FCC 47 CFR PART 15 SUBPART C

CERTIFICATION TEST REPORT

FOR

60 GHz WIRELESS BACKHAUL MESH NODE RADIO

MODEL NUMBER: FBC-1601

FCC ID: 2AK7S-FBC1601

REPORT NUMBER: 11787578-E1V3

ISSUE DATE: August 29, 2017

Prepared for
FCL TECH, INC.
1601 WILLOW ROAD,
MENLO PARK, CA 94025

Prepared by
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NVLAP LAB CODE 200065-0

Revision History

Rev.	Issue Date	Revisions	Revised By
V1	07/05/2017	Initial Issue	M. Heckrotte
V2	08/24/2017	Added statement regarding horn antennas in section 7. Revised FCC Rule citations in sections 8.3, 8.5, 8.8 and 9.	M. Heckrotte
V3	08/29/2017	Clarified procedures in sections 8.2 and 8.5.	M. Heckrotte

TABLE OF CONTENTS

1. ATTESTATION OF TEST RESULTS

COMPANY NAME: FCL TECH, INC.
1601 WILLOW ROAD
MENLO PARK, CA 94025

EUT DESCRIPTION: 60GHz WIRELESS BACKHAUL RADIO

MODEL: FBC-1601

SERIAL NUMBER: TG100P03021700025

DATE TESTED: MAY 19 – 25, 2017

APPLICABLE STANDARDS	
STANDARD	**TEST RESULTS**
CFR 47 Part 15 Subpart C	Complies

UL Verification Services Inc. tested the above equipment in accordance with the requirements set forth in the above standards. All indications of Pass/Fail in this report are opinions expressed by UL Verification Services Inc. based on interpretations and/or observations of test results. Measurement Uncertainties were not taken into account and are published for informational purposes only. The test results show that the equipment tested is capable of demonstrating compliance with the requirements as documented in this report.

Note: The results documented in this report apply only to the tested sample, under the conditions and modes of operation as described herein. This document may not be altered or revised in any way unless done so by UL Verification Services Inc. and all revisions are duly noted in the revisions section. Any alteration of this document not carried out by UL Verification Services Inc. will constitute fraud and shall nullify the document. This report must not be used by the client to claim product certification, approval, or endorsement by NVLAP, NIST, any agency of the Federal Government, or any agency of any government.

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Tested By:

GIA-PIAO CHIN
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2. TEST METHODOLOGY

The tests documented in this report were performed in accordance with ANSI C63.10-2013, FCC CFR 47 Part 15 Subpart C and KDB 447498 D01 General RF Exposure Guidance v06.

3. SCOPE OF REPORT

This report covers the 60 GHz radio.

This report also includes an RF Exposure evaluation for simultaneous transmission operations of two 60 GHz radios and an embedded Bluetooth radio, FCC ID: 2AK7S-FBC1701.

4. FACILITIES AND ACCREDITATION

The test sites and measurement facilities used to collect data are located at 47173 Benicia Street, Fremont, California, USA.

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

47173 Benicia Street	47266 Benicia Street
☐ Chamber A	☐ Chamber D
☒ Chamber B	☐ Chamber E
☐ Chamber C	☐ Chamber F
	☐ Chamber G
	☐ Chamber H

UL Verification Services Inc. is accredited by NVLAP, Laboratory Code 200065-0. The full scope of accreditation can be viewed at http://ts.nist.gov/standards/scopes/2000650.htm.

5. CALIBRATION AND UNCERTAINTY

5.1. 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.

5.2. MEASUREMENT UNCERTAINTY

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

PARAMETER	UNCERTAINTY
Conducted Disturbance, 0.15 to 30 MHz	±3.52 dB
Radiated Disturbance, 30 to 1000 MHz	±4.94 dB
Radiated Disturbance, 1 to 6 GHz	±3.86 dB
Radiated Disturbance, 6 to 18 GHz	±4.23 dB
Radiated Disturbance, 18 to 26 GHz	±5.30 dB
Radiated Disturbance, 26 to 40 GHz	±3.23 dB
Radiated Disturbance, 40 GHz above	±3.50dB

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

6. EQUIPMENT UNDER TEST

6.1. MANUFACTURER'S DESCRIPTION OF EUT

The EUT is a point-to-point outdoor backhaul mesh node radio system, operating within the 57 to 64 GHz band, intended for deployment in a dense urban environment.

The EUT is powered by an external power supply with nominal voltage of 54 VDC.

Model FBC-1601 has two configurations, Primary and Secondary. The RF assembly is identical in each configuration. The Primary, model FBC-1601 (T100P), utilizes a fully populated digital board. The Secondary, model FBC-1601 (T100S), utilizes the same digital board depopulated with fewer I/O ports.

Multiple (up to 4) radios may be installed at a single location, oriented to serve different 90-degree sectors. The main beam from each transmitter is steered within that transmitter's sector as required to service that sector. It is possible for beams from two adjacent 60 GHz transmitters to overlap at or near the boundaries of adjacent sectors. Such overlapping beams are not correlated as the two transmitters are not phase-locked.

A Bluetooth LE 4.0 radio module (FCC ID: 2AK7S-FBC1701) is embedded in the system, and is simultaneously transmitting with the 60 GHz radio(s).

6.2. OUTPUT POWER

The dual phased-array antennas are integral. Two operating configurations are available: single array of antenna and dual array of antenna. Output Power is measured in the worst-case mode for each operating configuration, at the highest power setting (power index) for each configuration.

The highest conducted RF output power occurs on Channel 3 in the single array of antenna configuration.

Antenna Config.	Channel	Frequency (GHz)	Power Index	Peak Output Power (dBm)	Peak Output Power (mW)
One	1	58.32	14 6	9.61	9.14
One	2	60.48	14 6	8.92	7.80
One	3	62.64	14 6	9.73	9.40
Two	1	58.32	18 6	6.11	4.08
Two	2	60.48	18 6	4.72	2.97
Two	3	62.64	18 6	6.23	4.19

6.3. DESCRIPTION OF AVAILABLE ANTENNAS

Two 8 x 36 phased-array antennas, each with gain of 32 dBi, are available, yielding a maximum total gain of 35 dBi for the dual array of antenna configuration.

6.4. SOFTWARE AND FIRMWARE

The firmware installed in the EUT during testing was FW203/bcm20130a0_mi_001.001.203_rf/linus/scripts.

The test utility software used during testing was Pkteng.

Individual power-controlled script is used for testing of each channel. Therefore, total of six power-controlled scripts, three for each antenna configuration, are available.

6.5. DESCRIPTION OF TEST SETUP

SUPPORT EQUIPMENT

PERIPHERAL SUPPORT EQUIPMENT LIST			
Description	**Manufacturer**	**Model**	**Serial Number**
Laptop	Lenovo	T440s	SL10G10663JS
Laptop Power Supply	Lenovo	ADLX90NCC2A	11S45N0251Z1ZS9C515BSV
Power Supply	Mean Well	HEP-185-48A	RB5A058787

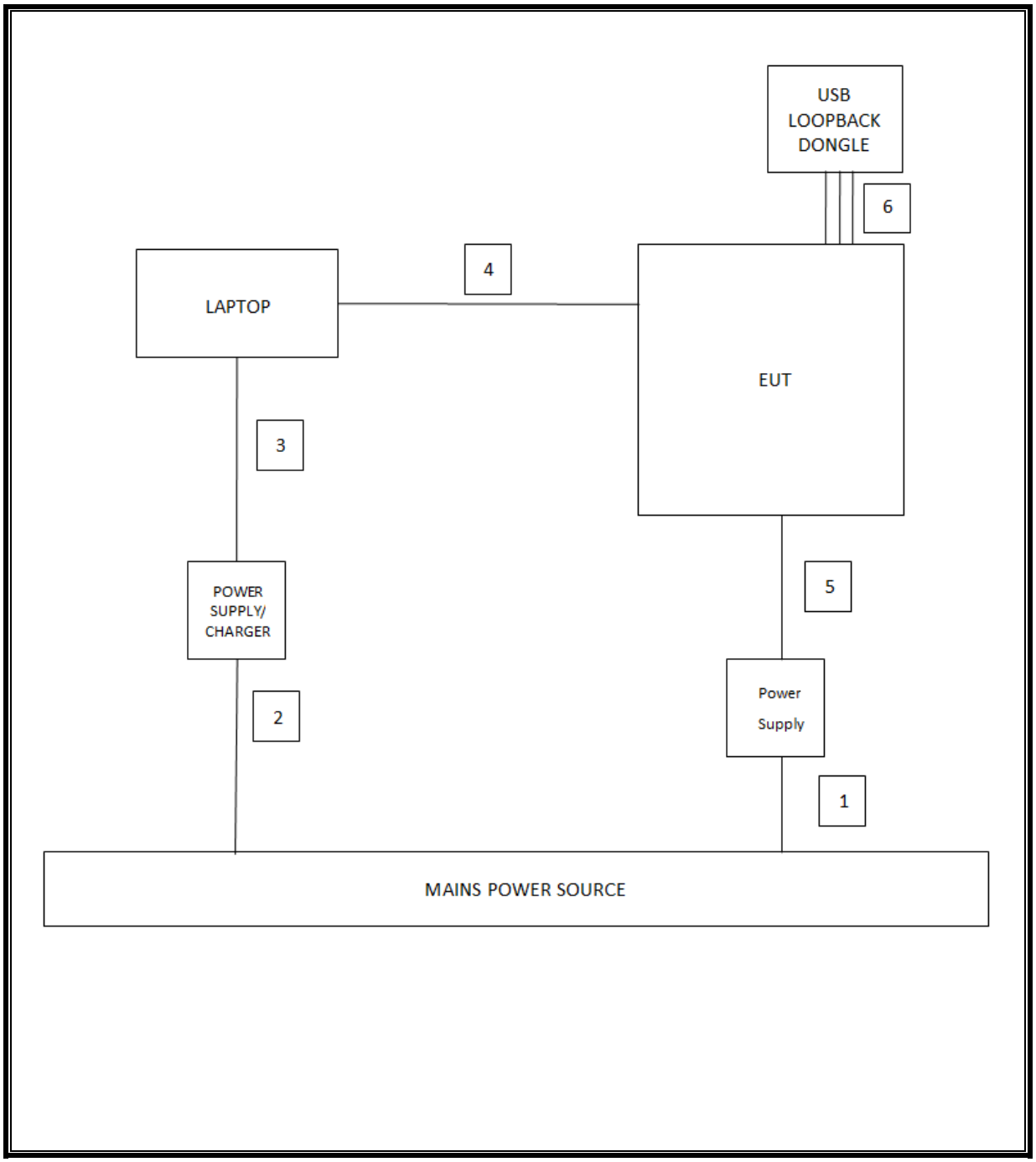
I/O CABLES

I/O Cable List						
Cable No	**Port**	**# of identical ports**	**Connector Type**	**Cable Type**	**Cable Length (m)**	**Remarks**
1	AC	1	3-Prong	Unshielded	1.1	AC Main
2	AC	1	3-Prong	Unshielded	0.9	Laptop Main
3	DC	1	Slim Tip	Unshielded	1.83	Laptop DC
4	Ethernet	1	RJ45	Unsheilded	2.1	Laptop - EUT
5	DC	1	Push-In	Unshielded	0.4	DC Input
6	USB	3	USB	Loopback Dongle	N/A	Loopback dongle plugged in at USB ports

TEST SETUP

A support Laptop was connected to the EUT for programming the test mode and is not part of the test setup. The support equipment Laptop was connected to the charger during testing.

SETUP DIAGRAM FOR TESTS



7. TEST AND MEASUREMENT EQUIPMENT

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

Test Equipment List					
Description	**Manufacturer**	**Model**	**S/N**	**Local ID (T No.)**	**Cal Due**
PXA Signal Analyzer	Agilent	N9030A	MY52350427	313	8/31/2017
Horn antenna, 33-50 GHz	CMI	HO22R	--	--	CNR
LNA, 40-50 GHz	Spacek Labs	SL4510-33-4W	14J05	1099	10/10/2017
Horn Antenna, 50-75 GHz	CMI	HO15R	--	--	CNR
LNA, 50-75 GHz	Vivatech	VTLNA-15-6018-FB	2013051	--	5/30/2017
Harmonic Mixer, 50-80 GHz	Keysight	M1970V	MY51390830	994	8/18/2017
Horn Antenna, 75-110 GHz	CMI	HO10R	--	--	CNR
LNA, 75-110 GHz	Spacek	SLW-22-5	15J04	1600079	7/1/2017
Harmonic Mixer, 75-110 GHz	Keysight	M1970W	MY51430784	993	8/12/2017
Horn Antenna, 110-170 GHz	CMI	HO6R	--	--	CNR
LNA, 110-170 GHz	Vivatech	VTLNA-06S01	2015085	--	7/1/2017
Harmonic Mixer, 110-170 GHz	OML	M06HWDXA	F90519-2	150918-1	8/31/2017
Horn Antenna, 170-260 GHz	CMI	HO4R	--	--	CNR
Harmonic Mixer, 170-260 GHz	OML	M04HWDXA	150918-1	--	8/31/2017
Digital Signal Analyzer, 8 GHz	Agilent	DSA90804A	MY51420139	215	9/6/2017
Low Pass Filter, 10 MHz	Solar Electric Co.	6623-10	136101	417	10/7/2017
P-Series Power Meter	Keysight	N1911A	MY55196013	1262	7/8/2017
Power Sensor, 50-75 GHz	Agilent	V8486-CFG002-H01	MY44420424	234	9/2/2017
RF Detector, 50-75 GHz	Spacek Labs	DV-2P	17A27	--	CNR
Analog Signal Generator, 40 GHz	Agilent	E8257D	MY48050681	181	8/19/2017
Horn Antenna, 18-26.5GHz	ARA	MWH-1826/B	2093387	449	5/26/2017
Spectrum Analyzer, 40GHz	Agilent	8564E	3943A01643	106	9/7/2017
Preamplifier, 1-26.5GHz	Agilent	8449B	3008A04710	404	7/5/2017
Horn Antenna, 26-40 GHz	ARA	MWH-2640/B	--	446	5/26/2017
Preamplifier, 26-40 GHz	Miteq	NSP4000-SP2	924343	88	4/29/2018
PXA Signal Analyzer	Agilent	N9030A	MY53311010	905	1/11/2018
PXA Signal Analyzer	Agilent	N9030A	MY53310593	907	1/23/2018
Hybrid Antenna, 30-1000 MHz	Sunol Sciences	JB3	A051314-2	130	9/23/2017
Preamp, 1000 MHz	Sonoma	310N	--	300	11/10/2017
Horn Antenna, 1-18 GHz	ETS Lindgren	3117	--	346	3/28/2017
9KHz-30MHz LISN	FCC	50/250-25-2-01-CISPR16		1310	6/8/2017
EMI Test Receiver	Rohde & Schwarz	ESR		1436	1/6/2018
Chamber, Environmental	Thermotron	SE-600-10-10	29800	80	8/21/2017
True RMS Multimeter	Fluke	77IV	30860448	1747	4/15/2018
Power Supply, AC	Elgar-Ametek	CW2501M	1307A03505	350	CNR
Conducted Software	UL	UL EMC	Ver 9.5, July 22, 2014		
RF PreAmplifier, 1-18 GHz	Miteq	AFS42-00101800-25-S-42	--	493	2/5/2018
Radiated Software	UL	UL EMC	Ver 9.5, April 26, 2016		

All horn antennas at and above the 33-50 GHz band are standard gain horns. In accordance with C63.10 clause 4.4.3 (a) these antennas do not need to be calibrated. UL measures the critical dimensions on an annual basis and checks for damage and deterioration before each test.

8. APPLICABLE LIMITS AND TEST RESULTS

8.1. WORST-CASE MODE

The laboratory performed baseline tests and determined that the worst-case mode is BPSK MCS1. All final tests were performed with the EUT configured to operate in BPSK MCS1.

8.2. DUTY CYCLE

LIMIT

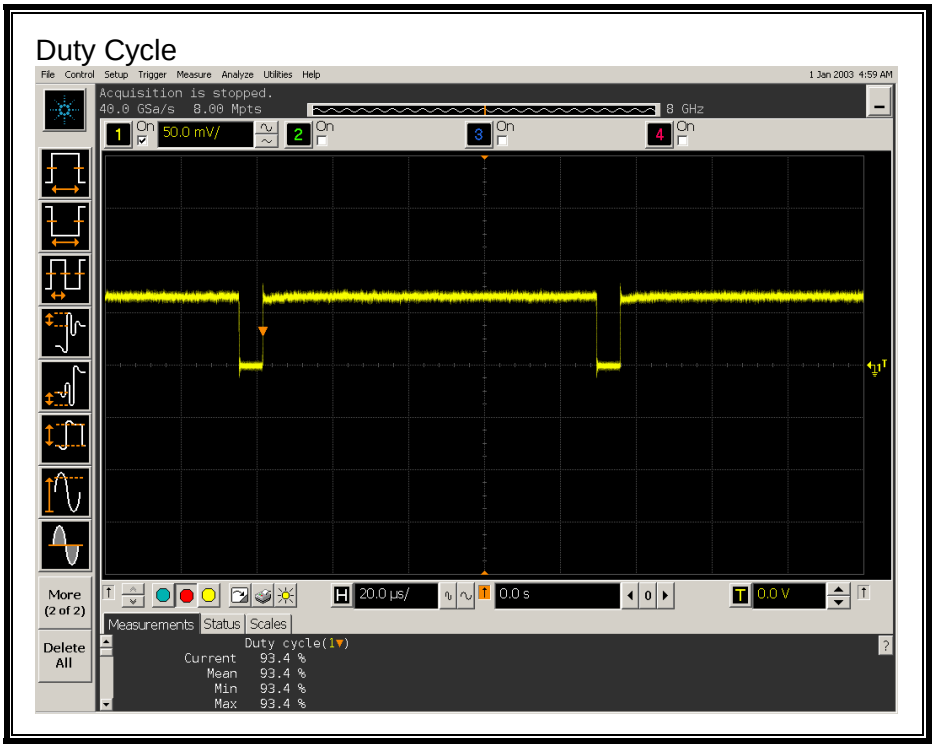
None; for reporting purposes only.

TEST PROCEDURE

An antenna, located approximately 5.1 m from the EUT, was connected to the input of an RF detector, and the output of the detector was connected to an oscilloscope. The internal duty cycle function of the oscilloscope is utilized to measure the duty cycle.

RESULTS

Duty Cycle Correction Factor = 10 * Log (0.934) = 0.30 dB



8.3. 6 dB BANDWIDTH

APPLICABLE RULE

§15.255 (d) (1) For the purposes of this paragraph, emission bandwidth is defined as the instantaneous frequency range occupied by a steady state radiated signal with modulation, outside which the radiated power spectral density never exceeds 6 dB below the maximum radiated power spectral density in the band, as measured with a 100 kHz resolution bandwidth spectrum analyzer. The center frequency must be stationary during the measurement interval, even if not stationary during normal operation (e.g. for frequency hopping devices).

LIMIT

None; for reporting purposes only.

TEST PROCEDURE

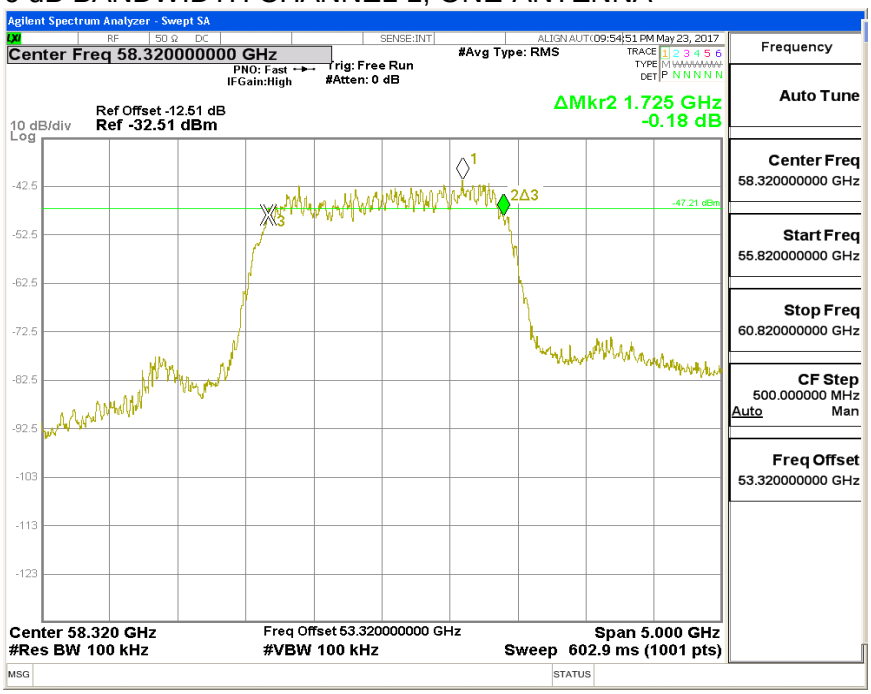
The spectrum analyzer and external mixer are set up to measure the radiated output of the transmitter.

RESULTS

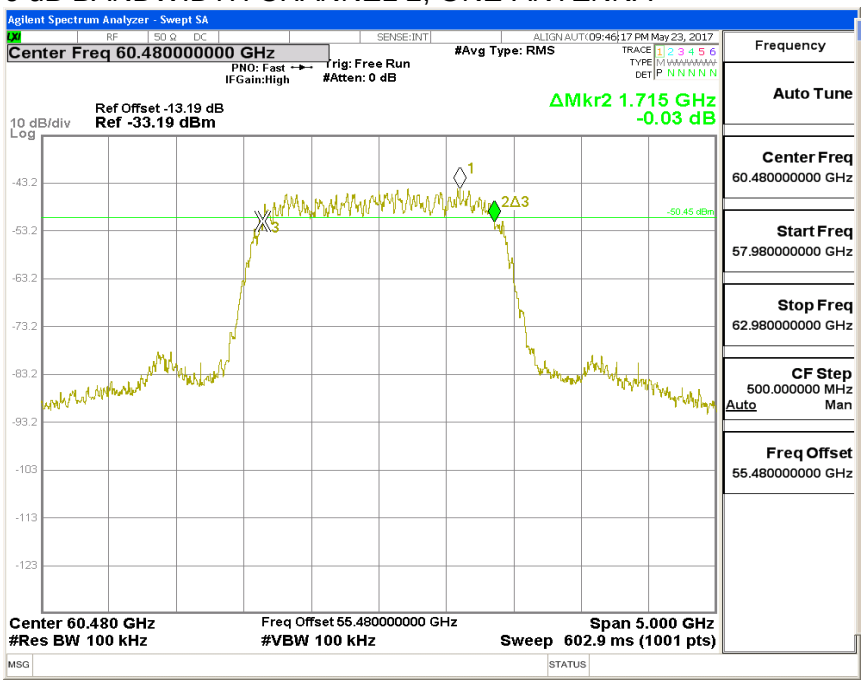
Antenna Config.	Channel	Frequency (GHz)	6 dB Bandwidth (GHz)
One	1	58.32	1.725
One	2	60.48	1.715
One	3	62.64	1.100
Two	1	58.32	1.605
Two	2	60.48	1.695
Two	3	62.64	1.530

6 dB BANDWIDTH, ONE-ANTENNA

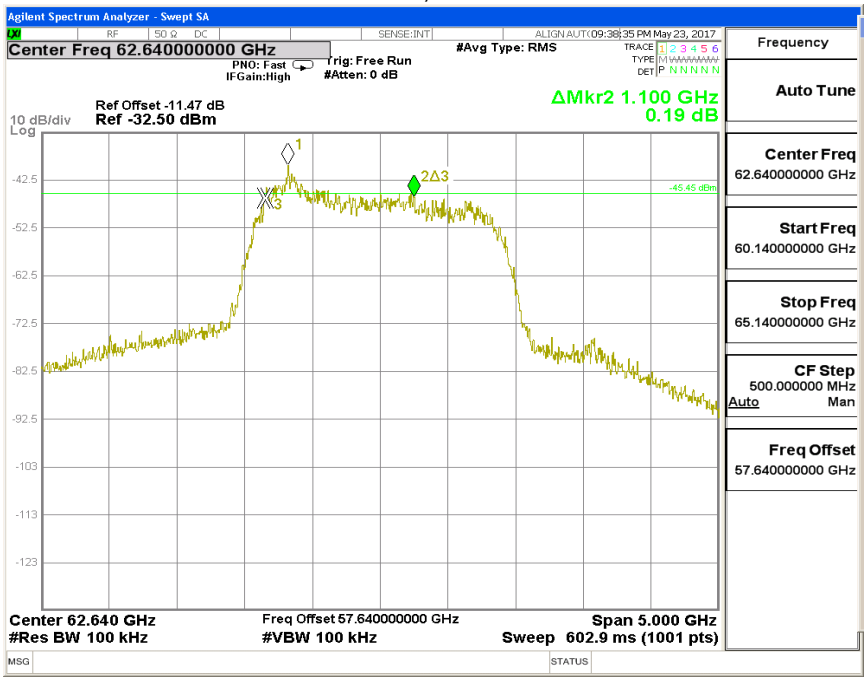
6 dB BANDWIDTH CHANNEL 1, ONE-ANTENNA



6 dB BANDWIDTH CHANNEL 2, ONE-ANTENNA

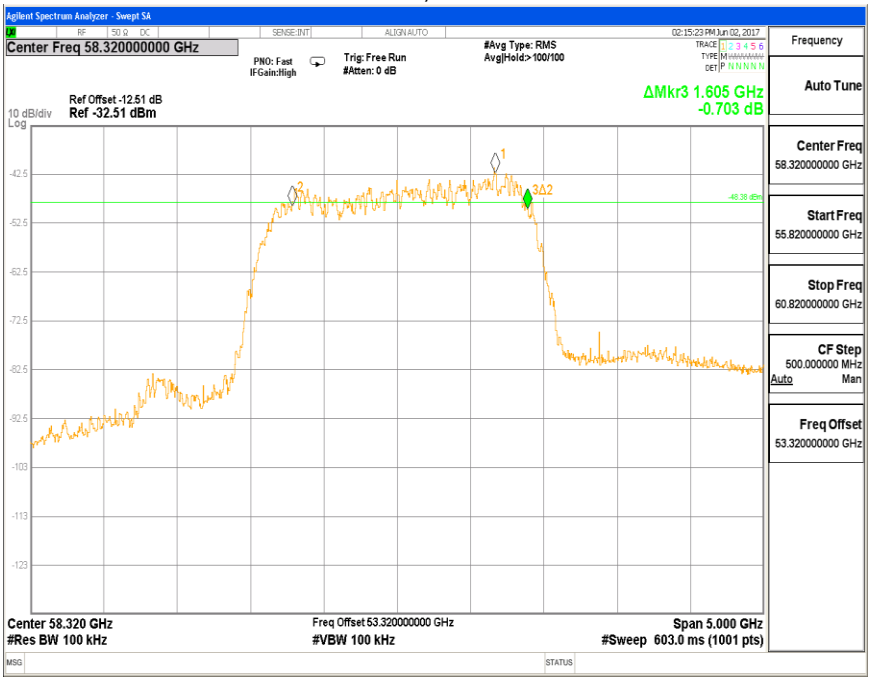


6 dB BANDWIDTH CHANNEL 3, ONE-ANTENNA

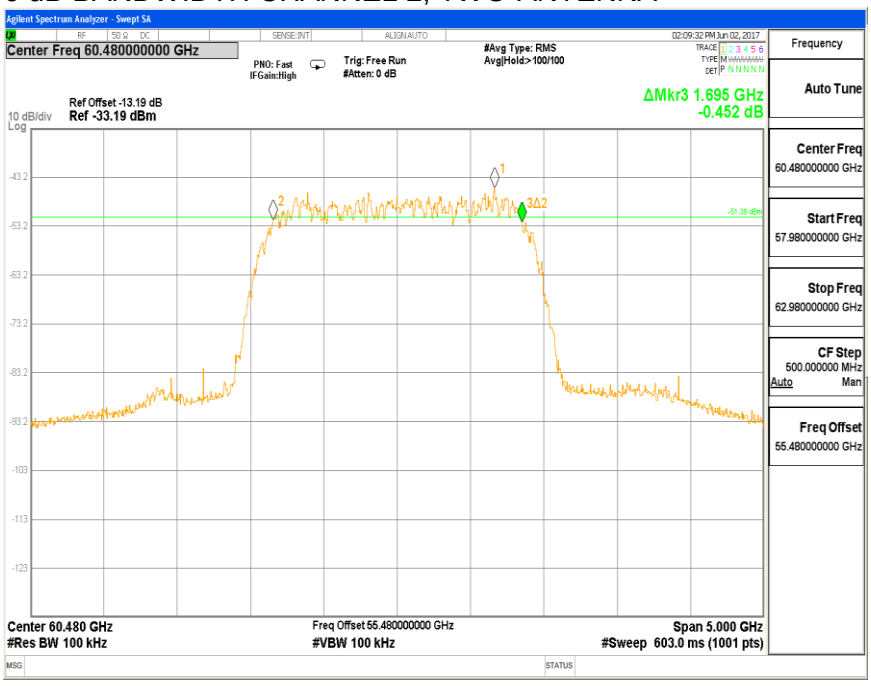


6 dB BANDWIDTH, TWO-ANTENNA

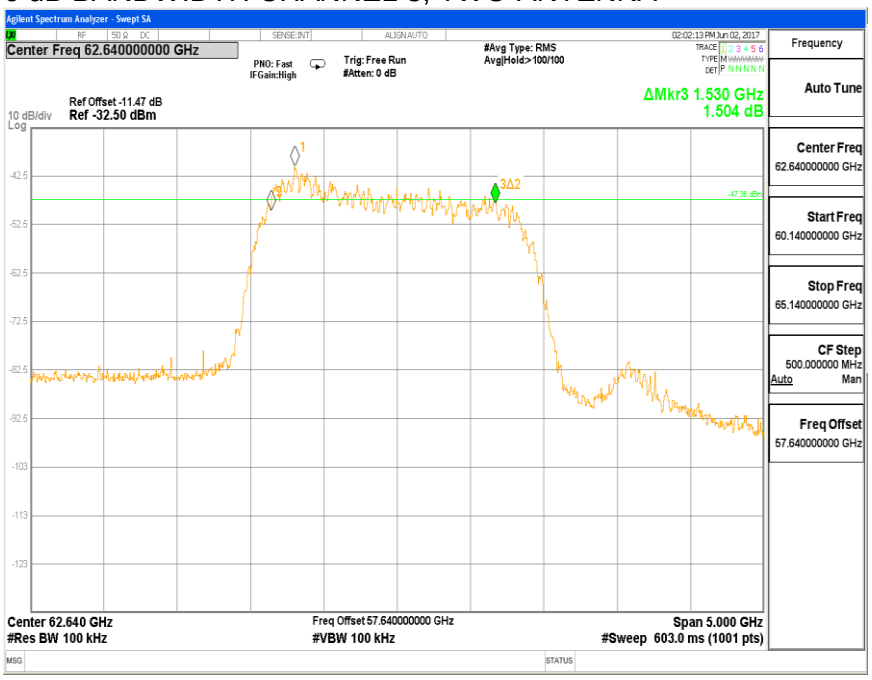
6 dB BANDWIDTH CHANNEL 1, TWO-ANTENNA



6 dB BANDWIDTH CHANNEL 2, TWO-ANTENNA



6 dB BANDWIDTH CHANNEL 3, TWO-ANTENNA



8.4. 99% and 26 dB BANDWIDTH

LIMIT

None; for reporting purposes only.

TEST PROCEDURE

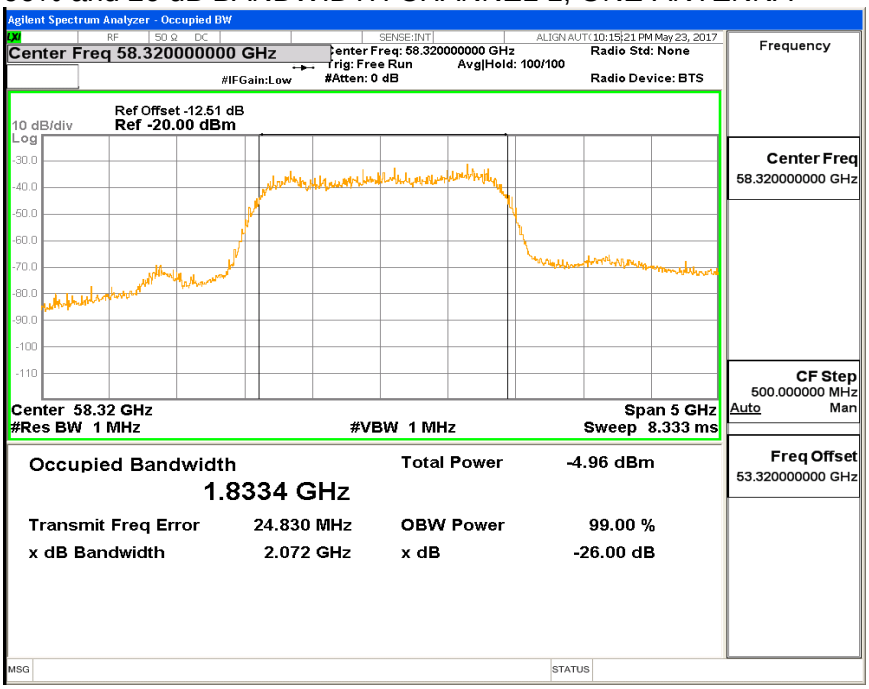
The spectrum analyzer and external mixer are set up to measure the radiated output of the transmitter.

RESULTS

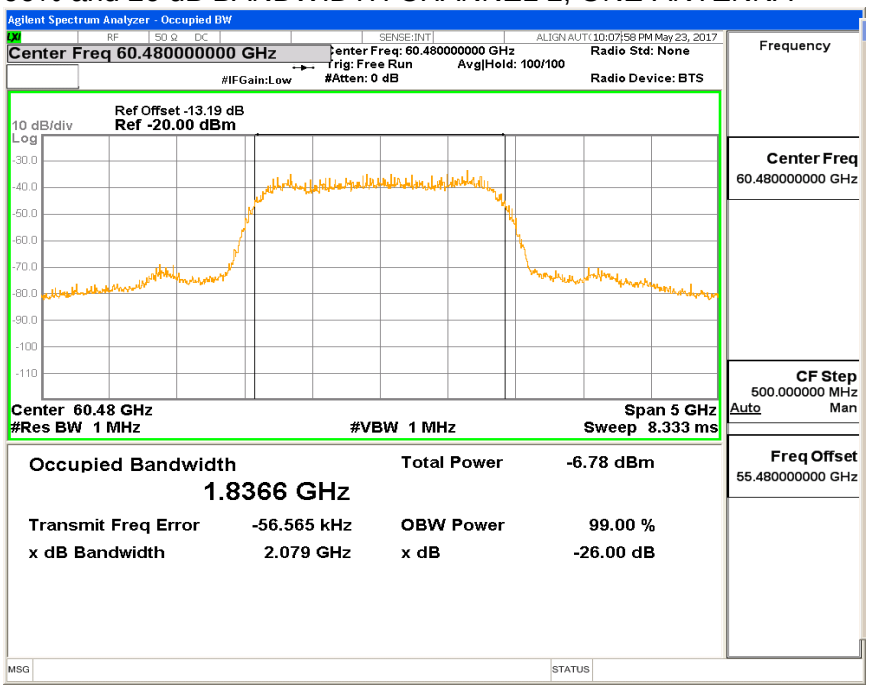
Antenna Config.	Channel	Frequency (GHz)	99% Bandwidth (GHz)	26 dB Bandwidth (GHz)
One	1	58.32	1.8334	2.072
One	2	60.48	1.8366	2.079
One	3	62.64	1.8323	2.041
Two	1	58.32	1.8258	2.043
Two	2	60.48	1.8234	2.062
Two	3	62.64	1.8009	2.034

99% and 26 dB BANDWIDTH, ONE-ANTENNA

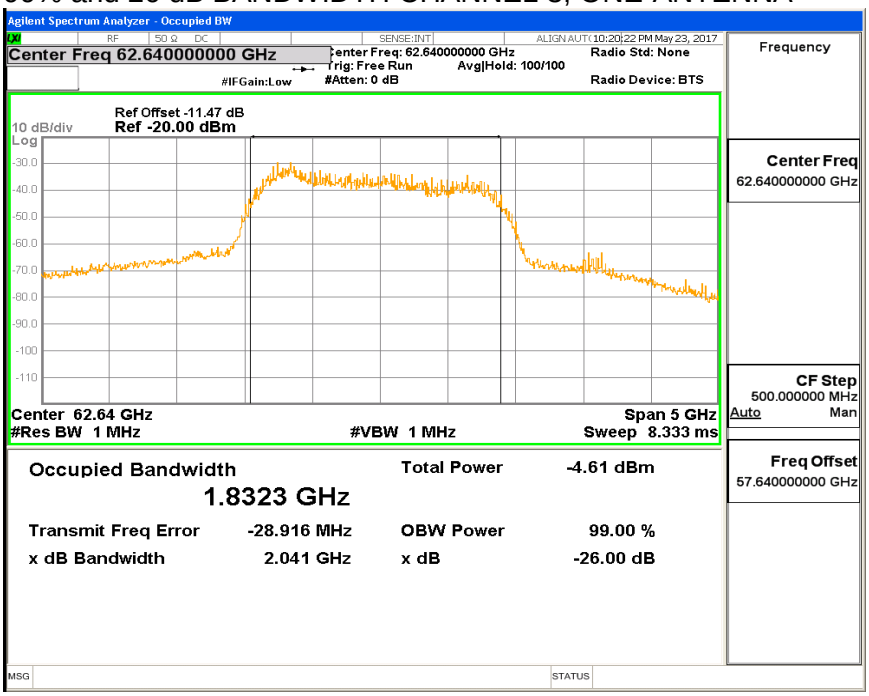
99% and 26 dB BANDWIDTH CHANNEL 1, ONE-ANTENNA



99% and 26 dB BANDWIDTH CHANNEL 2, ONE-ANTENNA

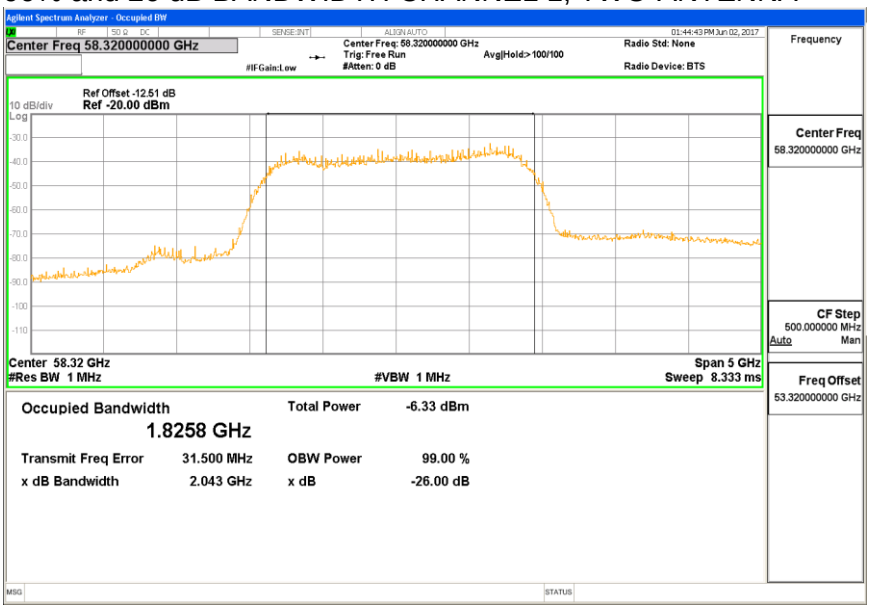


99% and 26 dB BANDWIDTH CHANNEL 3, ONE-ANTENNA

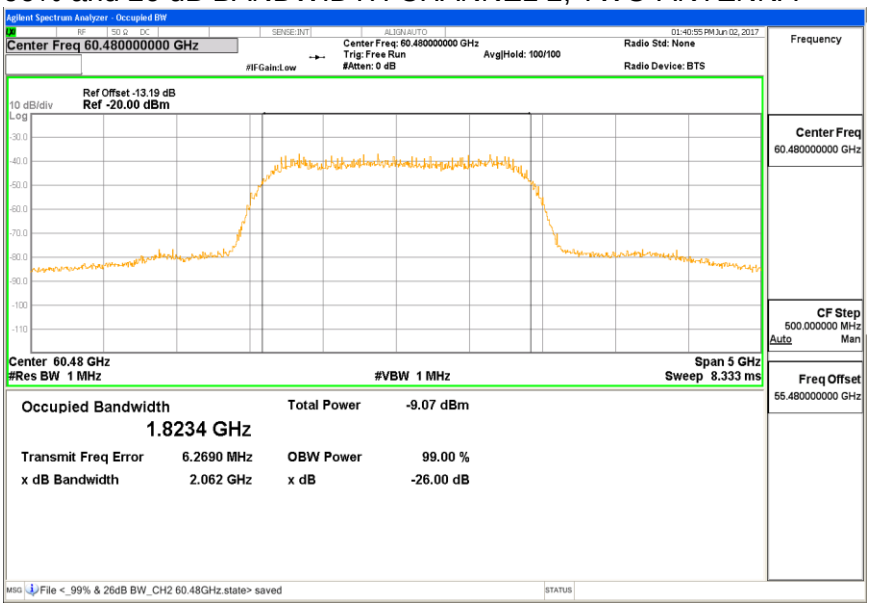


99% and 26 dB BANDWIDTH, TWO-ANTENNA

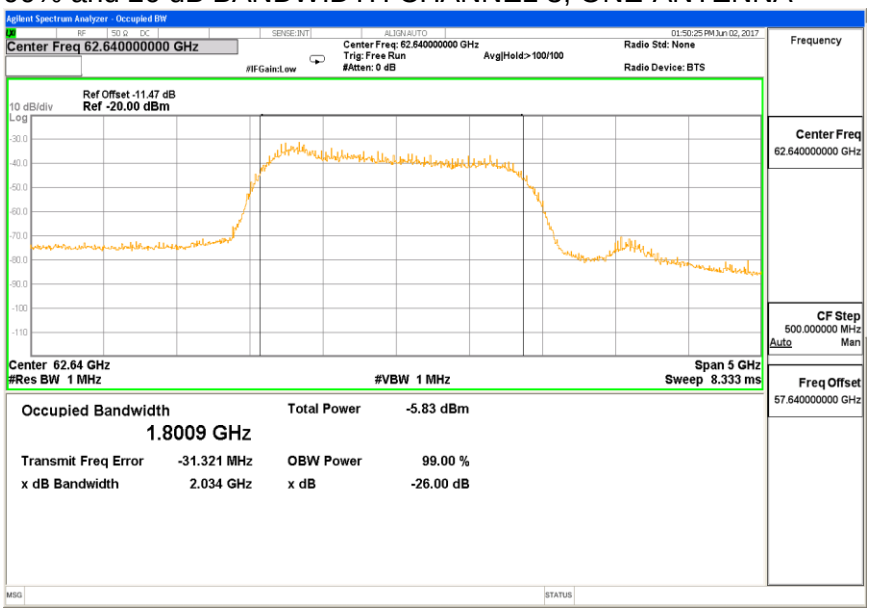
99% and 26 dB BANDWIDTH CHANNEL 1, TWO-ANTENNA



99% and 26 dB BANDWIDTH CHANNEL 2, TWO-ANTENNA



99% and 26 dB BANDWIDTH CHANNEL 3, ONE-ANTENNA



8.5. AVERAGE AND PEAK RADIATED POWER

LIMIT

§ 15.255 (b) Operation permitted within the 57-71 GHz band, emission levels shall not exceed the following equivalent isotropically radiated power (EIRP):

§ 15.255 (b) (1) (i) The average power of any emission shall not exceed 40 dBm and the peak power of any emission shall not exceed 43 dBm.

§ 15.255 (b) (1) (ii) For fixed point-to-point transmitters located outdoors, the average power of any emission shall not exceed 82 dBm, and shall be reduced by 2 dB for every dB that the antenna gain is less than 51 dBi. The peak power of any emission shall not exceed 85 dBm, and shall be reduced by 2 dB for every dB that the antenna gain is less than 51 dBi.

§ 15.255 (b) (1) (ii) (A) The provisions in this paragraph for reducing transmit power based on antenna gain shall not require that the power levels be reduced below the limits specified in paragraph (b) (1) (i) of this section.

Antenna Gain = 35 dBi

Average Limit	82 dBm – (2 * (51 dBi – 35 dBi)) = 82 dBm – 32 dB = 50 dBm EIRP
Peak Limit	85 dBm – (2 * (51 dBi – 35 dBi)) = 85 dBm – 32 dB = 53 dBm EIRP

Antenna Gain = 32 dBi

Average Limit	82 dBm – (2 * (51 dBi – 32 dBi)) = 82 dBm – 38 dB = 44 dBm EIRP
Peak Limit	85 dBm – (2 * (51 dBi – 32 dBi)) = 85 dBm – 38 dB = 47 dBm EIRP

The applicant declares to apply limit stated on § 15.255(b) (1) (i) for the EUT.

TEST PROCEDURE

§ 15.255 (d) (2) Peak transmitter conducted output power shall be measured with an RF detector that has a detection bandwidth that encompasses the 57-71 GHz band and that has a video bandwidth of at least 10 MHz

ANSI C63.10 Clause 9.11

Measurements are made at a distance greater than or equal to the far field boundary distance. The measured power level is converted to EIRP using the Friis equation:

$EIRP = P_T * G_T = (P_R / G_R) * (4 * Pi * D / \lambda)^2$

where,

P_R is the received power
G_R is the gain of the receive measurement antenna
D is the measurement distance
λ is the wavelength

Notes: For average power measurements P_R is corrected for duty cycle.
Calculations are made in the log form equivalent to the linear form listed above.

FAR FIELD BOUNDARY CALCULATIONS

The far-field boundary is given as:

$R_{far\ field} = (2 * L^2) / \lambda$

where,

L = Largest Antenna Dimension, including the reflector, in meters
λ = wavelength in meters

Channe	Frequency (GHz)	L (m)	Lambda (m)	R (Far Field) (m)
1	58.32	0.11	0.0051	4.70
2	60.48	0.11	0.0050	4.88
3	62.64	0.11	0.0048	5.05

Radiated power measurements are performed at a 5.1 meter test distance.

RESULTS

LOW CHANNEL (1), ONE-ANTENNA

PEAK POWER

Frequency (GHz)	Measurement Distance (m)	Measured Peak Voltage (mV)	Measured Power (dBm)	Rx Antenna Gain (dBi)	Rx Waveguide Loss (dB)
58.32	5.1	74.30	-17.60	23.00	0.30
EIRP (dBm)	**Limit (dBm)**	**Margin (dBm)**			
41.61	43.0	-1.4			

AVERAGE POWER

Frequency (GHz)	Measurement Distance (m)	Measured Average Voltage (mV)	Measured Power (dBm)	Rx Antenna Gain (dBi)	Rx Waveguide Loss (dB)	Duty Cycle Corr Fact (dB)
58.32	5.1	46.50	-20.30	23.00	0.30	0.30
EIRP (dBm)	**Limit (dBm)**	**Margin (dBm)**				
39.21	40.0	-0.8				

MID CHANNEL (2), ONE-ANTENNA

PEAK POWER

Frequency (GHz)	Measurement Distance (m)	Measured Peak Voltage (mV)	Measured Power (dBm)	Rx Antenna Gain (dBi)	Rx Waveguide Loss (dB)
60.48	5.1	50.00	-18.60	23.00	0.30
EIRP (dBm)	**Limit (dBm)**	**Margin (dBm)**			
40.92	43.0	-2.1			

AVERAGE POWER

Frequency (GHz)	Measurement Distance (m)	Measured Average Voltage (mV)	Measured Power (dBm)	Rx Antenna Gain (dBi)	Rx Waveguide Loss (dB)	Duty Cycle Corr Fact (dB)
60.48	5.1	33.10	-21.20	23.00	0.30	0.30
EIRP (dBm)	**Limit (dBm)**	**Margin (dBm)**				
38.62	40.0	-1.4				

HIGH CHANNEL (3), ONE-ANTENNA

PEAK POWER

Frequency (GHz)	Measurement Distance (m)	Measured Peak Voltage (mV)	Measured Power (dBm)	Rx Antenna Gain (dBi)	Rx Waveguide Loss (dB)
62.64	5.1	52.30	-18.10	23.00	0.30
EIRP (dBm)	**Limit (dBm)**	**Margin (dBm)**			
41.73	43.0	-1.3			

AVERAGE POWER

Frequency (GHz)	Measurement Distance (m)	Measured Average Voltage (mV)	Measured Power (dBm)	Rx Antenna Gain (dBi)	Rx Waveguide Loss (dB)	Duty Cycle Corr Fact (dB)
62.64	5.1	34.50	-20.70	23.00	0.30	0.30
EIRP (dBm)	**Limit (dBm)**	**Margin (dBm)**				
39.43	40.0	-0.6				

LOW CHANNEL (1), TWO-ANTENNA

PEAK POWER

Frequency (GHz)	Measurement Distance (m)	Measured Peak Voltage (mV)	Measured Power (dBm)	Rx Antenna Gain (dBi)	Rx Waveguide Loss (dB)
58.32	5.1	66.60	-18.10	23.00	0.30
EIRP (dBm)	**Limit (dBm)**	**Margin (dBm)**			
41.11	43.0	-1.9			

AVERAGE POWER

Frequency (GHz)	Measurement Distance (m)	Measured Average Voltage (mV)	Measured Power (dBm)	Rx Antenna Gain (dBi)	Rx Waveguide Loss (dB)	Duty Cycle Corr Fact (dB)
58.32	5.1	44.20	-20.60	23.00	0.30	0.30
EIRP (dBm)	**Limit (dBm)**	**Margin (dBm)**				
38.91	40.0	-1.1				

MID CHANNEL (2), TWO-ANTENNA

PEAK POWER

Frequency (GHz)	Measurement Distance (m)	Measured Peak Voltage (mV)	Measured Power (dBm)	Rx Antenna Gain (dBi)	Rx Waveguide Loss (dB)
60.48	5.1	39.10	-19.80	23.00	0.30
EIRP (dBm)	**Limit (dBm)**	**Margin (dBm)**			
39.72	43.0	-3.3			

AVERAGE POWER

Frequency (GHz)	Measurement Distance (m)	Measured Average Voltage (mV)	Measured Power (dBm)	Rx Antenna Gain (dBi)	Rx Waveguide Loss (dB)	Duty Cycle Corr Fact (dB)
60.48	5.1	27.50	-22.10	23.00	0.30	0.30
EIRP (dBm)	**Limit (dBm)**	**Margin (dBm)**				
37.72	40.0	-2.3				

HIGH CHANNEL (3), TWO-ANTENNA

PEAK POWER

Frequency (GHz)	Measurement Distance (m)	Measured Peak Voltage (mV)	Measured Power (dBm)	Rx Antenna Gain (dBi)	Rx Waveguide Loss (dB)
62.64	5.1	49.50	-18.60	23.00	0.30
EIRP (dBm)	**Limit (dBm)**	**Margin (dBm)**			
41.23	43.0	-1.8			

AVERAGE POWER

Frequency (GHz)	Measurement Distance (m)	Measured Average Voltage (mV)	Measured Power (dBm)	Rx Antenna Gain (dBi)	Rx Waveguide Loss (dB)	Duty Cycle Corr Fact (dB)
62.64	5.1	33.10	-20.90	23.00	0.30	0.30
EIRP (dBm)	**Limit (dBm)**	**Margin (dBm)**				
39.23	40.0	-0.8				

8.6. PEAK CONDUCTED OUTPUT POWER

LIMIT

§15.255 (d) Except as specified paragraph (d)(1) of this section, the peak transmitter conducted output power shall not exceed 500 mW. Depending on the gain of the antenna, it may be necessary to operate the intentional radiator using a lower peak transmitter output power in order to comply with the EIRP limits specified in paragraph (b) of this section.

§15.255 (b) Within the 57-71 GHz band, emission levels shall not exceed the following equivalent isotropically radiated power (EIRP):

§15.255 (d) (1) Transmitters with an emission bandwidth of less than 100 MHz must limit their peak transmitter conducted output power to the product of 500 mW times their emission bandwidth divided by 100 MHz. For the purposes of this paragraph, emission bandwidth is defined as the instantaneous frequency range occupied by a steady state radiated signal with modulation, outside which the radiated power spectral density never exceeds 6 dB below the maximum radiated power spectral density in the band, as measured with a 100 kHz resolution bandwidth spectrum analyzer. The center frequency must be stationary during the measurement interval, even if not stationary during normal operation (e.g., for frequency hopping devices).

PROCEDURE

The maximum EUT antenna gain is subtracted from the Peak EIRP.

RESULTS

PEAK OUTP PEAK OUTPUT POWER - RF Det. Method

Antenna Config.	Frequency (GHz)	EIRP (dBm)	EUT Antenna Gain (dBi)	Output Power (dBm)	Output Power (mW)	6 dB Bandwidth (MHz)	Output Power Limit (mW)
One	58.32	41.61	32.00	9.61	9.14	1725	500
One	60.48	40.92	32.00	8.92	7.80	1715	500
One	62.64	41.73	32.00	9.73	9.40	1100	500
Two	58.32	41.11	35.00	6.11	4.08	1605	500
Two	60.48	39.72	35.00	4.72	2.96	1695	500
Two	62.64	41.23	35.00	6.23	4.20	1530	500

8.7. FREQUENCY STABILITY

LIMIT

§15.255 (e) Fundamental emissions must be contained within the frequency bands specified in this section during all conditions of operation. Equipment is presumed to operate over the temperature range - 20 to +50 degrees Celsius with an input voltage variation of 85% to 115% of rated input voltage, unless justification is presented to demonstrate otherwise.

TEST PROCEDURE

The radio module is placed in an environmental chamber, with power furnished by an adjustable source. The carrier frequency is counted at each condition and compared with the reference condition.

RESULTS

Reference Conditions: 120VAC @ 20ºC		CHANNEL 2	
Power Supply (VDC/VAC)	**Environment Temperature (ºC)**	**Frequency (MHz)**	**Delta (kHz)**
120.00	50	60577.9666000	0.600
120.00	40	60577.9689000	2.900
120.00	30	60577.9681000	2.100
120.00	***20***	***60577.9660000***	***Reference***
120.00	10	60577.9633000	-2.700
120.00	0	60577.9611000	-4.900
120.00	-10	60577.9582000	-7.800
120.00	-20	60577.9584000	-7.600
102.00	20	60577.9660000	0.000
138	20	60577.9660000	0.000

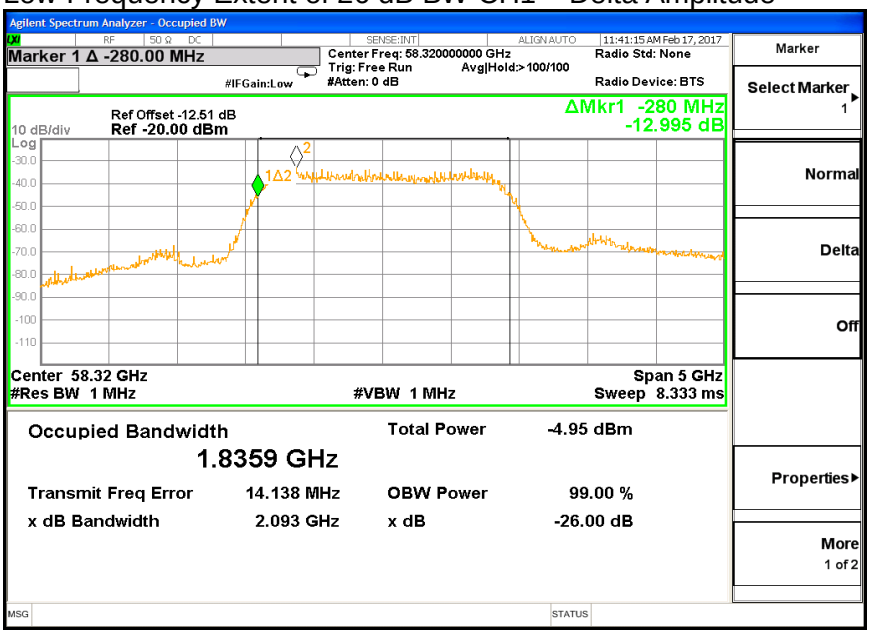
97.966 MHz CW baseband signal yields offset from Channel 2 center frequency, 60.48 GHz.

Worst case delta = 7.8 kHz or round up to 10 kHz for following calculation.

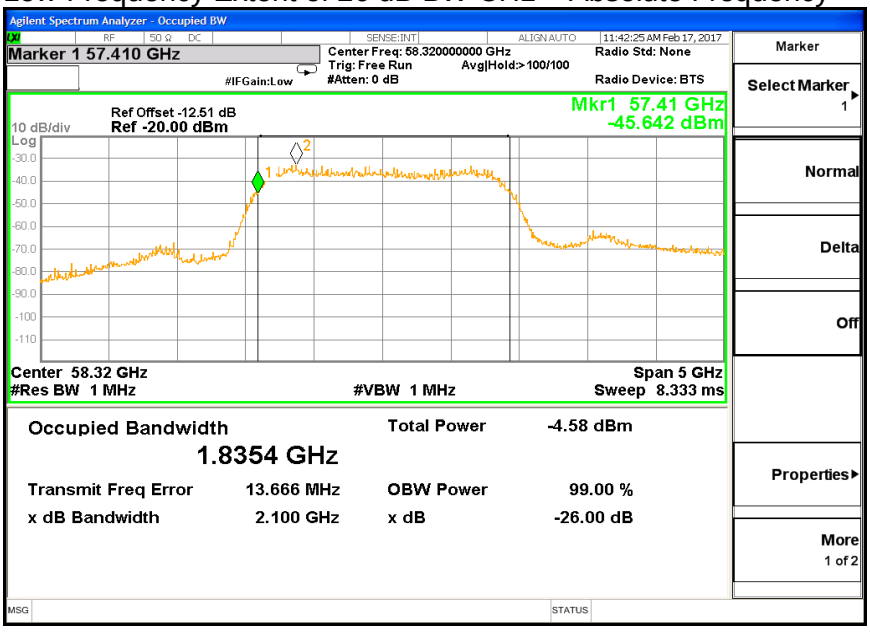
LOW-FREQUENCY EXTENT OF 26 dB BW COMPARED TO 57 GHz AUTHORIZED BAND EDGE

Extent of 26 dB BW (at normal temperature)	57.41000 GHz
Tolerance from Frequency Stability	± .00001 GHz
Extent of 26 dB BW (over temperature extremes)	57.40999 GHz

Low-Frequency Extent of 26 dB BW CH1 – Delta Amplitude



Low-Frequency Extent of 26 dB BW CH1 – Absolute Frequency



8.8. TX SPURIOUS EMISSIONS

LIMITS

§15.255 (c) (1) The power density of any emissions outside the 57-71 GHz band shall consist solely of spurious emissions.

§15.255 (c) (2) Radiated emissions below 40 GHz shall not exceed the general limits in §15.209.

§15.255 (c) (3) Between 40 GHz and 200 GHz, the level of these emissions shall not exceed 90 pW/cm^2 at a distance of 3 meters.

§15.255 (c) (4) The levels of the spurious emissions shall not exceed the level of the fundamental emission.

PROCEDURE FOR 30 MHz TO 40 GHz

ANSI C63.10

PROCEDURE FOR 40 TO 200 GHz

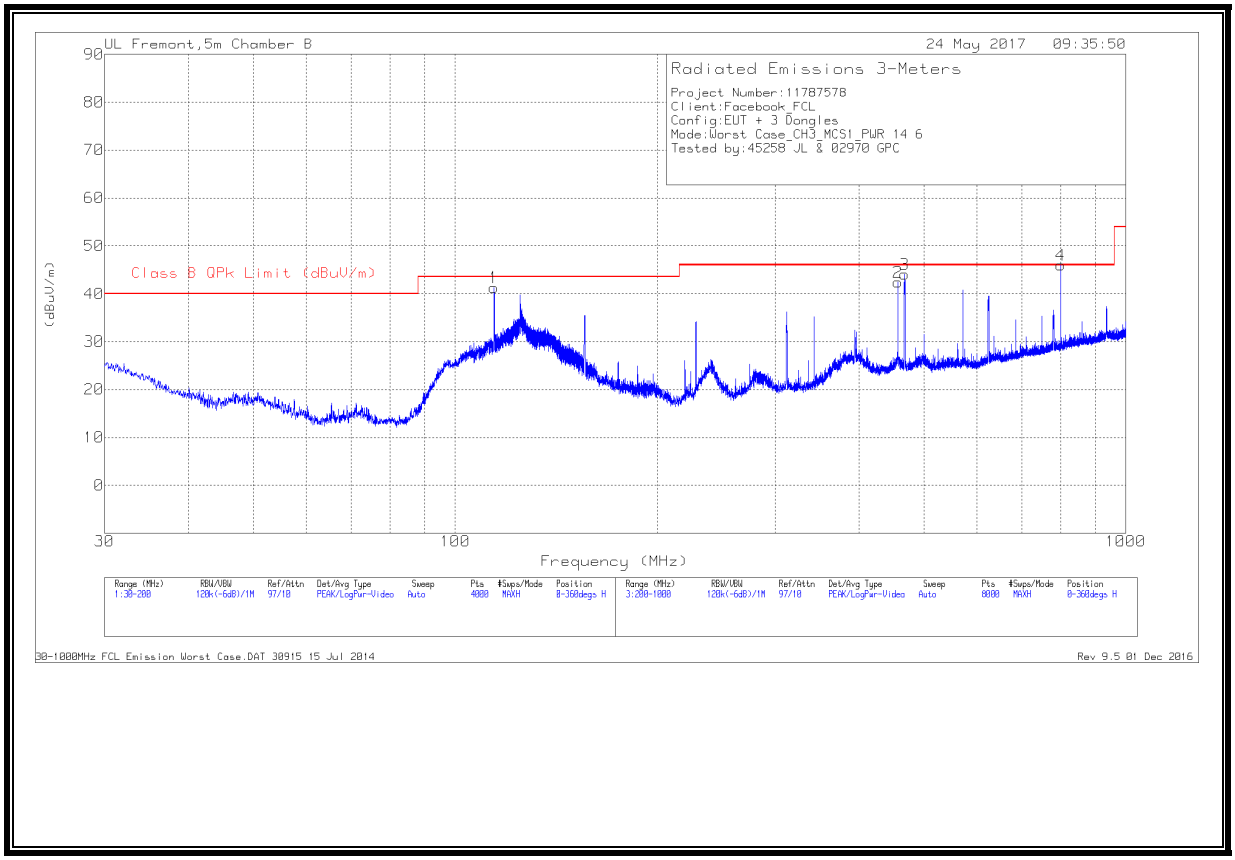
ANSI C63.10

External harmonic mixers are utilized above 50 GHz. The EIRP is measured, then the power density at a 3 meter distance is calculated.

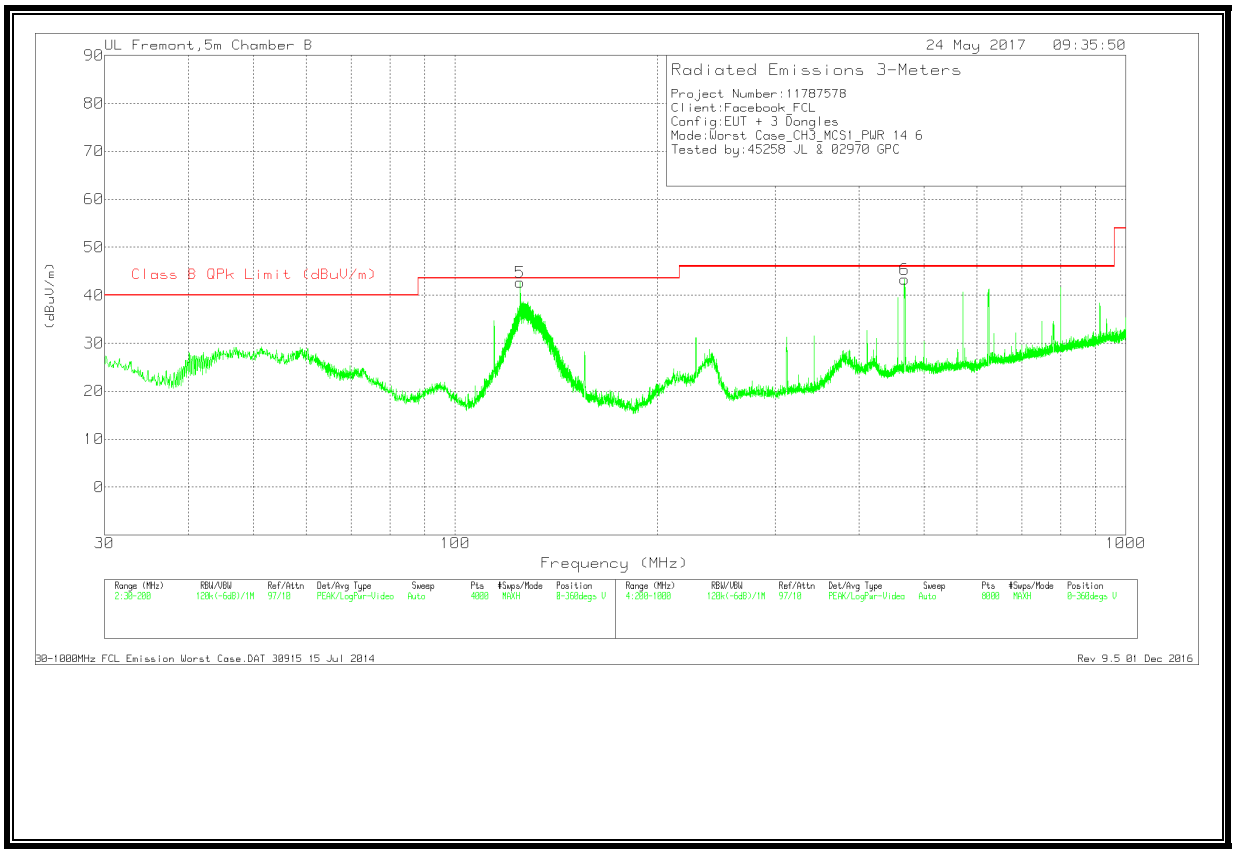
BPSK1 with Power Index 14 6 for Channel 3 of one-antenna configuration on the EUT was used for TX emission tests.

8.8.1. SPURIOUS EMISSION 30 TO 1000 MHz

TX SPURIOUS EMISSION 30 TO 1000 MHz (HORIZONTAL PLOT)



TX SPURIOUS EMISSION 30 TO 1000 MHz (VERTICAL PLOT)



TX SPURIOUS EMISSION 30 TO 1000 MHz

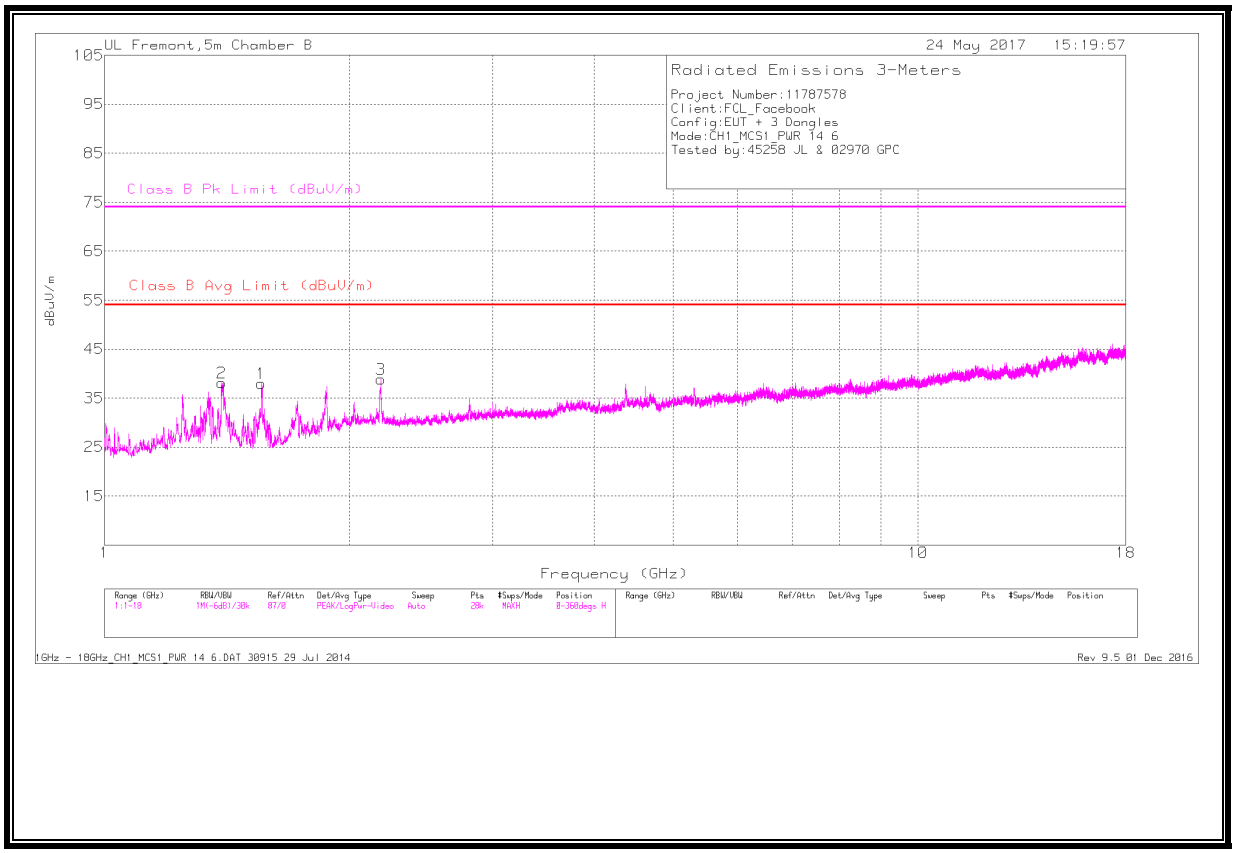
Trace Markers

Marker	Frequency (MHz)	Meter Reading (dBuV)	Det	AF T477 (dB/m)	Amp/Cbl (dB)	Corrected Reading (dBuV/m)	Class B QPk Limit (dBuV/m)	Margin (dB)	Azimuth (Degs)	Height (cm)	Polarity
1	114.2899	51	Qp	17.1	-27.8	40.3	43.52	-3.22	80	283	H
5	124.9857	51.29	Qp	17.8	-27.6	41.49	43.52	-2.03	229	104	V
2	457.1418	47	Qp	20.9	-26	41.9	46.02	-4.12	130	182	H
3	467.7918	45.28	Qp	21.2	-26	40.48	46.02	-5.54	130	185	H
6	468.0336	46.76	Qp	21.2	-25.9	42.06	46.02	-3.96	130	163	V
4	799.9958	44.81	Qp	25.2	-24.3	45.71	46.02	-.31	183	100	H

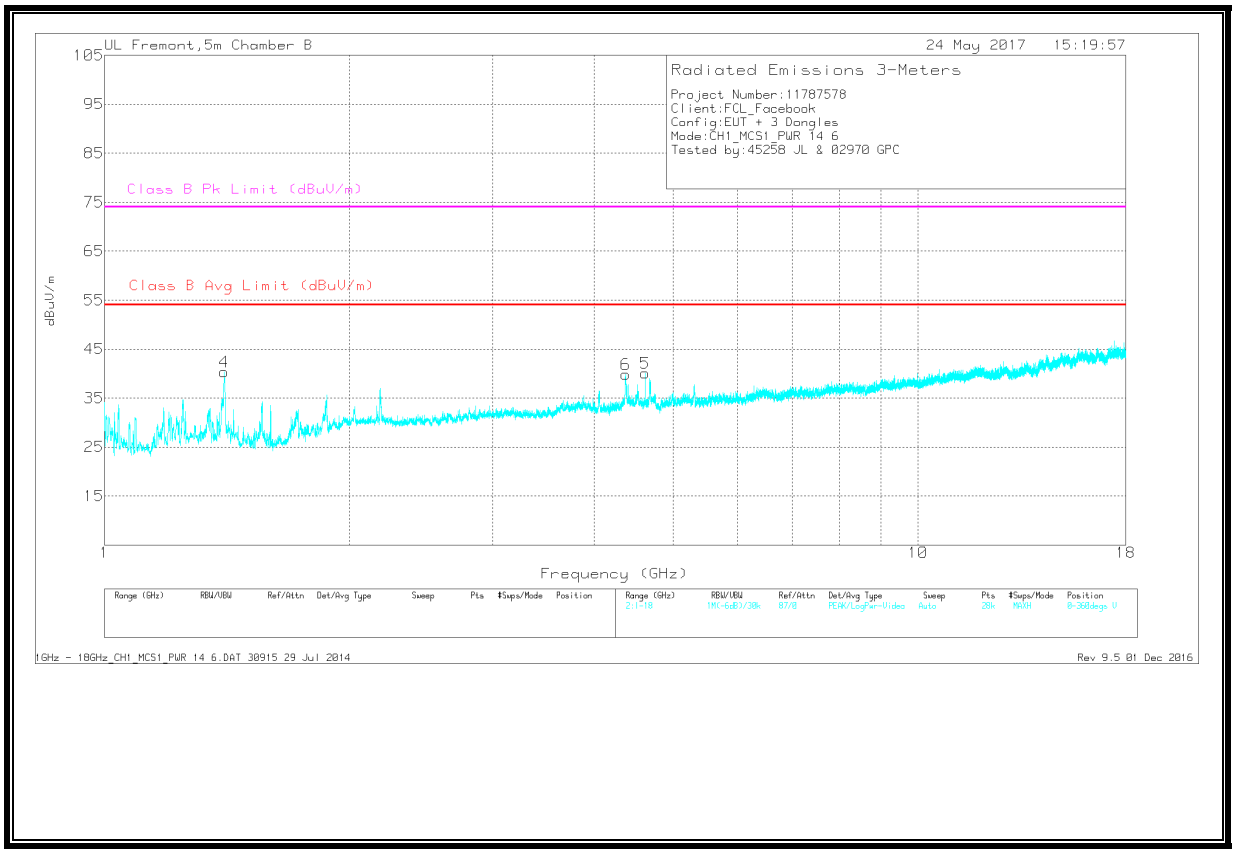
Qp - Quasi-Peak detector

8.8.2. SPURIOUS EMISSION 1 TO 18 GHz

CHANNEL 1 - TX SPURIOUS EMISSION 1 - 18 GHz (HORIZONTAL PLOT)



CHANNEL 1 – TX SPURIOUS EMISSION 1-18 GHz (VERTICAL PLOT)



CHANNEL 1 TX SPURIOUS EMISSION 1 - 18 GHz

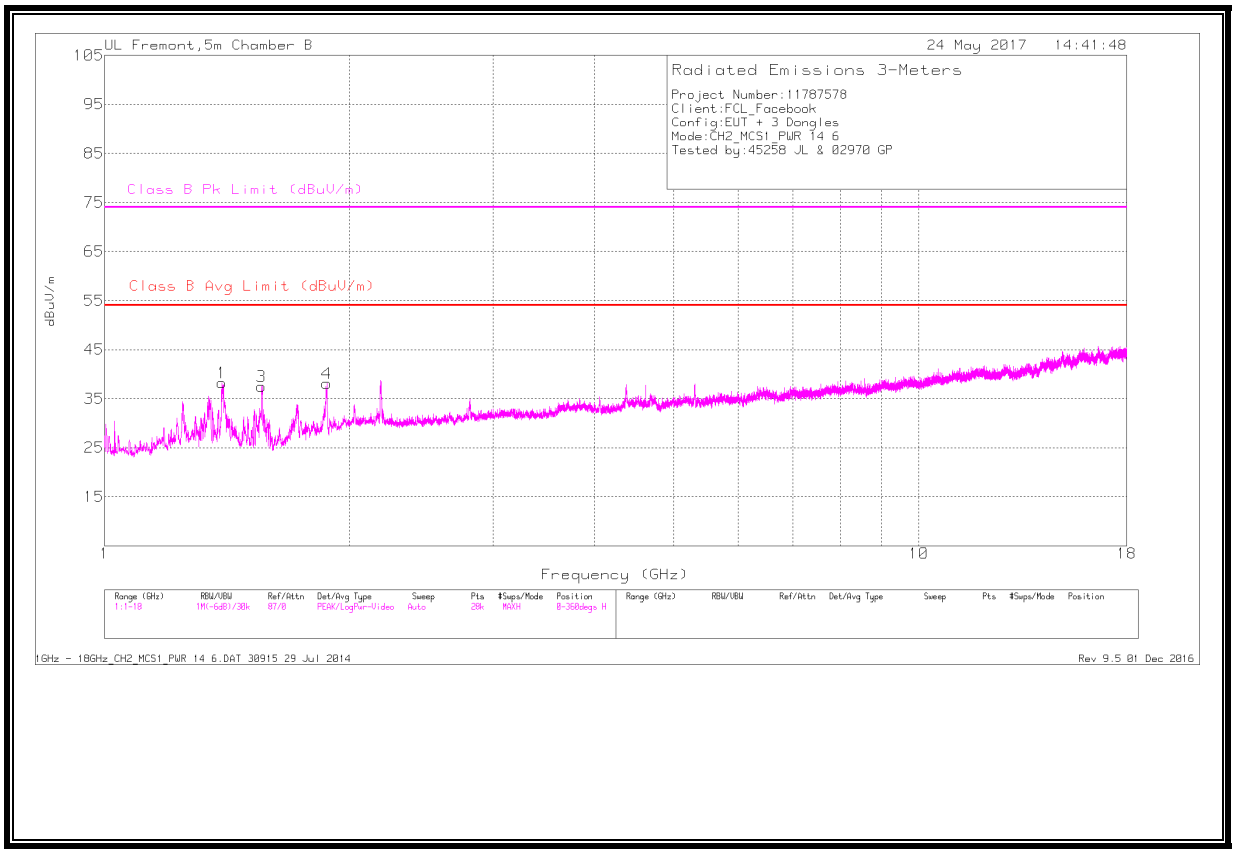
Trace Markers

Marker	Frequency (GHz)	Meter Reading (dBuV)	Det	AF T346 (dB/m)	Amp/Cbl (dB)	Corrected Reading dBuV/m	Class B Avg Limit (dBuV/m)	Avg Margin (dB)	Class B Pk Limit (dBuV/m)	PK Margin (dB)	Azimuth (Degs)	Height (cm)	Polarity
2	1.394	38.32	Av	28.8	-33.9	33.22	54	-20.78	-	-	197	175	H
2	1.395	48.92	Pk	28.8	-33.9	43.82	-	-	74	-30.18	197	175	H
4	1.402	56.76	Pk	28.7	-33.9	51.56	-	-	74	-22.44	54	261	V
4	1.403	40.71	Av	28.7	-33.9	35.51	54	-18.49	-	-	54	261	V
1	1.561	52.47	Pk	27.3	-33.7	46.07	-	-	74	-27.93	190	139	H
1	1.561	39.31	Av	27.3	-33.7	32.91	54	-21.09	-	-	190	139	H
3	2.186	47.99	Pk	32.1	-32.9	47.19	-	-	74	-26.81	93	103	H
3	2.186	33.23	Av	32.1	-32.9	32.43	54	-21.57	-	-	93	103	H
6	4.371	34.31	Av	34	-30.6	37.71	54	-16.29	-	-	222	316	V
6	4.372	47.99	Pk	34.1	-30.6	51.49	-	-	74	-22.51	222	316	V
5	4.62	41.6	Pk	34.4	-30	46	-	-	74	-28	94	230	V
5	4.62	33.44	Av	34.4	-30	37.84	54	-16.16	-	-	94	230	V

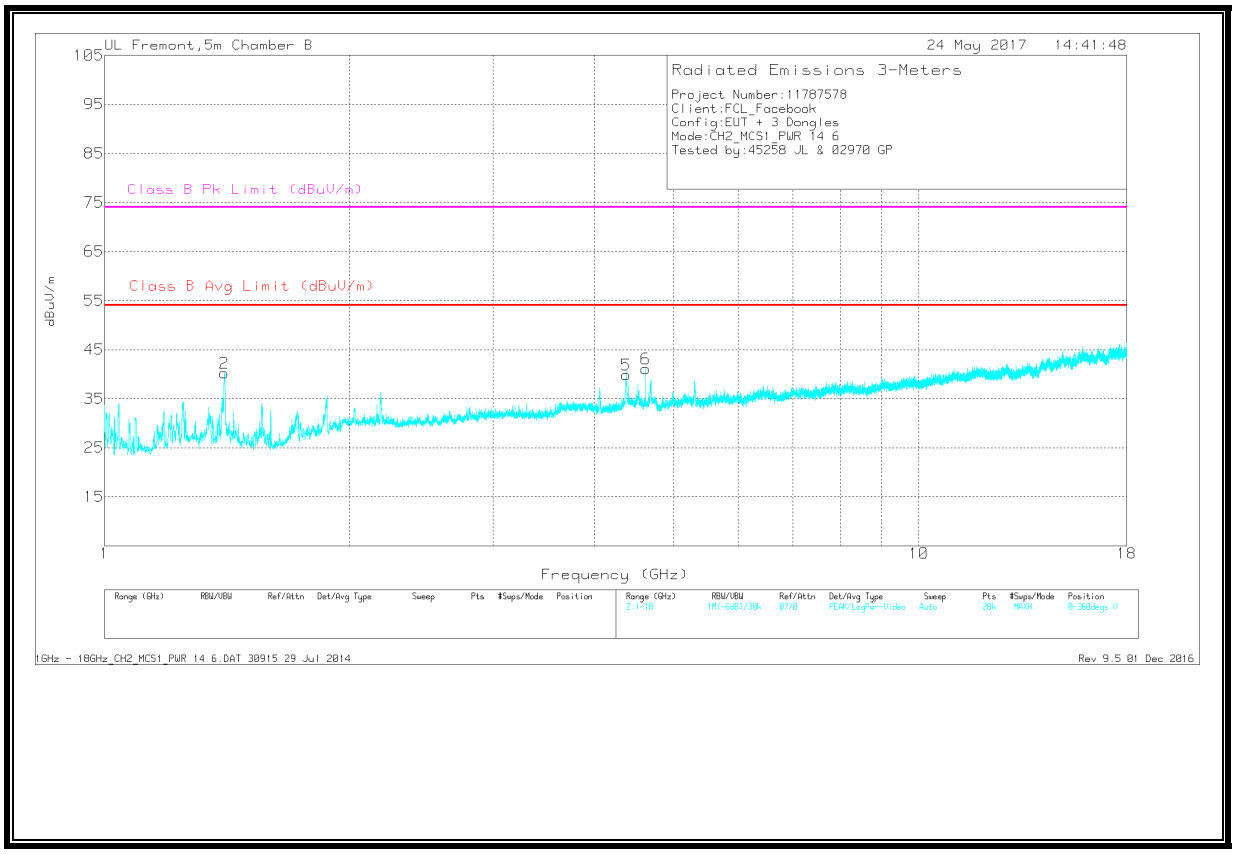
Pk - Peak detector

Av - Average detection

CHANNEL 2 - TX SPURIOUS EMISSION 1 - 18 GHz (HORIZONTAL PLOT)



CHANNEL 2 – TX SPURIOUS EMISSION 1 - 18 GHz (VERTICAL PLOT)



CHANNEL 2 TX SPURIOUS EMISSION 1 - 18 GHz

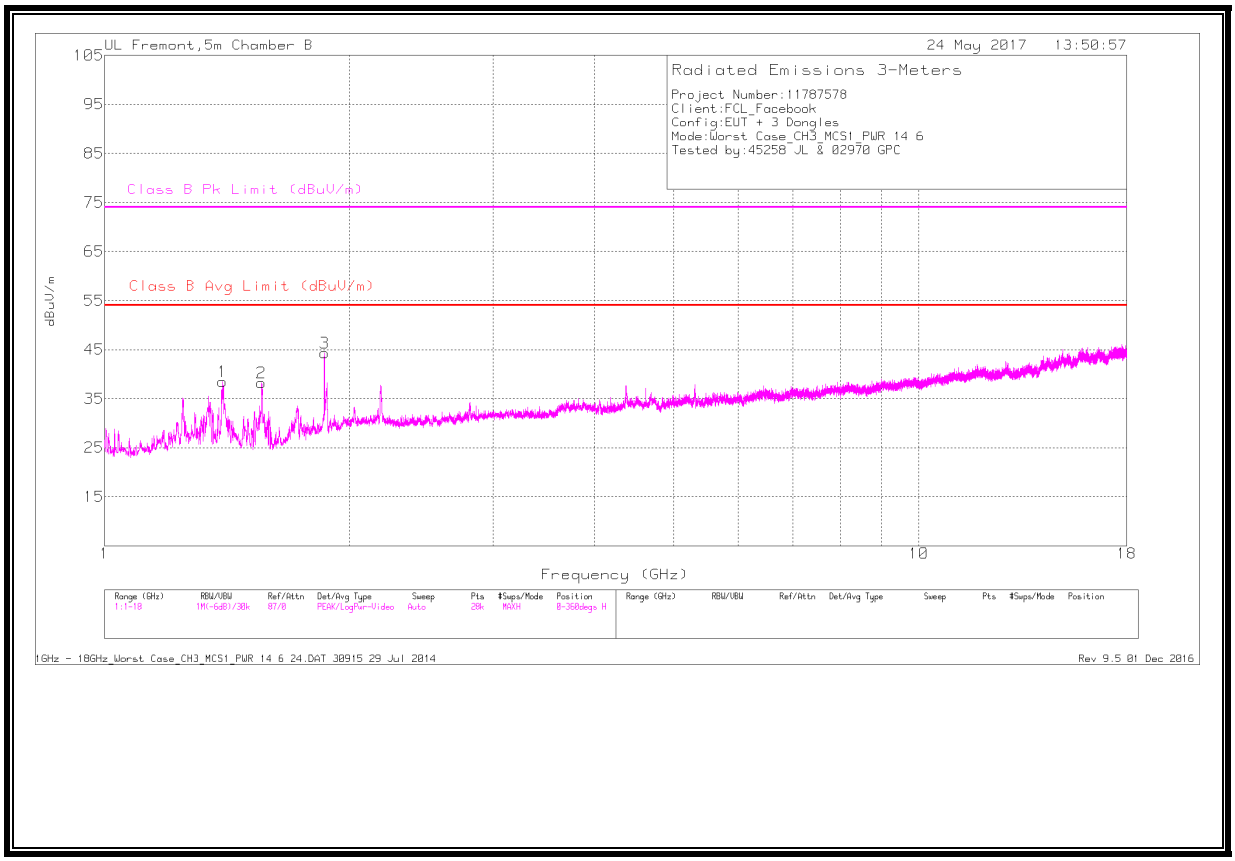
Trace Markers

Marker	Frequency (GHz)	Meter Reading (dBuV)	Det	AF T346 (dB/m)	Amp/Cbl (dB)	Corrected Reading dBuV/m	Class B Avg Limit (dBuV/m)	Avg Margin (dB)	Class B Pk Limit (dBuV/m)	PK Margin (dB)	Azimuth (Degs)	Height (cm)	Polarity
1	1.395	48.07	Pk	28.8	-33.9	42.97	-	-	74	-31.03	200	134	H
1	1.395	37.4	Av	28.8	-33.9	32.3	54	-21.7	-	-	200	134	H
2	1.402	57.24	Pk	28.7	-33.9	52.04	-	-	74	-21.96	43	260	V
2	1.402	38.08	Av	28.7	-33.9	32.88	54	-21.12	-	-	43	260	V
3	1.558	45.52	Pk	27.3	-33.7	39.12	-	-	74	-34.88	192	384	H
3	1.559	32.6	Av	27.3	-33.7	26.2	54	-27.8	-	-	192	384	H
4	1.873	40.89	Pk	30.5	-32.9	38.49	-	-	74	-35.51	322	273	H
4	1.873	27.65	Av	30.5	-32.9	25.25	54	-28.75	-	-	322	273	H
5	4.374	47.88	Pk	34.1	-30.6	51.38	-	-	74	-22.62	259	399	V
5	4.374	32.83	Av	34.1	-30.6	36.33	54	-17.67	-	-	259	399	V
6	4.62	40.62	Pk	34.4	-30	45.02	-	-	74	-28.98	348	223	V
6	4.62	33.28	Av	34.4	-30	37.68	54	-16.32	-	-	348	223	V

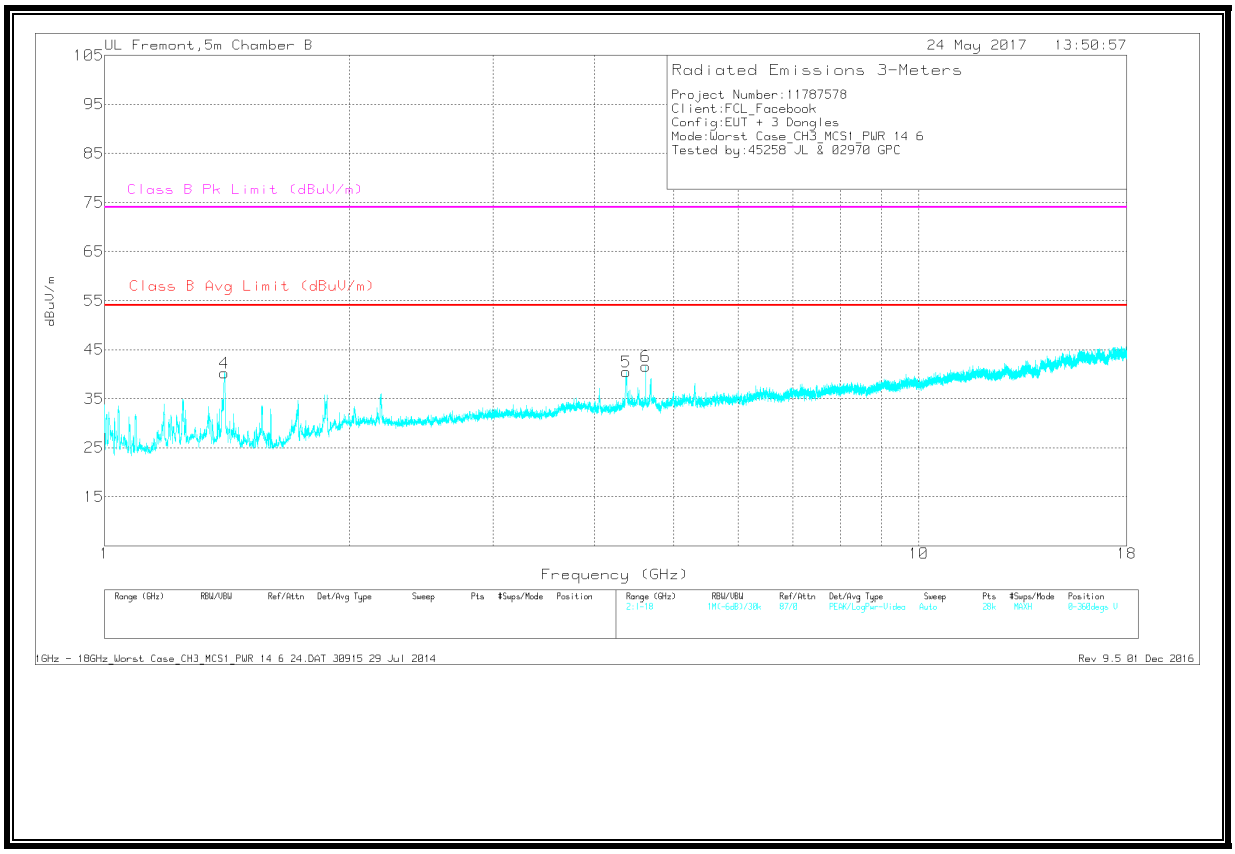
Pk - Peak detector

Av - Average detection

CHANNEL 3 - TX SPURIOUS EMISSION 1 - 18 GHz (HORIZONTAL PLOT)



CHANNEL 3 – TX SPURIOUS EMISSION 1 - 18 GHz (VERTICAL PLOT)



CHANNEL 3 TX SPURIOUS EMISSION 1 - 18 GHz

Trace Markers

Marker	Frequency (GHz)	Meter Reading (dBuV)	Det	AF T346 (dB/m)	Amp/Cbl (dB)	Corrected Reading dBuV/m	Class B Avg Limit (dBuV/m)	Avg Margin (dB)	Class B Pk Limit (dBuV/m)	PK Margin (dB)	Azimuth (Degs)	Height (cm)	Polarity
1	1.395	37.96	Av	28.8	-33.9	32.86	54	-21.14	-	-	201	135	H
1	1.397	48.45	Pk	28.8	-33.9	43.35	-	-	74	-30.65	201	135	H
4	1.402	38.81	Av	28.7	-33.9	33.61	54	-20.39	-	-	44	261	V
4	1.404	57.15	Pk	28.7	-33.9	51.95	-	-	74	-22.05	44	261	V
2	1.558	32.52	Av	27.3	-33.7	26.12	54	-27.88	-	-	193	385	H
2	1.559	45.2	Pk	27.3	-33.7	38.8	-	-	74	-35.2	193	385	H
3	1.861	47.3	Pk	30.4	-32.9	44.8	-	-	74	-29.2	323	272	H
3	1.861	27.82	Av	30.4	-32.9	25.32	54	-28.68	-	-	323	272	H
5	4.374	48.1	Pk	34.1	-30.6	51.6	-	-	74	-22.4	260	400	V
5	4.374	32.76	Av	34.1	-30.6	36.26	54	-17.74	-	-	260	400	V
6	4.62	42.1	Pk	34.4	-30	46.5	-	-	74	-27.5	349	222	V
6	4.62	34.53	Av	34.4	-30	38.93	54	-15.07	-	-	349	222	V

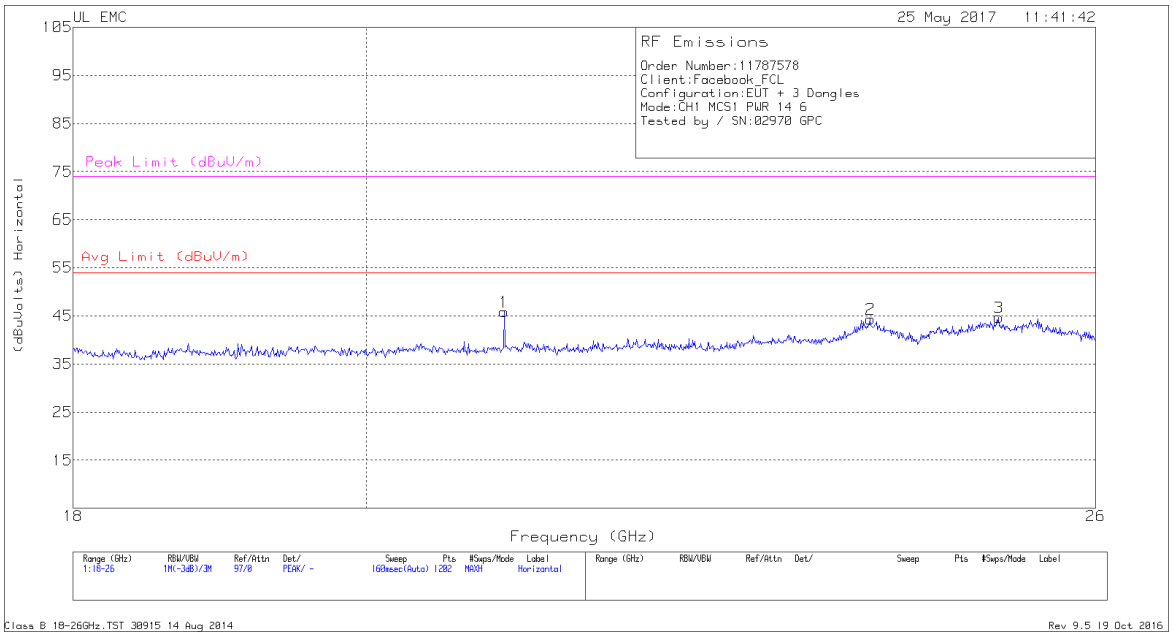
Pk - Peak detector

Av - Average detection

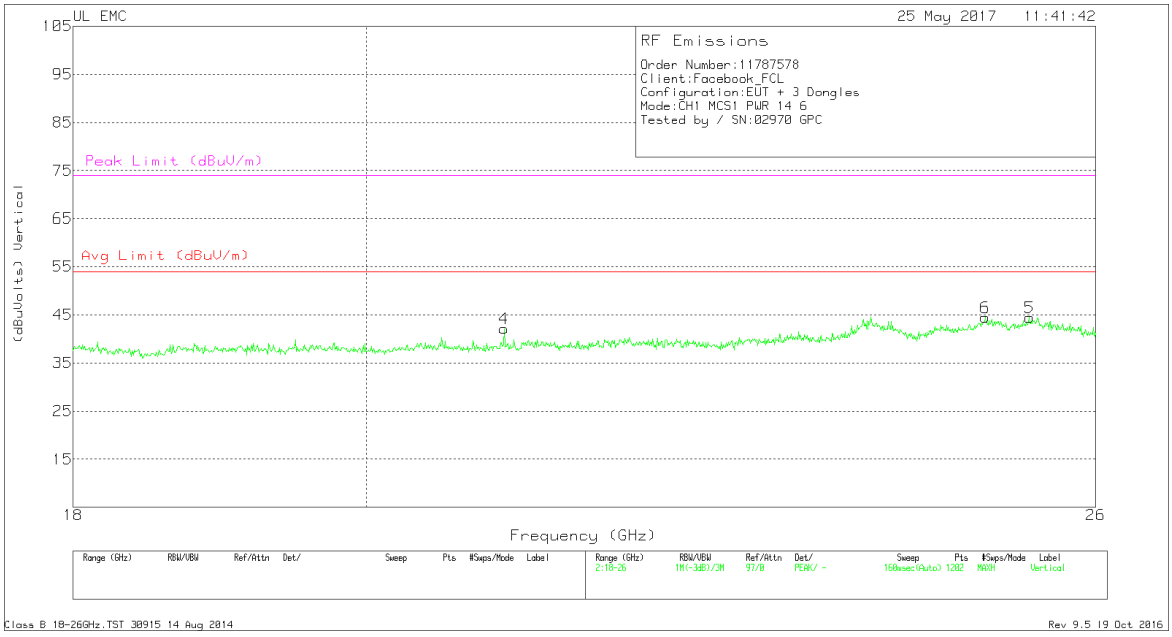
8.8.3. SPURIOUS EMISSION 18 TO 26 GHz

CHANNEL 1 - TX SPURIOUS EMISSION 18 TO 26 GHz (HORIZONTAL AND VERTICAL PLOTS)

Horizontal



Vertical



CHANNEL 1 - TX SPURIOUS EMISSION 18 TO 26 GHz

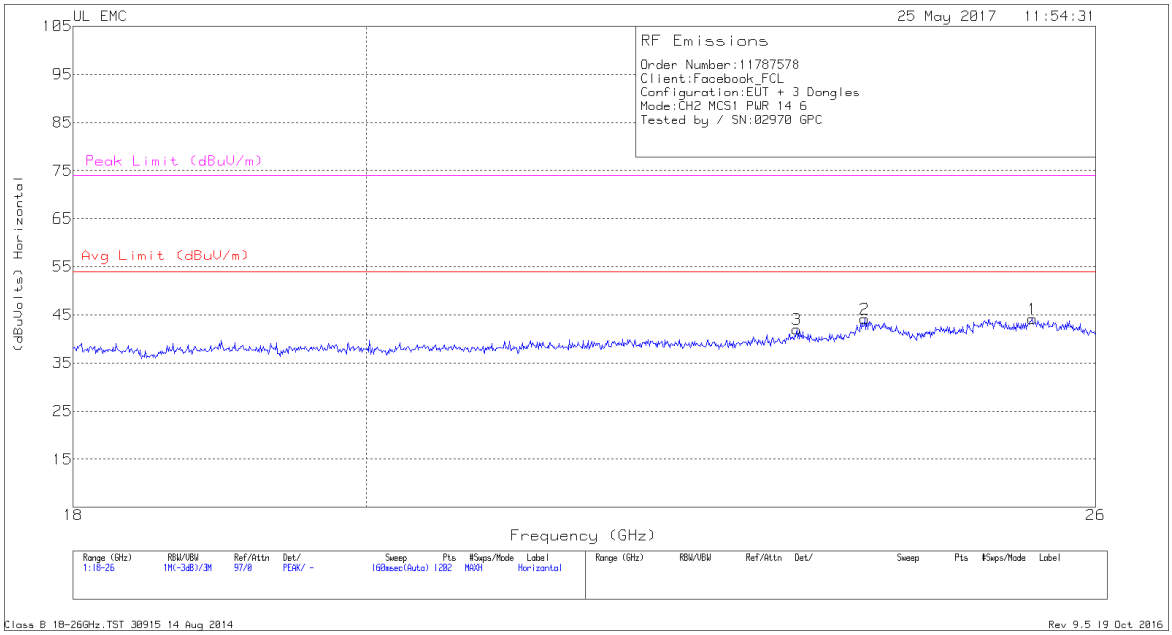
Trace Markers

Marker	Frequency (GHz)	Meter Reading (dBuV)	Det	AF T449 (dB/m)	Amp/Cbl (dB)	Dist Corr (dB)	Corrected Reading (dBuVolts)	Avg Limit (dBuV/m)	Avg Margin (dB)	Peak Limit (dBuV/m)	PK Margin (dB)	Polarity
1	21.017	47.63	Pk	33.2	-25.5	-9.5	45.83	54	-8.17	74	-28.17	H
2	23.975	44.03	Pk	34	-24.2	-9.5	44.33	54	-9.67	74	-29.67	H
3	25.107	44.37	Pk	34.3	-24.5	-9.5	44.67	54	-9.33	74	-29.33	H
4	21.017	43.97	Pk	33.2	-25.5	-9.5	42.17	54	-11.83	74	-31.83	V
5	25.387	44	Pk	34.3	-24.3	-9.5	44.5	54	-9.5	74	-29.5	V
6	24.988	44.2	Pk	34.2	-24.4	-9.5	44.5	54	-9.5	74	-29.5	V

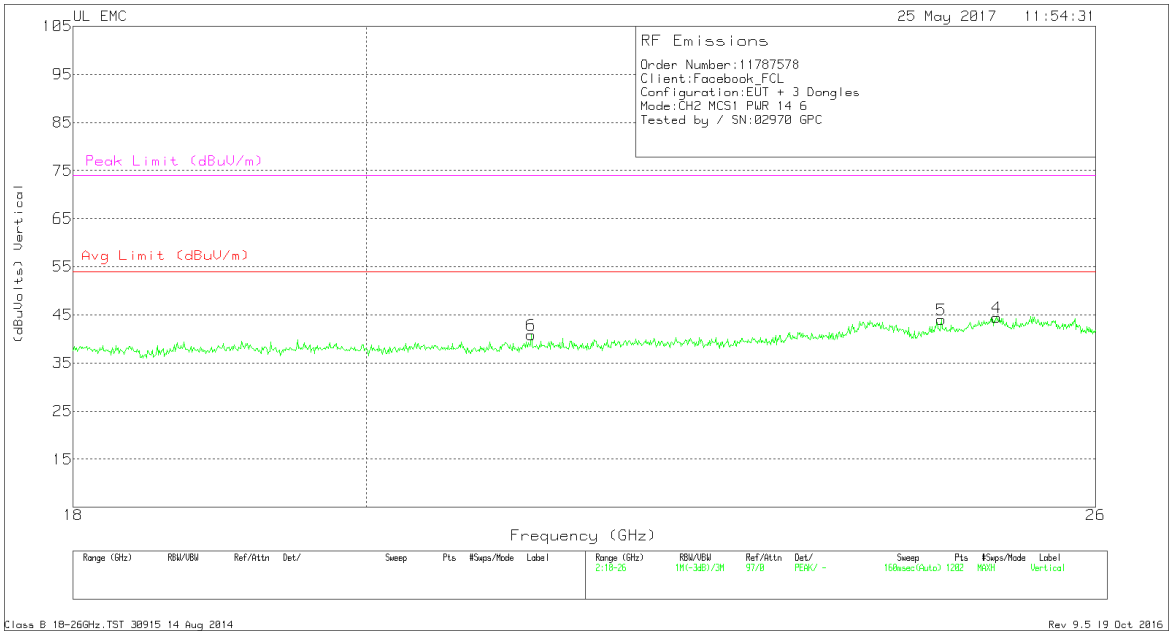
Pk - Peak detector

CHANNEL 2 - TX SPURIOUS EMISSION 18 TO 26 GHz (HORIZONTAL AND VERTICAL PLOTS)

Horizontal



Vertical



CHANNEL 2 -TX SPURIOUS EMISSION 18 TO 26 GHz

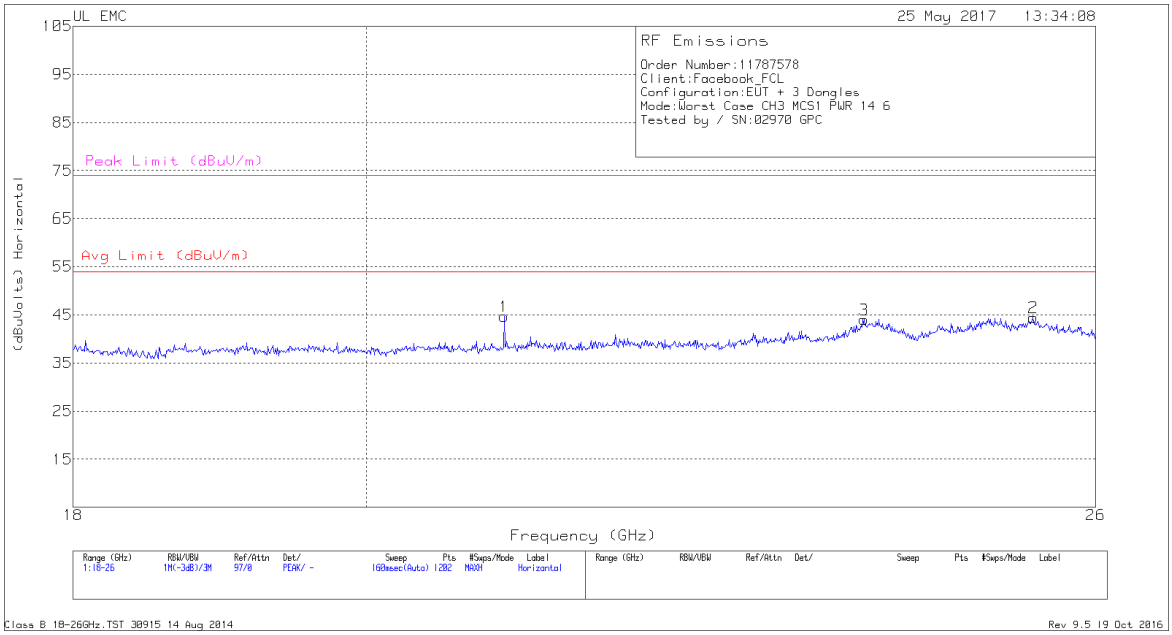
Trace Markers

Marker	Frequency (GHz)	Meter Reading (dBuV)	Det	AF T449 (dB/m)	Amp/Cbl (dB)	Dist Corr (dB)	Corrected Reading (dBuVolts)	Avg Limit (dBuV/m)	Avg Margin (dB)	Peak Limit (dBuV/m)	PK Margin (dB)	Polarity
1	25.414	43.67	Pk	34.3	-24.3	-9.5	44.17	54	-9.83	74	-29.83	H
2	23.928	43.67	Pk	34	-24	-9.5	44.17	54	-9.83	74	-29.83	H
3	23.349	42.7	Pk	33.6	-24.8	-9.5	42	54	-12	74	-32	H
4	25.087	44.2	Pk	34.3	-24.5	-9.5	44.5	54	-9.5	74	-29.5	V
5	24.595	43.5	Pk	34.1	-24.1	-9.5	44	54	-10	74	-30	V
6	21.224	42.23	Pk	33.1	-25	-9.5	40.83	54	-13.17	74	-33.17	V

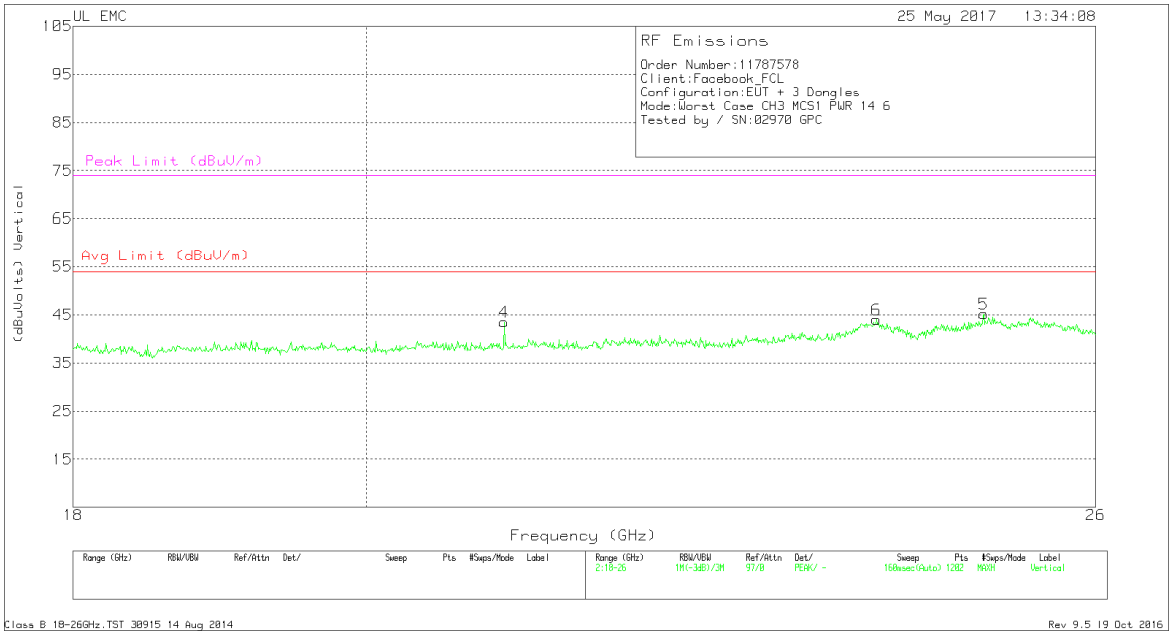
Pk - Peak detector

CHANNEL 3 - TX SPURIOUS EMISSION 18 TO 26 GHz (HORIZONTAL AND VERTICAL PLOTS)

Horizontal



Vertical



CHANNEL 3 -TX SPURIOUS EMISSION 18 TO 26 GHz

Trace Markers

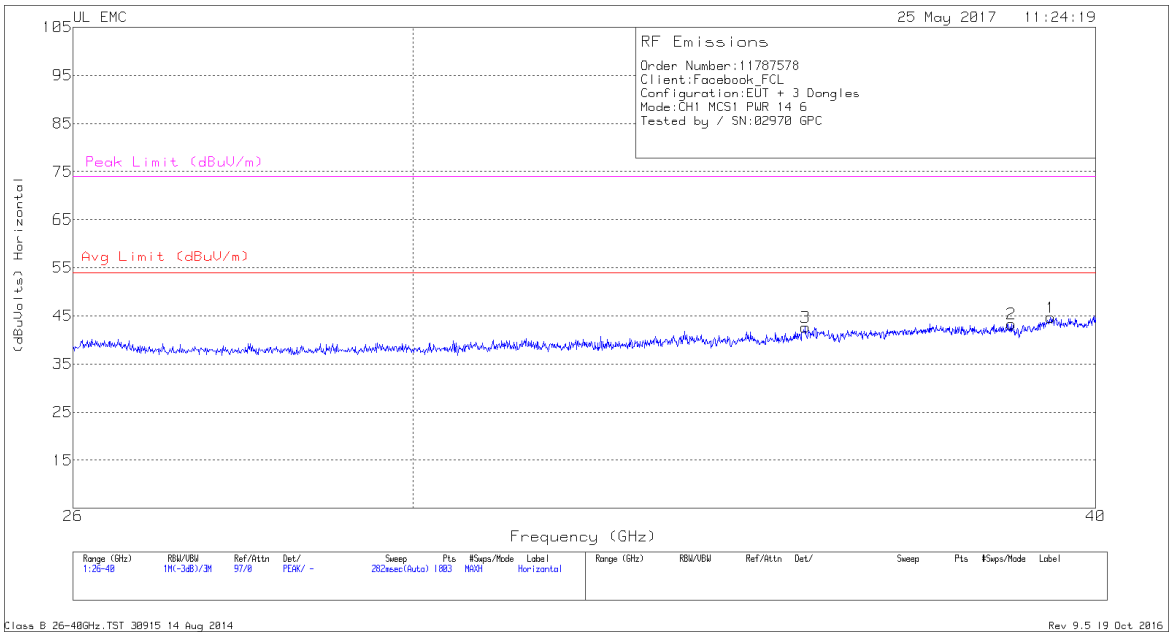
Marker	Frequency (GHz)	Meter Reading (dBuV)	Det	AF T449 (dB/m)	Amp/Cbl (dB)	Dist Corr (dB)	Corrected Reading (dBuVolts)	Avg Limit (dBuV/m)	Avg Margin (dB)	Peak Limit (dBuV/m)	PK Margin (dB)	Polarity
1	21.017	46.47	Pk	33.2	-25.5	-9.5	44.67	54	-9.33	74	-29.33	H
2	25.42	44	Pk	34.3	-24.3	-9.5	44.5	54	-9.5	74	-29.5	H
3	23.922	43.4	Pk	34	-23.9	-9.5	44	54	-10	74	-30	H
4	21.017	45.3	Pk	33.2	-25.5	-9.5	43.5	54	-10.5	74	-30.5	V
5	24.974	44.67	Pk	34.2	-24.2	-9.5	45.17	54	-8.83	74	-28.83	V
6	24.028	43.6	Pk	34	-24.1	-9.5	44	54	-10	74	-30	V

Pk - Peak detector

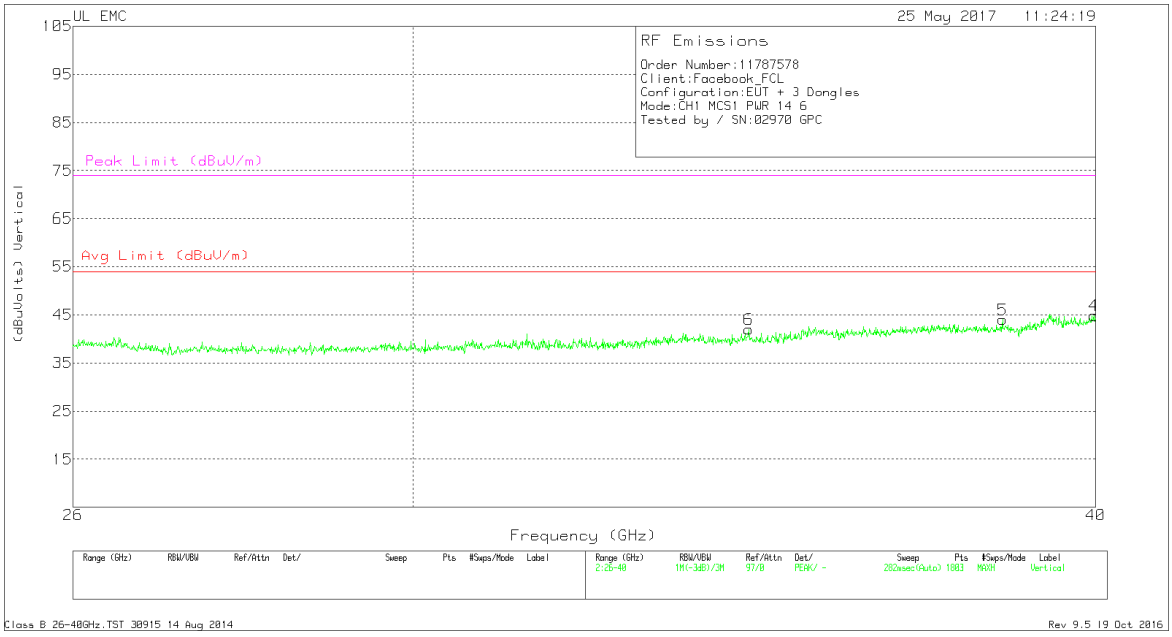
8.8.4. SPURIOUS EMISSION 26 TO 40 GHz

CHANNEL 1 - TX SPURIOUS EMISSION 26 TO 40 GHz (HORIZONTAL AND VERTICAL PLOTS)

Horizontal



Vertical



CHANNEL 1 - TX SPURIOUS EMISSION 26 TO 40 GHz

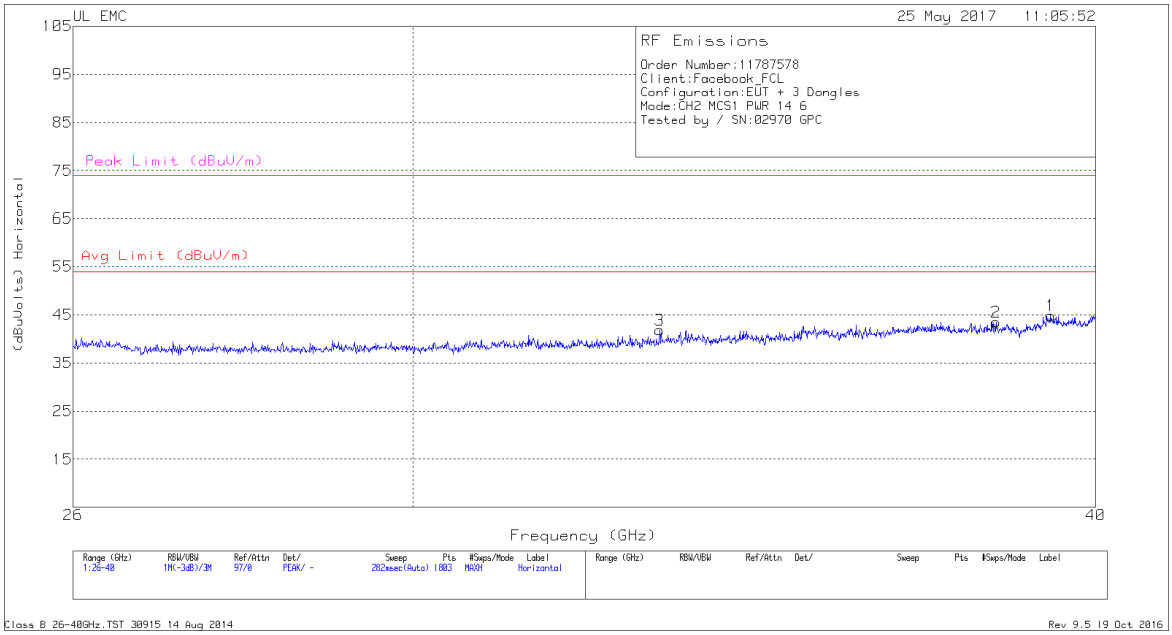
Trace Marker

Marker	Frequency (GHz)	Meter Reading (dBuV)	Det	T90 AF (dB/m)	Amp/Cbl (dB)	Dist Corr (dB)	Corrected Reading (dBuVolts)	Avg Limit (dBuV/m)	Avg Margin (dB)	Peak Limit (dBuV/m)	PK Margin (dB)	Polarity
1	39.246	47.97	Pk	38.6	-32.4	-9.5	44.67	54	-9.33	74	-29.33	H
2	38.602	49.13	Pk	36.9	-33.2	-9.5	43.33	54	-10.67	74	-30.67	H
3	35.393	48.47	Pk	37.8	-34.1	-9.5	42.67	54	-11.33	74	-31.33	H
4	39.969	48.03	Pk	37.5	-31.2	-9.5	44.83	54	-9.17	74	-29.17	V
5	38.462	49.8	Pk	37	-33.3	-9.5	44	54	-10	74	-30	V
6	34.562	47.9	Pk	37.4	-33.8	-9.5	42	54	-12	74	-32	V

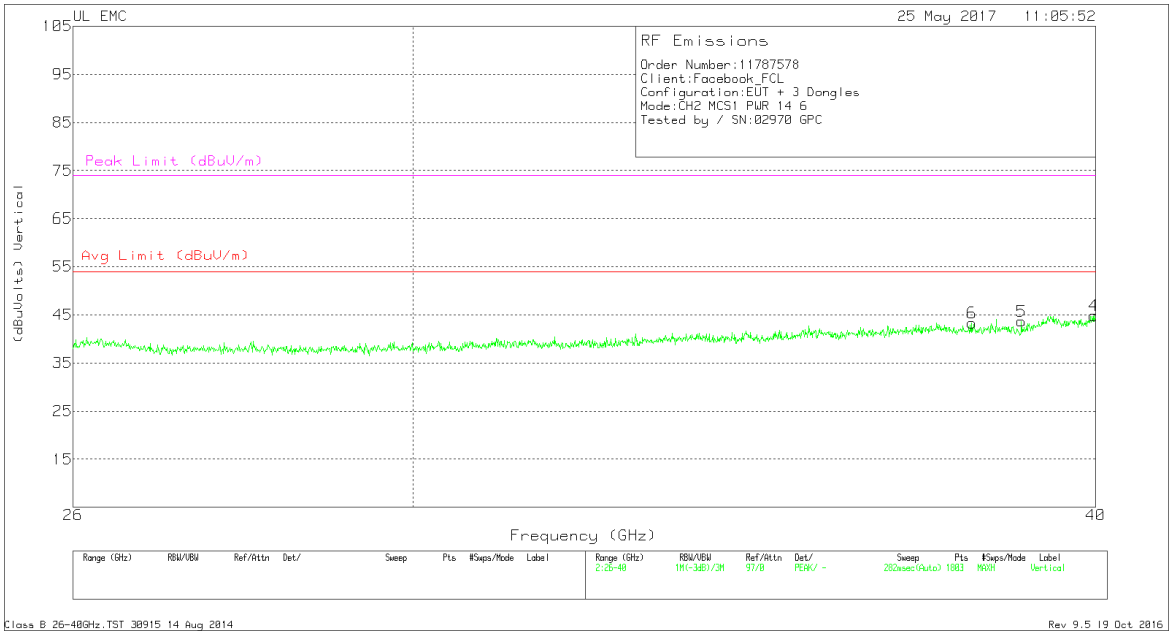
Pk - Peak detector

CHANNEL 2 - TX SPURIOUS EMISSION 26 TO 40 GHz (HORIZONTAL AND VERTICAL PLOTS)

Horizontal



Vertical



CHANNEL 2 - TX SPURIOUS EMISSION 26 TO 40 GHz

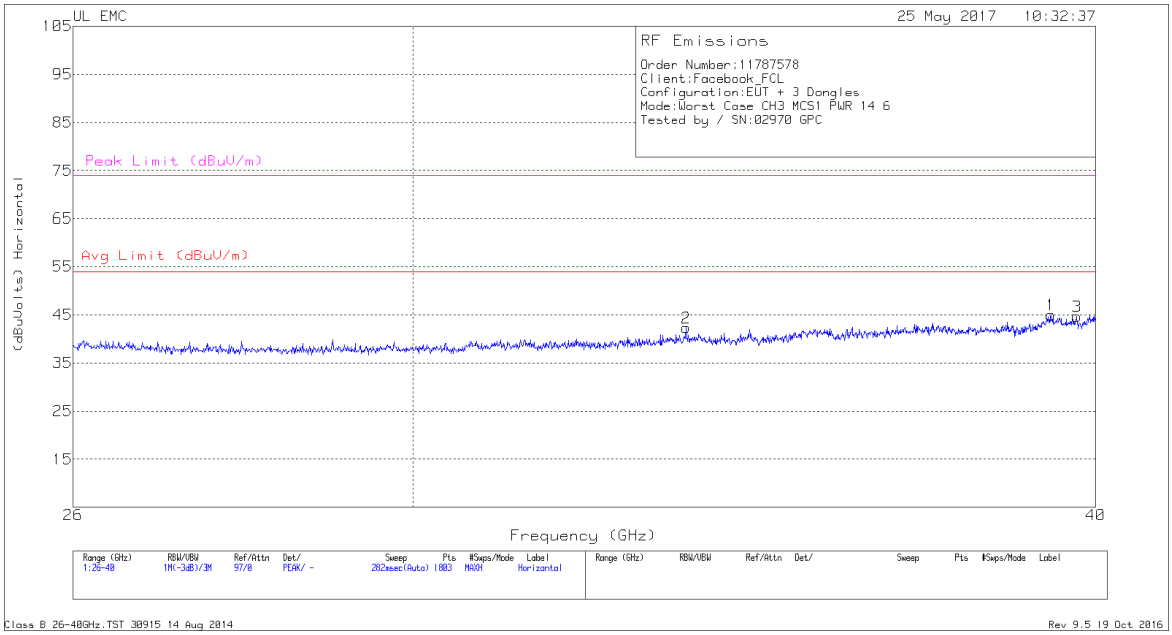
Trace Markers

Marker	Frequency (GHz)	Meter Reading (dBuV)	Det	T90 AF (dB/m)	Amp/Cbl (dB)	Dist Corr (dB)	Corrected Reading (dBuVolts)	Avg Limit (dBuV/m)	Margin (dB)	Peak Limit (dBuV/m)	PK Margin (dB)	Polarity
1	39.246	48.13	Pk	38.6	-32.4	-9.5	44.83	54	-9.17	74	-29.17	H
2	38.353	49.2	Pk	37.1	-33.3	-9.5	43.5	54	-10.5	74	-30.5	H
3	33.287	47.73	Pk	37	-33.4	-9.5	41.83	54	-12.17	74	-32.17	H
4	39.969	48.03	Pk	37.5	-31.2	-9.5	44.83	54	-9.17	74	-29.17	V
5	38.765	49.37	Pk	36.7	-32.9	-9.5	43.67	54	-10.33	74	-30.33	V
6	37.964	49.83	Pk	37.2	-34.2	-9.5	43.33	54	-10.67	74	-30.67	V

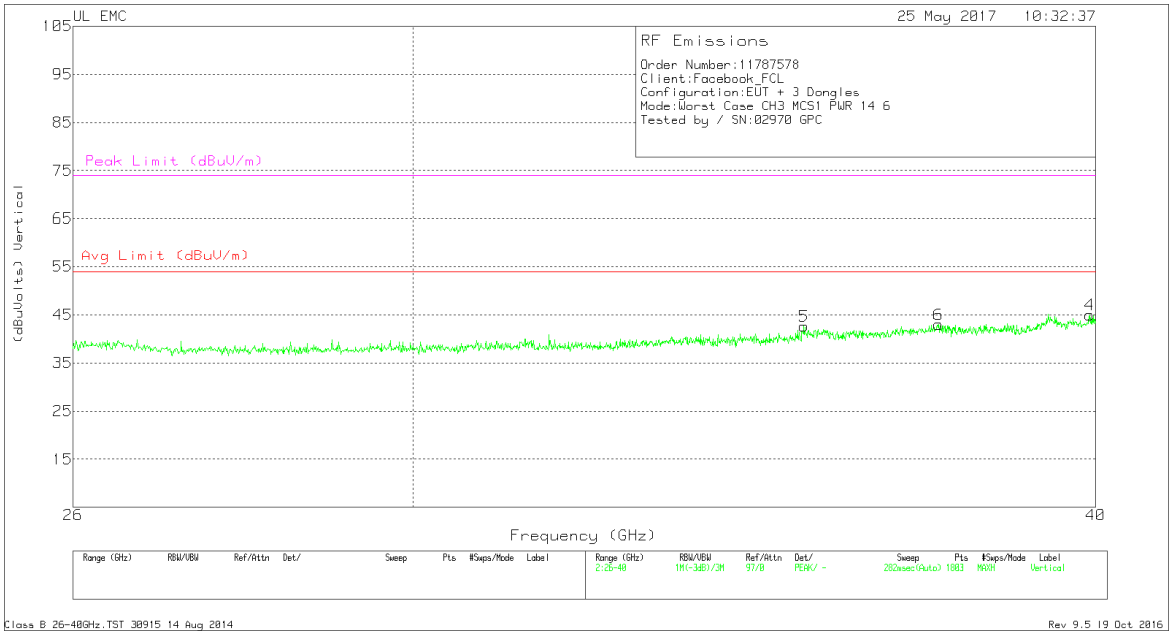
Pk - Peak detector

CHANNEL 3 - TX SPURIOUS EMISSION 26 TO 40 GHz (HORIZONTAL AND VERTICAL PLOTS)

Horizontal



Vertical



CHANNEL 3 - TX SPURIOUS EMISSION 26 TO 40 GHz

Trace Markers

Marker	Frequency (GHz)	Meter Reading (dBuV)	Det	T90 AF (dB/m)	Amp/Cbl (dB)	Dist Corr (dB)	Corrected Reading (dBuVolts)	Avg Limit (dBuV/m)	Avg Margin (dB)	Peak Limit (dBuV/m)	PK Margin (dB)	Polarity
1	39.254	48.3	Pk	38.6	-32.4	-9.5	45	54	-9	74	-29	H
2	33.66	48.13	Pk	36.9	-33.2	-9.5	42.33	54	-11.67	74	-31.67	H
3	39.681	48.77	Pk	37.2	-31.8	-9.5	44.67	54	-9.33	74	-29.33	H
4	39.899	48.3	Pk	37.4	-31.2	-9.5	45	54	-9	74	-29	V
5	35.37	48.27	Pk	37.8	-33.9	-9.5	42.67	54	-11.33	74	-31.33	V
6	37.436	49.5	Pk	37.3	-34.3	-9.5	43	54	-11	74	-31	V

Pk - Peak detector

8.8.5. SPURIOUS EMISSION 40 TO 200 GHz

CHANNEL 1, 2, and 3

No other higher emissions up to 200 GHz detected above the noise floor.

8.9. AC POWER LINE CONDUCTED EMISSIONS

LIMITS

§15.207

Frequency of emission (MHz)	Conducted limit (dBµV)	
	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

ANSI C63.10

RESULTS

WORST EMISSIONS

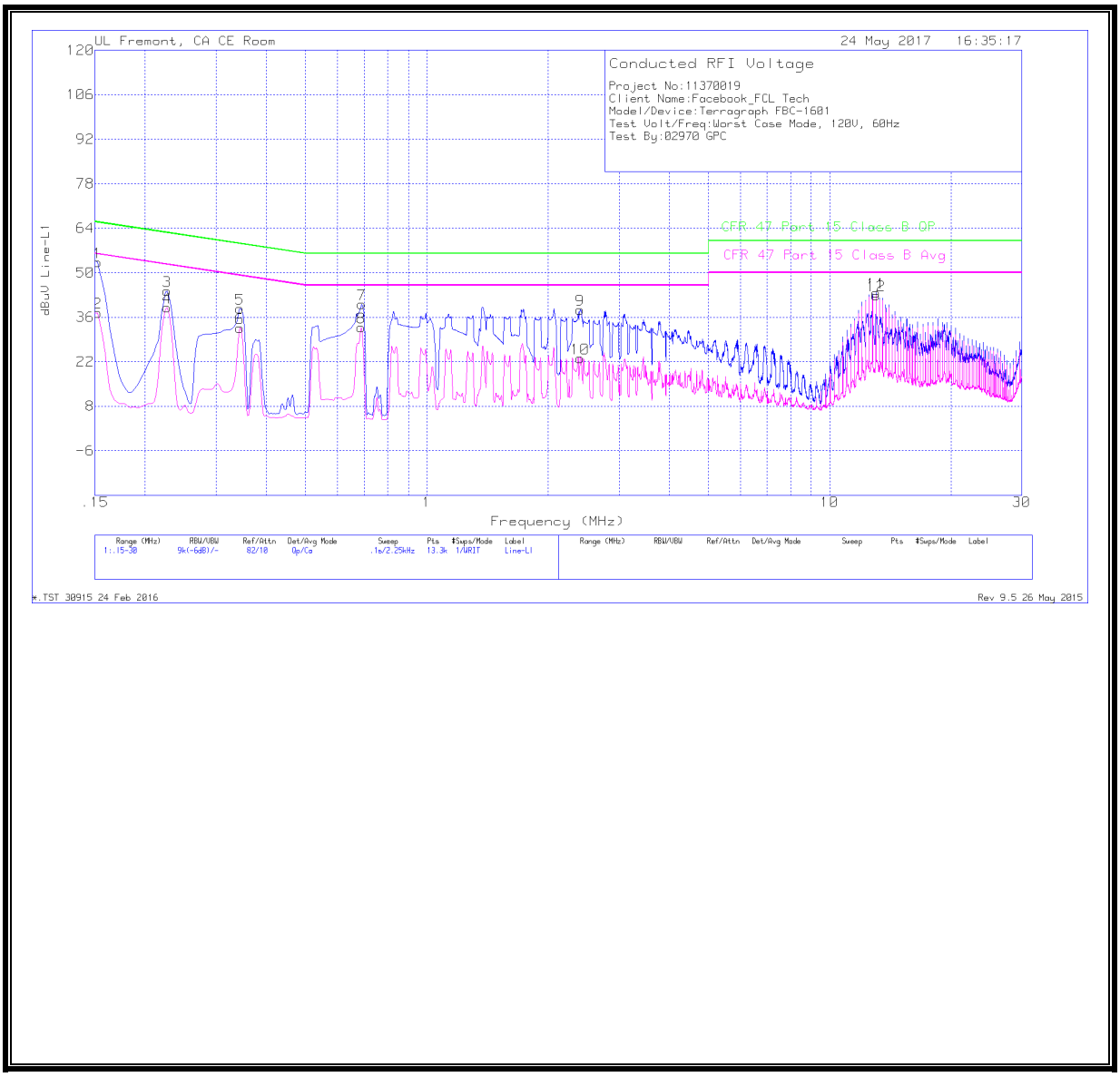
Range 1: Line-L1 .15 - 30MHz											
Marker	Frequency (MHz)	Meter Reading (dBuV)	Det	LISN L1	LC Cables C1&C3	Limiter (dB)	Corrected Reading dBuV	CFR 47 Part 15 Class B QP	QP Margin (dB)	CFR 47 Part 15 Class B Avg	Av(CISPR)Margin (dB)
1	.15225	43.07	Qp	.1	.1	10.1	53.37	65.88	-12.51	-	-
2	.15225	27.1	Ca	.1	.1	10.1	37.4	-	-	55.88	-18.48
3	.2265	34.14	Qp	0	.1	10.1	44.34	62.58	-18.24	-	-
4	.2265	28.82	Ca	0	.1	10.1	39.02	-	-	52.58	-13.56
5	.3435	28.51	Qp	0	.1	10.1	38.71	59.12	-20.41	-	-
6	.3435	22.36	Ca	0	.1	10.1	32.56	-	-	49.12	-16.56
7	.69	29.94	Qp	0	.1	10.1	40.14	56	-15.86	-	-
8	.68775	22.59	Ca	0	.1	10.1	32.79	-	-	46	-13.21
9	2.4045	28.14	Qp	0	.1	10.1	38.34	56	-17.66	-	-
10	2.4045	12.89	Ca	0	.1	10.1	23.09	-	-	46	-22.91
11	13.03575	33.31	Qp	.1	.2	10.2	43.81	60	-16.19	-	-
12	13.03575	32.32	Ca	.1	.2	10.2	42.82	-	-	50	-7.18

Range 2: Line-L2 .15 - 30MHz											
Marker	Frequency (MHz)	Meter Reading (dBuV)	Det	LISN L2	LC Cables C2&C3	Limiter (dB)	Corrected Reading dBuV	CFR 47 Part 15 Class B QP	QP Margin (dB)	CFR 47 Part 15 Class B Avg	Av(CISPR)Margin (dB)
13	.15225	42.7	Qp	0	0	10.1	52.8	65.88	-13.08	-	-
14	.15225	27.01	Ca	0	0	10.1	37.11	-	-	55.88	-18.77
15	.2265	34.65	Qp	0	.1	10.1	44.85	62.58	-17.73	-	-
16	.2265	29.78	Ca	0	.1	10.1	39.98	-	-	52.58	-12.6
17	.3435	34.15	Qp	0	.1	10.1	44.35	59.12	-14.77	-	-
18	.3435	27.99	Ca	0	.1	10.1	38.19	-	-	49.12	-10.93
19	.69	31.96	Qp	0	.1	10.1	42.16	56	-13.84	-	-
20	.68775	24.54	Ca	0	.1	10.1	34.74	-	-	46	-11.26
21	2.06925	28.76	Qp	0	.1	10.1	38.96	56	-17.04	-	-
22	2.06475	16.08	Ca	0	.1	10.1	26.28	-	-	46	-19.72
23	13.03575	33.61	Qp	.1	.2	10.2	44.11	60	-15.89	-	-
24	13.03575	32.41	Ca	.1	.2	10.2	42.91	-	-	50	-7.09

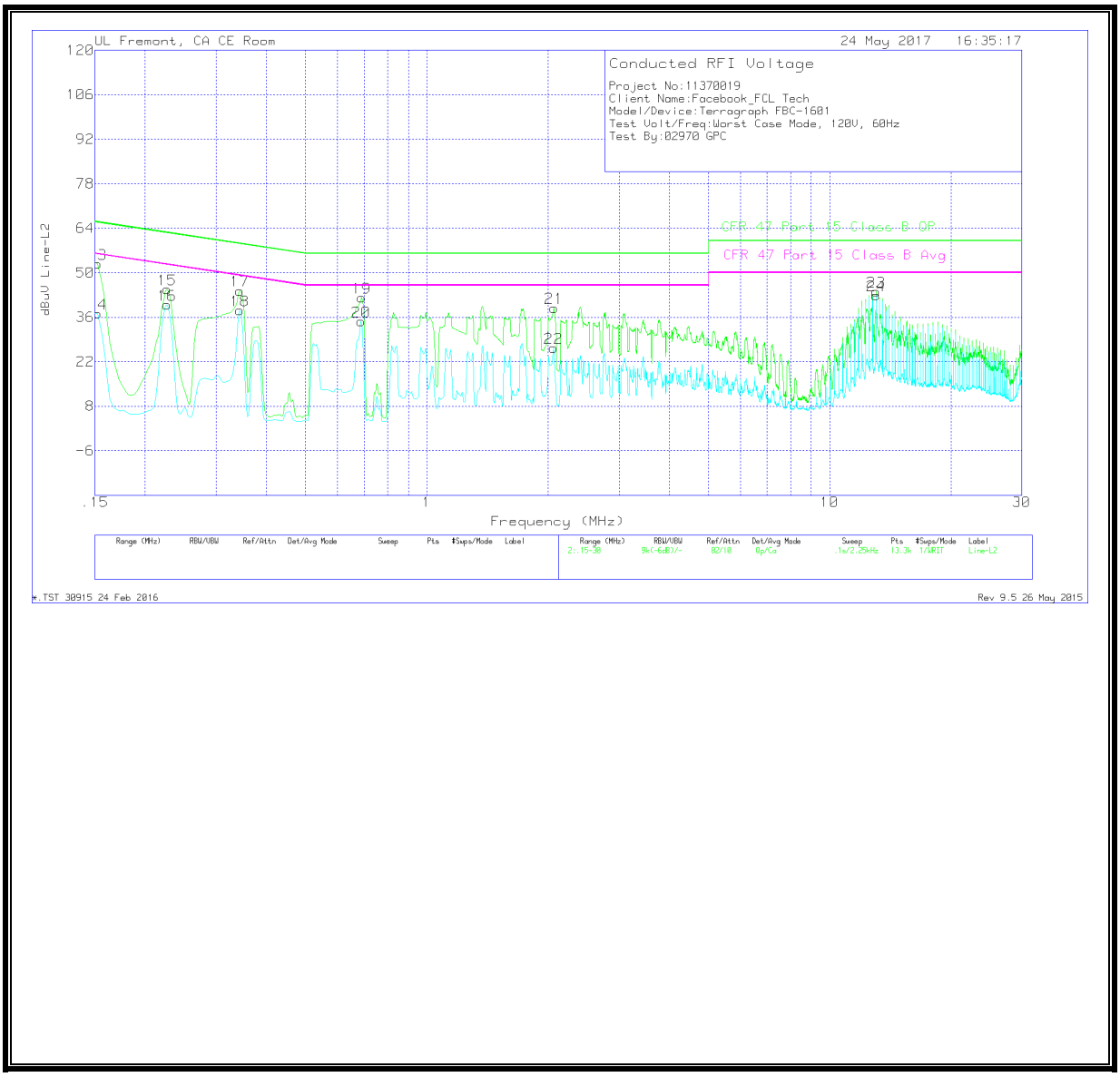
Qp - Quasi-Peak detector

Ca - CISPR average detection

LINE 1 RESULTS



LINE 2 RESULTS



9. GROUP INSTALLATION

LIMIT

§15.255 (g) Any transmitter that has received the necessary FCC equipment authorization under the rules of this chapter may be mounted in a group installation for simultaneous operation with one or more other transmitter(s) that have received the necessary FCC equipment authorization, without any additional equipment authorization. However, no transmitter operating under the provisions of this section may be equipped with external phase-locking inputs that permit beam-forming arrays to be realized.

RESULTS

The frequency, amplitude and phase of the transmit signal are set within the EUT. There are no external phase-locking inputs or any other means of combining two or more units together to realize a beam-forming array.