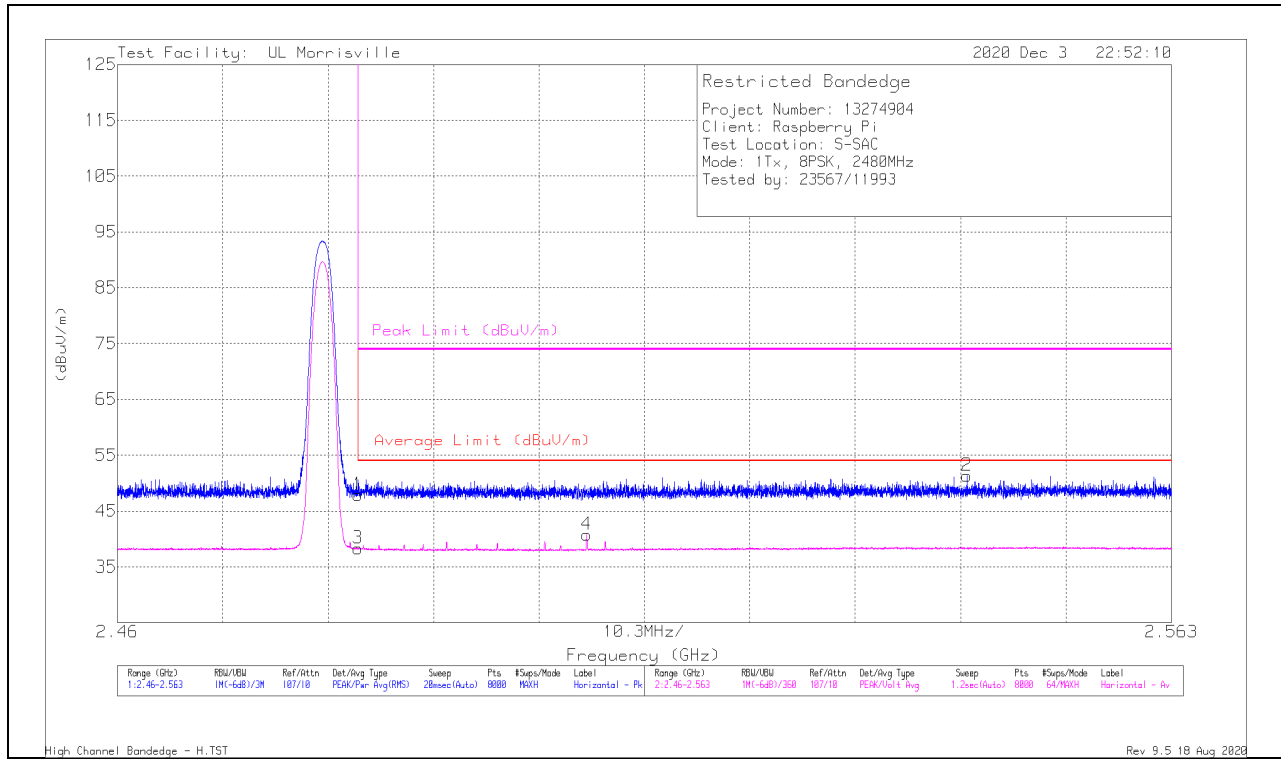
Pk - Peak detector

V1TV: VB=1/Ton, Linear Voltage Average where: Ton is packet duration

Note: The DCCF was calculated based on the worst case 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 100 ms or 2x 3.125 ms = 6.25 ms on any channel. Therefore, 20log (6.25 / 100) = - 24dB.

BANDEDGE (HIGH CHANNEL)

HORIZONTAL RESULT



Marker	Frequency (GHz)	Meter Reading (dBuV)	Det	AT0067 (dB/m)	Amp/Cbl/Filtr/Pad (dB)	DC Corr (dB)	Corrected Reading (dBuV/m)	Average Limit (dBuV/m)	Margin (dB)	Peak Limit (dBuV/m)	PK Margin (dB)	Azimuth (Degs)	Height (cm)	Polarity
1	* ** 2.4835	39.55	Pk	32.4	-24.1	0	47.85	-	-	74	-26.15	237	306	H
2	** 2.54301	42.89	Pk	32.6	-24.2	0	51.29	-	-	74	-22.71	237	306	H
3	* ** 2.4835	29.97	V1TV	32.4	-24.1	-24	14.27	54	-39.73	-	-	237	306	H
4	** 2.50587	32.42	V1TV	32.4	-24.1	-24	16.72	54	-37.28	-	-	237	306	H

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

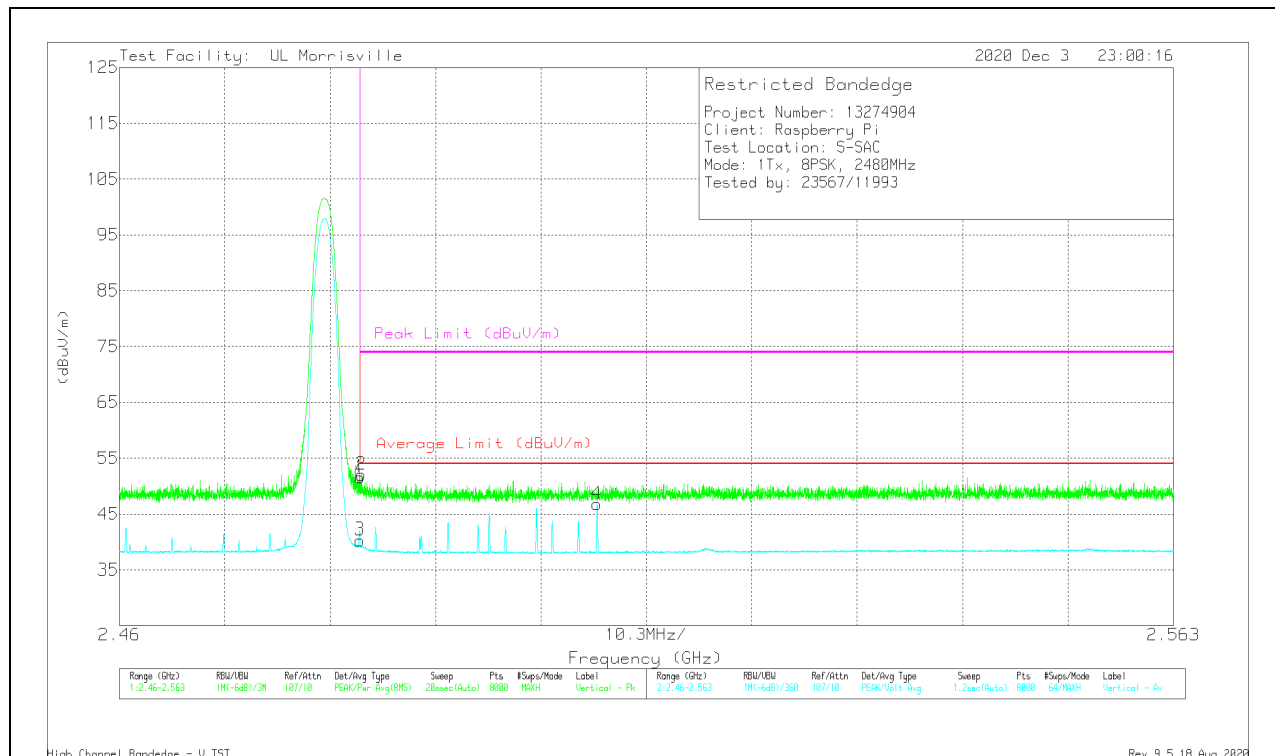
** - indicates frequency in Taiwan NCC LP0002 Restricted Band

Pk - Peak detector

V1TV: VB=1/Ton, Linear Voltage Average where: Ton is packet duration

Note: The DCCF was calculated based on the worst case 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 100 ms or 2x 3.125 ms = 6.25 ms on any channel. Therefore, 20log (6.25 / 100) = - 24dB.

VERTICAL RESULT



Marker	Frequency (GHz)	Meter Reading (dBuV)	Det	AT0067 (dB/m)	Amp/Cbl/Filtr/Pad (dB)	DC Corr (dB)	Corrected Reading (dBuV/m)	Average Limit (dBuV/m)	Margin (dB)	Peak Limit (dBuV/m)	PK Margin (dB)	Azimuth (Degs)	Height (cm)	Polarity
1	* ** 2.4835	43.24	Pk	32.4	-24.1	0	51.54	-	-	74	-22.46	136	105	V
2	* ** 2.4836	43.72	Pk	32.4	-24.1	0	52.02	-	-	74	-21.98	136	105	V
3	* ** 2.4835	32.02	V1TV	32.4	-24.1	-24	16.32	54	-37.68	-	-	136	105	V
4	** 2.50668	38.5	V1TV	32.4	-24.1	-24	22.8	54	-31.2	-	-	136	105	V

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

** - indicates frequency in Taiwan NCC LP0002 Restricted Band

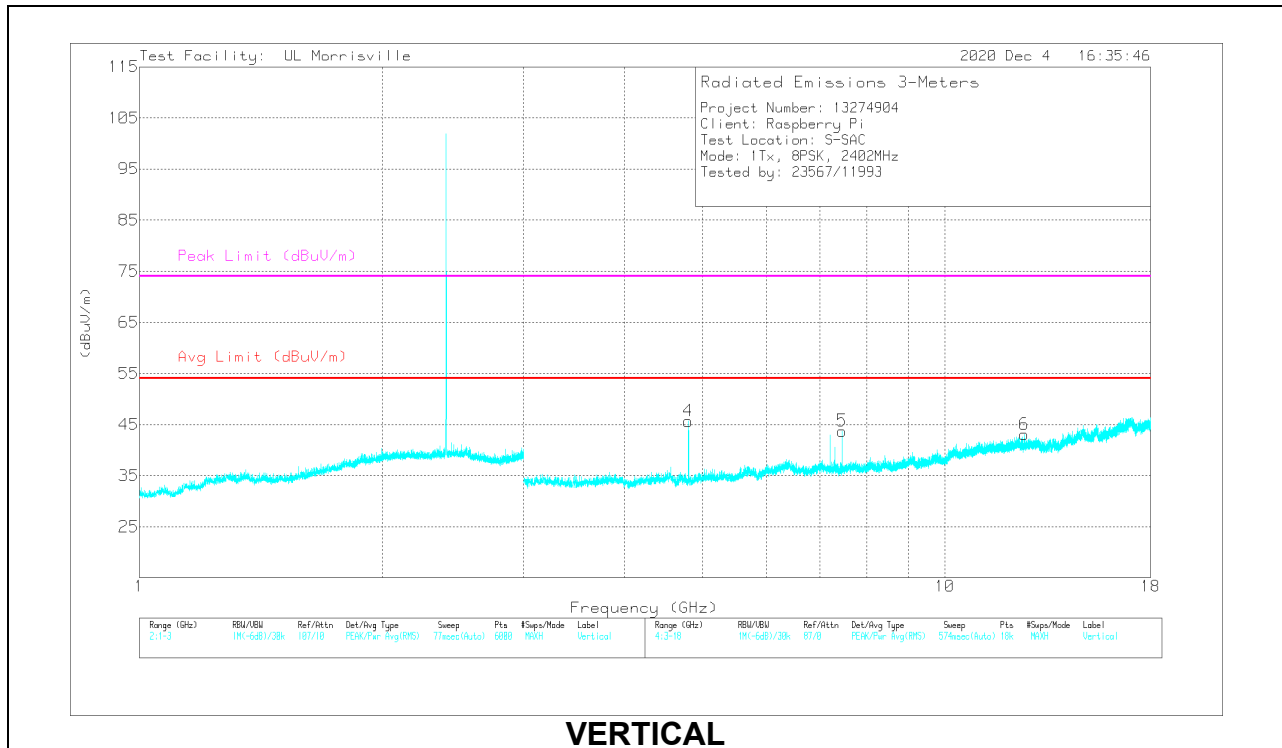
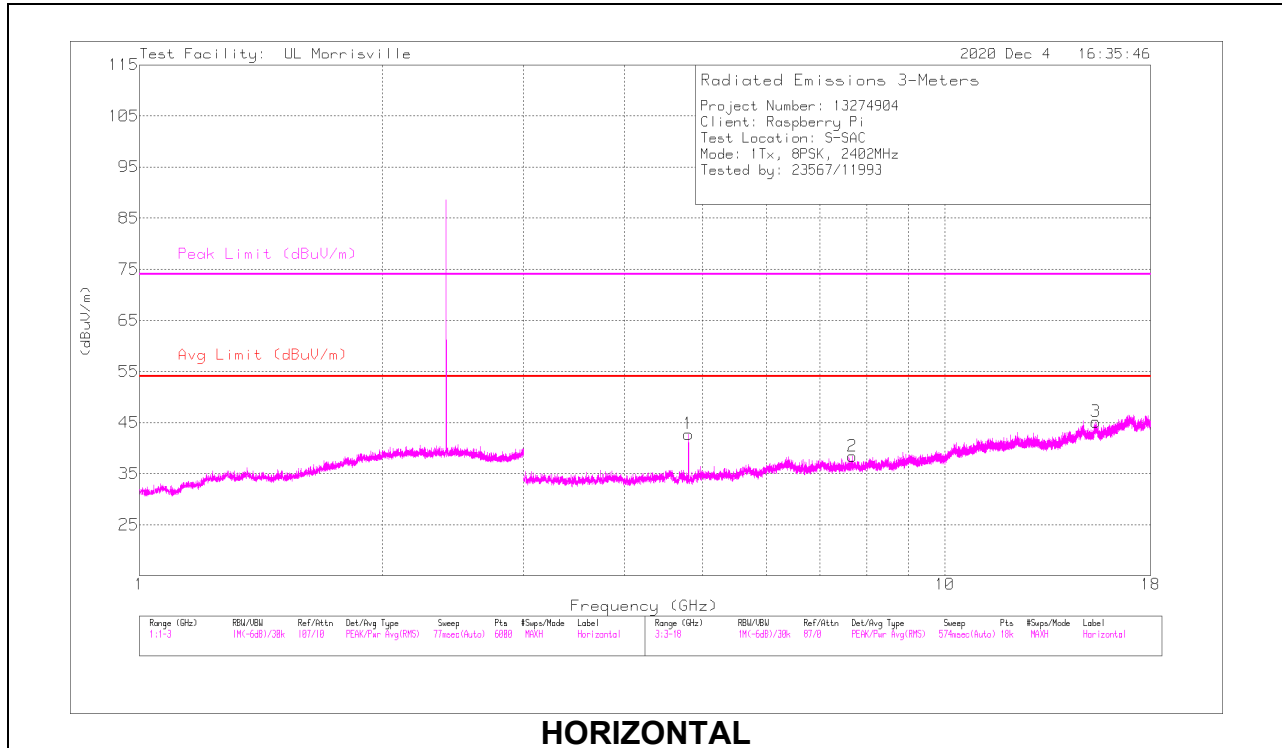
Pk - Peak detector

V1TV: VB=1/Ton, Linear Voltage Average where: Ton is packet duration

Note: The DCCF was calculated based on the worst case 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 100 ms or 2x 3.125 ms = 6.25 ms on any channel. Therefore, 20log (6.25 / 100) = - 24dB.

HARMONICS AND SPURIOUS EMISSIONS

LOW CHANNEL RESULTS



RADIATED EMISSIONS

Marker	Frequency (GHz)	Meter Reading (dBuV)	Det	AT0067 (dB/m)	Amp/Cbl/Filtr/Pad (dB)	DC Corr (dB)	Corrected Reading (dBuV/m)	Avg Limit (dBuV/m)	Margin (dB)	Peak Limit (dBuV/m)	PK Margin (dB)	Azimuth (Degs)	Height (cm)	Polarity
1	*** 4.80405	45.11	PK2	34	-30.9	0	48.21	-	-	74	-25.79	31	104	H
	*** 4.80413	36.68	V1TV	34	-30.9	-24	15.78	54	-38.22	-	-	31	104	H
2	*** 7.67633	35.88	PK2	35.7	-27.5	0	44.08	-	-	74	-29.92	197	125	H
	*** 7.6761	23.26	V1TV	35.7	-27.5	-24	7.46	54	-46.54	-	-	197	125	H
3	** 15.38872	34.37	PK2	40.3	-22.3	0	52.37	-	-	74	-21.63	208	167	H
	** 15.38767	20.73	V1TV	40.3	-22.3	-24	14.73	54	-39.27	-	-	208	167	H
4	** 4.804	48.07	PK2	34	-30.9	0	51.17	-	-	74	-22.83	225	105	V
	*** 4.80403	40.53	V1TV	34	-30.9	-24	19.63	54	-34.37	-	-	225	105	V
5	*** 7.45025	36.2	PK2	35.6	-27.7	0	44.1	-	-	74	-29.9	300	366	V
	*** 7.45134	22.96	V1TV	35.6	-27.7	-24	6.86	54	-47.14	-	-	300	366	V
6	** 12.54148	34.17	PK2	39.1	-24.6	0	48.67	-	-	74	-25.33	141	360	V
	** 12.54228	21.29	V1TV	39.1	-24.6	-24	11.79	54	-42.21	-	-	141	360	V

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

** - indicates frequency in Taiwan NCC LP0002 Restricted Band

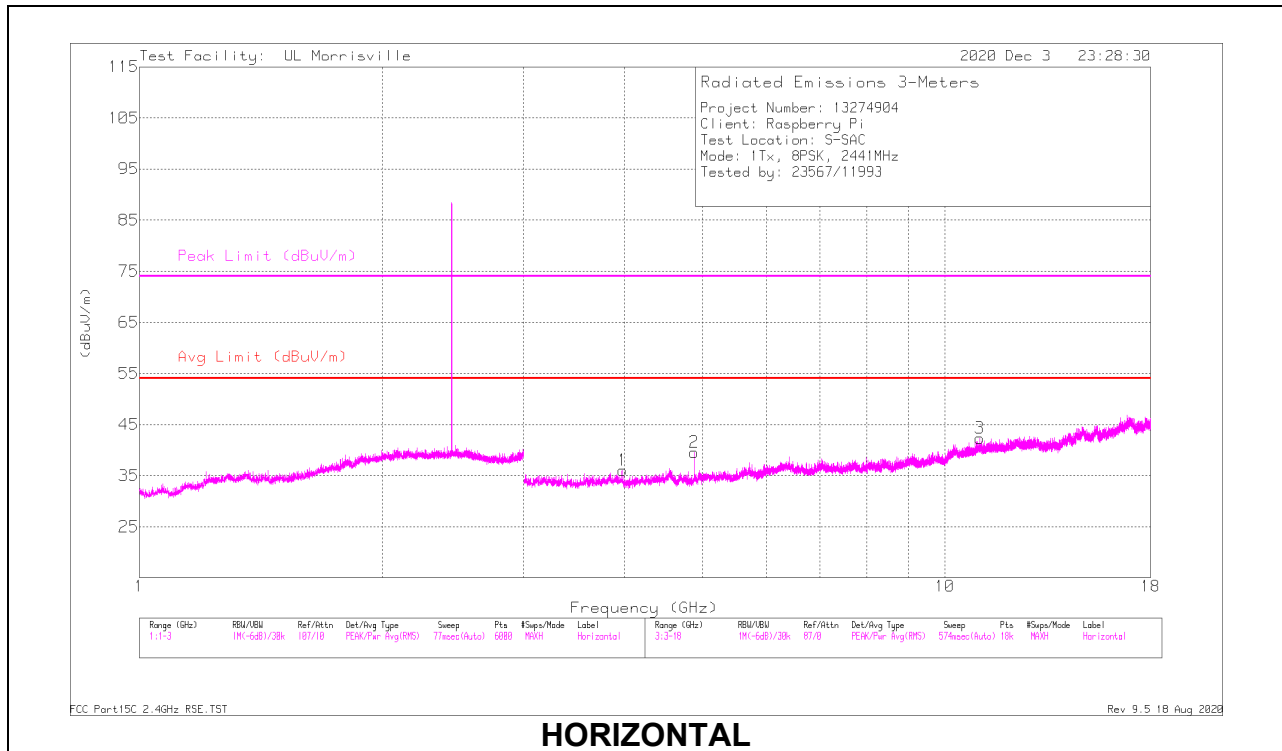
PK2: Maximum Peak

V1TV: VB=1/Ton, Linear Voltage Average where: Ton is packet duration

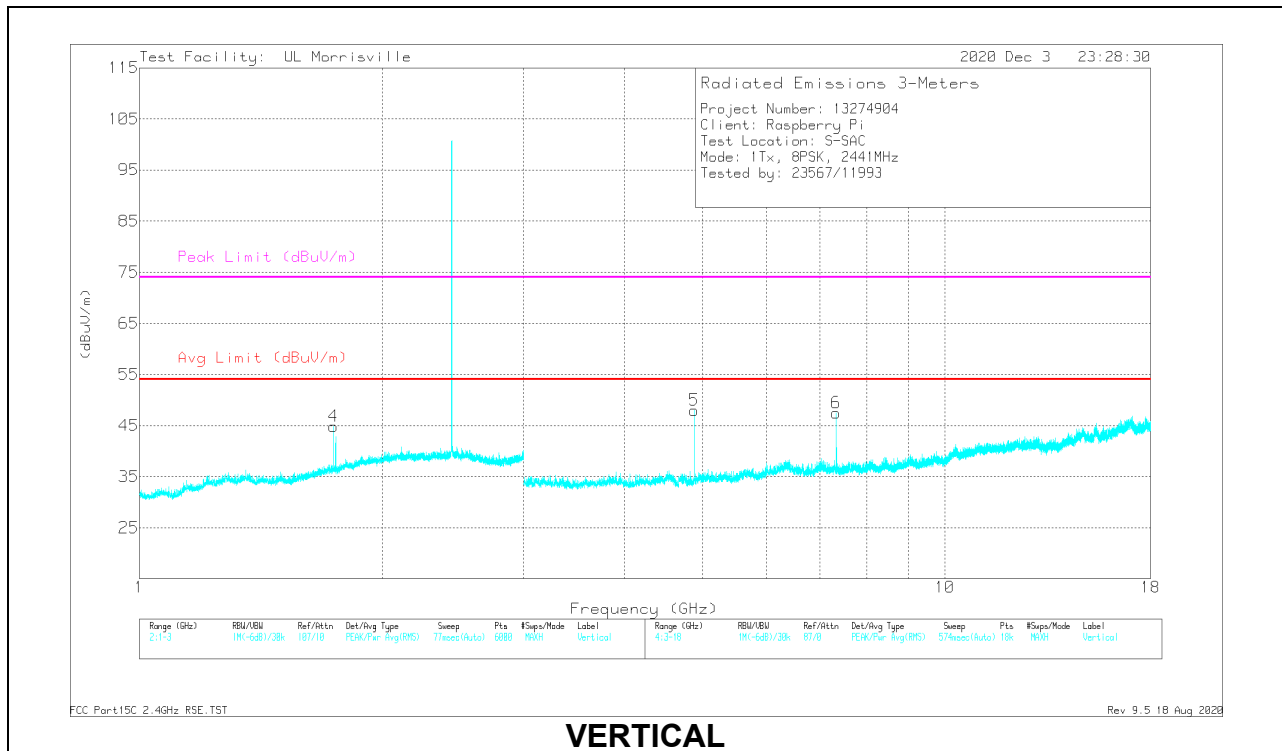
Pk - Peak detector

Note: The DCCF was calculated based on the worst case 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 100 ms or 2x 3.125 ms = 6.25 ms on any channel. Therefore, 20log (6.25 / 100) = - 24dB.

MID CHANNEL RESULTS



HORIZONTAL



VERTICAL

RADIATED EMISSIONS

Marker	Frequency (GHz)	Meter Reading (dBuV)	Det	AT0067 (dB/m)	Amp/Cbl/Filtr/Pad (dB)	DC Corr (dB)	Corrected Reading (dBuV/m)	Avg Limit (dBuV/m)	Margin (dB)	Peak Limit (dBuV/m)	PK Margin (dB)	Azimuth (Degs)	Height (cm)	Polarity
4	** 1.74065	35.35	PK2	29.7	-22.2	0	42.85	-	-	74	-31.15	343	242	V
	** 1.74184	25.83	V1TV	29.7	-22.2	-24	9.33	54	-44.67	-	-	343	242	V
1	*** 3.98168	39.52	PK2	33.4	-31.7	0	41.22	-	-	74	-32.78	113	101	H
	*** 3.98018	26.83	V1TV	33.4	-31.7	-24	4.53	54	-49.47	-	-	113	101	H
2	*** 4.88196	43.8	PK2	34	-30.8	0	47	-	-	74	-27	6	101	H
	*** 4.88208	34.77	V1TV	34	-30.8	-24	13.97	54	-40.03	-	-	6	101	H
3	*** 11.0458	33.74	PK2	38.1	-24	0	47.84	-	-	74	-26.16	355	311	H
	*** 11.04582	21.24	V1TV	38.1	-24	-24	11.34	54	-42.66	-	-	355	311	H
5	*** 4.88212	49.18	PK2	34	-30.8	0	52.38	-	-	74	-21.62	220	160	V
	*** 4.88201	41.9	V1TV	34	-30.8	-24	21.1	54	-32.9	-	-	220	160	V
6	*** 7.32363	46.15	PK2	35.6	-27.4	0	54.35	-	-	74	-19.65	223	130	V
	*** 7.32311	36.84	V1TV	35.6	-27.4	-24	21.04	54	-32.96	-	-	223	130	V

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

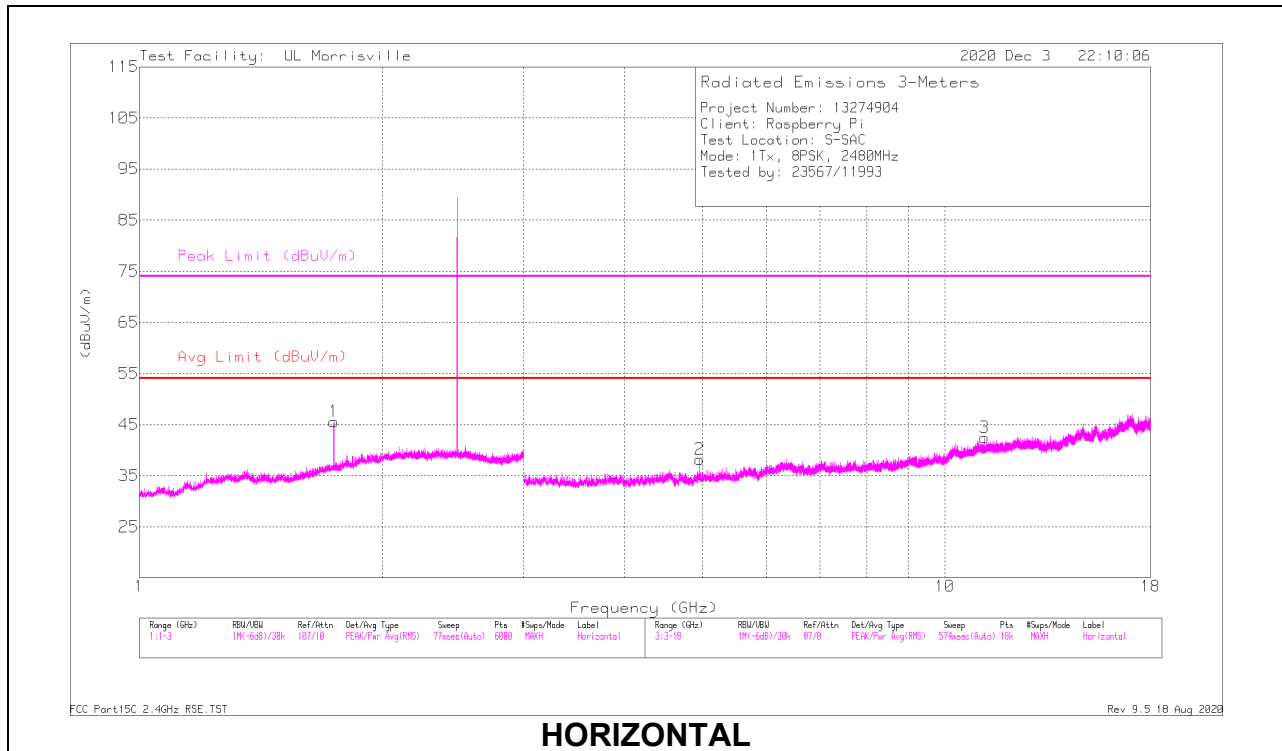
** - indicates frequency in Taiwan NCC LP0002 Restricted Band

PK2: Maximum Peak

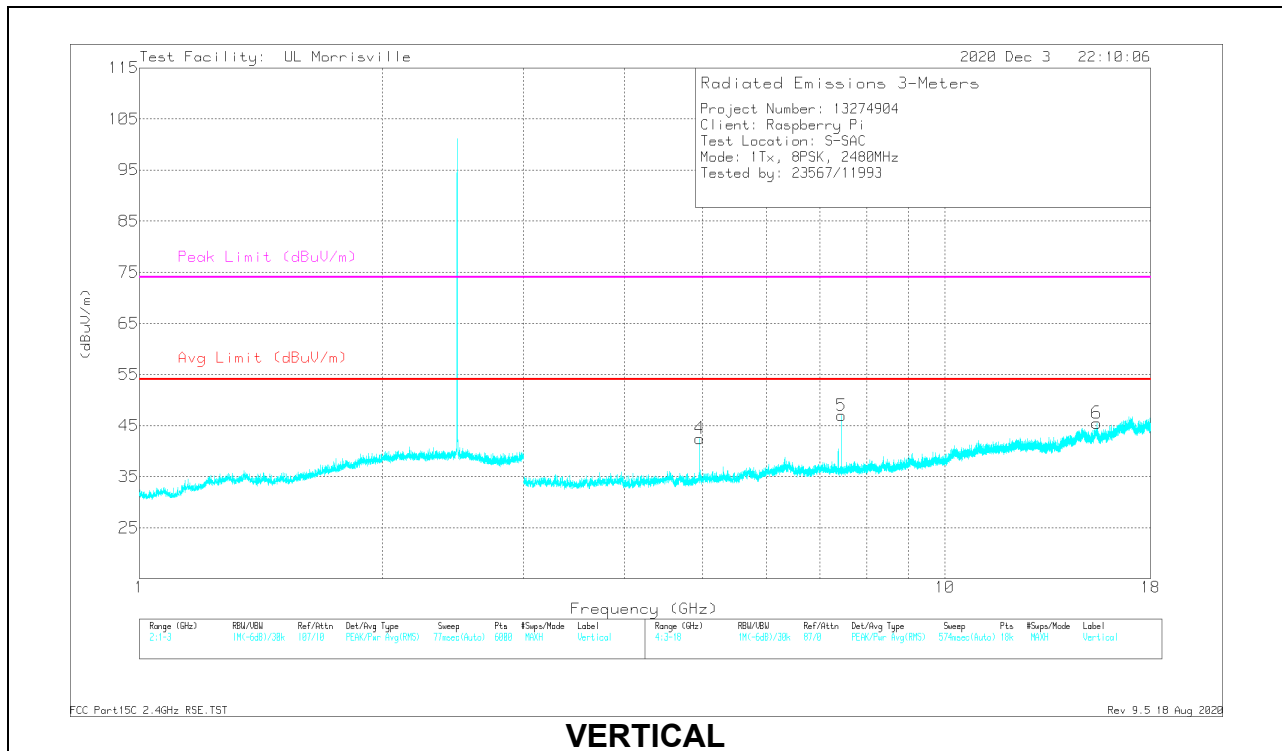
V1TV: VB=1/Ton, Linear Voltage Average where: Ton is packet duration

Note: The DCCF was calculated based on the worst case 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 100 ms or 2x 3.125 ms = 6.25 ms on any channel. Therefore, 20log (6.25 / 100) = - 24dB.

HIGH CHANNEL RESULTS



HORIZONTAL



VERTICAL

RADIATED EMISSIONS

Marker	Frequency (GHz)	Meter Reading (dBuV)	Det	AT0067 (dB/m)	Amp/Cbl/Filtr/Pad (dB)	DC Corr (dB)	Corrected Reading (dBuV/m)	Avg Limit (dBuV/m)	Margin (dB)	Peak Limit (dBuV/m)	PK Margin (dB)	Azimuth (Degs)	Height (cm)	Polarity
1	** 1.74177	35.62	PK2	29.7	-22.2	0	43.12	-	-	74	-30.88	150	111	H
	** 1.7418	23.32	V1TV	29.7	-22.2	-24	6.82	54	-47.18	-	-	150	111	H
2	*** 4.95961	41.77	PK2	33.9	-31	0	44.67	-	-	74	-29.33	12	112	H
	*** 4.96003	31.3	V1TV	33.9	-31	-24	10.2	54	-43.8	-	-	12	112	H
3	*** 11.1981	33.8	PK2	38.1	-24.1	0	47.8	-	-	74	-26.2	47	184	H
	*** 11.19736	21.01	V1TV	38.1	-24.1	-24	11.01	54	-42.99	-	-	47	184	H
4	*** 4.9604	47.29	PK2	33.9	-31	0	50.19	-	-	74	-23.81	226	102	V
	*** 4.96004	39.46	V1TV	33.9	-31	-24	18.36	54	-35.64	-	-	226	102	V
5	*** 7.44005	44.35	PK2	35.6	-27.7	0	52.25	-	-	74	-21.75	204	102	V
	*** 7.4401	35.2	V1TV	35.6	-27.7	-24	19.1	54	-34.9	-	-	204	102	V
6	*** 15.43625	33.51	PK2	40.3	-22.1	0	51.71	-	-	74	-22.29	249	309	V
	*** 15.43653	20.6	V1TV	40.3	-22.1	-24	14.8	54	-39.2	-	-	249	309	V

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

** - indicates frequency in Taiwan NCC LP0002 Restricted Band

PK2: Maximum Peak

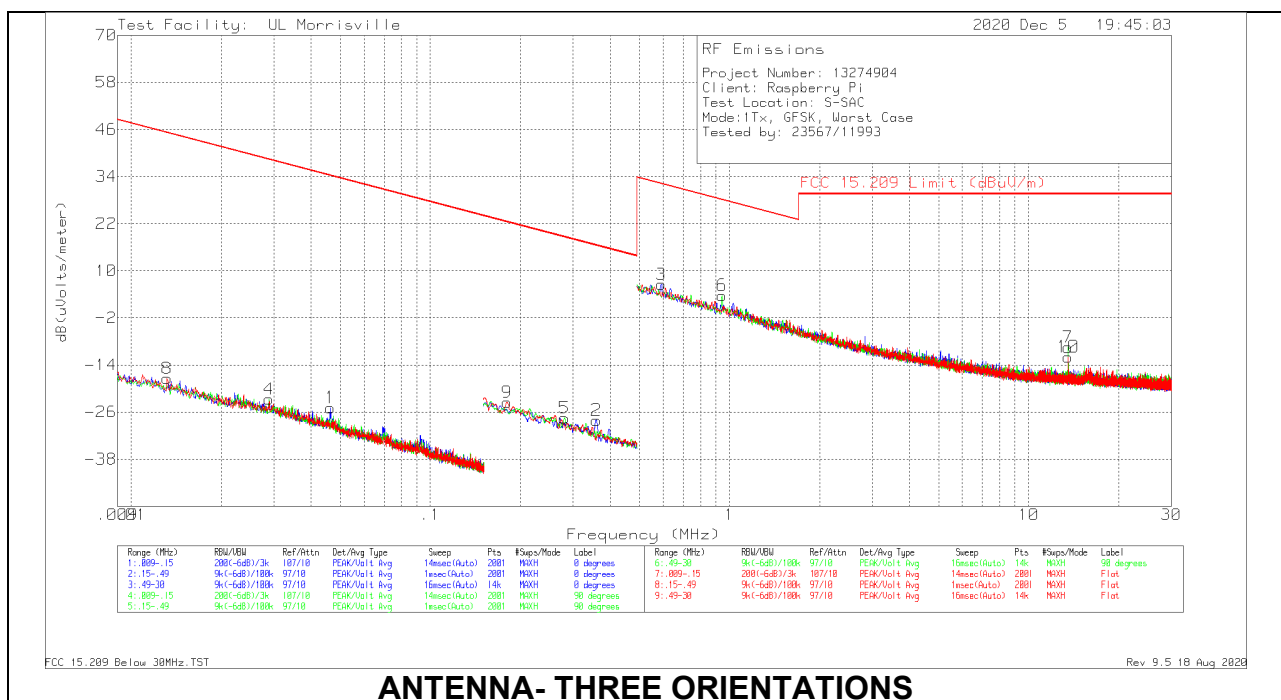
V1TV: VB=1/Ton, Linear Voltage Average where: Ton is packet duration

Note: The DCCF was calculated based on the worst case 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 100 ms or 2x 3.125 ms = 6.25 ms on any channel. Therefore, 20log (6.25 / 100) = - 24dB.

10.2. WORST CASE BELOW 30MHZ

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 $40 \cdot \log(\text{test distance} / \text{specification distance})$.

The below 30 MHz limits in CFR 47, Part 15, Subpart C, paragraph 15.209 (a), are identical to those in RSS-GEN Section 8.9, Table 6, since the measurements are performed in terms of magnetic field strength and converted to electric field strength levels (as reported in the table) using the free space impedance of 377Ω . For example, the measurement frequency 13.19 kHz resulted in a level of -17.44 dBuV/m , which is equivalent to $-17.44 - 51.5 = -68.94 \text{ dBuA/m}$, which has the same margin, -62.64dB , to the corresponding RSS-GEN Table 6 limit as it has to be 15.209(a) limit.

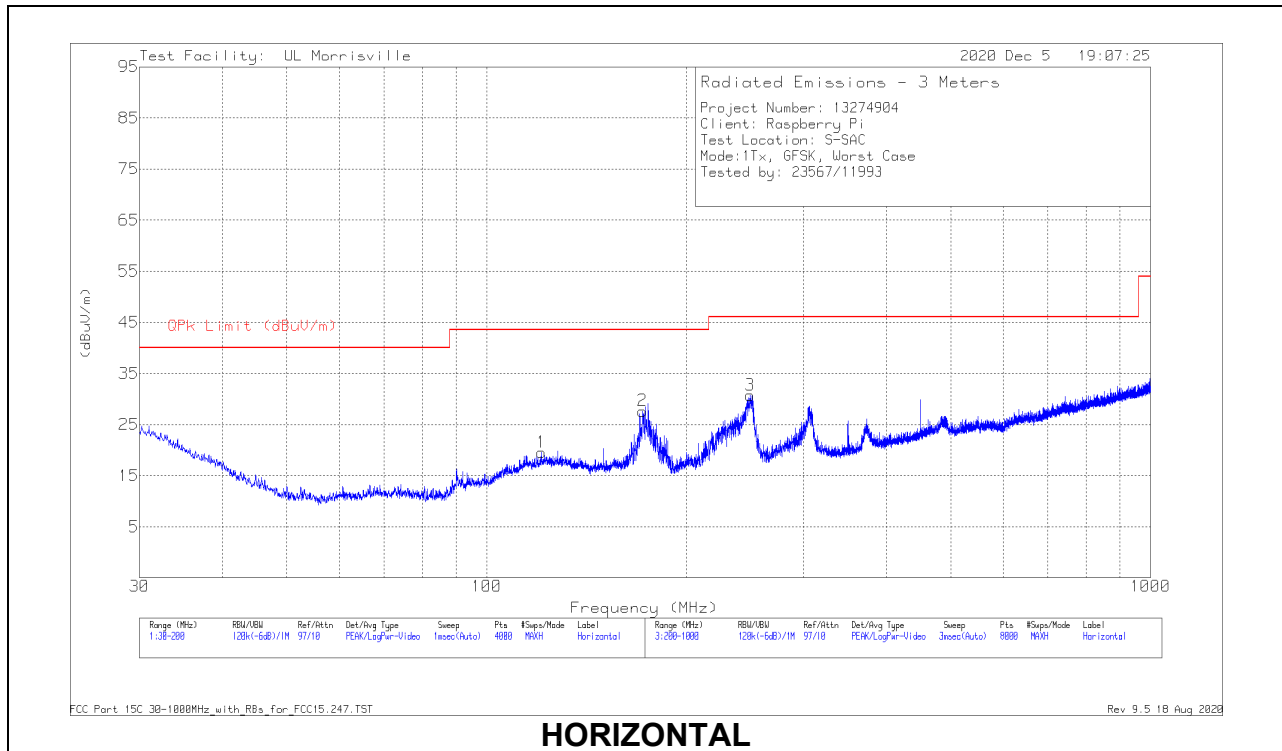


ANTENNA- THREE ORIENTATIONS

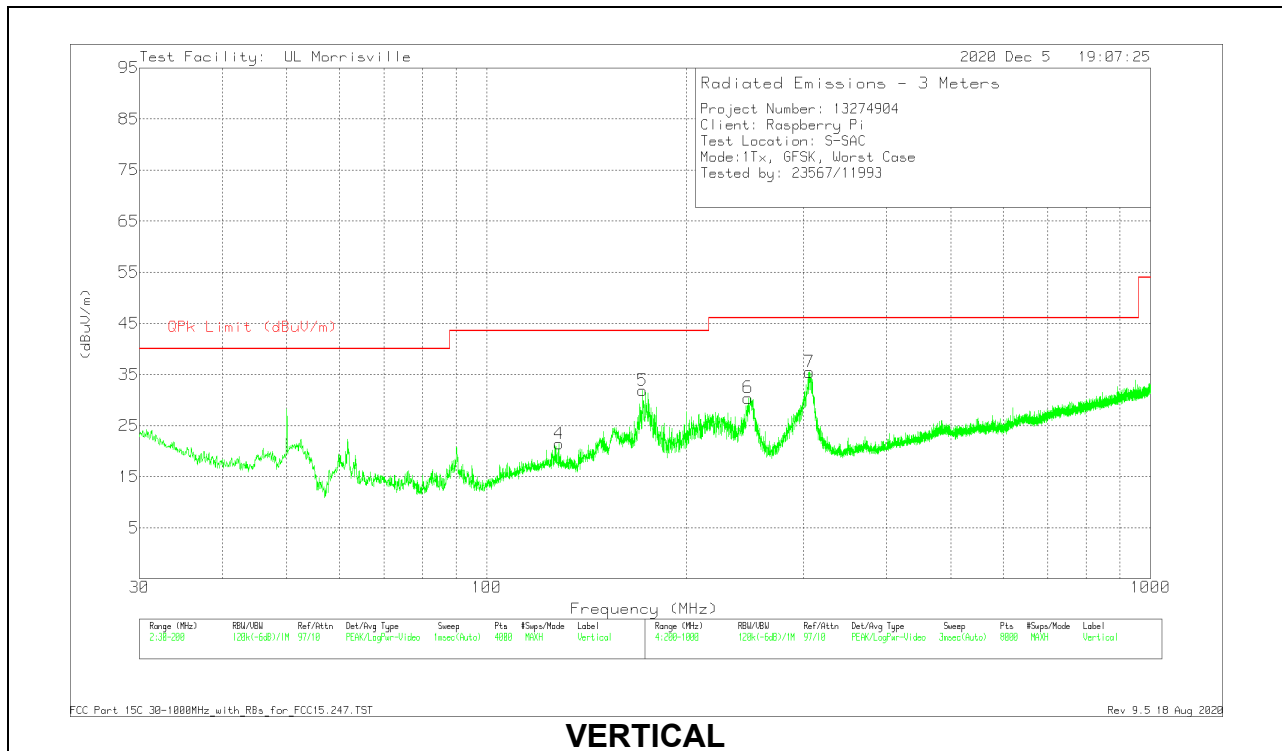
Marker	Frequency (MHz)	Meter Reading (dBuV)	Det	AT0079 (dB/m)	Cbl (dB)	Dist. Corr. Factor (dB)	Corrected Reading dB(uVolts/meter)	FCC 15.209 QP/AV Limit (dBuV/m)	FCC 15.209 PK Limit (dBuV/m)	Margin (dB)	Azimuth (Degs)
8	.01319	45.86	Pk	16.6	.1	-80	-17.44	45.2	65.2	-62.64	0-360
4	.02888	43.9	Pk	13.3	.1	-80	-22.7	38.39	58.39	-61.09	0-360
1	.04628	43.23	Pk	11.8	.1	-80	-24.87	34.3	54.3	-59.17	0-360
9	.18052	45.55	Pk	10.8	.1	-80	-23.55	22.47	42.47	-46.02	0-360
5	.28073	41.71	Pk	10.7	.1	-80	-27.49	18.64	38.64	-46.13	0-360
2	.3591	41.21	Pk	10.6	.1	-80	-28.09	16.5	36.5	-44.59	0-360
3	.59118	35.48	Pk	10.8	.2	-40	6.48	32.17	-	-25.69	0-360
6	.94322	32.61	Pk	10.9	.2	-40	3.71	28.11	-	-24.4	0-360
7	13.5596	19.39	Pk	10.4	.7	-40	-9.51	29.54	-	-39.05	0-360
10	13.56171	16.97	Pk	10.4	.7	-40	-11.93	29.54	-	-41.47	0-360

Pk - Peak detector

10.3. WORST CASE BELOW 30-1000MHZ



HORIZONTAL



VERTICAL

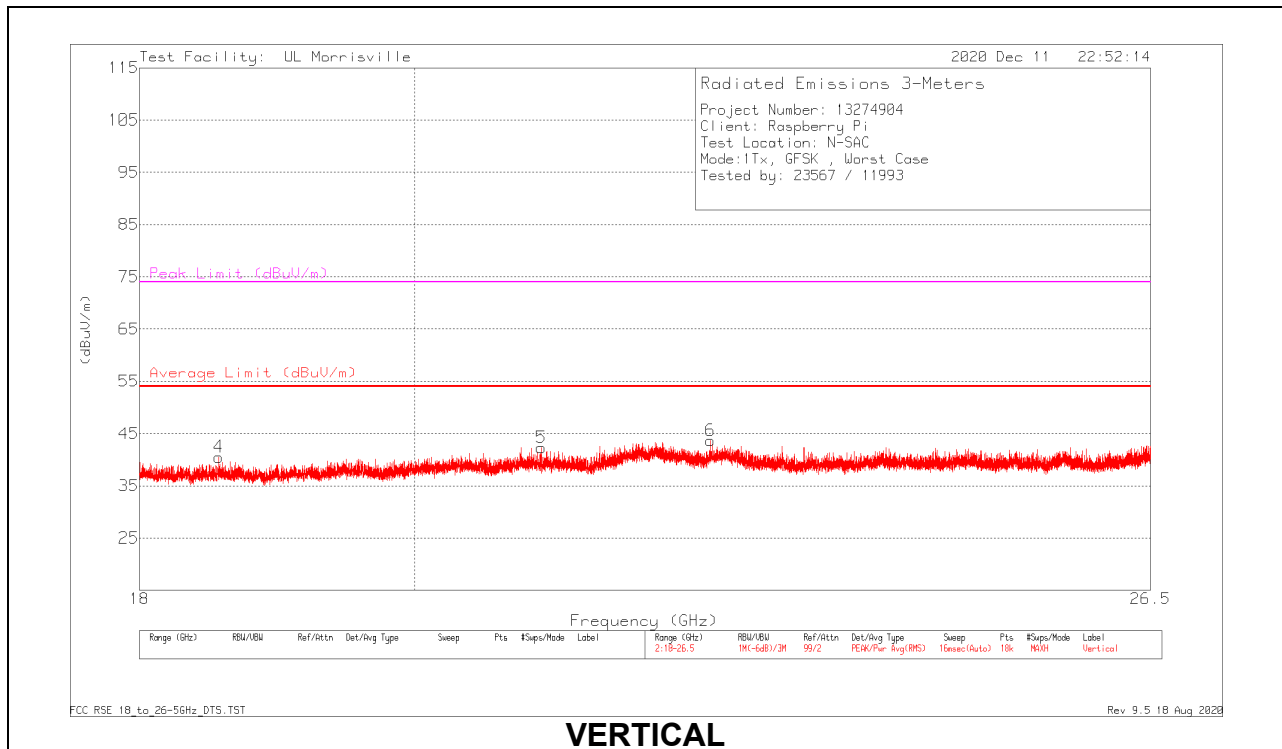
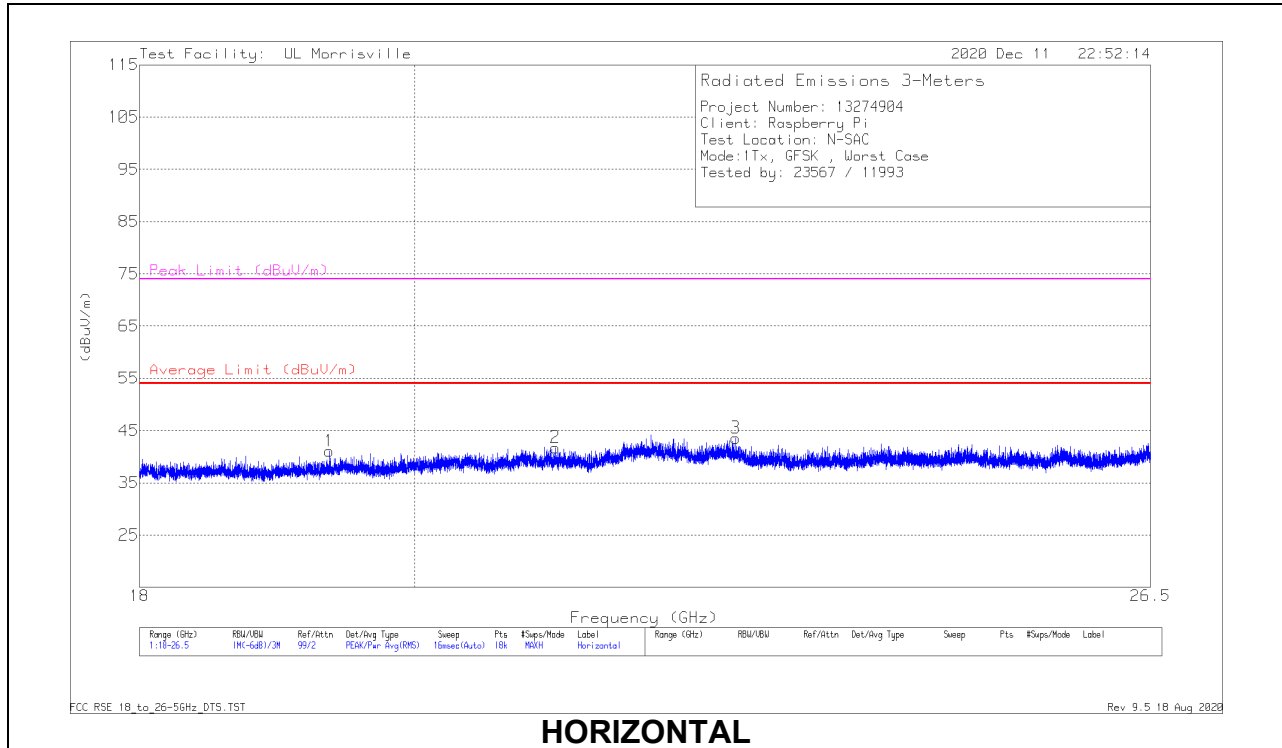
Marker	Frequency (MHz)	Meter Reading (dBuV)	Det	AT0075 AF (dB/m)	Amp/Cbl (dB)	Corrected Reading (dBuV/m)	QPk Limit (dBuV/m)	Margin (dB)	Azimuth (Degs)	Height (cm)	Polarity
1	* ** 121.0161	29.84	Pk	20.1	-30.4	19.54	43.52	-23.98	0-360	99	H
2	* ** 171.7742	39.56	Pk	17.9	-29.8	27.66	43.52	-15.86	0-360	299	H
4	* ** 128.4555	31.5	Pk	20.1	-30.2	21.4	43.52	-22.12	0-360	101	V
5	* ** 171.8167	43.74	Pk	17.9	-29.8	31.84	43.52	-11.68	0-360	101	V
3	* ** 249.4064	42.24	Pk	17.6	-29.1	30.74	46.02	-15.28	0-360	101	H
6	* ** 247.6062	42.02	Pk	17.6	-29.2	30.42	46.02	-15.6	0-360	101	V
7	306.3138	44.46	Pk	19.7	-28.7	35.46	-	-	0-360	199	V

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

** - indicates frequency in Taiwan NCC LP0002 Restricted Band

Pk - Peak detector

10.4. WORST CASE 18-26 GHZ



Marker	Frequency (GHz)	Meter Reading (dBuV)	Det	AT0063 AF (dB/m)	Amp/CBL (dB)	Corrected Reading (dBuV/m)	Average Limit (dBuV/m)	Margin (dB)	Peak Limit (dBuV/m)	Margin (dB)	Azimuth (Degs)	Height (cm)	Polarity
1	*** 19.35441	48.36	Pk	33.4	-40.7	41.06	54	-12.94	74	-32.94	0-360	149	H
2	*** 21.10503	48.44	Pk	34.2	-40.9	41.74	54	-12.26	74	-32.26	0-360	101	H
3	*** 22.61292	48.38	Pk	36.1	-40.9	43.58	54	-10.42	74	-30.42	0-360	149	H
4	*** 18.55347	47.81	Pk	33.2	-40.5	40.51	54	-13.49	74	-33.49	0-360	150	V
5	*** 20.99075	49.02	Pk	34.3	-41	42.32	54	-11.68	74	-31.68	0-360	250	V
6	*** 22.39427	48.05	Pk	36.6	-41	43.65	54	-10.35	74	-30.35	0-360	101	V

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

11. 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

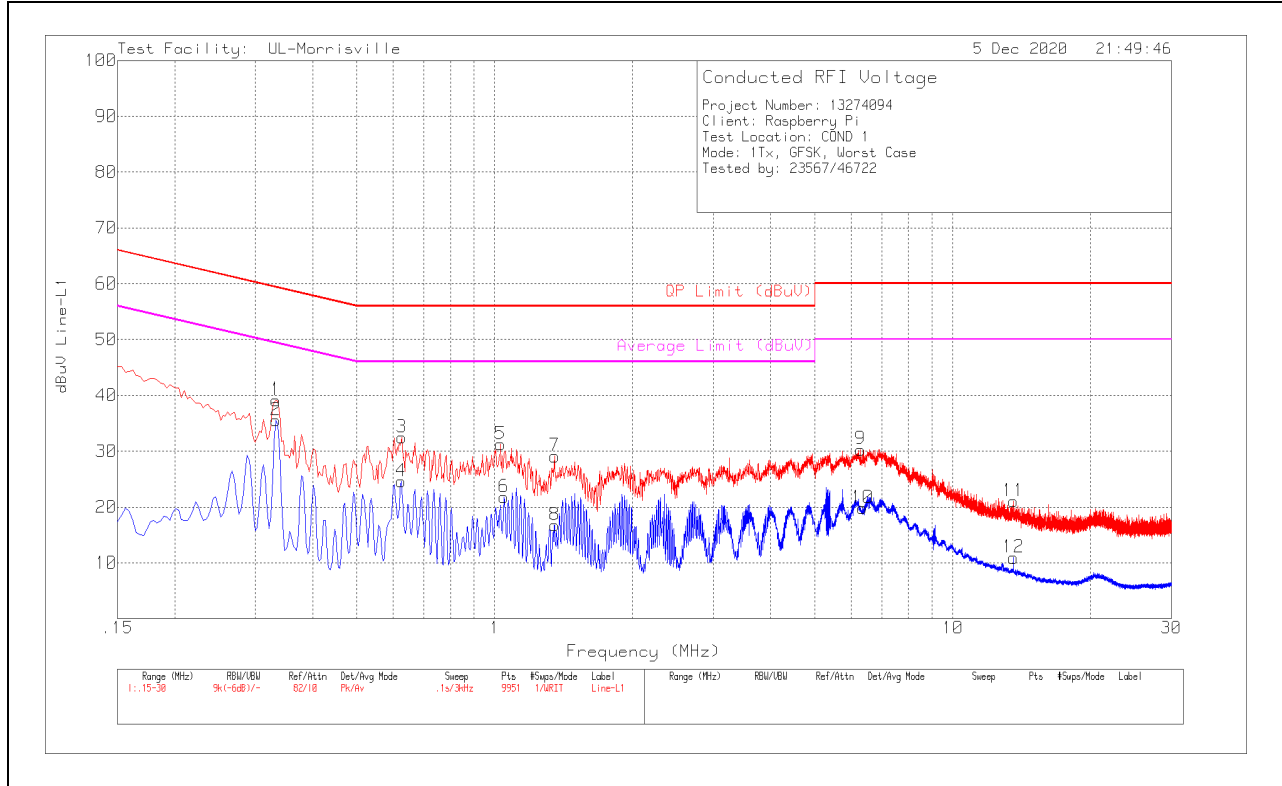
The EUT is placed on a non-conducting table 40 cm from the vertical ground plane and 80 cm above the horizontal ground plane. The EUT is configured in accordance with ANSI C63.4.

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 lines.

11.1.1. AC POWER LINE NORM

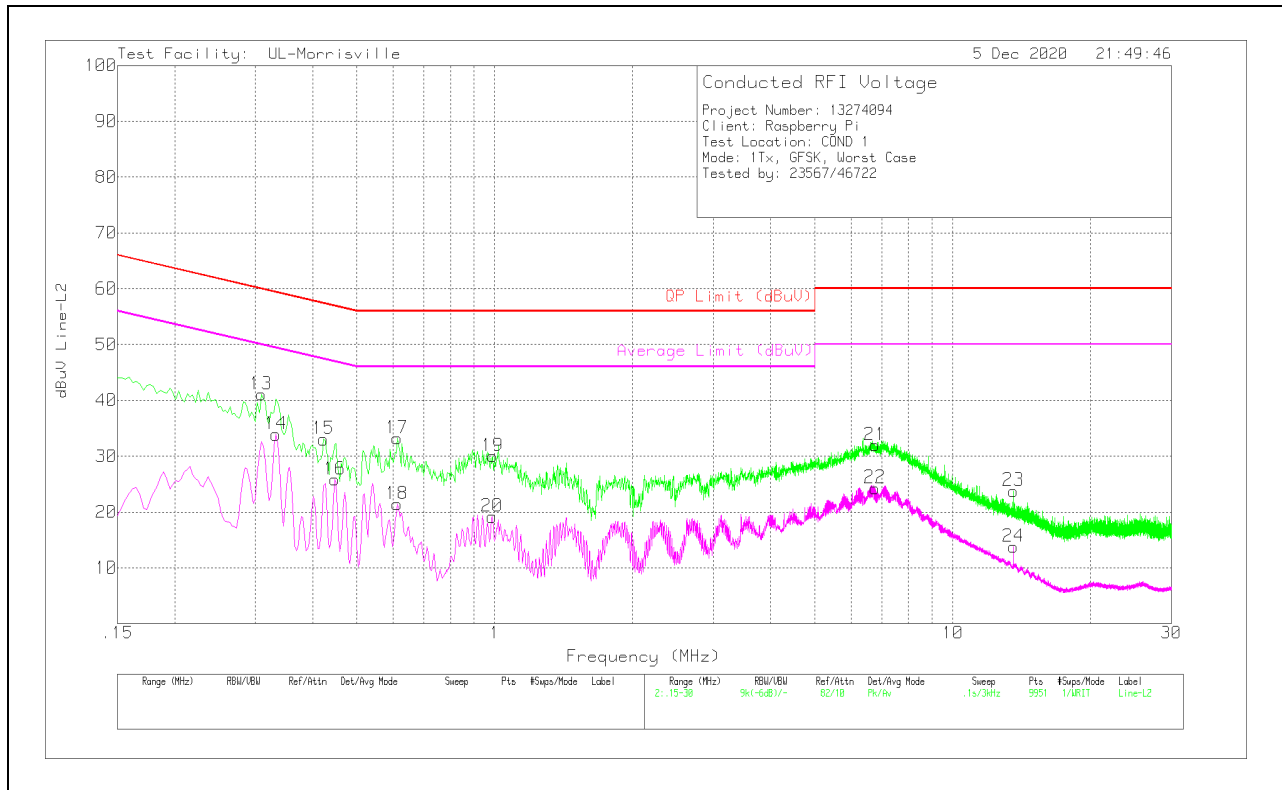
LINE 1 RESULTS



Range 1: Line-L1 .15 - 30MHz										
Marker	Frequency (MHz)	Meter Reading (dBuV)	Det	LISN VCF (dB)	Cbl/Limiter (dB)	Corrected Reading dBuV	QP Limit (dBuV)	Margin (dB)	Average Limit (dBuV)	Margin (dB)
1	.333	29.34	Pk	.1	9.7	39.14	59.38	-20.24	-	-
2	.333	25.74	Av	.1	9.7	35.54	-	-	49.38	-13.84
3	.627	22.65	Pk	0	9.8	32.45	56	-23.55	-	-
4	.624	14.82	Av	0	9.8	24.62	-	-	46	-21.38
5	1.029	21.46	Pk	0	9.8	31.26	56	-24.74	-	-
6	1.047	11.94	Av	0	9.8	21.74	-	-	46	-24.26
7	1.35	19.3	Pk	0	9.8	29.1	56	-26.9	-	-
8	1.35	6.94	Av	0	9.8	16.74	-	-	46	-29.26
9	6.291	20.32	Pk	.1	9.9	30.32	60	-29.68	-	-
10	6.354	9.84	Av	.1	9.9	19.84	-	-	50	-30.16
11	13.548	10.93	Pk	.1	10	21.03	60	-38.97	-	-
12	13.56	.81	Av	.1	10	10.91	-	-	50	-39.09

Pk – Peak Detector
 Av – Average Detector

LINE 2 RESULTS



Range 2: Line-L2 .15 - 30MHz										
Marker	Frequency (MHz)	Meter Reading (dBuV)	Det	LISN VCF (dB)	Cbl/Limiter (dB)	Corrected Reading dBuV	QP Limit (dBuV)	Margin (dB)	Average Limit (dBuV)	Margin (dB)
13	.309	31.26	Pk	.1	9.7	41.06	60	-18.94	-	-
14	.333	24.1	Av	.1	9.7	33.9	-	-	49.38	-15.48
15	.423	23.14	Pk	.1	9.8	33.04	57.39	-24.35	-	-
16	.447	16.04	Av	.1	9.7	25.84	-	-	46.93	-21.09
17	.612	23.37	Pk	0	9.8	33.17	56	-22.83	-	-
18	.612	11.57	Av	0	9.8	21.37	-	-	46	-24.63
19	.99	20.19	Pk	0	9.8	29.99	56	-26.01	-	-
20	.987	9.35	Av	0	9.8	19.15	-	-	46	-26.85
21	6.759	21.98	Pk	.1	9.9	31.98	60	-28.02	-	-
22	6.756	14.29	Av	.1	9.9	24.29	-	-	50	-25.71
23	13.56	13.69	Pk	.1	10	23.79	60	-36.21	-	-
24	13.56	3.66	Av	.1	10	13.76	-	-	50	-36.24

Pk – Peak Detector
 Av – Average Detector

12. SETUP PHOTOS

Please refer to R13274094-EP1 for setup photos.

END OF TEST REPORT