

# TEST REPORT

**Report Number. :** R14516988-E1

**Applicant :** Product Safety Consulting  
605 Country Club Drive,  
Suites I & J, Bensenville, IL 60106

**Model :** S2000C

**Brand :** Colgate

**FCC ID :** 2AL5Y-S2000C

**EUT Description :** Connected Toothbrush

**Test Standard(s) :** FCC 47 CFR PART 15 SUBPART C:2022

**Date Of Issue:**  
2023-01-30

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



---

## REPORT REVISION HISTORY

Rev.	Issue Date	Revisions	Revised By
V1	2022-10-14	Initial Issue	Noah Bennett
V2	2022-11-01	Updated section 6.1 and 6.6	Noah Bennett
V3	2023-01-12	Updated Section 2 to Include Client Provided Data	Charles Moody
V4	2023-01-30	Added Attenuation Information	Charles Moody

## TABLE OF CONTENTS

<b>REPORT REVISION HISTORY .....</b>	<b>2</b>
<b>TABLE OF CONTENTS .....</b>	<b>3</b>
<b>1. ATTESTATION OF TEST RESULTS .....</b>	<b>5</b>
<b>2. TEST RESULTS SUMMARY.....</b>	<b>6</b>
<b>3. TEST METHODOLOGY .....</b>	<b>6</b>
<b>4. FACILITIES AND ACCREDITATION .....</b>	<b>6</b>
<b>5. DECISION RULES AND MEASUREMENT UNCERTAINTY.....</b>	<b>7</b>
5.1. METROLOGICAL TRACEABILITY.....	7
5.2. DECISION RULES.....	7
5.3. MEASUREMENT UNCERTAINTY.....	7
5.4. SAMPLE CALCULATION .....	7
<b>6. EQUIPMENT UNDER TEST .....</b>	<b>8</b>
6.1. EUT DESCRIPTION .....	8
6.2. MAXIMUM OUTPUT POWER.....	8
6.3. DESCRIPTION OF AVAILABLE ANTENNAS.....	8
6.4. SOFTWARE AND FIRMWARE.....	8
6.5. WORST-CASE CONFIGURATION AND MODE.....	8
6.6. DESCRIPTION OF TEST SETUP.....	9
<b>7. MEASUREMENT METHOD .....</b>	<b>10</b>
<b>8. TEST AND MEASUREMENT EQUIPMENT .....</b>	<b>11</b>
<b>9. ANTENNA PORT TEST RESULTS.....</b>	<b>14</b>
9.1. ON TIME AND DUTY CYCLE.....	14
9.2. 6 dB BANDWIDTH.....	15
9.2.1. BLE (1Mbps).....	15
9.3. OUTPUT POWER.....	16
9.3.1. BLE (1Mbps).....	16
9.4. AVERAGE POWER.....	17
9.4.1. BLE (1Mbps).....	17
9.5. POWER SPECTRAL DENSITY .....	18
9.5.1. BLE (1Mbps).....	18
9.6. CONDUCTED SPURIOUS EMISSIONS.....	19
9.6.1. BLE (1Mbps).....	20

---

<b>10. RADIATED TEST RESULTS .....</b>	<b>21</b>
10.1. LIMITS AND PROCEDURE .....	21
10.2. TRANSMITTER ABOVE 1 GHZ.....	22
10.2.1. BLE (1Mbps).....	22
10.3. WORST CASE BELOW 30MHZ.....	32
10.4. WORST CASE BELOW 1 GHZ.....	33
10.5. WORST CASE 18-26 GHZ.....	35
<b>11. AC POWER LINE CONDUCTED EMISSIONS .....</b>	<b>37</b>
11.1.1. AC Power Line Norm.....	37
<b>12. SETUP PHOTOS .....</b>	<b>39</b>

# 1. ATTESTATION OF TEST RESULTS

**COMPANY NAME:** Colgate-Palmolive Company  
909 River Road  
PISCATAWAY, NJ, 08854-5503, USA

**EUT DESCRIPTION:** Connected toothbrush

**MODEL:** S2000C

**BRAND:** Colgate

**SERIAL NUMBER:** Non-Serialized

**SAMPLE RECEIPT DATE:** 2022-09-29

**DATE TESTED:** 2022-09-29 TO 2022-10-05

APPLICABLE STANDARDS	
STANDARD	TEST RESULTS
CFR 47 Part 15 Subpart C:2022	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:

Prepared By:



---

Brian Kiewra  
Project Engineer  
Consumer Technology Division  
UL LLC.

---

Noah Bennett  
Electrical Engineer  
Consumer Technology Division  
UL LLC.

## 2. TEST RESULTS SUMMARY

FCC Clause	Requirement	Result	Comment
See Comment	Duty Cycle	Reporting purposes only	ANSI C63.10 Section 11.6.
15.247 (a) (2)	6dB BW	Complies	None.
15.247 (b) (3)	Output Power	Complies	None.
See Comment	Average power	Reporting purposes only	Per ANSI C63.10, Section 11.9.2.3.2.
15.247 (e)	PSD	Complies	None.
15.247 (d)	Conducted Spurious Emissions	Complies	None.
15.209, 15.205	Radiated Emissions	Complies	None.
15.207	AC Mains Conducted Emissions	Complies	None.

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

Below is a list of the data/info provided by the customer:

- 1.) Antenna type and gain (see section 6.3)
- 2.) Cable Loss (see section 9.3 and 9.4)

## 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.

## 4. FACILITIES AND ACCREDITATION

UL LLC is accredited by A2LA, Certificate Number #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 checked="" type="checkbox"/>	Building 2800 Suite Perimeter Park Dr. Suite B Morrisville, NC 27560, U.S.A	US0067	27265	825374

## 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	U <sub>Lab</sub>
Radio Frequency (Spectrum Analyzer)	141.2 Hz
Occupied Channel Bandwidth	1.22%
RF output power, conducted	1.3 dB (PK) 0.45 dB (AV)
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	0.57°C
Humidity	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:

$$\text{Field Strength (dBuV/m)} = \text{Measured Voltage (dBuV)} + \text{Antenna Factor (dB/m)} + \text{Cable Loss (dB)} - \text{Preamp Gain (dB)}$$
$$36.5 \text{ dBuV} + 18.7 \text{ dB/m} + 0.6 \text{ dB} - 26.9 \text{ dB} = 28.9 \text{ dBuV/m}$$

#### **MAINS CONDUCTED EMISSIONS**

Where relevant, the following sample calculation is provided:

$$\text{Final Voltage (dBuV)} = \text{Measured Voltage (dBuV)} + \text{Cable Loss (dB)} + \text{Limiter Factor (dB)} + \text{LISN Insertion Loss.}$$
$$36.5 \text{ dBuV} + 0 \text{ dB} + 10.1 \text{ dB} + 0 \text{ dB} = 46.6 \text{ dBuV}$$

## 6. EQUIPMENT UNDER TEST

### 6.1. EUT DESCRIPTION

The EUT is a Bluetooth Limited Energy battery operated toothbrush for consumer use. Accessories include DC contact charger and AC adapter.

### 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	BLE	-4.16	0.38

### 6.3. DESCRIPTION OF AVAILABLE ANTENNAS

The antenna(s) gain and type, as provided by the manufacturer' are as follows:

Frequency Range (MHz)	Antenna Gain (dBi)	Antenna Type
2402-2480	2dBi	Chip Type 3216 Surface mount

### 6.4. SOFTWARE AND FIRMWARE

The EUT firmware installed during testing was v2.0.

The test utility software used during testing was Nordic SDK Version 17.2 and nRF52 stack version 6.1.1

### 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 EUT only supports 1 data rate of 1Mbps, therefore, all testing was done in that data rate.

The EUT was tested while connected to a DC contact charger on AC Mains to represent Worst Case.

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

## 6.6. DESCRIPTION OF TEST SETUP

### SUPPORT EQUIPMENT

Support Equipment List				
Description	Manufacturer	Model	Serial Number	FCC ID
Laptop	Dell	Inspiron 15 3000	5KPQJP3	N/A
Laptop	Lenovo	ThinkPad T450	11989F32-3DE1-4C7D-B46D-7243CCCA9AE62	N/A
AC Adaptor	BOSE	S008AHU0500160	072381Z60770084AE	N/A
DC Contact Charger	Colgate	N/A	N/A	N/A

### I/O CABLES

I/O Cable List						
Cable No.	Port	# of Identical Ports	Connector Type	Cable Type	Cable Length (m)	Remarks
1	1	1	USB to UART	Shielded	>3m	Programming cable
2	2	1	USB-A	Shielded	<3m	Connected EUT charger to AC Adaptor

### TEST SETUP

The EUT is connected to a test laptop and configured before the tests. Test software exercised the radio card. Programming cable (1) and Laptop removed for testing.

### SETUP DIAGRAMS

Please refer to R14516988-EP1 for setup diagrams

## 7. MEASUREMENT METHOD

Duty Cycle: ANSI C63.10 Section 11.6

6 dB BW: ANSI C63.10 Subclause -11.8.1

Output Power: ANSI C63.10 Subclause -11.9.1.3 Method PKPM1 Peak-reading power meter  
Output Power: ANSI C63.10 Subclause -11.9.2.3.2 Method AVGPM-G (Measurement using a gated RF average-reading power meter)

PSD: ANSI C63.10 Subclause -11.10.2 Method PKPSD (peak PSD)

Radiated emissions non-restricted frequency bands: ANSI C63.10 Subclause -11.11 and 6.10.4

Radiated emissions restricted frequency bands: ANSI C63.10 Subclause -11.12.1 and 6.10.5

AC Power Line Conducted Emissions: ANSI C63.10-2013, Section 6.2.

Radiated Spurious Emissions: ANSI C63.10-2013 Section 6.3 to 6.6

## 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.
<b>Conducted 1</b>					
HI0091	Environmental Meter	Fisher Scientific	15-077-963	2022-07-20	2023-07-20
PWM001	RF Power Meter	Keysight Technologies	N1912A	2022-08-30	2023-08-30
PWS007	Wideband Power Sensor, 50MHz – 18GHz	Keysight Technologies	N1921A	2022-03-22	2023-03-22
SA0025	Spectrum Analyzer	Keysight Technologies	N9030A	2022-05-02	2023-05-02
SOFTEMI	Antenna Port Software	UL	Version 2022.8.16		
<b>Conducted 2</b>					
HI0090	Environmental Meter	Fisher Scientific	15-077-963	2022-07-20	2023-07-20
PWM003	RF Power Meter	Keysight Technologies	N1911A	2022-09-10	2023-09-10
PWS005	Wideband Power Sensor, 50MHz – 18GHz	Keysight Technologies	N1921A	2022-06-15	2023-06-15
SA0027	Spectrum Analyzer	Keysight Technologies	N9030A	2022-05-24	2023-05-24
SOFTEMI	Antenna Port Software	UL	Version 2022.8.16		
<b>Fittings Used</b>					
226559	10dB SMA Attenuator	CentricRF	C1852-10	2022-05-03	2023-05-03

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	2022-04-05	2023-04-05
HI0091	Environmental Meter	Fisher Scientific	15-077-963	2022-07-20	2023-07-20
LISN003	LISN, 50-ohm/50-uH, 250uH 2-conductor, 25A	Fischer Custom Com.	FCC-LISN-50/250-25-2-01	2022-08-01	2023-08-01
75141	EMI Test Receiver 9kHz-7GHz	Rohde & Schwarz	ESCI 7	2022-08-03	2023-08-03
ATA222	Transient Limiter, 0.009-100MHz	Electro-Metrics	EM-7600	2022-04-05	2023-04-05
PS215	AC Power Source	Elgar	CW2501M (s/n 1523A02397)	NA	NA
SOFTEMI	EMI Software	UL	Version 9.5 (18 Oct 2021)		
	<b>Miscellaneous (if needed)</b>				
CDECABLE001	ANSI C63.4 1m extension cable.	UL	Per Annex B of ANSI C63.4	2022-09-12	2023-09-12

Test Equipment Used - Radiated Disturbance Emissions Test Equipment (Morrisville – Chamber 2)

Equip. ID	Description	Manufacturer/Brand	Model Number	Last Cal.	Next Cal.
	<b>0.009-30MHz</b>				
AT0079	Active Loop Antenna	ETS-Lindgren	6502	2022-09-12	2023-09-12
	<b>30-1000 MHz</b>				
AT0074	Hybrid Broadband Antenna	Sunol Sciences Corp.	JB3	2022-09-07	2023-09-07
	<b>1-18 GHz</b>				
206211	Double-Ridged Waveguide Horn Antenna, 1 to 18 GHz	ETS Lindgren	3117	2022-03-21	2023-03-21
	<b>18-40 GHz</b>				
AT0063	Horn Antenna, 18-26.5GHz	ARA	MWH-1826/B	2021-11-04	2022-11-04
	<b>Gain-Loss Chains</b>				
C2-SAC01	Gain-loss string: 0.009-30MHz	Various	Various	2022-05-10	2023-05-10
C2-SAC02	Gain-loss string: 25-1000MHz	Various	Various	2022-05-10	2023-05-10
C2-SAC03	Gain-loss string: 1-18GHz	Various	Various	2022-05-10	2023-05-10
C2-SAC04	Gain-loss string: 18-40GHz	Various	Various	2022-05-10	2023-05-10
	<b>Receiver &amp; Software</b>				
197955	Spectrum Analyzer	Rohde & Schwarz	ESW44	2022-03-08	2023-03-08
SA0026	Spectrum Analyzer	Agilent	N9030A	2022-08-02	2023-08-02
SOFTEMI	EMI Software	UL	Version 9.5 (18 Oct 2021)		
	<b>Additional Equipment used</b>				
HI0092	Environmental Meter	Fisher Scientific	17025 (s/n 160938893)	2022-03-17	2023-03-17

## 9. ANTENNA PORT TEST RESULTS

### 9.1. ON TIME AND DUTY CYCLE

#### LIMITS

None; for reporting purposes only.

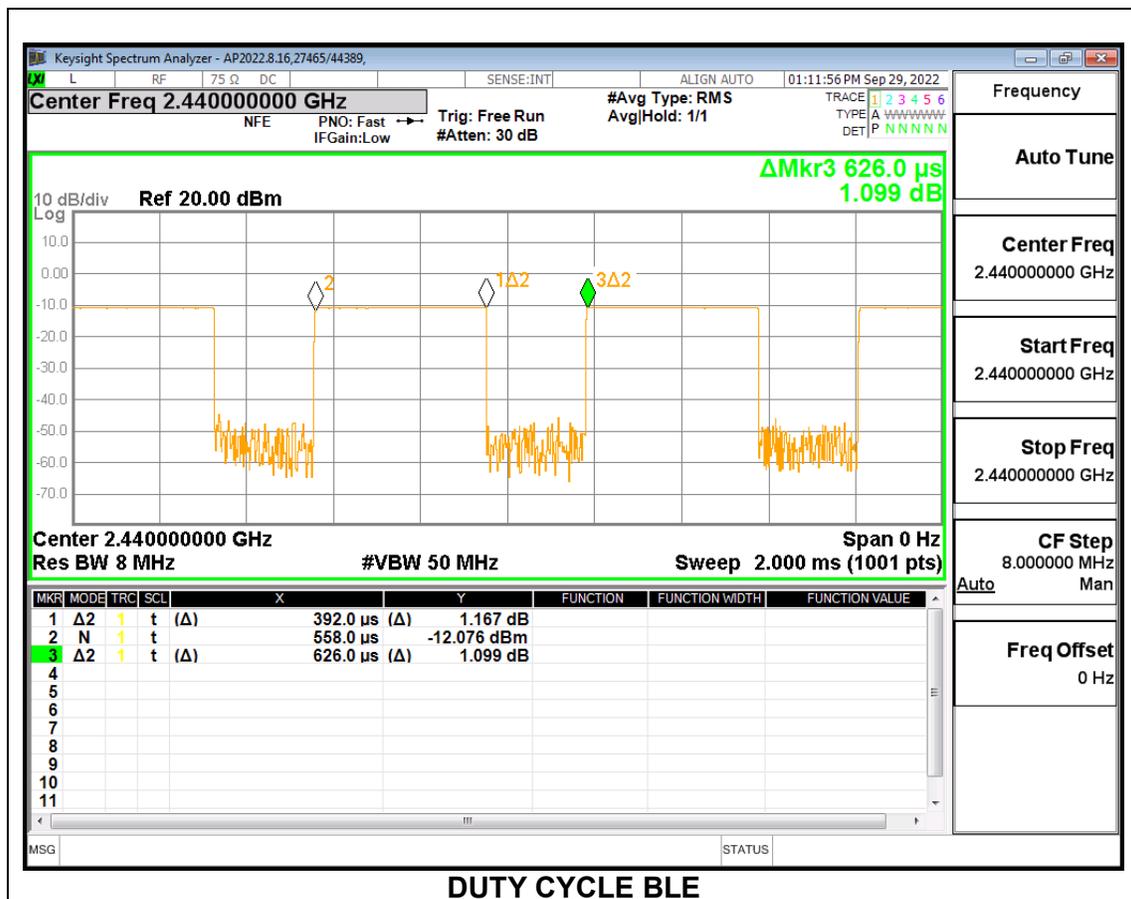
#### PROCEDURE

KDB 558074 Zero-Span Spectrum Analyzer Method, ANSI C63.10 Section 11.6

#### 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/B Minimum VBW (kHz)
2.4GHz Band						
BLE	0.392	0.626	0.626	62.62	4.07	2.551

#### DUTY CYCLE PLOTS



## 9.2. 6 dB BANDWIDTH

### LIMITS

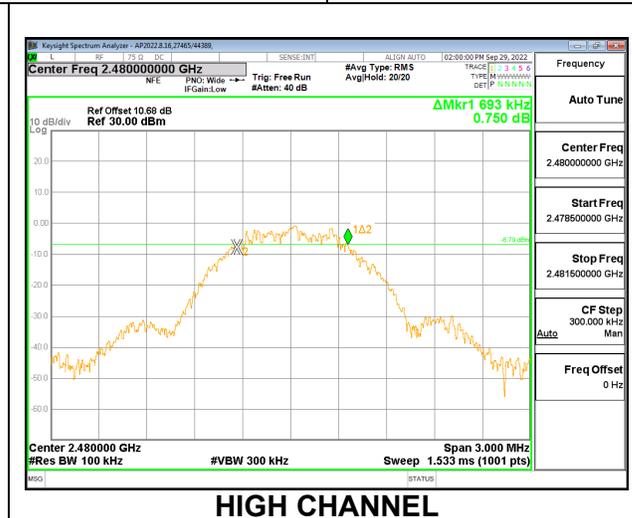
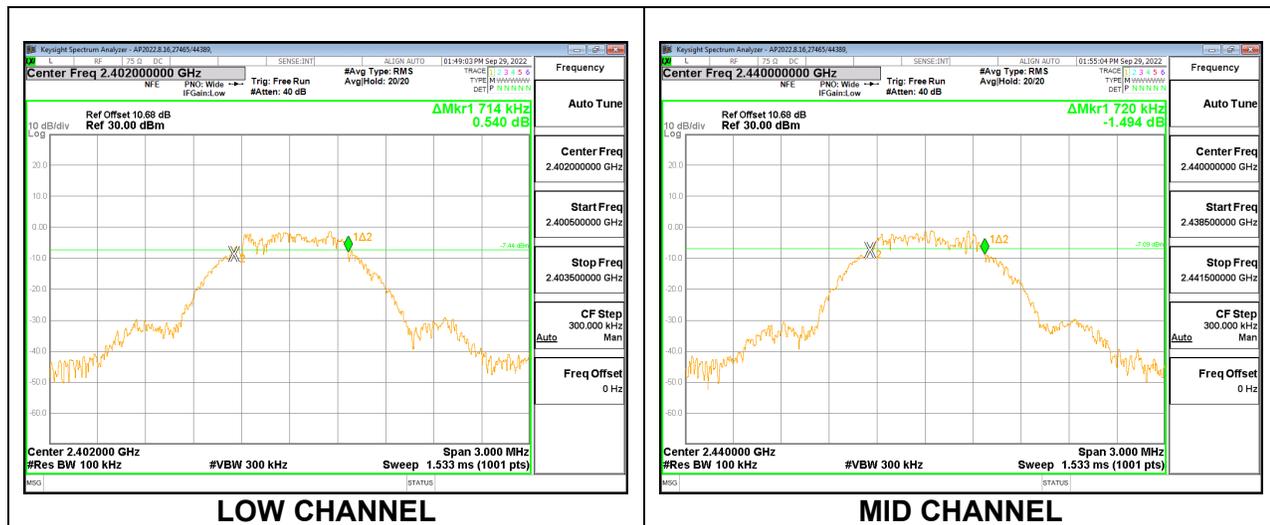
FCC §15.247 (a) (2)

The minimum 6 dB bandwidth shall be at least 500 kHz.

### RESULTS

#### 9.2.1. BLE (1Mbps)

Channel	Frequency (MHz)	6 dB Bandwidth (MHz)	Minimum Limit (MHz)
Low	2402	0.714	0.5
Middle	2440	0.720	0.5
High	2480	0.693	0.5



### 9.3. OUTPUT POWER

#### LIMITS

FCC §15.247 (b) (3)

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

#### TEST PROCEDURE

The transmitter output is connected to a power meter.

The cable assembly insertion loss of 10.68 dB (including 9.68 dB pad and 1.0 dB cable) was entered as an offset in the power meter.

The power output was measured on the EUT antenna port using SMA cable with 10dB attenuator connected to a power meter. Peak output power was read directly from power meter.

#### RESULTS

##### 9.3.1. BLE (1Mbps)

<b>Tested By:</b>	85502/44389, 27465/44389
<b>Date:</b>	9/29/2022

<b>Channel</b>	<b>Frequency (MHz)</b>	<b>Peak Power Reading (dBm)</b>	<b>Limit (dBm)</b>	<b>Margin (dB)</b>
Low	2402	-4.83	30	-34.830
Middle	2440	-4.48	30	-34.480
High	2480	-4.16	30	-34.160

## 9.4. AVERAGE POWER

### LIMITS

None; for reporting purposes only.

### TEST PROCEDURE

The transmitter output is connected to a gated average power meter.

The cable assembly insertion loss of 10.68 dB (including 9.68 dB pad and 1.0 dB cable) was entered as an offset in the power meter.

The power output was measured on the EUT antenna port using SMA cable with 10dB attenuator connected to a power meter. Gated average output power was read directly from power meter.

### RESULTS

#### 9.4.1. BLE (1Mbps)

<b>Tested By:</b>	85502/44389, 27465/44389
<b>Date:</b>	9/29/2022

<b>Channel</b>	<b>Frequency (MHz)</b>	<b>AV power (dBm)</b>
Low	2402	-5.57
Middle	2440	-5.25
High	2480	-4.9

## 9.5. POWER SPECTRAL DENSITY

### LIMITS

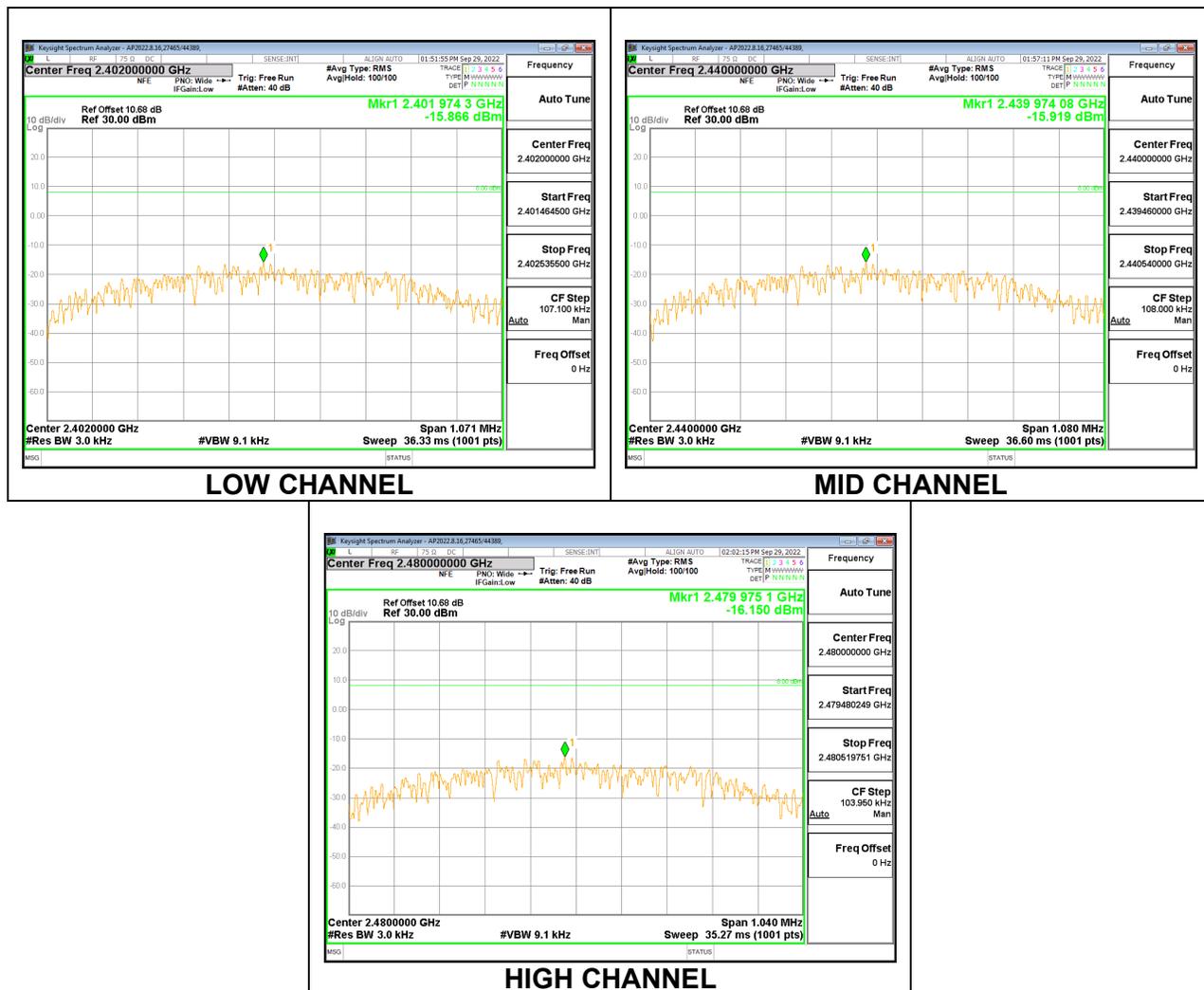
FCC §15.247 (e)

The power spectral density conducted from the transmitter to the antenna shall not be greater than 8 dBm in any 3 kHz band during any time interval of continuous transmission.

### RESULTS

#### 9.5.1. BLE (1Mbps)

Channel	Frequency (MHz)	PSD (dBm/3kHz)	Limit (dBm/3kHz)	Margin (dB)
Low	2402	-15.866	8	-23.87
Middle	2440	-15.919	8	-23.92
High	2480	-16.150	8	-24.15



## **9.6. CONDUCTED SPURIOUS EMISSIONS**

### **LIMITS**

FCC §15.247 (d)

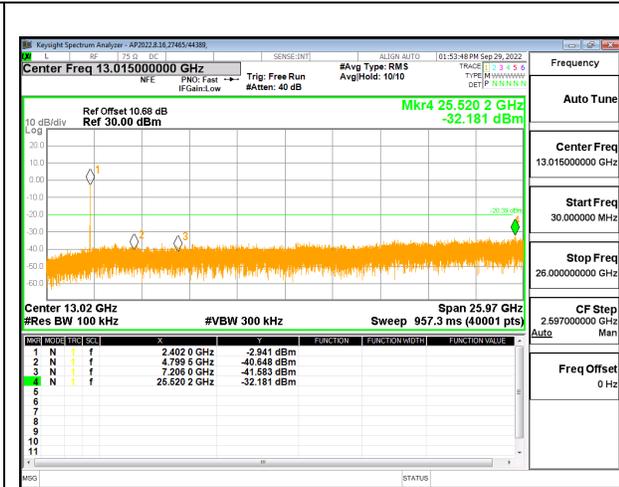
Output power was measured based on the use of a peak measurement, therefore the required attenuation is -20dBc.

### **RESULTS**

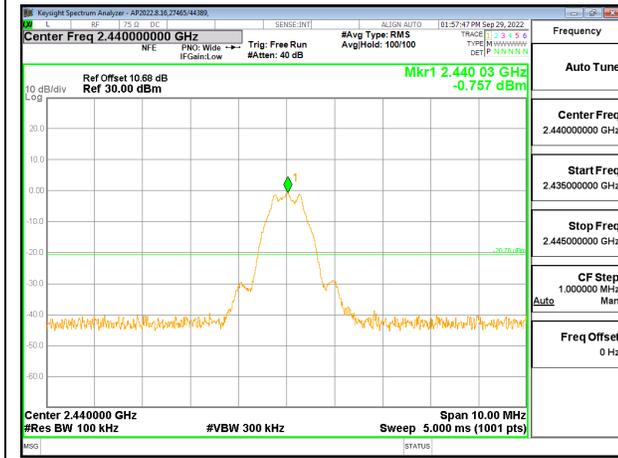
### 9.6.1. BLE (1Mbps)



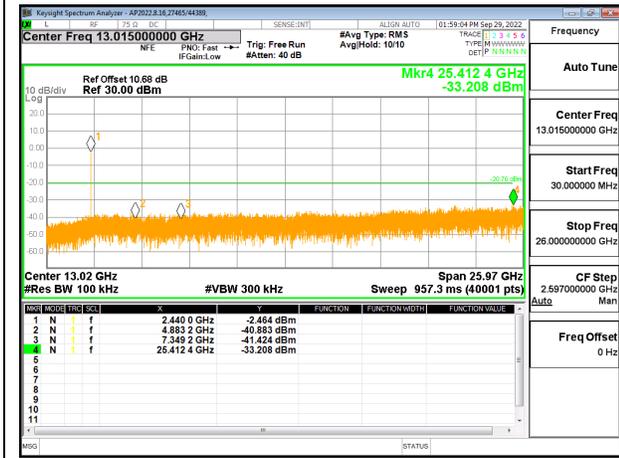
LOW CHANNEL BANDEDGE



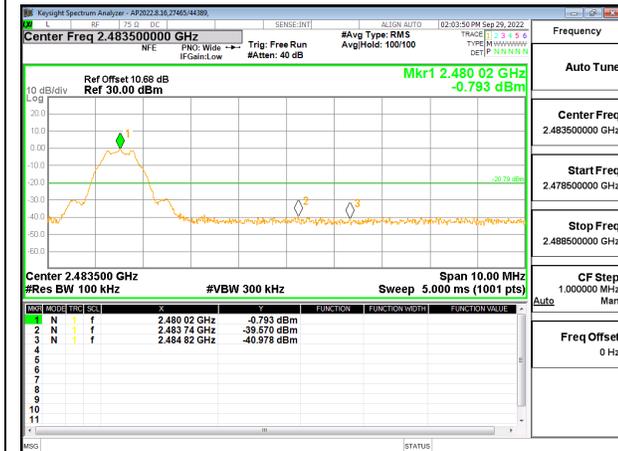
OUT-OF-BAND LOW CHANNEL



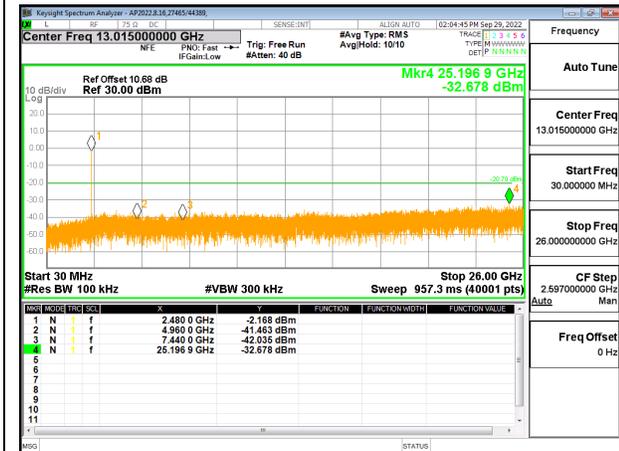
IN-BAND REFERENCE LEVEL



OUT-OF-BAND MID CHANNEL



HIGH CHANNEL BANDEDGE



OUT-OF-BAND HIGH CHANNEL

## 10. RADIATED TEST RESULTS

### 10.1. LIMITS AND PROCEDURE

#### LIMITS

FCC §15.205 and §15.209

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 or average (9-90kHz and 110-490kHz).

For pre-scans above 1 GHz the resolution bandwidth is set to 1 MHz; the video bandwidth is set to 3 MHz 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 as applicable for average measurements. Linear voltage averaging was used.

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). Based 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.

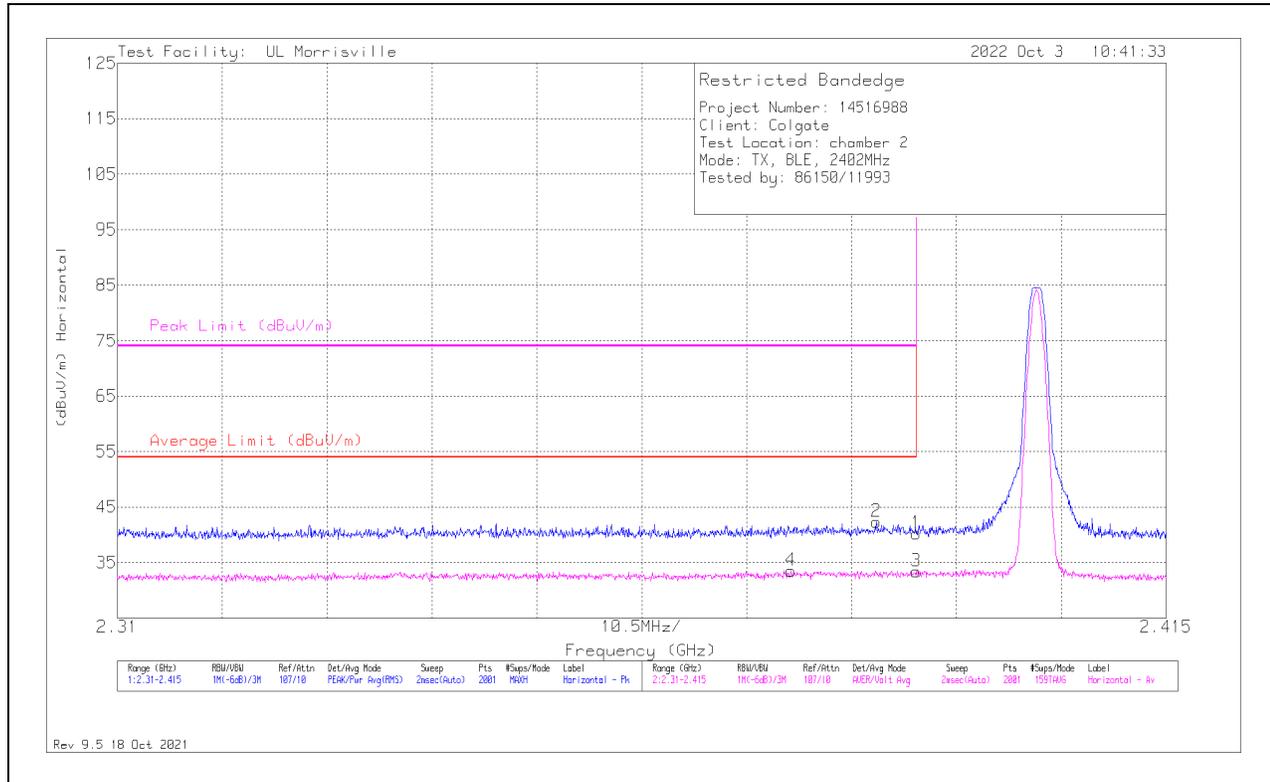
## 10.2. TRANSMITTER ABOVE 1 GHz

### 10.2.1. BLE (1Mbps)

#### Antenna 1

#### BANDEDGE (LOW CHANNEL)

#### HORIZONTAL RESULT



Marker	Frequency (GHz)	Meter Reading (dBuV)	Det	206211 (dB/m)	Gain/Loss (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	*** 2.38996	32.01	Pk	32	-23.8	0	40.21	-	-	74	-33.79	92	113	H
2	*** 2.38597	34.17	Pk	32	-23.8	0	42.37	-	-	74	-31.63	92	113	H
3	*** 2.38996	21.19	ADV	32	-23.8	4.07	33.46	54	-20.54	-	-	92	113	H
4	*** 2.37741	21.23	ADV	32.1	-23.9	4.07	33.5	54	-20.5	-	-	92	113	H

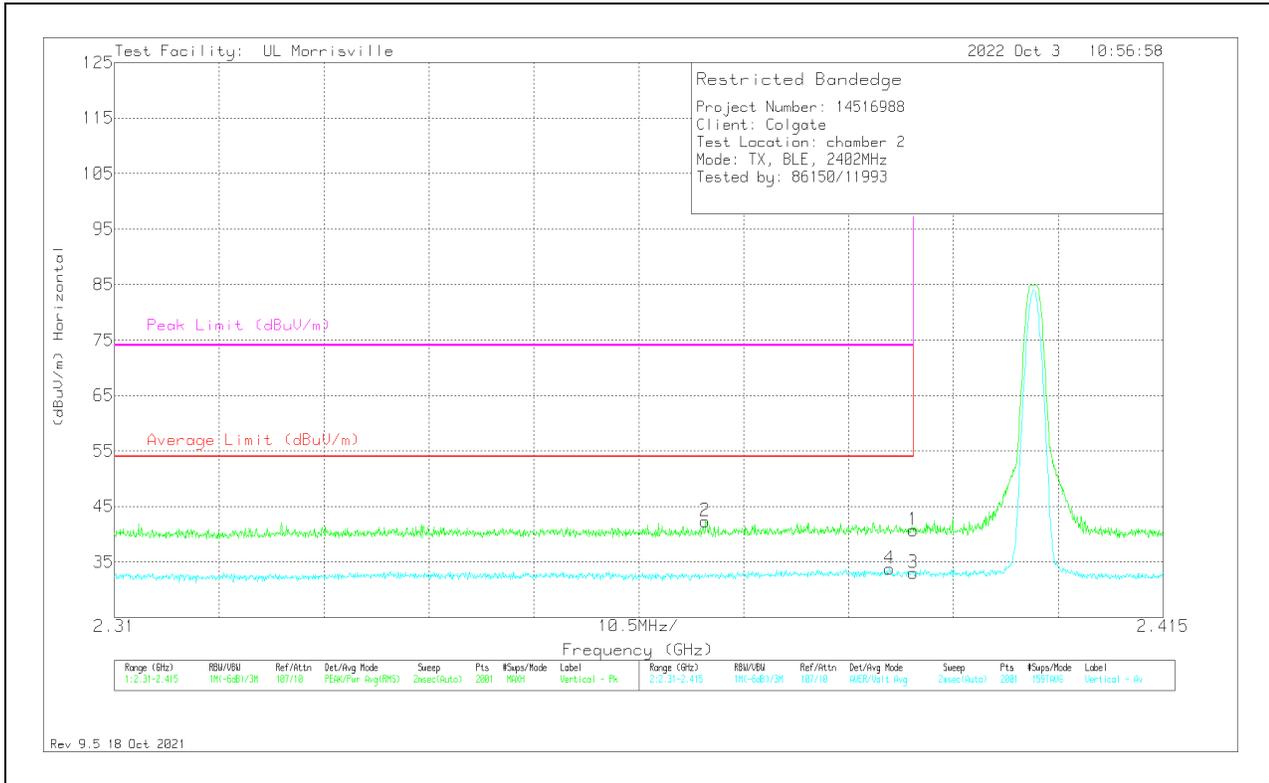
\* - indicates frequency in CFR47 Pt 15 / IC RSS-Restricted Band

\*\* - indicates frequency in Taiwan NCC LP0002 Restricted Band

Pk - Peak detector

ADV - Linear Voltage Average

### VERTICAL RESULT

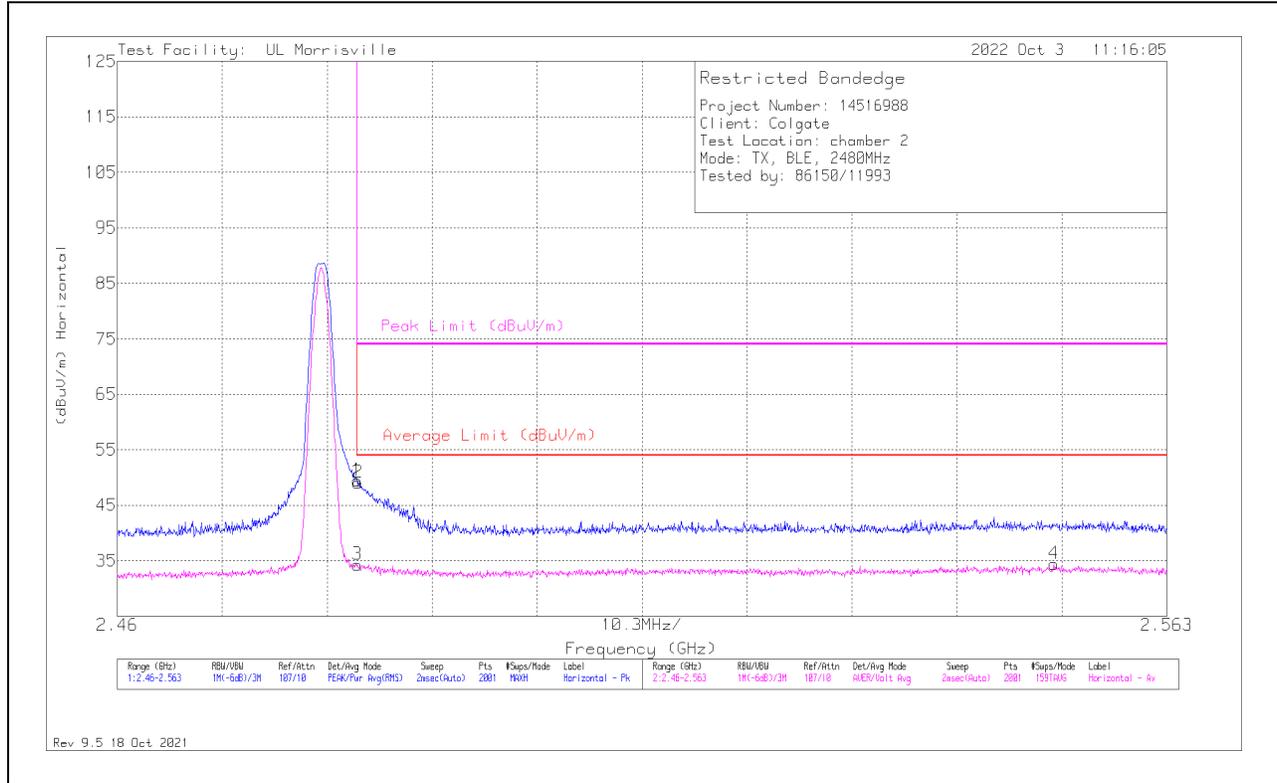


Marker	Frequency (GHz)	Meter Reading (dBuV)	Det	206211 (dB/m)	Gain/Loss (dB)	DC Corr (dB)	Corrected Reading (dBuV/m)	Average Limit (dBuV/m)	Margin (dB)	Peak Limit (dBuV/m)	PK Margin (dB)	Azimuth (Degs)	Height (cm)	Polarity
1	*** 2.38996	32.52	Pk	32	-23.8	0	40.72	-	-	74	-33.28	95	378	V
2	*** 2.36917	34.44	Pk	32	-24.1	0	42.34	-	-	74	-31.66	95	378	V
3	*** 2.38996	20.79	ADV	32	-23.8	4.07	33.06	54	-20.94	-	-	95	378	V
4	*** 2.3876	21.46	ADV	32	-23.8	4.07	33.73	54	-20.27	-	-	95	378	V

\* - indicates frequency in CFR47 Pt 15 / IC RSS-Restricted Band  
 \*\* - indicates frequency in Taiwan NCC LP0002 Restricted Band  
 Pk - Peak detector  
 ADV - Linear Voltage Average

**BANDEDGE (HIGH CHANNEL)**

**HORIZONTAL RESULT**



Marker	Frequency (GHz)	Meter Reading (dBuV)	Det	206211 (dB/m)	Gain/Loss (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	*** 2.48354	41.45	Pk	32.3	-24.3	0	49.45	-	-	74	-24.55	17	375	H
2	*** 2.48364	41.08	Pk	32.3	-24.3	0	49.08	-	-	74	-24.92	17	375	H
3	* ** 2.48354	22.21	ADV	32.3	-24.3	4.07	34.28	54	-19.72	-	-	17	375	H
4	** 2.55193	22.42	ADV	32.5	-24.6	4.07	34.39	54	-19.61	-	-	17	375	H

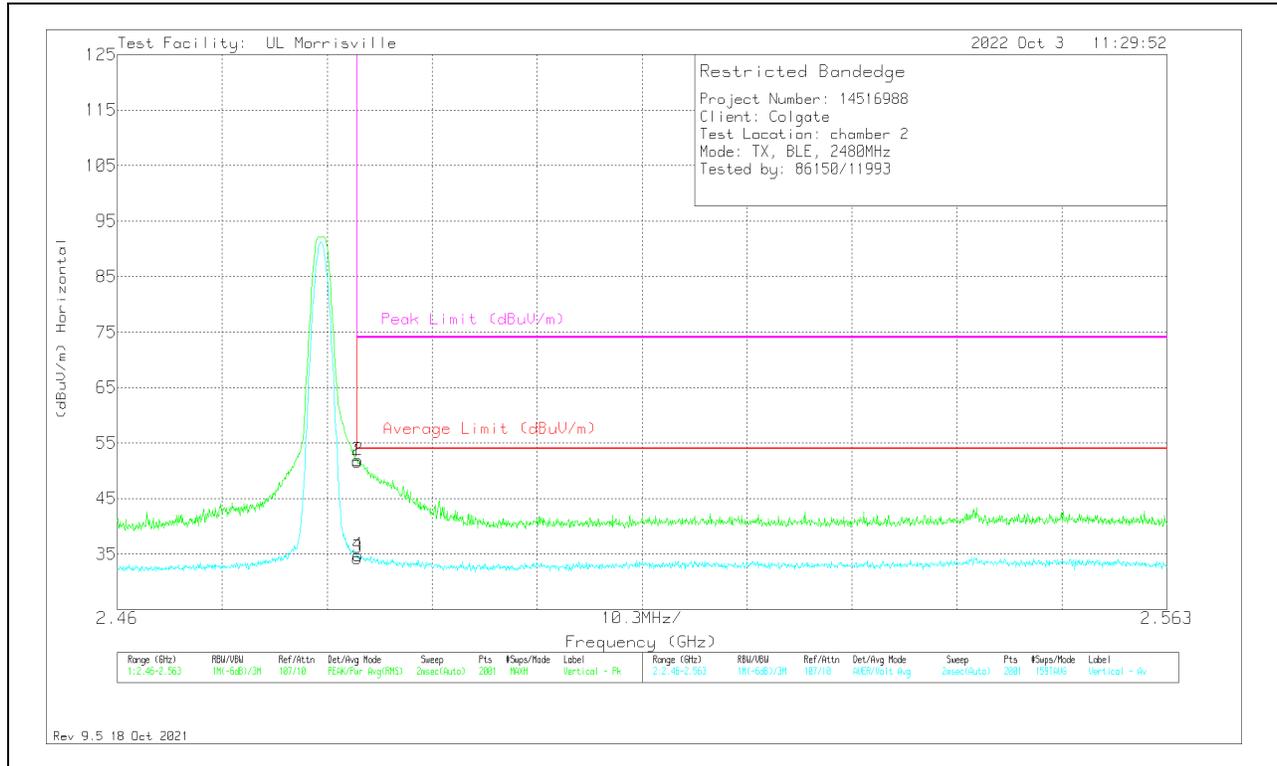
\* - indicates frequency in CFR47 Pt 15 / IC RSS-Restricted Band

\*\* - indicates frequency in Taiwan NCC LP0002 Restricted Band

Pk - Peak detector

ADV - Linear Voltage Average

### VERTICAL RESULT

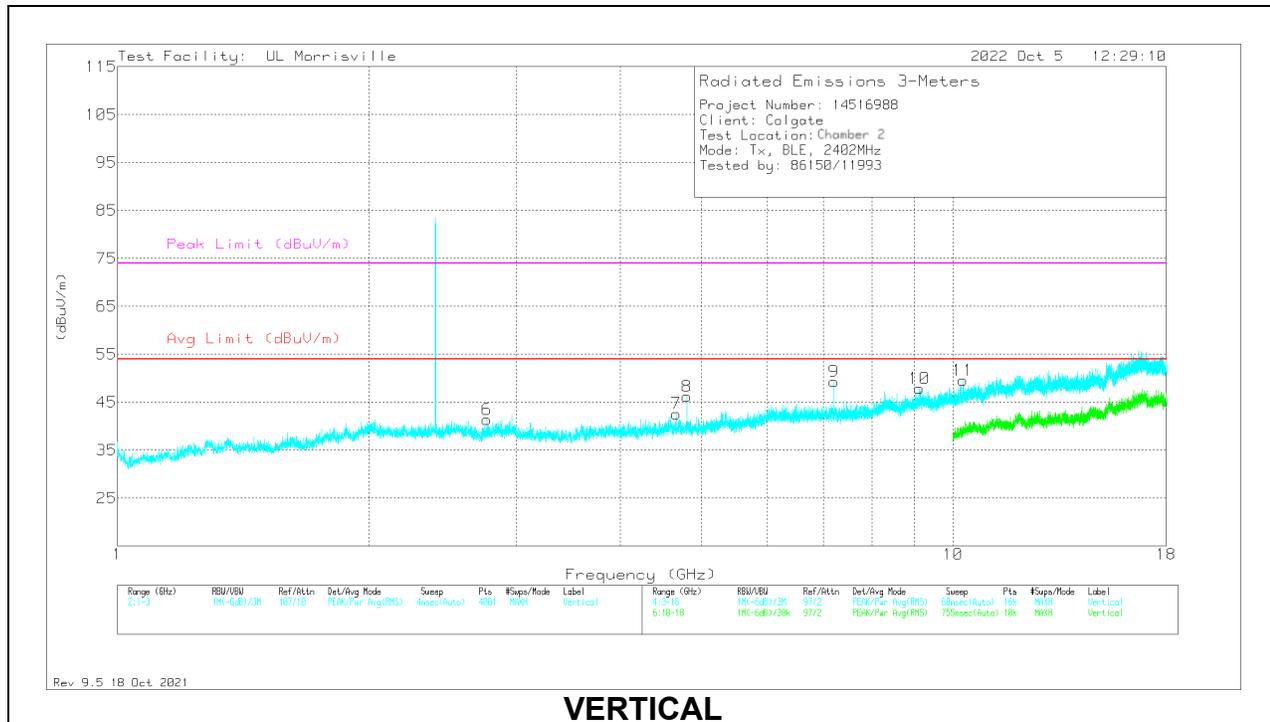
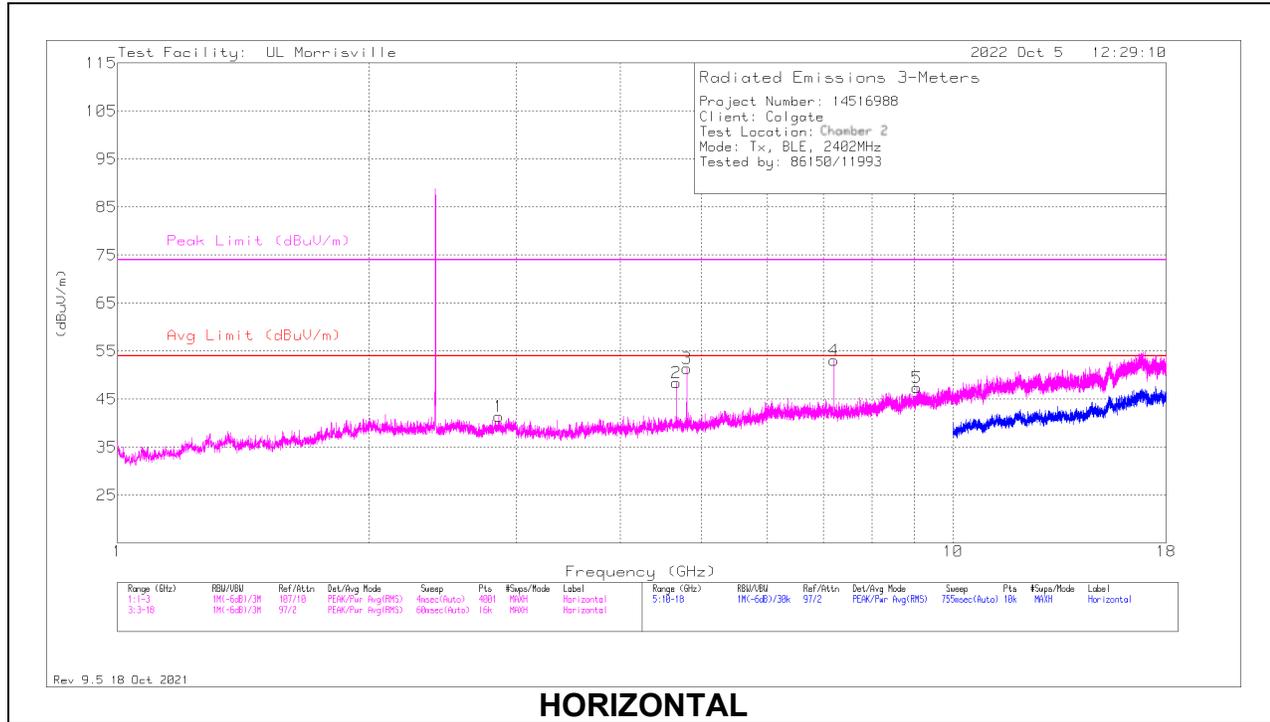


Marker	Frequency (GHz)	Meter Reading (dBuV)	Det	206211 (dB/m)	Gain/Loss (dB)	DC Corr (dB)	Corrected Reading (dBuV/m)	Average Limit (dBuV/m)	Margin (dB)	Peak Limit (dBuV/m)	PK Margin (dB)	Azimuth (Degs)	Height (cm)	Polarity
1	*** 2.48354	43.7	Pk	32.3	-24.3	0	51.7	-	-	74	-22.3	45	352	V
2	*** 2.48359	43.85	Pk	32.3	-24.3	0	51.85	-	-	74	-22.15	45	352	V
3	*** 2.48354	22.2	ADV	32.3	-24.3	4.07	34.27	54	-19.73	-	-	45	352	V
4	*** 2.48364	22.68	ADV	32.3	-24.3	4.07	34.75	54	-19.25	-	-	45	352	V

\* - indicates frequency in CFR47 Pt 15 / IC RSS-Restricted Band  
 \*\* - indicates frequency in Taiwan NCC LP0002 Restricted Band  
 Pk - Peak detector  
 ADV - Linear Voltage Average

**HARMONICS AND SPURIOUS EMISSIONS**

**LOW CHANNEL RESULTS**



**RADIATED EMISSIONS**

Marker	Frequency (GHz)	Meter Reading (dBuV)	Det	206211 (dB/m)	Gain/Loss (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	*** 2.8595	34.89	Pk	32.3	-25.8	0	41.39	54	-12.61	74	-32.61	0-360	200	H
6	*** 2.7705	35.08	Pk	32.2	-25.9	0	41.38	54	-12.62	74	-32.62	0-360	101	V
2	*** 4.66596	50.33	PK2	34.2	-31.1	0	53.43	-	-	74	-20.57	68	111	H
	*** 4.66625	28.97	ADV	34.2	-31.1	4.07	36.14	54	-17.86	-	-	68	111	H
3	*** 4.80447	49.86	PK2	34	-31	0	52.86	-	-	74	-21.14	66	112	H
	*** 4.80414	43.26	ADV	34	-30.9	4.07	50.43	54	-3.57	-	-	66	112	H
5	*** 9.06188	36.54	Pk	36.1	-25.3	0	47.34	54	-6.66	74	-26.66	0-360	101	H
7	*** 4.66594	39.55	Pk	34.2	-31.1	0	42.65	54	-11.35	74	-31.35	0-360	101	V
8	*** 4.80375	43.08	Pk	34	-30.9	0	46.18	54	-7.82	74	-27.82	0-360	101	V
10	*** 9.12	36.99	Pk	36.2	-25.3	0	47.89	54	-6.11	74	-26.11	0-360	200	V
9	7.20563	41.81	Pk	35.6	-28.1	0	49.31	-	-	-	-	0-360	101	V
4	7.20656	45.59	Pk	35.6	-28.1	0	53.09	-	-	-	-	0-360	101	H
11	10.28719	36.05	Pk	37.3	-23.8	0	49.55	-	-	-	-	0-360	101	V

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

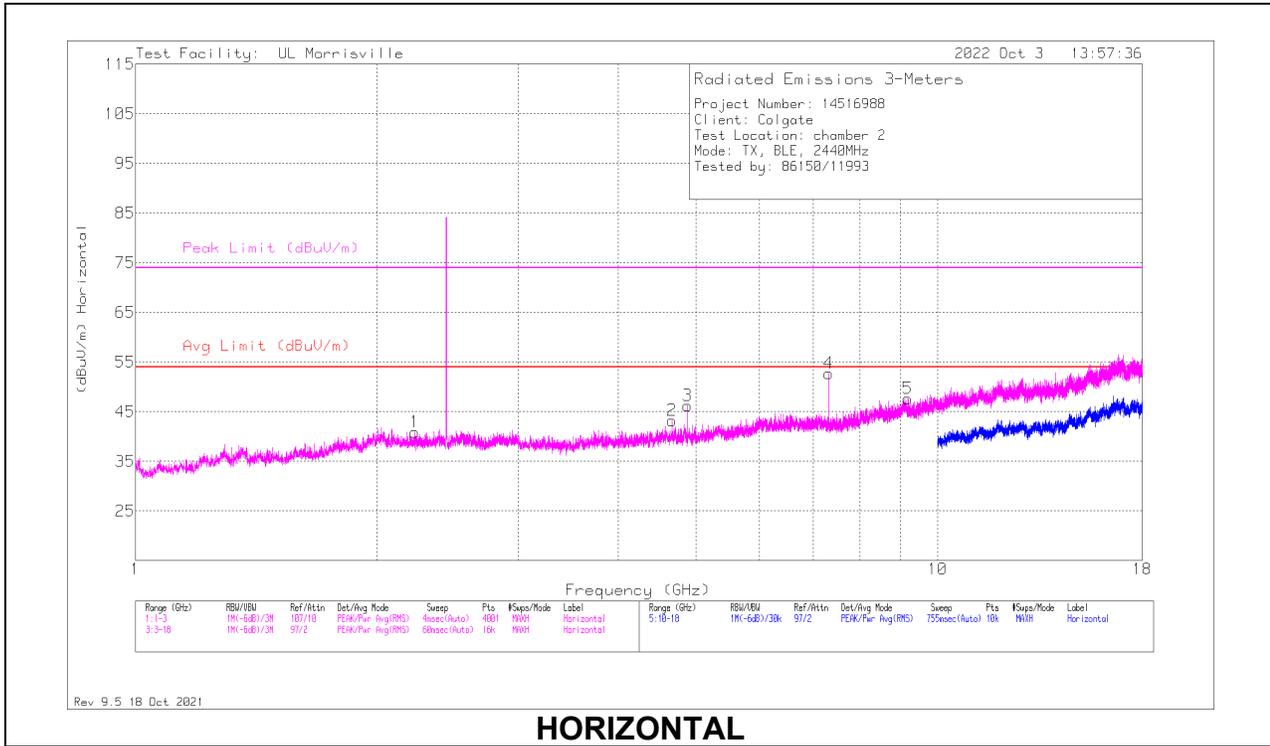
\*\* - indicates frequency in Taiwan NCC LP0002 Restricted Band

Pk - Peak detector

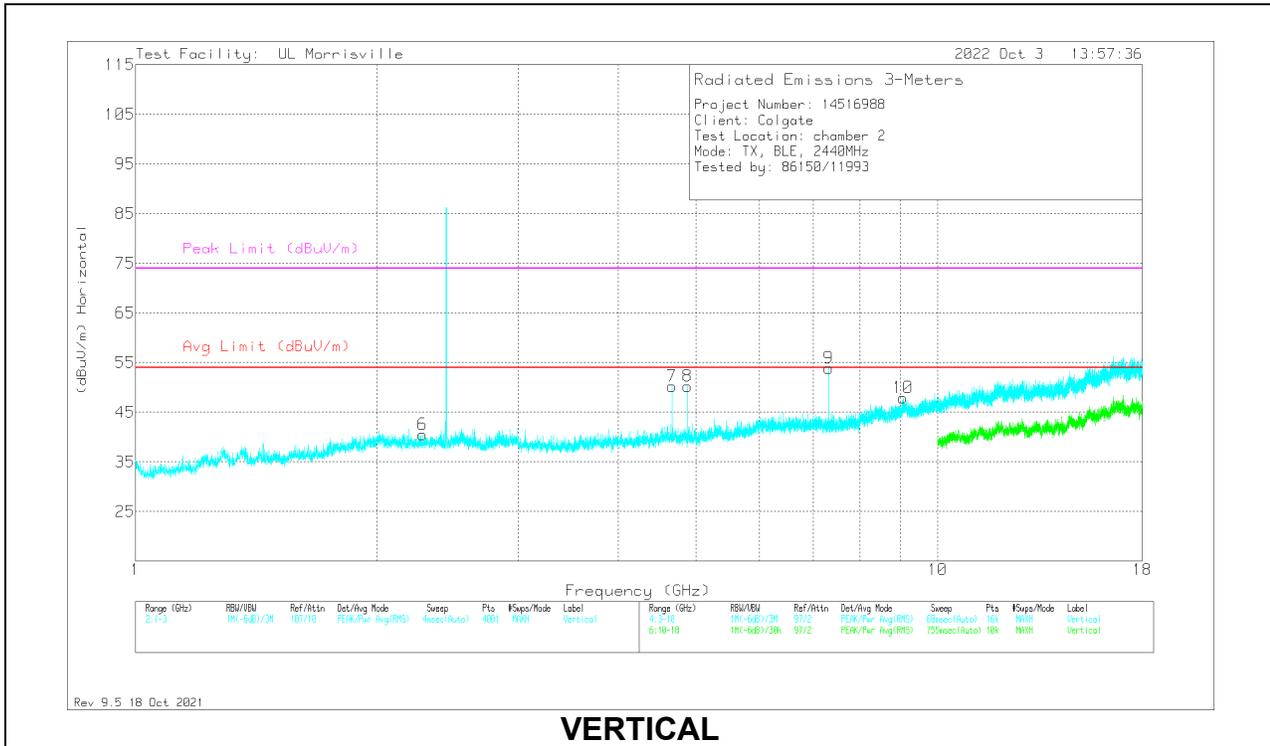
PK2 - Maximum Peak

ADV - Linear Voltage Average

### MID CHANNEL RESULTS



### HORIZONTAL



### VERTICAL

**RADIATED EMISSIONS**

Marker	Frequency (GHz)	Meter Reading (dBuV)	Det	206211 (dB/m)	Gain/Loss (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	*** 2.231	32.85	Pk	31.7	-23.6	0	40.95	54	-13.05	74	-33.05	0-360	101	H
6	*** 2.2805	32.53	Pk	31.6	-23.6	0	40.53	54	-13.47	74	-33.47	0-360	199	V
2	*** 4.66594	40.19	Pk	34.2	-31.1	0	43.29	54	-10.71	74	-30.71	0-360	200	H
3	*** 4.87969	43.11	Pk	33.9	-30.8	0	46.21	54	-7.79	74	-27.79	0-360	101	H
4	** 7.3192	45.77	PK2	35.6	-26.7	0	54.67	-	-	74	-19.33	79	107	H
	*** 7.31927	35.14	ADV	35.6	-26.7	4.07	48.11	54	-5.89	-	-	79	107	H
5	*** 9.18469	36.99	Pk	36.3	-25.6	0	47.69	54	-6.31	74	-26.31	0-360	101	H
7	*** 4.66611	50.4	PK2	34.2	-31.1	0	53.5	-	-	74	-20.5	112	110	V
	*** 4.66625	29	ADV	34.2	-31.1	4.07	36.17	54	-17.83	-	-	112	110	V
8	*** 4.87966	49.08	PK2	33.9	-30.8	0	52.18	-	-	74	-21.82	110	124	V
	*** 4.88004	42.05	ADV	33.9	-30.8	4.07	49.22	54	-4.78	-	-	110	124	V
9	*** 7.31924	46.32	PK2	35.6	-26.7	0	55.22	-	-	74	-18.78	62	207	V
	*** 7.31932	36.3	ADV	35.6	-26.7	4.07	49.27	54	-4.73	-	-	62	207	V
10	*** 9.06188	37.05	Pk	36.1	-25.3	0	47.85	54	-6.15	74	-26.15	0-360	200	V

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

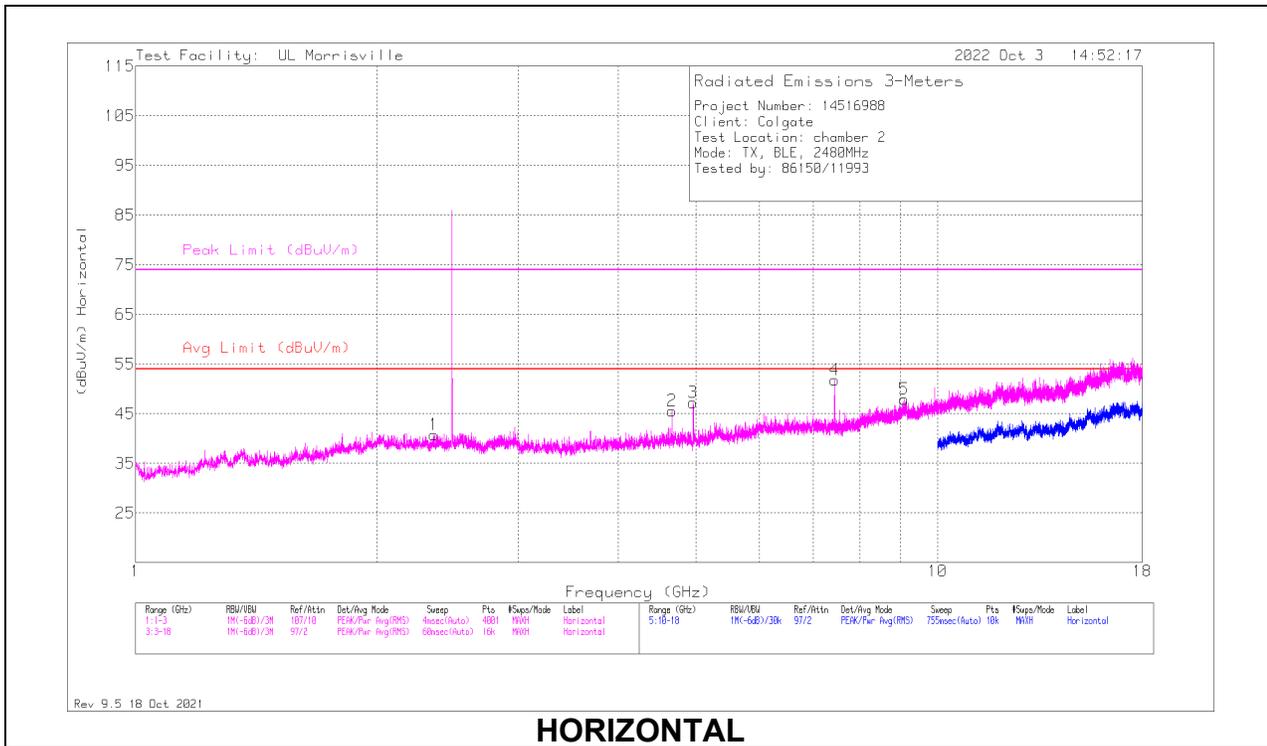
\*\* - indicates frequency in Taiwan NCC LP0002 Restricted Band

Pk - Peak detector

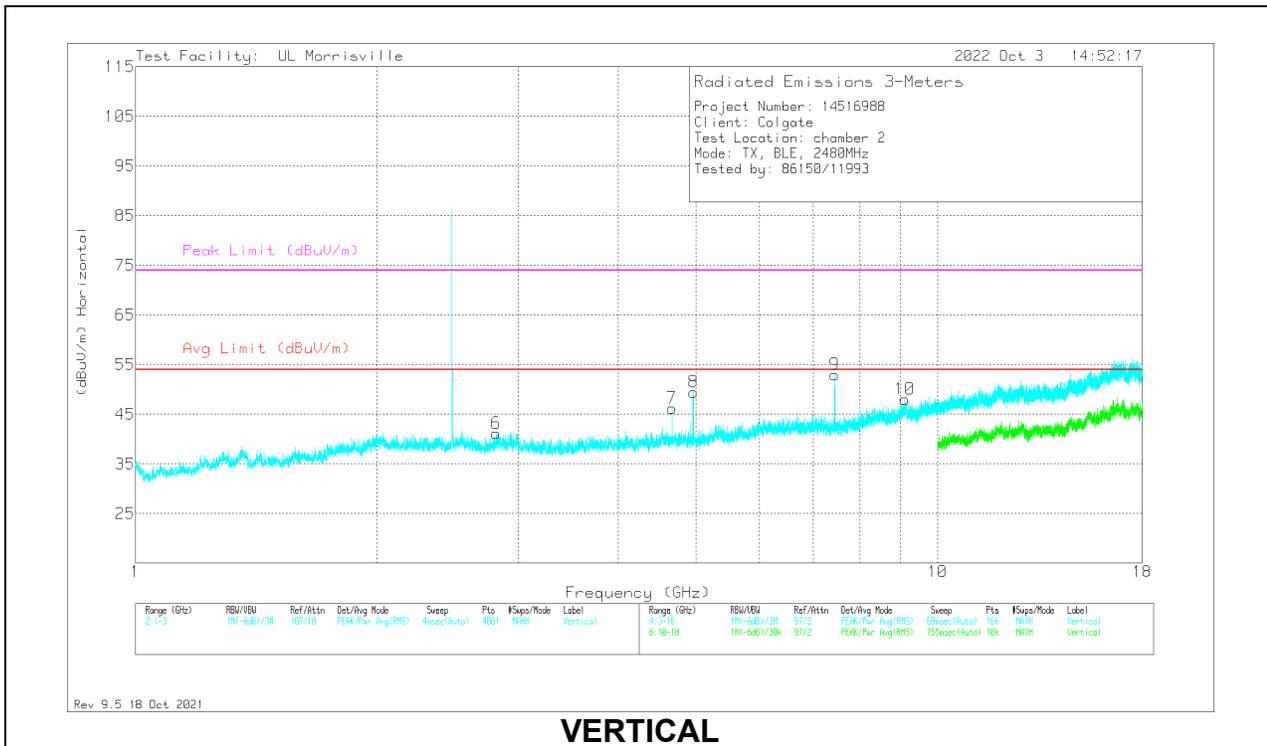
PK2 - Maximum Peak

ADV - Linear Voltage Average

### HIGH CHANNEL RESULTS



**HORIZONTAL**



**VERTICAL**

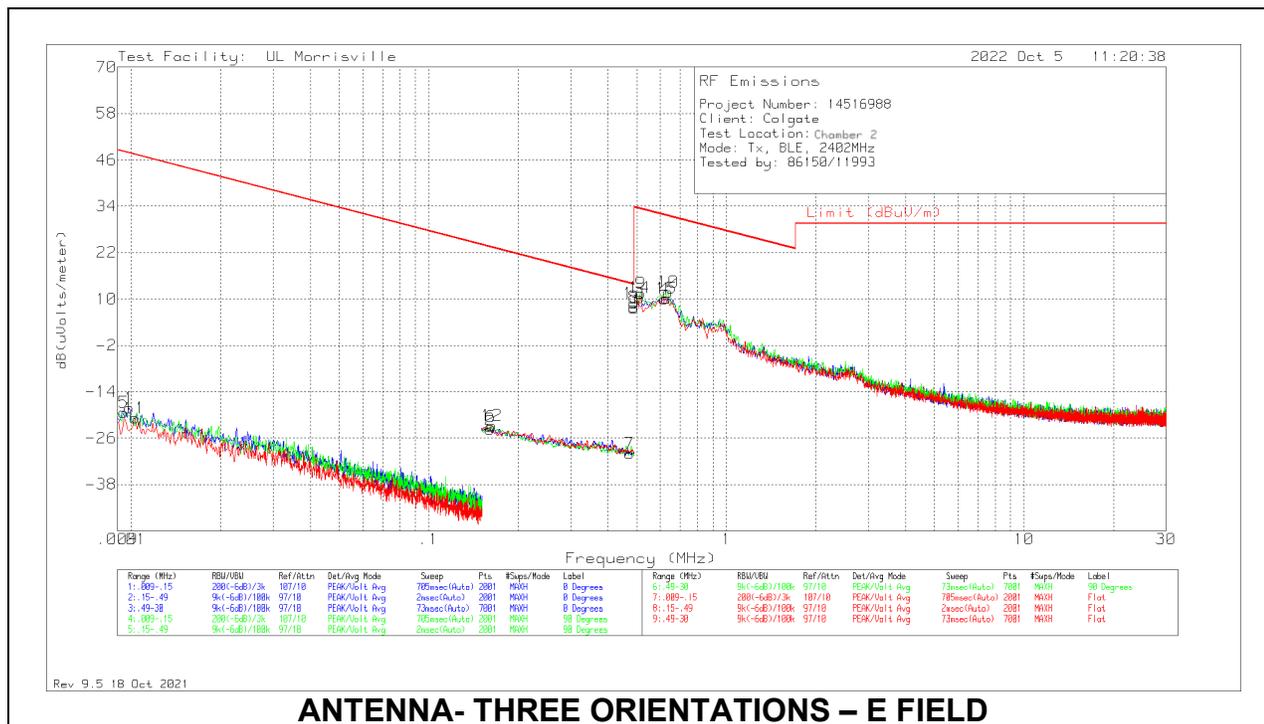
**RADIATED EMISSIONS**

Marker	Frequency (GHz)	Meter Reading (dBuV)	Det	206211 (dB/m)	Gain/Loss (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	*** 2.3575	32.91	Pk	31.9	-24	0	40.81	54	-13.19	74	-33.19	0-360	199	H
6	*** 2.8185	34.58	Pk	32.4	-25.8	0	41.18	54	-12.82	74	-32.82	0-360	199	V
2	*** 4.66594	42.5	Pk	34.2	-31.1	0	45.6	54	-8.4	74	-28.4	0-360	101	H
3	*** 4.95938	44.25	Pk	33.9	-30.9	0	47.25	54	-6.75	74	-26.75	0-360	101	H
4	*** 7.43933	46.32	PK2	35.6	-27.5	0	54.42	-	-	74	-19.58	63	111	H
	*** 7.43944	35.89	ADV	35.6	-27.5	4.07	48.06	54	-5.94	-	-	63	111	H
5	*** 9.08063	37.39	Pk	36.1	-25.6	0	47.89	54	-6.11	74	-26.11	0-360	101	H
7	*** 4.66594	43.11	Pk	34.2	-31.1	0	46.21	54	-7.79	74	-27.79	0-360	101	V
8	*** 4.95939	49.48	PK2	33.9	-30.9	0	52.48	-	-	74	-21.52	80	270	V
	*** 4.96003	42.8	ADV	33.9	-30.9	4.07	49.87	54	-4.13	-	-	80	270	V
9	*** 7.43937	47.29	PK2	35.6	-27.5	0	55.39	-	-	74	-18.61	51	212	V
	*** 7.43943	37.97	ADV	35.6	-27.5	4.07	50.14	54	-3.86	-	-	51	212	V
10	*** 9.10219	37.94	PK2	36.2	-25.5	0	48.64	-	-	74	-25.36	295	155	V
	*** 9.10372	25.4	ADV	36.2	-25.5	4.07	40.17	54	-13.83	-	-	295	155	V
11	9.91875	38.3	Pk	37	-25.1	0	50.2	-	-	-	-	0-360	101	H

\* - indicates frequency in CFR47 Pt 15 / IC RSS-Restricted Band  
 \*\* - indicates frequency in Taiwan NCC LP0002 Restricted Band  
 Pk - Peak detector  
 PK2 - Maximum Peak  
 ADV - Linear Voltage Average

### 10.3. WORST CASE BELOW 30MHZ

#### SPURIOUS EMISSIONS BELOW 30 MHz (WORST-CASE CONFIGURATION)



ANTENNA- THREE ORIENTATIONS – E FIELD

#### Below 30MHz Data – E FIELD

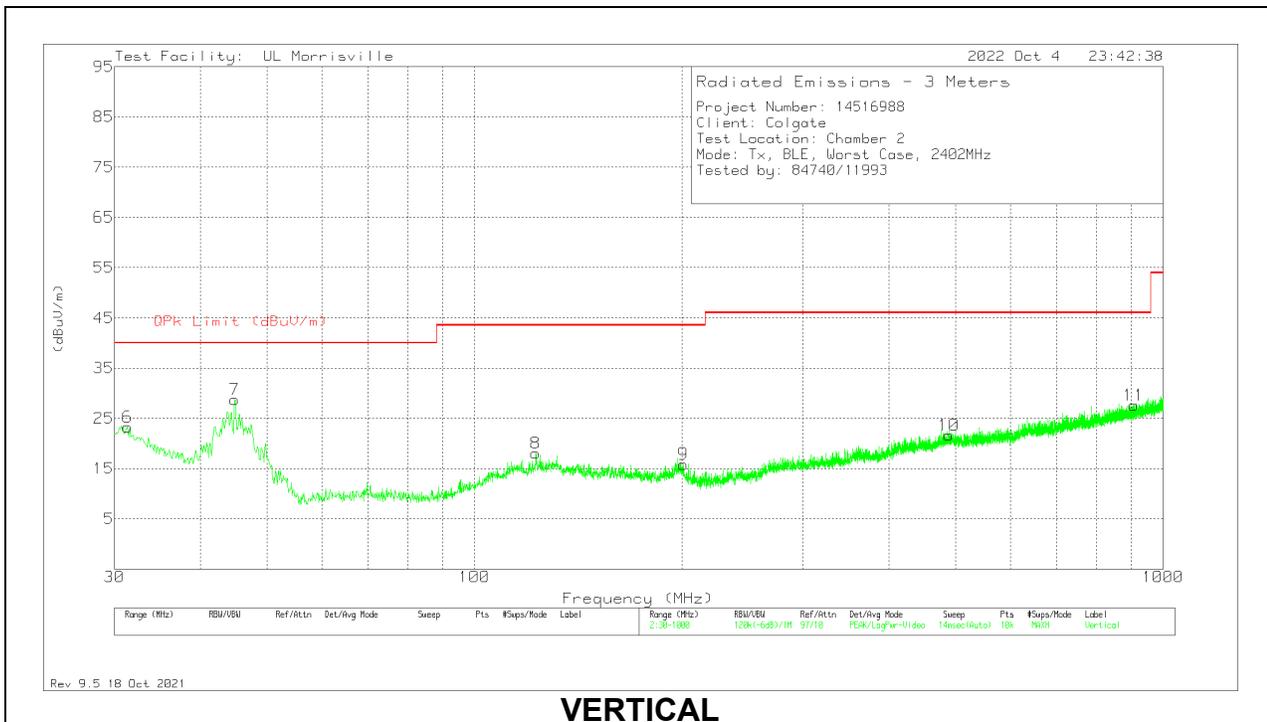
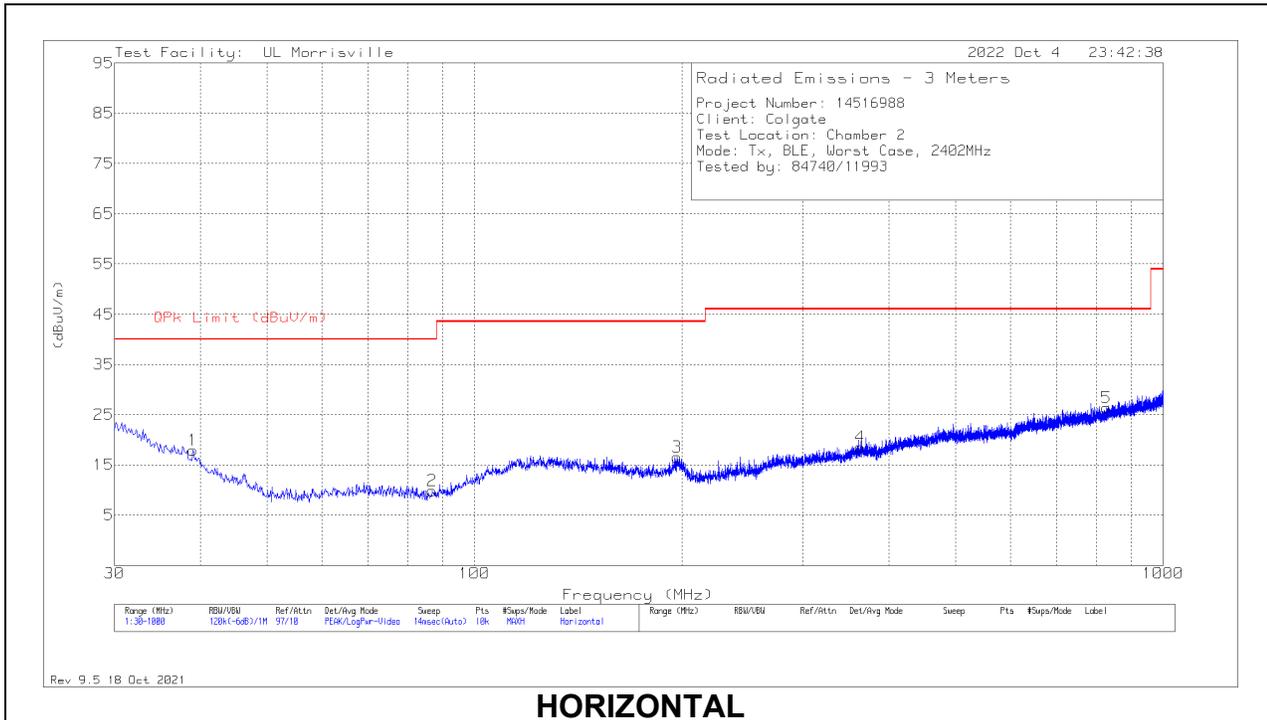
Marker	Frequency (MHz)	Meter Reading (dBuV)	Det	AT0079 (dB/m)	Gain/Loss (dB)	Dist. Corr. Factor (dB)	Corrected Reading dB(uVolts/meter)	QP/AV Limit (dBuV/m)	PK Limit (dBuV/m)	Margin (dB)	Azimuth (Degs)	Height (cm)	Loop Angle
5	.00943	41.88	Pk	18.7	.1	-80	-19.32	48.12	68.12	-67.44	0-360	400	90 degs
1	.00985	43.24	Pk	18.5	.1	-80	-18.16	47.73	67.73	-65.89	0-360	400	0 degs
11	.01028	40.87	PK	18.3	.1	-80	-20.73	47.37	-	-68.1	0-360	400	Flat
2	.16037	45.12	Pk	11.1	.1	-80	-23.68	23.5	43.5	-47.18	0-360	400	0 degs
6	.16122	45.77	Pk	11.1	.1	-80	-23.03	23.46	43.46	-46.49	0-360	400	90 degs
12	.16275	46.05	Pk	11.1	.1	-80	-22.75	23.37	43.37	-46.12	0-360	400	Flat
7	.47181	38.85	Pk	11	.1	-80	-30.05	14.13	34.13	-44.18	0-360	400	90 degs
3	.49	36.47	Pk	11	.1	-40	7.57	13.8	33.8	-6.23	0-360	400	0 degs
8	.50736	34.15	Qp	11.1	.1	-40	5.35	33.5	-	-28.15	131	100	90 degs
13	.50045	33.97	Qp	11.1	.1	-40	5.17	33.62	-	-28.45	349	100	Flat
14	.51108	39.15	Pk	11.1	.1	-40	10.35	33.43	-	-23.08	0-360	400	Flat
9	.5153	40.27	Pk	11.1	.1	-40	11.47	33.36	-	-21.89	0-360	400	90 degs
4	.6207	38.79	Pk	11.1	.2	-40	10.09	31.75	-	-21.66	0-360	400	0 degs
15	.62913	38.82	Pk	11.1	.2	-40	10.12	31.63	-	-21.51	0-360	400	Flat
10	.63756	40.48	Pk	11.1	.2	-40	11.78	31.51	-	-19.73	0-360	400	90 degs

Pk - Peak detector  
 Qp - Quasi-Peak detector

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).

### 10.4. WORST CASE BELOW 1 GHZ

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



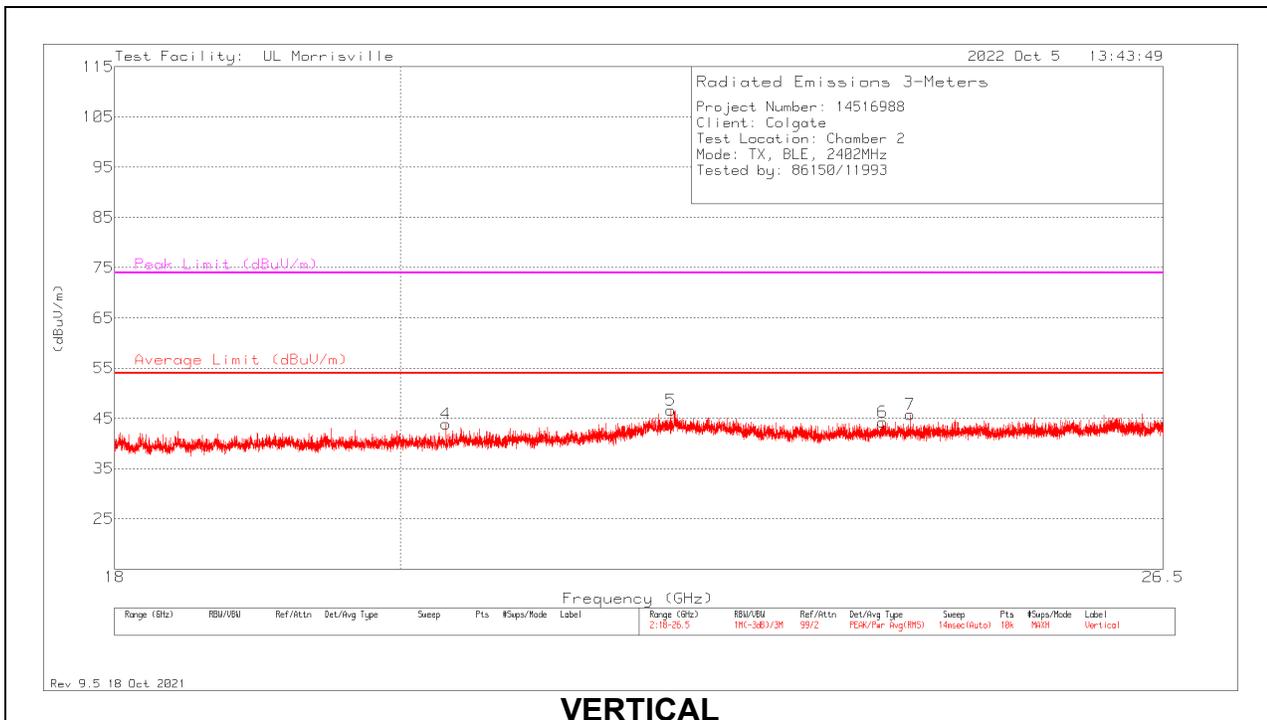
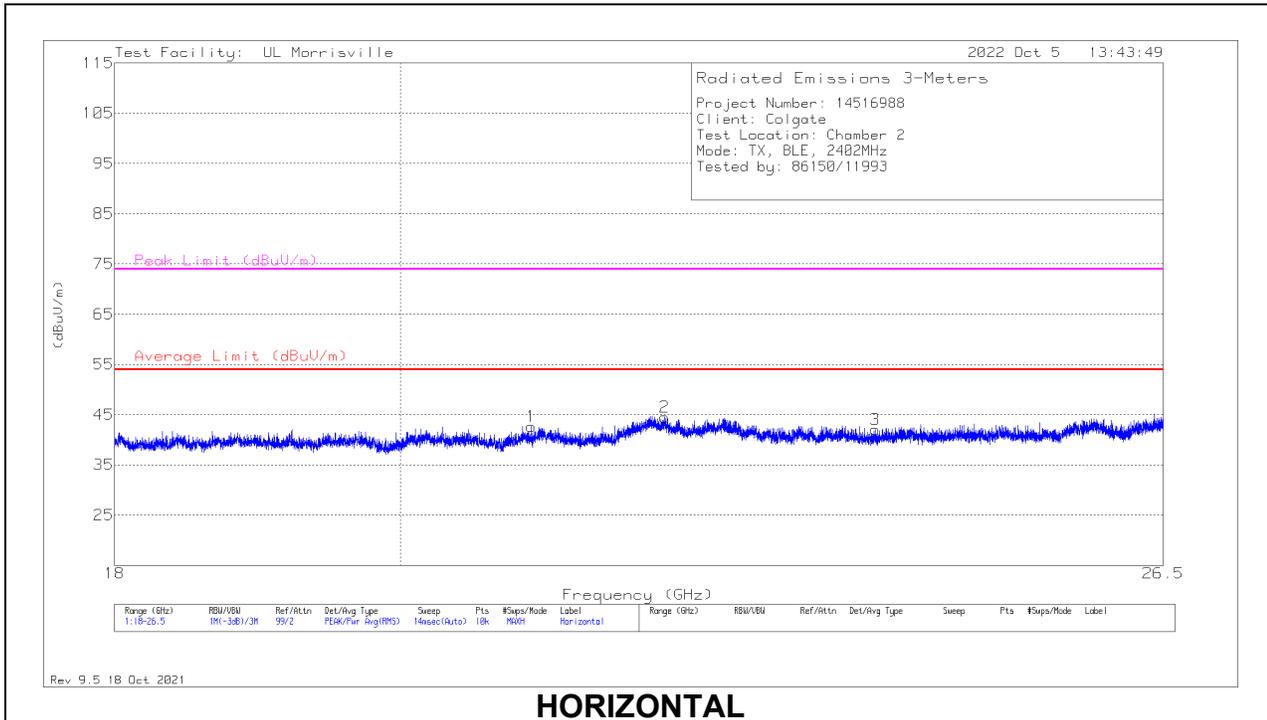
**Below 1GHz Data**

Marker	Frequency (MHz)	Meter Reading (dBUV)	Det	AT0074 (dB/m)	Gain/Loss (dB)	Corrected Reading (dBUV/m)	QPk Limit (dBUV/m)	Margin (dB)	Azimuth (Degs)	Height (cm)	Polarity
1	39.021	28.41	Pk	20.7	-31.2	17.91	40	-22.09	0-360	399	H
2	86.745	27.07	Pk	13.5	-30.7	9.87	40	-30.13	0-360	101	H
3	196.84	27.2	Pk	18.9	-29.5	16.6	43.52	-26.92	0-360	199	H
4	363.486	25.85	Pk	21	-28.3	18.55	46.02	-27.47	0-360	101	H
5	827.049	25.11	Pk	27.3	-26	26.41	46.02	-19.61	0-360	399	H
6	31.358	28.33	Pk	26.3	-31.4	23.23	40	-16.77	0-360	299	V
7	44.841	43.29	Pk	16.5	-31.1	28.69	40	-11.31	0-360	101	V
8	122.732	28.48	Pk	19.9	-30.3	18.08	43.52	-25.44	0-360	101	V
9	200.817	26.68	Pk	18.6	-29.4	15.88	43.52	-27.64	0-360	199	V
10	488.034	25.44	Pk	23.9	-27.7	21.64	46.02	-24.38	0-360	299	V
11	906.104	24.85	Pk	28	-25.2	27.65	46.02	-18.37	0-360	101	V

Pk - Peak detector

### 10.5. WORST CASE 18-26 GHZ

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



**18 – 26GHz Data**

Marker	Frequency (GHz)	Meter Reading (dBuV)	Det	AT0063 (dB/m)	Gain/Loss (dB)	DC Corr (dB)	Corrected Reading (dBuV/m)	Average Limit (dBuV/m)	Margin (dB)	Peak Limit (dBuV/m)	Margin (dB)	Azimuth (Degs)	Height (cm)	Polarity
1	*** 20.9906	46.84	Pk	34.2	-38.4	0	42.64	54	-11.36	74	-31.36	0-360	100	H
2	*** 22.04895	45.85	Pk	37	-38.3	0	44.55	54	-9.45	74	-29.45	0-360	249	H
3	*** 23.82818	44.7	Pk	34.9	-37.6	0	42	54	-12	74	-32	0-360	199	H
4	*** 20.33943	48.49	Pk	33.8	-38.4	0	43.89	54	-10.11	74	-30.11	0-360	150	V
5	*** 22.09996	47.72	Pk	37.1	-38.2	0	46.62	54	-7.38	74	-27.38	0-360	150	V
6	*** 23.89619	46.72	Pk	34.9	-37.4	0	44.22	54	-9.78	74	-29.78	0-360	200	V
7	24.14101	48.31	Pk	35	-37.5	0	45.81	-	-	-	-	0-360	150	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)

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

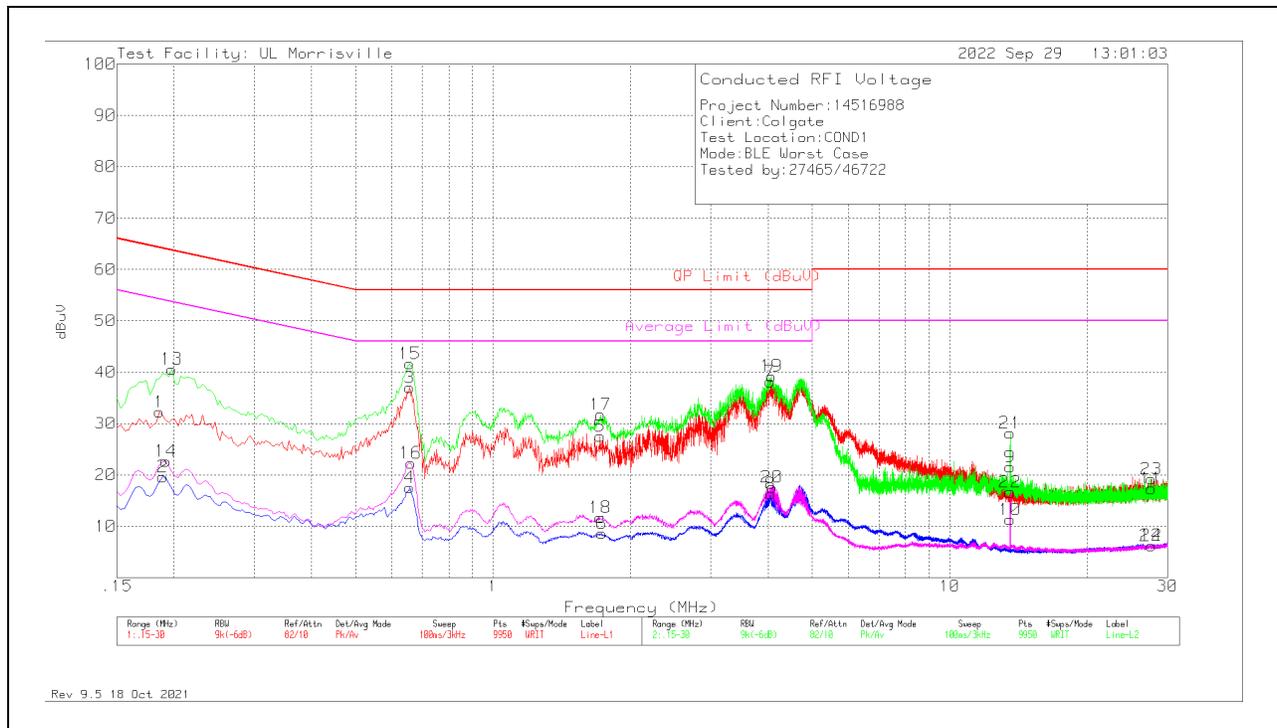
The EUT is placed on a non-conducting table 40 cm from the vertical ground plane and 80 cm above the horizontal ground plane. The EUT is configured in accordance with ANSI C63.4.

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.

## RESULTS

### 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	.186	22.26	Pk	.2	9.8	32.26	64.21	-31.95	-	-
2	.189	9.62	Av	.2	9.8	19.62	-	-	54.08	-34.46
3	.657	27.2	Pk	0	9.8	37	56	-19	-	-
4	.657	7.73	Av	0	9.8	17.53	-	-	46	-28.47
5	1.716	17.69	Pk	0	9.8	27.49	56	-28.51	-	-
6	1.731	-1.16	Av	0	9.8	8.64	-	-	46	-37.36
7	4.044	28.28	Pk	0	9.9	38.18	56	-17.82	-	-
8	4.053	6.41	Av	0	9.9	16.31	-	-	46	-29.69
9	13.56	11.44	Pk	.1	10	21.54	60	-38.46	-	-
10	13.56	1.21	Av	.1	10	11.31	-	-	50	-38.69
11	27.621	6.86	Pk	.3	10.2	17.36	60	-42.64	-	-
12	27.606	-4.25	Av	.3	10.2	6.25	-	-	50	-43.75

Pk - Peak detector  
 Av - Average detection

**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	.198	30.59	Pk	.2	9.8	40.59	63.69	-23.1	-	-
14	.192	12.66	Av	.2	9.8	22.66	-	-	53.95	-31.29
15	.657	31.85	Pk	0	9.8	41.65	56	-14.35	-	-
16	.66	12.5	Av	0	9.8	22.3	-	-	46	-23.7
17	1.719	21.92	Pk	0	9.8	31.72	56	-24.28	-	-
18	1.716	1.89	Av	0	9.8	11.69	-	-	46	-34.31
19	4.071	29.33	Pk	0	9.9	39.23	56	-16.77	-	-
20	4.077	7.71	Av	0	9.9	17.61	-	-	46	-28.39
21	13.56	18.03	Pk	.1	10	28.13	60	-31.87	-	-
22	13.56	6.53	Av	.1	10	16.63	-	-	50	-33.37
23	27.63	8.7	Pk	.3	10.2	19.2	60	-40.8	-	-
24	27.609	-4.27	Av	.3	10.2	6.23	-	-	50	-43.77

Pk - Peak detector  
 Av - Average detection

## 12. SETUP PHOTOS

Please refer to R14516988-EP1 for setup photos

**END OF TEST REPORT**