CLASS 2 PERMISSIVE CHANGE TEST REPORT

Report Number: R12444044-E5

Applicant	:	CyberOptics Corporation 5900 Golden Hills Drive Golden Valley, MN 55416, USA
Model	:	APS3 / APS-FPD
FCC ID	:	SPD003
IC	:	6210A-003
EUT Description	:	Airborne Particle Sensor
Test Standard(s)	:	FCC 47 CFR PART 15 SUBPART C ISED RSS-247 ISSUE 2 ISED RSS-GEN ISSUE 5

Date Of Issue:
2020-03-09

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

NVLAP TESTING
NVLAP Lab code: 200246-0

REPORT REVISION HISTORY

Ver.	Issue Date	Revisions	Revised By
1	2020-01-14	Initial Issue	Brian T. Kiewra
2	2020-03-09	Removed data reuse section.	Brian T. Kiewra

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TABLE OF CONTENTS

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1. ATTESTATION OF TEST RESULTS

COMPANY NAME: CyberOptics Corporation
5900 Golden Hills Drive
Golden Valley, MN 55416, USA

EUT DESCRIPTION: Airborne Particle Sensor

MODEL: APS3 / APS- FPD

SERIAL NUMBER: APS3: JE108101
APS-FPD: FP000208

DATE TESTED: 2018-11-19 to 2019-11-27

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

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

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

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

Approved & Released
For UL LLC By:

Jeffrey Moser
Operations Leader
UL – Consumer Technology Division

Prepared By:

Brian T. Kiewra
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UL – Consumer Technology Division

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2. TEST METHODOLOGY

The tests documented in this report were performed in accordance with FCC CFR 47 Part 2, FCC CFR 47 Part 15, ANSI C63.10-2013, KDB 558074 D01 15.247 Meas Guidance v05, RSS-GEN Issue 5, and RSS-247 Issue 2.

3. FACILITIES AND ACCREDITATION

The test sites and measurement facilities used to collect data are located at 12 Laboratory Drive, Research Triangle Park, North Carolina 27709, USA and 2800 Perimeter Park Dr., Suite B, Morrisville, North Carolina 27560, USA. The following table identifies which facilities were utilized for radiated emission measurements documented in this report. Specific facilities are also identified in the test results sections.

12 Laboratory Dr.	2800 Perimeter Park Dr.
Site Code: 2180C	
☐ Chamber A	☒ Chamber North
☐ Chamber C	☒ Chamber South

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

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4. CALIBRATION AND UNCERTAINTY

4.1. MEASURING INSTRUMENT CALIBRATION

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

4.2. SAMPLE CALCULATION

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

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

4.3. MEASUREMENT UNCERTAINTY

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

PARAMETER	UNCERTAINTY
RF output power, conducted	1.3 dB (PK) , 0.45 dB (AV)
All emissions, radiated	4.88 dB

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

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5. EQUIPMENT UNDER TEST

5.1. EUT DESCRIPTION

The EUT is an airborne particle sensor with a Bluetooth radio. The EUT only supports GFSK modulation.

APS3 is intended to be used inside semiconductor fabrication tools, and is the shape of a wafer, that is 300 mm diameter. Whereas the APS-FPD which uses the same PCBA is targeted to the flat panel display industry. The APS-FPD housing is made of PEEK plastic and is relatively square as opposed to the standard APS3 housing.

Radiated testing performed on both models in this report.
Power measurements performed on APS-FPD.

5.2. MAXIMUM OUTPUT POWER

Power not measured other than to confirm correct transmit power for radiated emissions. The power is covered in report CYBR0077.1 . A default power setting was used as dictated by Cyberoptics. This power setting was for a target power of 11-12dBm.

5.3. DESCRIPTION OF AVAILABLE ANTENNAS

The radio utilizes an inverted-F PCB antenna with a maximum gain of 1.5 dBi.

5.4. SOFTWARE AND FIRMWARE

The firmware installed in the EUT during testing was BC4 v26.4279
The test utility software used during testing was BlueTest3 v1.24

5.5. WORST-CASE CONFIGURATION AND MODE

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

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

The fundamentals of both EUTs were investigated in three orthogonal orientations X, Y, and Z. It was determined that Z orientation was worst-case orientation for the APS3 and X orientation was worst-case for the APS-FPD. Therefore, all final radiated testing was performed with the APS3 in Z orientation and the APS-FPD in X orientation.

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

GFSK mode: DH5

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5.6. DESCRIPTION OF TEST SETUP

SUPPORT EQUIPMENT

Support Equipment List				
Description	**Manufacturer**	**Model**	**Serial Number**	**FCC ID**
Battery Pack	Power Bank	XT-5000	NA	NA

I/O CABLES

I/O Cable List						
Cable No.	**Port**	**# of Identical Ports**	**Connector Type**	**Cable Type**	**Cable Length (m)**	**Remarks**
1	USB	1	USB	USB	<1m	Connected to battery pack

TEST SETUP

The EUT was installed in a typical configuration. The customer provided test software to exercise the EUTs during test. Refer to the following diagram.

SETUP DIAGRAMS

Please refer to R12444044-EP5 for setup diagrams

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6. TEST AND MEASUREMENT EQUIPMENT

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

Test Equipment Used - Wireless Conducted Measurement Equipment

Equipment ID	Description	Manufacturer	Model Number	Last Cal.	Next Cal.
T177 (PRE0079253)	Spectrum Analyzer	Agilent Technologies	E4446A	2018-04-12	2019-04-12
PWM004 (PRE0137346)	RF Power Meter	Keysight Technologies	N1911A	2018-07-30	2019-07-30
PWS004 (PRE0126443)	Peak and Avg Power Sensor, 50MHz to 6GHz	Keysight Technologies	E9323A	2018-07-30	2019-07-30
SN 161024885	Environmental Meter	Fisher Scientific	15-077-963	2016-12-23	2018-12-23

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

Equipment ID	Description	Manufacturer	Model Number	Last Cal.	Next Cal.
0.009-30MHz (Loop Ant.)					
AT0079	Active Loop Antenna	ETS-Lindgren	6502	2018-01-02	2019-01-02
30-1000 MHz					
AT0073	Hybrid Broadband Antenna	Sunol Sciences Corp.	JB3	2018-08-06	2019-08-06
1-18 GHz					
AT0072	Double-Ridged Waveguide Horn Antenna, 1 to 18 GHz	ETS Lindgren	3117	2018-04-30	2019-04-30
Gain-Loss Chains					
N-SAC01	Gain-loss string: 0.009-30MHz	Various	Various	2018-09-06	2019-09-06
N-SAC02	Gain-loss string: 25-1000MHz	Various	Various	2018-05-20	2019-05-20
N-SAC03	Gain-loss string: 1-18GHz	Various	Various	2018-03-23	2019-03-23
Receiver & Software					
SA0027	Spectrum Analyzer	Agilent	N9030A	2018-04-04	2019-04-04
SOFTEMI	EMI Software	UL	Version 9.5	NA	NA
Additional Equipment used					
s/n 161024690	Environmental Meter	Fisher Scientific	15-077-963	2016-12-21	2018-12-21

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

Equipment ID	Description	Manufacturer	Model Number	Last Cal.	Next Cal.
1-18 GHz					
AT0069	Double-Ridged Waveguide Horn Antenna, 1 to 18 GHz	ETS Lindgren	3117	2018-04-30	2019-04-30
AT0072	Double-Ridged Waveguide Horn Antenna, 1 to 18 GHz	ETS Lindgren	3117	2019-04-22	2020-04-22
18-40 GHz					
AT0076	Horn Antenna, 18-26.5GHz	ARA	MWH-1826/B	2018-11-08	2019-11-08
Gain-Loss Chains					
S-SAC03	Gain-loss string: 1-18GHz	Various	Various	2018-03-20	2019-03-20
S-SAC03	Gain-loss string: 1-18GHz	Various	Various	2019-03-13	2020-03-13
S-SAC04	Gain-loss string: 18-40GHz	Various	Various	2018-09-30	2019-03-31
Receiver & Software					
SA0026	Spectrum Analyzer	Agilent	N9030A	2018-03-20	2019-03-20
SA0025	Spectrum Analyzer	Agilent	N9030A	2018-04-30	2019-04-30
SA0025	Spectrum Analyzer	Agilent	N9030A	2019-02-28	2020-02-28
SOFTEMI	EMI Software	UL	Version 9.5	NA	NA
Additional Equipment used					
s/n 161024887	Environmental Meter	Fisher Scientific	15-077-963	2016-12-23	2018-12-23
s/n 181474409	Environmental Meter	Fisher Scientific	15-077-963	2018-07-27	2020-07-27

Note: All equipment was within calibration at time of use.

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7. MEASUREMENT METHODS

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

Out-of-band emissions in non-restricted bands: ANSI C63.10 Section 7.8.6 & 7.8.8

Out-of-band emissions in restricted bands: ANSI C63.10:2013 Sections 6.3-6.6

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8. ANTENNA PORT TEST RESULTS

8.1. ON TIME AND DUTY CYCLE

LIMITS

None; for reporting purposes only.

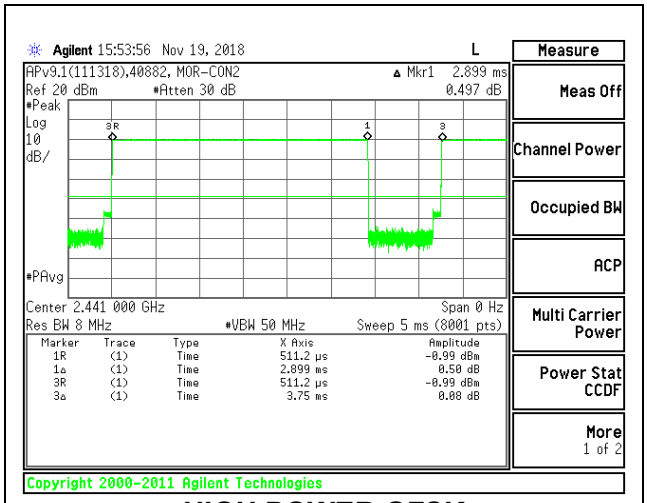
PROCEDURE

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

ON TIME AND DUTY CYCLE RESULTS

Mode	ON Time B (msec)	Period (msec)	Duty Cycle x (linear)	Duty Cycle (%)	Duty Cycle Correction Factor (dB)	1/T Minimum VBW (kHz)
High Bluetooth GFSK	2.90	3.75	0.773	77.3%	1.12	0.345

DUTY CYCLE PLOTS



HIGH POWER GFSK

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9. RADIATED TEST RESULTS

LIMITS

FCC §15.205 and §15.209

RSS-GEN, Section 8.9 and 8.10.

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

TEST PROCEDURE

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

For measurements below 1 GHz the resolution bandwidth is set to 120 kHz for peak detection measurements or 120 kHz for quasi-peak detection measurements for the 30-1000 MHz range, 9 kHz for peak detection measurements or 9 kHz for quasi-peak detection measurements for the 0.15-30 MHz range and 200 Hz for peak detection measurements or 200 Hz for quasi-peak detection measurements for the 9 to 150 kHz 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 as applicable for average measurements. For this test program, average measurements were performed using Peak detection with the resolution bandwidth set for 1 MHz and the Video Bandwidth set for 1/Ton, where Ton equals the transmit 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.

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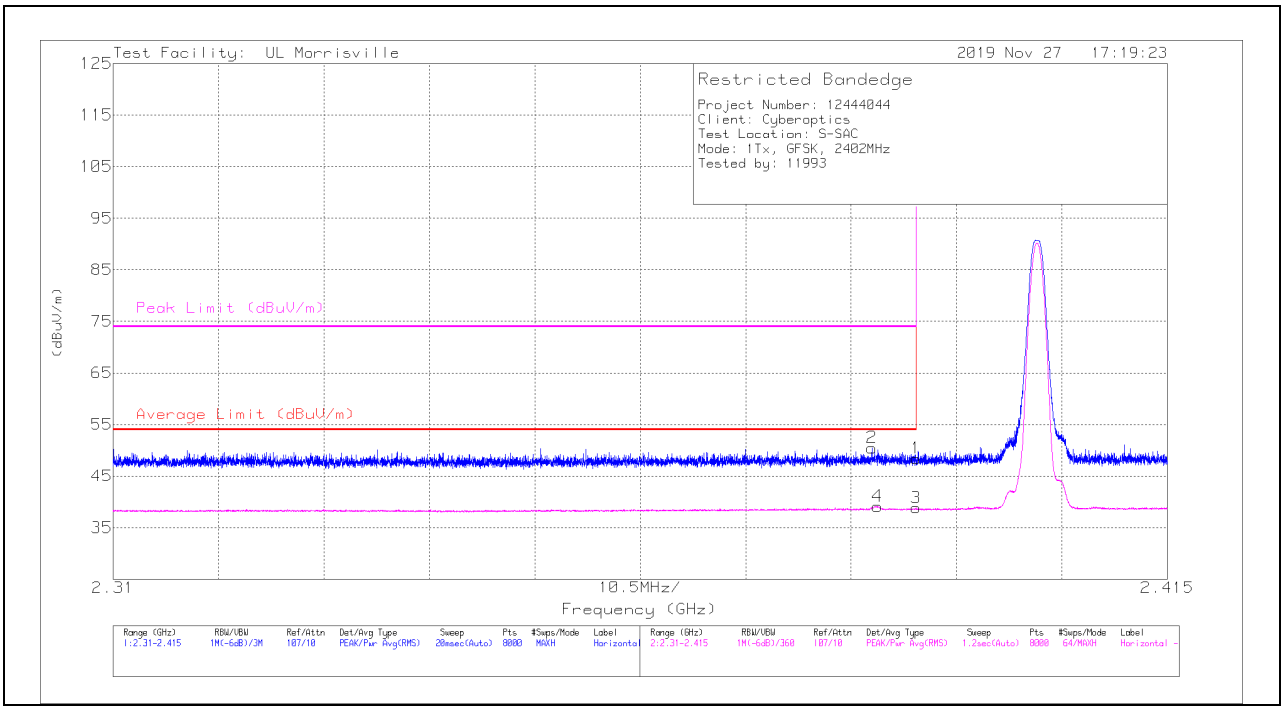
9.1. TRANSMITTER ABOVE 1 GHz

9.1.1. BLUETOOTH BASIC DATA RATE GFSK MODULATION – APS3

BANDEDGE (LOW CHANNEL)

HORIZONTAL RESULT



Marker	Frequency (GHz)	Meter Reading (dBuV)	Det	AT0072 (dB/m)	Amp/Cbl/Fltr/Pad (dB)	Corrected Reading (dBuV/m)	Average Limit (dBuV/m)	Margin (dB)	Peak Limit (dBuV/m)	PK Margin (dB)	Azimuth (Degs)	Height (cm)	Polarity
1	* ** 2.39	40.63	Pk	31.9	-24.1	48.43	-	-	74	-25.57	172	323	H
2	* ** 2.38557	42.7	Pk	31.9	-24.1	50.5	-	-	74	-23.5	172	323	H
3	* ** 2.39	31.06	V1TR	31.9	-24.1	38.86	54	-15.14	-	-	172	323	H
4	* ** 2.38614	31.33	V1TR	31.9	-24.1	39.13	54	-14.87	-	-	172	323	H

* - indicates frequency in CFR47 Pt 15 / IC RSS-Restricted Band
** - indicates frequency in Taiwan NCC LP0002 Restricted Band
Pk - Peak detector
V1TR - U-NII: VB=1/Ton, RMS Average where: Ton is packet duration

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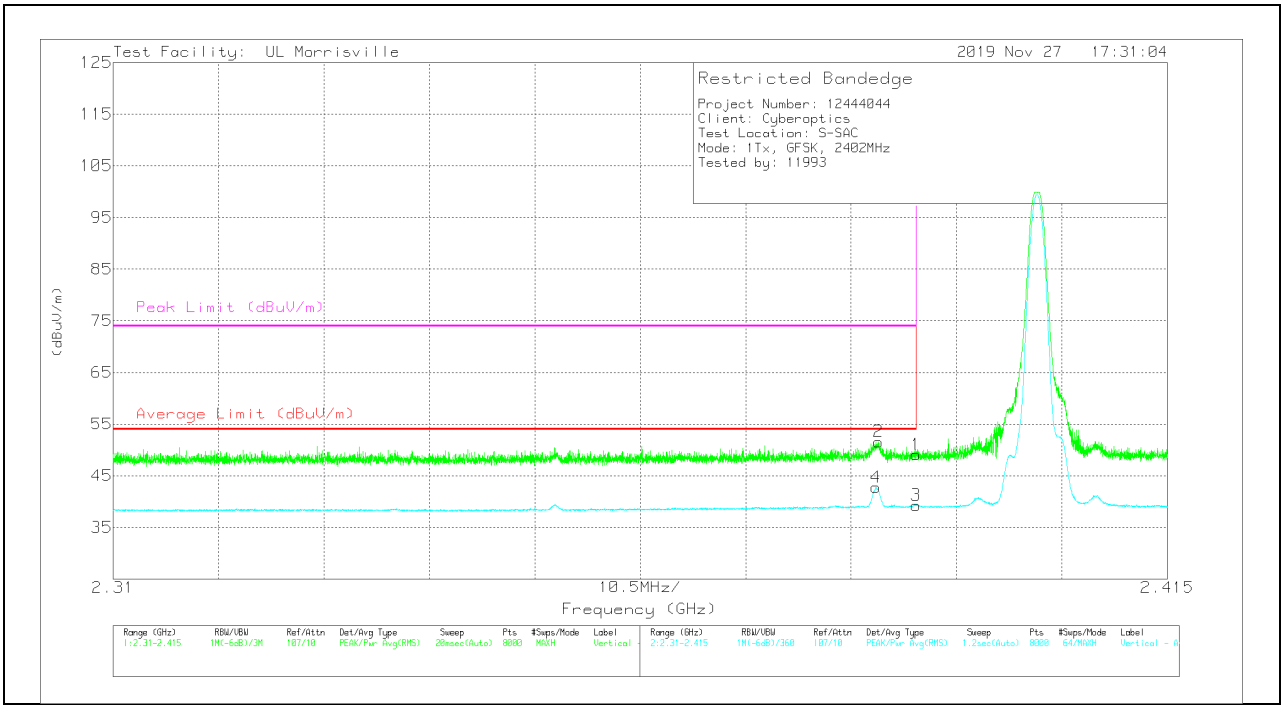
VERTICAL RESULT



Marker	Frequency (GHz)	Meter Reading (dBuV)	Det	AT0072 (dB/m)	Amp/Cbl/Fltr/Pad (dB)	Corrected Reading (dBuV/m)	Average Limit (dBuV/m)	Margin (dB)	Peak Limit (dBuV/m)	PK Margin (dB)	Azimuth (Degs)	Height (cm)	Polarity
1	* ** 2.39	41.27	Pk	31.9	-24.1	49.07	-	-	74	-24.93	92	341	V
2	* ** 2.38624	43.8	Pk	31.9	-24.1	51.6	-	-	74	-22.4	92	341	V
3	* ** 2.39	31.48	V1TR	31.9	-24.1	39.28	54	-14.72	-	-	92	341	V
4	* ** 2.38597	34.95	V1TR	31.9	-24.1	42.75	54	-11.25	-	-	92	341	V

* - indicates frequency in CFR47 Pt 15 / IC RSS-Restricted Band
** - indicates frequency in Taiwan NCC LP0002 Restricted Band
Pk - Peak detector
V1TR - U-NII: VB=1/Ton, RMS Average where: Ton is packet duration

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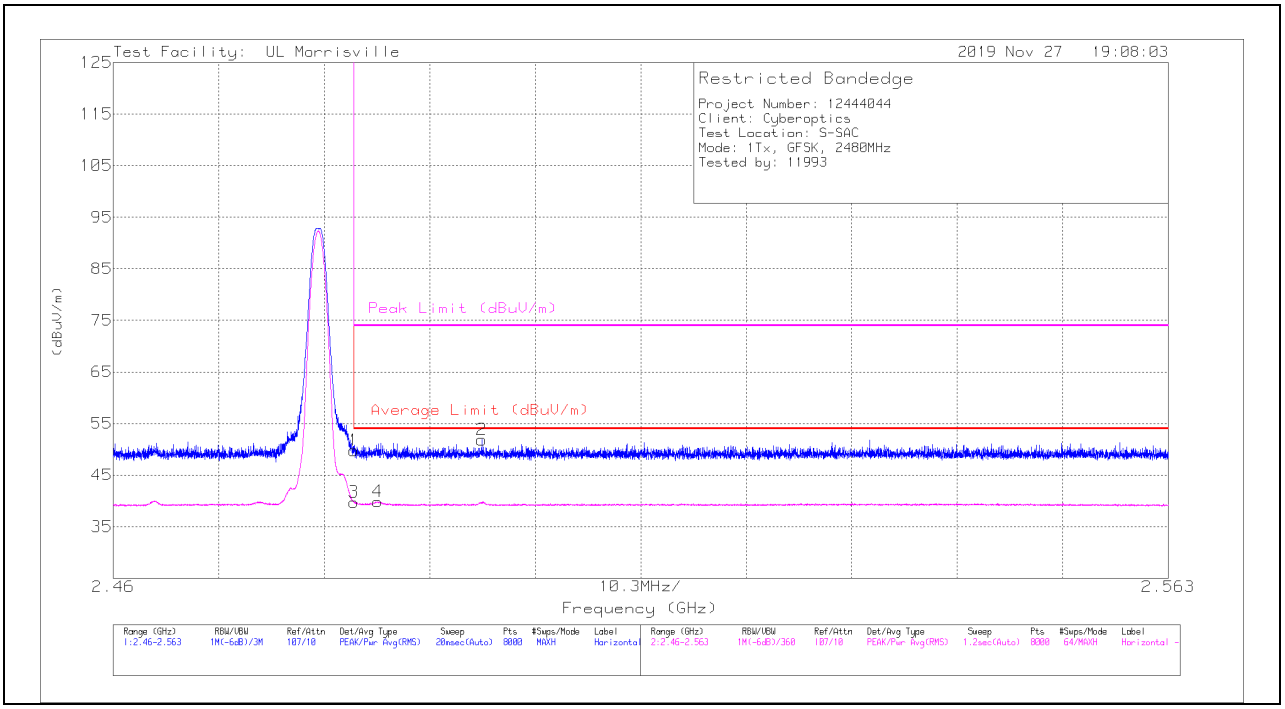
BANDEDGE (HIGH CHANNEL)

HORIZONTAL RESULT



Marker	Frequency (GHz)	Meter Reading (dBuV)	Det	AT0072 (dB/m)	Amp/Cbl/Fltr/Pad (dB)	Corrected Reading (dBuV/m)	Average Limit (dBuV/m)	Margin (dB)	Peak Limit (dBuV/m)	PK Margin (dB)	Azimuth (Degs)	Height (cm)	Polarity
1	* ** 2.4835	41.49	Pk	32.3	-24	49.79	-	-	74	-24.21	286	396	H
2	* ** 2.49598	43.56	Pk	32.3	-24	51.86	-	-	74	-22.14	286	396	H
3	* ** 2.4835	31.47	V1TR	32.3	-24	39.77	54	-14.23	-	-	286	396	H
4	* ** 2.48581	31.56	V1TR	32.3	-24	39.86	54	-14.14	-	-	286	396	H

* - indicates frequency in CFR47 Pt 15 / IC RSS-Restricted Band
** - indicates frequency in Taiwan NCC LP0002 Restricted Band
Pk - Peak detector
V1TR - U-NII: VB=1/Ton, RMS Average where: Ton is packet duration

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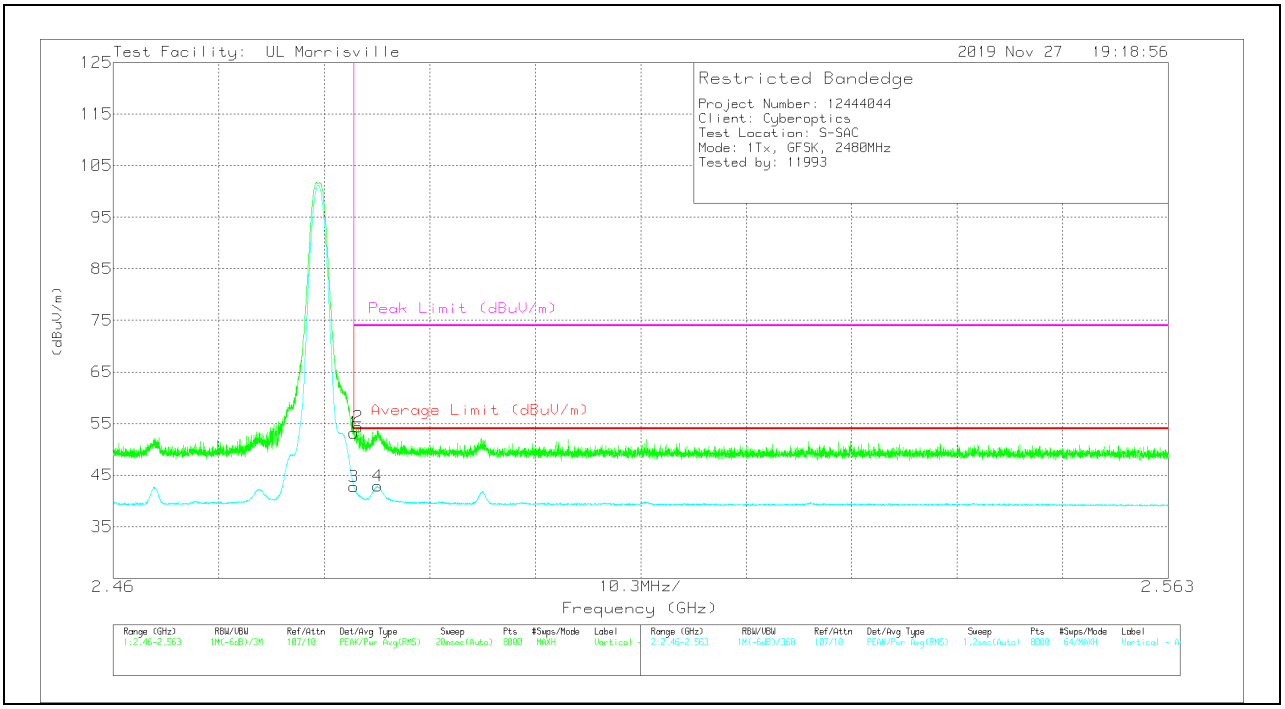
VERTICAL RESULT



Marker	Frequency (GHz)	Meter Reading (dBuV)	Det	AT0072 (dB/m)	Amp/Cbl/Fltr/Pad (dB)	Corrected Reading (dBuV/m)	Average Limit (dBuV/m)	Margin (dB)	Peak Limit (dBuV/m)	PK Margin (dB)	Azimuth (Degs)	Height (cm)	Polarity
1	* ** 2.4835	44.91	Pk	32.3	-24	53.21	-	-	74	-20.79	74	351	V
2	* ** 2.48391	46.03	Pk	32.3	-24	54.33	-	-	74	-19.67	74	351	V
3	* ** 2.4835	34.44	V1TR	32.3	-24	42.74	54	-11.26	-	-	74	351	V
4	* ** 2.48583	34.56	V1TR	32.3	-24	42.86	54	-11.14	-	-	74	351	V

* - indicates frequency in CFR47 Pt 15 / IC RSS-Restricted Band
** - indicates frequency in Taiwan NCC LP0002 Restricted Band
Pk - Peak detector
V1TR - U-NII: VB=1/Ton, RMS Average where: Ton is packet duration

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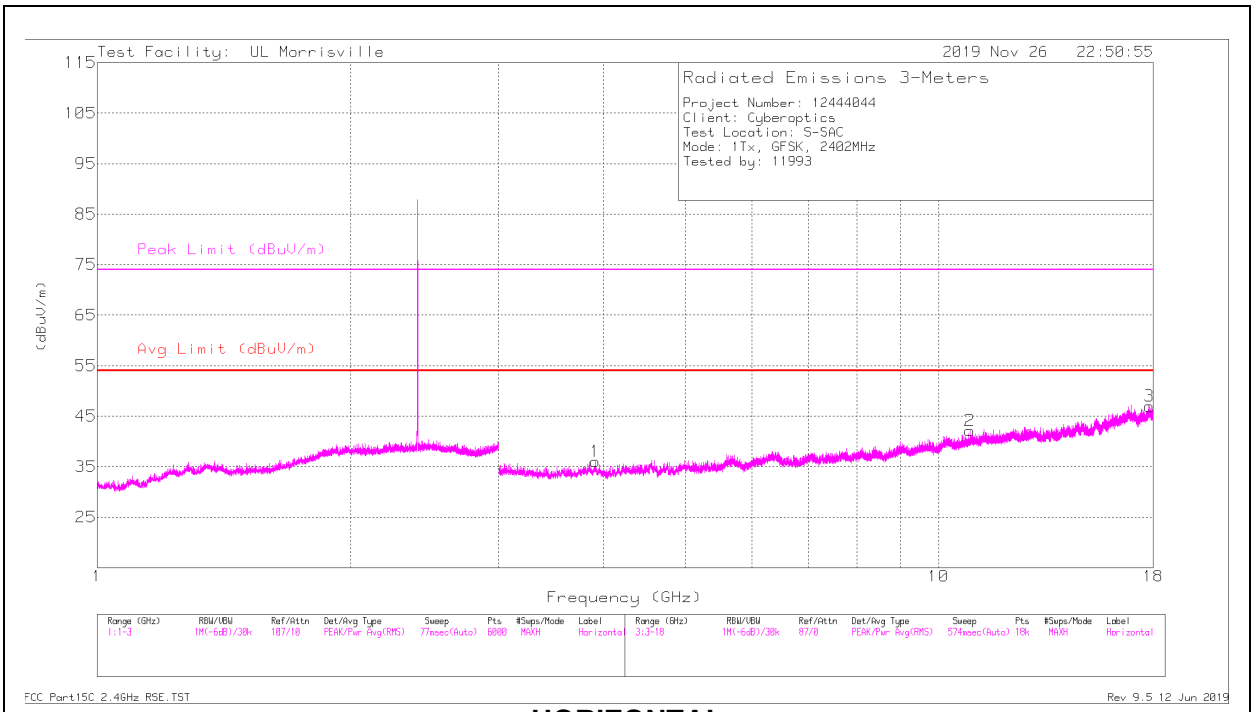
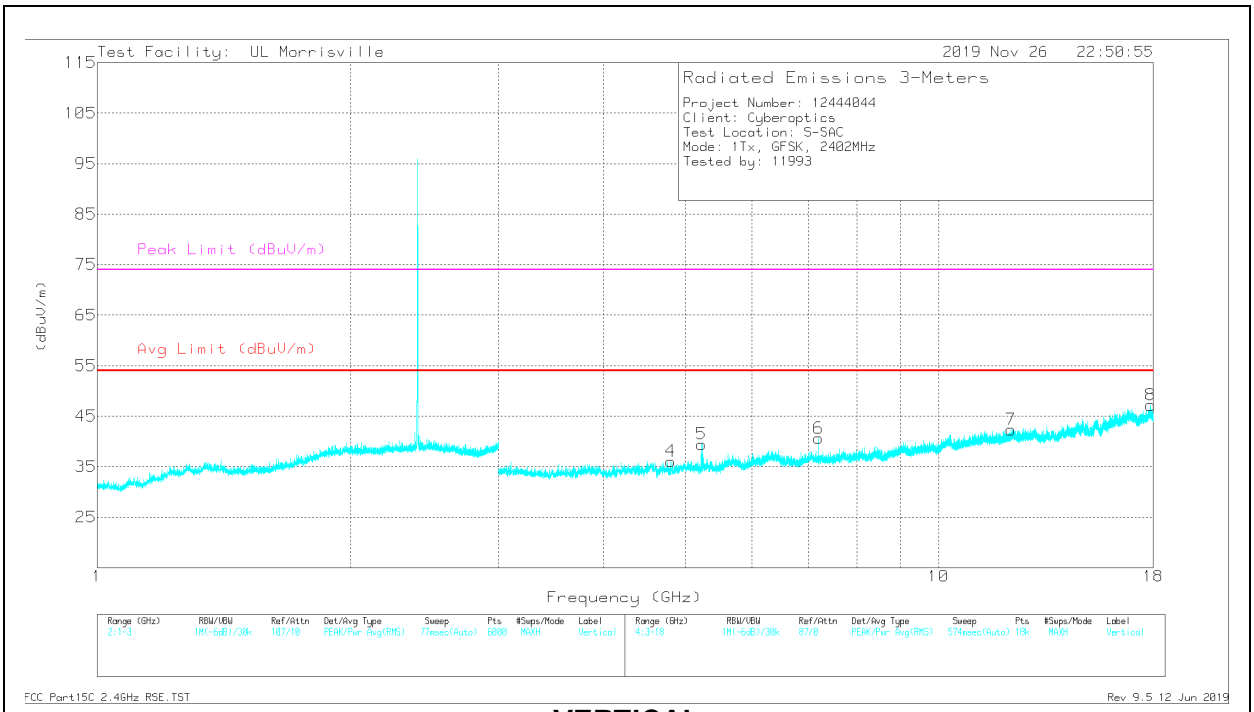
HARMONICS AND SPURIOUS EMISSIONS

LOW CHANNEL RESULTS



HORIZONTAL



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RADIATED EMISSIONS

Marker	Frequency (GHz)	Meter Reading (dBuV)	Det	AT0072 (dB/m)	Amp/Cbl/Fltr/Pad (dB)	Corrected Reading (dBuV/m)	Avg Limit (dBuV/m)	Margin (dB)	Peak Limit (dBuV/m)	PK Margin (dB)	Azimuth (Degs)	Height (cm)	Polarity
1	* ** 3.90796	40.62	PK-U	33.4	-31.8	42.22	-	-	74	-31.78	177	153	H
	* ** 3.90586	28.58	V1TR	33.4	-31.8	30.18	54	-23.82	-	-	177	153	H
2	* ** 10.8963	33.74	PK-U	37.9	-24.4	47.24	-	-	74	-26.76	200	230	H
	* ** 10.89627	22.49	V1TR	37.9	-24.4	35.99	54	-18.01	-	-	200	230	H
3	* ** 17.80709	33.17	PK-U	41.2	-20.8	53.57	-	-	74	-20.43	147	358	H
	* ** 17.80709	21.5	V1TR	41.2	-20.8	41.9	54	-12.1	-	-	147	358	H
4	* ** 4.80406	40.98	PK-U	34.2	-31	44.18	-	-	74	-29.82	220	256	V
	* ** 4.80401	33.49	V1TR	34.2	-31	36.69	54	-17.31	-	-	220	256	V
5	** 5.22564	37.7	PK-U	34.3	-30.5	41.5	-	-	74	-32.5	61	305	V
	** 5.22487	26.9	V1TR	34.3	-30.5	30.7	54	-23.3	-	-	61	305	V
7	* ** 12.20651	33.86	PK-U	38.9	-23.8	48.96	-	-	74	-25.04	309	274	V
	* ** 12.20795	22.49	V1TR	38.9	-23.8	37.59	54	-16.41	-	-	309	274	V
8	* ** 17.86956	32.74	PK-U	41.2	-20.6	53.34	-	-	74	-20.66	241	254	V
	* ** 17.86588	21.96	V1TR	41.2	-20.7	42.46	54	-11.54	-	-	241	255	V
6	7.20607	32.91	Pk	35.7	-28	40.61	-	-	-	-	0-360	199	V

* - indicates frequency in CFR47 Pt 15 / IC RSS-Restricted Band
** - indicates frequency in Taiwan NCC LP0002 Restricted Band
PK-U - U-NII: Maximum Peak
V1TR - U-NII: VB=1/Ton, RMS Average where: Ton is packet duration
Pk - Peak detector

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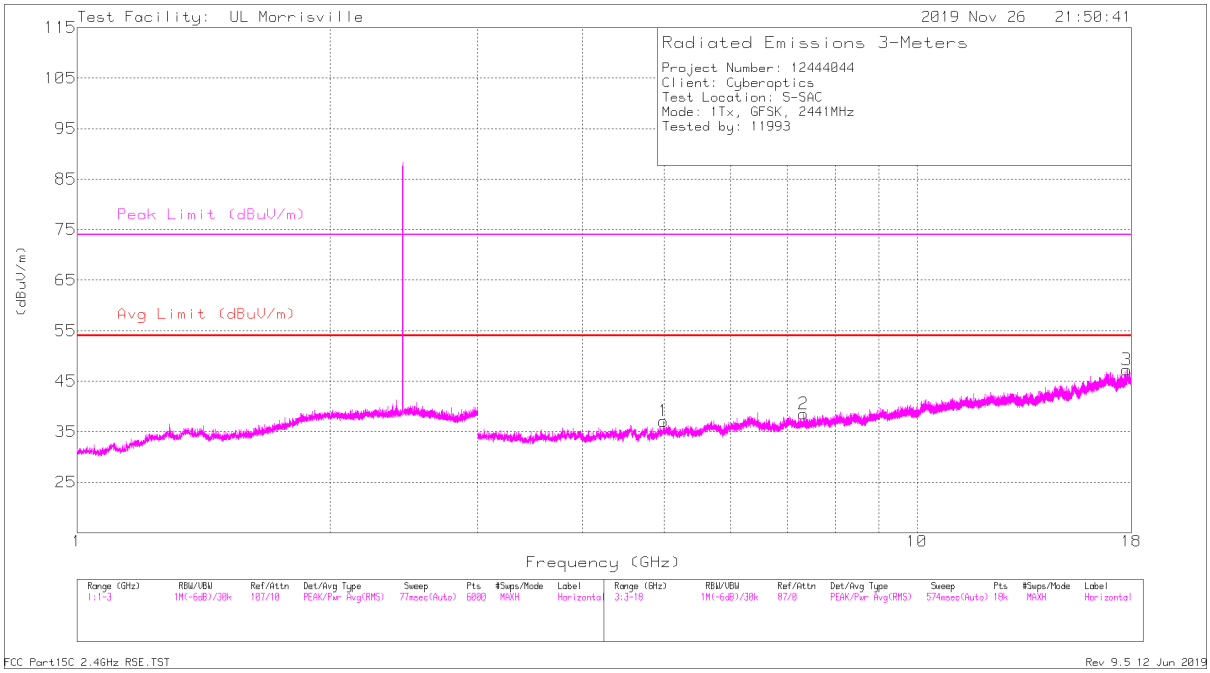
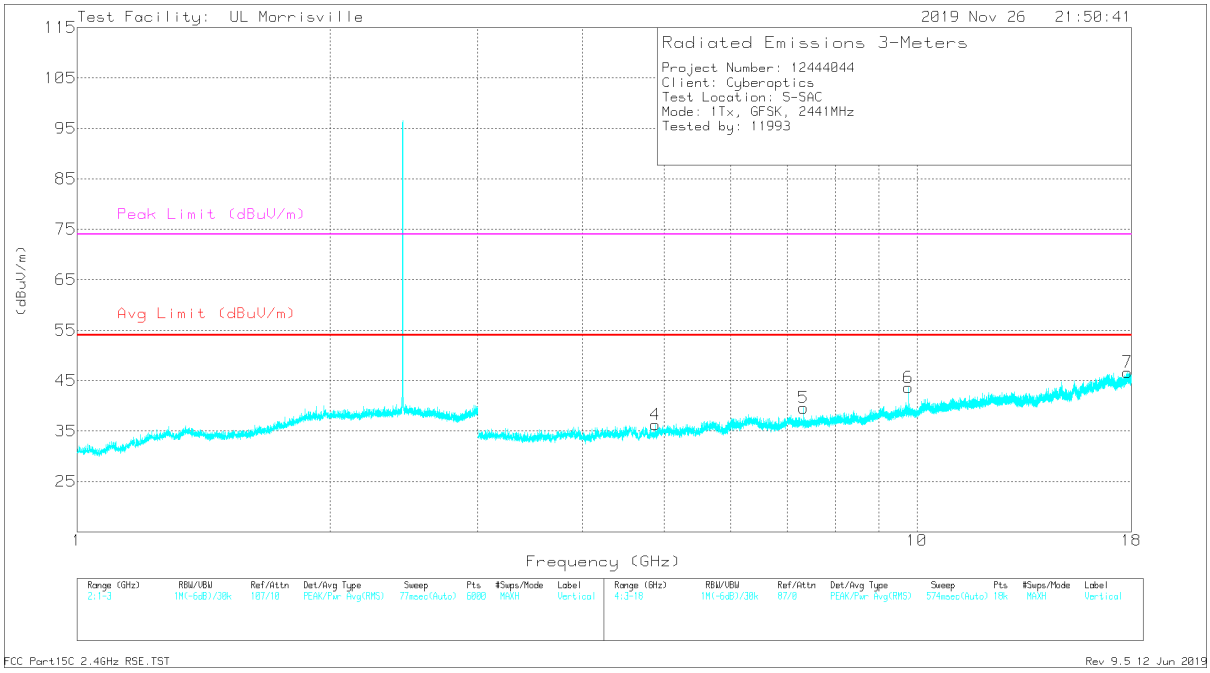
MID CHANNEL RESULTS



HORIZONTAL



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RADIATED EMISSIONS

Marker	Frequency (GHz)	Meter Reading (dBuV)	Det	AT0072 (dB/m)	Amp/Cbl/Fltr/Pad (dB)	Corrected Reading (dBuV/m)	Avg Limit (dBuV/m)	Margin (dB)	Peak Limit (dBuV/m)	PK Margin (dB)	Azimuth (Degs)	Height (cm)	Polarity
1	* ** 4.99291	40.25	PK-U	34.1	-31.1	43.25	-	-	74	-30.75	22	216	H
	* ** 4.9911	27.72	V1TR	34.1	-31.1	30.72	54	-23.28	-	-	22	216	H
2	* ** 7.3297	35.64	PK-U	35.7	-27.5	43.84	-	-	74	-30.16	101	116	H
	* ** 7.3281	24.08	V1TR	35.7	-27.5	32.28	54	-21.72	-	-	101	116	H
3	* ** 17.76988	33.02	PK-U	41.2	-21.4	52.82	-	-	74	-21.18	139	238	H
	* ** 17.7703	22.12	V1TR	41.2	-21.4	41.92	54	-12.08	-	-	139	238	H
4	* ** 4.88234	40.94	PK-U	34	-30.6	44.34	-	-	74	-29.66	143	320	V
	* ** 4.88203	32.29	V1TR	34	-30.6	35.69	54	-18.31	-	-	143	320	V
5	* ** 7.32349	39.57	PK-U	35.7	-27.5	47.77	-	-	74	-26.23	313	290	V
	* ** 7.32331	30.65	V1TR	35.7	-27.5	38.85	54	-15.15	-	-	313	290	V
7	* ** 17.81971	32.87	PK-U	41.2	-20.8	53.27	-	-	74	-20.73	44	250	V
	* ** 17.81937	22.2	V1TR	41.4	-22.5	41.1	54	-12.9	-	-	44	251	V
6	9.76288	32.13	Pk	37.1	-25.6	43.63	-	-	-	-	0-360	199	V

* - indicates frequency in CFR47 Pt 15 / IC RSS-Restricted Band
** - indicates frequency in Taiwan NCC LP0002 Restricted Band
PK-U - U-NII: Maximum Peak
V1TR - U-NII: VB=1/Ton, RMS Average where: Ton is packet duration
Pk - Peak detector

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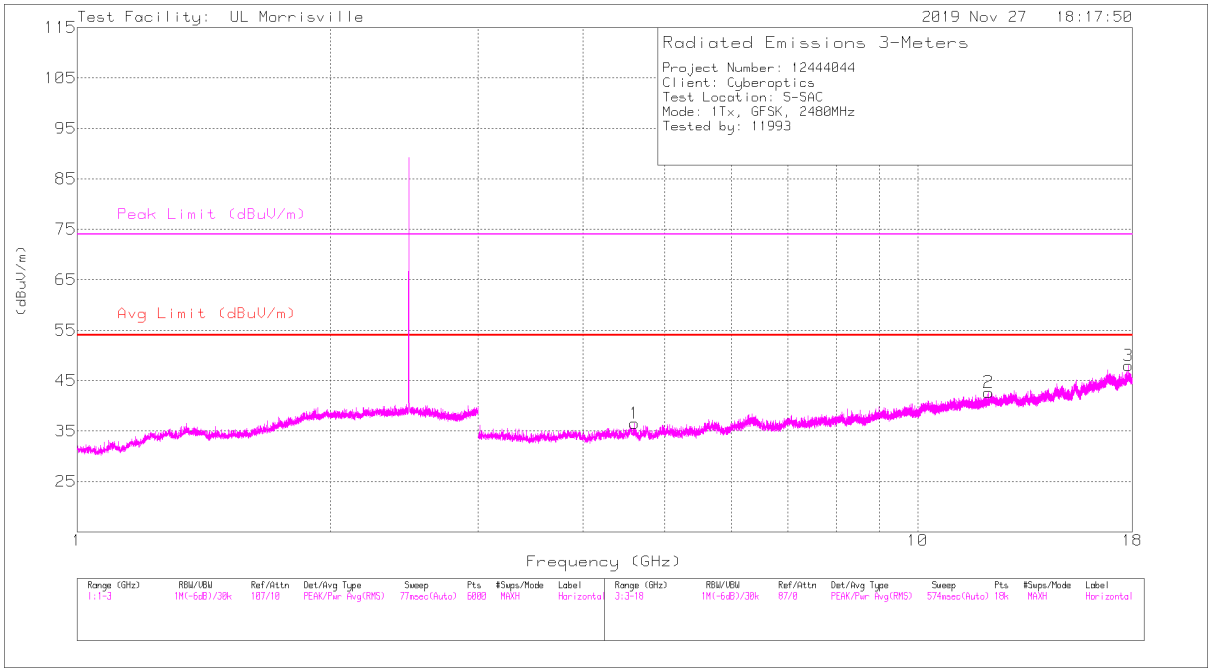
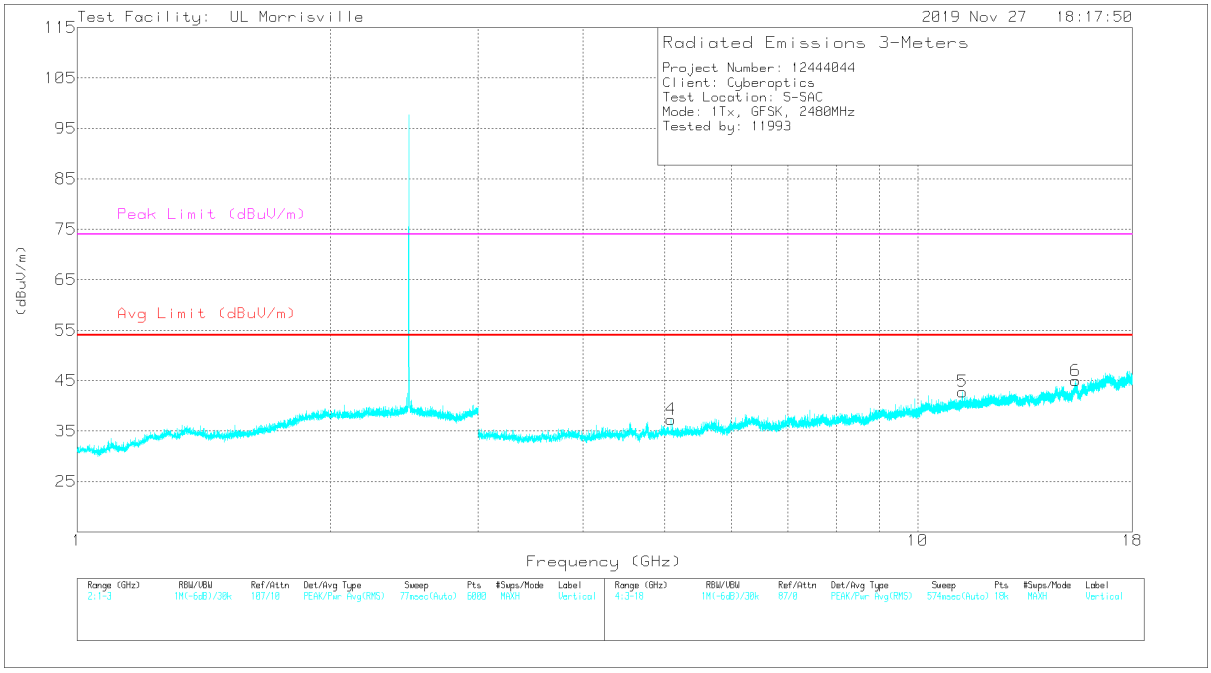
HIGH CHANNEL RESULTS



HORIZONTAL



VERTICAL

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RADIATED EMISSIONS

Marker	Frequency (GHz)	Meter Reading (dBuV)	Det	AT0072 (dB/m)	Amp/Cbl/Fltr/Pad (dB)	Corrected Reading (dBuV/m)	Avg Limit (dBuV/m)	Margin (dB)	Peak Limit (dBuV/m)	PK Margin (dB)	Azimuth (Degs)	Height (cm)	Polarity
1	* ** 4.60277	39.58	PK-U	34.1	-31.6	42.08	-	-	74	-31.92	172	318	H
	* ** 4.59964	28	V1TR	34.1	-31.6	30.5	54	-23.5	-	-	172	318	H
2	* ** 12.14263	33.6	PK-U	38.8	-24	48.4	-	-	74	-25.6	96	131	H
	* ** 12.14392	22.13	V1TR	38.8	-24	36.93	54	-17.07	-	-	96	131	H
3	* ** 17.80758	33.76	PK-U	41.2	-20.8	54.16	-	-	74	-19.84	194	272	H
	* ** 17.80573	22.08	V1TR	41.2	-20.8	42.48	54	-11.52	-	-	194	272	H
4	* ** 5.08344	38.88	PK-U	34.2	-31.1	41.98	-	-	74	-32.02	23	136	V
	* ** 5.08367	27.56	V1TR	34.2	-31.1	30.66	54	-23.34	-	-	23	136	V
5	* ** 11.31225	33.19	PK-U	38	-22.9	48.29	-	-	74	-25.71	337	327	V
	* ** 11.31205	21.42	V1TR	38	-22.9	36.52	54	-17.48	-	-	337	327	V
6	* ** 15.41708	32.99	PK-U	39.9	-21.7	51.19	-	-	74	-22.81	60	326	V
	* ** 15.41755	21.64	V1TR	39.9	-21.7	39.84	54	-14.16	-	-	60	326	V

* - indicates frequency in CFR47 Pt 15 / IC RSS-Restricted Band
** - indicates frequency in Taiwan NCC LP0002 Restricted Band
PK-U - U-NII: Maximum Peak
V1TR - U-NII: VB=1/Ton, RMS Average where: Ton is packet duration

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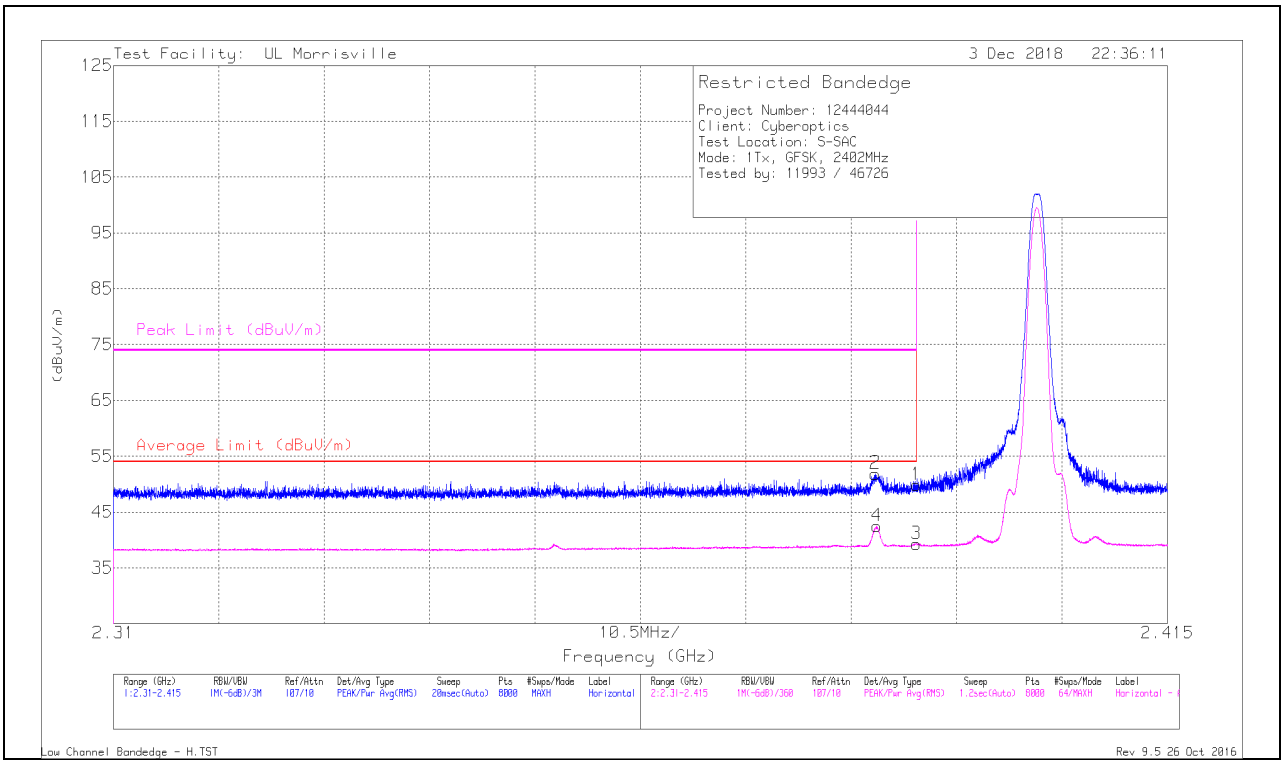
9.1.2. BLUETOOTH BASIC DATA RATE GFSK MODULATION – APS-FPD

BANDEDGE (LOW CHANNEL)

HORIZONTAL RESULT



Marker	Frequency (GHz)	Meter Reading (dBuV)	Det	AT0069 AF (dB/m)	Amp/Cbl/Fltr/Pad (dB)	Corrected Reading (dBuV/m)	Average Limit (dBuV/m)	Margin (dB)	Peak Limit (dBuV/m)	PK Margin (dB)	Azimuth (Degs)	Height (cm)	Polarity
1	* ** 2.39	42.01	Pk	32	-24.2	49.81	-	-	74	-24.19	64	156	H
2	* ** 2.386	44.17	Pk	32	-24.3	51.87	-	-	74	-22.13	64	156	H
3	* ** 2.39	31.44	V1TR	32	-24.2	39.24	54	-14.76	-	-	64	156	H
4	* ** 2.386	34.64	V1TR	32	-24.2	42.44	54	-11.56	-	-	64	156	H

* - indicates frequency in CFR47 Pt 15 / IC RSS-Restricted Band
** - indicates frequency in Taiwan NCC LP0002 Restricted Band
Pk - Peak detector
V1TR - U-NII: VB=1/Ton, RMS Average where: Ton is packet duration

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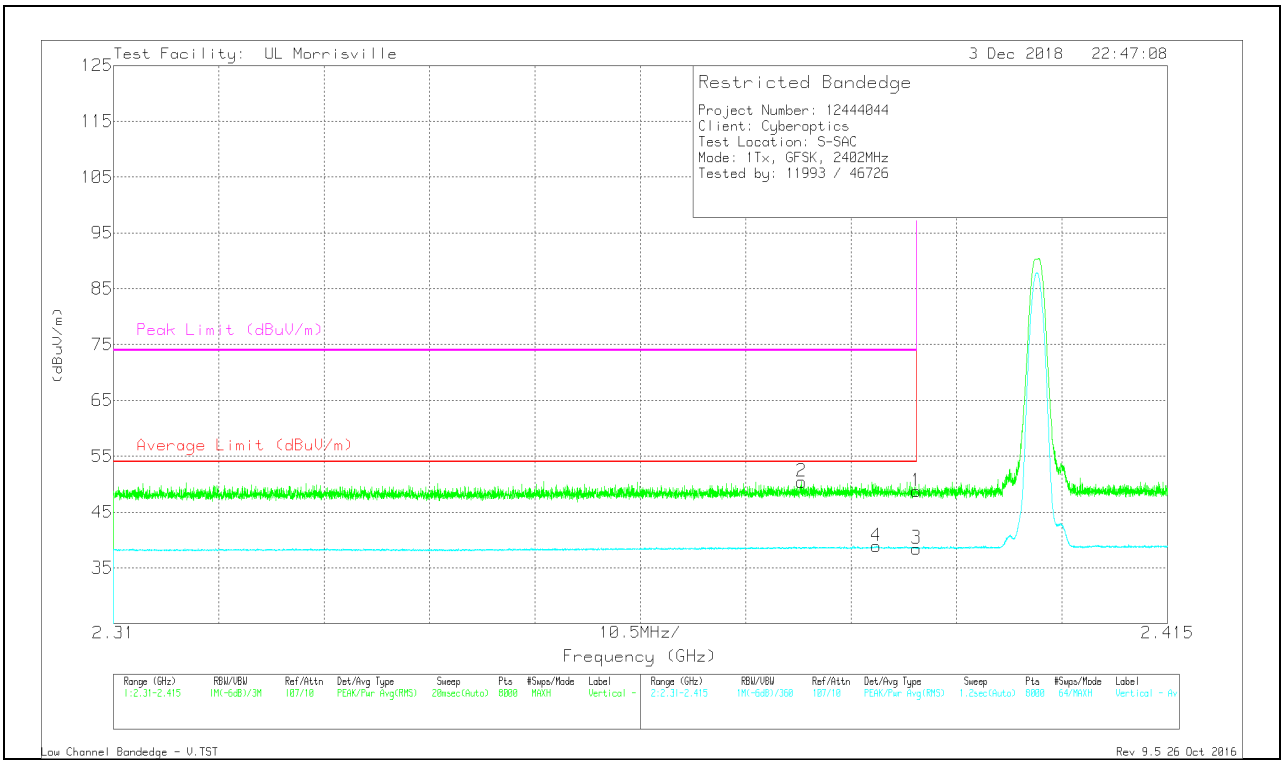
VERTICAL RESULT



Marker	Frequency (GHz)	Meter Reading (dBuV)	Det	AT0069 AF (dB/m)	Amp/Cbl/Fltr/Pad (dB)	Corrected Reading (dBuV/m)	Average Limit (dBuV/m)	Margin (dB)	Peak Limit (dBuV/m)	PK Margin (dB)	Azimuth (Degs)	Height (cm)	Polarity
1	* ** 2.39	40.91	Pk	32	-24.2	48.71	-	-	74	-25.29	260	288	V
2	* ** 2.379	42.72	Pk	32	-24.3	50.42	-	-	74	-23.58	260	288	V
3	* ** 2.39	30.67	V1TR	32	-24.2	38.47	54	-15.53	-	-	260	288	V
4	* ** 2.386	31.21	V1TR	32	-24.3	38.91	54	-15.09	-	-	260	288	V

* - indicates frequency in CFR47 Pt 15 / IC RSS-Restricted Band
** - indicates frequency in Taiwan NCC LP0002 Restricted Band
Pk - Peak detector
V1TR - U-NII: VB=1/Ton, RMS Average where: Ton is packet duration

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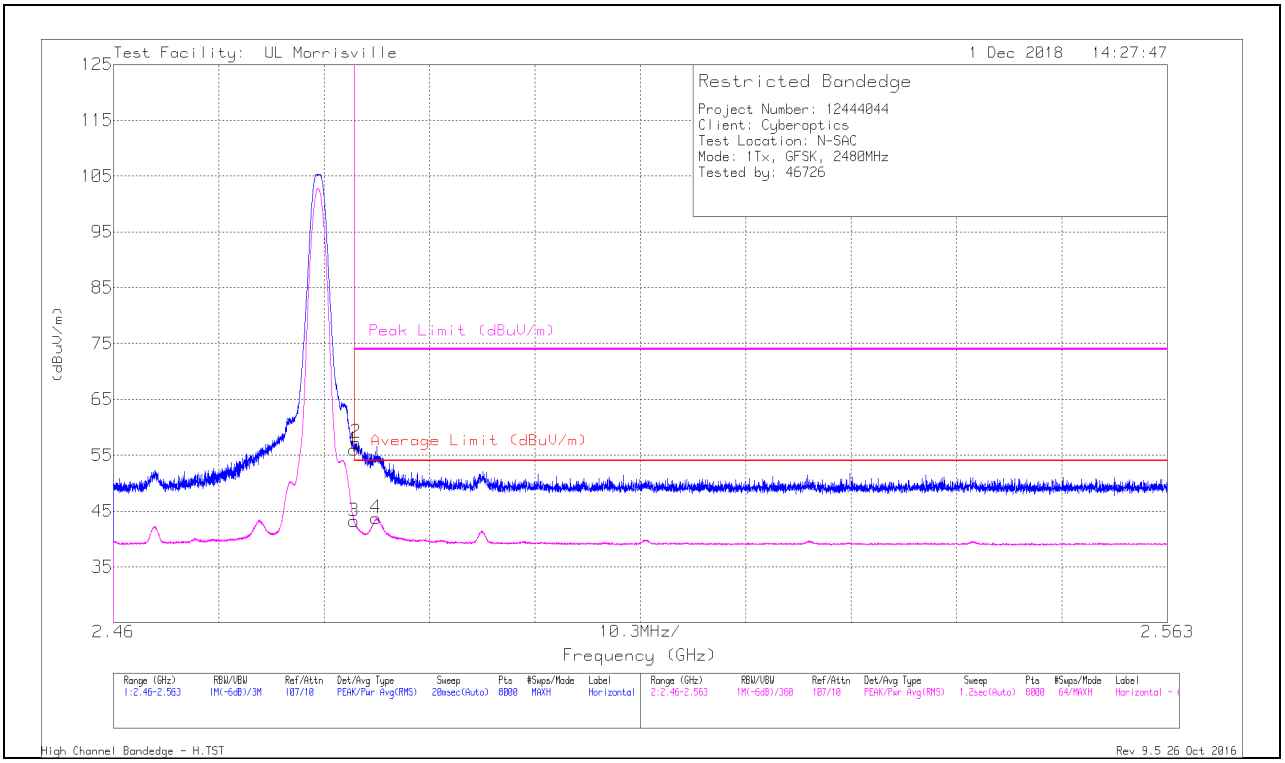
BANDEDGE (HIGH CHANNEL)

HORIZONTAL RESULT



Marker	Frequency (GHz)	Meter Reading (dBuV)	Det	AT0072 AF (dB/m)	Amp/Cbl/Fltr/Pad (dB)	Corrected Reading (dBuV/m)	Average Limit (dBuV/m)	Margin (dB)	Peak Limit (dBuV/m)	PK Margin (dB)	Azimuth (Degs)	Height (cm)	Polarity
1	* ** 2.484	48.08	Pk	32.4	-24.5	55.98	-	-	74	-18.02	202	130	H
2	* ** 2.484	49.37	Pk	32.4	-24.5	57.27	-	-	74	-16.73	202	130	H
3	* ** 2.484	35.33	V1TR	32.4	-24.5	43.23	54	-10.77	-	-	202	130	H
4	* ** 2.486	35.85	V1TR	32.4	-24.5	43.75	54	-10.25	-	-	202	130	H

* - indicates frequency in CFR47 Pt 15 / IC RSS-Restricted Band
** - indicates frequency in Taiwan NCC LP0002 Restricted Band
Pk - Peak detector
V1TR - U-NII: VB=1/Ton, RMS Average where: Ton is packet duration

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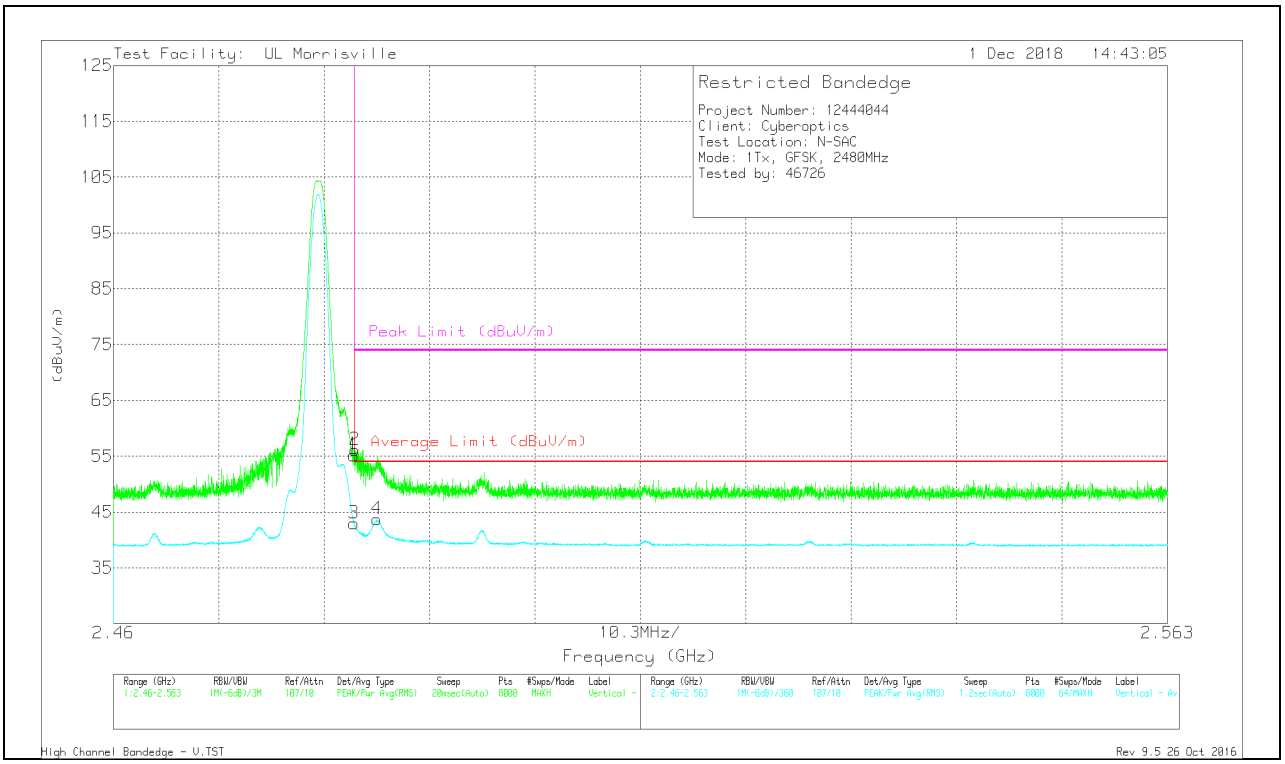
VERTICAL RESULT



Marker	Frequency (GHz)	Meter Reading (dBuV)	Det	AT0072 AF (dB/m)	Amp/Cbl/Fltr/Pad (dB)	Corrected Reading (dBuV/m)	Average Limit (dBuV/m)	Margin (dB)	Peak Limit (dBuV/m)	PK Margin (dB)	Azimuth (Degs)	Height (cm)	Polarity
1	* ** 2.484	47.31	Pk	32.4	-24.5	55.21	-	-	74	-18.79	6	322	V
2	* ** 2.484	48.23	Pk	32.4	-24.5	56.13	-	-	74	-17.87	6	322	V
3	* ** 2.484	35.03	V1TR	32.4	-24.5	42.93	54	-11.07	-	-	6	322	V
4	* ** 2.486	35.81	V1TR	32.4	-24.5	43.71	54	-10.29	-	-	6	322	V

* - indicates frequency in CFR47 Pt 15 / IC RSS-Restricted Band
** - indicates frequency in Taiwan NCC LP0002 Restricted Band
Pk - Peak detector
V1TR - U-NII: VB=1/Ton, RMS Average where: Ton is packet duration

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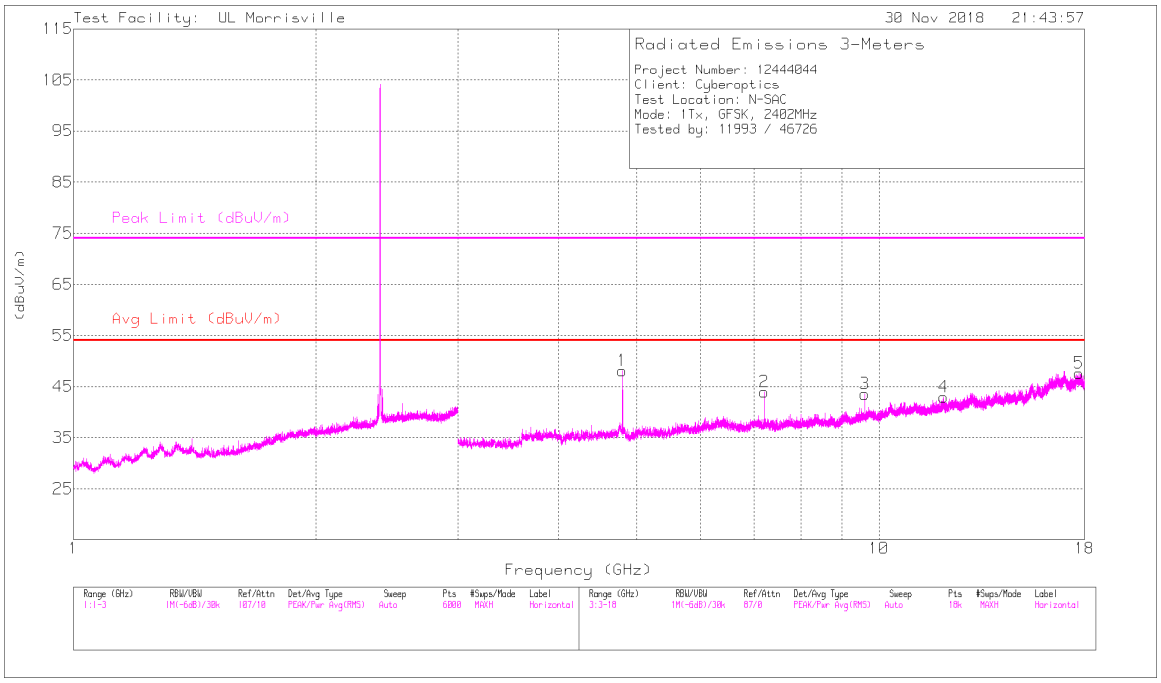
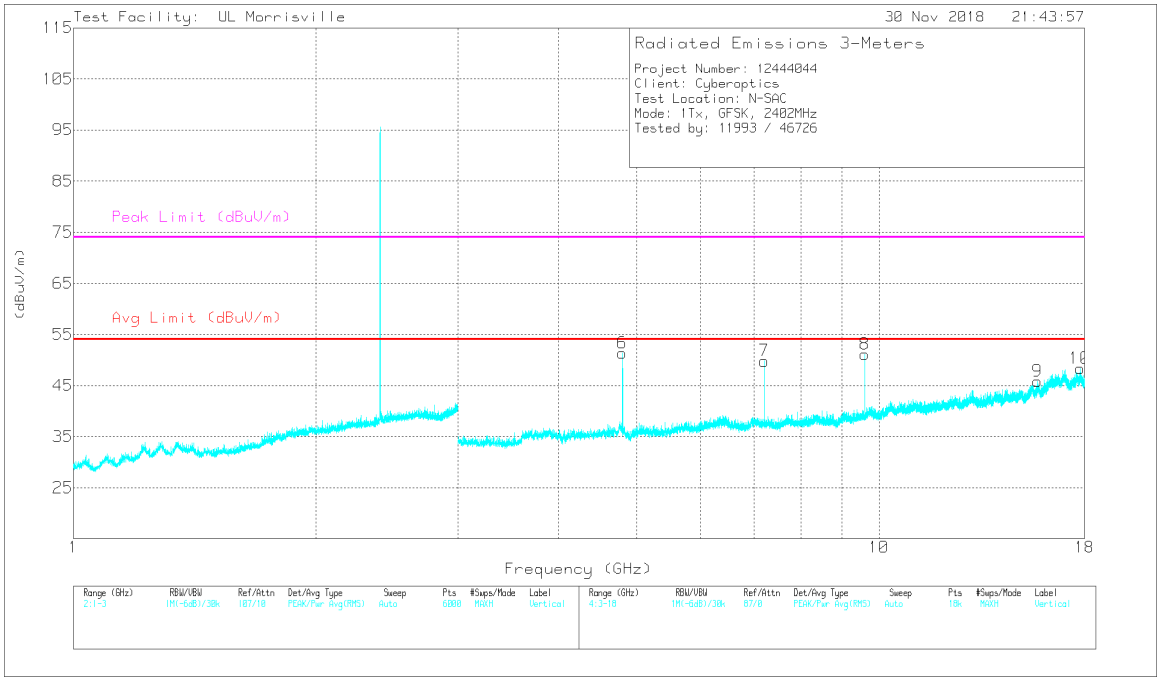
HARMONICS AND SPURIOUS EMISSIONS

LOW CHANNEL RESULTS



HORIZONTAL



VERTICAL

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RADIATED EMISSIONS

Marker	Frequency (GHz)	Meter Reading (dBuV)	Det	AT0072 AF (dB/m)	Amp/Cbl/Fltr/Pad (dB)	Corrected Reading (dBuV/m)	Avg Limit (dBuV/m)	Margin (dB)	Peak Limit (dBuV/m)	PK Margin (dB)	Azimuth (Degs)	Height (cm)	Polarity
1	* ** 4.804	49.94	PK-U	34.1	-31.8	52.24	-	-	74	-21.76	0	103	H
	* ** 4.804	43.01	V1TR	34.1	-31.8	45.31	54	-8.69	-	-	0	103	H
4	* ** 12.035	35.05	PK-U	38.7	-25.7	48.05	-	-	74	-25.95	141	334	H
	* ** 12.037	24.09	V1TR	38.7	-25.7	37.09	54	-16.91	-	-	141	334	H
5	* ** 17.72	35.96	PK-U	41.6	-23.8	53.76	-	-	74	-20.24	126	286	H
	* ** 17.716	24.27	V1TR	41.6	-23.8	42.07	54	-11.93	-	-	126	286	H
6	* ** 4.804	52.88	PK-U	34.1	-31.8	55.18	-	-	74	-18.82	238	108	V
	* ** 4.804	47.54	V1TR	34.1	-31.8	49.84	54	-4.16	-	-	238	108	V
9	* ** 15.729	36.01	PK-U	40.2	-24.5	51.71	-	-	74	-22.29	325	178	V
	* ** 15.726	24.88	V1TR	40.2	-24.6	40.48	54	-13.52	-	-	325	178	V
10	* ** 17.768	35.99	PK-U	41.5	-23.3	54.19	-	-	74	-19.81	148	195	V
	* ** 17.768	24.33	V1TR	41.5	-23.3	42.53	54	-11.47	-	-	148	195	V
2	7.205	38.42	Pk	35.6	-30.1	43.92	-	-	-	-	0-360	102	H
7	7.205	44.31	Pk	35.6	-30.1	49.81	-	-	-	-	0-360	102	V
8	9.608	42.19	Pk	36.9	-28	51.09	-	-	-	-	0-360	102	V
3	9.609	34.63	Pk	36.9	-28	43.53	-	-	-	-	0-360	102	H

* - indicates frequency in CFR47 Pt 15 / IC RSS-Restricted Band
** - indicates frequency in Taiwan NCC LP0002 Restricted Band
PK-U - U-NII: Maximum Peak
V1TR - U-NII: VB=1/Ton, RMS Average where: Ton is packet duration
Pk - Peak detector

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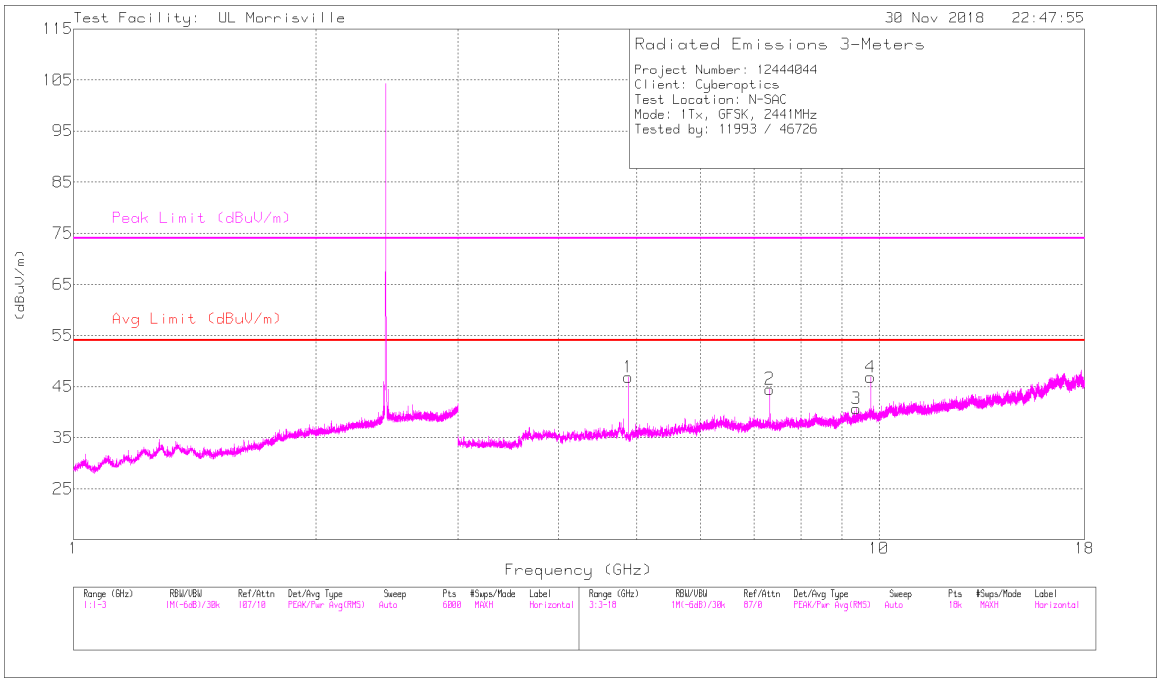
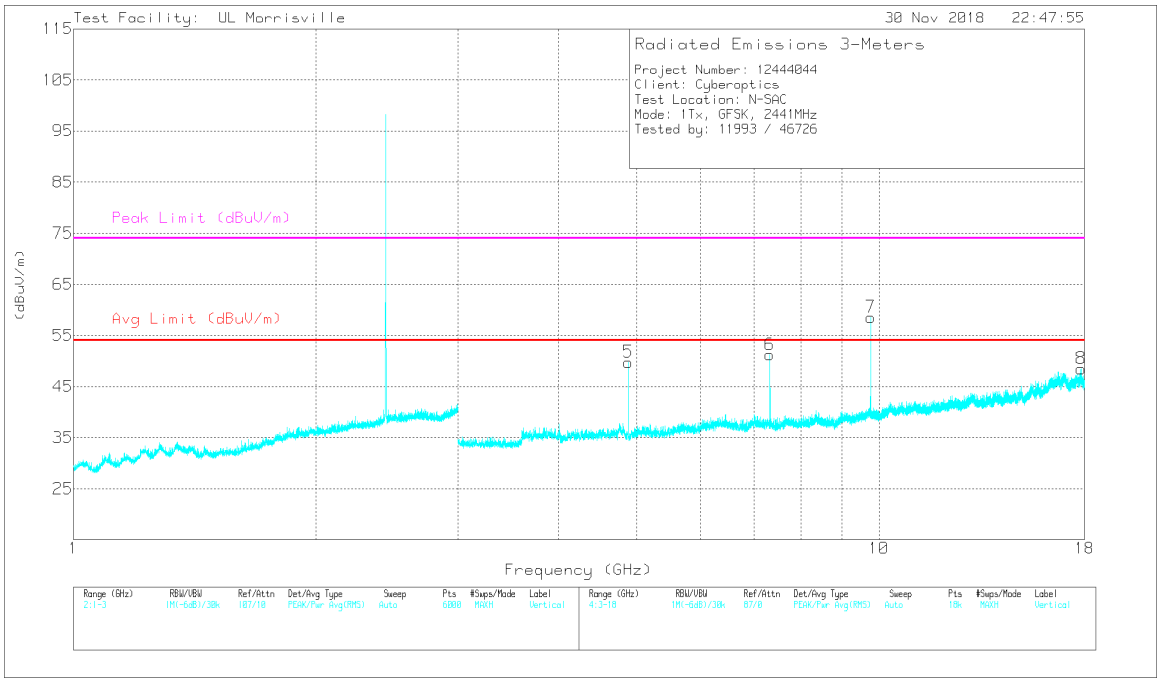
MID CHANNEL RESULTS



HORIZONTAL



VERTICAL

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RADIATED EMISSIONS

Marker	Frequency (GHz)	Meter Reading (dBuV)	Det	AT0072 AF (dB/m)	Amp/Cbl/Fltr/Pad (dB)	Corrected Reading (dBuV/m)	Avg Limit (dBuV/m)	Margin (dB)	Peak Limit (dBuV/m)	PK Margin (dB)	Azimuth (Degs)	Height (cm)	Polarity
1	* ** 4.882	47.13	PK-U	34.1	-31.6	49.63	-	-	74	-24.37	120	106	H
	* ** 4.882	40.35	V1TR	34.1	-31.6	42.85	54	-11.15	-	-	120	106	H
2	* ** 7.323	43.76	PK-U	35.6	-29.2	50.16	-	-	74	-23.84	11	110	H
	* ** 7.323	35.04	V1TR	35.6	-29.2	41.44	54	-12.56	-	-	11	110	H
3	* ** 9.376	37.69	PK-U	36.5	-28.1	46.09	-	-	74	-27.91	28	252	H
	* ** 9.373	26.36	V1TR	36.5	-28.2	34.66	54	-19.34	-	-	28	252	H
5	* ** 4.882	51.28	PK-U	34.1	-31.6	53.78	-	-	74	-20.22	234	110	V
	* ** 4.882	45.54	V1TR	34.1	-31.6	48.04	54	-5.96	-	-	234	110	V
6	* ** 7.323	49.16	PK-U	35.6	-29.2	55.56	-	-	74	-18.44	66	103	V
	* ** 7.323	42.44	V1TR	35.6	-29.2	48.84	54	-5.16	-	-	66	103	V
8	* ** 17.827	36.52	PK-U	41.6	-22.6	55.52	-	-	74	-18.48	141	112	V
	* ** 17.827	23.86	V1TR	41.6	-22.6	42.86	54	-11.14	-	-	141	112	V
4	9.763	37.13	Pk	37	-27.3	46.83	-	-	-	-	0-360	102	H
7	9.765	48.86	Pk	37	-27.3	58.56	-	-	-	-	0-360	102	V

* - indicates frequency in CFR47 Pt 15 / IC RSS-Restricted Band
** - indicates frequency in Taiwan NCC LP0002 Restricted Band
PK-U - U-NII: Maximum Peak
V1TR - U-NII: VB=1/Ton, RMS Average where: Ton is packet duration
Pk - Peak detector

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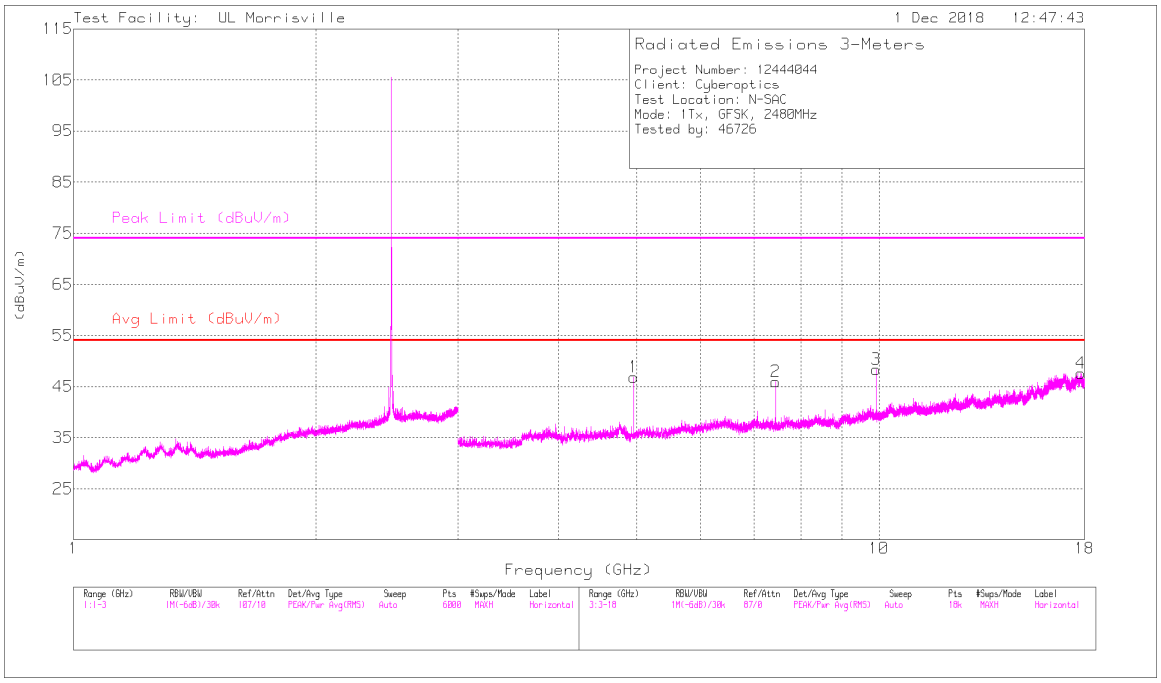
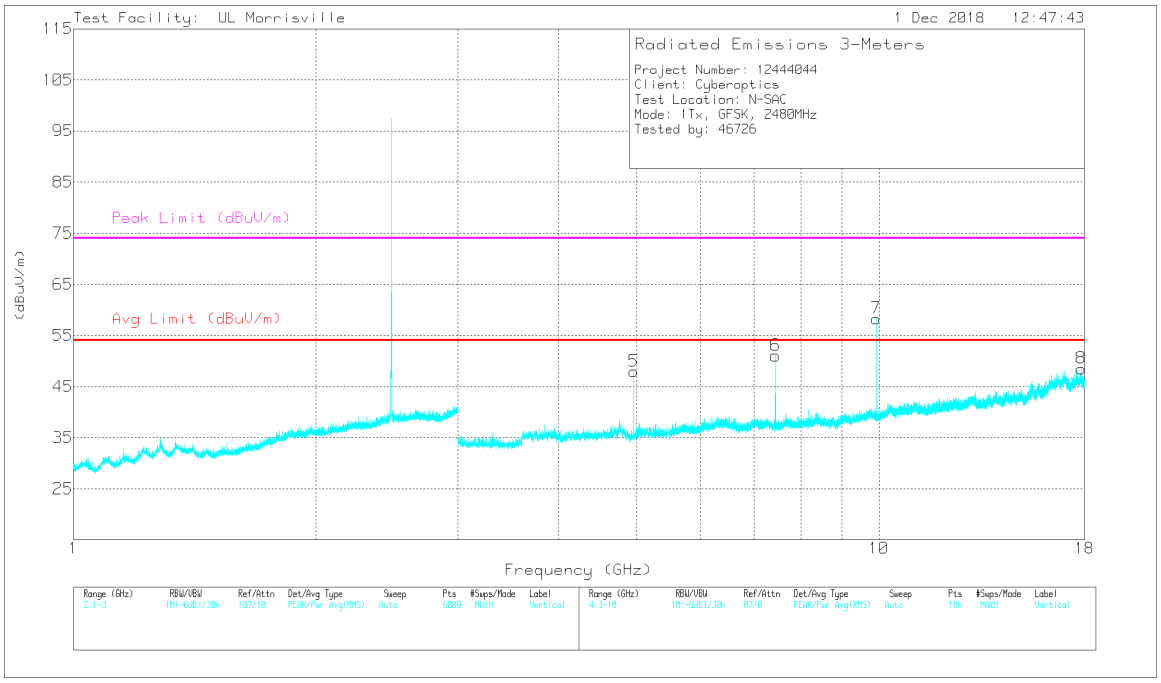
HIGH CHANNEL RESULTS



HORIZONTAL



VERTICAL

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RADIATED EMISSIONS

Markers	Frequency (GHz)	Meter Reading (dBuV)	Det	AT0072 AF (dB/m)	Amp/Cbl/Fltr/Pad (dB)	Corrected Reading (dBuV/m)	Avg Limit (dBuV/m)	Margin (dB)	Peak Limit (dBuV/m)	PK Margin (dB)	Azimuth (Degs)	Height (cm)	Polarity
1	* ** 4.96	47.91	PK-U	34.1	-32.5	49.51	-	-	74	-24.49	175	126	H
	* ** 4.96	40.71	V1TR	34.1	-32.5	42.31	54	-11.69	-	-	175	126	H
2	* ** 7.44	44.65	PK-U	35.6	-29.2	51.05	-	-	74	-22.95	15	115	H
	* ** 7.44	35.4	V1TR	35.6	-29.2	41.8	54	-12.2	-	-	15	115	H
4	* ** 17.822	35.72	PK-U	41.6	-22.6	54.72	-	-	74	-19.28	256	205	H
	* ** 17.822	23.76	V1TR	41.6	-22.6	42.76	54	-11.24	-	-	256	205	H
3	9.92	45.34	PK-U	37.1	-27.8	54.64	-	-	-	-	343	115	H
	9.92	35.74	V1TR	37.1	-27.8	45.04	-	-	-	-	343	115	H
5	* ** 4.96	49.81	PK-U	34.1	-32.5	51.41	-	-	74	-22.59	228	130	V
	* ** 4.96	43.48	V1TR	34.1	-32.5	45.08	54	-8.92	-	-	228	130	V
6	* ** 7.44	50.77	PK-U	35.6	-29.2	57.17	-	-	74	-16.83	59	107	V
	* ** 7.44	43.82	V1TR	35.6	-29.2	50.22	54	-3.78	-	-	59	107	V
8	* ** 17.829	35.67	PK-U	41.6	-22.6	54.67	-	-	74	-19.33	226	148	V
	* ** 17.829	23.68	V1TR	41.6	-22.6	42.68	54	-11.32	-	-	226	148	V
7	9.92	51.6	PK-U	37.1	-27.8	60.9	-	-	-	-	232	105	V
	9.92	43.01	V1TR	37.1	-27.8	52.31	-	-	-	-	232	105	V

* - indicates frequency in CFR47 Pt 15 / IC RSS-Restricted Band
** - indicates frequency in Taiwan NCC LP0002 Restricted Band
PK-U - U-NII: Maximum Peak
V1TR - U-NII: VB=1/Ton, RMS Average where: Ton is packet duration

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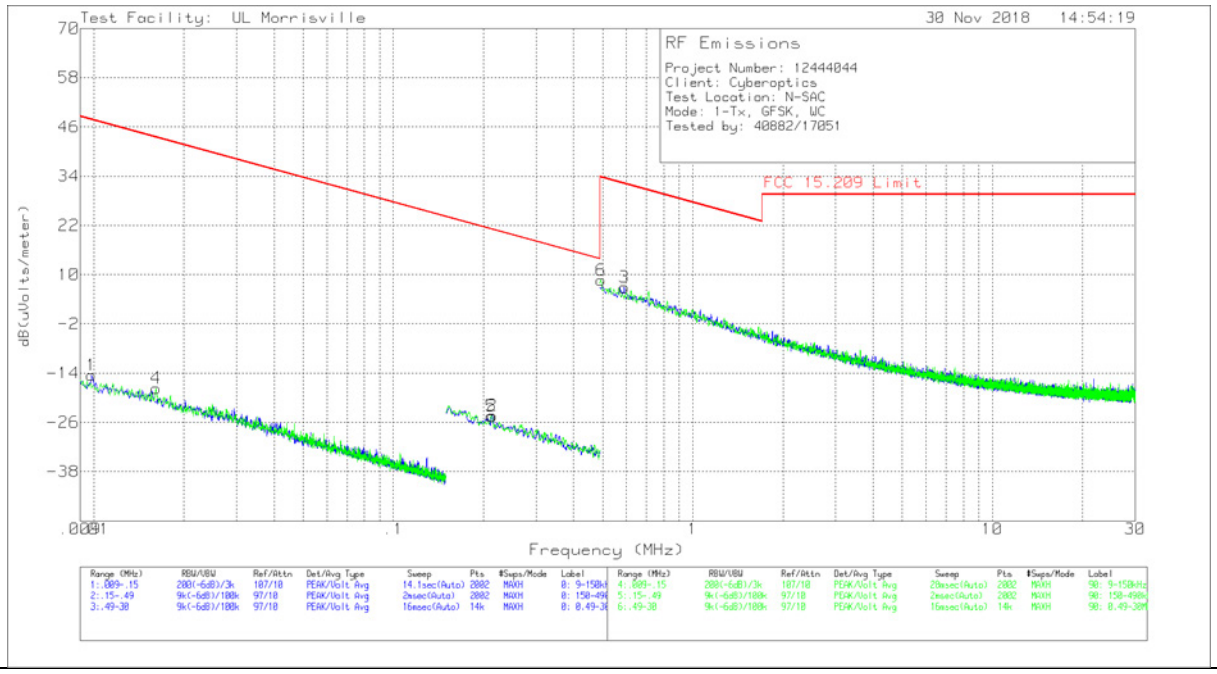
9.2. Worst Case Below 1 GHz

Note: All measurements were made at a test distance of 3 m. The spurious emissions data in the plots and tabular data are corrected from the measurement distance (3m) to the specification distance (300 m from 9-490 kHz and 30 m from 490 kHz – 30 MHz). The correction factor for the limits were 40*Log (test distance / specification distance).

Although these tests were performed at a test site other than an open area test site, adequate comparison measurements were confirmed against an open area test site. Therefore sufficient tests were made to demonstrate that the alternative site produces results that correlate with the ones of tests made in an open field based on KDB 414788.

SPURIOUS EMISSIONS 0.009 to 30 MHz (WORST-CASE CONFIGURATION) – APS3



0.009 to 30MHz Data

Marker	Frequency (MHz)	Meter Reading (dBuV)	Det	AT0079 AF (dB/m)	Cbl (dB)	Dist. Corr. Factor (dB)	Corrected Reading dB(uV/m)	FCC 15.209 QP Limit	FCC 15.209 AV Limit	FCC 15.209 PK Limit	Worst-Case Margin (dB)	Azimuth (Degs)
1	.00984	46.58	Pk	18.8	.1	-80	-14.52	-	47.74	67.74	-62.26	0-360
4	.01614	46.12	Pk	16.1	.1	-80	-17.68	-	43.45	63.45	-61.13	0-360
5	.21265	43.94	Pk	11.5	.1	-80	-24.46	-	21.05	41.05	-45.51	0-360
2	.21384	44.03	Pk	11.5	.1	-80	-24.37	-	21	41	-45.37	0-360
6	.49316	37.01	Pk	11.5	.1	-40	8.61	33.74	-	-	-25.13	0-360
3	.59118	35.29	Pk	11.5	.1	-40	6.89	32.17	-	-	-25.28	0-360

Pk - Peak detector

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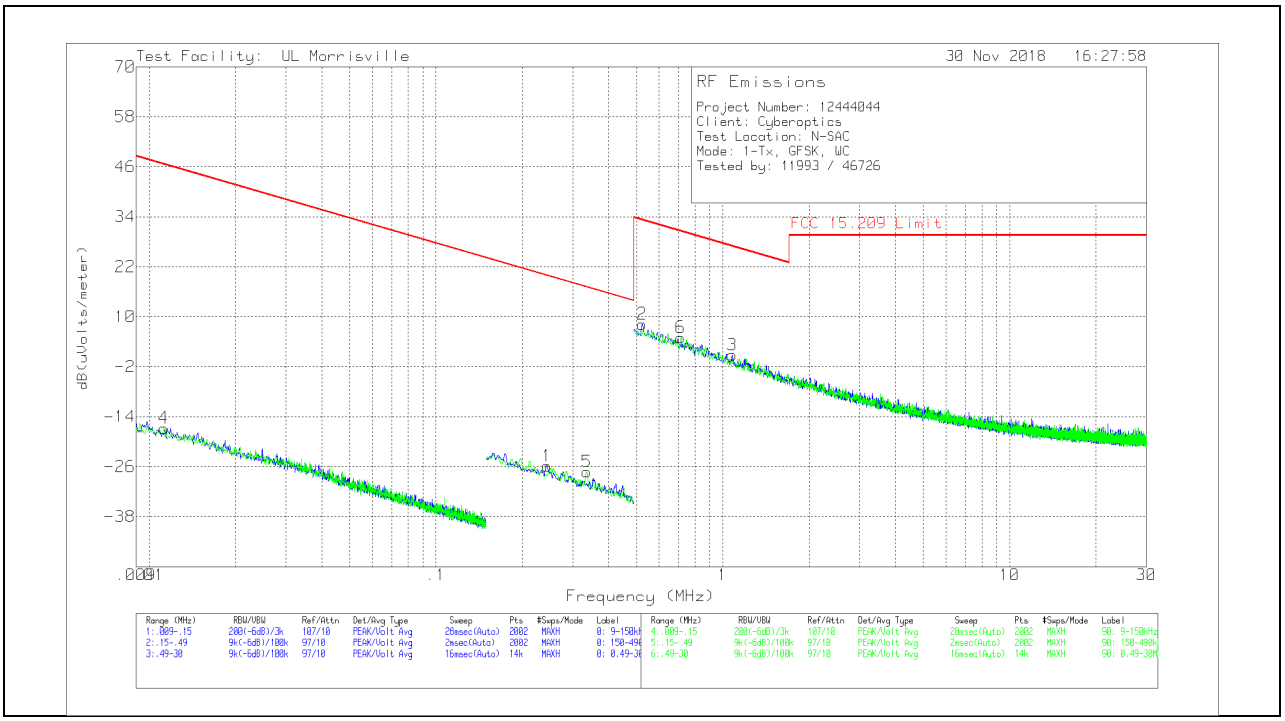
SPURIOUS EMISSIONS 0.009 to 30 MHz (WORST-CASE CONFIGURATION) – APS-FPD



0.009 to 30MHz Data

Marker	Frequency (MHz)	Meter Reading (dBuV)	Det	AT0079 AF (dB/m)	Cbl (dB)	Dist. Corr. Factor (dB)	Corrected Reading dB(uV/m)	FCC 15.209 QP Limit	FCC 15.209 AV Limit	FCC 15.209 PK Limit	Worst-Case Margin (dB)	Azimuth (Degs)
4	.01124	44.92	Pk	18.2	.1	-80	-16.78	-	46.59	66.59	-63.37	0-360
1	.24418	42.55	Pk	11.5	.1	-80	-25.85	-	19.85	39.85	-45.7	0-360
5	.33522	41.13	Pk	11.5	.1	-80	-27.27	-	17.1	37.1	-44.37	0-360
2	.52373	36.6	Pk	11.5	.1	-40	8.2	33.22	-	-	-25.02	0-360
6	.71345	33.4	Pk	11.5	.1	-40	5	30.54	-	-	-25.54	0-360
3	1.07813	29.12	Pk	11.5	.2	-40	.82	26.95	-	-	-26.13	0-360

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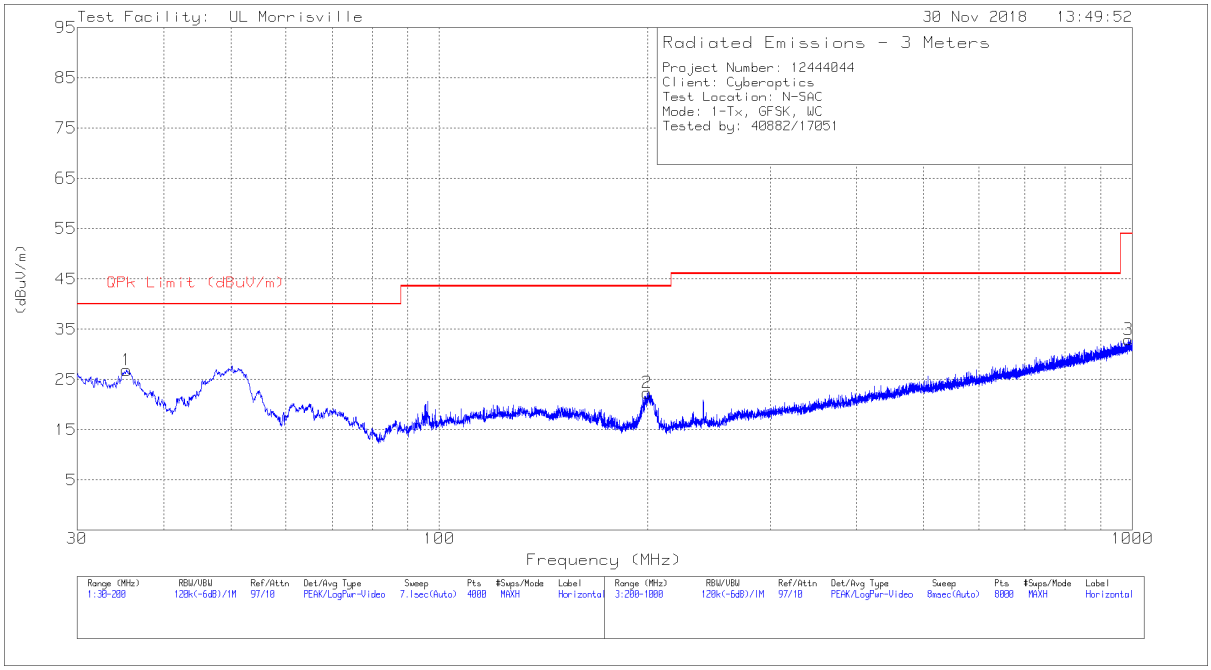
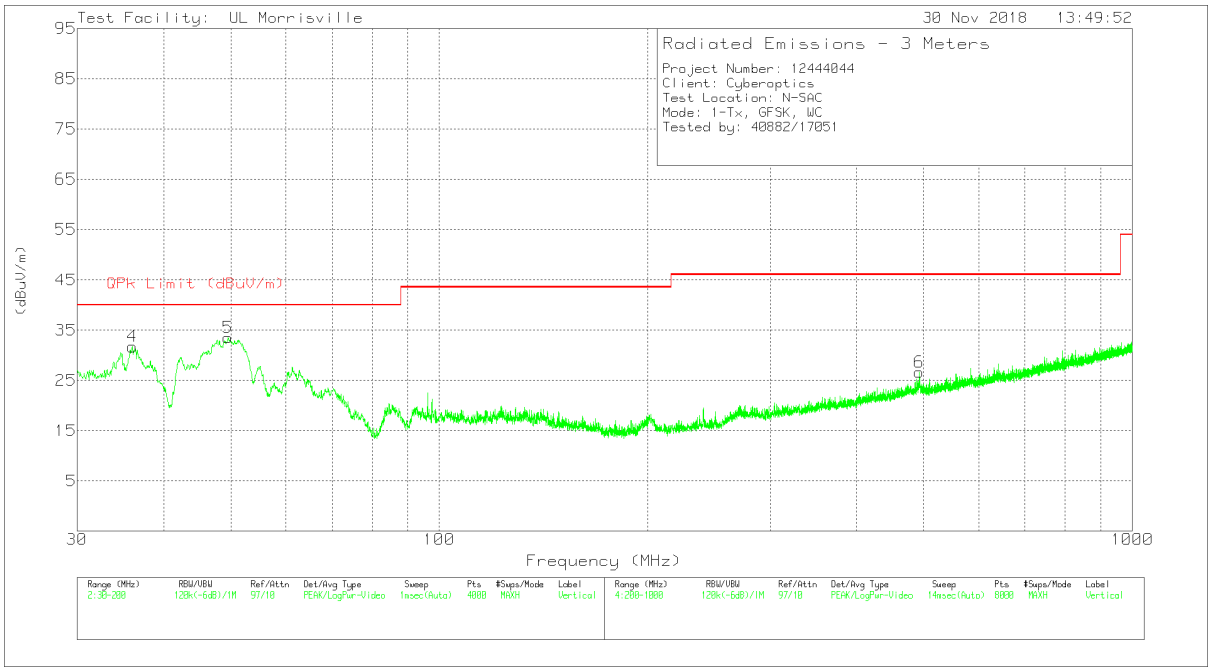
SPURIOUS EMISSIONS 30 TO 1000 MHz (WORST-CASE CONFIGURATION) – APS3



HORIZONTAL



VERTICAL

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30 to 1000MHz Data

Marker	Frequency (MHz)	Meter Reading (dBuV)	Det	AT0073 ACF (dB/m)	Amp/Cbl (dB)	Corrected Reading (dBuV/m)	QPk Limit (dBuV/m)	Margin (dB)	Azimuth (Degs)	Height (cm)	Polarity
1	35.3564	34.55	Pk	24	-31.7	26.85	40	-13.15	0-360	102	H
4	36.0366	39.93	Pk	23.5	-31.7	31.73	40	-8.27	0-360	102	V
5	49.5551	50.31	Pk	14.7	-31.5	33.51	40	-6.49	0-360	102	V
2	199.2788	33.15	Pk	19.4	-30.2	22.35	43.52	-21.17	0-360	102	H
6	492.9381	31.16	Pk	24.1	-28.6	26.66	46.02	-19.36	0-360	102	V
3	987.7024	28.33	Pk	29.8	-25.2	32.93	53.97	-21.04	0-360	102	H

Pk - Peak detector

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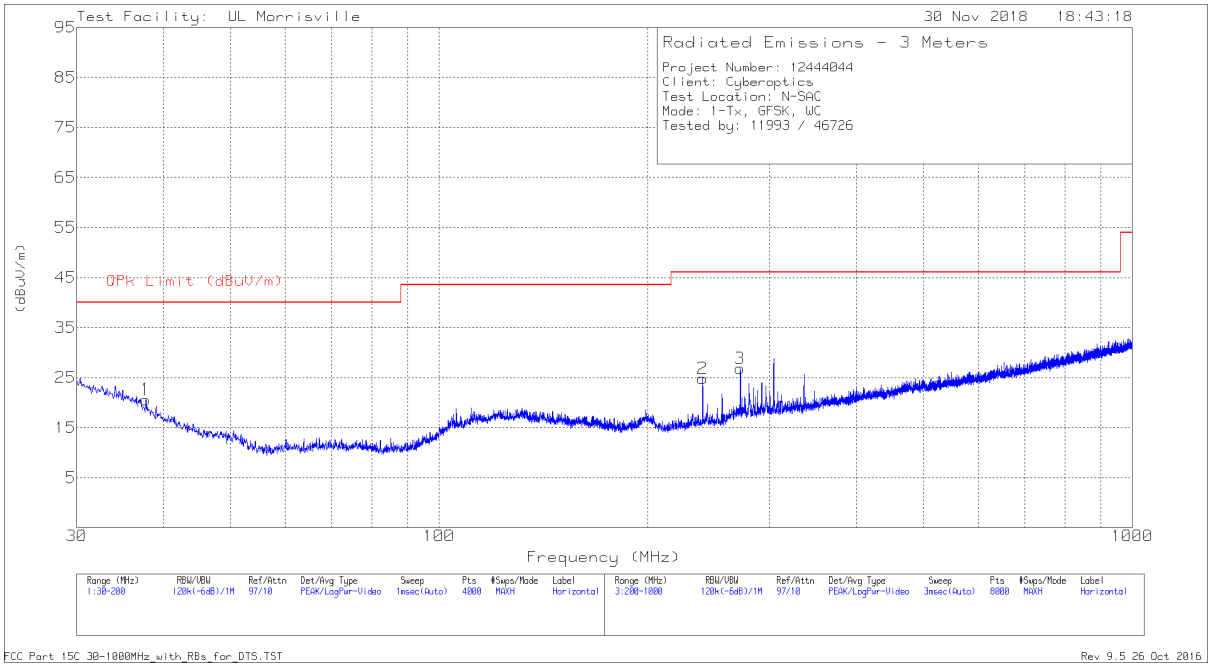
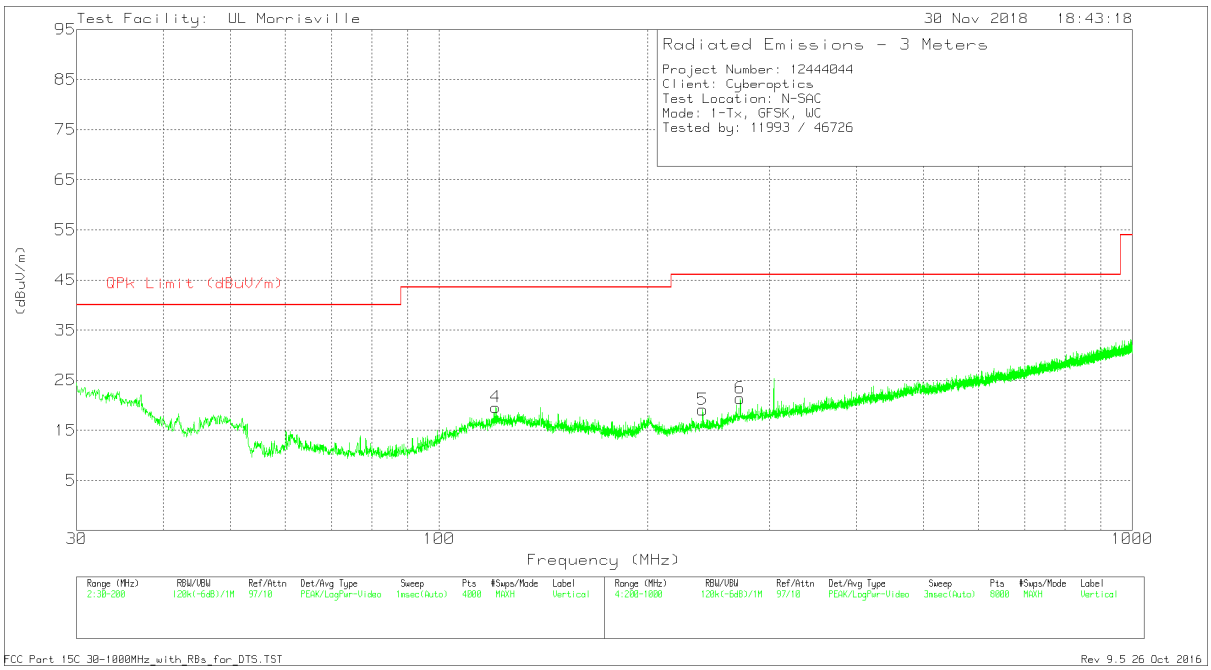
SPURIOUS EMISSIONS 30 TO 1000 MHz (WORST-CASE CONFIGURATION) – APS-FPD



HORIZONTAL



VERTICAL

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30 to 1000MHz Data

Marker	Frequency (MHz)	Meter Reading (dBuV)	Det	AT0073 ACF (dB/m)	Amp/Cbl (dB)	Corrected Reading (dBuV/m)	QPk Limit (dBuV/m)	Margin (dB)	Azimuth (Degs)	Height (cm)	Polarity
1	* ** 37.7583	30.1	Pk	22.2	-31.7	20.6	40	-19.4	0-360	399	H
4	* ** 120.761	30.42	Pk	20	-30.8	19.62	43.52	-23.9	0-360	102	V
2	* ** 240.0052	36.52	Pk	18.2	-29.9	24.82	46.02	-21.2	0-360	199	H
3	* ** 272.0094	36.6	Pk	19.8	-29.6	26.8	46.02	-19.22	0-360	102	H
5	* ** 240.0052	30.83	Pk	18.2	-29.9	19.13	46.02	-26.89	0-360	199	V
6	* ** 272.0094	31.18	Pk	19.8	-29.6	21.38	46.02	-24.64	0-360	102	V

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

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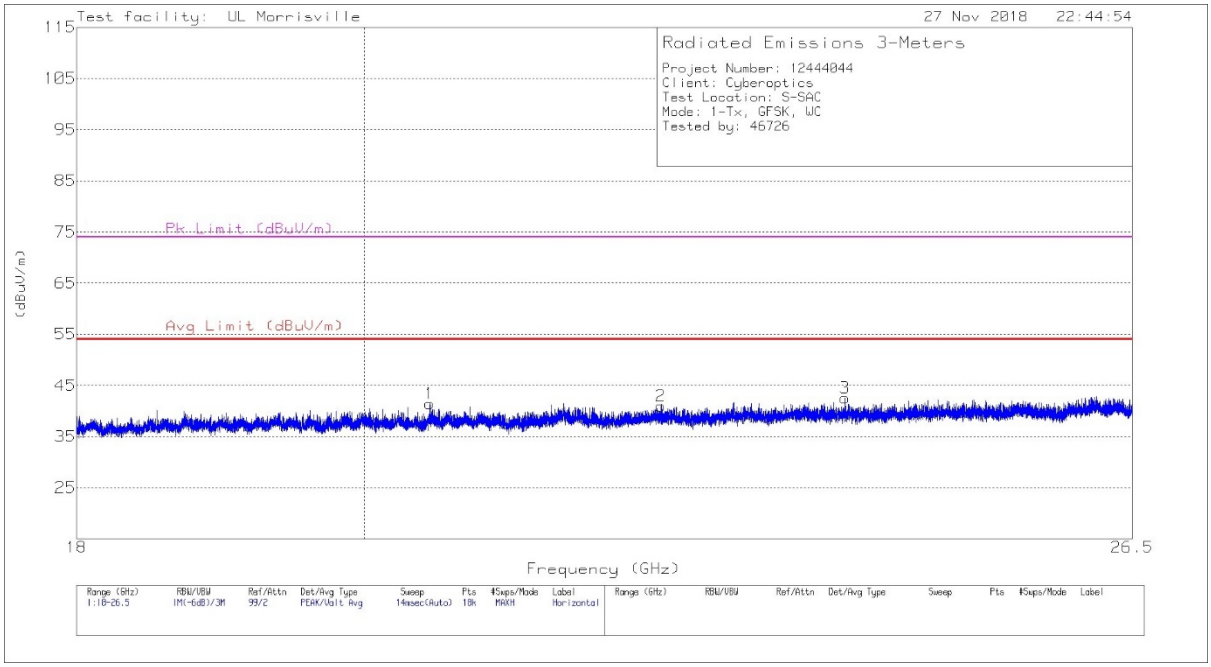
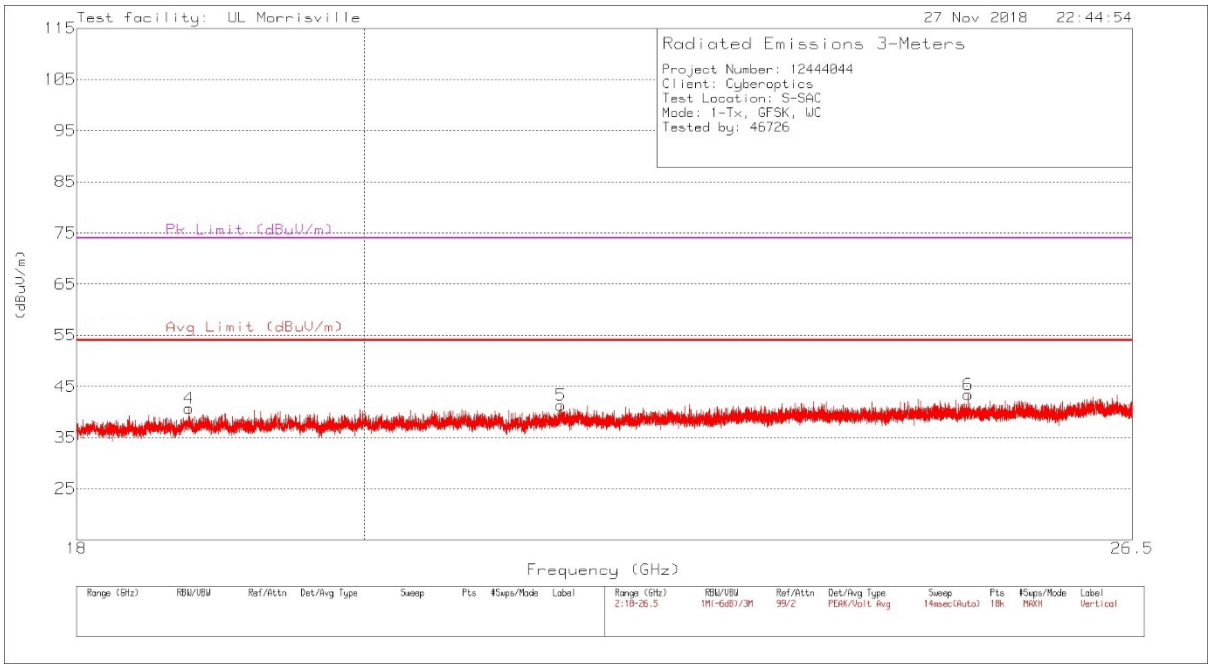
9.3. Worst Case 18-26 GHz

SPURIOUS EMISSIONS 18-26 GHz (WORST-CASE CONFIGURATION) – APS3



HORIZONTAL



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18 – 26GHz DATA

Marker	Frequency (GHz)	Meter Reading (dBuV)	Det	AT0076 AF (dB/m)	Cbl/Amp (dB)	Corrected Reading (dBuV/m)	Class B Avg Limit (dBuV/m)	Margin (dB)	Class B Pk Limit (dBuV/m)	Margin (dB)	Azimuth (Degs)	Height (cm)	Polarity
4	18.756	47.08	Pk	32.5	-38.9	40.68	54	-13.32	74	-33.32	0-360	151	V
1	20.487	46.33	Pk	33.2	-38.1	41.43	54	-12.57	74	-32.57	0-360	299	H
5	21.497	46.21	Pk	33.4	-38.3	41.31	54	-12.69	74	-32.69	0-360	101	V
2	22.296	45.64	Pk	33.4	-38.1	40.94	54	-13.06	74	-33.06	0-360	249	H
3	23.855	45.85	Pk	34	-37.3	42.55	54	-11.45	74	-31.45	0-360	102	H
6	24.954	45.74	Pk	34.4	-36.7	43.44	54	-10.56	74	-30.56	0-360	299	V

Pk - Peak detector

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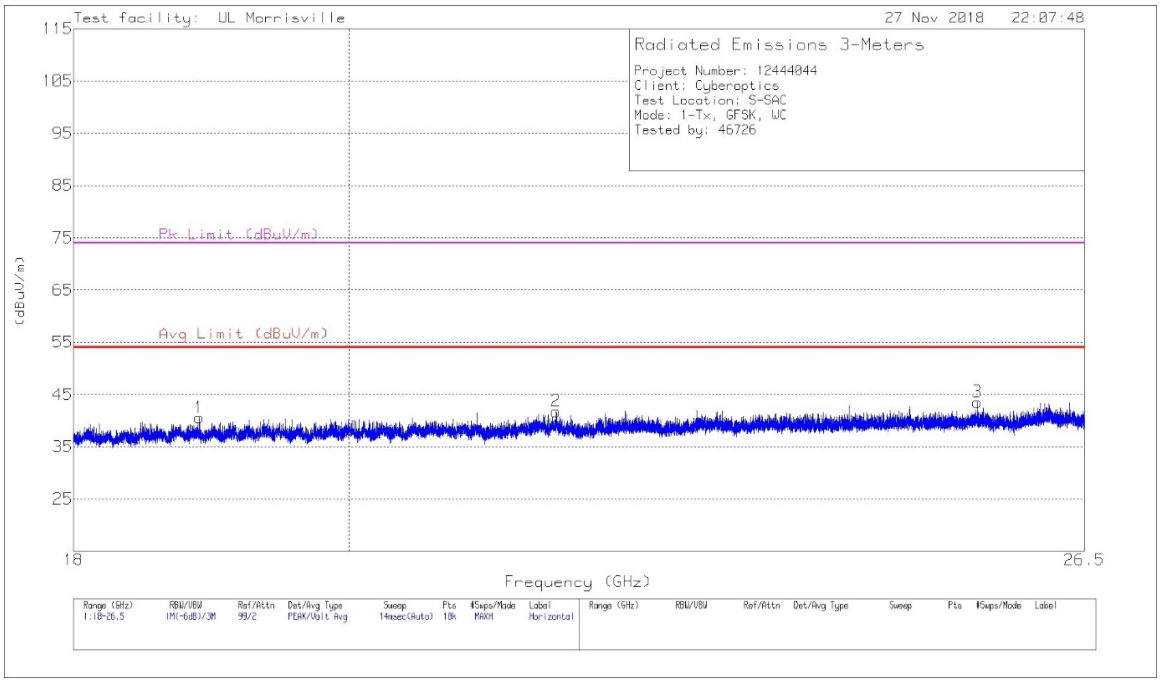
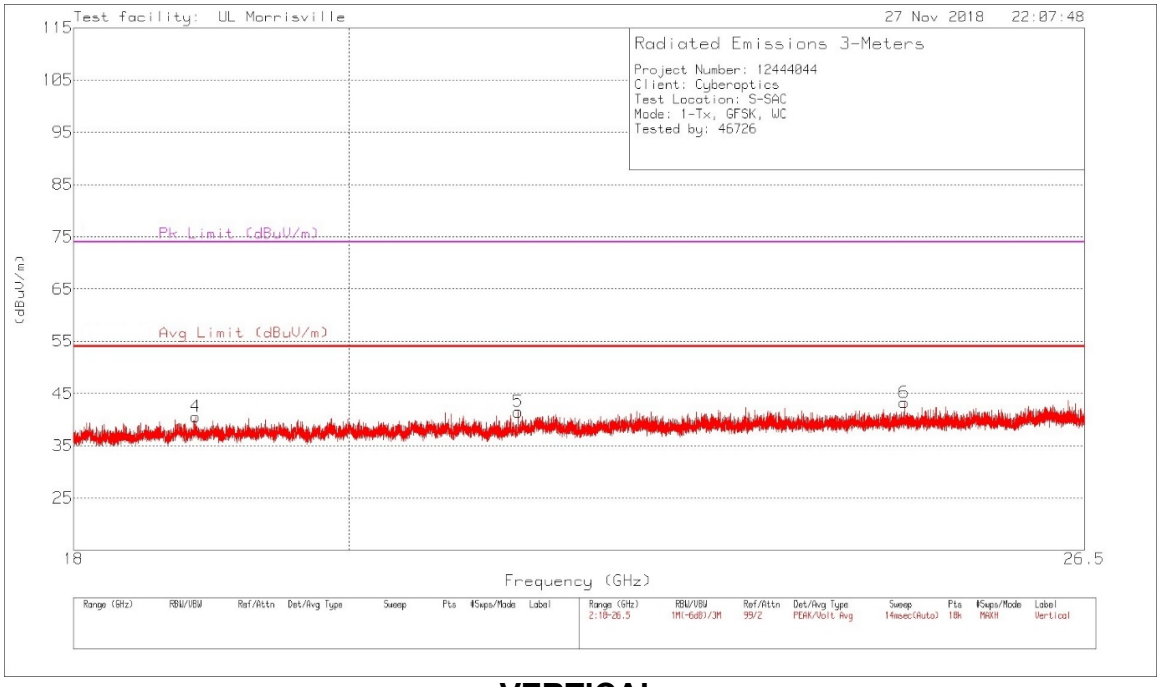
SPURIOUS EMISSIONS 18-26 GHz (WORST-CASE CONFIGURATION) - APS-FPD



HORIZONTAL



VERTICAL

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18 – 26GHz DATA

Marker	Frequency (GHz)	Meter Reading (dBuV)	Det	AT0076 AF (dB/m)	Cbl/Amp (dB)	Corrected Reading (dBuV/m)	Class B Avg Limit (dBuV/m)	Margin (dB)	Class B Pk Limit (dBuV/m)	Margin (dB)	Azimuth (Degs)	Height (cm)	Polarity
4	18.859	46.75	Pk	32.6	-38.8	40.55	54	-13.45	74	-33.45	0-360	101	V
1	18.887	46.77	Pk	32.7	-38.9	40.57	54	-13.43	74	-33.43	0-360	299	H
5	21.339	46.72	Pk	33.1	-38.3	41.52	54	-12.48	74	-32.48	0-360	300	V
2	21.65	46.47	Pk	33.3	-38	41.77	54	-12.23	74	-32.23	0-360	249	H
6	24.734	45.81	Pk	34.3	-36.8	43.31	54	-10.69	74	-30.69	0-360	251	V
3	25.434	45.57	Pk	34.4	-36.4	43.57	54	-10.43	74	-30.43	0-360	249	H

Pk - Peak detector

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10. SETUP PHOTOS

Please refer to R12444044-EP5 for setup photos

END OF REPORT

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