TEST REPORT

Bureau Veritas CPS Korea Tech Limited (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-250002(1)	

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: LTE-V2X-OBU
- Model Name: ETF-PRO-OC02
- Brand: None
- FCC ID: 2BHJL-ETF-PRO-OC02

3. Manufacturer

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

4. Date of Test : 2025. 04. 14. ~ 2025. 04. 15.

5. Test Method Used : FCC CFR 47, Part 95L
511808 D01 C-V2X v02
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 Bureau Veritas CPS Korea Tech Limited 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)

2025. 05. 21.

Bureau Veritas CPS Korea Tech Limited

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1. GENERAL INFORMATION

1.1 Test Facility

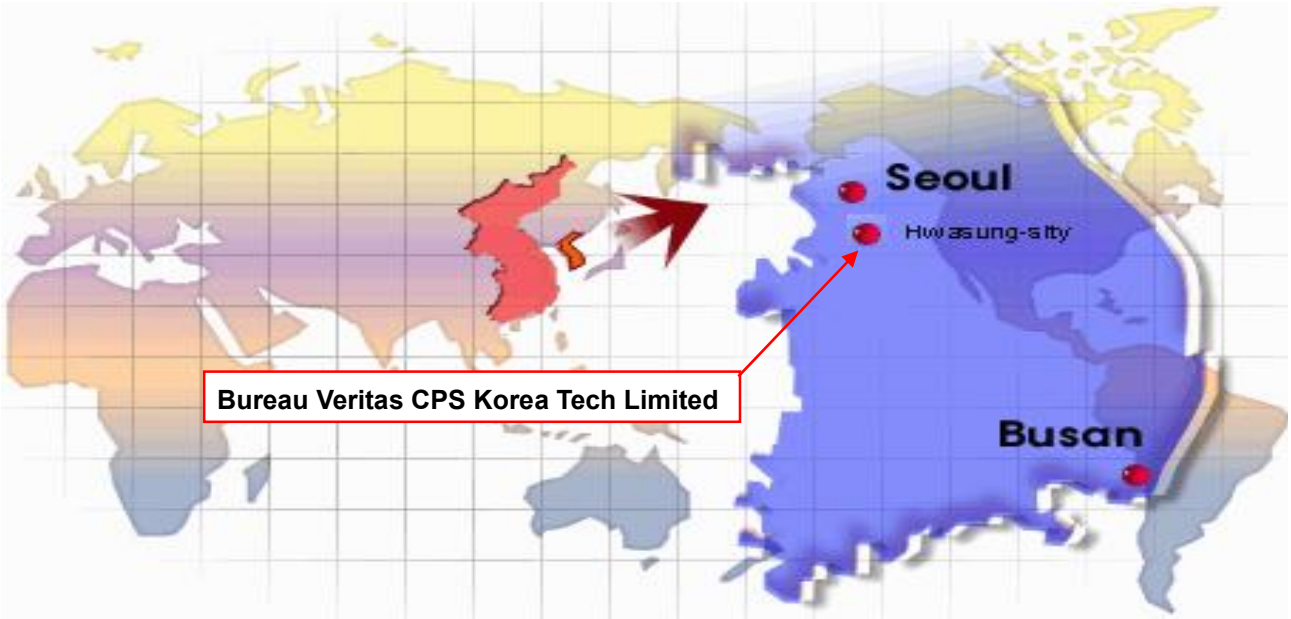
Test laboratory and address

Bureau Veritas CPS Korea Tech Limited
(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	2025. 04. 18.
1	Added information regarding antenna operation to the Remarks section.	5	Mi-Young, Lee	2025. 05. 21.

2. EQUIPMENT DESCRIPTION

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

Equipment Name	LTE-V2X-OBU
Model No	ETF-PRO-OC02
Usage	LTE-V2X-OBU
Serial Number	Proto type
Modulation type	16QAM
Emission Type	D1D
Maximum output power(E.I.R.P)	22.95 dBm
Operated Frequency	5 905 MHz ~ 5 925 MHz(Center Frequency: 5 915 MHz)
Channel Number	1
Operation temperature	-40 ℃ ~ 85 ℃
Power Source	DC 12 V
Antenna Description	External dipole array antenna, gain : 8 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 the manufacturer. Please refer to the specifications or user manual for more detailed description. 4. This EUT operates in SISO mode on ANT1 and ANT2, and does not support MIMO functionality.
FCC ID	2BHJL-ETF-PRO-OC02

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
Notebook	80QQ	PF0E1J1Z	Lenovo PC HK Limited	-

3.3 Product Modification

N/A

3.4 Declared Exemptions and Additional Product Notes

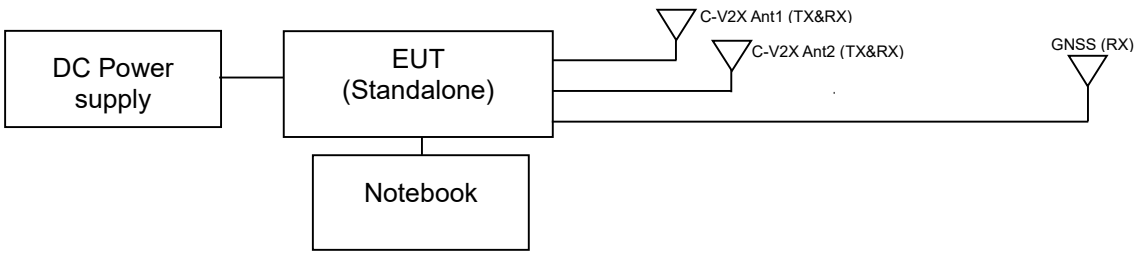
The EUT is an FCC Part 95, Subpart L device. The EUT is permanently installed in a transportation vehicle. As such, digital emissions are exempt from US regulations per FCC 15.103(a). The manufacturer declares compliance with all provisions of FCC Part 95L listed herein.

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

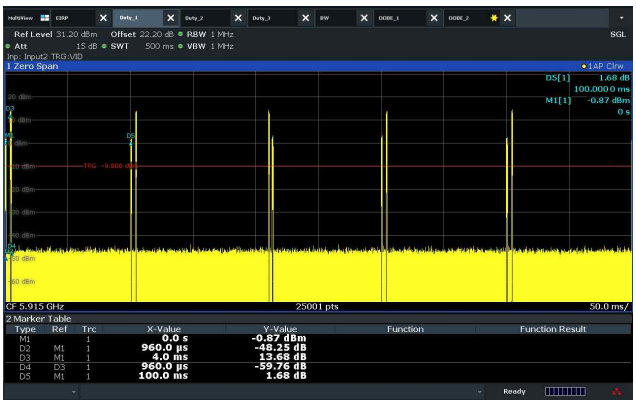
3.8 Duty Cycle Of Test signal

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

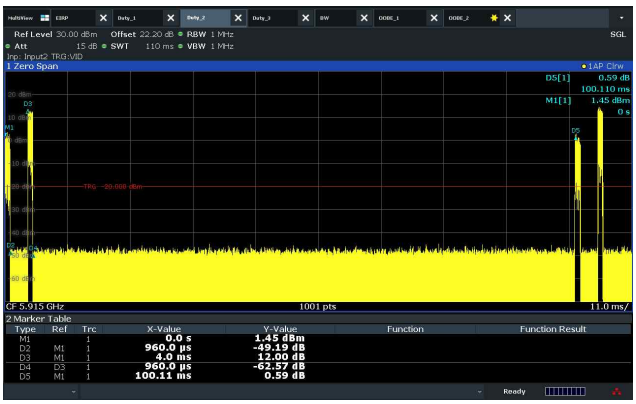
Mode	Voltage [V]	Frequency [MHz]	Data rate [Mbps]	Tx Cycle Time [ms]	Tx On-Time [ms]	Duty Cycle [%]	Duty Correction [dB]
C-V2X	12.0	5 915	30.7	100.1	1.92	1.92	17.17

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

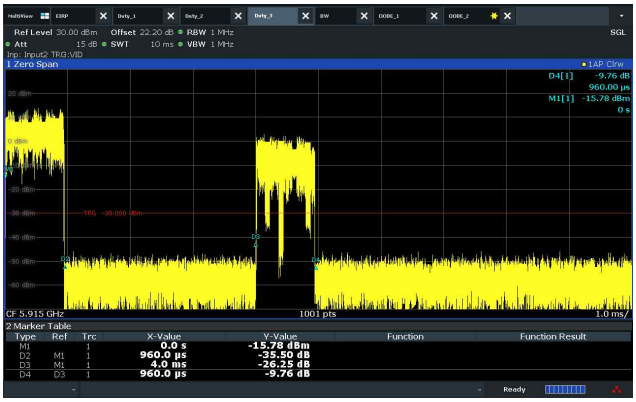
500 ms



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	2026.01.08	1 year	☐
5	Spectrum Analyzer	FSV30	104029	Rohde & Schwarz	2025.08.12	1 year	☐
6	Spectrum Analyzer	FSV30	20-353063	Rohde & Schwarz	2026.01.08	1 year	☐
7	Spectrum Analyzer	FSV40	101727	Rohde & Schwarz	2025.08.12	1 year	☐
8	Signal Analyzer	FSW43	101294	Rohde & Schwarz	2026.01.08	1 year	☒
9	Signal Analyzer	FSW85	101602	Rohde & Schwarz	2025.07.03	1 year	☐
10	EMI Test Receiver	ESCI7	100823	Rohde & Schwarz	2026.01.07	1 year	☐
11	EMI Test Receiver	ESPI	100488	Rohde & Schwarz	2026.01.06	1 year	☐
12	EMI Test Receiver	ESI	837514/004	Rohde & Schwarz	2025.08.12	1 year	☒
13	Vector Signal Analyzer	89441A	3416A02620	Agilent Technology	2026.01.09	1 year	☐
14	Network Analyzer	8753ES	US39170869	AGILENT	2025.08.13	1 year	☐
15	EPM Series Power meter	E4418B	GB39512547	Agilent Technology	2026.01.08	1 year	☐
16	RF Power Sensor	E9300A	MY41496631	Agilent Technology	2026.01.08	1 year	☐
17	Microwave Frequency Counter	5352B	2908A00480	Agilent Technology	2026.01.06	1 year	☐
18	Audio Analyzer	8903B	3514A16919	Agilent Technology	2026.01.06	1 year	☐
19	Audio Telephone Analyzer	DD-5601CID	520010281	CREDIX	2026.01.06	1 year	☐
20	Modulation Analyzer	8901A	3041A05716	H.P	2026.01.08	1 year	☐
21	Digital storage Oscilloscope	TDS3052	B015962	Tektronix	2025.08.13	1 year	☐
22	ESG-D Series Signal Generator	E4436B	US39260458	Agilent Technology	2026.01.09	1 year	☐
23	Vector Signal Generator	SMBV100A	257557	Rohde & Schwarz	2026.01.09	1 year	☐
24	GNSS Signal Generator	TC-2800A	2800A000494	TESCOM CO., LTD.	2026.01.09	1 year	☐
25	Signal Generator	SMB100A	179628	Rohde & Schwarz	2026.01.09	1 year	☒
26	Signal Generator	N5173B	MY57280148	KEYSIGHT	2026.03.27	1 year	☐
27	SLIDAC	None	0207-4	Myoung sung Ele.	2026.01.06	1 year	☐
28	DC Power supply	DDPS-3K	U03-109	Digitech Power	2026.01.07	1 year	☐
29	DC Power supply	E3610A	KR24104505	Agilent Technology	2026.01.06	1 year	☐
30	DC Power supply	UP-3005T	68	Unicon Co.,Ltd	2026.01.06	1 year	☐
31	DC Power Supply	SM 3400-D	114701000117	DELTA ELEKTRONIKA	2026.01.06	1 year	☐
32	DC Power supply	6632B	MY43004005	Agilent Technology	2026.01.06	1 year	☒
33	DC Power Supply	6632B	MY43004137	Agilent Technology	2026.01.06	1 year	☐
34	Termination	1433-3	LM718	WEINSCHEL	2026.01.08	1 year	☐
35	Termination	1432-3	QR946	AEROFLEX/WEINSCHEL	2026.01.08	1 year	☐
36	Attenuator	8498A	3318A09485	HP	2026.01.08	1 year	☐
37	Step Attenuator	8494B	3308A32809	HP	2026.01.08	1 year	☐
38	RF Step Attenuator	RSP	100091	Rohde & Schwarz	2026.01.09	1 year	☐
39	Attenuator	18B50W-20F	64671	INMET	2026.01.09	1 year	☐
40	Attenuator	10 dB	1	Rohde & Schwarz	2026.01.08	1 year	☐
41	Attenuator	54A-10	74564	WEINSCHEL	2025.08.19	1 year	☒
42	Attenuator	56-10	66920	WEINSCHEL	2026.01.08	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	2026.01.08	1 year	☐
47	3Way Power divider	KPDSU3W	00070365	KMW	2025.08.12	1 year	☐
48	4Way Power divider	70052651	173834	KRYTAR	2026.01.08	1 year	☐
49	3Way Power divider	1580	SQ361	WEINSCHEL	2026.01.08	1 year	☐
50	OSP	OSP120	101577	Rohde & Schwarz	2026.01.09	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	2026.01.09	1 year	☐
53	Dual directional coupler	772D	2839A00924	HEWLETT PACKARD	2026.01.09	1 year	☐
54	Band rejection filter	3TNF-0006	26	DOVER Tech	2026.01.09	1 year	☐
55	Band rejection filter	3TNF-0007	311	DOVER Tech	2026.01.09	1 year	☐
56	Band rejection filter	WTR-BRF2442-84NN	09020001	WAVE TECH Co.,LTD	2026.01.09	1 year	☐
57	Band rejection filter	WRCJV12-5695-5725-5825-5855-50SS	1	Wainwright Instruments GmbH	2026.01.09	1 year	☐
58	Band rejection filter	WRCJV12-5120-5150-5350-5380-40SS	4	Wainwright Instruments GmbH	2026.01.09	1 year	☐
59	Band rejection filter	WRCGV10-2360-2400-2500-2540-50SS	2	Wainwright Instruments GmbH	2026.01.09	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	2026.01.09	1 year	☐
63	Highpass Filter	WHJS1100-10EF	1	WAINWRIGHT	2026.01.08	1 year	☐
64	Highpass Filter	WHJS3000-10EF	1	WAINWRIGHT	2026.01.08	1 year	☐
65	Highpass Filter	WHNX6-5530-7000-26500-40CC	2	Wainwright Instruments GmbH	2026.01.13	1 year	☒
66	Highpass Filter	WHNX6-2370-3000-26500-40CC	4	Wainwright Instruments GmbH	2026.01.13	1 year	☐
67	WideBand Radio Communication Tester	CMW500	102276	Rohde & Schwarz	2026.01.09	1 year	☐
68	WideBand Radio Communication Tester	CMW500	117235	Rohde & Schwarz	2026.01.15	1 year	☐
69	WideBand Radio Communication Tester	MT8000A	6261987920	Anritsu	2026.01.08	1 year	☐
70	WideBand Radio Communication Tester	MT8821C	6262287695	Anritsu	2026.01.08	1 year	☐
71	Bluetooth Tester	TC-3000B	3000B6A0166	TESCOM CO., LTD.	2026.01.10	1 year	☐
72	Loop Antenna	6502	9203-0493	EMCO	2025.05.23	2 year	☐
73	Loop Antenna	FMZB1513	#374	Schwarzbeck	2027.02.11	2 year	☒
74	BiconiLog Antenna(R)	3142C	35880	ETS-LINDGREN	2026.10.17	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	2026.02.21	1 year	☐
78	Horn Antenna	QMS-00208	21909	STEATITE ANTENNA	2026.03.31	1 year	☐
79	Horn Antenna(R)	3117	00135191	ETS-LINDGREN	2026.03.24	1 year	☒
80	Horn Antenna(T)	3115	2996	EMCO	2026.01.07	1 year	☐
81	Horn Antenna(R)	BBHA 9170	9170-722	SCHWARZBECK	2026.01.13	1 year	☒
82	Horn Antenna(T)	BBHA 9170	743	SCHWARZBECK	2026.01.07	1 year	☐
83	AMPLIFIER(A_10)	TK-PA01S	220109-L	TESTEK	2026.01.07	1 year	☐
84	AMPLIFIER(C_3)	TK-PA01S	200141-L	TESTEK	2025.08.12	1 year	☒
85	PREAMPLIFIER(C_3)	8449B	3008A02577	Agilent	2026.01.06	1 year	☐
86	RF PRE AMPLIFIER	SCU08F2	100762	Rohde & Schwarz	2025.08.22	1 year	☐
87	AMPLIFIER	TK-PA18	150003	TESTEK	2026.01.07	1 year	☒
88	AMPLIFIER	TK-PA1840H	160010-L	TESTEK	2026.01.06	1 year	☒

4. SUMMARY TEST RESULTS

Description of Test	FCC Rule	Result/Remarks	Reference Clause	Used	Test Result
Occupied Bandwidth	2.1049 95.3203	26 dB BW: 19.62 MHz F_L: 5 905.192 MHz F_H: 5 924.808 MHz 99% BW: 17.96 MHz	Clause 5.1	☒	Compliance
Frequency Stability	2.1055 95.3203	6.12 ppm			
C-V2x Transmit Power	2.1046 95.3204(a)	19.68 dBm EIRP	Clause 5.2	☒	Compliance
Transmit Emission Mask(OOBE)	95.3205(a)	Meet the requirement of limit. Minimum passing margin is –16.74 dB at 5 895.57 MHz (Abs. value: -32.74 dBm)	Clause 5.3	☒	Compliance
Transmit Chain Spurious Emissions	95.3205(a)	Meet the requirement of limit. Minimum passing margin is –15.65 dB at 39 485.0 MHz (Abs. value: -43.65 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

511808 D01 C-V2X v02

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 : (20 ~ 21) ℃ • 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. The 99% occupied bandwidth is the difference between these two frequencies.

FOR 26dB BANDWIDTH

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

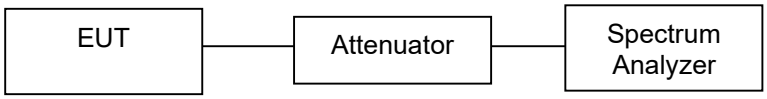
•Set the VBW > RBW.

•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

ANT1

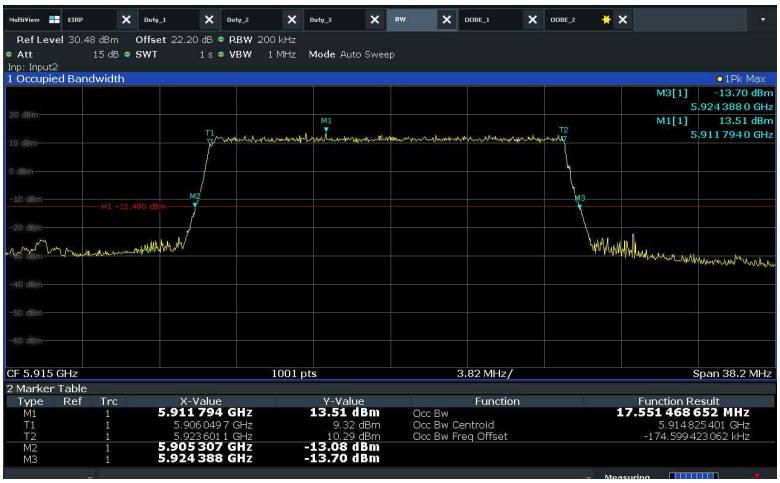
Mode	Voltage [V]	Frequency [MHz]	26 dB Bandwidth [MHz]	F_L [MHz]	F_L Limit [MHz]	F_H [MHz]	F_H Limit [MHz]	99 % Bandwidth [MHz]	Test Results
C-V2X	12.0	5 915	19.08	5 905.269	5 905	5 924.350	5 925	17.53	Compliance

NOTE:
•KDB Guidance 511808 D01 C-V2X v02, section 3.1 Both 26dB and 99% OBW is to be measured.
•OBW must stay within the channel.
•26 dB Bandwidth = F_H - F_L

ANT2

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	12.0	5 915	19.08	5 905.307	5 905	5 924.388	5 925	17.55	Compliance

NOTE:
•KDB Guidance 511808 D01 C-V2X v02, section 3.1 Both 26dB and 99% OBW is to be measured.
•OBW must stay within the channel.
•26 dB Bandwidth = F_H - F_L



- Frequency Stability
- ANT1

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	13.8	5 905.296	5 905	5 924.379	5 925	19.08	-27.44	Compliance
75	12.0	5 905.293	5 905	5 924.376	5 925	19.08	-28.04	Compliance
75	10.2	5 905.289	5 905	5 924.371	5 925	19.08	-28.77	Compliance
65	12.0	5 905.286	5 905	5 924.366	5 925	19.08	-29.44	Compliance
55	12.0	5 905.281	5 905	5 924.362	5 925	19.08	-30.20	Compliance
45	12.0	5 905.277	5 905	5 924.357	5 925	19.08	-30.94	Compliance
35	12.0	5 905.274	5 905	5 924.353	5 925	19.08	-31.51	Compliance
25	12.0	5 905.269	5 905	5 924.350	5 925	19.08	-32.21	Compliance
15	12.0	5 905.264	5 905	5 924.345	5 925	19.08	-33.00	Compliance
5	12.0	5 905.260	5 905	5 924.342	5 925	19.08	-33.64	Compliance
-5	12.0	5 905.255	5 905	5 924.339	5 925	19.08	-34.31	Compliance
-15	12.0	5 905.251	5 905	5 924.334	5 925	19.08	-35.08	Compliance
-20	12.0	5 905.247	5 905	5 924.330	5 925	19.08	-35.77	Compliance
-25	12.0	5 905.244	5 905	5 924.325	5 925	19.08	-36.47	Compliance
-30	13.8	5 905.241	5 905	5 924.322	5 925	19.08	-37.01	Compliance
-30	12.0	5 905.237	5 905	5 924.318	5 925	19.08	-37.65	Compliance
-30	10.2	5 905.233	5 905	5 924.314	5 925	19.08	-38.35	Compliance
	$F_{L\,MIN}$	5 905.233	$F_{H\,MAX}$	5 924.379	OBW_{MAX}	19.08		Compliance

NOTE:
•KDB Guidance 511808 D01 C-V2x v02, section 3.1 the 26 dB OBW is measured.
•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

- ANT2

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	13.8	5 905.335	5 905	5 924.413	5 925	19.08	-21.29	Compliance
75	12.0	5 905.330	5 905	5 924.409	5 925	19.08	-22.00	Compliance
75	10.2	5 905.325	5 905	5 924.406	5 925	19.08	-22.74	Compliance
65	12.0	5 905.322	5 905	5 924.402	5 925	19.08	-23.36	Compliance
55	12.0	5 905.319	5 905	5 924.398	5 925	19.08	-23.90	Compliance
45	12.0	5 905.314	5 905	5 924.395	5 925	19.08	-24.60	Compliance
35	12.0	5 905.310	5 905	5 924.392	5 925	19.08	-25.19	Compliance
25	12.0	5 905.307	5 905	5 924.388	5 925	19.08	-25.78	Compliance
15	12.0	5 905.303	5 905	5 924.384	5 925	19.08	-26.47	Compliance
5	12.0	5 905.299	5 905	5 924.381	5 925	19.08	-27.07	Compliance
-5	12.0	5 905.294	5 905	5 924.378	5 925	19.08	-27.74	Compliance
-15	12.0	5 905.290	5 905	5 924.374	5 925	19.08	-28.38	Compliance
-20	12.0	5 905.286	5 905	5 924.370	5 925	19.08	-29.12	Compliance
-25	12.0	5 905.282	5 905	5 924.365	5 925	19.08	-29.84	Compliance
-30	13.8	5 905.277	5 905	5 924.361	5 925	19.08	-30.61	Compliance
-30	12.0	5 905.274	5 905	5 924.358	5 925	19.08	-31.14	Compliance
-30	10.2	5 905.269	5 905	5 924.354	5 925	19.08	-31.83	Compliance
	$F_{L\,MIN}$	5 905.269	$F_{H\,MAX}$	5 924.354	OBW_{MAX}	19.08		Compliance

NOTE:
•KDB Guidance 511808 D01 C-V2x v02, section 3.1 the 26 dB OBW is measured.
•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

Channel (MHz)	**Channel Bandwidth** (MHz)	**EIRP** with Geofencing outside zone (dBm/BW)	**EIRP** with Geofencing operating within zone* *or* without Geofencing (dBm/BW)
5895-5905	10	33	23
5905-5915	10	33	33†
5915-5925	10	33	33†
5895-5915	20	33	23
5905-5925	20	33	33†
5895-5925	30	33	23
	* Coordination zones of §90.387(b)[2] † Reduced to 27dBm within ± 5 degrees of horizontal		

Table 1. OBU EIRP Limits

5.2.2 Test Environment conditions

• Ambient temperature : (20 ~ 21) ℃ • Relative Humidity : (42 ~ 43) % R.H.

5.2.3 Measurement Procedure

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

a) OBUs employing C-V2X technologies shall have a maximum EIRP that does not exceed the limits provided in §95.3204. The EIRP is measured as the maximum EIRP toward the horizon or horizontally, whichever is greater, based on the gain associated with the main or center of the transmission beam. The EIRP may be calculated from conducted power measurements using characterized antenna data or the antenna data sheet; however, the antenna data must have sufficient resolution to determine the antenna gain within ±5 degrees from the horizontal plane.

b) Radiated measurements shall be made if there is insufficient resolution in the antenna data to determine compliance. The resolution should be such that the antenna gain can be determined at ±5 degrees elevation. The general test setup is shown in Figure 2. The OBU transmit antenna shall be placed at a height of 1.5 meters and oriented such that the antenna's main lobe is facing parallel to the ground plane. The OBU shall be configured for testing to represent the actual installation.

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

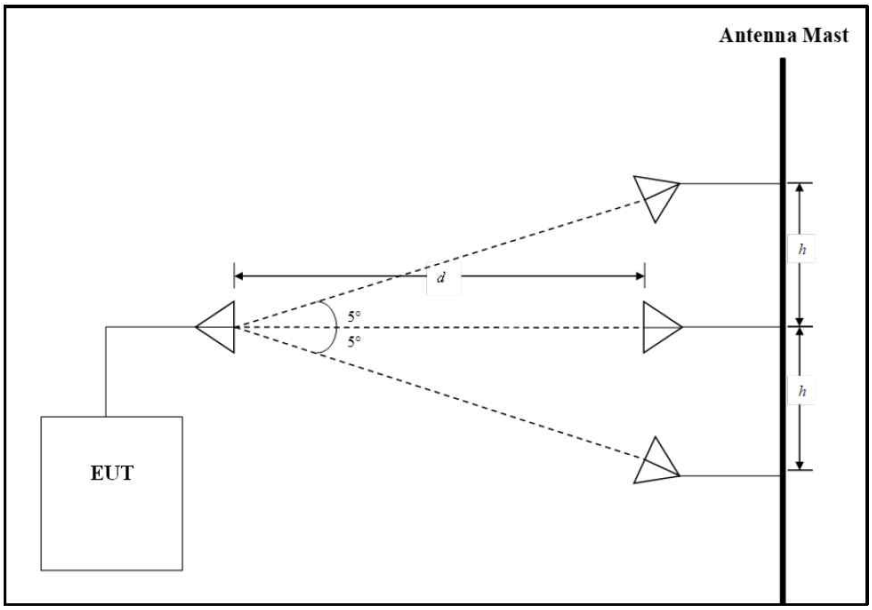


Figure 2. C-V2X OBU Radiated Test Setup Diagram

d) Several operating bands require the beam to be evaluated based on whether the device is transmitting in the coordination zone or operating without geofencing capabilities, as shown in Table 1. To determine compliance in these bands, after the maximum EIRP is measured, the receive measurement antenna shall be elevated to the appropriate height4 relative to the transmit antenna. Measurements or calculations for EIRP shall be performed at the upper and lower edges of the ±5-degree beam width. If the maximum EIRP is less than 27 dBm, then additional testing for ±5 degrees is not required.

e) OBUs with a maximum EIRP > 27 dBm shall describe the mechanism for reducing the main beam power to 27 dBm under §95.3204(a)(5) when the beam is within the ± 5 degrees elevation from the horizontal plane.

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 [dBm]	Test Results
C-V2X_Ant1	5 915	3	118.21	95.26	22.95	27.0	Compliance
C-V2X_Ant2	5 915	3	118.18	95.26	22.92	27.0	Compliance

NOTE:

• KDB Guidance 511808 D01 C-V2x v02, section 3.2.1 d). 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 + 20log$_{10}$(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) = 20log$_{10}$(d) – 104.8

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

5.3 Transmit Emission Mask(OOBE)

5.3.1 Standard Applicable

FCC

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

1. -16 dBm/100 kHz within ± 1 megahertz of the band edges.
2. -13 dBm/MHz within ± 1 megahertz to ± 5 megahertz of the band edges.
3. -16 dBm/MHz within ± 5 megahertz to ± 30 megahertz of the band edges and
4. -28 dBm/MHz beyond 30 megahertz from the band edges.

5.3.2 Test Environment conditions

• Ambient temperature : (20 ~ 21) ℃ • Relative Humidity : (40 ~ 42) % R.H.

5.3.3 Measurement Procedure

RSUs and OBUs must comply with the following guidelines:

a) Conducted limits measured at the antenna input must not exceed:

1. -16 dBm/100 kHz within ± 1 megahertz of the band edges.
2. -13 dBm/MHz within ± 1 megahertz to ± 5 megahertz of the band edges.
3. -16 dBm/MHz within ± 5 megahertz to ± 30 megahertz of the band edges and
4. -28 dBm/MHz beyond 30 megahertz from the band edges.

b) Compliance can be verified using an RMS average detector.

c) The general test methods of ANSI C63.26, section 5.7.3 and 5.7.4 shall be used.

d) There is no requirement as to how the plots are to be formatted or displayed, as long as all applicable data is presented.

e) For example, if the lab possesses a spectrum analyzer capable of performing segmented measurements with control of RBW, VBW, sweep time, number of points, detector type, etc., per segment, then all the segments from 1. – 4. in a) above, may appear on one single plot as shown in Figure 3.

f) When using the emission mask for plots or segments, ensure that the spectrum analyzer's automatic measurement feature is enabled to clearly display the "pass" or "fail" result on the plot as shown in Figure 3.

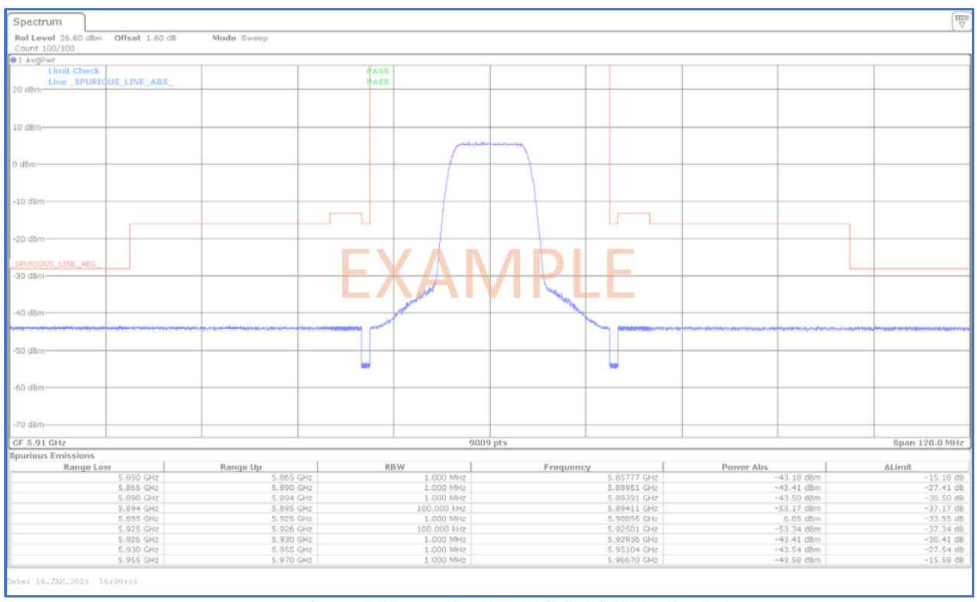


Figure 3. Example of C-V2X OOBE limits plot

g) If this method is used, then the report shall also include an example table from one channel displaying the RBW, VBW, sweep time, number of points, detector, etc. for each range in the emission mask.

Sweep List

	Range 1	Range 2	Range 3	Range 4	Range 5	Range 6	Range 7	Range 8	Range 9
Range Start	5.85 GHz	5.865 GHz	5.89 GHz	5.894 GHz	5.895 GHz	5.925 GHz	5.926 GHz	5.93 GHz	5.955 GHz
Range Stop	5.865 GHz	5.89 GHz	5.894 GHz	5.895 GHz	5.925 GHz	5.926 GHz	5.93 GHz	5.955 GHz	5.97 GHz
Filter Type	Gaussian	Gaussian	Gaussian	Gaussian	Gaussian	Gaussian	Gaussian	Gaussian	Gaussian
RBW	1 MHz	1 MHz	1 MHz	100 kHz	1 MHz	100 kHz	1 MHz	1 MHz	1 MHz
VBW	3 MHz	3 MHz	3 MHz	300 kHz	3 MHz	300 kHz	3 MHz	3 MHz	3 MHz
Sweep Time Mode	Auto	Auto	Auto	Auto	Auto	Auto	Auto	Auto	Auto
Sweep Time	1.01 ms	1.01 ms	1.01 ms	1.01 ms	1.01 ms	1.01 ms	1.01 ms	1.01 ms	1.01 ms
Detector	RMS	RMS	RMS	RMS	RMS	RMS	RMS	RMS	RMS
Ref. Level	26.6 dBm	26.6 dBm	26.6 dBm	26.6 dBm	26.6 dBm	26.6 dBm	26.6 dBm	26.6 dBm	26.6 dBm
RF Att. Mode	Manual	Manual	Manual	Manual	Manual	Manual	Manual	Manual	Manual
RF Attenuator	40 dB	40 dB	40 dB	40 dB	40 dB	40 dB	40 dB	40 dB	40 dB
Preamp	Off	Off	Off	Off	Off	Off	Off	Off	Off
Sweep Points	1001	1001	1001	1001	1001	1001	1001	1001	1001
Stop After Sweep	Off	Off	Off	Off	Off	Off	Off	Off	Off
Transducer	None	None	None	None	None	None	None	None	None
Limit Check	Absolute	Absolute	Absolute	Absolute	Absolute	Absolute	Absolute	Absolute	Absolute
Abs Limit Start	-28 dBm	-16 dBm	-13 dBm	-16 dBm	40 dBm	-16 dBm	-13 dBm	-16 dBm	-28 dBm
Abs Limit Stop	-28 dBm	-16 dBm	-13 dBm	-16 dBm	40 dBm	-16 dBm	-13 dBm	-16 dBm	-28 dBm

Figure 4. Example table of Spectrum Analyzer settings

h) If individual segments are measured, and the pertinent information, RBW, VBW, sweep time, number of points, etc. are displayed on the plot, then there is no need to add an additional sweep list table.

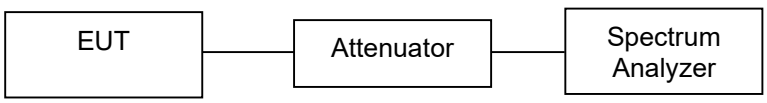
i) For devices with MIMO capabilities, follow the procedures specified in KDB Publication 662911 for summing emissions or adjusting emission levels measured on individual outputs by 10 log (NANT), where NANT is the number of outputs.

j) Testing shall be performed on all potential channel bandwidths and all potential power outputs which the RSU or OBU is capable of transmitting. If the RSU or OBU is capable of carrier aggregation (e.g., transmit a 10 MHz and 20 MHz channel simultaneously) then these combinations shall also be investigated. Care shall be taken to evaluate the impact of intermodulation while additional carriers are active and multiple configurations are possible (e.g., varying resource block configurations for 4G LTE).

k) Measurements shall be performed up to 40 GHz.

l) In addition to conducted measurements, the RSU or OBU shall also be tested for cabinet radiation with the antenna output terminated into a load.

5.3.4 Test setup



5.3.5 Measurement Result

Mode	Frequency [MHz]	Measurement Results [dBm]	Limit [dBm]	Test Results
C-V2X_Ant1	5 915	Note	Note	Compliance
C-V2X_Ant2	5 915	Note	Note	Compliance

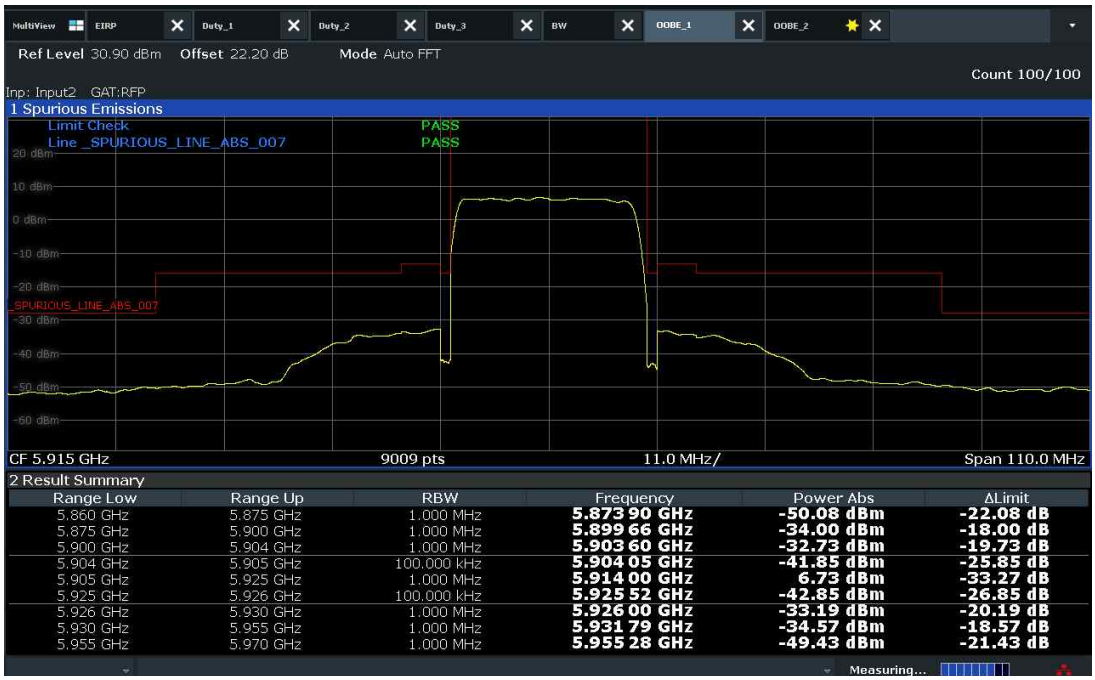
Note:
Refer to following test plots

5.3.6 Test Plot (OOBE)

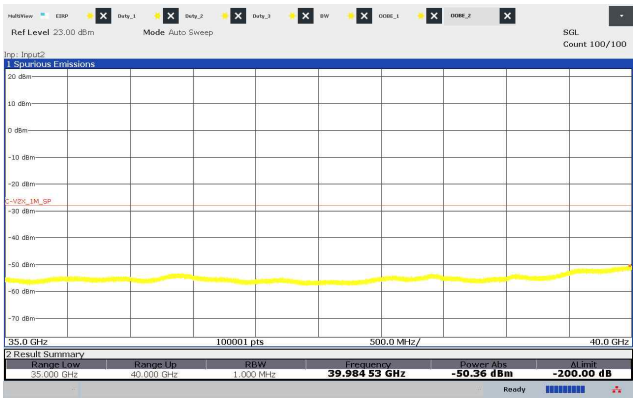
Table of Spectrum Analyzer Settings

	Range 1	Range 2	Range 3	Range 4	Range 5	Range 6	Range 7	Range 8	Range 9
Range Start	5.86 GHz	5.875 GHz	5.9 GHz	5.904 GHz	5.905 GHz	5.925 GHz	5.926 GHz	5.93 GHz	5.955 GHz
Range Stop	5.875 GHz	5.9 GHz	5.904 GHz	5.905 GHz	5.925 GHz	5.926 GHz	5.93 GHz	5.955 GHz	5.97 GHz
Filter Type	Normal(3dB)	Normal(3dB)	Normal(3dB)	Normal(3dB)	Normal(3dB)	Normal(3dB)	Normal(3dB)	Normal(3dB)	Normal(3dB)
RBW	1 MHz	1 MHz	1 MHz	100 kHz	1 MHz	100 kHz	1 MHz	1 MHz	1 MHz
VBW	3 MHz	3 MHz	3 MHz	300 kHz	3 MHz	300 kHz	3 MHz	3 MHz	3 MHz
Sweep Time Mode	Auto	Auto	Auto	Auto	Auto	Auto	Auto	Auto	Auto
Sweep Time	1.01 ms	1.01 ms	1.01 ms	1.01 ms	1.01 ms	1.01 ms	1.01 ms	1.01 ms	1.01 ms
Detector	RMS	RMS	RMS	RMS	RMS	RMS	RMS	RMS	RMS
Ref Level	40 dBm	40 dBm	40 dBm	40 dBm	40 dBm	40 dBm	40 dBm	40 dBm	40 dBm
RF Att Mode	Manual	Manual	Manual	Manual	Manual	Manual	Manual	Manual	Manual
RF Attenuation	20 dB	20 dB	20 dB	20 dB	20 dB	20 dB	20 dB	20 dB	20 dB
Preamp	Off	Off	Off	Off	Off	Off	Off	Off	Off
Sweep Points	1001	1001	1001	1001	1001	1001	1001	1001	1001
Stop After Sweep	Off	Off	Off	Off	Off	Off	Off	Off	Off
Transducer	None	None	None	None	None	None	None	None	None
Limit Check	Absolute	Absolute	Absolute	Absolute	Absolute	Absolute	Absolute	Absolute	Absolute
Abs Limit Start	-28 dBm	-16 dBm	-13 dBm	-16 dBm	40 dBm	-16 dBm	-13 dBm	-16 dBm	-28 dBm
Abs Limit Stop	-28 dBm	-16 dBm	-13 dBm	-16 dBm	40 dBm	-16 dBm	-13 dBm	-16 dBm	-28 dBm

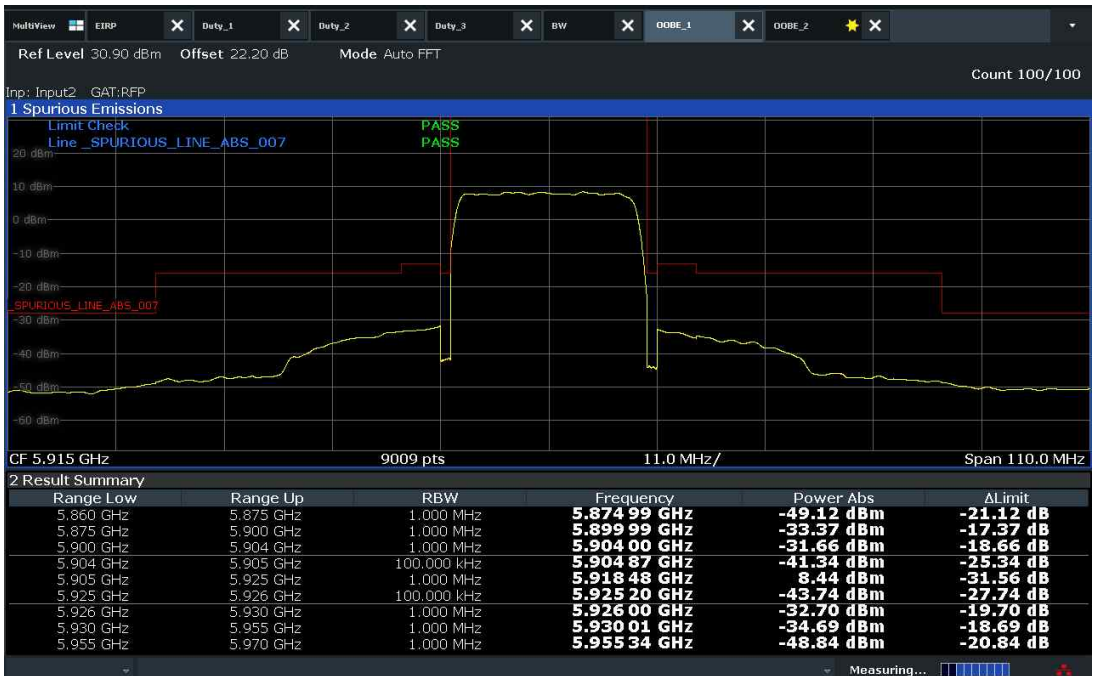
C-V2X OOBE_ANT1



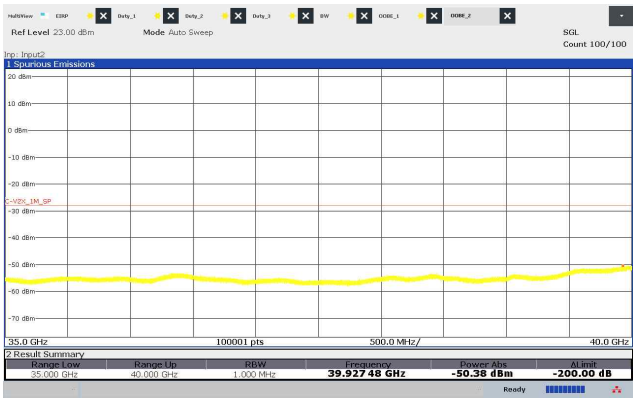
C-V2X OOBE_ANT1



C-V2X OOBE_ANT2



C-V2X OOBE_ANT2



5.4 Transmit Chain Spurious Emissions

5.4.1 Standard Applicable

FCC

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

1. -16 dBm/100 kHz within ± 1 megahertz of the band edges.
2. -13 dBm/MHz within ± 1 megahertz to ± 5 megahertz of the band edges.
3. -16 dBm/MHz within ± 5 megahertz to ± 30 megahertz of the band edges and
4. -28 dBm/MHz beyond 30 megahertz from the band edges.

5.4.2 Test Environment conditions

• Ambient temperature : (20 ~ 21) ℃ • Relative Humidity : (42 ~ 43) % 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.

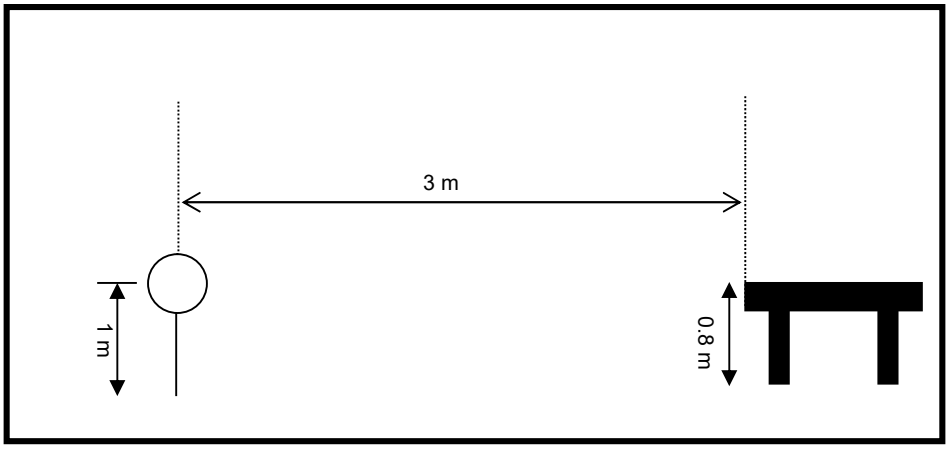
5.4.4 Measurement Uncertainty

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.

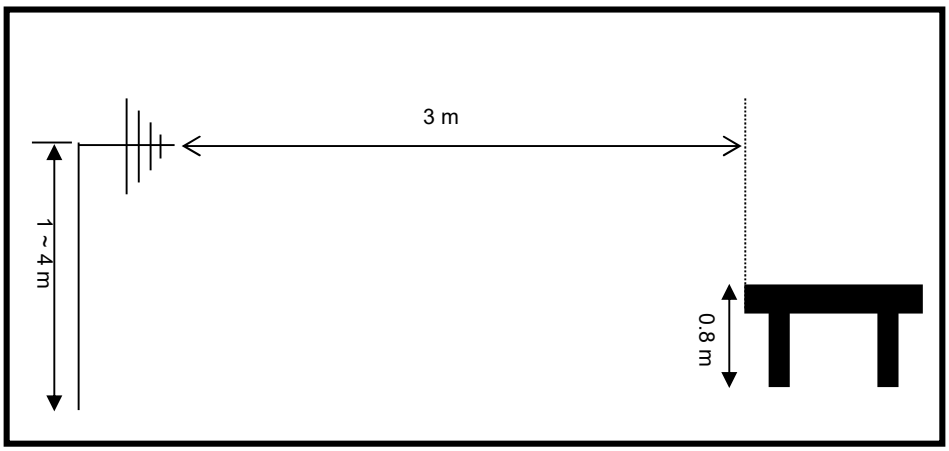
Radiated Emission measurement: Below 1 GHz: 3.88 dB (CL: Approx 95 %, k=2)
Above 1 GHz: 3.04 dB (CL: Approx 95 %, k=2)

5.4.5 Test Configuration

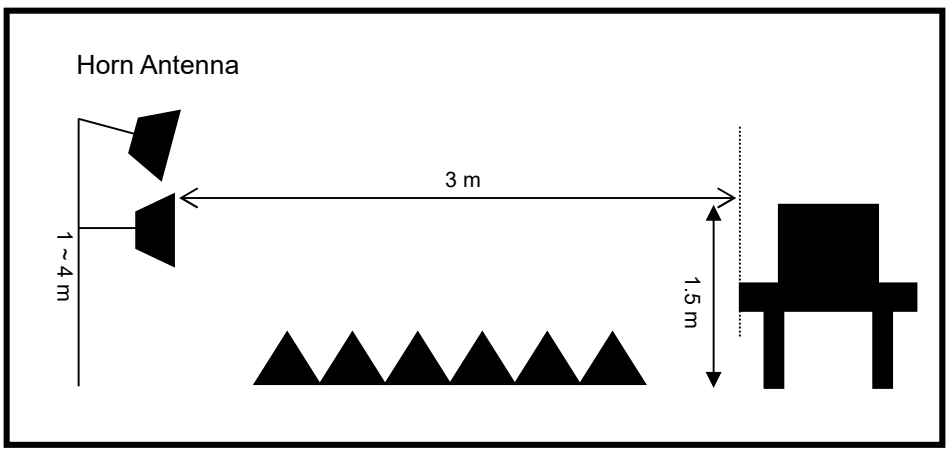
Radiated emission setup, below 30 MHz



Radiated emission setup, below 1 000 MHz



Radiated emission setup, above 1 GHz



5.4.6 Measurement Result

ANT1

Meas. Range (㎓)	Freq. (㎓)	Reading (dB㎶/m)	Antenna			CL (dB)	AMP (dB)	Meas Result (dB㎶/m)	EIRP (dBm)	Limit (dBm)	Mgn. (dB)	Result
		PK	Height (m)	Pol. (H/V)	Fctr. (dB/m)			PK	PK		PK	
0.03 ~ 1.0	0.237	39.62	1-4	H	17.52	2.23	46.43	39.62	-55.58	-28	27.58	Compliance
	0.089	33.08	1-4	V	13.00	1.38	46.53	33.08	-62.12	-28	34.12	Compliance
1.0 ~ 3.0	2.935	39.89	1.5	H	32.67	7.48	45.57	39.89	-55.31	-28	27.31	Compliance
	2.499	40.76	1.5	V	32.50	6.77	45.66	40.76	-54.44	-28	26.44	Compliance
3.0 ~ 7.0	6.365	42.63	1.5	H	35.58	11.78	44.94	42.63	-52.57	-28	24.57	Compliance
	5.671	43.22	1.5	V	34.57	10.96	45.32	43.22	-51.98	-28	23.98	Compliance
7.0 ~ 18.0	17.201	50.78	1.5	H	41.68	19.64	44.46	50.78	-44.42	-28	16.42	Compliance
	17.103	51.58	1.5	V	41.74	19.62	44.66	51.58	-43.62	-28	15.62	Compliance
18.0 ~ 26.0	25.771	54.27	1.5	H	39.28	15.84	48.92	54.27	-40.93	-28	12.93	Compliance
	24.857	54.60	1.5	V	39.13	15.27	49.39	54.60	-40.60	-28	12.60	Compliance
26.0 ~ 40.0	39.897	51.60	1.5	H	46.20	19.14	50.51	51.60	-43.60	-28	15.60	Compliance
	39.554	51.65	1.5	V	46.20	19.05	50.98	51.65	-43.55	-28	15.55	Compliance

※Note

•Freq.(㎒) : Measurement frequency

•Reading(dB㎶/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 (dB㎶/m) :Reading(dB㎶/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 v02, section 3.3

•Mgn(dB) : Limit (dBm) − EIRP(dBm)

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

ANT2

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	
0.03 ~ 1.0	0.245	40.61	1-4	H	17.89	2.27	46.42	40.61	-54.59	-28	26.59	Compliance
	0.087	34.13	1-4	V	12.72	1.36	46.53	34.13	-61.07	-28	33.07	Compliance
1.0 ~ 3.0	2.407	40.50	1.5	H	32.22	6.85	45.67	40.50	-54.70	-28	26.70	Compliance
	2.493	40.29	1.5	V	32.48	6.78	45.66	40.29	-54.91	-28	26.91	Compliance
3.0 ~ 7.0	6.953	43.58	1.5	H	35.69	12.09	44.69	43.58	-51.62	-28	23.62	Compliance
	6.906	43.25	1.5	V	35.68	12.06	44.71	43.25	-51.95	-28	23.95	Compliance
7.0 ~ 18.0	16.910	51.23	1.5	H	41.72	19.53	44.75	51.23	-43.97	-28	15.97	Compliance
	16.878	51.34	1.5	V	41.69	19.51	44.71	51.34	-43.86	-28	15.86	Compliance
18.0 ~ 26.0	25.096	54.55	1.5	H	39.21	15.39	49.25	54.55	-40.65	-28	12.65	Compliance
	25.828	54.81	1.5	V	39.28	15.88	48.89	54.81	-40.39	-28	12.39	Compliance
26.0 ~ 40.0	39.656	51.01	1.5	H	46.20	19.07	50.84	51.01	-44.19	-28	16.19	Compliance
	39.690	51.18	1.5	V	46.20	19.08	50.79	51.18	-44.02	-28	16.02	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 v02, section 3.3

•Mgn(dB) : Limit (dBm) － EIRP(dBm)

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