HCT CO.,LTD.
74, Seoicheon-ro 578beon-gil, Majang-myeon, Icheon-si, Gyeonggi-do, 17383.Rep. of KOREA
TEL: +82-31-645-6300 **FAX: +82-31-645-6401**

FCC 24 GHz Radar Report

Certification

Applicant Name:
Mobile Appliance, Inc.

Address:
Gwanyang-dong-1701~1706, Daerung Techno #15, 401, Simin-daero, Dongan-gu, Anyang-si, Gyeonggi-do, Korea

Date of Issue:
May 08, 2019

Test Site/Location:
HCT CO., LTD., 74,Seoicheon-ro 578beon-gil,Majang-myeo,Icheon-si, Gyeonggi-do, 17383, Rep. of KOREA

Report No.: HCT-RF-1905-FC006-R1

FCC ID:	**WHBMBDASHCAMF**
APPLICANT:	**Mobile Appliance, Inc.**

Model:	Mercedes-Benz Dashcam Front
EUT Type:	Mercedes-Benz Dashcam Front
Max. RF Output Power:	106.88 dBuV/m @3 m
Operating Frequency	24194.822 MHz ~ 24215.578 MHz
Modulation type	CW
FCC Classification:	Low Power communication Device Transmitter(DXX)
FCC Rule Part(s):	Part 15.249

Engineering Statement:

The measurements shown in this report were made in accordance with the procedures indicated, and the emissions from this equipment were found to be within the limits applicable. I assume full responsibility for the accuracy and completeness of these measurements, and for the qualifications of all persons taking them.

HCT CO., LTD. Certifies that no party to this application has subject to a denial of Federal benefits that includes FCC benefits pursuant to section 5301 of the Anti-Drug Abuse Act of 1998,21 U.S. C.853(a)

Report prepared by : Kwang Il Yoon
Engineer of Telecommunication testing center

Approved by : Kwon Jeong
Manager of Telecommunication testing center

Version

TEST REPORT NO.	DATE	DESCRIPTION
HCT-RF-1905-FC006	May 07, 2019	- First Approval Report
HCT-RF-1905-FC006-R1	May 08, 2019	- The frequency range has changed.

Table of Contents

1. EUT DESCRIPTION

Model	Mercedes-Benz Dashcam Front	
EUT Type	Mercedes-Benz Dashcam Front	
Power Supply	DC 12.0 V	
Frequency Range	24150 MHz -24250 MHz	
Operating Frequency	24194.822 MHz ~ 24215.578 MHz	
Fundamental Field Strength Level	Peak	106.88 dBuV/m @3 m
	Average	105.58 dBuV/m @3 m
Modulation Type	CW	
Antenna Specification	Antenna type: PCB antenna Peak Gain : 7 dBi Maximum Dimension : 24.1 mm	
Date(s) of Tests	April 08, 2019 ~ May 07 2019	

2. TEST METHODOLOGY

The measurement procedure described in the American National Standard of Procedures for Compliance Testing of Unlicensed Wireless Devices (ANSI C63.10-2013) Operating Under §15.245" were used in the measurement.

2.1 EUT CONFIGURATION

The EUT configuration for testing is installed on RF field strength measurement to meet the Commissions requirement and operating in a manner that intends to maximize its emission characteristics in a continuous normal application.

2.2 EUT EXERCISE

The EUT was operated in the engineering mode to fix the Tx frequency that was for the purpose of the measurements. According to its specifications, the EUT must comply with the requirements of the Section 15.249 under the FCC Rules Part 15 Subpart C.

2.3 GENERAL TEST PROCEDURES

Conducted Emissions

The EUT is placed on the turntable, which is 0.8 m above ground plane. According to the requirements in Section 6.2 of ANSI C63.10. (Version :2013) Conducted emissions from the EUT measured in the frequency range between 0.15 MHz and 30MHz using CISPR Quasi-peak and average detector modes.

Radiated Emissions

The EUT is placed on a turn table, which is 0.8 m above ground plane below 1GHz. Above 1GHz with 1.5m using absorbers between the EUT and receive antenna. The turntable shall rotate 360 degrees to determine the position of maximum emission level. EUT is set far-field distance away from the receiving antenna, which varied from 1 m to 4 m to find out the highest emission. And also, each emission was to be maximized by changing the polarization of receiving antenna both horizontal and vertical. In order to find out the max. emission, the relative positions of this hand-held transmitter (EUT) was rotated through three orthogonal axes according to the requirements in Section 8 of ANSI C63.10. (Version: 2013)

2.4 DESCRIPTION OF TEST MODES

The EUT has been tested under operating condition. Test program used to control the EUT for staying in continuous transmitting and receiving mode is programmed.

3. INSTRUMENT CALIBRATION

The measuring equipment, which was utilized in performing the tests documented herein, has been calibrated in accordance with the manufacturer's recommendations for utilizing calibration equipment's, which is traceable to recognized national standards.
Especially, all antenna for measurement is calibrated in accordance with the requirements of C63.5 (Version : 2006).

4. FACILITIES AND ACCREDITATIONS

4.1 FACILITIES

The SAC(Semi-Anechoic Chamber) and conducted measurement facility used to collect the radiated data are located at the 74, Seoicheon-ro 578beon-gil, Majang-myeon, Icheon-si, Gyeonggi-do, Korea. The site is constructed in conformance with the requirements of ANSI C63.4. (Version :2014) and CISPR Publication 22. Detailed description of test facility was submitted to the Commission and accepted dated April 02, 2018 (Registration Number: KR0032)

4.2 EQUIPMENT

Radiated emissions are measured with one or more of the following types of Linearly polarized antennas: tuned dipole, bi-conical, log periodic, bi-log, and/or ridged waveguide, horn. Spectrum analyzers with pre-selectors and quasi-peak detectors are used to perform radiated measurements. Conducted emissions are measured with Line Impedance Stabilization Networks and EMI Test Receivers. Calibrated wideband preamplifiers, coaxial cables, and coaxial attenuators are also used for making measurements.
All receiving equipment conforms to CISPR Publication 16-1, "Radio Interference Measuring Apparatus and Measurement Methods."

5. ANTENNA REQUIREMENTS

According to FCC 47 CFR §15.203:

"An intentional radiator antenna shall be designed to ensure that no antenna other than that furnished by the responsible party can be used with the device. The use of a permanently attached antenna or of an antenna that uses a unique coupling to the intentional radiator shall be considered sufficient to comply with the provisions of this section."

* The antennas of this E.U.T are permanently attached.

*The E.U.T Complies with the requirement of §15.203

6. MEASUREMENT UNCERTAINTY

The measurement uncertainties shown below were calculated in accordance with the requirements of ANSI C63.4:2014.

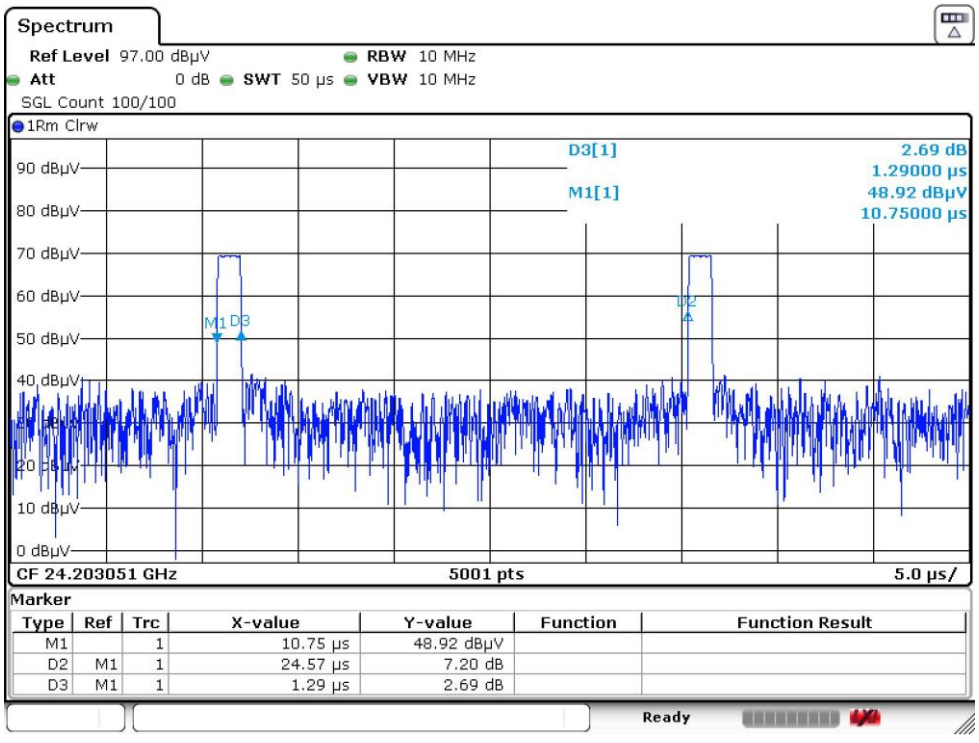
All measurement uncertainty values are shown with a coverage factor of k = 2 to indicate a 95 % level of confidence.

Parameter	Expanded Uncertainty (±dB)
Conducted Disturbance (150 kHz ~ 30 MHz)	1.82
Radiated Disturbance (9 kHz ~ 30 MHz)	3.40
Radiated Disturbance (30 MHz ~ 1 GHz)	4.80
Radiated Disturbance (1 GHz ~ 18 GHz)	5.70
Radiated Disturbance (18 GHz ~ 40 GHz)	5.44
Radiated Disturbance (40 GHz ~ 60 GHz)	5.29
Radiated Disturbance (60 GHz ~ 90 GHz)	5.31
Radiated Disturbance (90 GHz ~ 100 GHz)	5.29

7. SUMMARY TEST OF RESULTS

Test Description	FCC Part Section(s)	Test Limit	Test Condition	Test Result
Occupied Bandwidth	§2.1049	N/A	RADIATED	PASS
Fundamental Field Strength Level	§15.249(a)	< 250 mV/m		PASS
Harmonic Field Strength Level	§15.249(a)	< 2500 mV/m		PASS
General Field Strength Limits (Restricted Bands and Radiated Emission Limits)	§15.205, 15.209, 15.249(d)	< 15.209 limits or 50dB below the level of the fundamental		PASS

Measurement Result of 24 GHz Radar Transmit On/Off Timing



- The EUT duty cycle is calculated according to ANSI C63.26 - 5.2.4.3.4.

Duty Cycle = On-time / Transmitter period = 1.29 us / 24.57 us = 0.0525

Duty Correction = 10 log (1/duty cycle) = 10 log (1/0.0525) = 12.8 dB

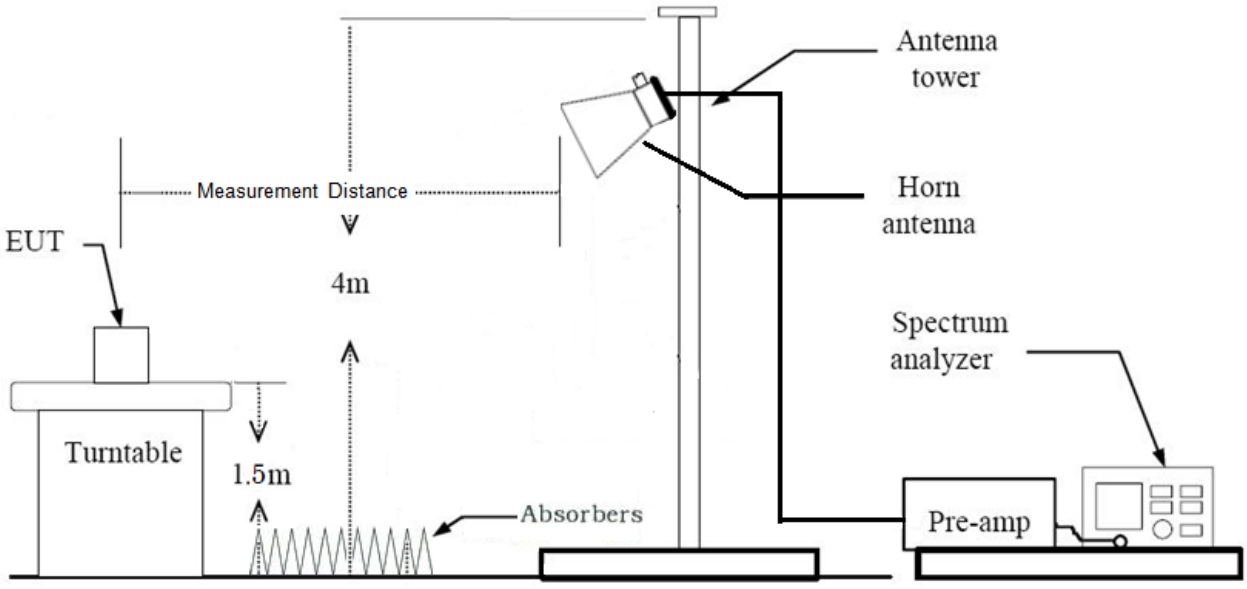
8. TEST RESULT

8.1 OCCUPIED BANDWIDTH MEASUREMENT

Test Requirements and limit, §2.1049

The occupied bandwidth, that is the frequency bandwidth such that, below its lower and above its upper frequency limits, the mean powers radiated are each equal to 0.5 percent of the total mean power radiated by a given emission shall be measured.

▣ TEST CONFIGURATION



▣ TEST PROCEDURE

The transmitter output is connected to the Spectrum Analyzer.

RBW = 1% to 3% of the 99% bandwidth.

VBW ≥ 3 x RBW

Detector = Peak

Trace mode = max hold

Sweep = auto couple

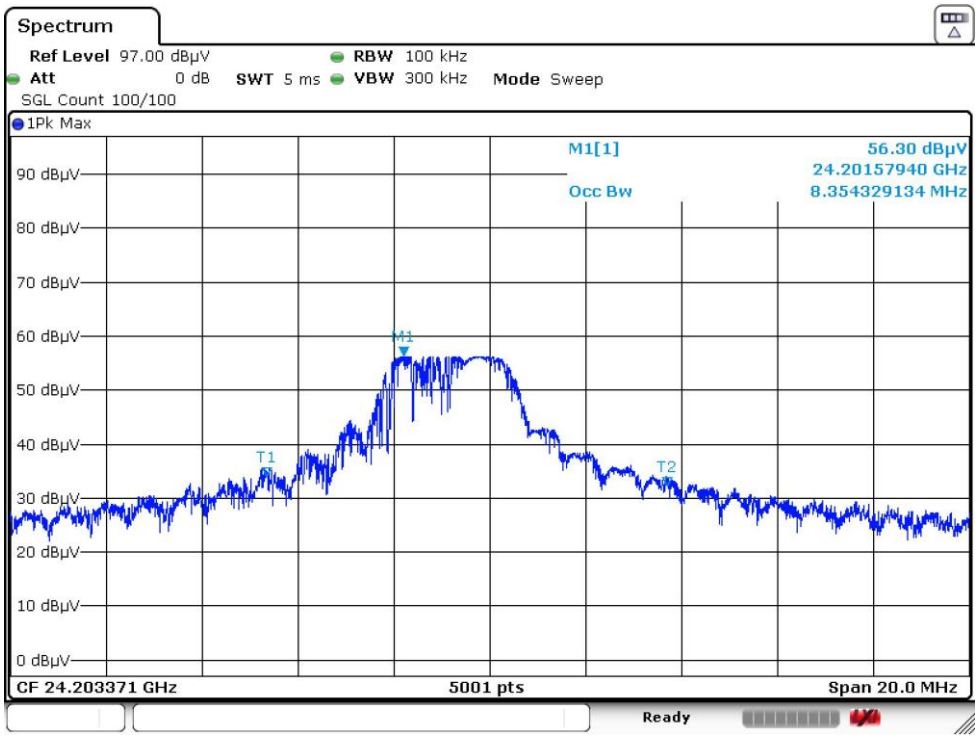
Allow the trace to stabilize

Note : 1. We tested Occupied Bandwidth using the automatic bandwidth measurement capability of a spectrum analyzer.

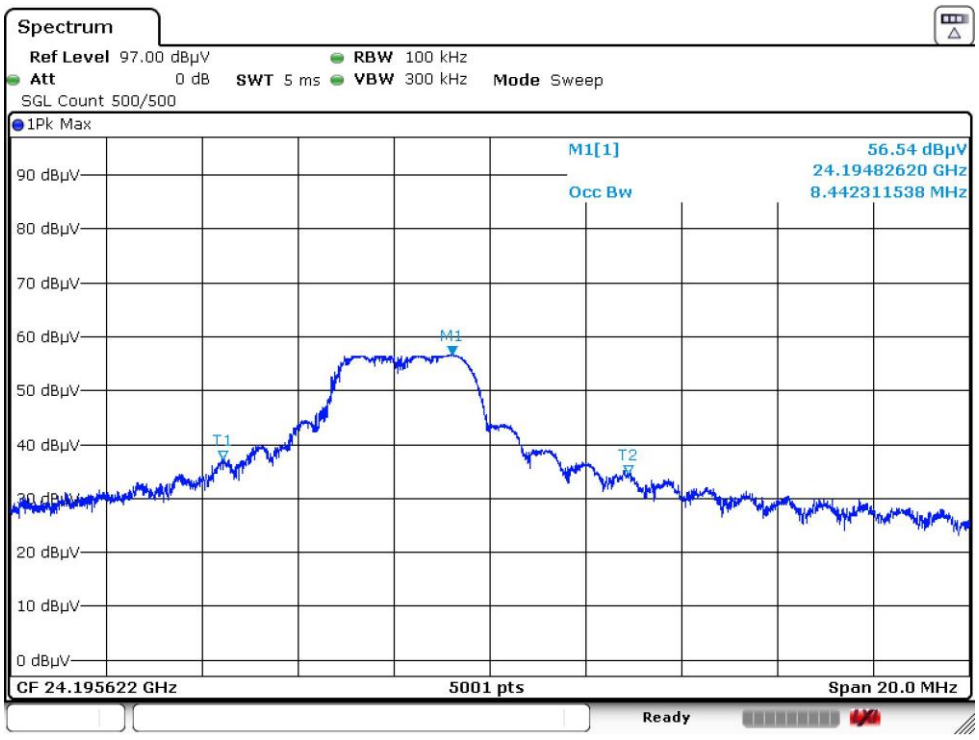
2. Measured distance : 1 m

▣ RESULT PLOTS

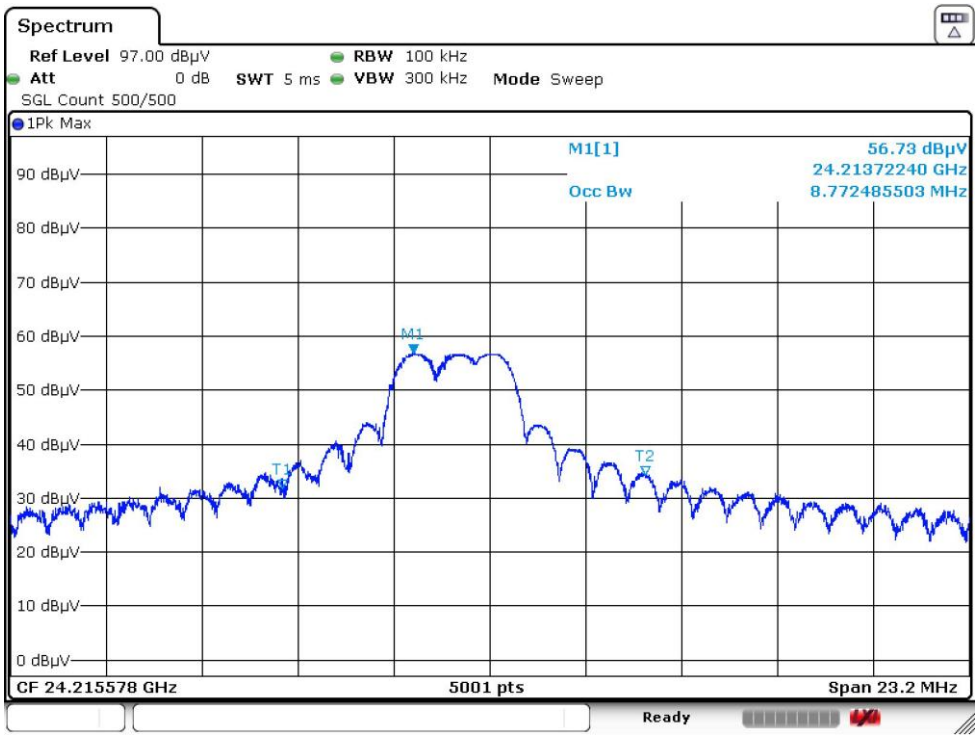
Occupied Bandwidth plot (Low Channel)



Occupied Bandwidth plot (Mid Channel)



Occupied Bandwidth plot (High Channel)



8.2 RADIATED MEASUREMENT.

Test Requirements and limit, §15.249 (d)

Operation within the bands 902–928 MHz, 2400–2483.5 MHz, 5725–5875 MHZ, and 24.0–24.25 GHz.

(a) Except as provided in paragraph (b) of this section, the field strength of emissions from intentional radiators operated within these frequency bands shall comply with the following:

Fundamental frequency	Field strength of fundamental (millivolts/meter)	Field strength of harmonics (microvolts/meter)
902-928 MHz	50	500
2400-2483.5 MHz	50	500
5725-5875 MHz	50	500
24.0-24.25 GHz	250	2500

(c) Field strength limits are specified at a distance of 3 meters.

(d) Emissions radiated outside of the specified frequency bands, except for harmonics, shall be attenuated by at least 50 dB below the level of the fundamental or to the general radiated emission limits in §15.209, whichever is the lesser attenuation.

(e) As shown in §15.35(b), for frequencies above 1000 MHz, the field strength limits in paragraphs (a) and (b) of this section are based on average limits. However, the peak field strength of any emission shall not exceed the maximum permitted average limits specified above by more than 20 dB under any condition of modulation. For point-to-point operation under paragraph (b) of this section, the peak field strength shall not exceed 2500 millivolts/meter at 3 meters along the antenna azimuth

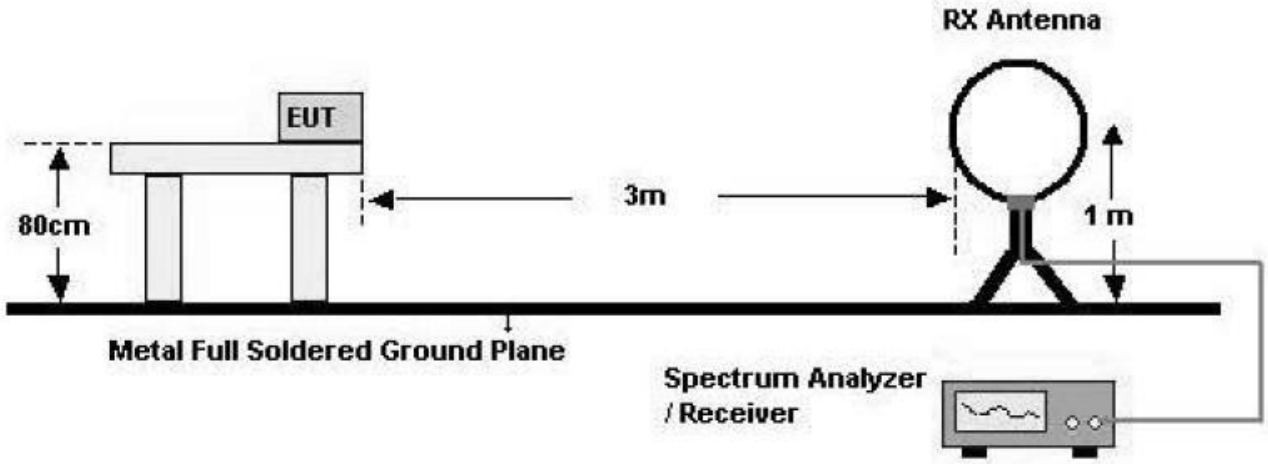
Test Procedure

1. The EUT is placed on a turntable, which is 1.5 m above ground plane.
2. The turntable shall be rotated for 360 degrees to determine the position of maximum emission level.
3. In case from 9 kHz to 18 GHz, EUT is set 3 m away from the receiving antenna, which is varied from 1m to 4m to find out the highest emissions.
   In case from 18 GHz to 60 GHz, EUT is set 1 m away from the receiving antenna, which is varied from 1m to 4m to find out the highest emissions.
   In case above 60 GHz, EUT is set 1.5 m away from the receiving antenna, which is varied from 1m to 4m to find out the highest emissions.
4. Maximum procedure was performed on the six highest emissions to ensure EUT compliance.
5. And also, each emission was to be maximized by changing the polarization of receiving antenna both horizontal and vertical.
6. Repeat above procedures until the measurements for all frequencies are complete.
7. Measured Distance

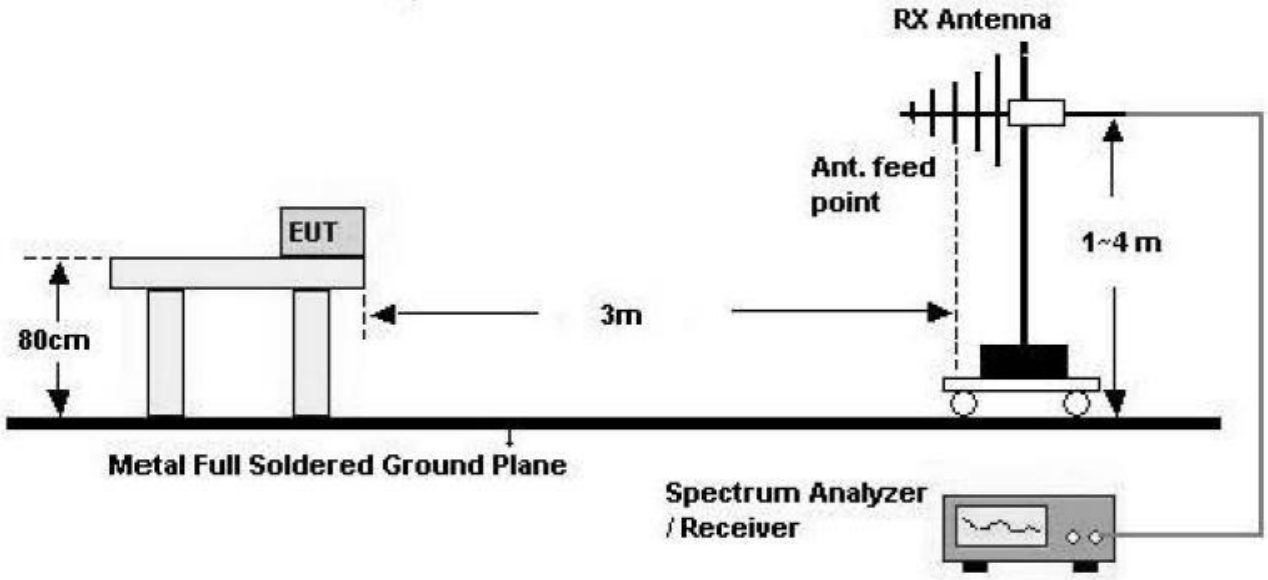
Frequency Range(GHz)	Frequency (MHz)	Antenna Size(m)	Far Field Distance(m)	Measured Distance(m)
24.000 ~ 24.250	24125	0.0214	0.0732736	1
18 ~ 40	40000		0.122122667	1
40 ~ 60	60000		0.183184	1
60 ~ 90	90000		0.274776	1
90 ~ 100	100000		0.305306667	1

Test Configuration

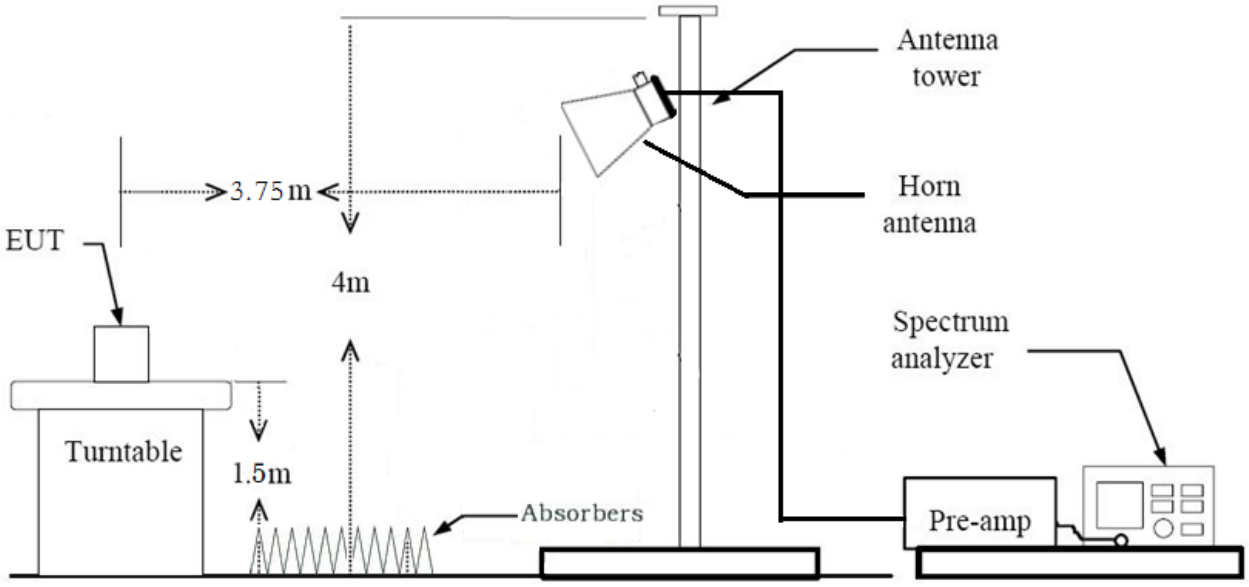
Below 30 MHz



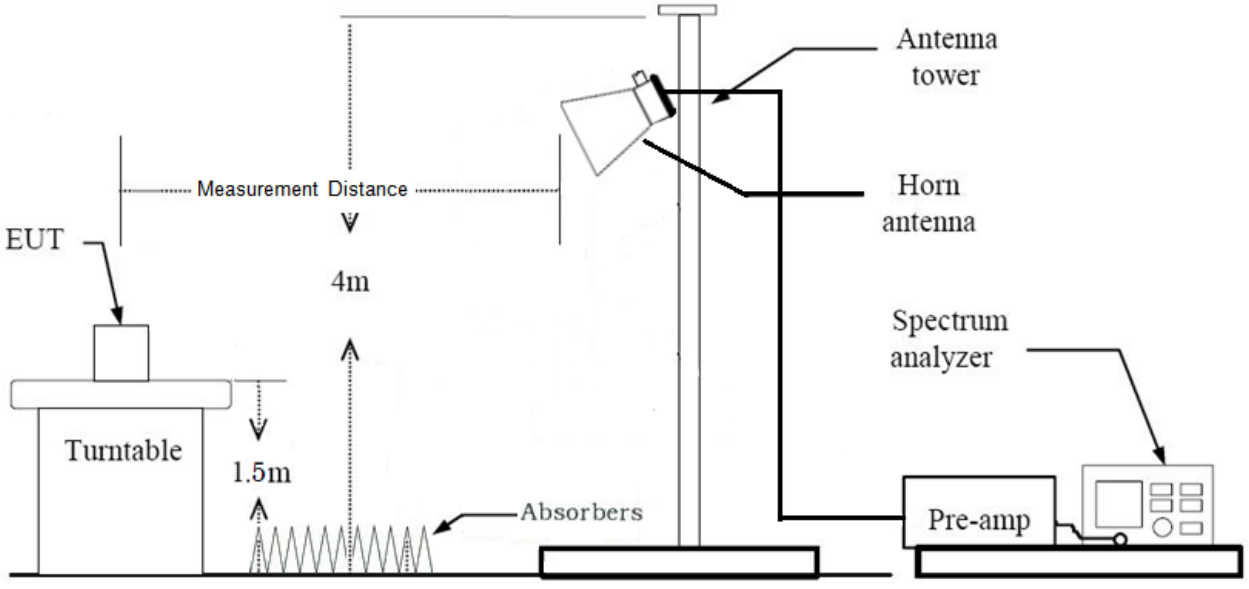
30 MHz - 1 GHz



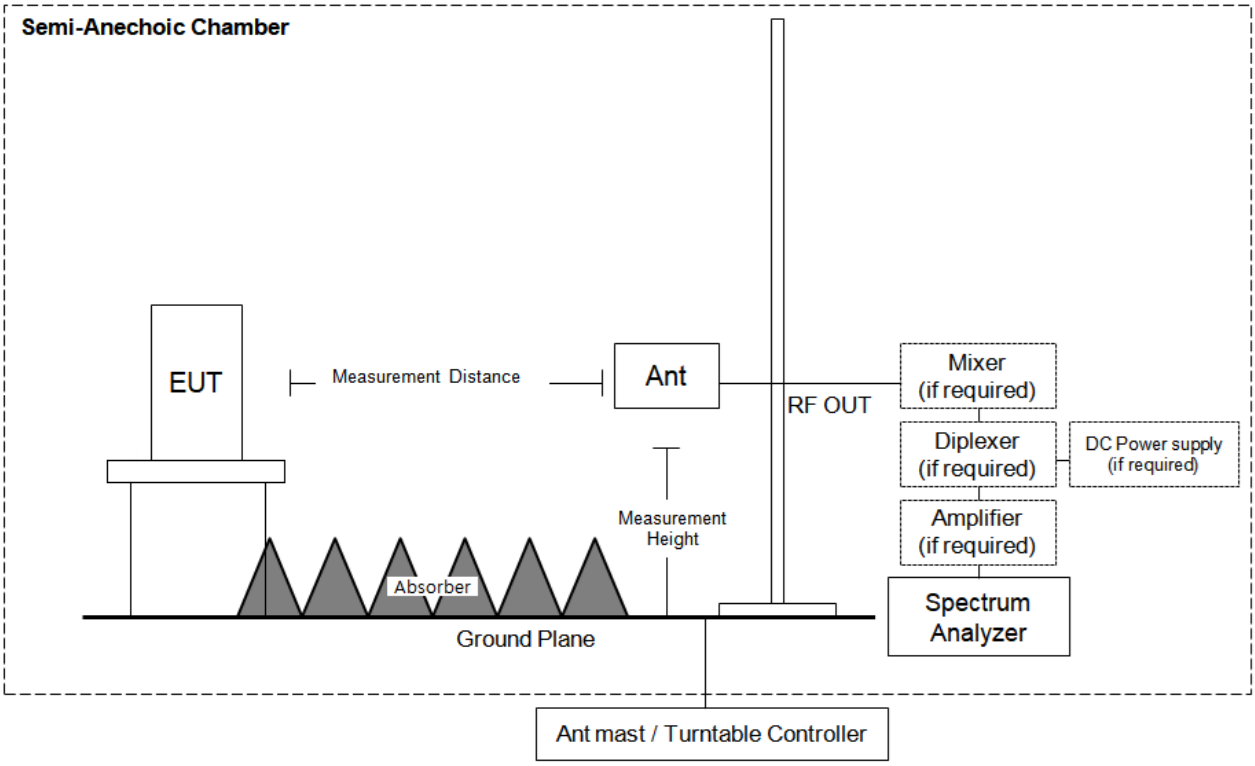
1 GHz – 18 GHz



18 GHz – 40 GHz



40 GHz – 100 GHz



▣ FIELD STRENGTH OF FUNDAMENTAL TEST RESULTS

Low Channel

Frequency [GHz]	Reading [dBuV/m]	A.F.+C.L. [dB]	Ant. Pol. [H/V]	D.E.F [dB]	Duty Cycle Factor (dB)	Total [dBuV/m]	Limit [dBuV/m]	Margin [dB]	Measurement Type
24.194822	71.52	44.82	V	-9.54	-	106.80	127.96	21.16	PK
24.194822	57.50	44.82	V	-9.54	12.80	105.58	107.96	2.38	AV

Mid Channel

Frequency [GHz]	Reading [dBuV/m]	A.F.+C.L. [dB]	Ant. Pol. [H/V]	D.E.F [dB]	Duty Cycle Factor (dB)	Total [dBuV/m]	Limit [dBuV/m]	Margin [dB]	Measurement Type
24.203371	71.20	44.82	V	-9.54	-	106.48	127.96	21.48	PK
24.203371	57.48	44.82	V	-9.54	12.80	105.56	107.96	2.40	AV

High Channel

Frequency [GHz]	Reading [dBuV/m]	A.F.+C.L. [dB]	Ant. Pol. [H/V]	D.E.F [dB]	Duty Cycle Factor (dB)	Total [dBuV/m]	Limit [dBuV/m]	Margin [dB]	Measurement Type
24.215578	71.60	44.82	V	-9.54	-	106.88	127.96	21.08	PK
24.215578	57.50	44.82	V	-9.54	12.80	105.58	107.96	2.38	AV

※ A·F: ANTENNA FACTOR

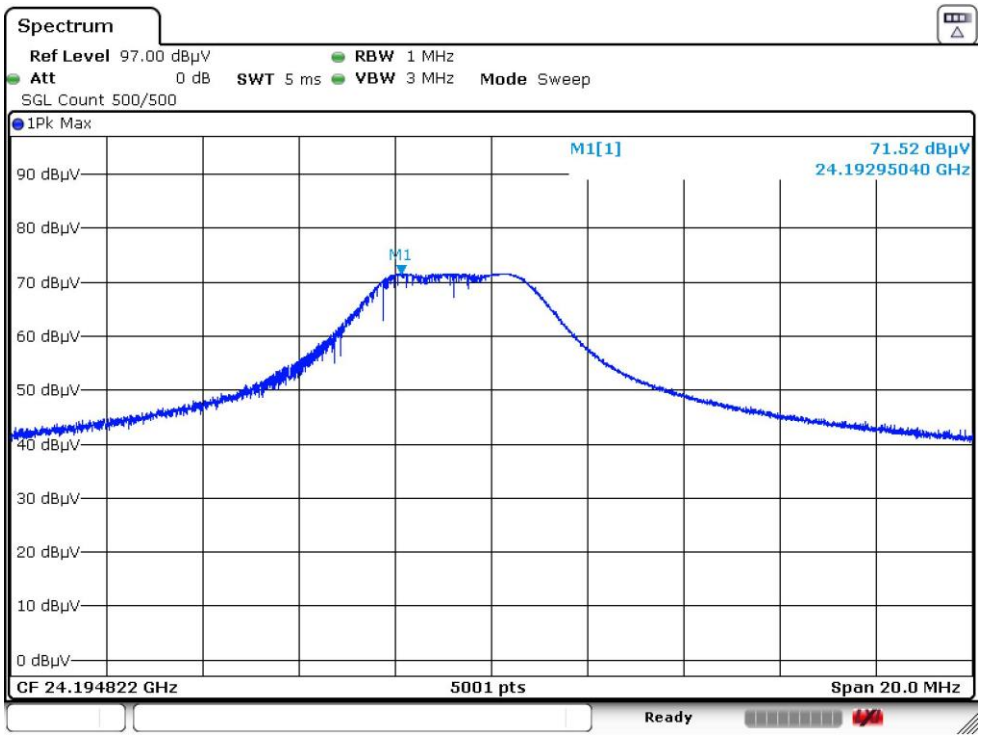
C·L: CABLE LOSS

Note :

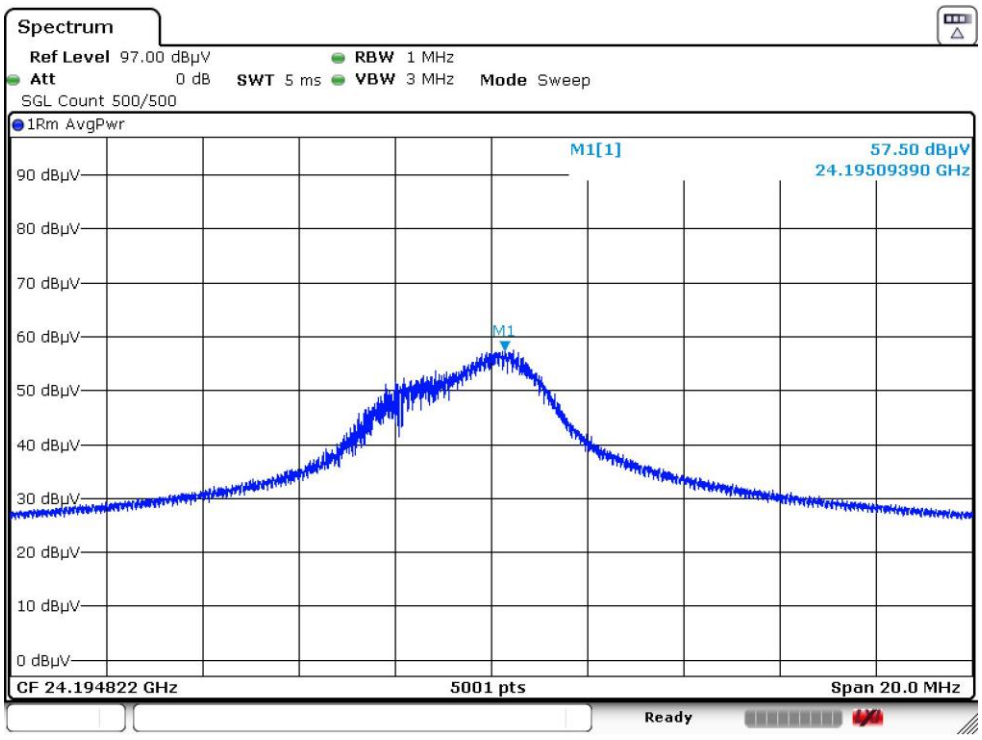
1. Total = Reading Value + Antenna Factor + Cable Loss + Distance Factor + Duty Cycle Factor
2. Distance extrapolation factor = 20 log (test distance / specific distance) (dB)
3. Measured Distance : 1 m
4. We have done x, y, z planes in EUT and horizontal and vertical polarization in detecting antenna.

▣ RESULT PLOTS

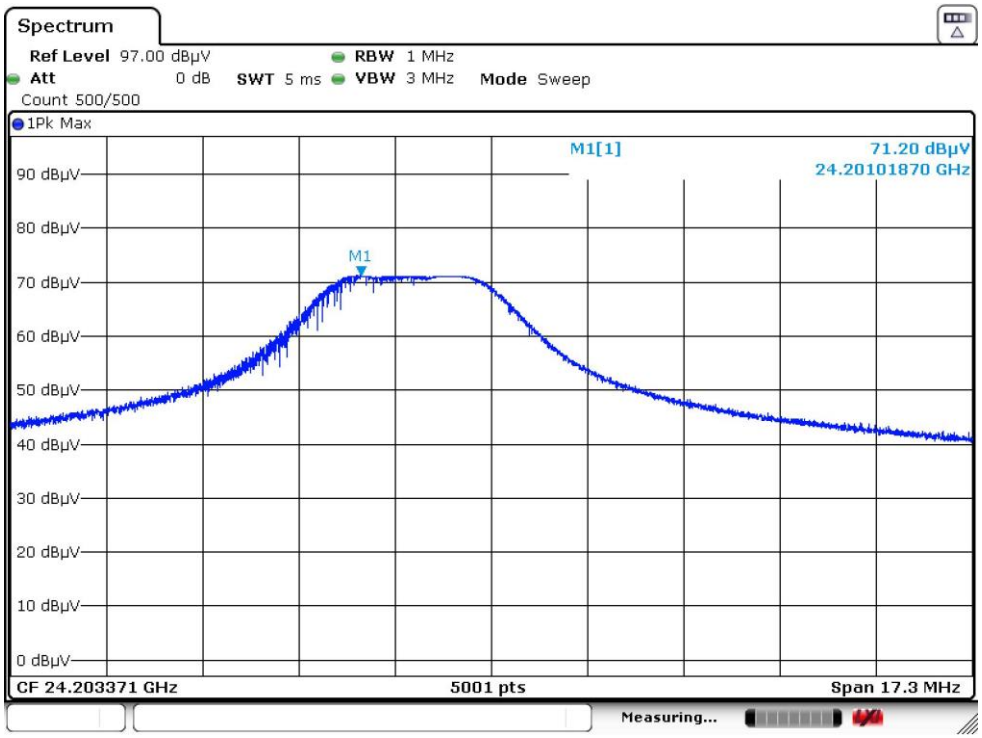
Fundamental Field Strength plot (Peak - Vertical)_Low Channel



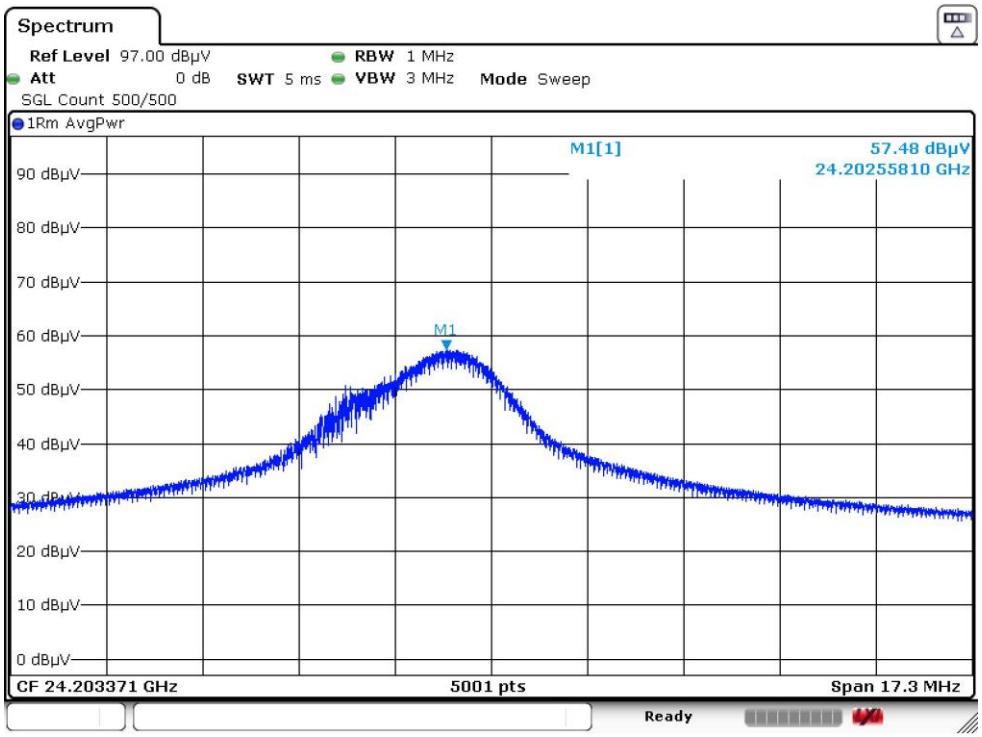
Fundamental Field Strength plot (Average - Vertical)_Low Channel



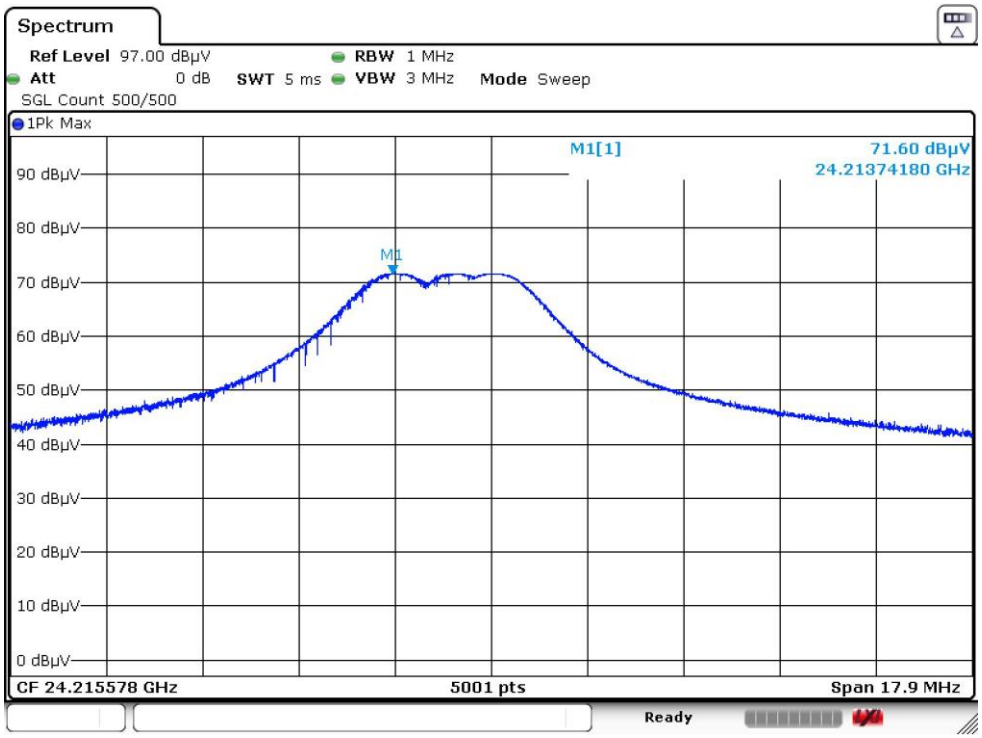
Fundamental Field Strength plot (Peak - Vertical)_Mid Channel



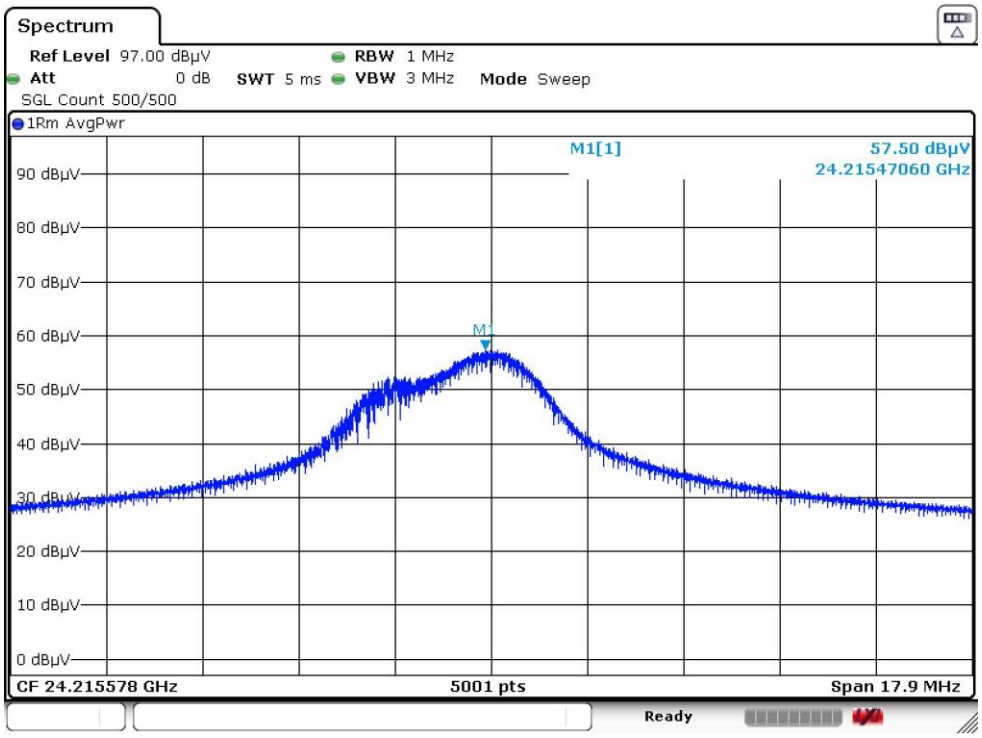
Fundamental Field Strength plot (Average - Vertical)_Mid Channel



Fundamental Field Strength plot (Peak - Vertical)_High Channel



Fundamental Field Strength plot (Average - Vertical)_High Channel



▣ FIELD STRENGTH OF HARMONICS and RADIATED SPURIOUS EMISSIONS TEST RESULTS

9 kHz – 30MHz

Operation Mode: Continuous TX Mode

Frequency	Reading	Ant. factor	Cable loss	Ant. POL	Total	Limit	Margin
MHz	dBuV/m	dBm/m	dBm	(H/V)	dBuV/m	dBuV/m	dB
No Critical peaks found							

Notes:

1. Measuring frequencies from 9 kHz to the 30MHz.
2. The reading of emissions are attenuated more than 20 dB below the permissible limits or the field strength is too small to be measured.
3. Distance extrapolation factor = 40 log (specific distance / test distance) (dB)
4. Limit line = specific Limits (dBuV) + Distance extrapolation factor
5. We have done x, y, z planes in EUT and horizontal and vertical polarization in detecting antenna.
6. The test results for below 30 MHz is correlated to an open site.
   The result on OATS is about 2 dB higher than semi-anechoic chamber(10 m chamber)

TEST RESULTS

Below 1 GHz

Operation Mode: Continuous TX Mode

Frequency	Reading	Ant. factor	Cable loss	Ant. POL	Total	Limit	Margin
MHz	dBuV/m	dBm/m	dBm	(H/V)	dBuV/m	dBuV/m	dB
No Critical peaks found							

Notes:

1. Measuring frequencies from 30 MHz to the 1 GHz.
2. Radiated emissions measured in frequency range from 30 MHz to 1000 MHz were made with an instrument using Quasi peak detector mode.
3. We have done x, y, z planes in EUT and horizontal and vertical polarization in detecting antenna.

1 GHz – 18 GHz

Operation Frequency: Continuous TX Mode

Frequency [MHz]	Reading [dBuV/m]	A.F.+C.L.-AMP G +D.F. [dBm]	ANT. POL [H/V]	Total [dBuV/m]	Limit [dBuV/m]	Margin [dB]	Measurement Type
No Critical peaks found							

※ A·F: ANTENNA FACTOR
C·L: CABLE LOSS
AMP G: AMPLIFIER GAIN

Notes:

1. Measuring frequencies from 1 GHz to the 10th harmonic of highest fundamental frequency.
2. Measurements above show only up to 6 maximum emissions noted, or would be lesser if no specific emissions from the EUT are recorded (ie: margin > 20 dB from the applicable limit) and considered that's already beyond the background noise floor.
3. Radiated emissions measured in frequency above 1000MHz were made with an instrument using Peak detector mode and average detector mode of the emission shown in Actual FS column.
4. Total = Reading Value + Antenna Factor + Cable Loss – Amplifier Gain + Distance Factor
5. We have done x, y, z planes in EUT and horizontal and vertical polarization in detecting antenna.
6. Measurement distance : 1 m

18 GHz – 40 GHz

Operation Frequency: Continuous TX Mode

Front

Frequency [GHz]	Reading [dBuV/m]	A.F.+C.L. [dB]	Ant. Pol. [H/V]	D.E.F [dB]	Total [dBuV/m]	Limit [dBuV/m]	Margin [dB]	Measurement Type
*24.000	35.19	44.82	V	-9.54	70.47	74	3.53	PK
*24.000	6.73	44.82	V	-9.54	42.01	54	11.99	AV
*24.250	34.35	44.82	V	-9.54	69.63	74	4.37	PK
*24.250	8.94	44.82	V	-9.54	44.22	54	9.78	AV

※ A·F: ANTENNA FACTOR

C·L: CABLE LOSS

Note :

1. Total = Reading Value + Antenna Factor + Cable Loss + Distance Factor
2. Distance extrapolation factor = 20 log (test distance / specific distance) (dB)
3. Measured Distance : 1 m
4. We have done x, y, z planes in EUT and horizontal and vertical polarization in detecting antenna. Worst case is y plane and vertical polarization.
5. '*' is band edge frequency.

40 GHz – 100 GHz

Operation Frequency: Continuous TX Mode

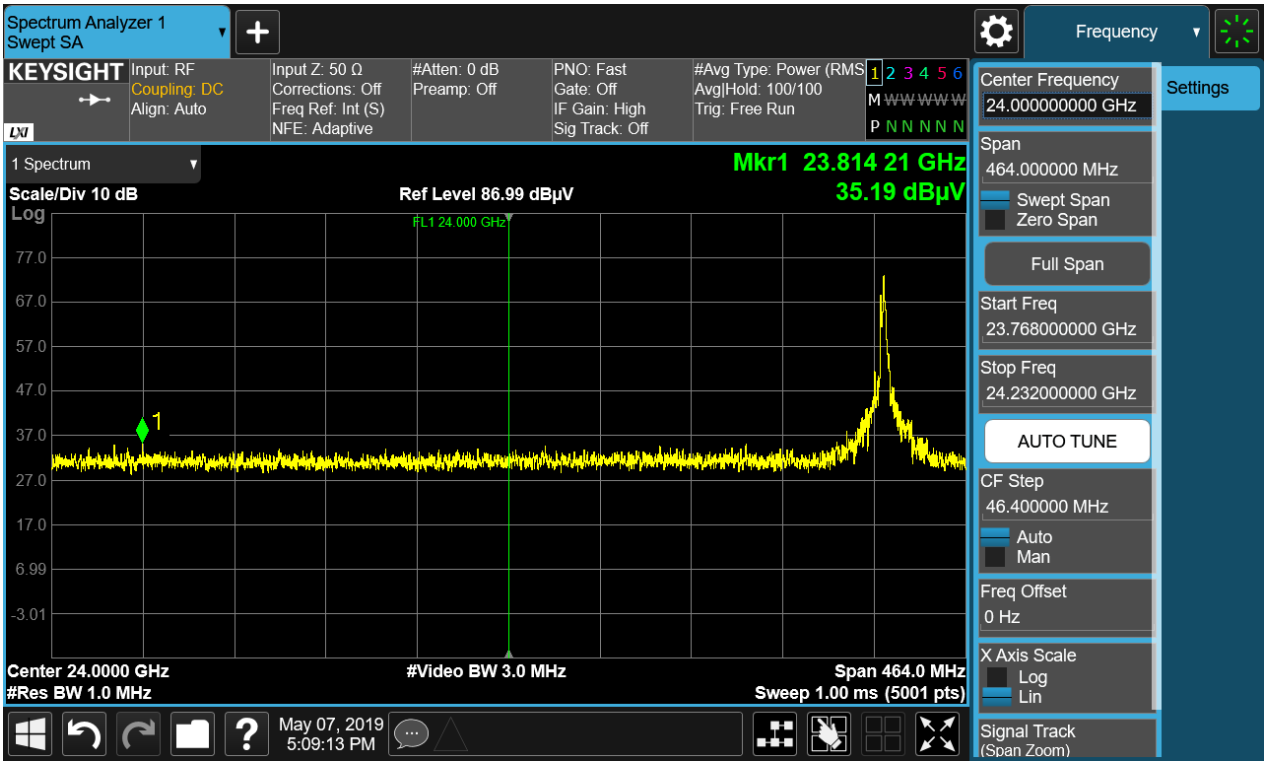
Frequency [GHz]	Reading [dBm]	AFCL [dB]	Ant. Pol. [H/V]	Conversion Factor [dB]	Total [dBuV/m]	Limit [dBuV/m]	Margin [dB]	Measurement Type
No Critical peaks found								

Note :

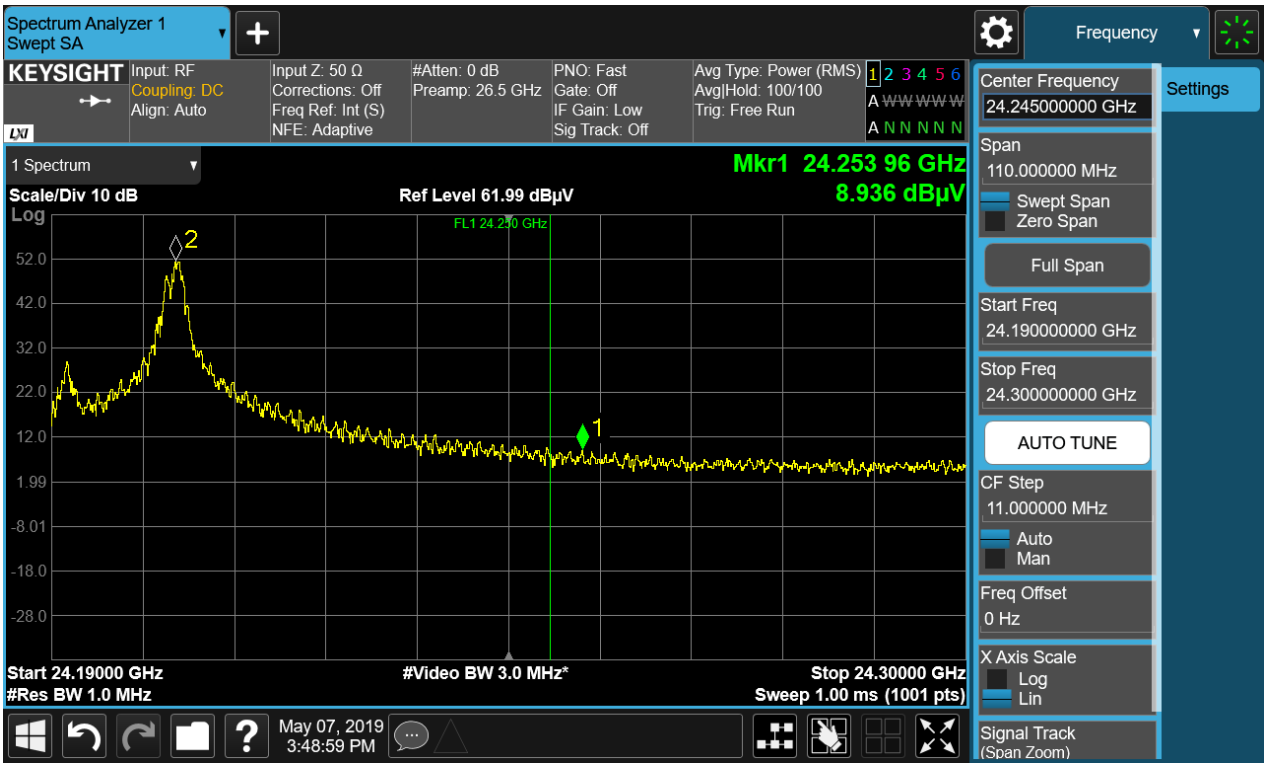
1. Total(dBuV/m) = Reading Value(dBm) + AFCL(dB) + Conversion Factor(dB)
   (cf. ANSI C63.10_2013 section 9.5)
2. Distance extrapolation factor = 20 log (test distance / specific distance) (dB)
3. Measured Distance : 1 m(40 GHz – 60 GHz), 1 m(60 GHz – 100 GHz)
4. We have done x, y, z planes in EUT and horizontal and vertical polarization in detecting antenna. Worst case is y plane and horizontal polarization.
5. In this test, AFCL factor consists of antenna factor, cable loss, mixer loss, amplifier gain
6. Conversion Factor = 20 log(D)-104.77 = 95.2 dB(where, distance is 3 m.)
7. Because of no critical emissions are detected in the test, only peak value is recorded in this report.

▣ RESULT PLOTS

Band Edge Plot(peak, x-V)



Band Edge Plot(average, x-V)



Note : Only the worst case plots for Radiated Spurious Emissions.

9. LIST OF TEST EQUIPMENT

Manufacturer	Model / Equipment	Calibration Date	Calibration Interval	Serial No.
Agilent	N9030B / PXA Signal Analyzer	08/29/2018	Annual	MY55480167
Schwarzbeck	BBHA 9170 / Horn Antenna	12/04/2017	Biennial	BBHA9170541
Innco system	CO3000 / Controller(Antenna mast)	N/A	N/A	CO3000-4p
Innco system	MA4640/800-XP-EP / Antenna Position Tower	N/A	N/A	N/A
Rohde&Schwarz	FSW / Spectrum Analyzer	09/27/2018	Annual	101256
Rohde&Schwarz	FSP / Spectrum Analyzer	09/19/2018	Annual	836650/016
Emco	2090 / Controller	N/A	N/A	060520
Ets	Turn Table	N/A	N/A	N/A
Rohde & Schwarz	Loop Antenna	01/18/2019	Biennial	1513-175
Schwarzbeck	VULB 9168 / Hybrid Antenna	08/31/2020	Biennial	9168-0895
Schwarzbeck	BBHA 9120D / Horn Antenna	06/30/2017	Biennial	9120D-1300
OML INC.	WR-19 Horn Antenna / Horn Antenna	N/A	N/A	18042301
OML INC.	WR-19 Horn Antenna / Horn Antenna	N/A	N/A	18042302
OML INC.	WR-12 Horn Antenna / Horn Antenna	N/A	N/A	18042301
OML INC.	WR-12 Horn Antenna / Horn Antenna	N/A	N/A	18042302
OML INC.	WR-08 Horn Antenna / Horn Antenna	N/A	N/A	18050101
OML INC.	WR-08 Horn Antenna / Horn Antenna	N/A	N/A	18050102
OML INC.	OML WR19 / Harmonic Mixer	09/26/2017	Annual	W19HWD
OML INC.	OML WR12 / Harmonic Mixer	09/26/2017	Annual	W12HWD
OML INC.	OML WR08 / Harmonic Mixer	09/26/2017	Annual	W08HWD
OML INC.	WR-19 / Source Module	09/26/2017	Annual	S19MS-A-160516-1
OML INC.	WR-12 / Source Module	09/26/2017	Annual	S12MS-A-160419-1
OML INC.	WR-08 / Source Module	09/26/2017	Annual	S08MS-A-160419-1
OML INC.	Diplexer L.O / Diplexer	07/24/2018	Annual	DPL518-160419-1
CERNEX	CBLU1183540 / Power Amplifier	07/10/2018	Annual	22964
CERNEX	CBL26405040 / Power Amplifier	06/29/2018	Annual	25956

Note:

1. Equipment listed above that calibrated during the testing period was set for test after the calibration.

2. Equipment listed above that has a calibration due date during the testing period, the testing is completed before equipment expiration date.

10. ANNEX A_TEST SETUP PHOTO

Please refer to test setup photo file no. as follows;

No.	Description
1	HCT-RF-1905-FC006-P