

FCC Test Report

Report No.: RF200204C24-4

FCC ID: A4R-G4CVZ

Test Model: G4CVZ

Received Date: Feb. 04, 2020

Test Date: Mar. 20 to June 16, 2020

Issued Date: June 24, 2020

Applicant: GOOGLE LLC

Address: 1600 Amphitheatre Parkway Mountain View, CA 94043

Issued By: Bureau Veritas Consumer Products Services (H.K.) Ltd., Taoyuan Branch
Hsin Chu Laboratory

Lab Address: E-2, No.1, Li Hsin 1st Road, Hsinchu Science Park, Hsinchu City 300,
Taiwan

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**FCC Registration /
Designation Number:** 723255 / TW2022

Test Lab (B): Bureau Veritas Consumer Products Services (H.K.) Ltd., Taoyuan Branch
Lin Kou Laboratories

Test Location: No.19, Hwa Ya 2nd Rd., Wen Hwa Vil., Kwei Shan Dist., Taoyuan City
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**FCC Registration /
Designation Number:** 788550 / TW0003



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Release Control Record

Issue No.	Description	Date Issued
RF200204C24-4	Original release.	June 24, 2020

1 Certificate of Conformity

Product: Thermostat

Test Model: G4CVZ

Sample Status: Engineering Sample

Applicant: GOOGLE LLC

Test Date: Mar. 20 to June 16, 2020

Standards: 47 CFR FCC Part 15, Subpart C (Section 15.255)
ANSI C63.10: 2013

The above equipment has been tested by **Bureau Veritas Consumer Products Services (H.K.) Ltd., Taoyuan Branch**, and found compliance with the requirement of the above standards. The test record, data evaluation & Equipment Under Test (EUT) configurations represented herein are true and accurate accounts of the measurements of the sample's EMC characteristics under the conditions specified in this report. This report contains AC Line Conducted Emissions test data that was produced under subcontract by Bureau Veritas Consumer Products Services (H.K.) Ltd., Taoyuan Branch Lin Kou Laboratories.

Prepared by : Phoenix Huang , **Date:** June 24, 2020
Phoenix Huang / Specialist

Approved by : Wen Yu , **Date:** June 24, 2020
Wen Yu / Supervisor

2 Summary of Test Results

Standard	Test Items	Limit	Test Procedure	Note	Remarks
§15.255 (f)	20 dB Bandwidth	61 -61.5 GHz	ANSI 63.10		Meet the requirement of limit.
§15.255 (f)	Frequency Stability	61 -61.5 GHz	ANSI 63.10	Extreme Temperature: -20, +50 °C	Meet the requirement of limit.
§15.255 (e)	6 dB Bandwidth / OBW	Reporting Purposes Only	ANSI 63.10		Reference only.
-	Duty Cycle	Reporting Purposes Only	ANSI 63.10		Reference only.
§15.255 (c)(2)	Peak EIRP	43 dBm	Substitution Method		Meet the requirement of limit.
§15.255 (c)(2)	Average EIRP	40 dBm	Substitution Method		Meet the requirement of limit.
-	Peak PSD	Reporting Purposes Only	ANSI 63.10		Reference only.
§15.255 (d)(2)	30 MHz - 40 GHz Radiated Emissions	74dBuV/m for Peak 54dBuV/m for Average	ANSI 63.10		Meet the requirement of limit. Minimum passing margin is -6.1 dB at 17913.30 MHz.
§15.255 (d)(3)	40 GHz - 200 GHz Radiated Emissions	90 pW/cm ²	ANSI 63.10	-10dBm EIRP at 3m	
§15.207	AC Line Conducted Emissions	Refer §15.207	ANSI 63.10		Meet the requirement of limit. Minimum passing margin is -28.92 dB at 25.02825 MHz.
§15.255 (g) / §1.1310(e)	RF Exposure	Refer §1.1310(e)	Calculation Only		See Note 2

Note:

1. Determining compliance based on the results of the compliance measurement, not taking into account measurement instrumentation uncertainty.
2. The " RF Exposure" was recorded in another test report.

2.1 Measurement Uncertainty

Where relevant, the following measurement uncertainty levels have been estimated for tests performed on the EUT as specified in CISPR 16-4-2:

Measurement	Frequency	Expanded Uncertainty (k=2) (±)
Conducted Emissions at mains ports	150kHz ~ 30MHz	2.8 dB
Radiated Emissions up to 1 GHz	30MHz ~ 1GHz	5.1 dB
Radiated Emissions above 1 GHz	1GHz ~ 6GHz	5.1 dB
	18GHz ~ 40GHz	5.3 dB
	40GHz ~ 200GHz	5.4 dB

2.2 Modification Record

There were no modifications required for compliance.

3 General Information

3.1 General Description of EUT

Product	Thermostat
Test Model	G4CVZ
Status of EUT	Normal Operating Condition
Battery Nominal Voltage	3 Vdc
Battery Voltage Operation Range	2.55 – 3.45 Vdc
Modulation Type	FMCW
Modulation Technology	Pulse
Transfer Rate	N/A
Operating Frequency	61 – 61.5 GHz
Antenna Type	Microstrip Patch ☒ Integral ☐ External
Antenna Connector	NA
Antenna Gain	5 dBi, ☒ Specified by manufacturer ☐ Measured
Test sequence / test software used:	See 3.2 Description of Test Modes
Output Power (EIRP)	15.27 dBm
Accessory Device	Refer to Notes as below
Data Cable Supplied	Refer to Notes as below

Note:

1. The above EUT information is declared by manufacturer and for more detailed features description, please refer to the manufacturer's specifications or user's manual.

3.2 Description of Test Modes

Frequency Range (GHz)	Channel	Frequency (GHz)	Duty Cycle
61 – 61.5	1	61.25	0.89%

3.2.1 Test Mode Applicability and Tested Channel Detail

EUT CONFIGURE MODE	APPLICABLE TO										DESCRIPTION
	DC	RE ≥ 1G	RE < 1G	PLC	6dB BW	20dB BW	FS	99% BW	OP	PSD	
1	√	√	√	√	√	√	√	√	√	√	Duty Cycle 0.89%

Where DC: Duty Cycle

RE < 1G: Radiated Emission below 1GHz

6dB BW: 6dB Bandwidth

FS: Frequency Stability

OP: Output Power

RE ≥ 1G: Radiated Emission above 1GHz

PLC: Power Line Conducted Emission

20dB BW: 20dB Bandwidth

99% BW: 99% Bandwidth

PSD: Power Spectral Density

Note: The EUT had been pre-tested on the positioned of each 3 axis. The worst case was found when positioned on **Y-plane**.

Duty Cycle Test:

- ☒ Pre-Scan has been conducted to determine the worst-case mode from all possible combinations between available modulations, data rates and antenna ports (if EUT with antenna diversity architecture).

- ☒ Following channel(s) was (were) selected for the final test as listed below.

Available Mode	Tested Mode	Modulation Technology	Modulation Type
1	1	Pulse	FMCW

Radiated Emission Test (Above 1GHz):

- ☒ Pre-Scan has been conducted to determine the worst-case mode from all possible combinations between available modulations, data rates and antenna ports (if EUT with antenna diversity architecture).

- ☒ Following channel(s) was (were) selected for the final test as listed below.

Available Mode	Tested Mode	Modulation Technology	Modulation Type
1	1	Pulse	FMCW

Radiated Emission Test (Below 1GHz):

- ☒ Pre-Scan has been conducted to determine the worst-case mode from all possible combinations between available modulations, data rates and antenna ports (if EUT with antenna diversity architecture).

- ☒ Following channel(s) was (were) selected for the final test as listed below.

Available Mode	Tested Mode	Modulation Technology	Modulation Type
1	1	Pulse	FMCW

Power Line Conducted Emission Test:

- ☒ Pre-Scan has been conducted to determine the worst-case mode from all possible combinations between available modulations, data rates and antenna ports (if EUT with antenna diversity architecture).

- ☒ Following channel(s) was (were) selected for the final test as listed below.

Available Mode	Tested Mode	Modulation Technology	Modulation Type
1	1	Pulse	FMCW

6dB Bandwidth Test:

- ☒ Pre-Scan has been conducted to determine the worst-case mode from all possible combinations between available modulations, data rates and antenna ports (if EUT with antenna diversity architecture).
- ☒ Following channel(s) was (were) selected for the final test as listed below.

Available Mode	Tested Mode	Modulation Technology	Modulation Type
1	1	Pulse	FMCW

20dB Bandwidth test:

- ☒ Pre-Scan has been conducted to determine the worst-case mode from all possible combinations between available modulations, data rates and antenna ports (if EUT with antenna diversity architecture).
- ☒ Following channel(s) was (were) selected for the final test as listed below.

Available Mode	Tested Mode	Modulation Technology	Modulation Type
1	1	Pulse	FMCW

Frequency stability test:

- ☒ Pre-Scan has been conducted to determine the worst-case mode from all possible combinations between available modulations, data rates and antenna ports (if EUT with antenna diversity architecture).
- ☒ Following channel(s) was (were) selected for the final test as listed below.

Available Mode	Tested Mode	Modulation Technology	Modulation Type
1	1	Pulse	FMCW

99% Bandwidth Test:

- ☒ Pre-Scan has been conducted to determine the worst-case mode from all possible combinations between available modulations, data rates and antenna ports (if EUT with antenna diversity architecture).
- ☒ Following channel(s) was (were) selected for the final test as listed below.

Available Mode	Tested Mode	Modulation Technology	Modulation Type
1	1	Pulse	FMCW

Output Power Measurement:

- ☒ Pre-Scan has been conducted to determine the worst-case mode from all possible combinations between available modulations, data rates and antenna ports (if EUT with antenna diversity architecture).
- ☒ Following channel(s) was (were) selected for the final test as listed below.

Available Mode	Tested Mode	Modulation Technology	Modulation Type
1	1	Pulse	FMCW

Power Spectral Density Measurement:

- ☒ Pre-Scan has been conducted to determine the worst-case mode from all possible combinations between available modulations, data rates and antenna ports (if EUT with antenna diversity architecture).
- ☒ Following channel(s) was (were) selected for the final test as listed below.

Available Mode	Tested Mode	Modulation Technology	Modulation Type
1	1	Pulse	FMCW

Test Condition:

APPLICABLE TO	ENVIRONMENTAL CONDITIONS	INPUT POWER	TESTED BY
DC	23deg. C, 62%RH	3Vdc	Weiwei Lo
RE $\geq$ 1G	23deg. C, 67%RH, 23deg. C, 67%RH	3Vdc	Weiwei Lo, Weiwei Lo
RE $<$ 1G	23deg. C, 67%RH	3Vdc	Weiwei Lo
PLC	25deg. C, 60%RH	120Vac, 60Hz (System)	Daniel Lin
6dB BW	23deg. C, 62%RH	3Vdc	Weiwei Lo
20dB BW	23deg. C, 62%RH	3Vdc	Weiwei Lo
FS	23deg. C, 62%RH	3Vdc	Weiwei Lo
99% BW	23deg. C, 62%RH	3Vdc	Weiwei Lo
OP	23deg. C, 62%RH	3Vdc	Weiwei Lo
PSD	23deg. C, 62%RH	3Vdc	Weiwei Lo

3.3 Description of Support Units

The EUT has been tested as an independent unit together with other necessary accessories or support units. The following support units or accessories were used to form a representative test configuration during the tests.

ID	Product	Brand	Model No.	Serial No.	FCC ID	Remarks
A.	Taco Box	GOOGLE LLC	NA	NA	NA	Provided by client
B.	AP	D-LINK	DIR-815	PVK21B5000399	KA21R815A1	Provided by Lab
C.	Laptop	DELL	E6440	6QLNM32	NA	Provided by Lab
D.	Battery	NA	AAA	NA	NA	Provided by Lab

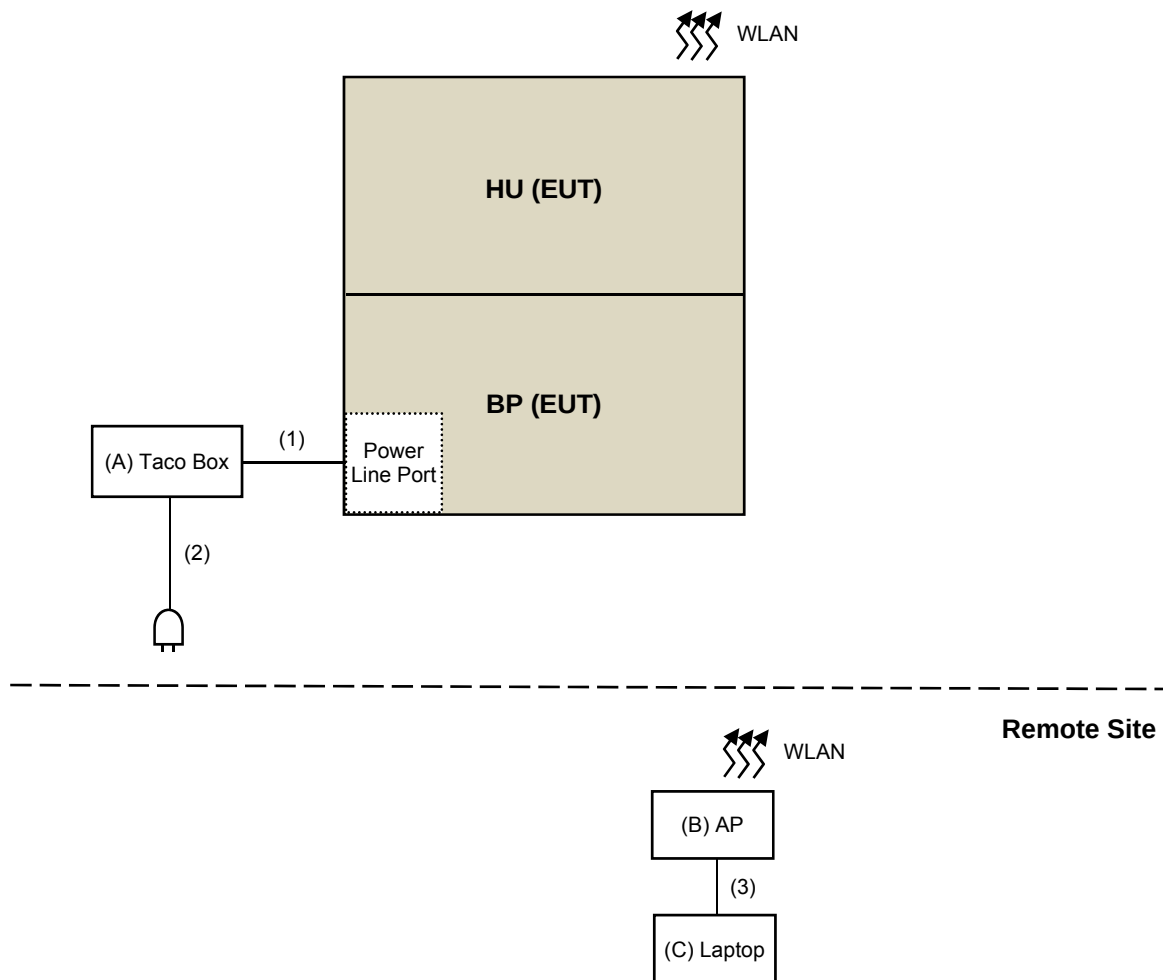
Note:

1. All power cords of the above support units are non-shielded (1.8m).

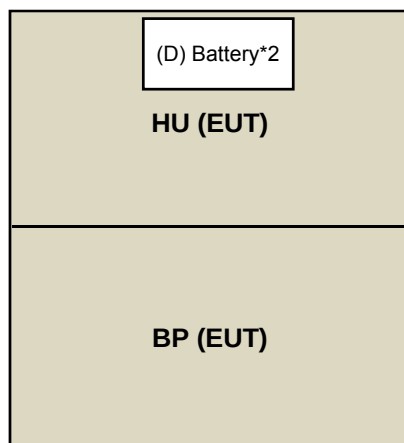
ID	Descriptions	Qty.	Length (m)	Shielding (Yes/No)	Cores (Qty.)	Remarks
1.	DC Cable	1	30	No	0	Provided by client
2.	Power Cable	1	1.5	No	0	Provided by client
3.	RJ-45	1	3	No	0	Provided by Lab

3.3.1 Configuration of System under Test

For Power Line Conducted Emission Test:



For Radiated Emission Test:



3.4 General Description of Applied Standards

The EUT is a RF Product. According to the specifications of the manufacturer, it must comply with the requirements of the following standards:

FCC Part 15, Subpart C (15.255)

KDB 414788 D01 Radiated Test Site v01r01

ANSI C63.10-2013

All test items have been performed and recorded as per the above standards.

3.5 Test Instruments

For Power Line Conducted Emission Test:

DESCRIPTION & MANUFACTURER	MODEL NO.	SERIAL NO.	CALIBRATED DATE	CALIBRATED UNTIL
Test Receiver ROHDE & SCHWARZ	ESR3	102412	Feb. 17, 2020	Feb. 16, 2021
RF signal cable (with 10dB PAD) Woken	5D-FB	Cable-cond2-01	Sep. 05, 2019	Sep. 04, 2020
LISN/AMN ROHDE & SCHWARZ (EUT)	ESH2-Z5	100100	Jan. 20, 2020	Jan. 19, 2021
LISN/AMN ROHDE & SCHWARZ (Peripheral)	ESH3-Z5	100312	Aug. 13, 2019	Aug. 12, 2020
Software ADT	BV ADT_Cond_ V7.3.7.4	NA	NA	NA

Note:

1. The calibration interval of the above test instruments are 12 months and the calibrations are traceable to NML/ROC and NIST/USA.
2. The test was performed in HwaYa Shielded Room 2.
- 3 Tested Date: Mar. 20, 2020

For Radiated Emission (Below 40GHz):

DESCRIPTION & MANUFACTURER	MODEL NO.	SERIAL NO.	CALIBRATED DATE	CALIBRATED UNTIL
Test Receiver R&S	ESR7	102026	Apr. 22, 2020	Apr. 21, 2021
Spectrum Analyzer Keysight	N9030B	MY57141948	May 22, 2020	May 21, 2021
Pre-Amplifier EMCI	EMC001340	980142	May 25, 2020	May 24, 2021
Loop Antenna Electro-Metrics	EM-6879	264	Feb. 18, 2020	Feb. 17, 2021
RF Cable	NA	LOOPCAB-001	Jan. 08, 2020	Jan. 07, 2021
RF Cable	NA	LOOPCAB-002	Jan. 08, 2020	Jan. 07, 2021
Pre-Amplifier EMCI	EMC330N	980538	Apr. 28, 2020	Apr. 27, 2021
Trilog Broadband Antenna SCHWARZBECK	VULB9168	9168-0842	Nov. 08, 2019	Nov. 07, 2020
RF Cable	8D	966-5-1	Apr. 29, 2020	Apr. 28, 2021
RF Cable	8D	966-5-2	Apr. 29, 2020	Apr. 28, 2021
RF Cable	8D	966-5-3	Apr. 29, 2020	Apr. 28, 2021
Fixed attenuator Mini-Circuits	UNAT-5+	PAD-ATT5-02	Jan. 14, 2020	Jan. 13, 2021
Horn_Antenna SCHWARZBECK	BBHA 9120D	9120D-1819	Nov. 24, 2019	Nov. 23, 2020
Pre-Amplifier EMCI	EMC12630SE	980509	Apr. 29, 2020	Apr. 28, 2021
RF Cable EMCI	EMC104-SM-SM-1500	180503	Apr. 29, 2020	Apr. 28, 2021
RF Cable EMCI	EMC104-SM-SM-2000	180501	Apr. 29, 2020	Apr. 28, 2021
RF Cable EMCI	EMC104-SM-SM-6000	180506	Apr. 29, 2020	Apr. 28, 2021
Pre-Amplifier EMCI	EMC184045SE	980387	Jan. 15, 2020	Jan. 14, 2021
Horn_Antenna SCHWARZBECK	BBHA 9170	BBHA9170519	Nov. 24, 2019	Nov. 23, 2020
RF Cable	EMC102-KM-KM-1200	160924	Jan. 15, 2020	Jan. 14, 2021
RF Cable	EMC-KM-KM-4000	200214	Mar. 11, 2020	Mar. 10, 2021
Software	ADT_Radiated_V8.7.08	NA	NA	NA
Boresight Antenna Tower & Turn Table Max-Full	MF-7802BS	MF780208530	NA	NA

Note:

1. The calibration interval of the above test instruments is 12 months and the calibrations are traceable to NML/ROC and NIST/USA.
2. The test was performed in 966 Chamber No. 5.
3. Loop antenna was used for all emissions below 30 MHz.
- 4 Tested Date: June 14, 2020

For Other Test (Above 40 GHz):

DESCRIPTION & MANUFACTURER	MODEL NO.	SERIAL NO.	CALIBRATED DATE	CALIBRATED UNTIL
Spectrum Analyzer Keysight	N9030A	MY55330160	Feb. 07, 2020	Feb. 06, 2021
*Horn Antenna (33~55GHz) OML	M22RH	110215-1	Oct. 17, 2017	Oct. 16, 2020
*Horn Antenna (50~75GHz) OML	M15HWD	110215-1	Oct. 17, 2017	Oct. 16, 2020
*Horn Antenna (75~110GHz) OML	M10RH	110215-1	Oct. 17, 2017	Oct. 16, 2020
*Horn Antenna(110~170GHz) OML	M06HWD	110215-1	Oct. 17, 2017	Oct. 16, 2020
*Horn Antenna (140~220GHz) OML	M05RH	110215-1	Oct. 17, 2017	Oct. 16, 2020
**Conical Horn Antenna (50~75GHz) Keysight	WR15CH-Conical	WR15CH_001	Jan. 20, 2020	Jan. 19, 2022
N9029AV15-DC9 - 50-75 GHz VDI Standard Downconverter with 9VDC supply Keysight	SA Extension WR15	SAX 381	CoC	CoC
N9029AV10-DC9 - 75-110 GHz VDI Standard Downconverter with 9VDC supply Keysight	SA Extension WR10	SAX 378	CoC	CoC
N9029AV06-DC9 - 110-170 GHz VDI Standard Downconverter with 9VDC supply Keysight	SA Extension WR6.5	SAX 377	CoC	CoC
**N9029AV05-DC9 - 140-220 GHz VDI Standard Downconverter with 9VDC supply Keysight	SA Extension WR5.1	SAX 375	Dec. 09, 2019	Dec. 08, 2021
*Millimeter-Wave Signal Generator Frequency Extension Module (50~75 GHz) Keysight	E8257DV15	SGX 050	CoC	CoC
PSG analog signal generator Keysight	E8257D	MY53401987	June 21, 2019	June 20, 2020
Boresight Antenna Tower & Turn Table Max-Full	MF-7802BS	MF780208530	NA	NA
DC Power Supply Topward	6603D	795558	NA	NA
Temperature & Humidity Chamber Giant Force	GTH-150-40-SP- AR	MAA0812-008	Jan. 16, 2020	Jan. 15, 2021
Voltage Meter FLUKE	179	89610322	Sep. 25, 2019	Sep. 24, 2020

Note:

1. The calibration interval of the above test instruments is 12 months and the calibrations are traceable to NML/ROC and NIST/USA.
2. *The calibration interval of the above test instruments is 36 months and the calibrations are traceable to NML/ROC and NIST/USA.
3. **The calibration interval of the above test instruments is 24 months and the calibrations are traceable to NML/ROC and NIST/USA.
4. Certificate of Conformance (CoC) which is issued by manufacturer states that the product meets the specification.
5. The test was performed in 966 Chamber No. 6
6. Tested Date: June 15 to 16, 2020

4 Test Types and Results

4.1 Duty Cycle Measurement

4.1.1 Applicable Rule and Limits of Duty Cycle Measurement

None: For reporting purposes only.

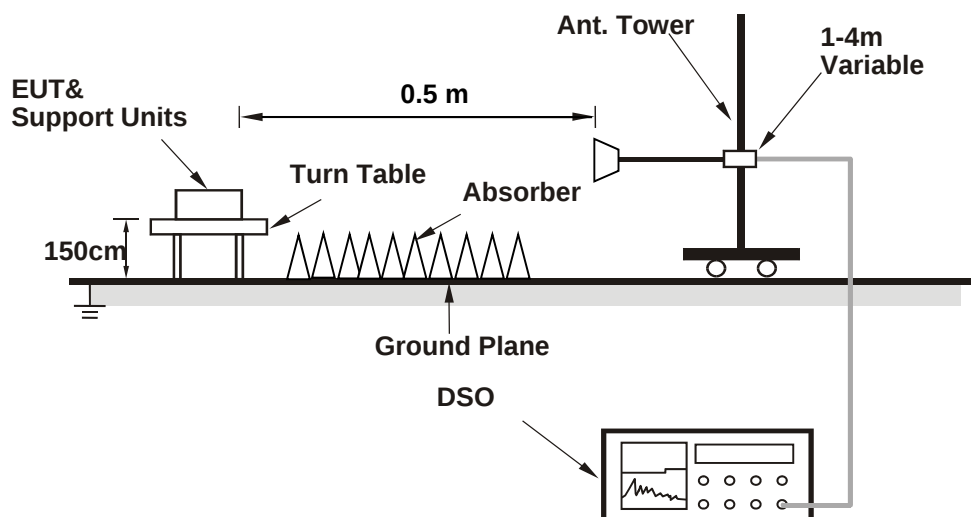
4.1.2 Test Procedures

The DSO and RF detector are set up to measure the radiated output of the transmitter.

4.1.3 Deviation from Test Standard

No deviation.

4.1.4 Test Setup

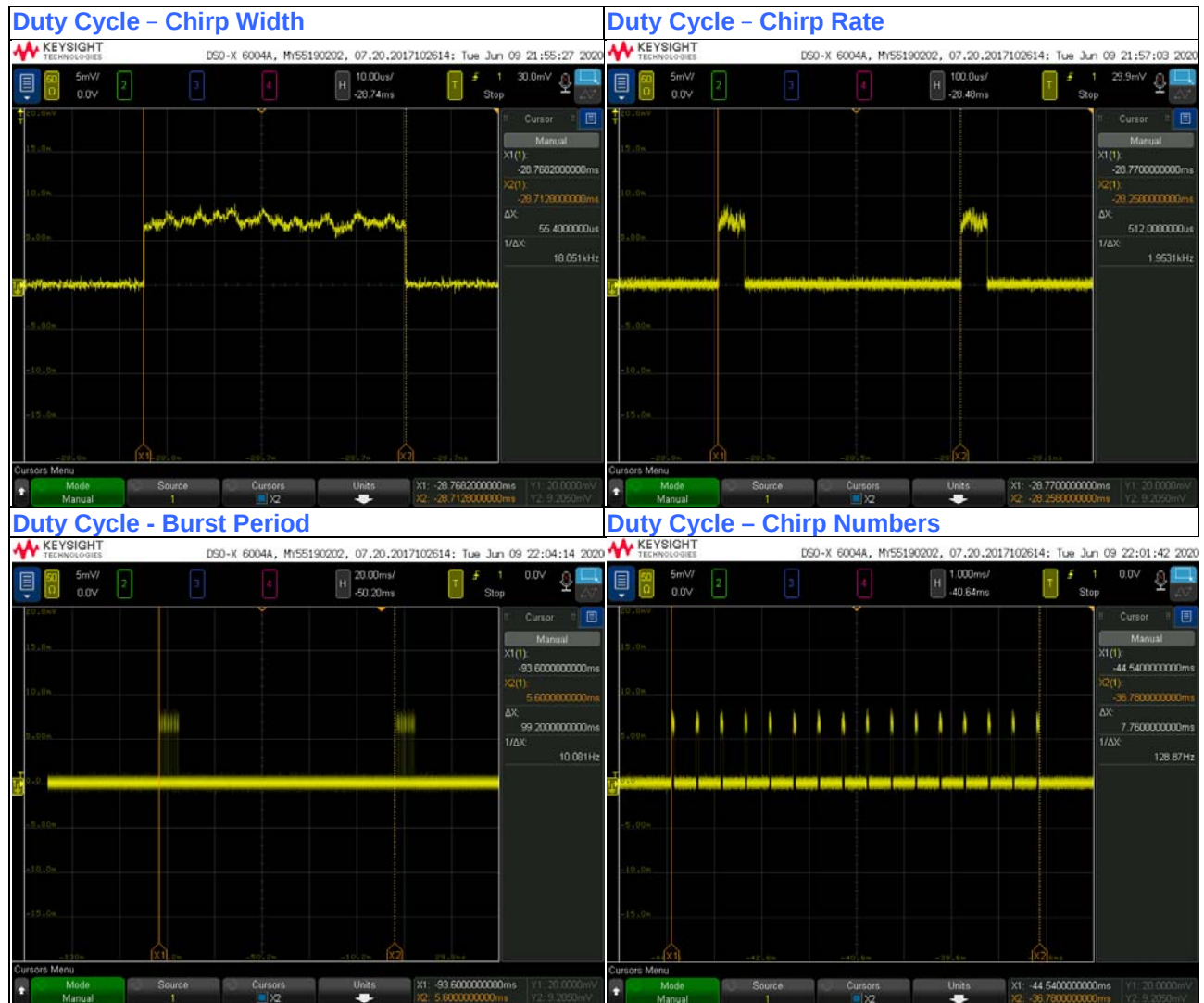


4.1.5 EUT Operating Conditions

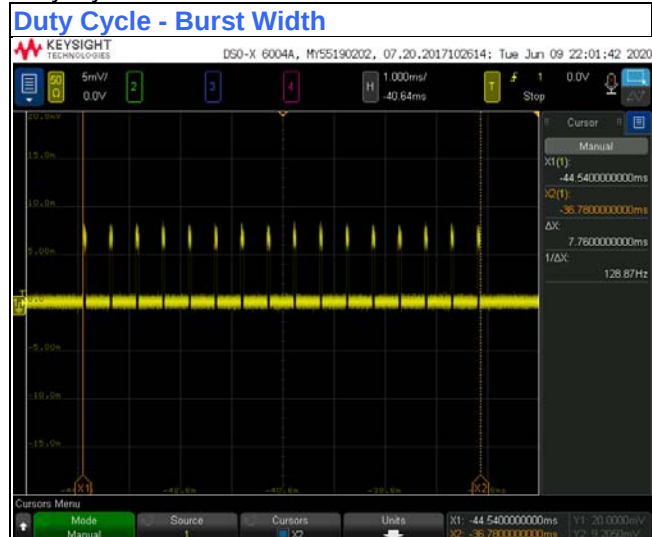
The software provided by client to enable the EUT under transmission condition continuously at specific channel frequencies individually.

4.1.6 Test Results

Maximum ON Time in a duty cycle observation period = (16 chirps) * (55.4 us/chirp) = 886.4 us
Duty Cycle: 0.8864 ms / 99.2 ms = 0.89%



Duty Cycle in the transmit interval: 0.8864 ms / 7.76 ms = 11.42%



4.2 Output Power Measurement

4.2.1 Applicable Rule and Limits of Output Power Measurement

Applicable Rule

According 47 CFR § 15.255(c)(2), which is for fixed field disturbance sensors that occupy 500 MHz or less of bandwidth and that are contained wholly within the frequency band 61-61.5 GHz, the average power of any emission, measured during the transmit interval, shall not exceed 40 dBm, and the peak power of any emission shall not exceed 43 dBm. In addition, the average power of any emission outside of the 61.0-61.5 GHz band, measured during the transmit interval, but still within the 57-71 GHz band, shall not exceed 10 dBm, and the peak power of any emission shall not exceed 13 dBm.

15.225 (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.

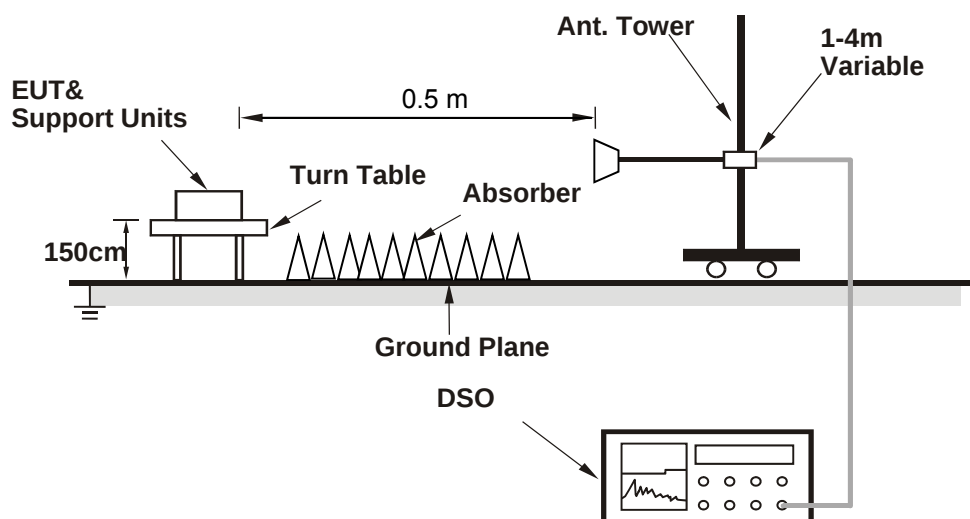
(1) Transmitters with an emission bandwidth of less than 100 MHz must limit their peak transmitter conducted output power to the product of 500 mW times their emission bandwidth divided by 100 MHz. For the purposes of this paragraph, emission bandwidth is defined as the instantaneous frequency range 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).

Limit

+43dBm Peak EIRP and +40 dBm Average EIRP

+27dBm conducted output power

4.2.2 Test Setup



4.2.3 Test Procedures

- Place the EUT in a continuous transmission mode.
- For radiated emission measurements, attach a test receive antenna for the fundamental frequency band to the RF input of an RF detector or a downconverter with an RF detector at the output.
- Connect the video output of the detector to the 50 ohm input of the DSO.
- Place the test receive antenna in the main beam of the EUT at a distance which will provide a signal within the operating range of the RF detector.
- Set the sampling rate of the DSO to the required value. Adjust the memory depth, the triggering and the sweep speed to obtain a display which is representative of the signal considering the type of modulation.
- For radiated emission measurements, calculate the distance to the far field boundary of the fundamental emission using following equation

$$d_{farfield} = \frac{2D^2}{\lambda}$$

where:

D = largest dimension of the transmit antenna

λ = wavelength

Tx patch antenna

Frequency (GHz)	L (m)	Lambda (m)	R (Far Field) (m)
57	0.03	0.00526	0.342
61	0.03	0.00492	0.366
61.5	0.03	0.00488	0.369
71	0.03	0.00423	0.426

Rx horn antenna

Frequency (GHz)	L (m)	Lambda (m)	R (Far Field) (m)
57	0.025	0.00526	0.238
61	0.025	0.00492	0.254
61.5	0.025	0.00488	0.256
671	0.025	0.00423	0.296

- Perform radiated emission measurements to keep maximize the received signal from the EUT in the far field.
- Record the average and peak from the DSO and the measurement distance.
- Disconnect the EUT from the RF input port of the instrumentation system.
- Connect a mm-wave source to the RF input port of the instrumentation system via a waveguide variable attenuator. The mm-wave source is unmodulated.
- Using substitution measurement.
- Measure and note the power.
- For conducted power measurements, calculate the conducted power using following equation

$$P_{cond} = EIRP - G_{dBi}$$

4.2.4 Deviation from Test Standard

No deviation.

4.2.5 EUT Operating Conditions

Same as Item 4.1.5.

4.2.6 Test Results

For Peak Power

Channel	Frequency (GHz)	Transmit Antenna	S.G Output Value (dBm)	EIRP (dBm)	EIRP Limit (dBm)	Pass /Fail
1	61.25	24	-8.73	15.27	43	Pass

For Peak Conducted Power

Channel	Frequency (GHz)	EIRP (dBm)	EUT Transmit Antenna Gain (dBi)	Conducted Output Power (dBm)	Conducted Output Power limit (dBm)	Pass /Fail
1	61.25	15.27	5	10.27	27	Pass

For Average Power

Channel	Frequency (GHz)	EIRP (dBm)	EIRP Limit (dBm)	Pass /Fail
1	61.25	5.85	40	Pass

Note:

1. The EIRP was evaluated on vertical and horizontal polarization, the worst case is Vertical polarization.
2. Average power = Peak power – $10 \cdot \log(1/\text{duty cycle in the transmit interval})$.

4.3 Radiated Emission Measurement

4.3.1 Limits of Radiated Emission Measurement

Spurious Emission	
Frequency Range	Limitation
Radiated emissions below 40GHz	Part 15.209
Between 40GHz and 200GHz	90pW/cm ² (at 3 meter)
57-61 GHz; 61.5-71 GHz band	47 CFR § 15.255(c)(2) (Average 10dBm, Peak 13 dBm)
Note: The levels of the spurious emissions shall not exceed the level of the fundamental emission	

Emissions radiated outside of the specified bands, shall be according to the general radiated limits in 15.209 as following:

Frequencies (MHz)	Field strength (microvolts/meter)	Measurement distance (meters)
0.009-0.490	2400/F(kHz)	300
0.490-1.705	24000/F(kHz)	30
1.705-30.0	30	30
30-88	100	3
88-216	150	3
216-960	200	3
Above 960	500	3

Note:

1. The lower limit shall apply at the transition frequencies.
2. Emission level (dBuV/m) = 20 log Emission level (uV/m).
3. As shown in 15.35(b), for frequencies above 1000MHz, the field strength limits are based on average detector, however, the peak field strength of any emission shall not exceed the maximum permitted average limits, specified above by more than 20dB under any condition of modulation.
4. Section 15.205 restricted bands of operation shall compliance with the limits in Section 15.209.

4.3.2 Test Procedures

For Radiated emission below 30MHz

- a. The EUT was placed on the top of a rotating table 0.8 meters above the ground at a 3 meter chamber room. The table was rotated 360 degrees to determine the position of the highest radiation.
- b. The EUT was set 3 meters away from the interference-receiving antenna, which was mounted on the top of a variable-height antenna tower.
- c. Parallel, perpendicular, and ground-parallel orientations of the antenna are set to make the measurement.
- d. For each suspected emission, the EUT was arranged to its worst case and the rotatable table was turned from 0 degrees to 360 degrees to find the maximum reading.
- e. The test-receiver system was set to Quasi-Peak Detect Function and Specified Bandwidth with Maximum Hold Mode.

Note:

1. The resolution bandwidth and video bandwidth of test receiver/spectrum analyzer is 9kHz at frequency below 30MHz.

For Radiated emission 30MHz to 40GHz

- a. The EUT was placed on the top of a rotating table 0.8 meters (for 30MHz ~ 1GHz) / 1.5 meters (for above 1GHz) above the ground at 3 meter chamber room for test. The table was rotated 360 degrees to determine the position of the highest radiation.
- b. The EUT was set 3 meters (30MHz-18GHz) / 1 meters (18GHz-40GHz) away from the interference-receiving antenna, which was mounted on the top of a variable-height antenna tower.
- c. The height of antenna is varied from one meter to four meters above the ground to determine the maximum value of the field strength. Both horizontal and vertical polarizations of the antenna are set to make the measurement.
- d. For each suspected emission, the EUT was arranged to its worst case and then the antenna was tuned to heights from 1 meter to 4 meters and the rotatable table was turned from 0 degrees to 360 degrees to find the maximum reading.
- e. The test-receiver system was set to quasi-peak detect function and specified bandwidth with maximum hold mode when the test frequency is below 1 GHz.
- f. The test-receiver system was set to peak and average detects function and specified bandwidth with maximum hold mode when the test frequency is above 1 GHz. If the peak reading value also meets average limit, measurement with the average detector is unnecessary.

Note:

1. The resolution bandwidth and video bandwidth of test receiver/spectrum analyzer is 120kHz for Quasi-peak detection (QP) at frequency below 1GHz.
2. The resolution bandwidth of test receiver/spectrum analyzer is 1 MHz and the video bandwidth is 3 MHz for Peak detection (PK) and Average detection (AV) at frequency above 1GHz.
3. All modes of operation were investigated and the worst-case emissions are reported.

For Radiated emission above 40GHz

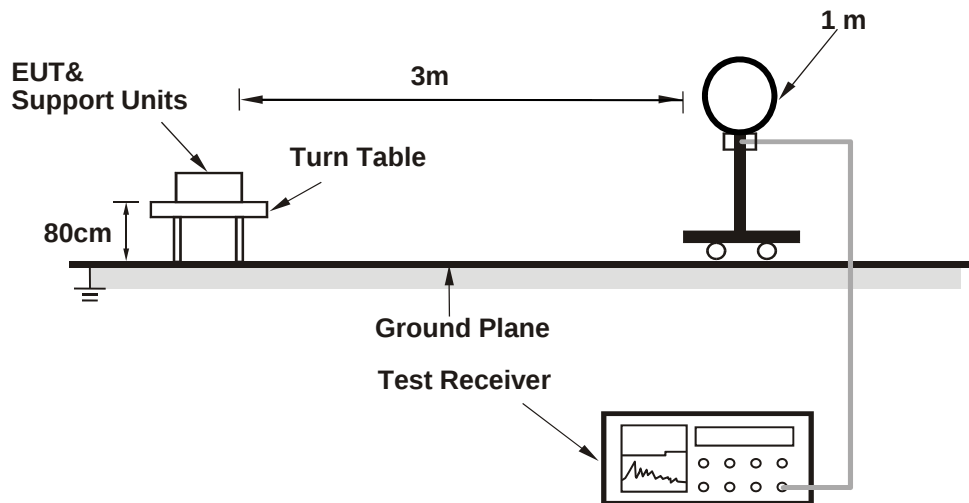
- a. Connect the test antenna covering the appropriate frequency range to a spectrum analyzer via an external mixer to the spectrum analyzer.
- b. Set spectrum analyzer RBW = 1 MHz, VBW = 3 MHz, average detector.
- c. Calculate the distance to the far field boundary and determine the maximum measurement distance.
- d. Perform an exploratory search for emissions and determine the approximate direction at which each observed emission emanates from the EUT.
- e. Exploratory measurements be made at a closer distance than the validated maximum measurement distance.
- f. Perform a final measurement; begin with the test antenna at the approximate position where the maximum level occurred during the exploratory scan.
- g. Slowly scan the test antenna around this position, slowly vary the test antenna polarization by rotating through at least 0° to 180°, and slowly vary the orientation of the test antenna to find the final position, polarization, and orientation at which the maximum level of the emission is observed.
- h. Record the measured reading with the test antenna fixed at this maximized position, polarization, and orientation. Record the measurement distance.
- i. Calculate the maximum field strength of the emission at the measurement distance and the adjusted/corrected power at the output of the test antenna.
- j. Calculate the EIRP from the measured field strength and then convert to the linear.
- k. Calculate the power density at the distance specified by the limit from the field strength at the distance specified by the limit.
- l. Repeat the preceding sequence for every emission observed in the frequency band under investigation.

4.3.3 Deviation from Test Standard

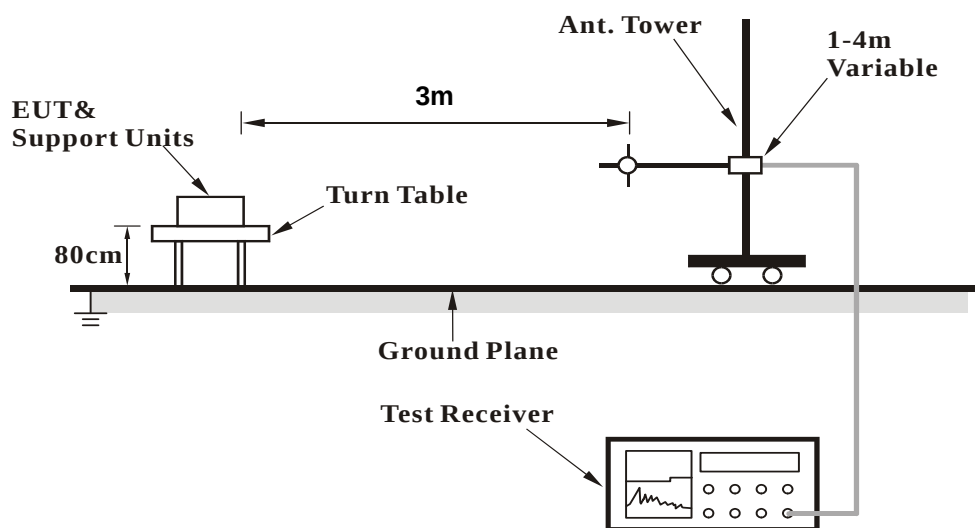
No deviation.

4.3.4 Test Setup

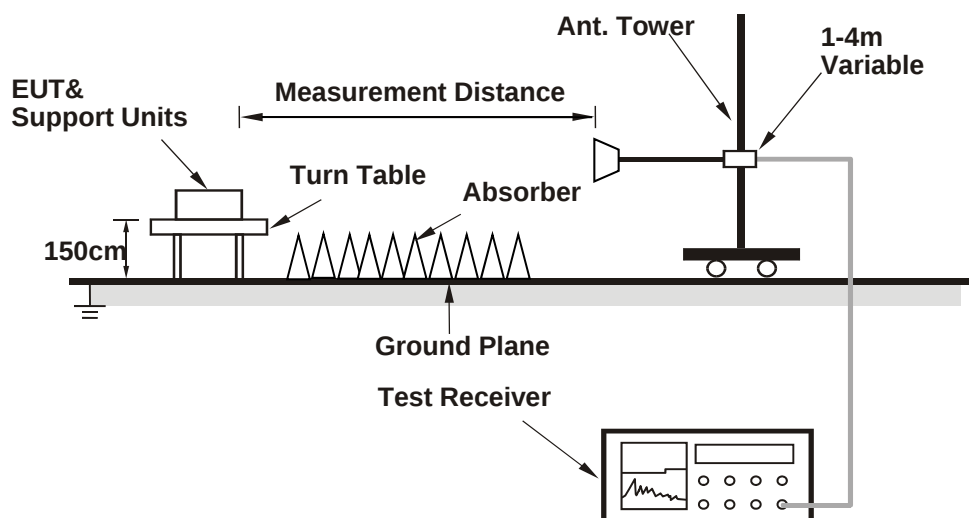
For Radiated emission below 30MHz



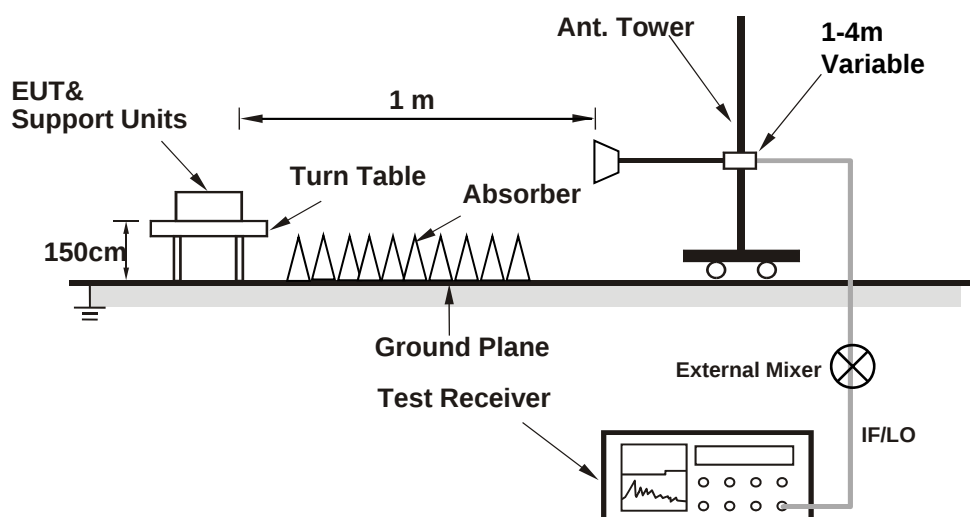
For Radiated emission 30MHz to 1GHz



For Radiated emission 1GHz to 40GHz



For Radiated emission above 40 GHz



For the actual test configuration, please refer to the attached file (Test Setup Photo).

KDB 414788 OATS and Chamber Correlation Justification

- Based on FCC 15.31 (f) (2): measurements may be performed at a distance closer than that specified in regulations; however, an attempt should be made to avoid making measurements in the near field.
- Open-field site and chamber correlation testing had been performed and chamber measured test result is the worst case test result.

4.3.5 EUT Operating Conditions

Same as Item 4.1.5.

4.3.6 Test Results

Above 1GHz Data:

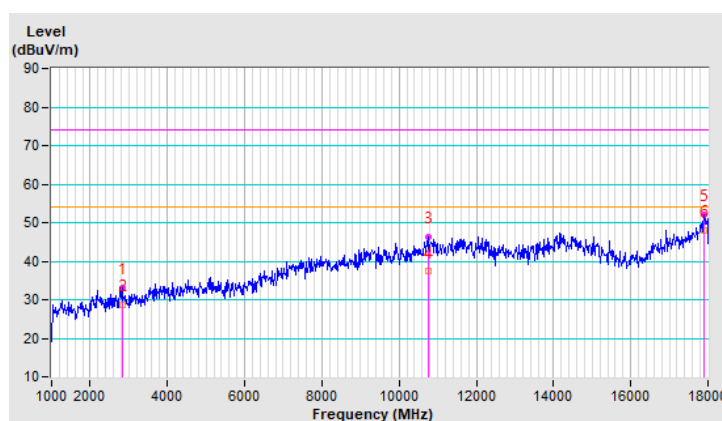
For 1~18GHz

Channel	TX Channel 1	Detector Function	Peak (PK)
Frequency Range	1GHz ~ 18GHz		Average (AV)

Antenna Polarity & Test Distance : Horizontal at 3 m								
No	Frequency (MHz)	Emission Level (dBuV/m)	Limit (dBuV/m)	Margin (dB)	Antenna Height (m)	Table Angle (Degree)	Raw Value (dBuV)	Correction Factor (dB/m)
1	2834.30	33.0 PK	74.0	-41.0	1.48 H	12	35.3	-2.3
2	2834.30	28.6 AV	54.0	-25.4	1.48 H	12	30.9	-2.3
3	10742.70	46.2 PK	74.0	-27.8	1.25 H	215	34.1	12.1
4	10742.70	37.3 AV	54.0	-16.7	1.25 H	215	25.2	12.1
5	17913.30	52.0 PK	74.0	-22.0	1.59 H	212	28.7	23.3
6	17913.30	47.9 AV	54.0	-6.1	1.59 H	212	24.6	23.3

Remarks:

1. Emission Level(dBuV/m) = Raw Value(dBuV) + Correction Factor(dB/m)
2. Correction Factor(dB/m) = Antenna Factor(dB/m) + Cable Factor(dB) – Pre-Amplifier Factor(dB)
3. Margin value = Emission Level – Limit value
4. The other emission levels were very low against the limit.

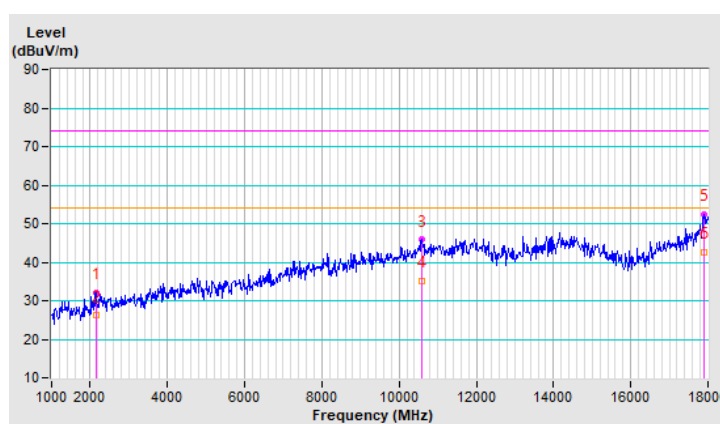


Channel	TX Channel 1	Detector Function	Peak (PK)
Frequency Range	1GHz ~ 18GHz		Average (AV)

Antenna Polarity & Test Distance : Vertical at 3 m								
No	Frequency (MHz)	Emission Level (dBuV/m)	Limit (dBuV/m)	Margin (dB)	Antenna Height (m)	Table Angle (Degree)	Raw Value (dBuV)	Correction Factor (dB/m)
1	2153.45	32.2 PK	74.0	-41.8	1.65 V	121	35.4	-3.2
2	2153.45	26.1 AV	54.0	-27.9	1.65 V	121	29.3	-3.2
3	10576.10	45.8 PK	74.0	-28.2	3.00 V	123	34.6	11.2
4	10576.10	35.2 AV	54.0	-18.8	3.00 V	123	24.0	11.2
5	17892.90	52.5 PK	74.0	-21.5	1.52 V	122	29.6	22.9
6	17892.90	42.6 AV	54.0	-11.4	1.52 V	122	19.7	22.9

Remarks:

1. Emission Level(dBuV/m) = Raw Value(dBuV) + Correction Factor(dB/m)
2. Correction Factor(dB/m) = Antenna Factor(dB/m) + Cable Factor(dB) – Pre-Amplifier Factor(dB)
3. Margin value = Emission Level – Limit value
4. The other emission levels were very low against the limit.



For 18~40GHz

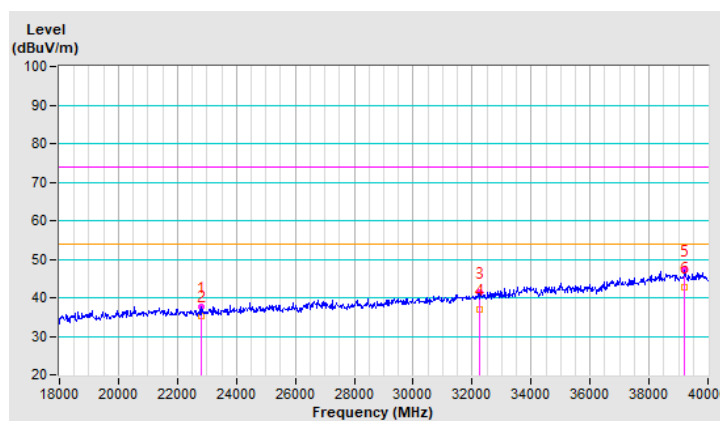
Channel	TX Channel 1	Detector Function	Peak (PK) Average (AV)
Frequency Range	18GHz ~ 40GHz		

Antenna Polarity: Horizontal								
NO.	FREQ. (MHz)	EMISSION LEVEL (dBuV/m)	LIMIT (dBuV/m)	MARGIN (dB)	ANTENNA HEIGHT (m)	TABLE ANGLE (Degree)	RAW VALUE (dBuV)	CORRECTION FACTOR (dB/m)
1	22815.80	37.7 PK	74.0	-36.3	1.50 H	263	50.6	-12.9
2	22815.80	35.4 AV	54.0	-18.6	1.50 H	263	48.3	-12.9
3	32265.90	41.5 PK	74.0	-32.5	1.50 H	144	52.2	-10.7
4	32265.90	37.1 AV	54.0	-16.9	1.50 H	144	47.8	-10.7
5	39212.40	47.2 PK	74.0	-26.8	1.50 H	360	51.0	-3.8
6	39212.40	42.9 AV	54.0	-11.1	1.50 H	360	46.7	-3.8

REMARKS:

1. Emission Level(dBuV/m) = Raw Value(dBuV) + Correction Factor(dB/m)
2. Correction Factor(dB/m) = Antenna Factor(dB/m) + Cable Factor(dB) – Pre-Amplifier Factor(dB)
3. The other emission levels were very low against the limit.
4. Margin value = Emission Level – Limit value
5. Shorter measurement distances was used to improve the measurement system's noise floor. As standard description is based on the measurement in distance of 3 meters, the data obtained at 1-meter distance was extrapolate results to the 3-m distance:
Test value at 3-meter distance (dBuV)
= Test value at 1 meter distance (dBuV) -20log(3/1)(dB)
= Test value at 1 meter distance (dBuV) -9.54(dB).

*Measurements made at 1 meter distance. Test value converted to account for 3-meter measurement distance.



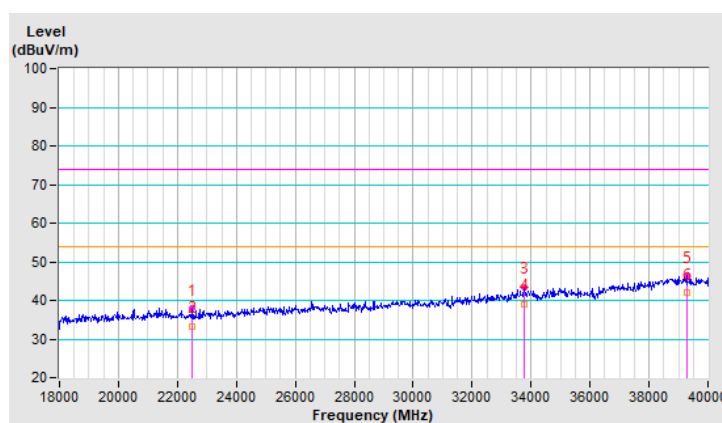
Channel	TX Channel 1	Detector Function	Peak (PK) Average (AV)
Frequency Range	18GHz ~ 40GHz		

Antenna Polarity: Vertical								
NO.	FREQ. (MHz)	EMISSION LEVEL (dBuV/m)	LIMIT (dBuV/m)	MARGIN (dB)	ANTENNA HEIGHT (m)	TABLE ANGLE (Degree)	RAW VALUE (dBuV)	CORRECTION FACTOR (dB/m)
1	22501.20	37.8 PK	74.0	-36.2	1.50 V	258	51.0	-13.2
2	22501.20	33.3 AV	54.0	-20.7	1.50 V	258	46.5	-13.2
3	33760.80	43.4 PK	74.0	-30.6	1.50 V	247	53.9	-10.5
4	33760.80	39.0 AV	54.0	-15.0	1.50 V	247	49.5	-10.5
5	39269.60	46.3 PK	74.0	-27.7	1.50 V	184	50.3	-4.0
6	39269.60	41.9 AV	54.0	-12.1	1.50 V	184	45.9	-4.0

REMARKS:

1. Emission Level(dBuV/m) = Raw Value(dBuV) + Correction Factor(dB/m)
2. Correction Factor(dB/m) = Antenna Factor(dB/m) + Cable Factor(dB) – Pre-Amplifier Factor(dB)
3. The other emission levels were very low against the limit.
4. Margin value = Emission Level – Limit value
5. Shorter measurement distances was used to improve the measurement system's noise floor. As standard description is based on the measurement in distance of 3 meters, the data obtained at 1-meter distance was extrapolate results to the 3-m distance:
 Test value at 3-meter distance (dBuV)
 = Test value at 1 meter distance (dBuV) -20log(3/1)(dB)
 = Test value at 1 meter distance (dBuV) -9.54(dB).

*Measurements made at 1 meter distance. Test value converted to account for 3-meter measurement distance.



For above 40GHz

In band emission

Channel	TX Channel 1	Detector Function	Peak (PK); Average (AV)
Frequency Range	57GHz ~ 61GHz; 61.5GHz~71GHz		

Antenna Polarity: Horizontal						
NO.	Frequency (GHz)	Raw Value (dBm/MHz)	Receiver Antenna Gain (dBi)	EIRP Level (dBm/MHz)	EIRP Limit (dBm/MHz)	Margin (dBm/MHz)
1	58.084	-79.484	23.3	-41.082 PK	13	-54.082
2	58.249	-92.819	23.3	-54.392 AV	10	-64.392
3	65.585	-79.076	23.3	-39.619 PK	13	-93.701
4	65.501	-92.287	23.3	-52.841 AV	10	-62.841
Antenna Polarity: Vertical						
NO.	Frequency (GHz)	Raw Value (dBm/MHz)	Receiver Antenna Gain (dBi)	EIRP Level (dBm/MHz)	EIRP Limit (dBm/MHz)	Margin (dBm/MHz)
1	57.880	-80.062	23.3	-41.690 PK	13	-54.69
2	58.260	-92.819	23.3	-54.390 AV	10	-64.390
3	67.466	-78.617	23.3	-38.914 PK	13	-51.914
4	65.499	-92.291	23.3	-52.845 AV	10	-62.845

Note:

1. The measured power level is converted to EIRP using the equation:

$$\text{EIRP} = \text{Raw Value} - \text{Receiver Antenna Gain} + 20 \cdot \log(4 \cdot 3.1416 \cdot D / \lambda)$$

where:

D is the measurement distance

λ is the wavelength

*Measurements made at 0.5 meter distance.

2. Power density formula as follows:

$$\text{Power density} = \text{EIRP} / (4 \cdot \pi \cdot r^2)$$

r is the standard distance at 3 meter

3. The far-field boundary is given in ANSI 63.10 as:

$$R \text{ far field} = (2 \cdot L^2) / \lambda$$

L is the Largest Antenna Dimension of measurement antenna, including the reflector

λ is the wavelength

V-Band

Frequency (GHz)	L (m)	Lambda (m)	R (Far Field) (m)
50	0.025	0.0075	0.208
75	0.025	0.0040	0.313

Out band emission

Channel	TX Channel 1	Detector Function	Average (AV)
Frequency Range	40GHz ~ 200GHz		

Antenna Polarity: Horizontal							
NO.	Frequency (GHz)	EIRP Level (dBm/MHz)	Raw Value (dBm/MHz)	Receiver Antenna Gain (dBi)	Power Density (pW/cm ²)	Power Density Limit (pW/cm ²)	Margin (pW/cm ²)
1	50.000	-77.529	24.0	-41.128	0.068	90	-89.932
2	51.239	-50.884	-88.197	23.3	0.007	90	-89.993
3	73.616	-47.524	-87.985	23.3	0.016	90	-89.984
4	77.100	-49.802	-90.664	23.3	0.009	90	-89.991
5	150.202	-46.698	-93.353	23.3	0.019	90	-89.981
6	170.004	-42.283	-90.013	23.3	0.052	90	-89.948
Antenna Polarity: Vertical							
NO.	Frequency (GHz)	EIRP Level (dBm/MHz)	Raw Value (dBm/MHz)	Receiver Antenna Gain (dBi)	Power Density (pW/cm ²)	Power Density Limit (pW/cm ²)	Margin (pW/cm ²)
1	49.864	-78.215	24.0	-41.838	0.058	90	-89.942
2	51.162	-51.357	-88.657	23.3	0.006	90	-89.994
3	73.988	-46.988	-87.492	23.3	0.018	90	-89.982
4	77.091	-49.692	-90.553	23.3	0.009	90	-89.991
5	159.811	-45.799	-92.992	23.3	0.023	90	-89.977
6	170.001	-42.297	-90.027	23.3	0.052	90	-89.948

Note:

1. The measured power level is converted to EIRP using the equation:

$$\text{EIRP} = \text{Raw Value} - \text{Receiver Antenna Gain} + 20 \cdot \log(4 \cdot 3.1416 \cdot D / \lambda)$$

where:

D is the measurement distance

λ is the wavelength

*Measurements made at 0.5 meter distance.

2. Power density formula as follows:

$$\text{Power density} = \text{EIRP} / (4 \cdot \pi \cdot r^2)$$

r is the standard distance at 3 meter

3. The far-field boundary is given in ANSI 63.10 as:

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

L is the Largest Antenna Dimension of measurement antenna, including the reflector

λ is the wavelength

Q-Band

Frequency (GHz)	L (m)	Lambda (m)	R (Far Field) (m)
40	0.03	0.0075	0.240
50	0.03	0.0060	0.300

V-Band

Frequency (GHz)	L (m)	Lambda (m)	R (Far Field) (m)
50	0.025	0.0075	0.208
75	0.025	0.0040	0.313

W-Band

Frequency (GHz)	L (m)	Lambda (m)	R (Far Field) (m)
75	0.018	0.0040	0.162
110	0.018	0.0027	0.238

D-Band

Frequency (GHz)	L (m)	Lambda (m)	R (Far Field) (m)
110	0.012	0.0027	0.106
170	0.012	0.0018	0.163

Y-Band

Frequency (GHz)	L (m)	Lambda (m)	R (Far Field) (m)
170	0.008	0.0018	0.073
260	0.008	0.0012	0.111

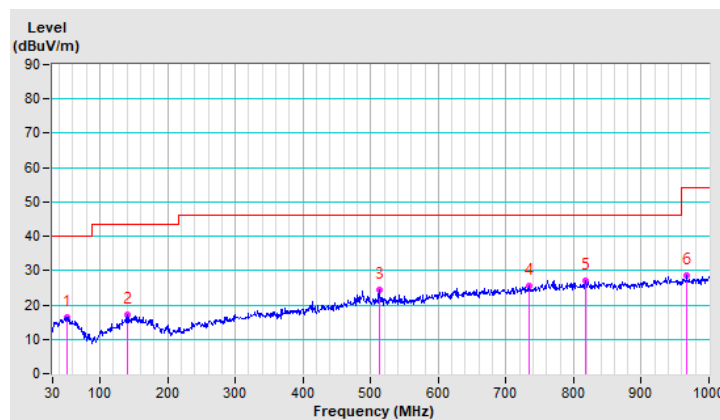
For below 1GHz

Channel	TX Channel 1	Detector Function	Quasi-Peak (QP)
Frequency Range	9kHz ~ 1GHz		

Antenna Polarity & Test Distance : Horizontal at 3 m								
No	Frequency (MHz)	Emission Level (dBuV/m)	Limit (dBuV/m)	Margin (dB)	Antenna Height (m)	Table Angle (Degree)	Raw Value (dBuV)	Correction Factor (dB/m)
1	52.26	16.3 QP	40.0	-23.7	1.00 H	98	28.8	-12.5
2	140.29	17.0 QP	43.5	-26.5	1.00 H	35	29.9	-12.9
3	512.84	24.3 QP	46.0	-21.7	1.00 H	15	31.3	-7.0
4	733.96	25.4 QP	46.0	-20.6	1.00 H	215	28.5	-3.1
5	817.63	27.1 QP	46.0	-18.9	1.00 H	205	29.2	-2.1
6	966.58	28.5 QP	54.0	-25.5	1.00 H	273	28.6	-0.1

Remarks:

1. Emission Level(dBuV/m) = Raw Value(dBuV) + Correction Factor(dB/m)
2. Correction Factor(dB/m) = Antenna Factor(dB/m) + Cable Factor(dB) – Pre-Amplifier Factor(dB)
3. Margin value = Emission Level – Limit value
4. The other emission levels were very low against the limit of frequency range 30MHz~1000MHz.
5. The emission levels were very low against the limit of frequency range 9kHz~30MHz: the amplitude of spurious emissions attenuated more than 20 dB below the permissible value to be report.

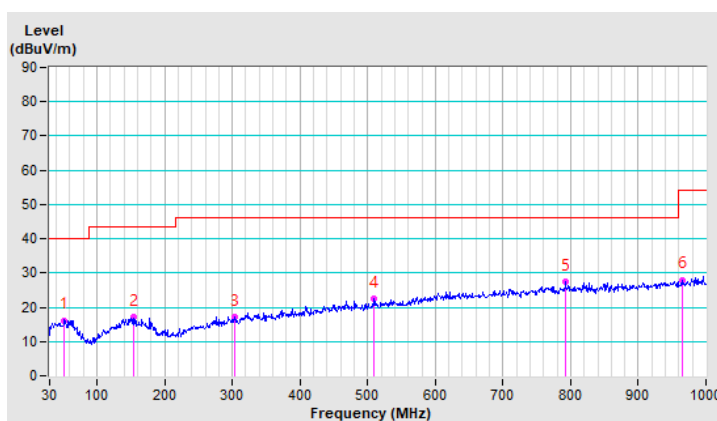


Channel	TX Channel 1	Detector Function	Quasi-Peak (QP)
Frequency Range	9kHz ~ 1GHz		

Antenna Polarity & Test Distance : Vertical at 3 m								
No	Frequency (MHz)	Emission Level (dBuV/m)	Limit (dBuV/m)	Margin (dB)	Antenna Height (m)	Table Angle (Degree)	Raw Value (dBuV)	Correction Factor (dB/m)
1	51.97	16.2 QP	40.0	-23.8	1.40 V	138	28.7	-12.5
2	153.68	17.0 QP	43.5	-26.5	1.20 V	11	29.4	-12.4
3	303.46	17.3 QP	46.0	-28.7	1.20 V	236	29.2	-11.9
4	509.74	22.5 QP	46.0	-23.5	1.10 V	157	29.6	-7.1
5	793.33	27.3 QP	46.0	-18.7	1.30 V	257	29.5	-2.2
6	964.69	28.0 QP	54.0	-26.0	1.00 V	44	28.1	-0.1

Remarks:

1. Emission Level(dBuV/m) = Raw Value(dBuV) + Correction Factor(dB/m)
2. Correction Factor(dB/m) = Antenna Factor(dB/m) + Cable Factor(dB) – Pre-Amplifier Factor(dB)
3. Margin value = Emission Level – Limit value
4. The other emission levels were very low against the limit of frequency range 30MHz~1000MHz.
5. The emission levels were very low against the limit of frequency range 9kHz~30MHz: the amplitude of spurious emissions attenuated more than 20 dB below the permissible value to be report.



4.4 Conducted Emission Measurement

4.4.1 Limits of Conducted Emission Measurement

Frequency (MHz)	Conducted Limit (dBuV)	
	Quasi-peak	Average
0.15 - 0.5	66 - 56	56 - 46
0.50 - 5.0	56	46
5.0 - 30.0	60	50

Note: 1. The lower limit shall apply at the transition frequencies.

2. The limit decreases in line with the logarithm of the frequency in the range of 0.15 to 0.50MHz.

4.4.2 Test Procedures

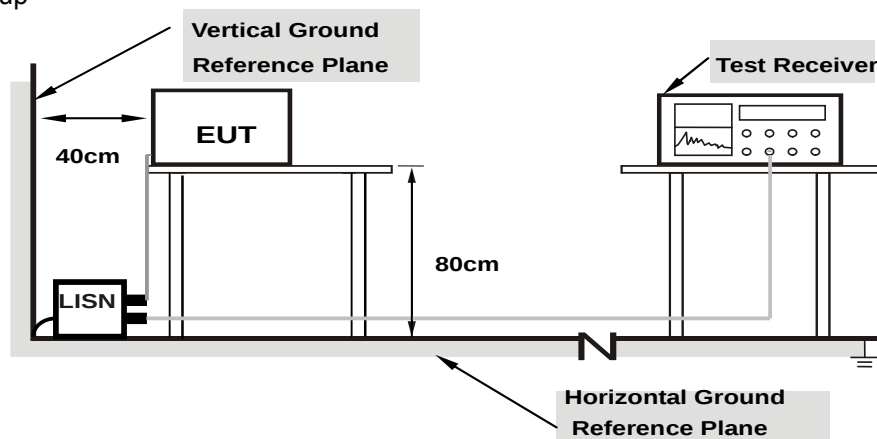
- The EUT was placed 0.4 meters from the conducting wall of the shielded room with EUT being connected to the power mains through a line impedance stabilization network (LISN). Other support units were connected to the power mains through another LISN. The two LISNs provide 50 ohm/ 50uH of coupling impedance for the measuring instrument.
- Both lines of the power mains connected to the EUT were checked for maximum conducted interference.
- The frequency range from 150kHz to 30MHz was searched. Emission levels under (Limit - 20dB) was not recorded.

Note: The resolution bandwidth and video bandwidth of test receiver is 9kHz for quasi-peak detection (QP) and average detection (AV) at frequency 0.15MHz-30MHz.

4.4.3 Deviation from Test Standard

No deviation.

4.4.4 Test Setup



Note: 1.Support units were connected to second LISN.

For the actual test configuration, please refer to the attached file (Test Setup Photo).

4.4.5 EUT Operating Conditions

Same as 4.1.5.

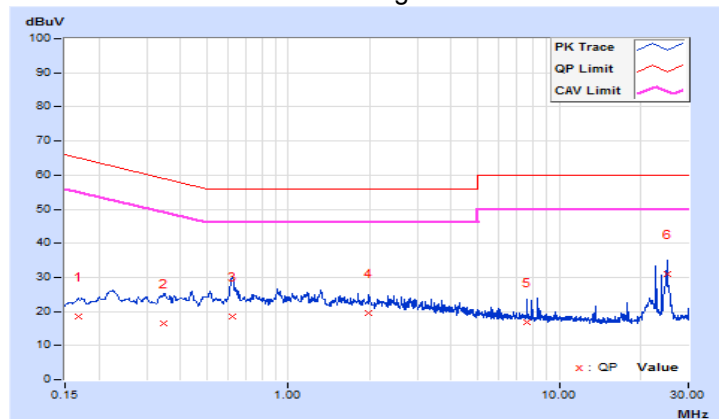
4.4.6 Test Results (Subcontract Item)

Channel	TX Channel 1		
Phase	Line (L)	Detector Function	Quasi-Peak (QP) / Average (AV)

Phase Of Power : Line (L)										
No	Frequency (MHz)	Correction Factor (dB)	Reading Value (dBuV)		Emission Level (dBuV)		Limit (dBuV)		Margin (dB)	
			Q.P.	AV.	Q.P.	AV.	Q.P.	AV.	Q.P.	AV.
1	0.16787	10.16	8.20	5.30	18.36	15.46	65.07	55.07	-46.71	-39.61
2	0.34791	10.19	6.30	4.33	16.49	14.52	59.01	49.01	-42.52	-34.49
3	0.62250	10.22	8.33	5.30	18.55	15.52	56.00	46.00	-37.45	-30.48
4	1.99050	10.30	9.20	6.23	19.50	16.53	56.00	46.00	-36.50	-29.47
5	7.58625	10.44	6.33	4.20	16.77	14.64	60.00	50.00	-43.23	-35.36
6	25.02825	10.48	20.60	10.17	31.08	20.65	60.00	50.00	-28.92	-29.35

Remarks:

1. Q.P. and AV. are abbreviations of quasi-peak and average individually.
2. The emission levels of other frequencies were very low against the limit.
3. Margin value = Emission level – Limit value
4. Correction factor = Insertion loss + Cable loss
5. Emission Level = Correction Factor + Reading Value

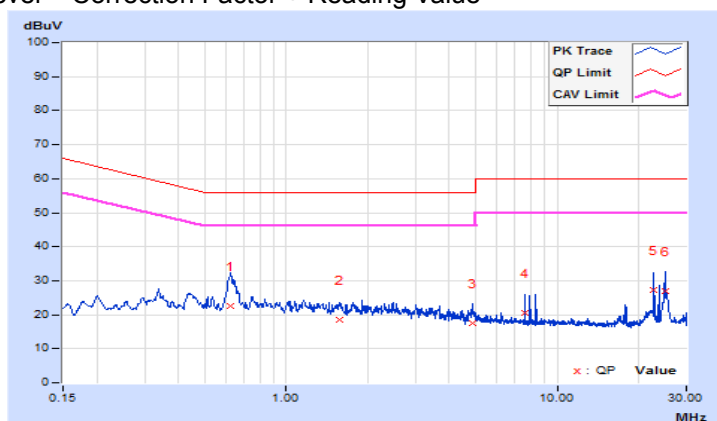


Channel	TX Channel 1		
Phase	Neutral (N)	Detector Function	Quasi-Peak (QP) / Average (AV)

Phase Of Power : Neutral (N)										
No	Frequency (MHz)	Correction Factor (dB)	Reading Value (dBuV)		Emission Level (dBuV)		Limit (dBuV)		Margin (dB)	
			Q.P.	AV.	Q.P.	AV.	Q.P.	AV.	Q.P.	AV.
1	0.62357	10.20	12.30	5.30	22.50	15.50	56.00	46.00	-33.50	-30.50
2	1.57875	10.26	8.30	5.90	18.56	16.16	56.00	46.00	-37.44	-29.84
3	4.89750	10.42	7.20	6.33	17.62	16.75	56.00	46.00	-38.38	-29.25
4	7.58625	10.50	9.88	5.30	20.38	15.80	60.00	50.00	-39.62	-34.20
5	22.76025	10.73	16.54	6.62	27.27	17.35	60.00	50.00	-32.73	-32.65
6	25.03050	10.65	16.22	6.34	26.87	16.99	60.00	50.00	-33.13	-33.01

Remarks:

1. Q.P. and AV. are abbreviations of quasi-peak and average individually.
2. The emission levels of other frequencies were very low against the limit.
3. Margin value = Emission level – Limit value
4. Correction factor = Insertion loss + Cable loss
5. Emission Level = Correction Factor + Reading Value



4.5 6dB Bandwidth Measurement

4.5.1 Applicable Rule and Limits of 6dB Bandwidth Measurement

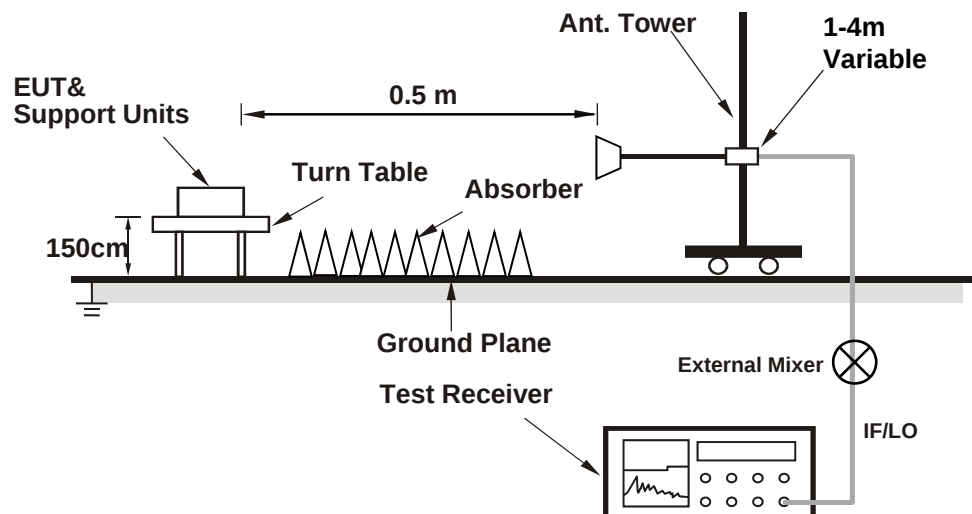
Applicable Rule

§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).

Limit

None: For reporting purposes only.

4.5.2 Test Setup



4.5.3 Test Procedure

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

4.5.4 Deviation from Test Standard

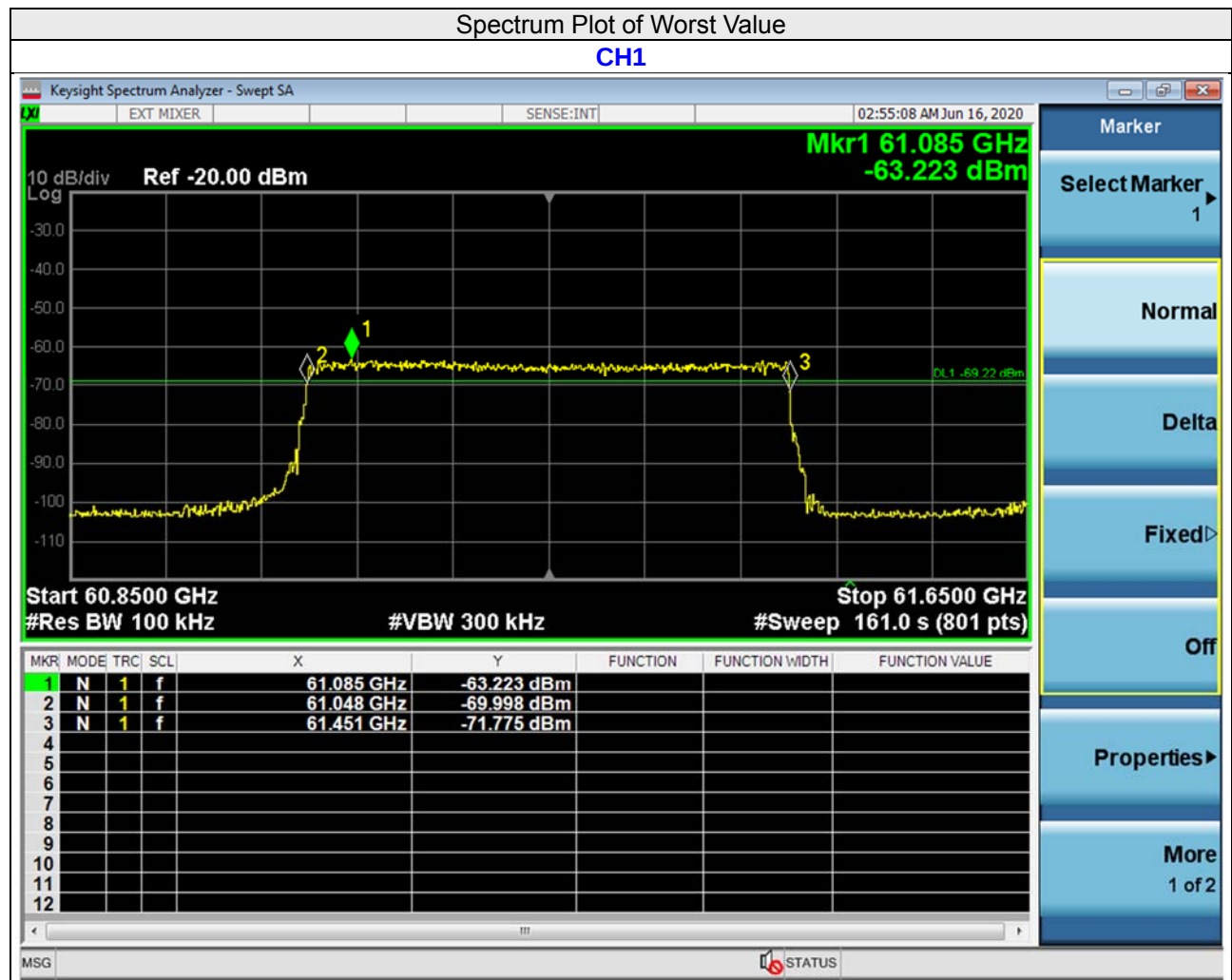
No deviation.

4.5.5 EUT Operating Conditions

Same as Item 4.1.5.

4.5.6 Test Result

Channel	Frequency (GHz)	6dB Bandwidth (GHz)
1	61.25	0.403



4.6 20dB Bandwidth Measurement

4.6.1 Applicable Rule and Limits of 20dB Bandwidth Measurement

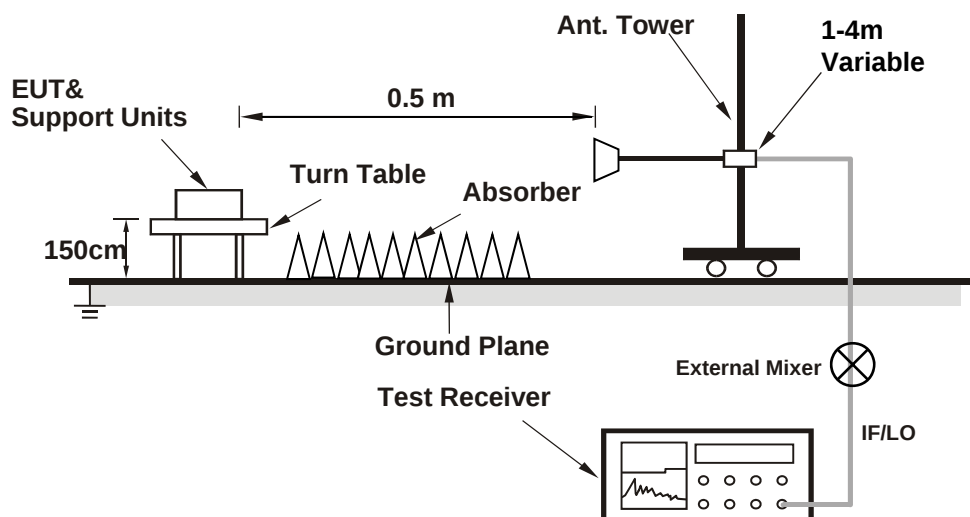
Applicable Rule

§15.215 (c) Intentional radiators operating under the alternative provisions to the general emission limits, as contained in §§15.217 through 15.257 and in subpart E of this part, must be designed to ensure that the 20 dB bandwidth of the emission, or whatever bandwidth may otherwise be specified in the specific rule section under which the equipment operates, is contained within the frequency band designated in the rule section under which the equipment is operated. In the case of intentional radiators operating under the provisions of subpart E, the emission bandwidth may span across multiple contiguous frequency bands identified in that subpart. The requirement to contain the designated bandwidth of the emission within the specified frequency band includes the effects from frequency sweeping, frequency hopping and other modulation techniques that may be employed as well as the frequency stability of the transmitter over expected variations in temperature and supply voltage.

Limit

61 to 61.5GHz

4.6.2 Test Setup



4.6.3 Test Procedure

The spectrum analyzer and external mixer are set up to measure the radiated output of the transmitter. Follow ANSI C63.10 Clauses 9.3 and 9.14. The 20 dB bandwidth is measured at the reference condition of 20 deg C and 3 VDC.

4.6.4 Deviation from Test Standard

No deviation.

4.6.5 EUT Operating Conditions

Same as Item 4.1.5.

4.6.6 Test Result

Results at Reference 20 Deg C and 3 Vdc Condition

20 dB Bandwidth (MHz)	Low Frequency (GHz)	High Frequency (GHz)
433.0	61.030	61.463



4.7 Frequency Stability Measurement

4.7.1 Applicable Rule and Limits of Frequency Stability Measurement

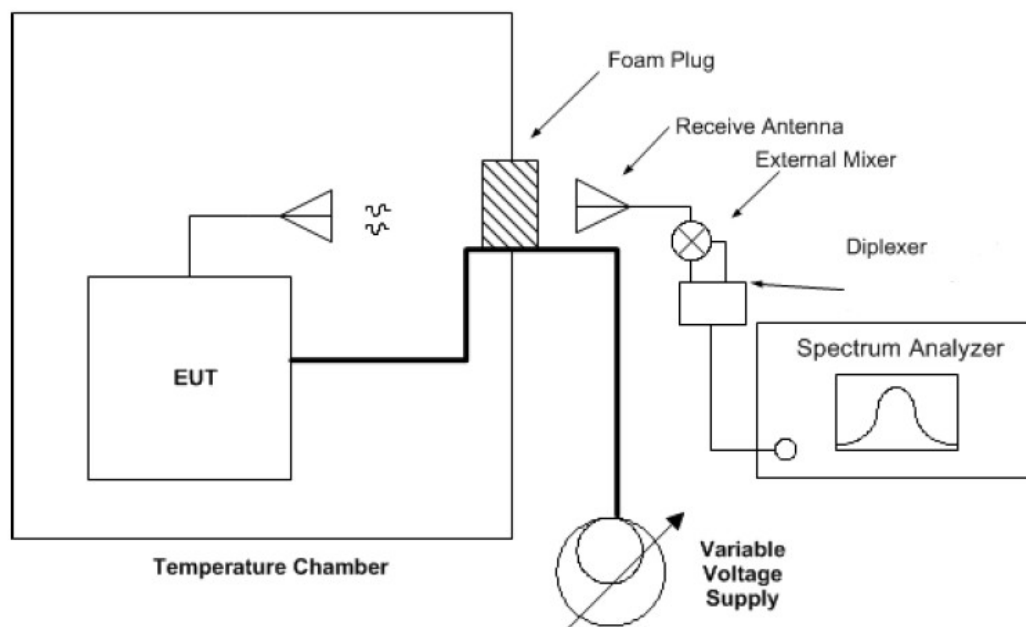
Applicable Rule

§15.255 (f) 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.

Limit

57 to 64 GHz

4.7.2 Test Setup



4.7.3 Test Procedure

The EUT is then placed in an environmental chamber and set to operate in a CW mode, with power furnished by an adjustable source. The carrier frequency is counted at each extreme condition and compared with the reference condition.

- a. Arrange EUT and test equipment as above setup configuration.
- b. With the EUT at ambient temperature and voltage source set to the EUT nominal operating voltage (100%), record the spectrum mask of the EUT emission on the spectrum analyzer.
- c. Vary EUT power supply between 85% and 115% of nominal, and record the frequency excursion of the EUT emission mask.
- d. Set the power supply to 100% nominal setting, and raise EUT operating temperature to 50 °C. Record the frequency excursion of the EUT emission mask.
- e. Repeat step d) at each 10 °C increment down to -20 °C

4.7.4 Deviation from Test Standard

No deviation.

4.7.5 EUT Operating Conditions

Same as Item 4.1.5.

4.7.6 Test Result

Delta over Temperature and Voltage Extremes

Frequency Stability Versus Temp.													
Operating Frequency: 61250 MHz													
TEMP. (°C)	Power Supply (Vdc)	0 Minute			2 Minutes			5 Minutes			10 Minutes		
		Low Freq. (MHz)	High Freq. (MHz)	Pass/ Fail	Low Freq. (MHz)	High Freq. (MHz)	Pass /Fail	Low Freq. (MHz)	High Freq. (MHz)	Pass/ Fail	Low Freq. (MHz)	High Freq. (MHz)	Pass/ Fail
50	3	61042.22	61451.20	Pass	61042.23	61451.23	Pass	61042.22	61451.21	Pass	61042.22	61451.19	Pass
40	3	61042.14	61451.52	Pass	61042.13	61451.48	Pass	61042.12	61451.47	Pass	61042.12	61451.52	Pass
30	3	61042.14	61451.13	Pass	61042.17	61451.15	Pass	61042.16	61451.12	Pass	61042.12	61451.13	Pass
20	3	61042.08	61451.36	Pass	61042.11	61451.36	Pass	61042.07	61451.35	Pass	61042.09	61451.35	Pass
10	3	61042.27	61451.50	Pass	61042.24	61451.54	Pass	61042.25	61451.51	Pass	61042.23	61451.51	Pass
0	3	61042.26	61451.46	Pass	61042.22	61451.45	Pass	61042.21	61451.45	Pass	61042.21	61451.45	Pass
-10	3	61041.92	61451.40	Pass	61041.89	61451.38	Pass	61041.92	61451.40	Pass	61041.88	61451.39	Pass
-20	3	61042.22	61451.21	Pass	61042.22	61451.21	Pass	61042.19	61451.20	Pass	61042.22	61451.19	Pass

Frequency Stability Versus Voltage													
Operating Frequency: 61250 MHz													
TEMP. (°C)	Power Supply (Vdc)	0 Minute			2 Minutes			5 Minutes			10 Minutes		
		Low Freq. (MHz)	High Freq. (MHz)	Pass/ Fail	Low Freq. (MHz)	High Freq. (MHz)	Pass /Fail	Low Freq. (MHz)	High Freq. (MHz)	Pass/ Fail	Low Freq. (MHz)	High Freq. (MHz)	Pass/ Fail
20	3.45	61042.09	61451.37	Pass	61042.10	61451.36	Pass	61042.08	61451.35	Pass	61042.09	61451.36	Pass
	3	61042.08	61451.36	Pass	61042.11	61451.36	Pass	61042.07	61451.35	Pass	61042.09	61451.35	Pass
	2.55	61042.08	61451.36	Pass	61042.10	61451.37	Pass	61042.08	61451.34	Pass	61042.10	61451.34	Pass

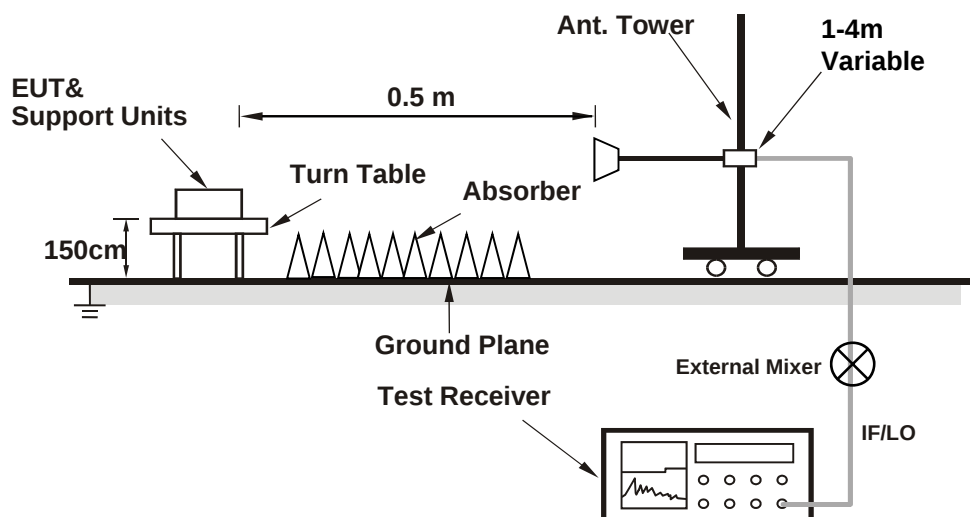
4.8 99% Bandwidth Measurement

4.8.1 Limits of 99% Bandwidth Measurement

Limit

None: For reporting purposes only.

4.8.2 Test Setup



4.8.3 Test Procedure

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

4.8.4 Deviation from Test Standard

No deviation.

4.8.5 EUT Operating Conditions

Same as Item 4.1.5.

4.8.6 Test Result

99% Bandwidth (MHz)
409.31



4.9 Peak Power Spectral Density Measurement

4.9.1 Applicable Rule and Limits of Peak Power Spectral Density Measurement

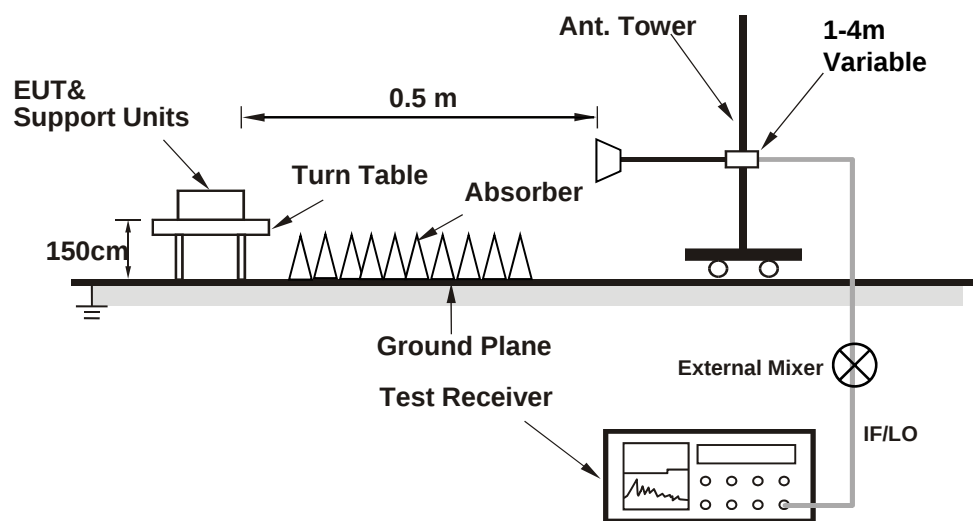
Applicable Rule

None: For reporting purposes only

Limit

None: For reporting purposes only.

4.9.2 Test Setup



4.9.3 Test Procedures

ANSI C63.10 Clause 9.10

The fundamental signal is measured in far-field condition using a Standard Gain Horn Antenna, Low Noise Amplifier, Downconverter and Spectrum Analyzer (PXA).

Spectrum analyzer peak detector measurements are corrected for the decreased sensitivity that results when a CW signal is swept through the RBW filter at a high rate compared to the bandwidth squared.

The derivation of the FMCW Desensitization Factor is given in Keysight Application Note 5952- 1039 Appendix B.

$$\alpha = \frac{1}{\sqrt[4]{1 + \left(\frac{2\ln(2)}{\pi}\right)^2 \left(\frac{F_s}{T_s B^2}\right)^2}}$$

and

FMCW Desensitization Factor = 20 Log(α)

Where

F_s = FMCW Sweep Width or Chirp Width

T_s = FMCW Sweep Time

B = 3-dB bandwidth of Gaussian RBW Filter

4.9.4 Deviation from Test Standard

No deviation.

4.9.5 EUT Operating Conditions

Same as Item 4.1.5.

4.9.6 Offset Calculation

Follow FCC KDB 412172 Determining ERP and ERIP DR01

$$EIRP = Pr + Lp$$

$$Pr = P_{meas} - Gr + Lc + L_{atten} - G_{amp}$$

$$Lp = 20\log(f) + 20\log(d) - 27.5$$

$$EIRP = P_{meas} - Gr + Lc + L_{atten} - G_{amp} + 20\log(f) + 20\log(d) - 27.5$$

P_{meas} : Raw Reading for The Measurement (dBm)

Gr : Receiver Antenna Gain (dBi)

Lc : Cable Loss (dB)

L_{atten} : Attenuation Loss (dB)

G_{amp} : Amplifier Gain (dB)

The Offset Value at 61.448 GHz:

Gr (dBi)	Lc (dB)	Latten (dB)	Gamp (dB)	f (MHz)	d (m)	Desensitization Factor (dB)	Offset (dB)
21	12.54	0	0	61448	0.5	5.239	53.79

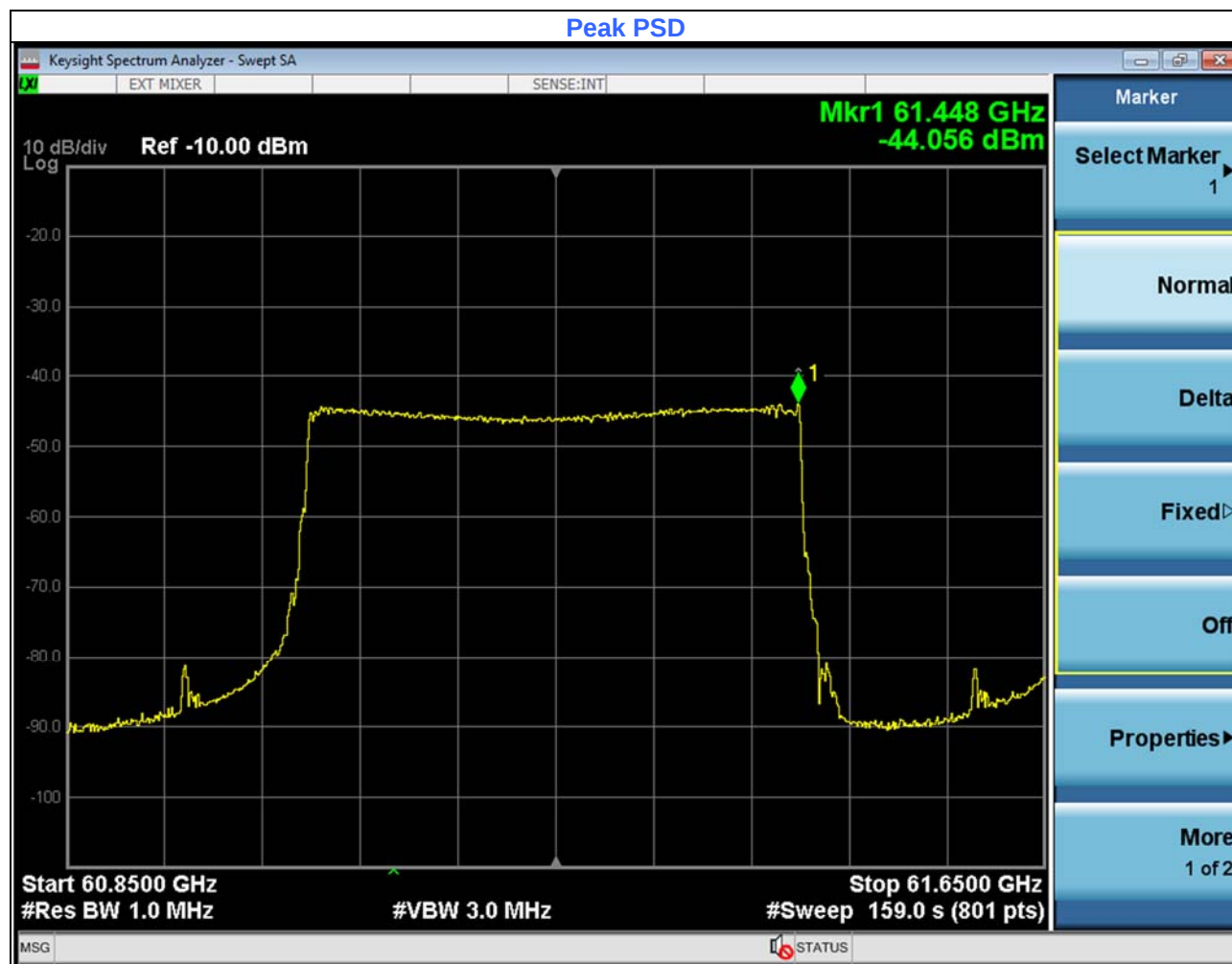
FMCW Desensitization Factor for RBW = 1 MHz

Start Freq (GHz)	Stop Freq (GHz)	FMCW Width (MHz)	Ramp Time (us)	Sweep Rate (MHz/us)	Sweep Rate (Hz/s)	RBW (MHz)	RBW (Hz)	Normalized Sweep Rate (lin)	Amplitude Loss (lin)	Amplitude Loss (dB)
61.05	61.45	400	55.4	7.22	7.22E+12	1.00	1.00E+06	7.22	0.55	-5.239

4.9.7 Test Results

Peak Power Spectral Density

Freq. (GHz)	Measured Distance (m)	RBW (MHz)	Norm. Swp Rate Corr Factor (dB)	Peak PSD (dBm/MHz EIRP)
61.25	0.5	1	5.239	14.973



5 Pictures of Test Arrangements

Please refer to the attached file (Test Setup Photo).

Appendix – Information of the Testing Laboratories

We, Bureau Veritas Consumer Products Services (H.K.) Ltd., Taoyuan Branch, were founded in 1988 to provide our best service in EMC, Radio, Telecom and Safety consultation. Our laboratories are FCC recognized accredited test firms and accredited according to ISO/IEC 17025.

If you have any comments, please feel free to contact us at the following:

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Web Site: www.bureauveritas-adt.com

The address and road map of all our labs can be found in our web site also.

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