SELECTED PORTIONS OF CFR 47 PART 15 SUBPART C §15.255

TEST REPORT

FOR

60 GHz OUTDOOR POINT-TO-MULTIPOINT TDD RADIO MESH

MODEL NUMBER: CE04

FCC ID: 2AAAS-CE04

REPORT NUMBER: 12393320-E1V2

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PREPARED FOR

National Technical Systems
41039 Boyce Road
Fremont, CA 94538, USA

ON BEHALF OF

VIVINT, INC.
4931 N. 300 West,
Provo, UT 84604, USA

Prepared by

UL VERIFICATION SERVICES INC
47173 BENICIA STREET
FREMONT, CA 94538, U.S.A.
TEL: (510) 771-1000
FAX: (510) 661-0888

NVLAP LAB CODE 200065-0

Revision History

Rev.	Issue Date	Revisions	Revised By
V1	8/9/2018	Initial Issue	Michael Heckrotte
V2	11/6/2018	Changed typo “Mash” to “Mesh” Removed Test Setup Photos Updated wordings on Section 6.1	Michael Heckrotte

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1. ATTESTATION OF TEST RESULTS

COMPANY NAME:	VIVINT, INC 4931 N. 300 WEST, PROVO, UT 84604, USA.
EUT DESCRIPTION:	60 GHz OUTDOOR POINT-TO-MULTIPOINT TDD RADIO MESH
MODEL:	CE04
SERIAL NUMBER:	0191803100040C
DATE TESTED:	JULY 5th & 6TH, 2018

APPLICABLE STANDARDS	
STANDARD	**TEST RESULTS**
Selected portions of CFR 47 Part 15 Subpart C §15.255	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.

Approved & Released For
UL Verification Services Inc. By:

MICHAEL HECKROTTE
PRINCIPAL ENGINEER
UL Verification Services Inc.

Prepared By:

GIA-PIAO CHIN
TEST ENGINEER
UL Verification Services Inc.

2. TEST METHODOLOGY

The tests documented in this report were performed in accordance with ANSI C63.10-2013 and FCC CFR 47 Part 15.

3. FACILITIES AND ACCREDITATION

The test sites and measurement facilities used to collect data are located at 47266 Benicia Street, Fremont, California, USA.

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.

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. 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%.

5. SCOPE OF TESTS PERFORMED

This report contains measurement data listed below:

1. Duty Cycle
2. Bandwidths (6dB Bandwidth, 99% & 26dB Bandwidths)
3. Peak Radiated EIRP & Average Radiated EIRP
4. Peak Conducted Power
5. Tx Spurious Emissions, 40 – 200 GHz

6. EQUIPMENT UNDER TEST

6.1. MANUFACTURER'S DESCRIPTION OF EUT

The Vivint Inc model CE04 is an outdoor 802.11ad (Multi)Point-to-Multipoint TDD transceiver, operating within the 57 – 64 GHz band, that is designed to provide fast network services to homes in rural environment. It is powered by PoE or direct 48 VDC adapter.

It also contains a 2.4 GHz 11bgn Wi-Fi transceiver for management purposes, which is not covered under this report.

The antenna system consists of two integral phased array antenna elements provided in each of the four directions. Each phased array antenna element has 30 antennas (4 faces of 60 (2x30) antennas = 240 total antennas). The antenna gain is 23 dBi.

6.2. OUTPUT POWER

The phase-array antenna pair is integral thus radiated measurements are made. The EIRP was measured at the worst-case condition, thus the EIRP measurement conditions correspond to the maximum EUT antenna gain. Therefore the maximum antenna gain of 23 dBi is used to calculate the Peak Output Power.

The peak conducted output power for Channel 1 is 8.7 dBm (7.41 mW).
The peak conducted output power for Channel 2 is 17.5 dBm (56.23 mW).
The peak conducted output power for Channel 3 is 17.6 dBm (57.54 mW).

6.3. DESCRIPTION OF TEST SETUP

SUPPORT EQUIPMENT

PERIPHERAL SUPPORT EQUIPMENT LIST			
Description	**Manufacturer**	**Model**	**Serial Number**
PoE Injector	Phihong	POE50U-560DG	P71304366A1
Ethernet Switch	TP-Link	TL-SG105E	2173509004882
Switch Power Supply	TP-Link	T090060-2C1	-
Laptop	HP	Probook	5cg5284dsw
Laptop Power Supply	HP	756413-003	WECJQ0CAR19CMW

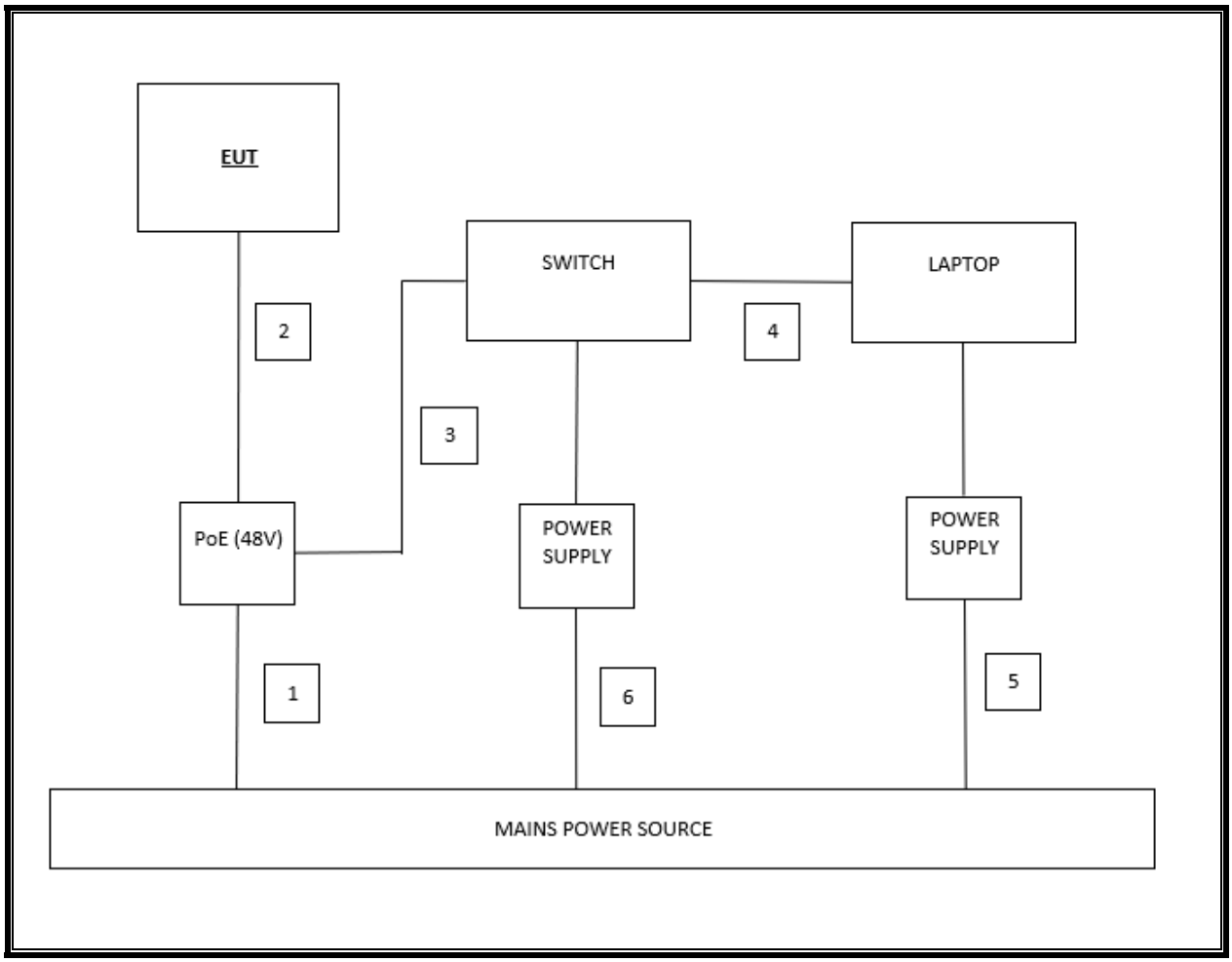
I/O CABLES

I/O Cable List						
Cable No	**Port**	**# of Identical Ports**	**Connector Type**	**Cable Type**	**Cable Length (m)**	**Remarks**
1	DC	1	2 Wire	Shielded	2	PoE - Main
2	Ethernet	1	RJ45	Shielded	2	PoE - EUT
3	Ethernet	1	Cat 6	Shielded	10	PoE - Switch
4	Ethernet	1	Cat 6	Shielded	10	Laptop - Switch
5	DC	1	2 Wire	Unshielded	2	Laptop - Main
6	DC	1	3 Wire	Unshielded	2	Switch - Main

TEST SETUP

A support Laptop was connected to the EUT via an ethernet switch and PoE for programming the test mode.

SETUP DIAGRAM FOR TESTS



During testing, one radio, from one quadrant, was transmitting at maximum power on the individual V-band channel.

The 2.4 GHz 11bgn Wi-Fi transceiver was turned off.

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	8/7/2018
Horn antenna, 33-50 GHz	CMI	HO22R	--	--	CNR
LNA, 40-50 GHz	Spacek Labs	SL4510-33-4W	14J05	1099	8/14/2018
Horn Antenna, 50-75 GHz	CMI	HO15R	--	--	CNR
LNA, 50-75 GHz	Vivatech	VTLNA-15-6018-FB	2013051	--	8/29/2018
Harmonic Mixer, 50-80 GHz	Keysight	M1970V	MY51390830	994	8/16/2018
Horn Antenna, 75-110 GHz	CMI	HO10R	--	--	CNR
LNA, 75-110 GHz	Spacek	SLW-22-5	15J04	1600079	8/30/2018
Harmonic Mixer, 75-110 GHz	Keysight	M1970W	MY51430784	993	8/16/2018
Horn Antenna, 110-170 GHz	CMI	HO6R	--	--	CNR
LNA, 110-170 GHz	Vivatech	VTLNA-06S01	2015085	--	8/31/2018
Harmonic Mixer, 110-170 GHz	OML	M06HWDXA	F90519-2	150918-1	8/14/2018
Horn Antenna, 170-260 GHz	CMI	HO4R	--	--	CNR
Harmonic Mixer, 170-260 GHz	OML	M04HWDXA	150918-1	--	8/14/2018
Digital Signal Analyzer, 8 GHz	Agilent	DSA90804A	MY51420139	215	9/18/2018
Low Pass Filter, 10 MHz	Solar Electric Co.	6623-10	136101	417	7/30/2018
P-Series Power Meter	Keysight	N1913A	MY53100006	412	3/5/2019
Power Sensor, 50-75 GHz	Agilent	V8486-H02	MY52300008	433	8/25/2018
RF Detector, 50-75 GHz	Spacek Labs	DV-2P	17A27	--	CNR
Analog Signal Generator, 40 GHz	Agilent	E8257D	MY48050681	181	8/3/2018

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. DUTY CYCLE

LIMIT

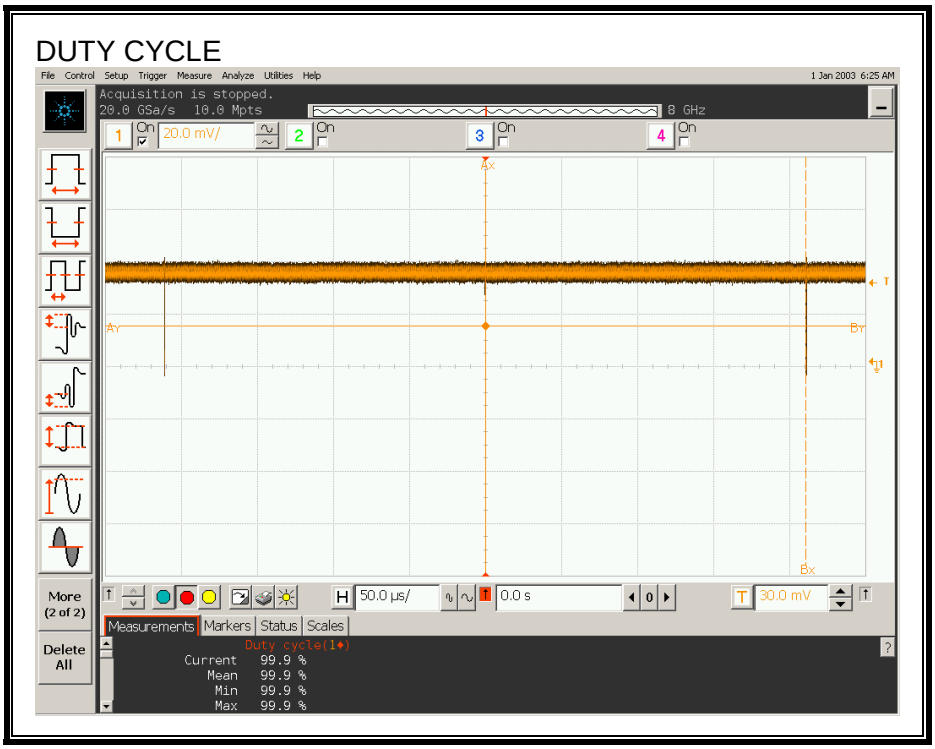
None; for reporting purposes only.

TEST PROCEDURE

An antenna, located approximately 3m from the EUT, was connected to the input of an 50-75 GHz 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.

RESULT

Duty Cycle Correction Factor = 10 * Log (0.999) = 0.004 dB



8.2. 6 dB BANDWIDTH

APPLICABLE RULE

§15.255 (e) (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

ANSI C63.10 Clause 9.3

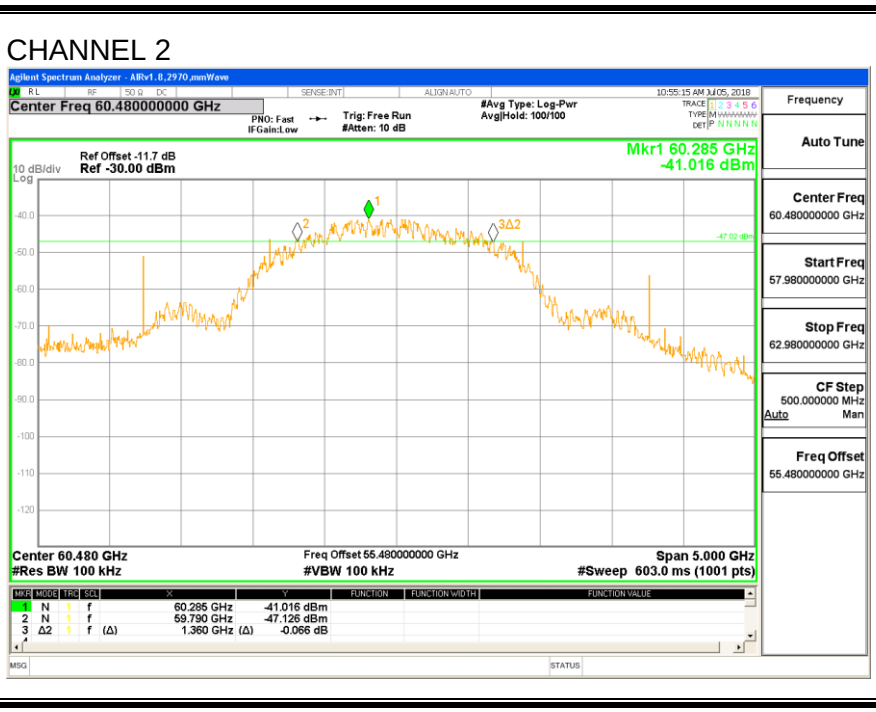
RESULTS

Channel	Frequency (GHz)	6 dB Bandwidth (GHz)
1	58.32	1.290
2	60.48	1.360
3	62.64	1.165

6 dB BANDWIDTH

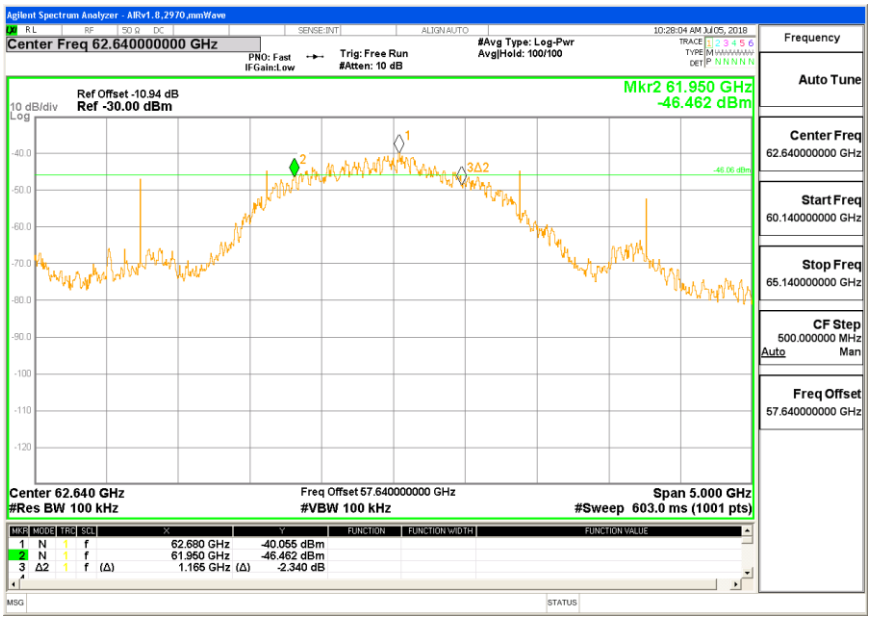
CHANNEL 1

CHANNEL 2



6 dB BANDWIDTH

CHANNEL 3



8.3. 99% and 26 dB BANDWIDTHS

LIMIT

None; for reporting purposes only.

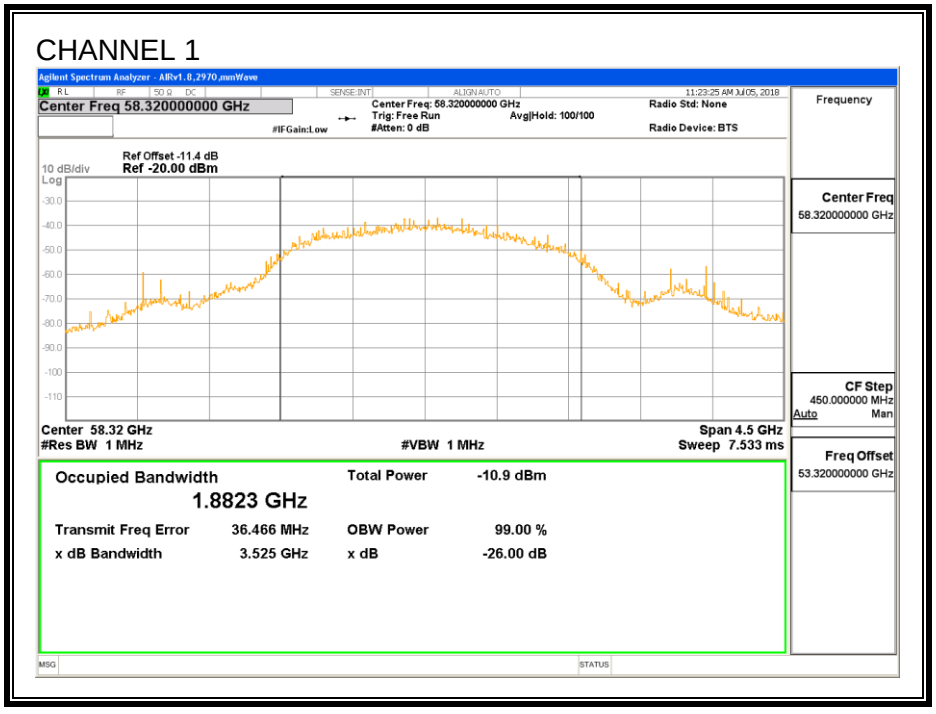
TEST PROCEDURE

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

RESULTS

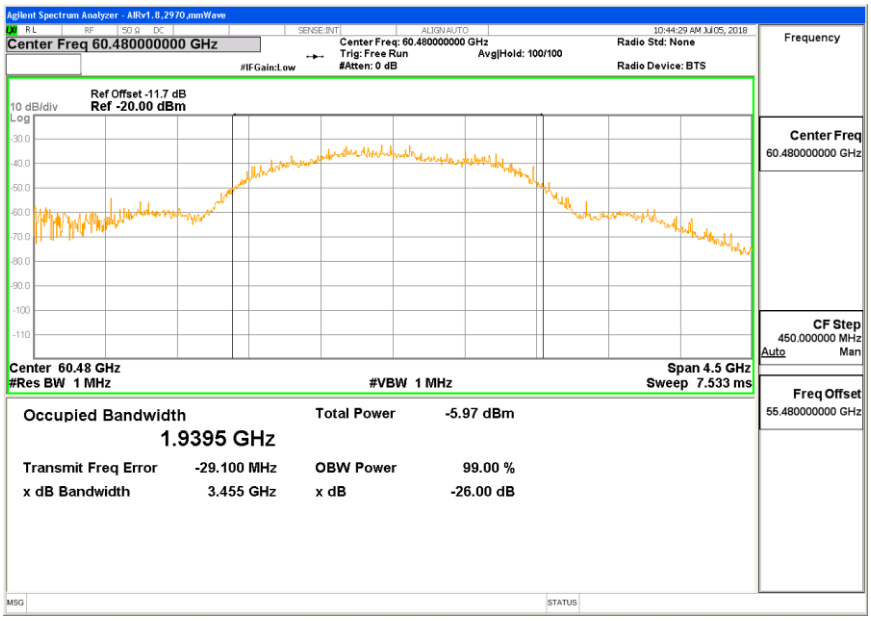
Channel	Frequency (GHz)	99% Bandwidth (GHz)	26 dB Bandwidth (GHz)
1	58.32	1.8823	3.5250
2	60.48	1.9395	3.4550
3	62.64	1.9345	3.5270

CHANNEL 1

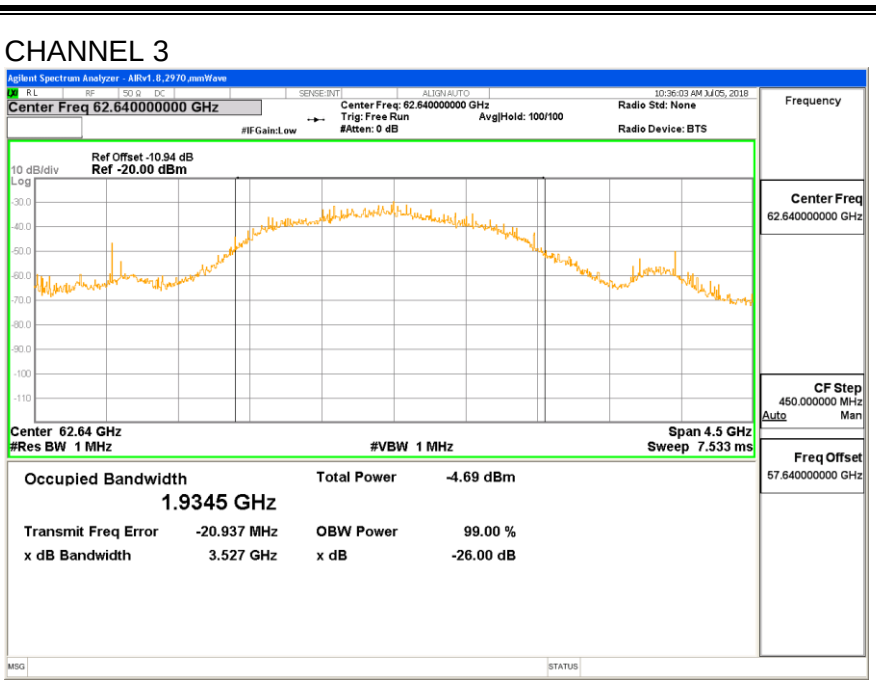


99% and 26 dB BANDWIDTH

CHANNEL 2



CHANNEL 3



8.4. PEAK AND AVERAGE RADIATED POWER

LIMIT

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

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

§ 15.255 (c) (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

TEST PROCEDURE

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

The dimension of integral patch-array antenna is 24mm x 24mm.

Channel	Frequency (GHz)	L (m)	Lambda (m)	R (Far Field) (m)
1	58.32	0.034	0.0051	0.45
2	60.48	0.034	0.0050	0.46
3	62.64	0.034	0.0048	0.48

Radiated power measurements are performed at a 3 meter test distance.

RESULTS

PEAK EIRP

Center Frequency (GHz)	CH	Meas. Dist. (m)	Measured Peak Voltage (mV)	Measured Power (dBm)	Waveguide Loss (dB)	Received Power (dBm)	Rx Ant. Gain (dBi)	EIRP (dBm)	EIRP Limit (dBm)	Margin (dB)	Pass Or Fail
58.32	1	3	24.82	-23.2	0.6	-22.6	23	31.7	43	-11.3	Pass
60.48	2	3	110.3	-14.7	0.6	-14.1	23	40.5	43	-2.5	Pass
62.64	3	3	98.3	-14.9	0.6	-14.3	23	40.6	43	-2.4	Pass

AVERAGE EIRP

Center Frequency (GHz)	CH	Meas. Dist. (m)	Duty Cycle %	Measured Avg Voltage (mV)	Measured Power (dBm)	Waveguide Loss (dB)	Received Power (dBm)	Rx Ant. Gain (dBi)	Duty Cycle Corr Fac (dB)	EIRP (dBm)	EIRP Limit (dBm)	Margin (dB)	Pass Or Fail
58.32	1	3	99.9	19.93	-24.5	0.6	-23.9	23	0.004	30.4	40	-9.6	Pass
60.48	2	3	99.9	95.34	-15.8	0.6	-15.2	23	0.004	39.4	40	-0.6	Pass
62.64	3	3	99.9	86.33	-15.8	0.6	-15.2	23	0.004	39.7	40	-0.3	Pass

8.5. PEAK CONDUCTED OUTPUT POWER

LIMIT

§15.255 (e) Except as specified paragraph (e) (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 (e) (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

ANSI C63.10 Clause 9.7

RESULTS

PEAK OUTPUT POWER

Frequency (GHz)	CH	Peak EIRP (dBm)	EUT Ant. Gain (dBi)	Output Power (dBm)	Output Power (mW)	Limit (mW)	Margin (mW)	Pass Or Fail
58.32	1	31.7	23.0	8.70	7.41	500	-493	Pass
60.48	2	40.5	23.0	17.50	56.23	500	-444	Pass
62.64	3	40.6	23.0	17.60	57.54	500	-442	Pass

8.6. TX SPURIOUS EMISSIONS, 40 – 200 GHz

LIMITS

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

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

TEST PROCEDURE

ANSI C63.10 Clause 9.12

RESULTS

Channel 1

Average EIRP				
Frequency (GHz)	**Measurement Distance (m)**	**Measured Power (dBm)**	**Total Receiving Gain (dBi)**	
56.56	3	-67.54	21.24	
Duty Cycle Factor Corr. Factor (dB)	**EIRP (dBm)**	**EIRP (W)**	**Specification Distance (m)**	
0.004	-11.75	0.00006690	3	
Power Density (W/m^2)	**Power Density (pW/cm^2)**	**Limit (pW/cm^2)**	**Margin (pW/cm&^2)**	**Pass or Fail**
0.0000005918	59.18	90.00	-30.82	Pass

No other emissions detected in the following bands:
40 - 57 GHz

No emissions detected in the following bands:
71 - 200 GHz

Channel 2 & Channel 3

No emissions detected in the following bands:
40 - 57 GHz
71 - 200 GHz