TEST REPORT

KOSTEC CO., Ltd. (Annyeong-dong) 26, 28, 30, Seja-ro 406beon-gil, Hwaseong-si, Gyeonggi-do, Republic of Korea Tel : 031-222-4251, Fax : -	Report No.: KST-FCR-240008(3)	KOSTEC

1. Applicant

- Name : Ettifos Co.
- Address : 405, 41, Beolmal-ro 50beon-gil, Bundang-gu, Seongnam-si, Gyeonggi-do, South Korea

2. Test Item

- Product Name: V2X-AIR CV2X
- Model Name: ETF-AIR-C02
- Brand: None
- FCC ID: 2BHJL-ETF-AIR-C02

3. Manufacturer

- Name : Ettifos Co.
- Address : 405, 41, Beolmal-ro 50beon-gil, Bundang-gu, Seongnam-si, Gyeonggi-do, South Korea

4. Date of Test : 2024. 09. 09. ~ 2024. 09. 10.

5. Test Method Used : FCC CFR 47, Part 95L + Waivers DA 24-363
511808 D01 C-V2X Waiver v01
ANSI C 63.26-2015

6. Test Result : Compliance

7. Note: None

Supplementary Information

The device bearing the brand name and FCC ID specified above has been shown to comply with the applicable technical standards as indicated in the measurement report and was tested in accordance with measurement procedures specified in ANSI C 63.26-2015.

We attest to the accuracy of data and all measurements reported herein were performed by KOSTEC Co., Ltd. and were made under Chief Engineer's supervision. We assume full responsibility for the completeness of these measurements and vouch for the qualifications of all persons taking them.

The results shown in this test report refer only to the sample(s) tested unless otherwise stated.
This test report is not related to KOLAS accreditation.

Affirmation	Tested by Name : Choo, Kwang-Yeol (Signature)	Technical Manager Name : Lee, Mi-Young (Signature)

2024. 11. 06.

KOSTEC Co., Ltd.

Table of Contents

1. GENERAL INFORMATION

1.1 Test Facility

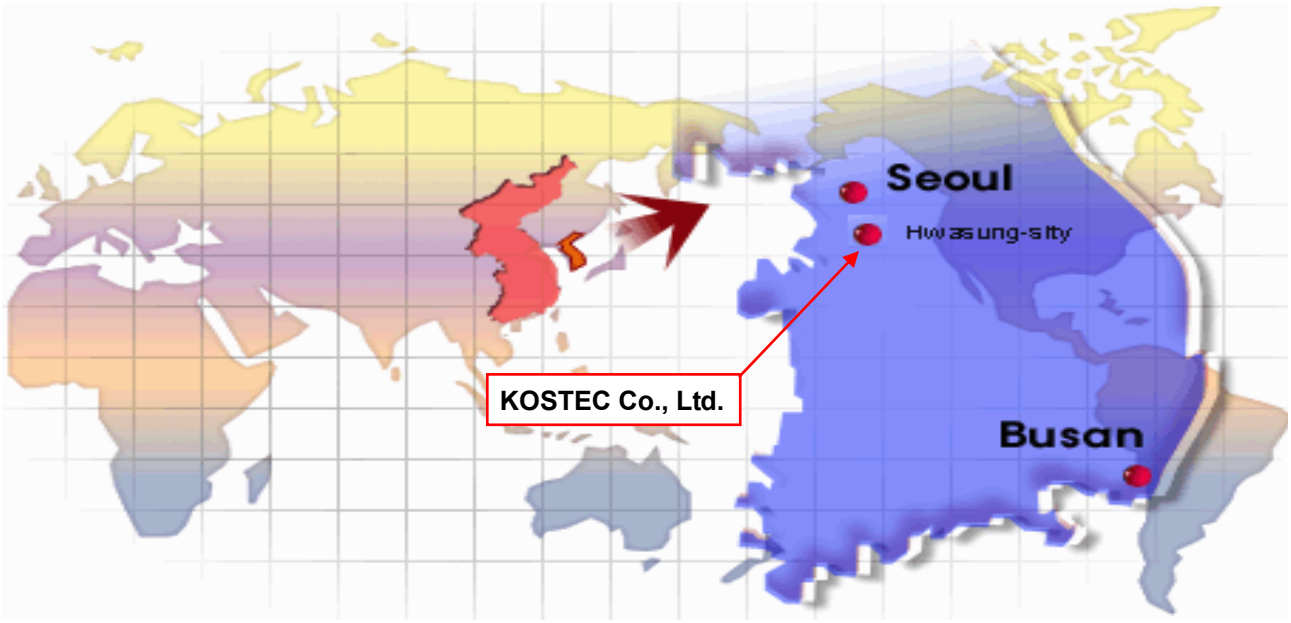
Test laboratory and address

KOSTEC Co., Ltd.
(Annyeong-dong) 26, 28, 30, Seja-ro 406beon-gil, Hwaseong-si, Gyeonggi-do, Republic of Korea
Telephone Number: 82-31-222-4251
Facsimile Number: -

Registration information

KOLAS No.: KT232
RRA (National Radio Research Agency): KR0041
FCC Designation No.: KR0041
IC Designation No.: KR0041
VCCI Membership No.: 2005

1.2 Location



1.3 Revision History of test report

Rev.	Revisions	Effect page	Reviewed	Date
-	Initial issue	All	Mi-Young, Lee	2024. 09. 27.
1	Clarified the measurement results of spurious emissions up to 40 GHz.	23	Mi-Young, Lee	2024. 10. 14.
2	Actual values have been added to the Summary Test Results.	11	Mi-Young, Lee	2024. 10. 25.
3	Typo correction in OOBE Measurement Procedure.	17	Mi-Young, Lee	2024. 11. 06.

2. EQUIPMENT DESCRIPTION

The product specification described herein was declared by manufacturer. And refer to user's manual for the details.

Equipment Name	V2X-AIR CV2X
Model No	ETF-AIR-C02
Usage	C-V2X OBU
Serial Number	Proto type
Modulation type	16QAM
Emission Type	D1D
Maximum output power(E.I.R.P)	21.73 dBm
Operated Frequency	5 905 MHz ~ 5 925 MHz(Center Frequency: 5 915 MHz)
Channel Number	1
Operation temperature	-30 ℃ ~ 75 ℃
Power Source	DC 5.0 V
Antenna Description	External Dipole antenna, gain : 2.19 dBi
Remark	1. The device was operating at its maximum output power for all measurements. 2. The radiation measurements are performed in X, Y, Z axis positioning. Only the worst case (X) is shown in the report. 3. The above DUT's information was declared by manufacturer. Please refer to the specifications or user manual for more detailed description.
FCC ID	2BHJL-ETF-AIR-C02

3. SYSTEM CONFIGURATION FOR TEST

3.1 Characteristics of equipment

The Equipment Under Test (EUT) contains the following capabilities: This equipment is C-V2X OBU. The detailed explanation is refer as user manual.

3.2 Used peripherals list

Description	Model No.	Serial No.	Manufacture	Remark
Adapter	FJ-SW20260505000	SHENZHEN FUJIAAPPLIANCE CO., LTD.	None	-

3.3 Product Modification

N/A

3.4 Declared Exemptions and Additional Product Notes

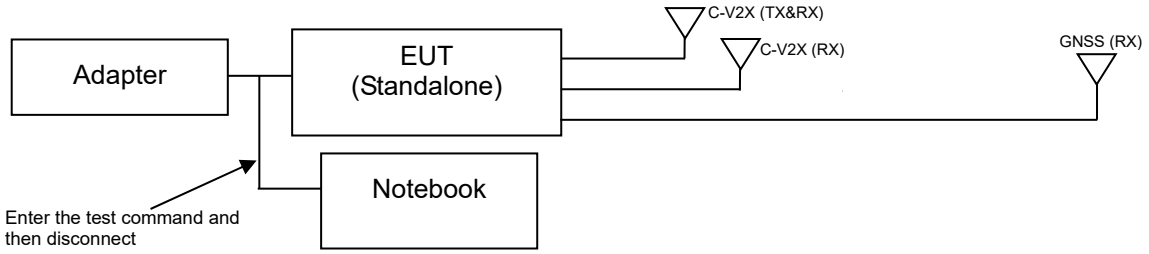
The EUT is an FCC Part 95, Subpart L device operating under FCC Order Waiver's according to FCC Docket N0. 19-138: DA 23-363. The EUT is permanently installed in a transportation vehicle. As such, digital emissions are exempt from US regulations per FCC 15.103(a). The manufacturer declares that they will comply with all the provisions as stated within the C-V2X waivers listed herein.

3.5 Operating Mode

Constantly transmitting with a modulated carrier at maximum power on the center frequency.

3.6 Test Setup of EUT

The measurements were taken in continuous transmit mode using the test mode which controlled by Teraterm. The test command and the test Jig and cables were provided by the applicant.



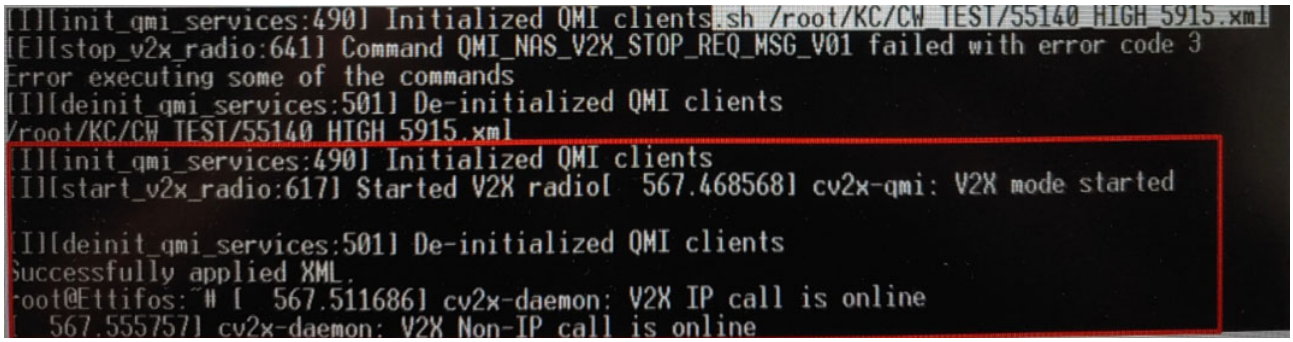
3.7 Parameters of Test Software Setting

During testing, Channel & Power Controlling Software provided by the customer was used to control the operating channel as well as the output power level. The RF output power selection is for the setting of RF output power expected by the customer and is going to be fixed on the firmware of the final end product.

▣ TX Power setting value during test

Band	Rate	TX Power setting value		
		Low CH	Middle CH	High CH
5.9 GHz band	30.7 Mbps	N/A	default	N/A

▣ Test Program : TeraTerm



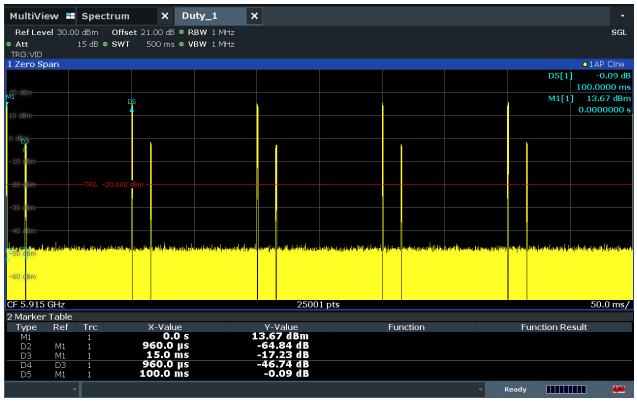
3.8 Duty Cycle Of Test signal

Duty cycle = Tx on/(Tx on+ Tx off),Duty factor = 10*log(1/duty cycle)

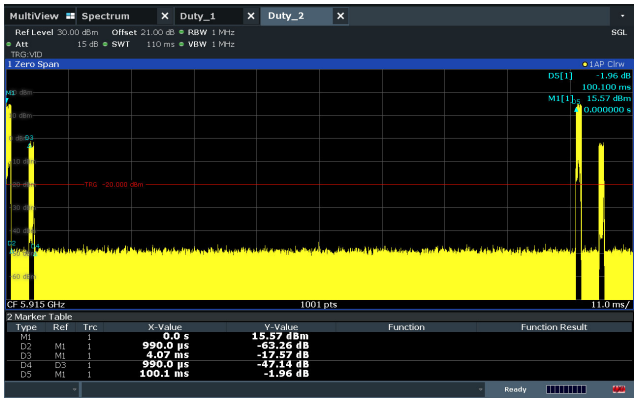
Mode	Voltage [V]	Frequency [MHz]	Data rate [Mbps]	Tx Cycle Time [ms]	Tx On-Time [ms]	Duty Cycle [%]	Duty Correction [dB]
C-V2X	5.0	5 915	30.7	100.1	1.91	1.9	17.19

NOTE:
Duty factor is shown as a data point only and is not considered in the calculation of fundamental power.

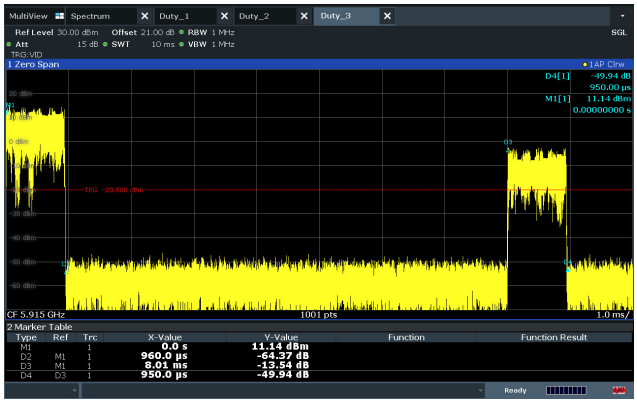
500 ms



110 ms



10 ms



3.9 Used Test Equipment List

No.	Instrument	Model	S/N	Manufacturer	Next Cal Date	Cal interval	used
1	T & H Chamber	PL-3J	15003623	ESPEC CORP	2025.08.13	1 year	☐
2	T & H Chamber	SH-662	93000067	ESPEC CORP	2025.08.13	1 year	☒
3	T & H Chamber	SH-642	93011406	ESPEC CORP	2025.08.13	1 year	☐
4	Spectrum Analyzer	8563EC	3046A00527	Agilent Technology	2025.01.09	1 year	☐
5	Spectrum Analyzer	FSV30	104029	Rohde & Schwarz	2025.08.12	1 year	☐
6	Spectrum Analyzer	FSV30	20-353063	Rohde & Schwarz	2025.01.09	1 year	☐
7	Spectrum Analyzer	FSV40	101727	Rohde & Schwarz	2025.08.12	1 year	☐
8	Signal Analyzer	FSW43	101294	Rohde & Schwarz	2025.01.15	1 year	☒
9	Signal Analyzer	FSW85	101602	Rohde & Schwarz	2025.07.03	1 year	☐
10	EMI Test Receiver	ESCI7	100823	Rohde & Schwarz	2025.01.09	1 year	☐
11	EMI Test Receiver	ESPI	100488	Rohde & Schwarz	2025.01.08	1 year	☐
12	EMI Test Receiver	ESI	837514/004	Rohde & Schwarz	2025.08.12	1 year	☒
13	Vector Signal Analyzer	89441A	3416A02620	Agilent Technology	2025.01.11	1 year	☐
14	Network Analyzer	8753ES	US39170869	AGILENT	2025.08.13	1 year	☐
15	EPM Series Power meter	E4418B	GB39512547	Agilent Technology	2025.01.10	1 year	☐
16	RF Power Sensor	E9300A	MY41496631	Agilent Technology	2025.01.10	1 year	☐
17	Microwave Frequency Counter	5352B	2908A00480	Agilent Technology	2025.01.10	1 year	☐
18	Audio Analyzer	8903B	3514A16919	Agilent Technology	2025.01.10	1 year	☐
19	Audio Telephone Analyzer	DD-5601CID	520010281	CREDIX	2025.01.08	1 year	☐
20	Modulation Analyzer	8901A	3041A05716	H.P	2025.01.10	1 year	☐
21	Digital storage Oscilloscope	TDS3052	B015962	Tektronix	2025.08.13	1 year	☐
22	ESG-D Series Signal Generator	E4436B	US39260458	Agilent Technology	2025.01.10	1 year	☐
23	Vector Signal Generator	SMBV100A	257557	Rohde & Schwarz	2025.01.10	1 year	☐
24	GNSS Signal Generator	TC-2800A	2800A000494	TESCOM CO., LTD.	2025.01.10	1 year	☐
25	Signal Generator	SMB100A	179628	Rohde & Schwarz	2025.01.10	1 year	☐
26	Signal Generator	N5173B	MY57280148	KEYSIGHT	2025.05.30	1 year	☐
27	SLIDAC	None	0207-4	Myoung sung Ele.	2025.01.09	1 year	☐
28	DC Power supply	DDPS-3K	U03-109	Digitech Power	2025.01.10	1 year	☐
29	DC Power supply	E3610A	KR24104505	Agilent Technology	2025.01.09	1 year	☐
30	DC Power supply	UP-3005T	68	Unicon Co.,Ltd	2025.01.09	1 year	☐
31	DC Power Supply	SM 3400-D	114701000117	DELTA ELEKTRONIKA	2025.01.08	1 year	☐
32	DC Power supply	6632B	MY43004005	Agilent Technology	2025.01.09	1 year	☐
33	DC Power Supply	6632B	MY43004137	Agilent Technology	2025.01.09	1 year	☒
34	Termination	1433-3	LM718	WEINSCHEL	2025.01.10	1 year	☐
35	Termination	1432-3	QR946	AEROFLEX/WEINSCHEL	2025.01.10	1 year	☐
36	Attenuator	8498A	3318A09485	HP	2025.01.10	1 year	☐
37	Step Attenuator	8494B	3308A32809	HP	2025.01.10	1 year	☐
38	RF Step Attenuator	RSP	100091	Rohde & Schwarz	2025.01.11	1 year	☐
39	Attenuator	18B50W-20F	64671	INMET	2025.01.10	1 year	☐
40	Attenuator	10 dB	1	Rohde & Schwarz	2025.01.10	1 year	☐
41	Attenuator	54A-10	74564	WEINSCHEL	2025.08.19	1 year	☒
42	Attenuator	56-10	66920	WEINSCHEL	2025.01.12	1 year	☐
43	Attenuator	SA18N100-20	001	FAIRVIEW MICROWAVE	2025.08.12	1 year	☐
44	Attenuator	SA26B-10	33464/2134	FAIRVIEW MICROWAVE	2025.08.19	1 year	☐
45	Attenuator	SA4018-10	DC 2126	FAIRVIEW MICROWAVE	2025.08.19	1 year	☒
46	Power divider	11636B	51212	HP	2025.01.12	1 year	☐
47	3Way Power divider	KPDSU3W	00070365	KMW	2025.08.12	1 year	☐
48	4Way Power divider	70052651	173834	KRYTAR	2025.01.12	1 year	☐
49	3Way Power divider	1580	SQ361	WEINSCHEL	2025.01.12	1 year	☐
50	OSP	OSP120	101577	Rohde & Schwarz	2025.01.11	1 year	☐
51	White noise audio filter	ST31EQ	101902	SoundTech	2025.08.13	1 year	☐

No.	Instrument	Model	S/N	Manufacturer	Next Cal Date	Cal interval	used
52	Dual directional coupler	778D	17693	HEWLETT PACKARD	2025.01.10	1 year	☐
53	Dual directional coupler	772D	2839A00924	HEWLETT PACKARD	2025.01.10	1 year	☐
54	Band rejection filter	3TNF-0006	26	DOVER Tech	2025.01.11	1 year	☐
55	Band rejection filter	3TNF-0007	311	DOVER Tech	2025.01.11	1 year	☐
56	Band rejection filter	WTR-BRF2442-84NN	09020001	WAVE TECH Co.,LTD	2025.01.10	1 year	☐
57	Band rejection filter	WRCJV12-5695-5725-5825-5855-50SS	1	Wainwright Instruments GmbH	2025.01.11	1 year	☐
58	Band rejection filter	WRCJV12-5120-5150-5350-5380-40SS	4	Wainwright Instruments GmbH	2025.01.11	1 year	☐
59	Band rejection filter	WRCGV10-2360-2400-2500-2540-50SS	2	Wainwright Instruments GmbH	2025.01.11	1 year	☐
60	Band rejection filter	CTF-155M-S1	001	RF One Electronics	2025.08.12	1 year	☐
61	Band rejection filter	CTF-435M-S1	001	RF One Electronics	2025.08.12	1 year	☐
62	Band rejection filter	CTF-5890M-70MS1	1	RF One Electronics	2025.01.11	1 year	☐
63	Highpass Filter	WHJS1100-10EF	1	WAINWRIGHT	2025.01.10	1 year	☐
64	Highpass Filter	WHJS3000-10EF	1	WAINWRIGHT	2025.01.10	1 year	☐
65	Highpass Filter	WHNX6-5530-7000-26500-40CC	2	Wainwright Instruments GmbH	2025.01.12	1 year	☒
66	Highpass Filter	WHNX6-2370-3000-26500-40CC	4	Wainwright Instruments GmbH	2025.01.12	1 year	☐
67	WideBand Radio Communication Tester	CMW500	102276	Rohde & Schwarz	2025.01.10	1 year	☐
68	WideBand Radio Communication Tester	CMW500	117235	Rohde & Schwarz	2025.01.10	1 year	☐
69	WideBand Radio Communication Tester	MT8000A	6261987920	Anritsu	2025.01.15	1 year	☐
70	WideBand Radio Communication Tester	MT8821C	6262287695	Anritsu	2025.01.09	1 year	☐
71	Bluetooth Tester	TC-3000B	3000B6A0166	TESCOM CO., LTD.	2025.01.10	1 year	☐
72	Loop Antenna	6502	9203-0493	EMCO	2025.05.23	2 year	☐
73	Loop Antenna	FMZB1513	#374	Schwarzbeck	2025.02.21	2 year	☒
74	BiconiLog Antenna(R)	3142C	35880	ETS-LINDGREN	2024.10.13	2 year	☒
75	Trilog-Broadband Antenna(R)	VULB 9168	9168-606	SCHWARZBECK	2026.09.03	2 year	☐
76	Biconical Antenna(T)	VUBA9117	9117-342	Schwarz beck	2026.01.16	2 year	☐
77	Horn Antenna	3115	9605-4834	EMCO	2025.02.29	1 year	☐
78	Horn Antenna	QMS-00208	21909	STEATITE ANTENNA	2025.04.22	1 year	☐
79	Horn Antenna(R)	3117	00135191	ETS-LINDGREN	2025.03.26	1 year	☒
80	Horn Antenna(T)	3115	2996	EMCO	2025.01.11	1 year	☐
81	Horn Antenna(R)	BBHA 9170	9170-722	SCHWARZBECK	2025.01.11	1 year	☒
82	Horn Antenna(T)	BBHA 9170	743	SCHWARZBECK	2025.01.16	1 year	☐
83	AMPLIFIER(A_10)	TK-PA01S	220109-L	TESTEK	2025.01.09	1 year	☐
84	AMPLIFIER(C_3)	TK-PA01S	200141-L	TESTEK	2025.08.12	1 year	☒
85	PREAMPLIFIER(C_3)	8449B	3008A02577	Agilent	2025.01.09	1 year	☐
86	RF PRE AMPLIFIER	SCU08F2	100762	Rohde & Schwarz	2025.08.22	1 year	☐
87	AMPLIFIER	TK-PA18	150003	TESTEK	2025.01.09	1 year	☒
88	AMPLIFIER	TK-PA1840H	160010-L	TESTEK	2025.01.12	1 year	☒
89	Horn Antenna	M19RH	T01	OML, Inc.	2025.04.03	1 year	☐
90	Horn Antenna	M12RH	T02	OML, Inc.	2025.04.03	1 year	☐
91	Horn Antenna	M08RH	T03	OML, Inc.	2025.04.03	1 year	☐
92	Horn Antenna	M05RH	T04	OML, Inc.	2025.04.03	1 year	☐
93	Horn Antenna	M03RH	T05	OML, Inc.	2025.04.03	1 year	☐
94	Harmonic Mixer	M12HWD	200529-1	OML, Inc.	2025.04.08	1 year	☐
95	Harmonic Mixer	M08HWD	200529-1	OML, Inc.	2025.04.08	1 year	☐
96	Harmonic Mixer	M05HWD	200529-1	OML, Inc.	2025.04.08	1 year	☐
97	Harmonic Mixer	M03HWD	200529-1	OML, Inc.	2025.04.08	1 year	☐
98	Source Module	S19MS-A	200529-1	OML, Inc.	2025.04.08	1 year	☐
99	Source Module	S12MS-A	200529-1	OML, Inc.	2025.04.08	1 year	☐
100	Source Module	S08MS-A	200529-1	OML, Inc.	2025.04.08	1 year	☐
101	Source Module	S05MS-A	200529-1	OML, Inc.	2025.04.08	1 year	☐
102	Source Module	S03MS-A	200529-1	OML, Inc.	2025.04.08	1 year	☐

4. SUMMARY TEST RESULTS

Description of Test	FCC Rule	Result/Remarks	Reference Clause	Used	Test Result
Occupied Bandwidth	2.1049 Waiver: DA 24-363	26 dB BW: 19.01 MHz F_L: 5 905.345 MHz F_H: 5 924.350 MHz 99% BW: 17.52 MHz	Clause 5.1	☒	Compliance
Frequency Stability	2.1055	6.07 ppm			
C-V2x Transmit Power	2.1046 Waiver: DA 24-363	21.73 dBm EIRP	Clause 5.2	☒	Compliance
Transmit Emission Mask(OOBE)	Waiver: DA 24-363	Meet the requirement of limit. Minimum passing margin is –5.73 dB at 5 891.73 MHz (Abs. value: -39.01 dBm)	Clause 5.3	☒	Compliance
Transmit Chain Spurious Emissions	Waiver: DA 24-363	Meet the requirement of limit. Minimum passing margin is –6.08 dB at 39 125.0 MHz (Abs. value: -46.08 dBm)	Clause 5.4	☒	Compliance
Compliance/pass : The EUT complies with the essential requirements in the standard. Not Compliance : The EUT does not comply with the essential requirements in the standard. N/A : The test was not applicable in the standard.					

Procedure Reference

FCC CFR 47, Part 95L + Waivers DA 24-363 (Emissions)

511808 D01 C-V2X Waiver v01

ANSI C 63.26-2015, ANSI C 63.4-2014

5. MEASUREMENT RESULTS

5.1 Occupied Bandwidth

5.1.1 Standard Applicable

FCC

The OBW is the frequency bandwidth such that, below its lower and above its upper frequency limits, the mean powers are each equal to 0.5% of the total mean power of the given emission.

5.1.2 Test Environment conditions

• Ambient temperature : (21 ~ 22) ℃ • Relative Humidity : (40 ~ 42) % R.H.

5.1.3 Measurement Procedure

FOR 99 PERCENT OCCUPIED BANDWIDTH

•The following procedure shall be used for measuring (99 %) power bandwidth:

•Set center frequency to the nominal EUT channel center frequency.

•Set span = 1.5 times to 5.0 times the OBW.

•Set RBW = 1 % to 5 % of the OBW

•Set VBW ≥ 3 · RBW

•Video averaging is not permitted. Where practical, a sample detection and single sweep mode shall be used. Otherwise, peak detection and max hold mode (until the trace stabilizes) shall be used.

•Use the 99 % power bandwidth function of the instrument (if available).

•If the instrument does not have a 99 % power bandwidth function, the trace data points are recovered and directly summed in power units. The recovered amplitude data points, beginning at the lowest frequency, are placed in a running sum until 0.5 % of the total is reached; that frequency is recorded as the lower frequency. The process is repeated until 99.5 % of the total is reached; that frequency is recorded as the upper frequency. Th e 99% occupied bandwidth is the difference between these two frequencies.

FOR 26dB BANDWIDTH

•Set RBW = approximately 1% of the emission bandwidth.

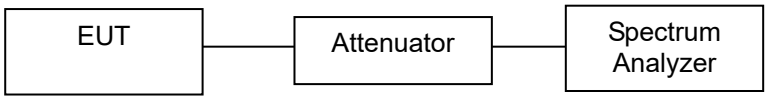
•Set the VBW > RBW.

•Detector = Peak.

•Trace mode = max hold.

•Measure the maximum width of the emission that is 26 dB down from the peak of the emission. Compare this with the RBW setting of the analyzer. Readjust RBW and repeat measurement as needed until the RBW/EBW ratio is approximately 1%.

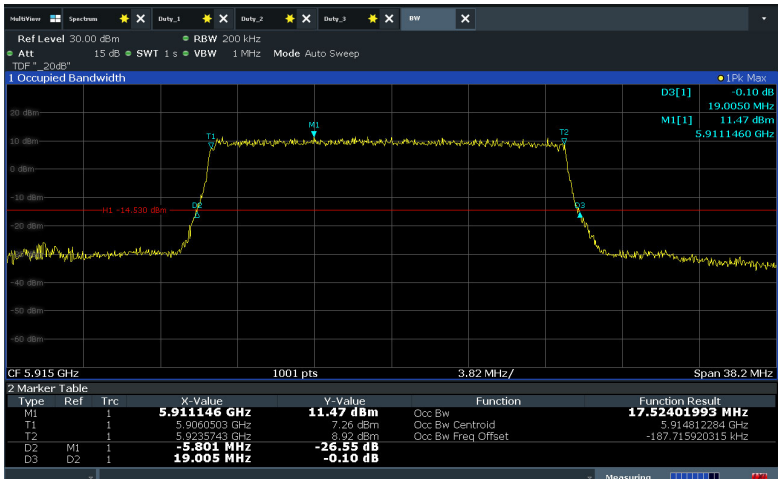
5.1.4 Test setup



5.1.5 Measurement Result

Mode	Voltage [V]	Frequency [MHz]	26 dB Bandwidth [MHz]	F_L [MHz]	F_L Limit [MHz]	F_H [MHz]	F_H Limit [MHz]	99 % Bandwidth [MHz]	Test Results
C-V2X	5.0	5 915	19.01	5 905.345	5 905	5 924.350	5 925	17.52	Compliance

NOTE:
•KDB Guidance 511808 D01 C-V2X Waiver v01, section 3.1 Both 26dB and 99% OBW is to be measured.
•FCC DA-24-363, section III(B)(19) C-V2X Joint Waiver, OBW must stay within the channel.
•F_L = Marker D2 = Marker M1 – 5.801 MHz = 5 905.345 MHz
•F_H = Marker D3 = F_L + 19.005 MHz = 5 924.350 MHz



- Frequency Stability

Temperature [℃]	Voltage [V]	F_L [MHz]	F_L Limit [MHz]	F_H [MHz]	F_H Limit [MHz]	26 dB BW [MHz]	Stability (ppm)	Test Results
75	5.75	5 905.375	5 905	5 924.378	5 925	19.00	4.88	Compliance
75	5.0	5 905.371	5 905	5 924.374	5 925	19.00	4.28	Compliance
75	4.25	5 905.367	5 905	5 924.371	5 925	19.00	3.63	Compliance
65	5.0	5 905.364	5 905	5 924.367	5 925	19.00	3.06	Compliance
55	5.0	5 905.359	5 905	5 924.363	5 925	19.00	2.30	Compliance
45	5.0	5 905.354	5 905	5 924.359	5 925	19.00	1.55	Compliance
35	5.0	5 905.350	5 905	5 924.355	5 925	19.01	0.78	Compliance
25	5.0	5 905.345	5 905	5 924.350	5 925	19.01	0.00	Compliance
15	5.0	5 905.341	5 905	5 924.346	5 925	19.01	-0.67	Compliance
5	5.0	5 905.338	5 905	5 924.342	5 925	19.00	-1.28	Compliance
-5	5.0	5 905.334	5 905	5 924.338	5 925	19.00	-1.94	Compliance
-15	5.0	5 905.330	5 905	5 924.335	5 925	19.00	-2.57	Compliance
-20	5.0	5 905.326	5 905	5 924.331	5 925	19.00	-3.22	Compliance
-25	5.0	5 905.322	5 905	5 924.326	5 925	19.00	-3.96	Compliance
-30	5.75	5 905.318	5 905	5 924.322	5 925	19.00	-4.67	Compliance
-30	5.0	5 905.314	5 905	5 924.317	5 925	19.00	-5.39	Compliance
-30	4.25	5 905.310	5 905	5 924.313	5 925	19.00	-6.07	Compliance
	$F_{L\ MIN}$	5 905.310	$F_{H\ MAX}$	5 924.378	OBW_{MAX}	19.01		Compliance

NOTE:
•KDB Guidance 511808 D01 C-V2x Waiver v01, section 3.1 the 26 dB OBW is measured.
•FCC DA-24-363, C-V2X Joint Waiver for channel edges.
•Frequency stability in reference to normal operating temp frequency is computed in ppm as: (Fc(temp)MHz - Fc (nom) MHz)/Fc(nom)MHz where Fc= FL+(FH-FL)/2

5.2 C-V2X Transmit Power

5.2.1 Standard Applicable

FCC

C-V2X OBU and RSU Operations

Frequency Range	Channel Bandwidth	OBU Limits	RSU EIRP Limit
5 905 – 5 925 MHz	20 MHz	33 dBm EIRP*, 27 dBm EIRP within 5 degrees of horizontal	33 dBm EIRP

*EIRP (equivalent isotropically radiated power)

5.2.2 Test Environment conditions

• Ambient temperature : (21 ~ 22) ℃ • Relative Humidity : (49 ~ 50) % R.H.

5.2.3 Measurement Procedure

According to requirements of 511808 D01 C-V2X Waiver v01, OBU Transmit Power Test Procedures：

a. The on-board unit (OBU) EIRP shall not exceed the limits provided in the relevant waiver grant. The EIRP may be calculated from the conducted measurement using antenna test data or the antenna data sheet; however, the antenna data must have sufficient resolution to determine the EIRP in the waiver grant-provided elevation from the horizontal plane.

b. Radiated emission measurements are necessary if there is not sufficient resolution in antenna data to determine compliance. The general test setup is shown in Figure 1. The OBU transmit antenna shall be placed at an elevation of 1.5 meters and oriented such that the main lobe of the antenna is facing parallel to the ground plane. The OBU shall also be configured for testing in a manner that is representative of the actual installation.

c. The measurement antenna may be placed at any test distance provided that it is in the far field of the OBU transmit antenna and at least 3 meters away.

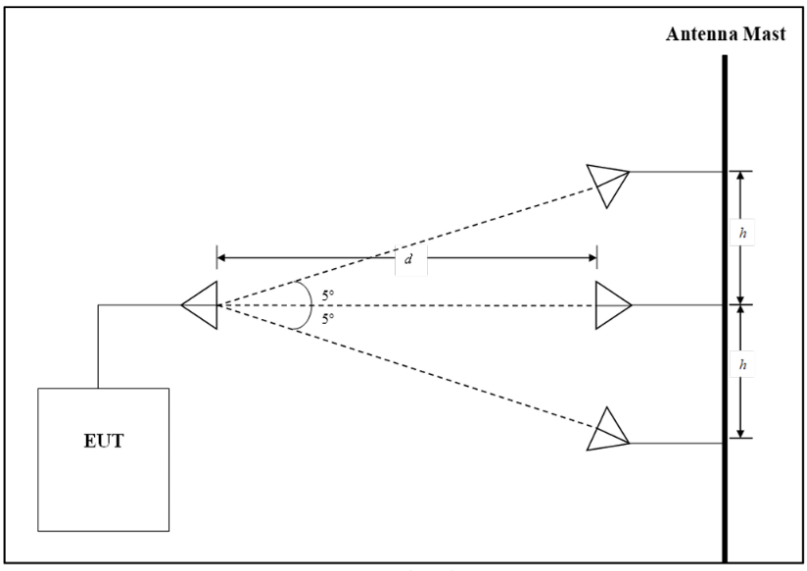


Figure 1. C-V2X OBU Radiated Test Setup Diagram

d. An investigation shall be performed to ensure that the peak antenna gain is being measured. Once determined, the main lobe of the receive measurement antenna shall be configured such that it is boresight or coincident to the main lobe of the transmit antenna.

e. After the peak EIRP is measured, the receive measurement antenna shall be elevated to the appropriate height as provided in the waiver grant relative to the transmit antenna.[3] The measurement antenna shall also be rotated up or down such that the transmit antenna remains in the main lobe of the measurement antenna.

5.2.4 Test setup

Please refer to the test setup photo

5.2.5 Measurement Result

Mode	Frequency [MHz]	Distance(d) [m]	Meas Result(E_0) [dBuV/m]	CF [dB]	EIRP [dBm]	EIRP Limit [MHz]	Test Results
C-V2X	5 915	3	116.99	95.26	21.73	27.0	Compliance

NOTE:

•FCC DA-24-363, section III(9) and (10) C-V2X Joint Waiver. 27dBm EIRP is chosen as the limit to show compliance without requiring additional elevation test data.

•Electric field measurements are typically made in terms of dBμV/m and need to be converted to EIRP. This can be accomplished using the following equation: EIRP (dBm) = $E_0 + 20\log_{10}(d) - 104.8$ where E_0 is the electric field measured in dBμV/m and d is the measurement distance in meters.

•CF(Conversion Factor) = $20\log_{10}(d) - 104.8$

•Meas Result (㏈㎶/m) : Test receiver reading value(Included Antenna factor.(㏈/m), CL(㏈), AMP(㏈) Factor)

5.3 Transmit Emission Mask(OOBE)

5.3.1 Standard Applicable

FCC

C-V2X Out-of-Band Emissions (OOBE) Limits

Frequency Offset (MHz from Channel Edge)	OOBE EIRP Limits for C-V2X Transmissions (dBm/100 kHz)**
0.0	-16.0
1.0	-22.0
10.0	-30.0
20.0	-40.0

5.3.2 Test Environment conditions

• Ambient temperature : (21 ~ 22) ℃ • Relative Humidity : (40 ~ 42) % R.H.

5.3.3 Measurement Procedure

According to requirements 511808 D01 C V2X Waiver v01r01, An illustration of an emissions mask that may be applicable to RSUs and OBUs can be found in Figure 2.

a. OOBE Mask Test Procedure

1. Connect output of the antenna port to a spectrum analyzer or EMI receiver, with appropriate attenuation, as to not damage the instrumentation.
2. Set the reference level of the measuring equipment in accordance with the general procedures in section 4.2.3 of ANSI C63.26 - 2016.
3. Measure the power spectral density of the OOBE using the following procedure:
4. Set instrument center frequency to the frequency of channel being measured.
5. Set the span to at least 4 times the OBW.
6. Set resolution bandwidth (RBW) = 100 kHz.
7. Set video bandwidth (VBW) ≥ 3 × RBW
8. Number of points in sweep ≥ [2 X span / RBW].
9. Sweep time = auto.
10. Detector = Peak
11. Trace mode = max hold.
12. Allow trace to fully stabilize.
13. In the case of devices which use multiple-input multiple-output (MIMO) technology, please follow the guidance in 662911 D01 Multiple Transmitter Output v02r01 E) 2) methods a) or c).
14. Use the instrumentation correction factors to account for cable loss and antenna gain since the final result is PSD EIRP. In the case of MIMO devices, please follow the guidance of 662911 D03 MIMO Antenna Gain Measurement v01 in determining aggregate antenna gain.

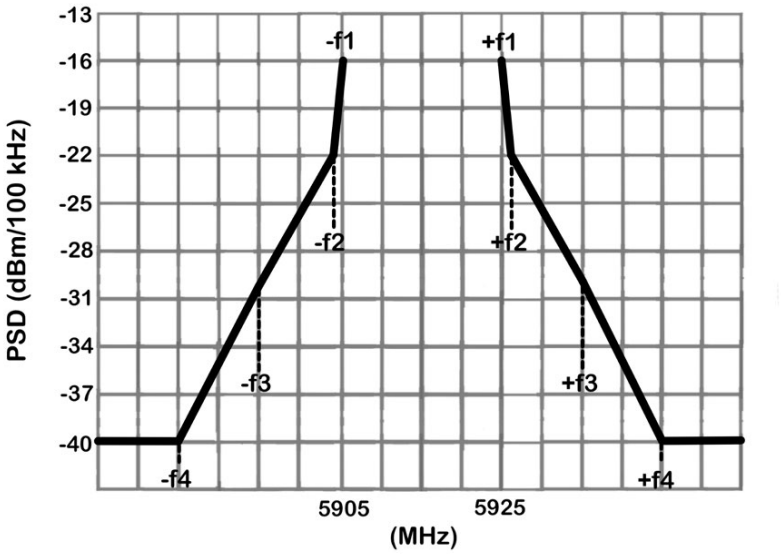
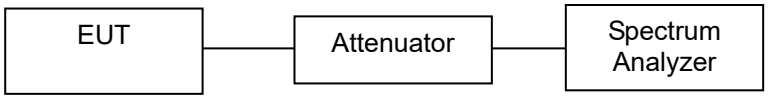


Figure 2. Emissions Mask

b. Keep in mind, the out-of-band emissions mask is based upon an absolute EIRP value in dBm/100 kHz and not a relative change in amplitude (dBr). Using the measuring equipment limit line function, develop the out-of-band emissions mask based on the emissions limits at the frequency offsets specified in the relevant waiver grant. For example, Figure 2 illustrates the emissions mask for the emissions levels at the frequency offsets described below:

1. +f1 and -f1 is the frequencies at the channel edge with an emissions level of -16 dBm/100 kHz.
2. +f2 and -f2 is a frequency offset of 1 MHz from the channel edge with an emissions level of -22 dBm/100 kHz.
3. +f3 and -f3 is a frequency offset of 10 MHz from the channel edge with an emissions level of -30 dBm/100 kHz.
4. +f4 and -f4 is a frequency offset of 20 MHz from the channel edge with an emissions level of -40 dBm/100 kHz.

5.3.4 Test setup

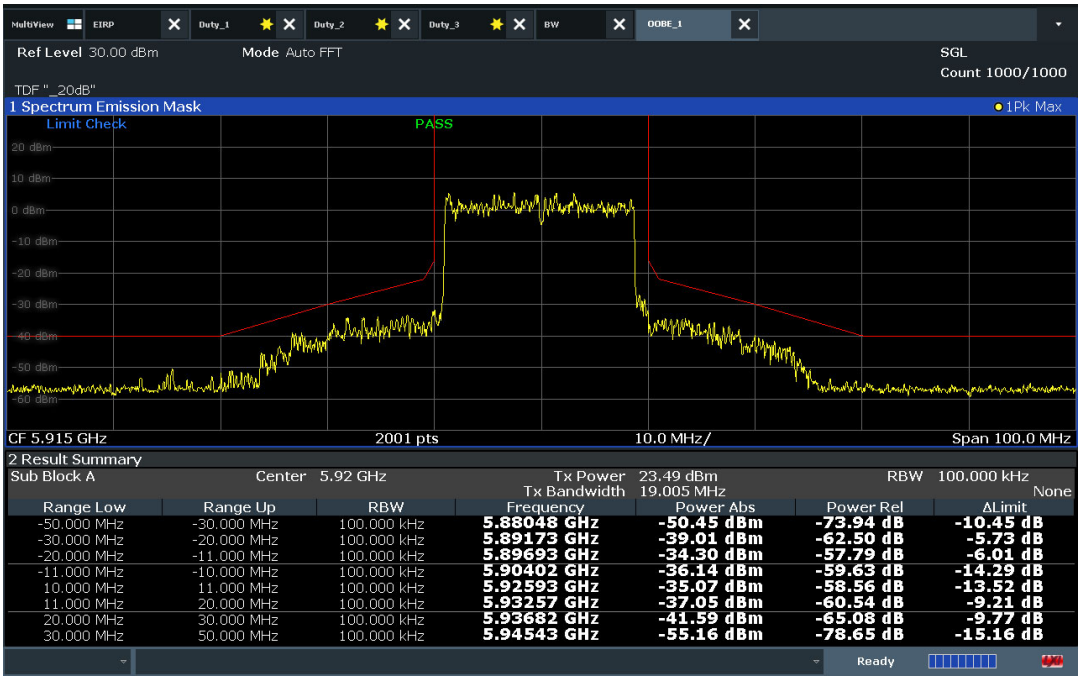


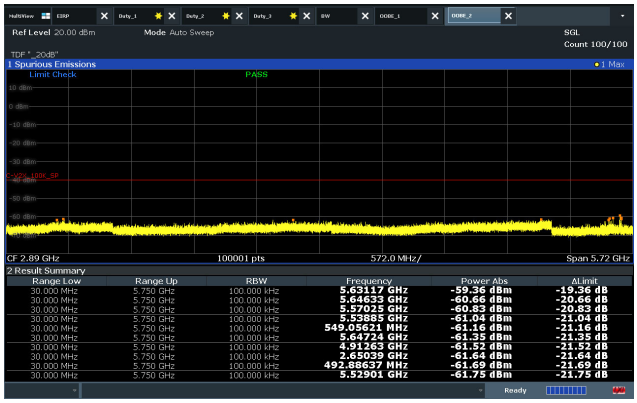
5.3.5 Measurement Result

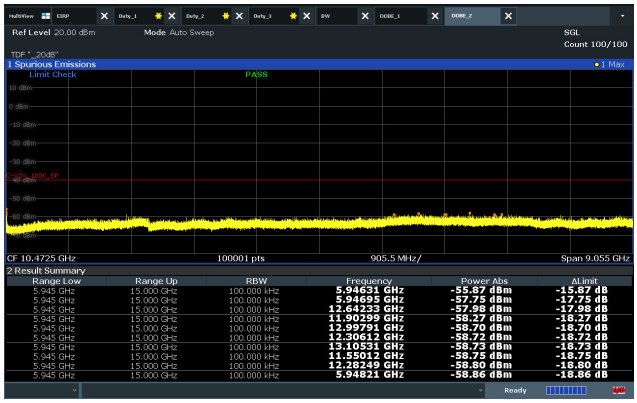
Mode	Frequency [MHz]	Measurement Results [dBm]	Limit [dBm]	Test Results
C-V2X	5 915	Note	Note	Compliance

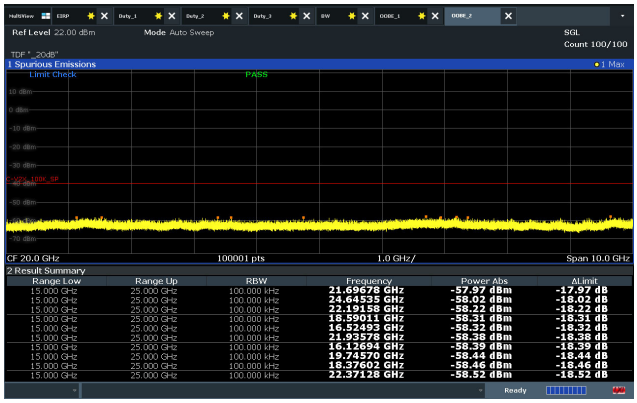
Note:
Refer to following test plots

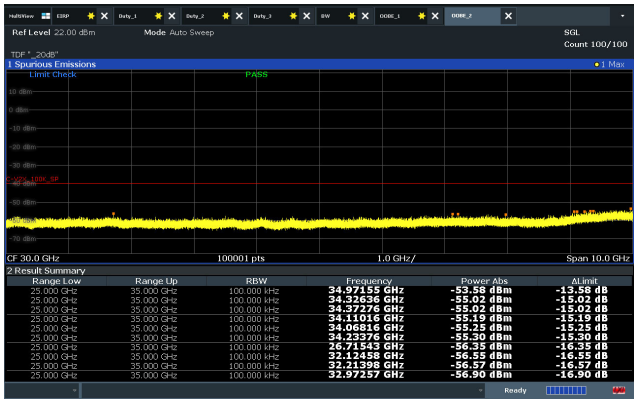
5.3.6 Test Plot (OOBE)

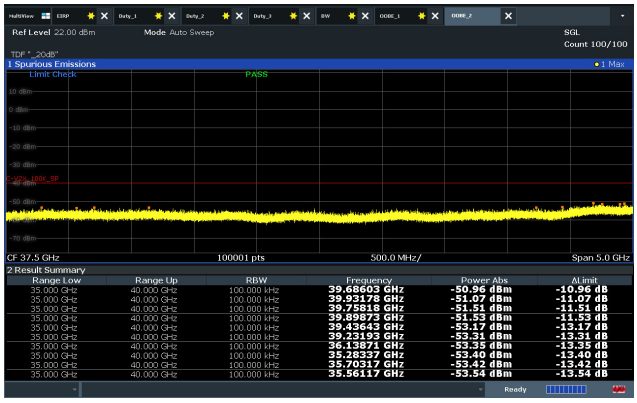












5.4 Transmit Chain Spurious Emissions

5.4.1 Standard Applicable

FCC

C-V2X Out-of-Band Emissions (OOBE) Limits

Frequency Offset (MHz from Channel Edge)	OOBE EIRP Limits for C-V2X Transmissions (dBm/100 kHz)**
0.0	-16.0
1.0	-22.0
10.0	-30.0
20.0	-40.0

5.4.2 Test Environment conditions

• Ambient temperature : (21 ~ 22) ℃ • Relative Humidity : (49 ~ 50) % R.H.

5.4.3 Measurement Procedure

The measurements procedure of the Spurious RF Radiated emissions is as following describe method.

1. The EUT was placed on the top of a rotating table (0.8 meters for below 1 GHz and 1.5 meters for above 1 GHz) above the ground at a 3 meter camber. The table was rotated 360 degree to determine the position of the highest radiation.
2. The EUT was set 3 meters away from the interference-receiving antenna, which was mounted on the top of a variable-height antenna master.
3. The antenna height 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.
4. 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 rotating table was turned from 0 - 360 degrees to find the maximum reading.
5. The measuring receiver was set to peak detector and specified bandwidth with max hold function.
6. Low, Middle and high channels were measured, and radiation measurements are performed in X, Y, Z axis positioning. And found the worst axis position and only the test worst case mode is recorded in the report.

• The spectrum is measured from 9kHz to the 10th harmonic of the fundamental frequency of the transmitter.

The worst-case emissions are reported.

• Field strengths are calculated using the Measurement quantity conversions in ANSI C63.26-2015 Section 5.2.7:

a) E(dBuV/m) = Measured amplitude level (dBm) + 107 + Cable Loss (dB) + Antenna Factor (dB/m)

b) EIRP (dBm) = E(dBuV/m) + 20logD - 104.8; where D is the measurement distance in meters.

5.4.4 Measurement Uncertainty

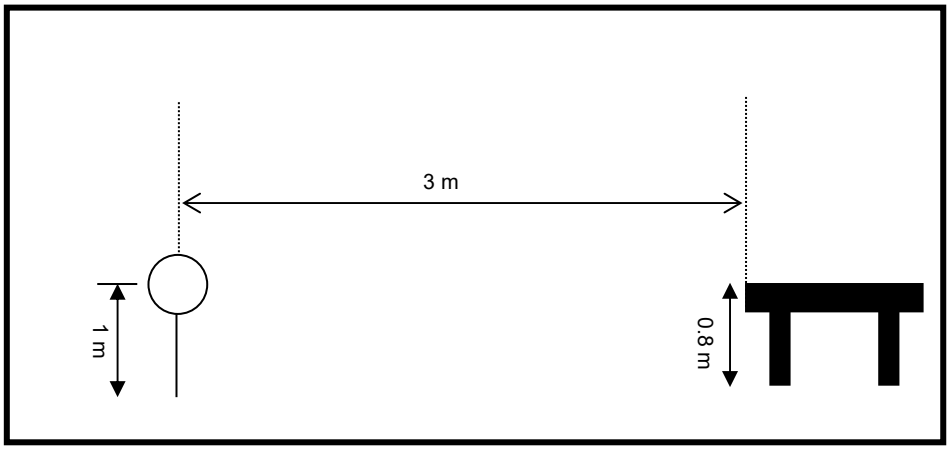
The measurement uncertainties shown below were calculated in accordance with the requirements of ANSI C63.10-2013. All measurement uncertainty values are shown with a coverage factor of k = 2 to indicate a 95% level of confidence. The measurement uncertainty shown below meets or exceeds the UCISPR measurement uncertainty values specified in CISPR 16-4-2 and, thus, can be compared directly to specified limits to determine compliance.

Radiated Emission measurement: Below 1 GHz: 3.88 dB (CL: Approx 95 %, k=2)

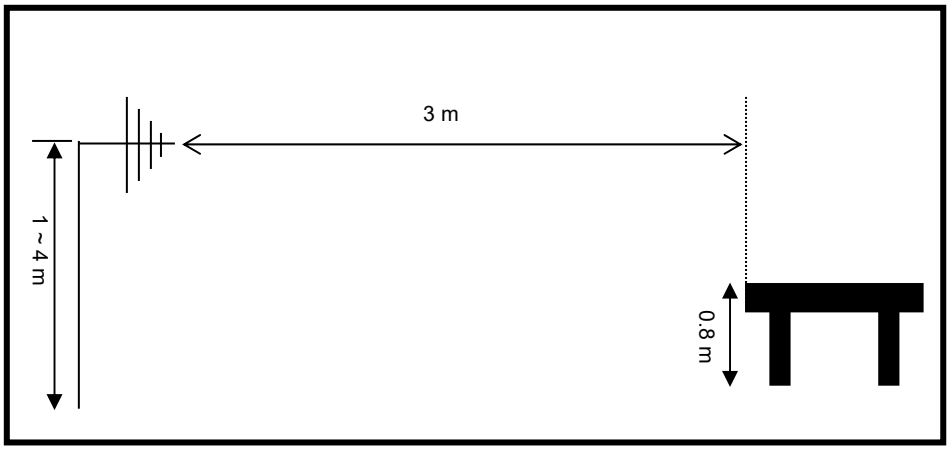
Above 1 GHz: 3.04 dB (CL: Approx 95 %, k=2)

5.4.5 Test Configuration

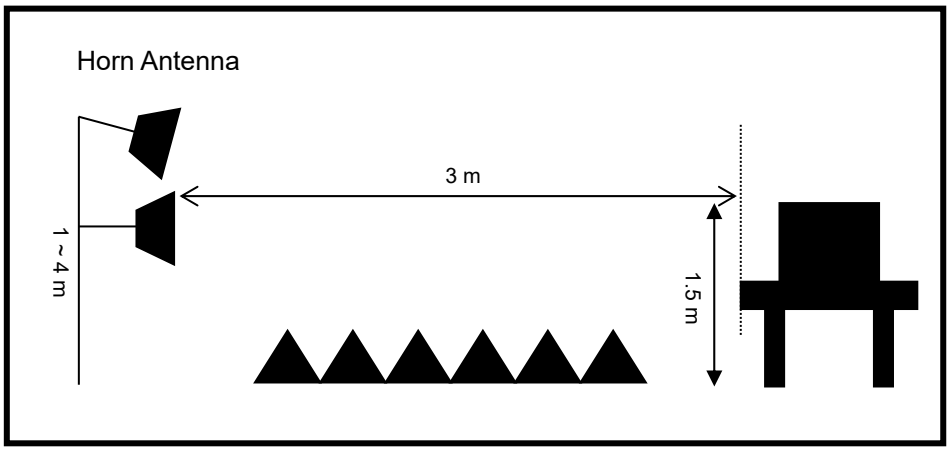
Radiated emission setup, below 30 MHz



Radiated emission setup, below 1 000 MHz



Radiated emission setup, above 1 GHz



5.4.6 Measurement Result

Meas. Range (GHz)	Freq. (GHz)	Reading (dBμV/m)	Antenna			CL (dB)	AMP (dB)	Meas Result (dBμV/m)	EIRP (dBm)	Limit (dBm)	Mgn. (dB)	Result
		PK	Height (m)	Pol. (H/V)	Fctr. (dB/m)			PK	PK		PK	
0.3 ~ 1.0	243.5	37.48	1-4	V	18.09	2.27	46.42	37.48	-57.72	-40	17.72	Compliance
	401.1	35.70	1-4	H	21.53	2.92	46.40	35.70	-59.50	-40	19.50	Compliance
	703.7	37.73	1-4	V	27.55	3.93	46.11	37.73	-57.47	-40	17.47	Compliance
1.0 ~ 3.0	2 466.2	44.92	1.5	V	31.57	9.88	45.83	44.92	-50.28	-40	10.28	Compliance
	2 499.0	43.86	1.5	H	31.60	9.77	45.84	43.86	-51.34	-40	11.34	Compliance
3.0 ~ 7.0	5 528.3	44.31	1.5	V	33.93	12.16	45.48	44.31	-50.89	-40	10.89	Compliance
	6 332.7	45.03	1.5	H	35.01	12.82	44.99	45.03	-50.17	-40	10.17	Compliance
7.0 ~ 18.0	17 725.0	42.45	1.5	H	44.29	3.80	43.42	42.45	-52.75	-40	12.75	Compliance
18.0 ~ 26.0	25 500.0	35.28	1.5	H	39.15	4.54	48.87	35.28	-59.92	-40	19.92	Compliance
26.0 ~ 40.0	39 125.0	49.12	1.5	H	45.80	5.66	51.59	49.12	-46.08	-40	6.08	Compliance

※Note

•Freq.(㎒) : Measurement frequency

•Reading(dBμV/m) : includes values for Antenna factor, Cable loss, and Amp gain

•Antenna (Height, Pol, Fctr) : Antenna Height, Polarization and Factor

•CL(dB) : Cable loss

•AMP(dB) : Preamplifier gain(dB)

•Measurement distance: 3 m

•Meas Result (dBμV/m) :Reading(dBμV/m)+ Antenna factor.(dB/m)+ CL(dB) - AMP(dB)

•EIRP(dBm): E(dBuV/m) + 20logD – 104.8; where D is measurement distance in meters.

•Limit(dBm): Limit according to ref. KDB Guidance 511808 D01 C-V2X Waiver v01, figure 2.

•Mgn(dB) : Limit (dBm) － EIRP(dBm)

•The transmitter radiated spectrum was investigated from 30 MHz to 40 GHz.