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TEST REPORT

FCC 24 GHz Radar Test for Jaguar Dash Cam Rear
Certification

APPLICANT
Mobile Appliance, Inc.

REPORT NO.
HCT-RF-2008-FC038

DATE OF ISSUE
14 August 2020

Tested by
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FCC 24 GHz Radar Test for Jaguar Dash Cam Rear

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Additional Model
Land Rover Dash Cam Rear

Applicant	**Mobile Appliance, Inc.** Gwanyang-dong-1701~1706, Daerung Techno #15, 401, Simin-daero, Dongan-gu, Anyang-si, Gyeonggi-do, Korea
Eut Type Model Name	Jaguar Dash Cam Rear Jaguar Dash Cam Rear
FCC ID	WHBJLRDASHCAMR
Max. RF Output Power	101.98 dBuV/m @3 m
Modulation type	FMCW
FCC Classification	Low Power communication Device Transmitter(DXX)
FCC Rule Part(s)	Part 15.249

The result shown in this test report refer only to the sample(s) tested unless otherwise stated.
This test results were applied only to the test methods required by the standard.

REVISION HISTORY

The revision history for this test report is shown in table.

Revision No.	Date of Issue	Description
0	August 14, 2020	Initial Release

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. It is further stated that upon the basis of the measurements made, the equipment tested is capable of operation in accordance with the requirements of the FCC Rules under normal use and maintenance.

CONTENTS

1. EUT DESCRIPTION

Model	Jaguar Dash Cam Rear	
Additional Model	Land Rover Dash Cam Rear	
EUT Type	Jaguar Dash Cam Rear	
Power Supply	DC 12 V	
Frequency Range	24050 MHz -24250 MHz	
Fundamental Field Strength Level	Peak	101.98 dBuV/m @3 m
	Average	93.71 dBuV/m @3 m
Modulation Type	FMCW	
Antenna Specification	Antenna type: PCB antenna Peak Gain : 7 dBi Maximum Dimension : 24.1 mm	
Date(s) of Tests	July 14, 2020 ~ August 13, 2020	
EUT serial numbers	JDARX200800001	

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 § 15.249" were used in the measurement.

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.

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.

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)

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 : 2017).

4. FACILITIES AND ACCREDITATIONS

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, 17383, Rep. of 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).

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."

(1) The antennas of this E.U.T are permanently attached.

(2) 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.

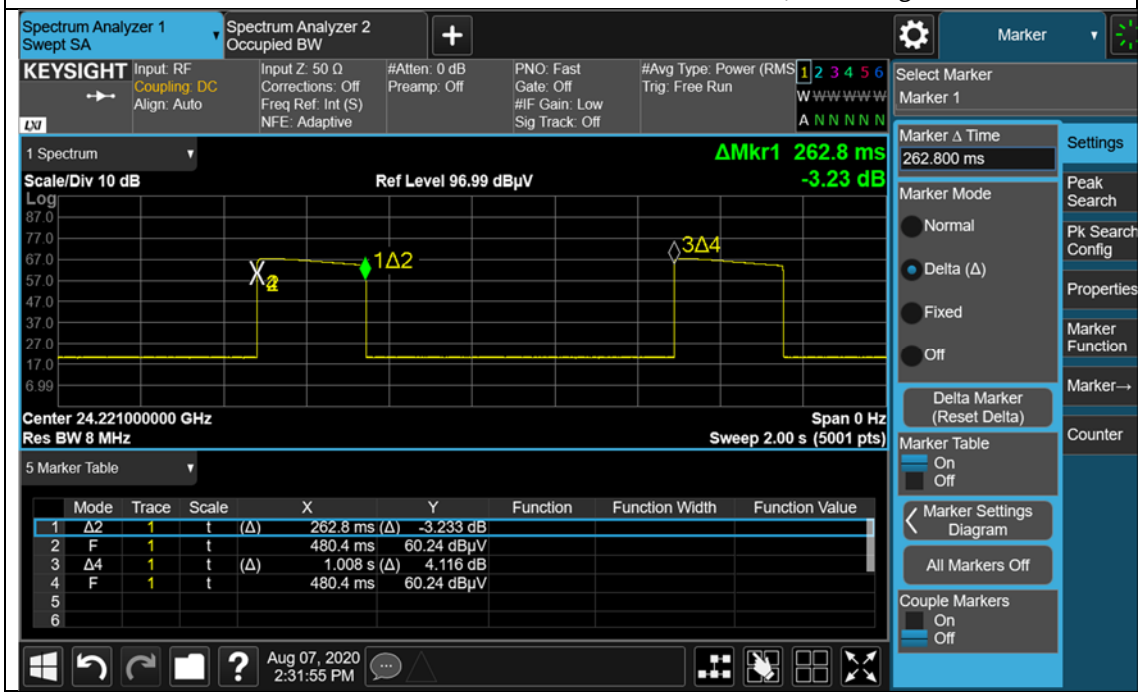
All measurement uncertainty values are shown with a coverage factor of $k = 2$ to indicate a 95 % level of confidence.

Parameter	E
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 = 262.8 ms / 1008 ms = 0.2607

Duty Correction = 10 log (1/duty cycle) = 10 log (1/0.2607) = 5.8384 dB

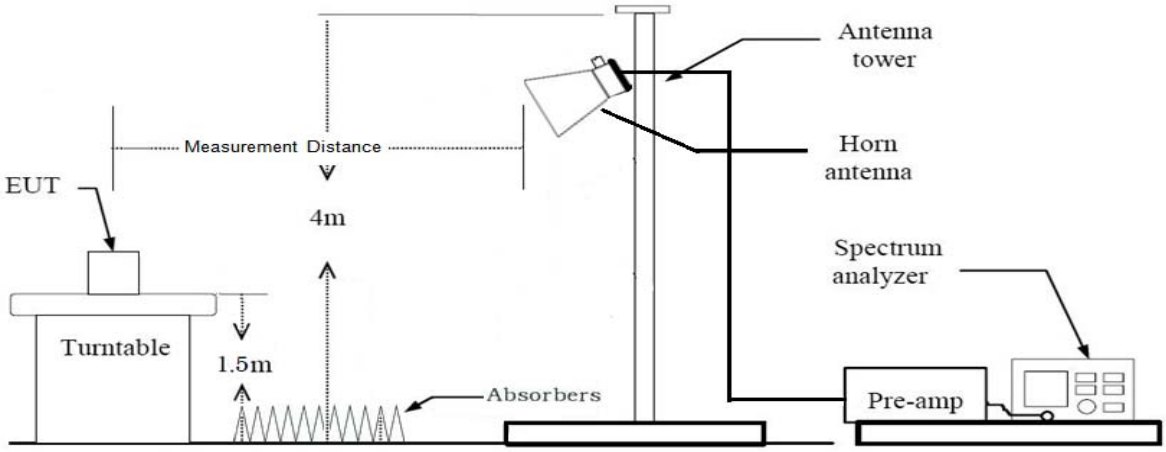
8. TEST RESULT

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

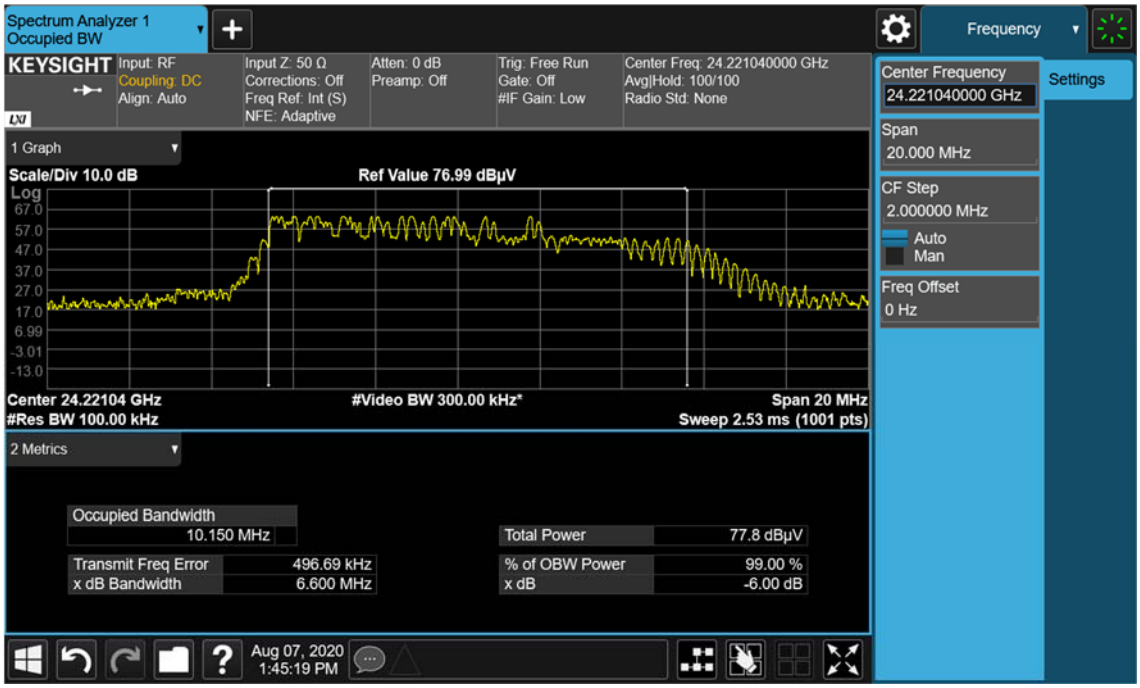
Allow the trace to stabilize

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



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

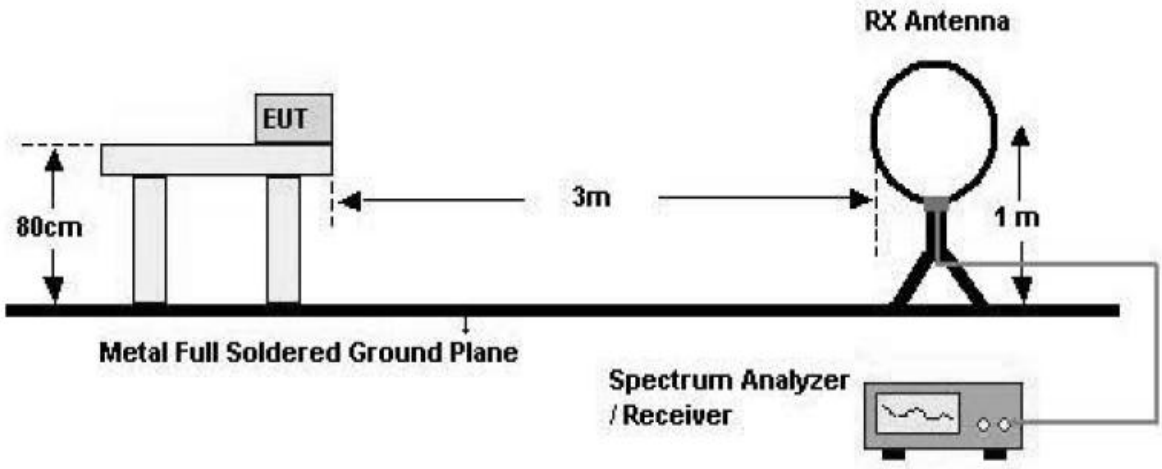
Test Procedure

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

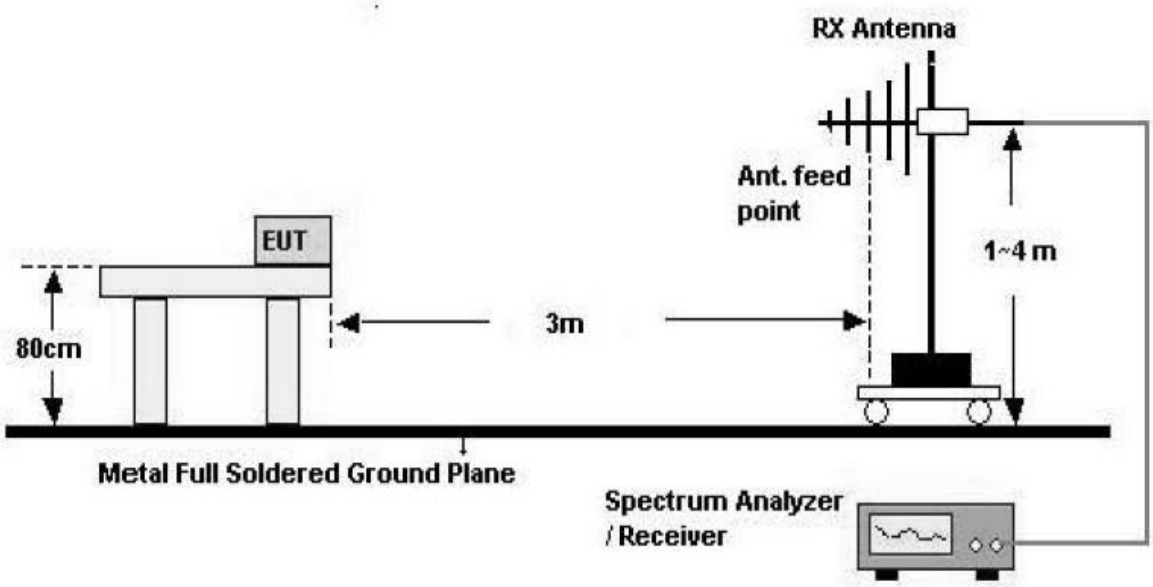
Frequency Range(GHz)	Frequency (MHz)	Antenna Size(m)	Far Field Distance(m)	Measured Distance(m)
24.000 ~ 24.250	24125	0.0214	0.0732736	1
18 ~ 40	40000		0.122122667	1
40 ~ 60	60000		0.183184	1
60 ~ 90	90000		0.274776	1
90 ~ 100	100000		0.305306667	1

Test Configuration

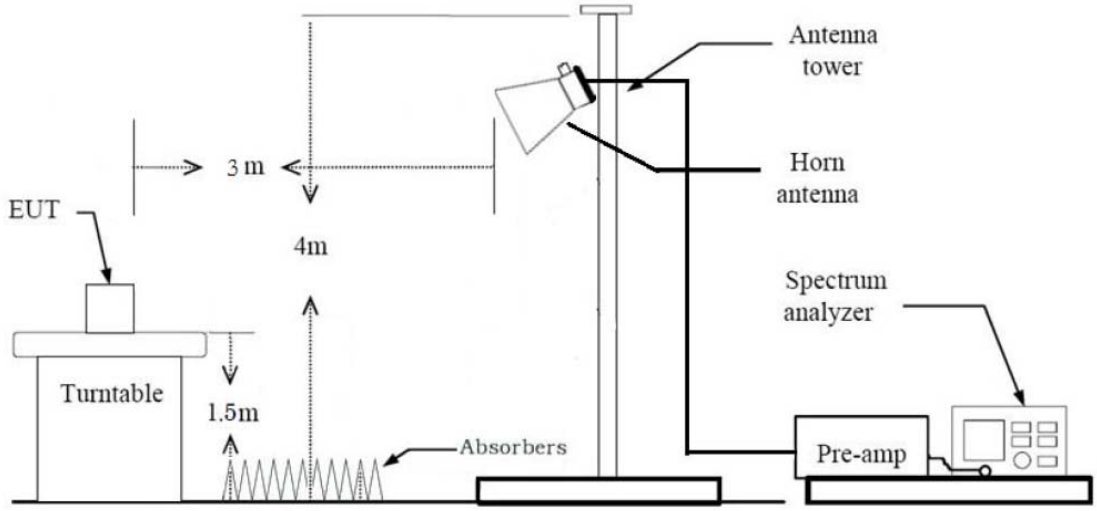
Below 30 MHz



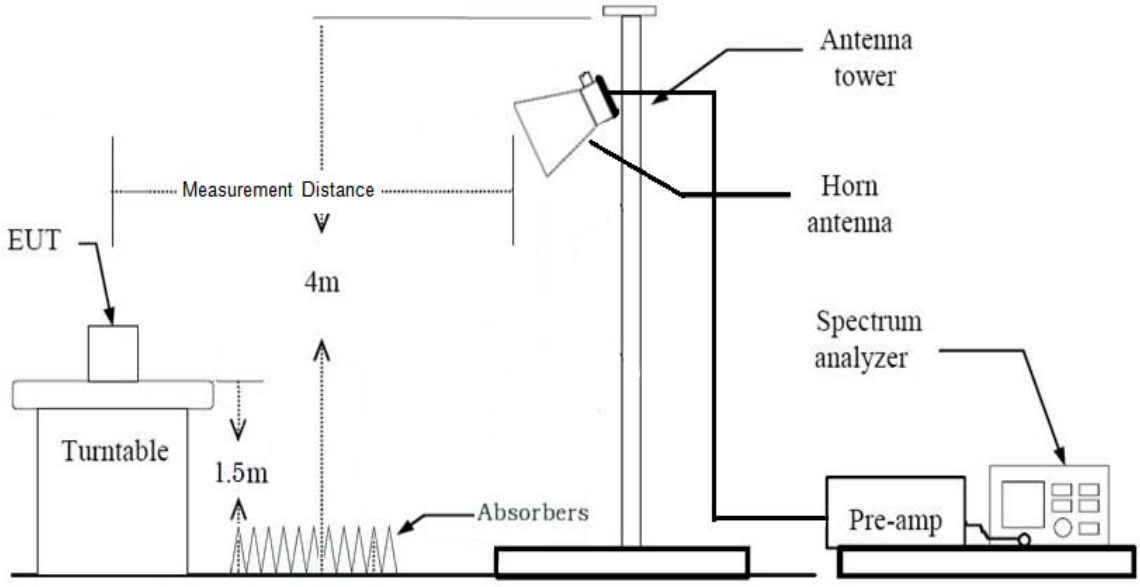
30 MHz - 1 GHz



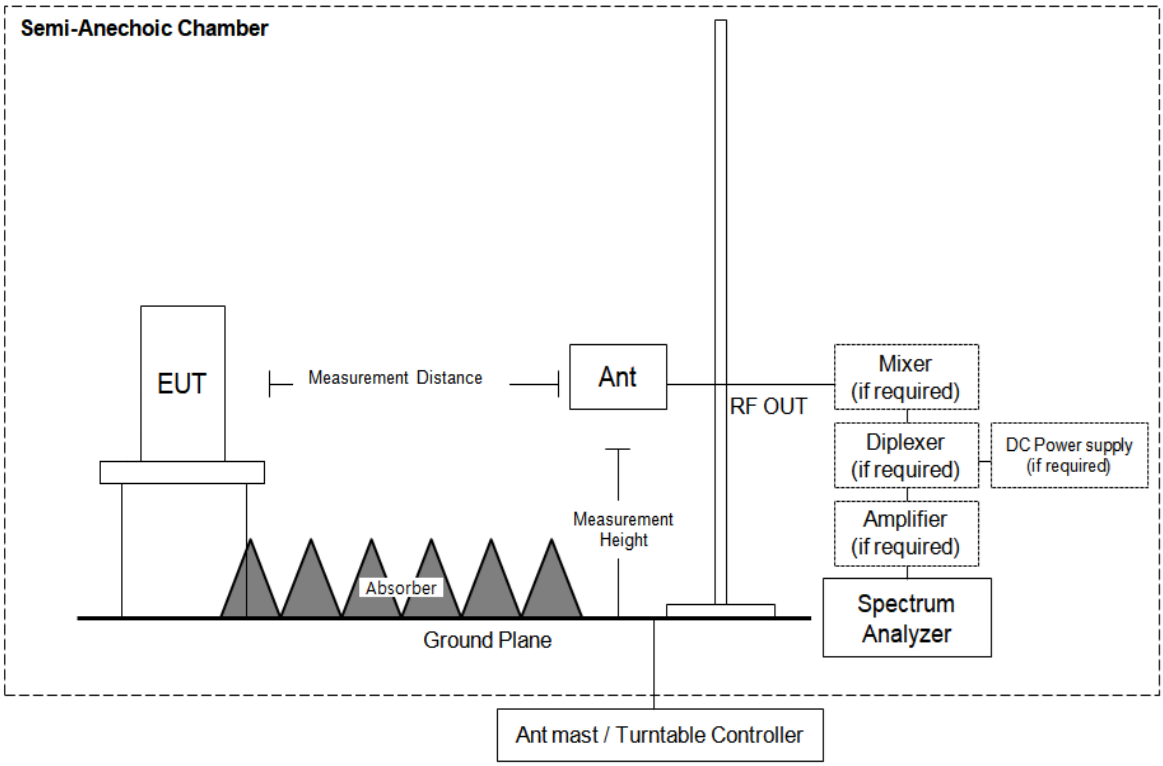
1 GHz – 18 GHz



18 GHz – 40 GHz



40 GHz – 100 GHz



▣ FIELD STRENGTH OF FUNDAMENTAL TEST RESULTS

Reading [dBuV/m]	A.F.+C.L. [dB]	Ant. Pol. [H/V]	D.F. [dB]	Duty Cycle Factor (dB)	Total [dBuV/m]	Limit [dBuV/m]	Margin [dB]	Measurement Type
65.84	45.68	V	-9.54	-	101.98	127.96	25.98	Peak
51.73	45.68	V	-9.54	5.84	93.71	107.96	14.25	Avg

※ A·F: ANTENNA FACTOR

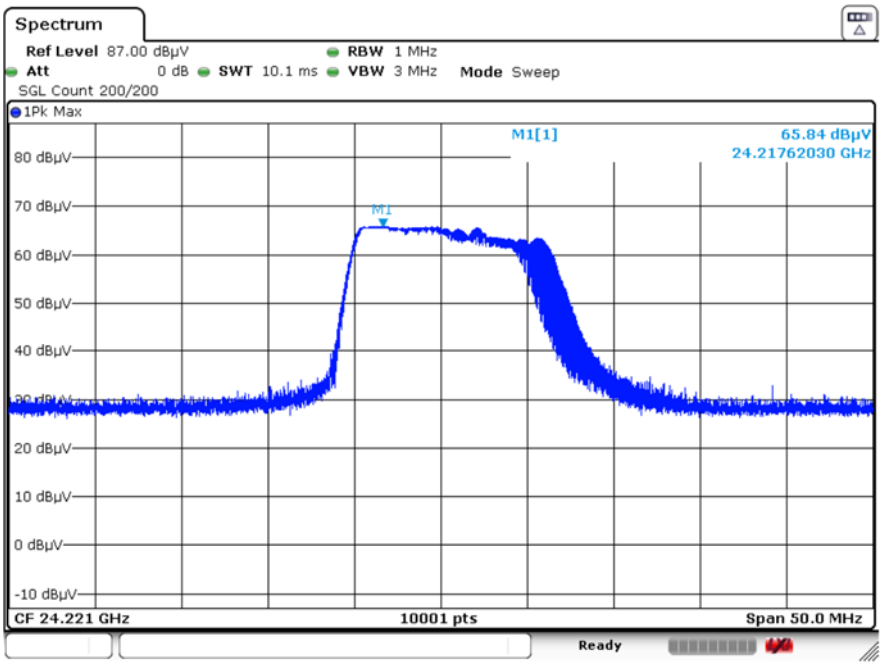
C·L: CABLE LOSS

Note :

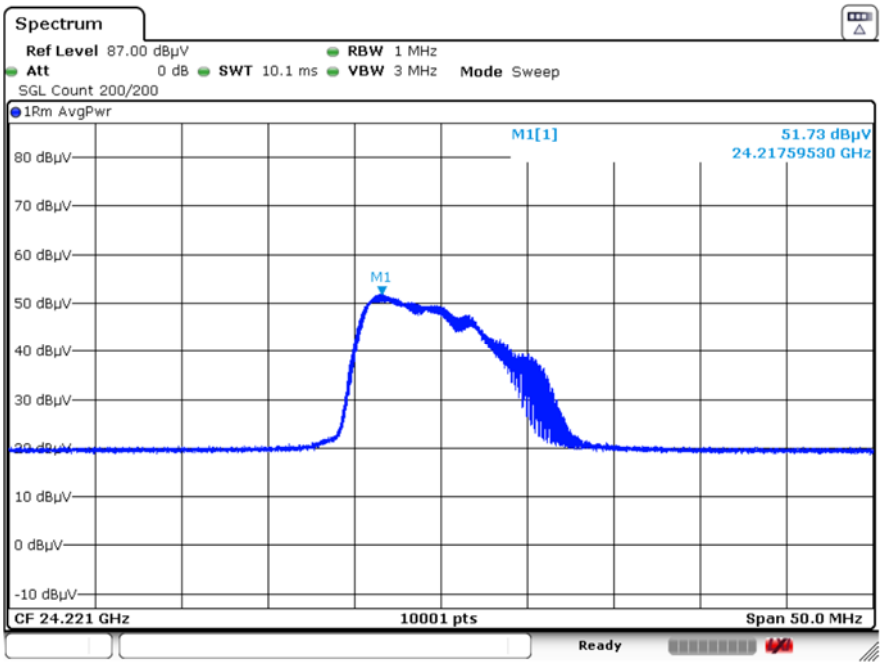
1. Total = Reading Value + Antenna Factor + Cable Loss + Distance Factor + Duty Cycle Factor
2. Distance extrapolation factor = 20 log (test distance / specific distance) (dB)
3. Measured Distance : 1 m
4. We have done x, y, z planes in EUT and horizontal and vertical polarization in detecting antenna.

▣ RESULT PLOTS

Fundamental Field Strength plot (Peak - Vertical)



Fundamental Field Strength plot (Average - Vertical)



▣ 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

Rear

Frequency [GHz]	Reading [dBuV/m]	A.F.+C.L. [dB]	Ant. Pol. [H/V]	D.F. [dB]	Duty Cycle Factor (dB)	Total [dBuV/m]	Limit [dBuV/m]	Margin [dB]	Measurement Type
*24.000	34.34	45.68	V	-9.54	-	70.48	74.00	3.52	Peak
*24.000	3.48	45.68	V	-9.54	5.84	45.46	54.00	8.54	Avg
*24.250	34.11	45.68	V	-9.54	-	70.25	74.00	3.75	Peak
*24.250	2.46	45.68	V	-9.54	5.84	44.44	54.00	9.56	Avg

※ 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 [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							

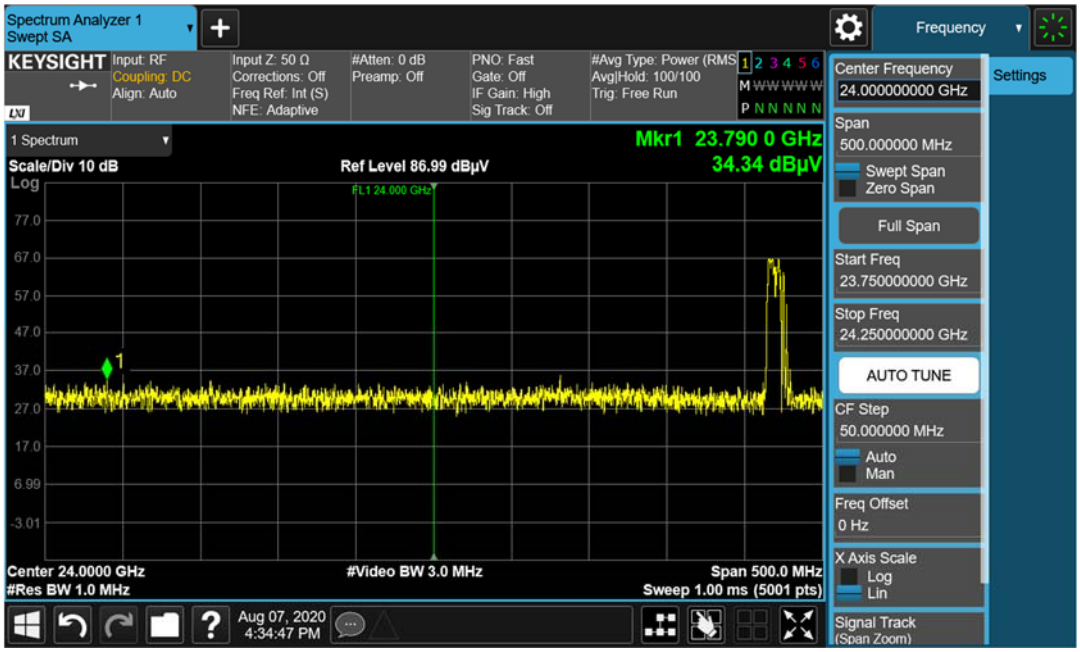
※ A·F: ANTENNA FACTOR
C·L: CABLE LOSS
AMP G: AMPLIFIER GAIN

Notes:

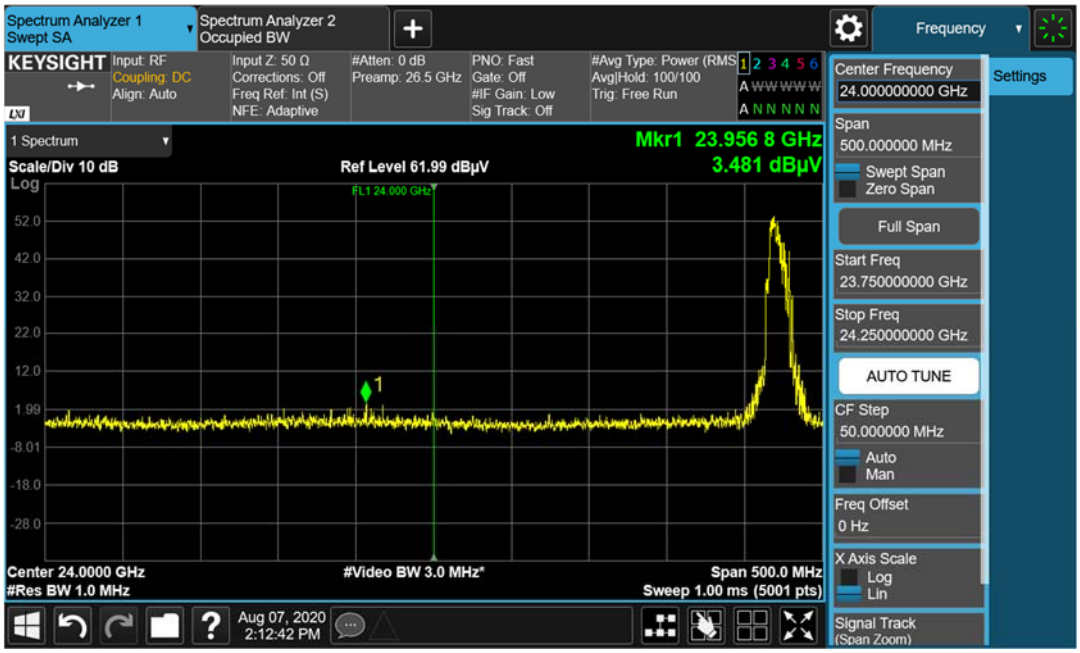
1. Measuring frequencies from 1 GHz to the 10th harmonic of highest fundamental frequency.
2. Measurements above show only up to 6 maximum emissions noted, or would be lesser if no specific emissions from the EUT are recorded (ie: margin > 20 dB from the applicable limit) and considered that's already 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

▣ RESULT PLOTS

Band Edge Plot(peak, Low_x-V)



Band Edge Plot(average, Low _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	06/04/2020	Annual	MY55480167
Schwarzbeck	BBHA 9170 / Horn Antenna	11/29/2019	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	09/09/2019	Annual	101256
Rohde&Schwarz	FSP / Spectrum Analyzer	09/11/2019	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	09/25/2019	Biennial	9120D-1298
OML INC.	WR-19 Horn Antenna / Horn Antenna	04/23/2020	Biennial	M19RH-160419-2
OML INC.	WR-19 Horn Antenna / Horn Antenna	04/23/2020	Biennial	M19RH-160419-1
OML INC.	WR-12 Horn Antenna / Horn Antenna	04/23/2020	Biennial	M12RH-160419-1
OML INC.	WR-12 Horn Antenna / Horn Antenna	04/23/2020	Biennial	M12RH-160419-2
OML INC.	WR-08 Horn Antenna / Horn Antenna	04/23/2020	Biennial	M08RH-160419-1
OML INC.	WR-08 Horn Antenna / Horn Antenna	04/23/2020	Biennial	M08RH-160419-2
OML INC.	OML WR19 / Harmonic Mixer	09/09/2019	Annual	M19HWD
OML INC.	OML WR12 / Harmonic Mixer	09/09/2019	Annual	M12HWD
OML INC.	OML WR08 / Harmonic Mixer	09/09/2019	Annual	M08HWD
OML INC.	WR-19 / Source Module	11/19/2019	Annual	S19MS-A-160516-1

OML INC.	WR-12 / Source Module	09/09/2019	Annual	S12MS-A-160419-1
OML INC.	WR-08 / Source Module	09/09/2019	Annual	S08MS-A-160419-1
OML INC.	Diplexer L.O / Diplexer	07/14/2020	Annual	DPL518-160419-1
CERNEX	CBLU1183540B-01 / Power Amplifier	03/12/2020	Annual	28548
CERNEX	CBL26405040 / Power Amplifier	03/23/2020	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-2008-FC038-P