# 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 |
| **Test Lab (A):** | Bureau Veritas Consumer Products Services (H.K.) Ltd., Taoyuan Branch Hsin Chu Laboratory |
| **Test Location:** | E-2, No.1, Li Hsin 1st Road, Hsinchu Science Park, Hsinchu City 300, Taiwan |
| **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 33383, TAIWAN |
| **FCC Registration / Designation Number:** | 788550 / TW0003 |

Testing Laboratory 2022

## Table of Contents

## 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)<br>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 ☐ Exrernal |
| 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 above 1GHz
**RE < 1G:** Radiated Emission below 1GHz
**PLC:** Power Line Conducted Emission
**6dB BW:** 6dB Bandwidth
**20dB BW** 20dB Bandwidth
**FS:** Frequency Stability
**99% BW:** 99% Bandwidth
**OP:** Output Power
**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≥1G | 23deg. C, 67%RH,<br>23deg. C, 67%RH | 3Vdc | Weiwei Lo,<br>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 |

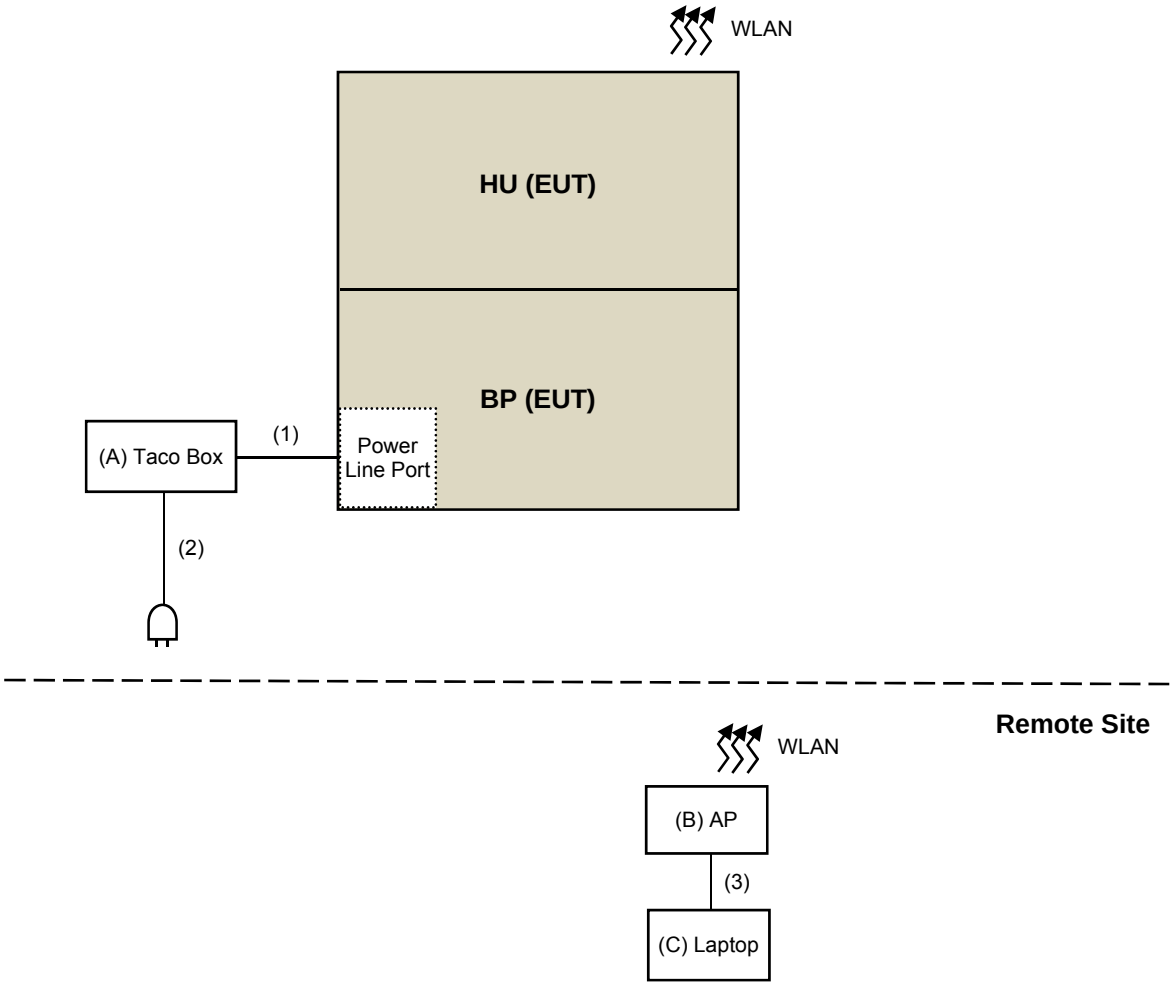
Note:

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

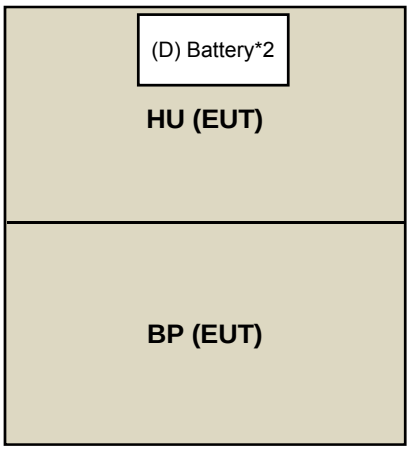
| ID | Descriptions | Qty. | Length (m) | Shielding (Yes/No) | Cores (Qty.) | Remarks |
|---|---|---|---|---|---|---|
| 1. | DC Cable | 1 | 30 | No | 0 | Provided by client |
| 2. | Power Cable | 1 | 1.5 | No | 0 | Provided by client |
| 3. | RJ-45 | 1 | 3 | No | 0 | Provided by Lab |

### 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<br>Keysight | N9030A | MY55330160 | Feb. 07, 2020 | Feb. 06, 2021 |
| *Horn Antenna (33~55GHz)<br>OML | M22RH | 110215-1 | Oct. 17, 2017 | Oct. 16, 2020 |
| *Horn Antenna (50~75GHz)<br>OML | M15HWD | 110215-1 | Oct. 17, 2017 | Oct. 16, 2020 |
| *Horn Antenna (75~110GHz)<br>OML | M10RH | 110215-1 | Oct. 17, 2017 | Oct. 16, 2020 |
| *Horn Antenna(110~170GHz)<br>OML | M06HWD | 110215-1 | Oct. 17, 2017 | Oct. 16, 2020 |
| *Horn Antenna (140~220GHz)<br>OML | M05RH | 110215-1 | Oct. 17, 2017 | Oct. 16, 2020 |
| **Conical Horn Antenna (50~75GHz)<br>Keysight | WR15CH-Conical | WR15CH_001 | Jan. 20, 2020 | Jan. 19, 2022 |
| N9029AV15-DC9 - 50-75 GHz VDI Standard Downconverter with 9VDC supply<br>Keysight | SA Extension WR15 | SAX 381 | CoC | CoC |
| N9029AV10-DC9 - 75-110 GHz VDI Standard Downconverter with 9VDC supply<br>Keysight | SA Extension WR10 | SAX 378 | CoC | CoC |
| N9029AV06-DC9 - 110-170 GHz VDI Standard Downconverter with 9VDC supply<br>Keysight | SA Extension WR6.5 | SAX 377 | CoC | CoC |
| **N9029AV05-DC9 - 140-220 GHz VDI Standard Downconverter with 9VDC supply<br>Keysight | SA Extension WR5.1 | SAX 375 | Dec. 09, 2019 | Dec. 08, 2021 |
| *Millimeter-Wave Signal Generator Frequency Extension Module (50~75 GHz)<br>Keysight | E8257DV15 | SGX 050 | CoC | CoC |
| PSG analog signal generator<br>Keysight | E8257D | MY53401987 | June 21, 2019 | June 20, 2020 |
| Boresight Antenna Tower & Turn Table<br>Max-Full | MF-7802BS | MF780208530 | NA | NA |
| DC Power Supply<br>Topward | 6603D | 795558 | NA | NA |
| Temperature & Humidity Chamber<br>Giant Force | GTH-150-40-SP-AR | MAA0812-008 | Jan. 16, 2020 | Jan. 15, 2021 |
| Voltage Meter<br>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.

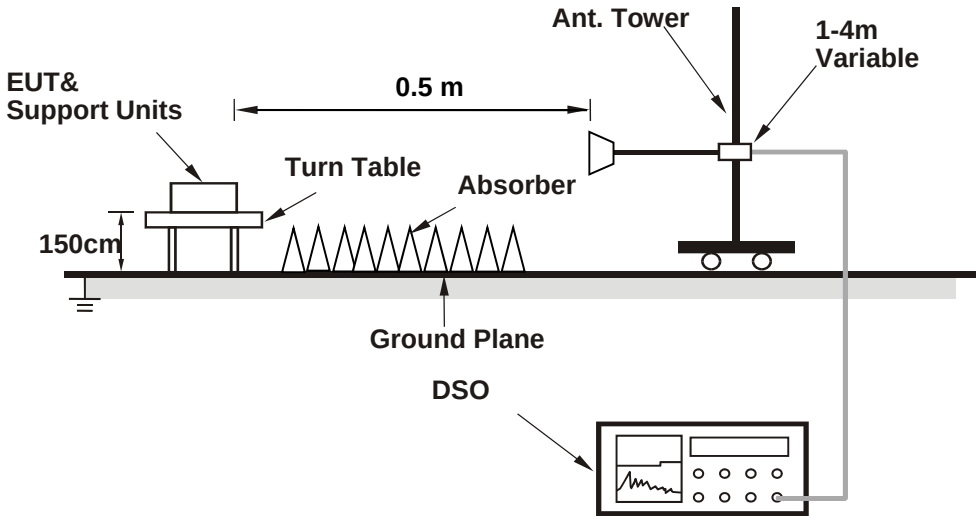
### 4.1.2 Test Procedures

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



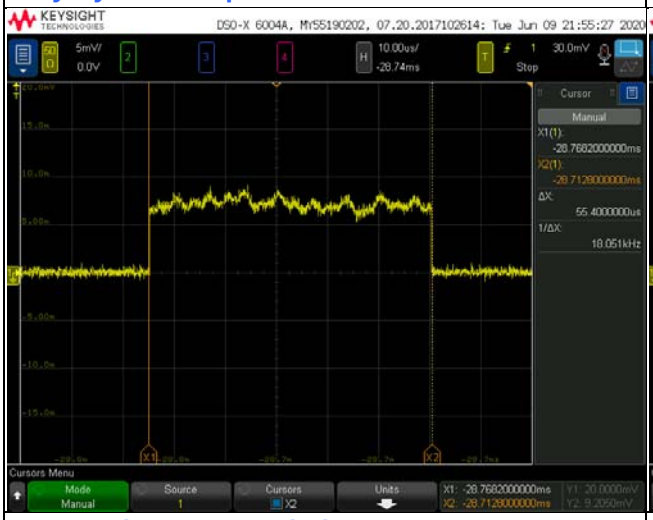

### 4.1.5 EUT Operating Conditions

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

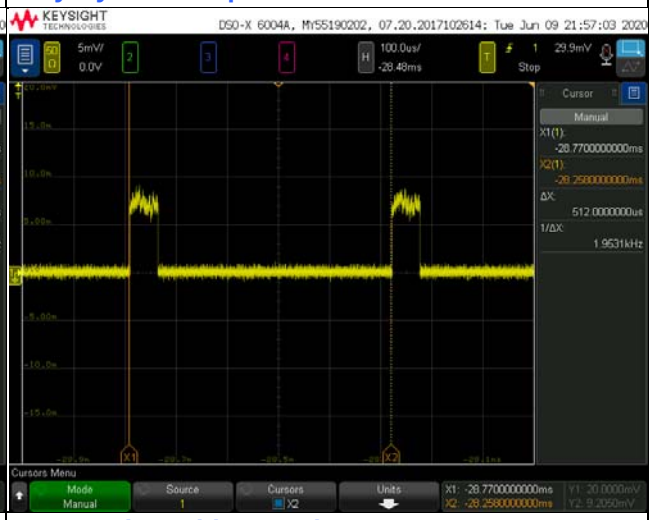
4.1.6 Test Results

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 – Chirp Width**

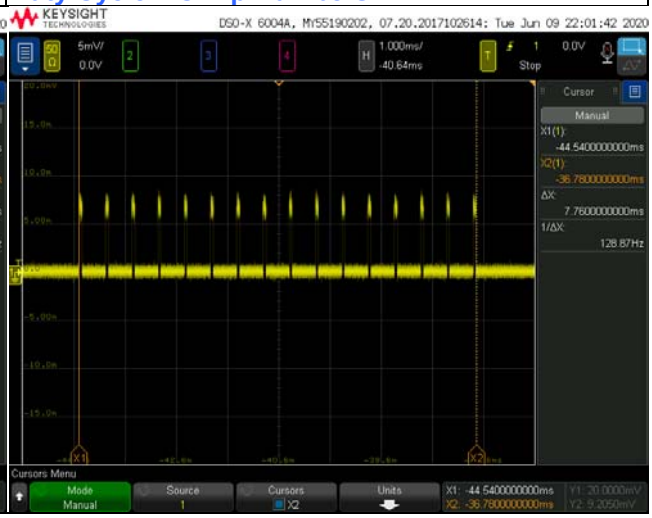



**Duty Cycle – Chirp Rate**



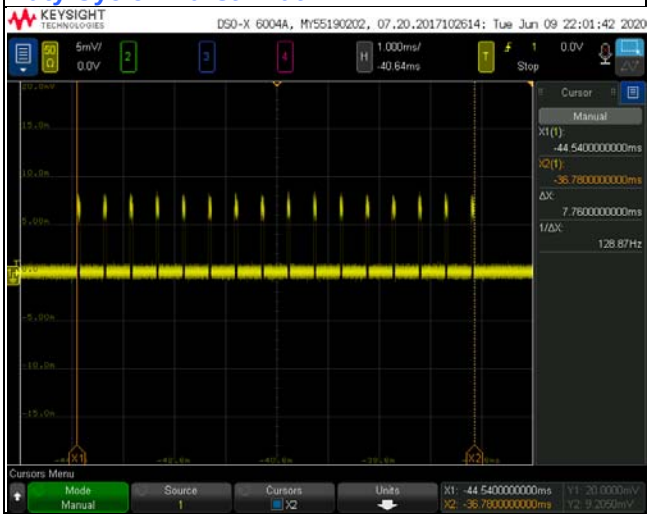

**Duty Cycle - Burst Period**


**Duty Cycle – Chirp Numbers**




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

**Duty Cycle - Burst Width**



## 4.2 Output Power Measurement

### 4.2.1 Applicable Rule and Limits of Output Power Measurement

**Applicable Rule**

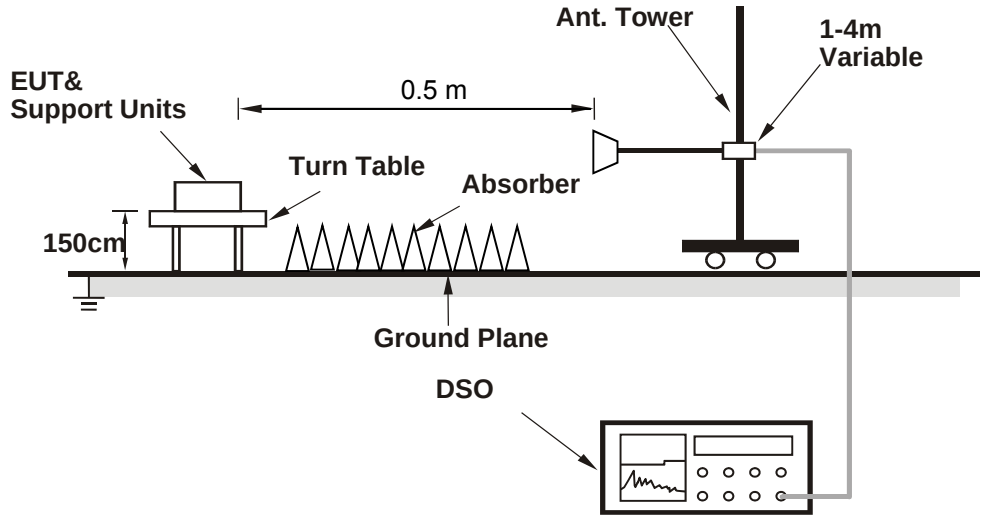
According 47 CFR § 15.255(c)(2), which is for fixed field disturbance sensors that occupy 500 MHz or less of bandwidth and that are contained wholly within the frequency band 61-61.5 GHz, the average power of any emission, measured during the transmit interval, shall not exceed 40 dBm, and the peak power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

a. Place the EUT in a continuous transmission mode.
b. 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.
c. Connect the video output of the detector to the 50 ohm input of the DSO.
d. 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.
e. 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.
f. 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 |

g. Perform radiated emission measurements to keep maximize the received signal from the EUT in the far field.
h. Record the average and peak from the DSO and the measurement distance.
i. Disconnect the EUT fromthe RF input port of the instrumentation system.
j. 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.
k. Using substitution measurement.
l. Measure and note the power.
m. 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*log(1/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:<br>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.

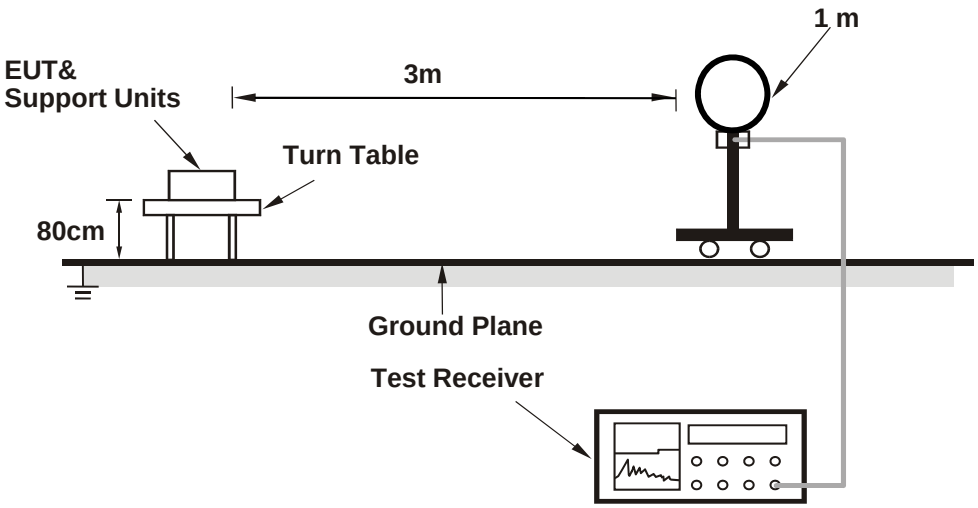
l. Repeat the preceding sequence for every emission observed in the frequency band under investigation.

4.3.3 Deviation from Test Standard

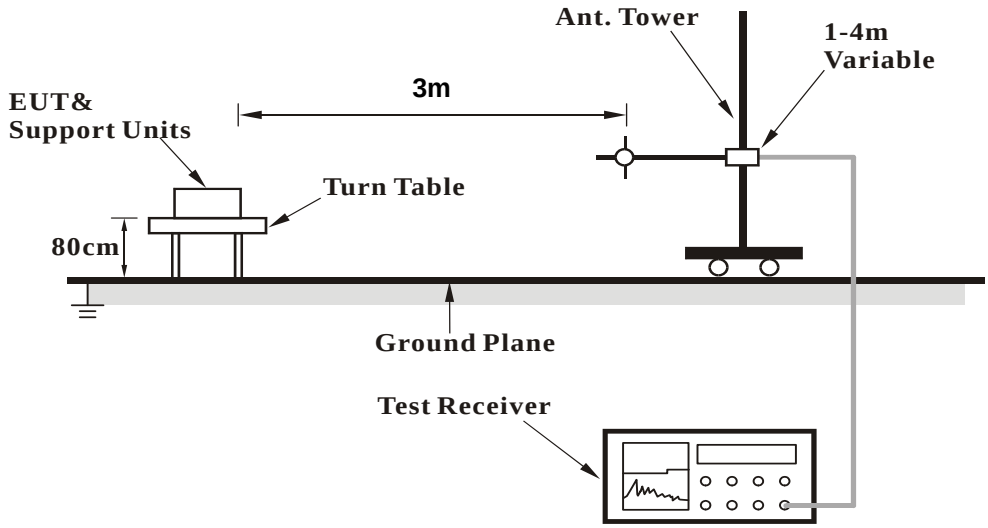
No deviation.

4.3.4 Test Setup

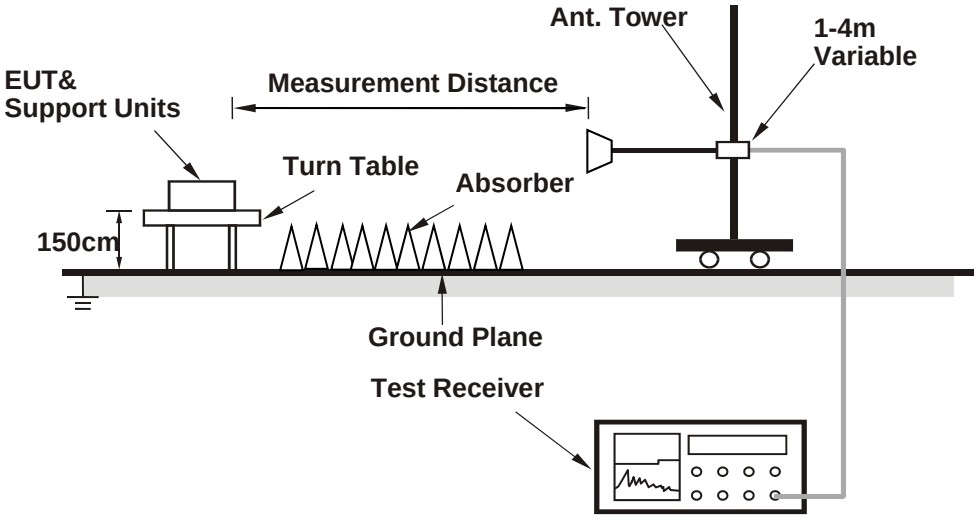
**For Radiated emission below 30MHz**



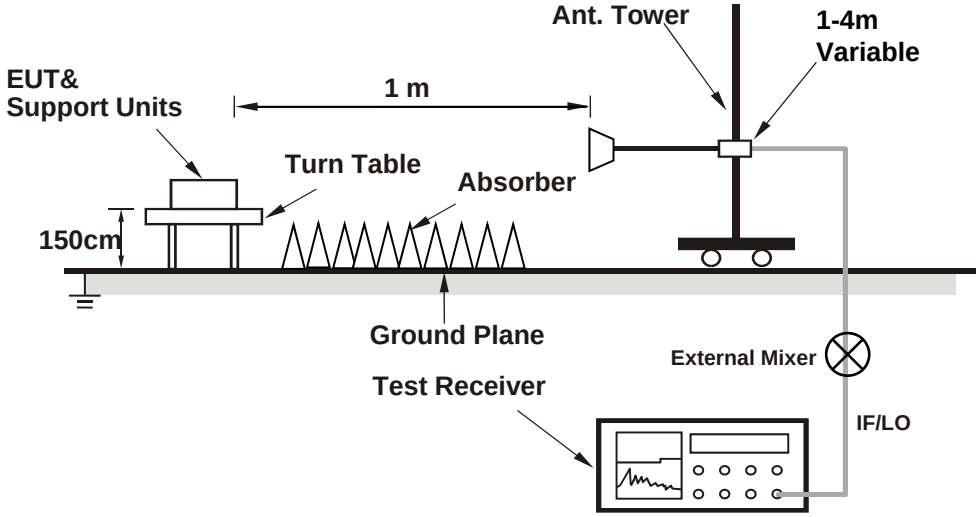

**For Radiated emission 30MHz to 1GHz**



**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:**

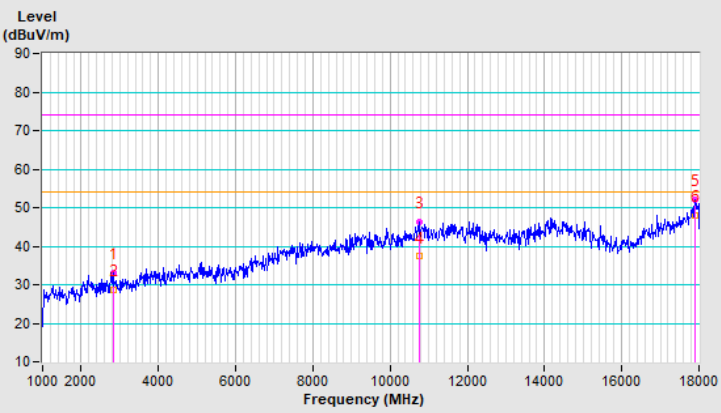
**For 1~18GHz**

| | | | |
|---|---|---|---|
| **Channel** | TX Channel 1 | **Detector Function** | Peak (PK)<br>Average (AV) |
| **Frequency Range** | 1GHz ~ 18GHz | | |

| 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.

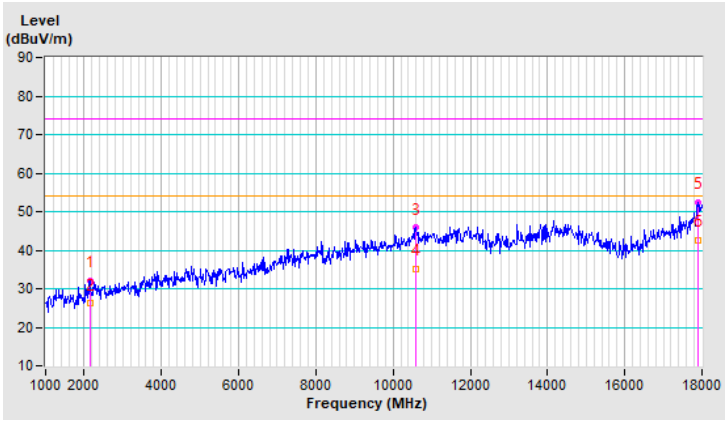


| Channel | TX Channel 1 | Detector Function | Peak (PK)<br>Average (AV) |
|---|---|---|---|
| Frequency Range | 1GHz ~ 18GHz | | |

| 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

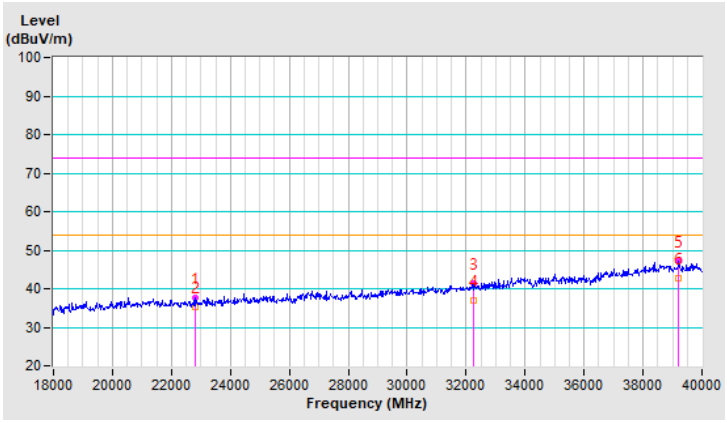
| Channel | TX Channel 1 | Detector Function | Peak (PK)<br>Average (AV) |
|---|---|---|---|
| Frequency Range | 18GHz ~ 40GHz | | |

| 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.



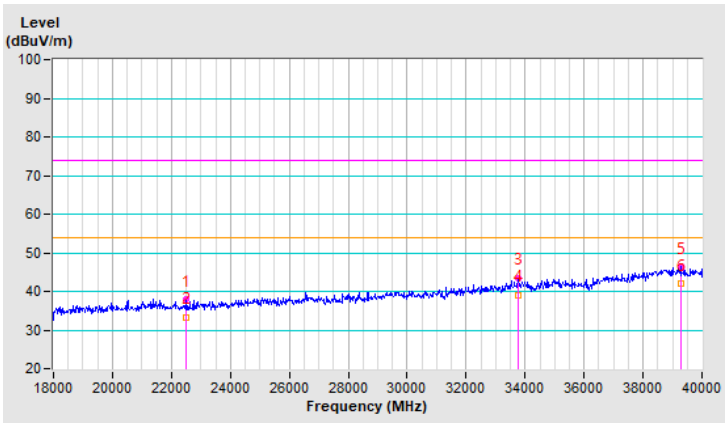
| Channel | TX Channel 1 | Detector Function | Peak (PK)<br>Average (AV) |
|---|---|---|---|
| Frequency Range | 18GHz ~ 40GHz | | |

| 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);<br>Average (AV) |
| **Frequency Range** | 57GHz ~ 61GHz;<br>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:
EIRP = Raw Value - Receiver Antenna Gain + 20*log(4*3.1416*D/λ)
where:
D is the measurement distance
λ is the wavelength
*Measurements made at 0.5 meter distance.
2. Power density formula as follows:
Power density = EIRP / (4 * Pi * r^2)
r is the standard distance at 3 meter
3. The far-field boundary is given in ANSI 63.10 as:
R far field = (2 * L^2) /λ
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:
EIRP = Raw Value - Receiver Antenna Gain + 20*log(4*3.1416*D/λ)
where:
D is the measurement distance
λ is the wavelength
*Measurements made at 0.5 meter distance.
2. Power density formula as follows:
Power density = EIRP / (4 * Pi * r^2)
r is the standard distance at 3 meter
3. The far-field boundary is given in ANSI 63.10 as:
R far field = (2 * L^2) /λ
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 |

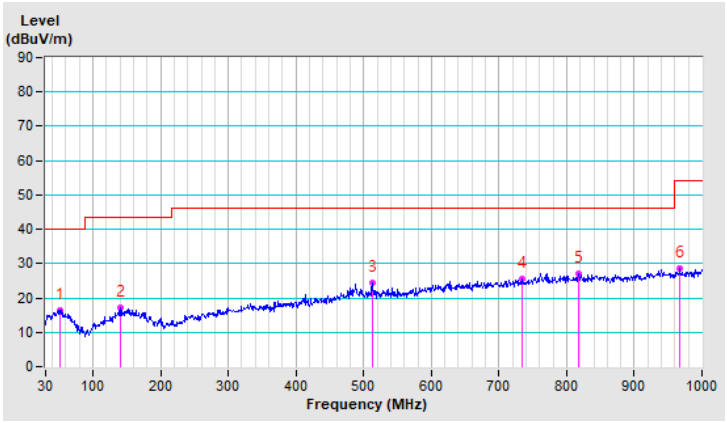
**For below 1GHz**

| | | | |
|---|---|---|---|
| **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.

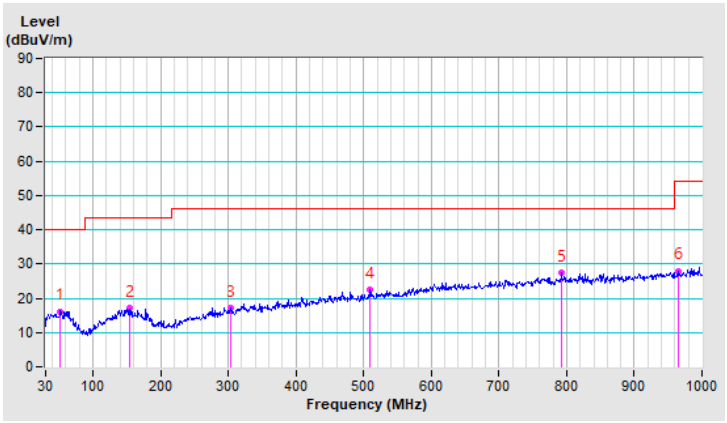


| Channel | TX Channel 1 | Detector Function | Quasi-Peak (QP) |
|---|---|---|---|
| Frequency Range | 9kHz ~ 1GHz | | |

| 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

a. 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.

b. Both lines of the power mains connected to the EUT were checked for maximum conducted interference.

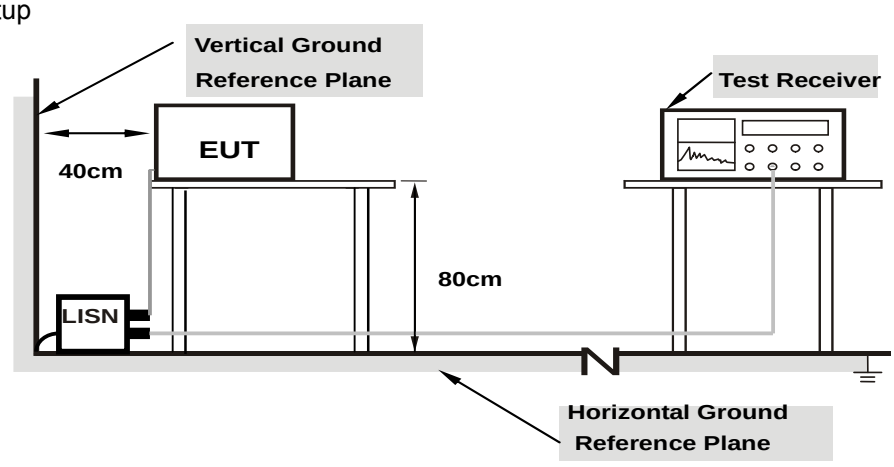
c. The frequency range from 150kHz to 30MHz was searched. Emission levels under (Limit - 20dB) was not recorded.

**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.

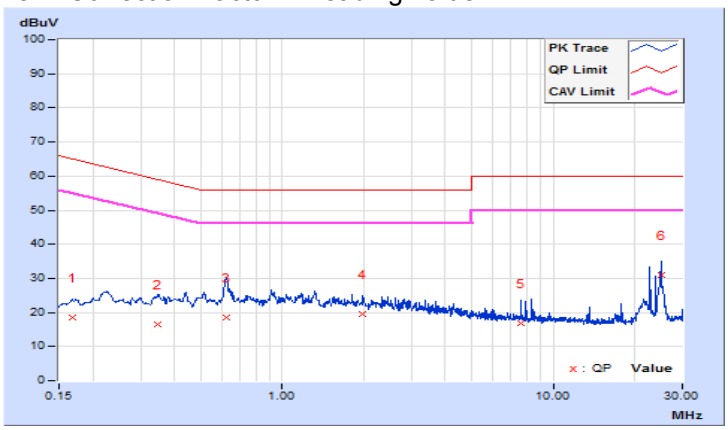
4.4.6 Test Results (Subcontract Item)

| 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

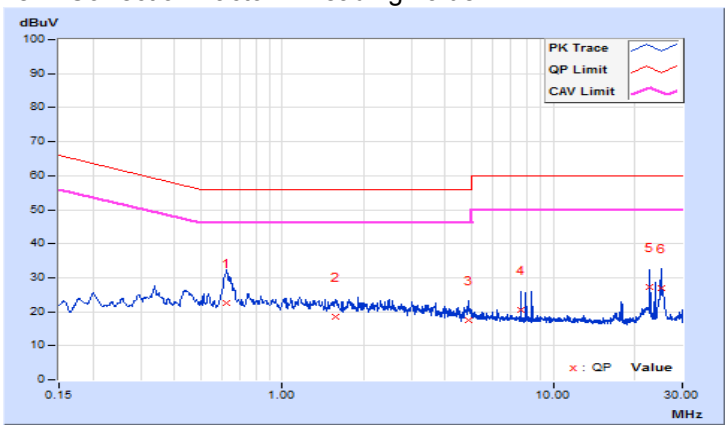


| Channel | TX Channel 1 | | |
|---|---|---|---|
| Phase | Neutral (N) | Detector Function | Quasi-Peak (QP) / Average (AV) |

| 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

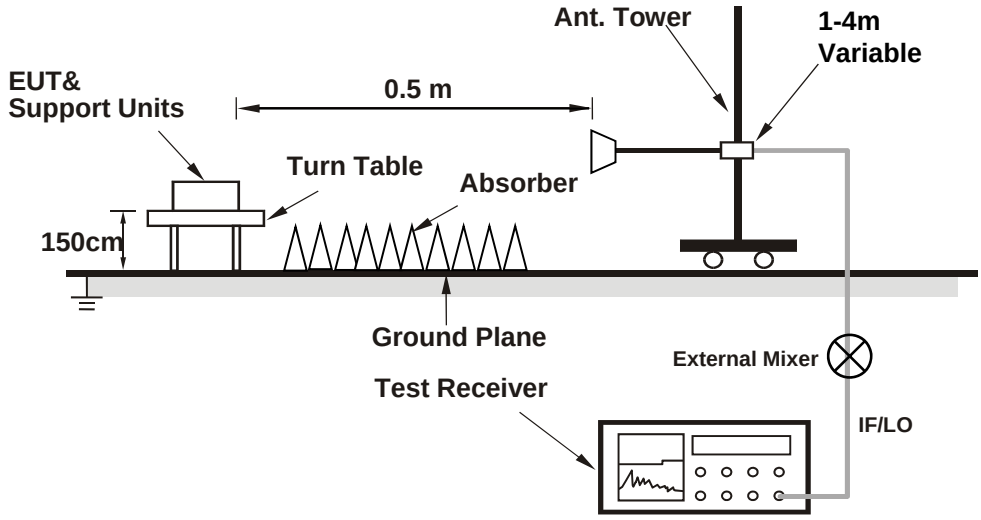
**Applicable Rule**

§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 fromTest 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 |

| Spectrum Plot of Worst Value |
|---|
| CH1 |

## 4.6 20dB Bandwidth Measurement

### 4.6.1 Applicable Rule and Limits of 20dB Bandwidth Measurement

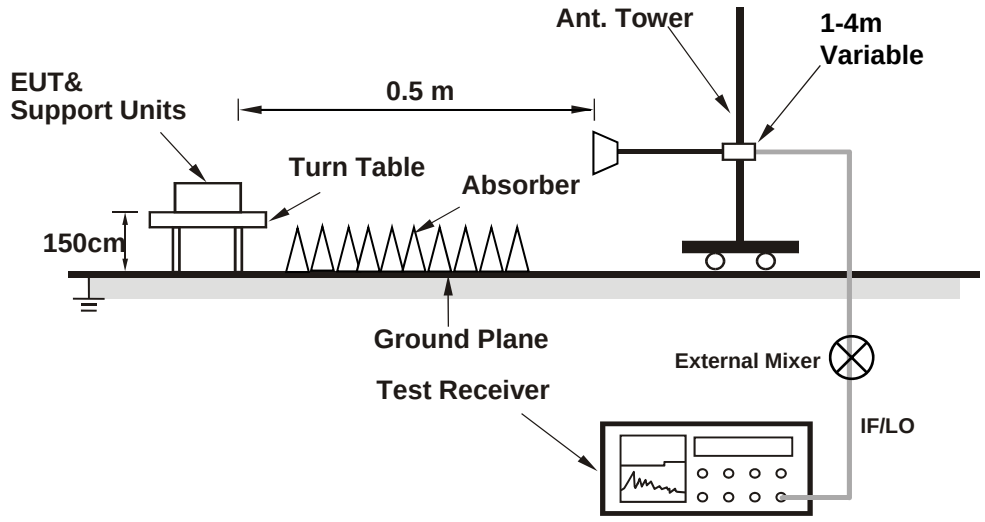
**Applicable Rule**

§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

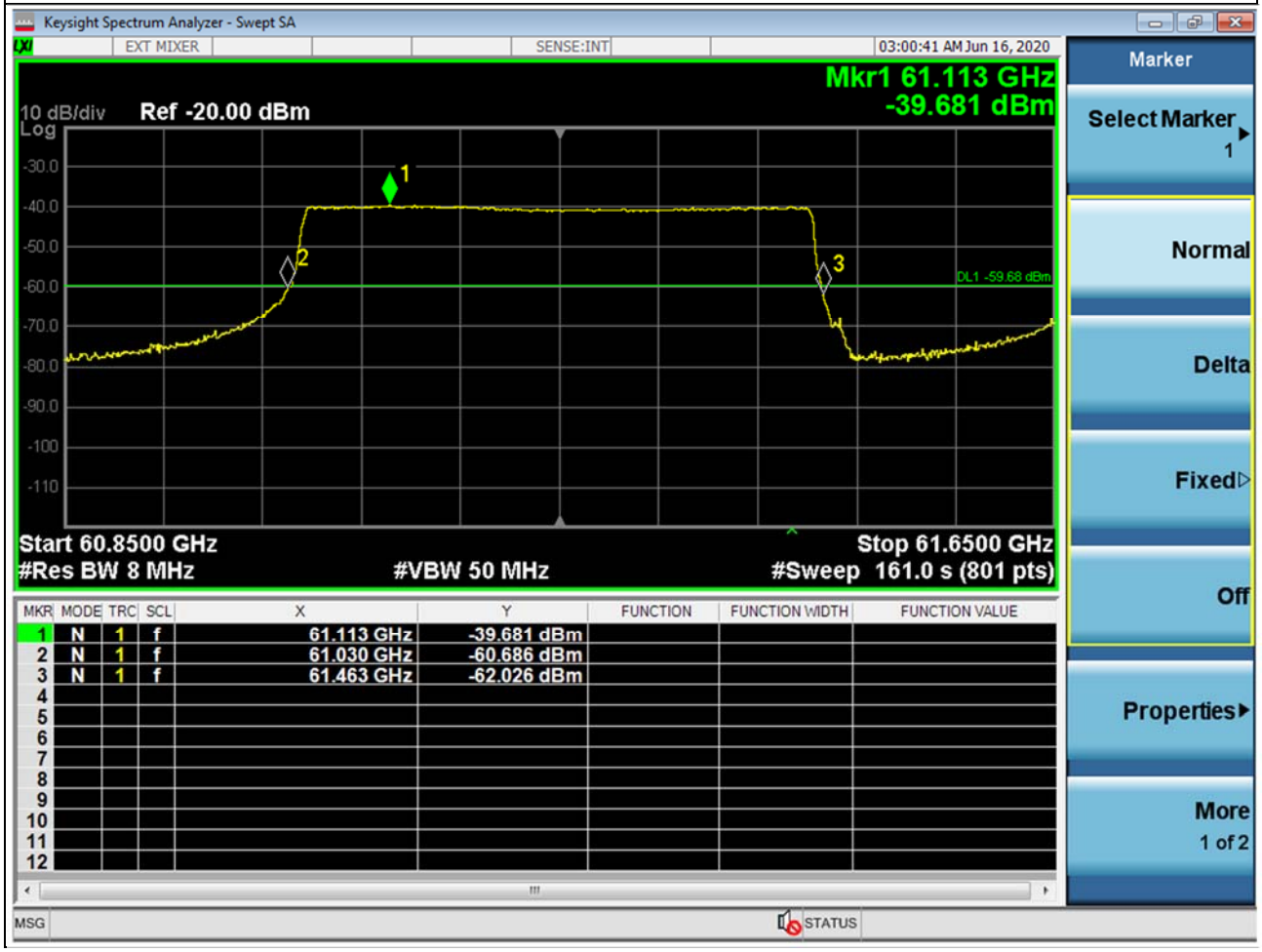
Same as Item 4.1.5.

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 |

**20 dB Bandwidth**



## 4.7 Frequency Stability Measurement

4.7.1 Applicable Rule and Limits of Frequency Stability Measurement

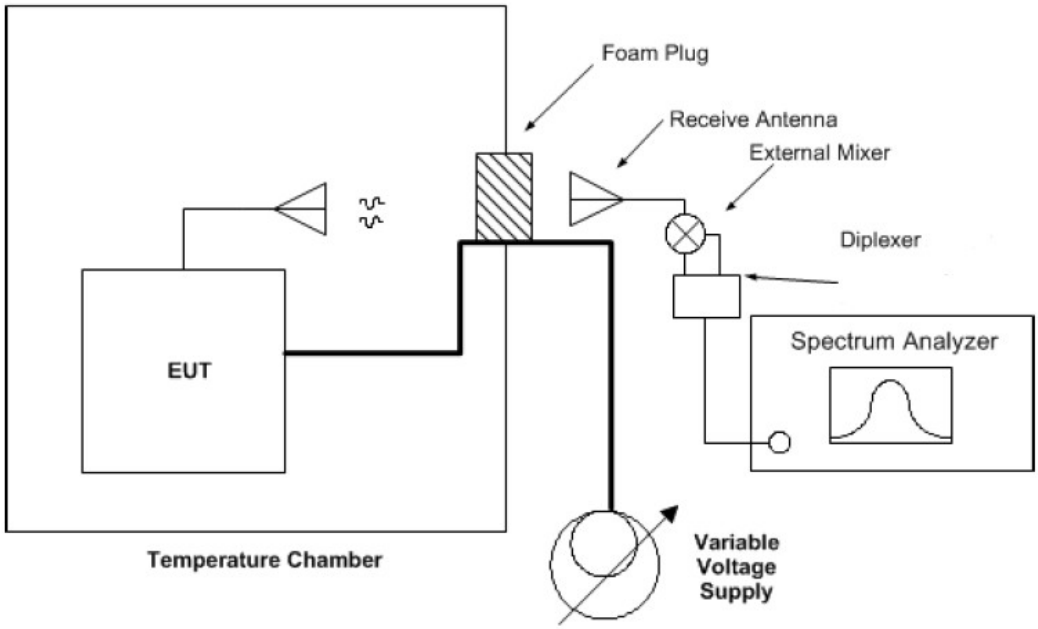
**Applicable Rule**

§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 fromTest 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. (℃) | 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. (℃) | 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 |

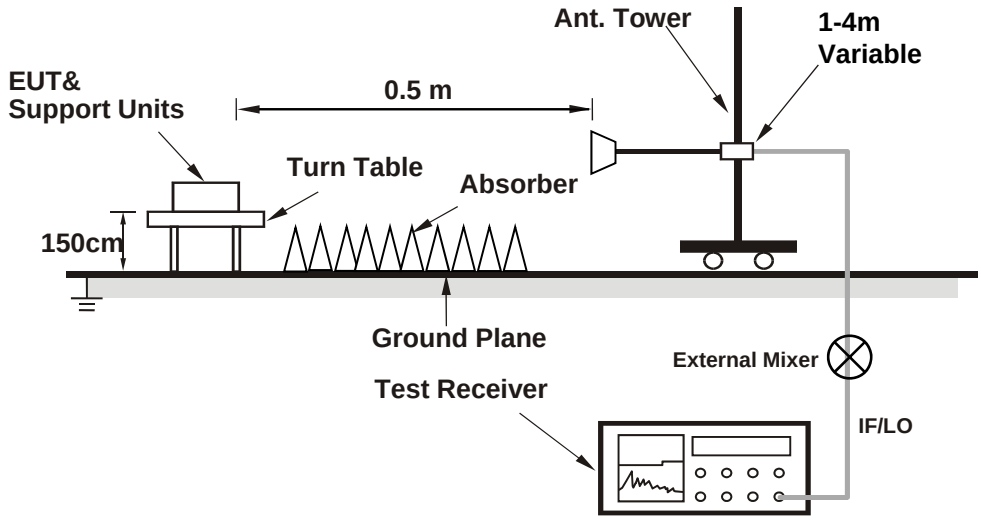
## 4.8 99% Bandwidth Measurement

### 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 fromTest 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 |

99% Bandwidth

## 4.9 Peak Power Spectral Density Measurement

### 4.9.1 Applicable Rule and Limits of Peak Power Spectral Density Measurement

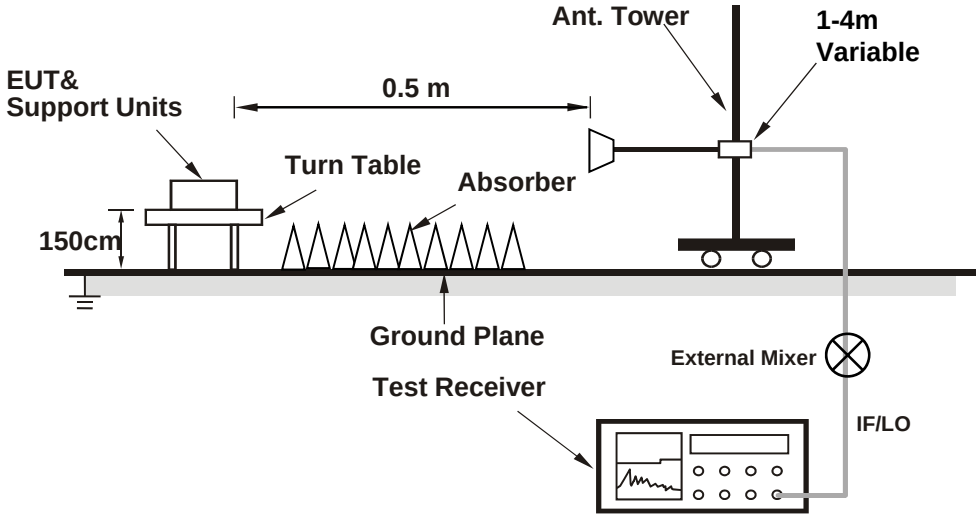
**Applicable Rule**

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 = Pmeas - Gr + Lc + Latten - Gamp
Lp = 20log(f) +20log(d) - 27.5

EIRP = Pmeas - Gr + Lc + Latten - Gamp + 20log(f) + 20log(d) - 27.5

Pmeas: Raw Reading for The Measurement (dBm)
Gr: Receiver Antenna Gain (dBi)
Lc: Cable Loss (dB)
Latten: Attenuation Loss (dB)
Gamp: 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

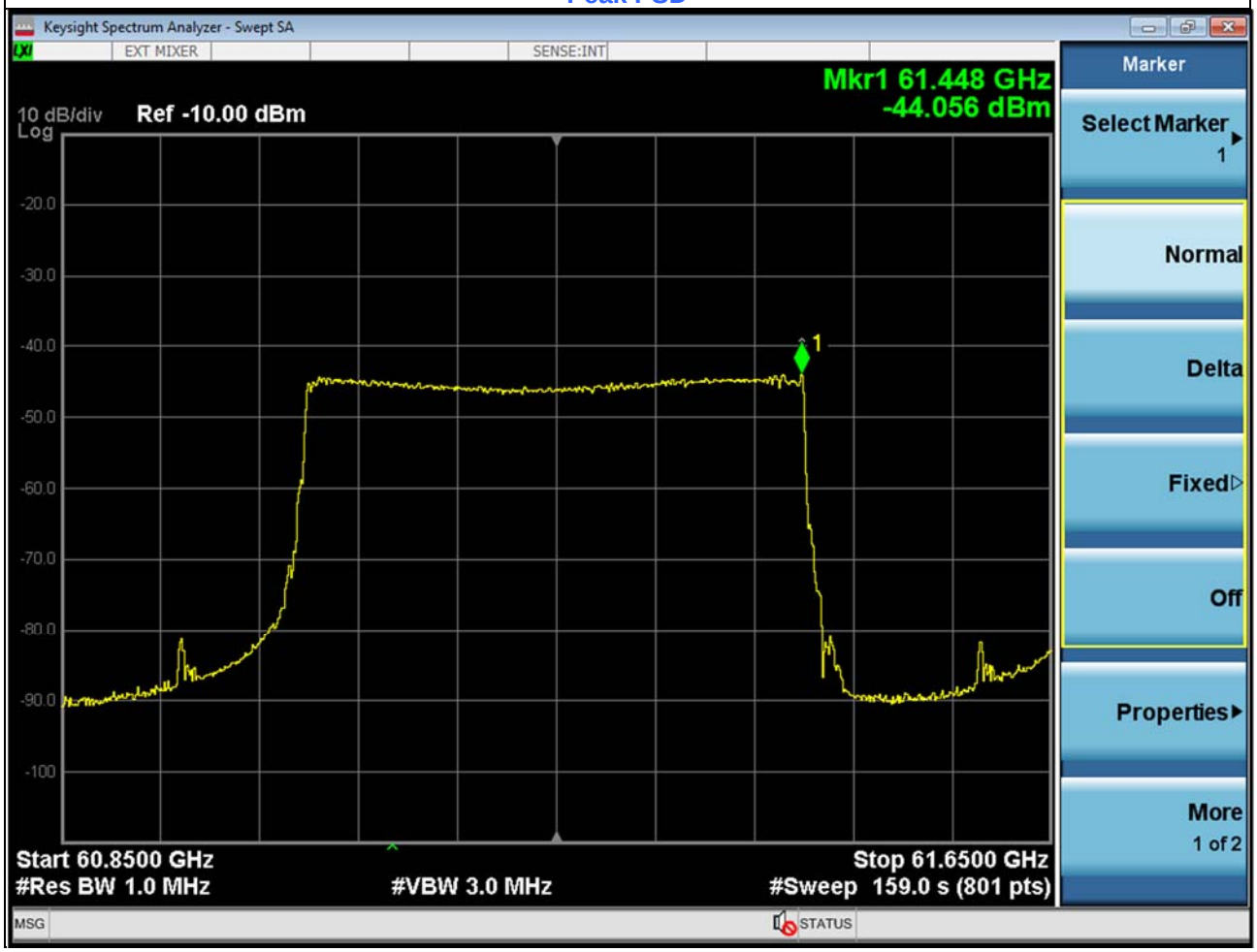
| Start Freq (GHz) | Stop Freq (GHz) | FMCW Width (MHz) | Ramp Time (us) | Sweep Rate (MHz/us) | Sweep Rate (Hz/s) | RBW (MHz) | RBW (Hz) | Normalized Sweep Rate (lin) | Amplitude Loss (lin) | Amplitude Loss (dB) |
|---|---|---|---|---|---|---|---|---|---|---|
| 61.05 | 61.45 | 400 | 55.4 | 7.22 | 7.22E+12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

Peak PSD



## 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:


**Lin Kou EMC/RF Lab**
Tel: 886-2-26052180
Fax: 886-2-26051924

**Hsin Chu EMC/RF/Telecom Lab**
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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.

**--- END ---**