FCC PART 95L
TEST AND MEASUREMENT REPORT

For

Delphi Electronics & Safety

2151 E. Lincoln Road, M/S C2E, Kokomo, IN 46904, USA

Model: V2X
FCC ID: L2C0064TR

Report Type:	**Product Type:**
Original Report	On-Board unit, 802.11p, with V2X Transceiver Radio

Prepared By:	Jimmy Xiao Test Engineer
Report Number:	R1606151-95
Report Date:	2016-08-16
Reviewed By:	Bo Li RF Lead
	Bay Area Compliance Laboratories Corp. 1274 Anvilwood Avenue, Sunnyvale, CA 94089, USA Tel: (408) 732-9162 Fax: (408) 732-9164

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DOCUMENT REVISION HISTORY

Revision Number	Report Number	Description of Revision	Date of Revision
0	R1606151-95	Original Report	2016-08-16

1 General Description

1.1 Product Description for Equipment Under Test (EUT)

This test and measurement report was prepared on behalf of *Delphi Electronics & Safety* and their product model: *V2X;* FCC ID: L2C0064TR or the "EUT" as referred to in this report. The EUT is On-Board Unit, 802.11p with V2X transceiver radio. The operating frequency is 5860MHz.

1.2 Mechanical Description of EUT

The EUT measures 18cm (L), 13cm (W), 2.5cm (H), and weighs 1.5 kg.

The data gathered are from a production sample provided by the manufacturer, serial number: R1606151-1*, assigned by BACL*

1.3 Objective

This report is prepared on behalf of *Delphi Electronics & safety* in accordance with Part 2, Part 95L. The objective is to determine compliance with FCC Part 95L.

1.4 Related Submittal(s)/Grant(s)

N/A

1.5 Test Methodology

All measurements contained in this report were conducted in accordance with ANSI TIA-603-D and ASTM E2213-03

1.6 Measurement Uncertainty

All measurements involve certain levels of uncertainties, especially in the field of EMC. The factors contributing to uncertainties are spectrum analyzer, cable loss, antenna factor calibration, antenna directivity, antenna factor variation with height, antenna phase center variation, antenna factor frequency interpolation, measurement distance variation, site imperfections, mismatch (average), and system repeatability.

Based on CISPR16-4-2:2011, The Treatment of Uncertainty in EMC Measurements, the values ranging from $\pm$2.0 dB for Conducted Emissions tests and $\pm$4.0 dB for Radiated Emissions tests are the most accurate estimates pertaining to uncertainty of EMC measurements at BACL Corp.

1.7 Test Facility

Bay area compliance Laboratories Corp. (BACL) is:
An independent Commercial Test Laboratory accredited to **ISO 17025: 2005** by **A2LA**, in the fields of: Electromagnetic Compatibility & Telecommunications covering Emissions, Immunity, Radio, RF Exposure, Safety and Telecom. This includes NEBS (Network Equipment Building System), Wireless RF, Telecommunications Terminal Equipment (TTE); Network Equipment; Information Technology Equipment (ITE); Medical Electrical Equipment; Industrial, Commercial, and Medical Test Equipment; Professional Audio and Video Equipment; Electronic (Digital) Products; Industrial and Scientific Instruments; Cabled Distribution Systems and Energy Efficiency Lighting.

2- An ENERGY STAR Recognized Laboratory, for the LM80 Testing, a wide variety of Luminares and Computers.

3- A NIST Designated Phase-I and Phase-II CAB including: ACMA (Australian Communication and Media Authority), BSMI (Bureau of Standards, Metrology and Inspection of Taiwan), IDA (Infocomm Development Authority of Singapore), IC(Industry Canada), Korea (Ministry of Communications Radio Research Laboratory), NCC (Formerly DGT; Directorate General of Telecommunication of Chinese Taipei) OFTA (Office of the Telecommunications Authority of Hong Kong), Vietnam, VCCI – Voluntary Control Council for Interference of Japan and a designated EU CAB (Conformity Assessment Body) (Notified Body) for the EMC and R&TTE Directives.

4- A Product Certification Body accredited to **ISO Guide 65: 1996** by **A2LA** to certify:
1- Unlicensed, Licensed radio frequency devices and Telephone Terminal Equipment for the FCC. Scope A1, A2, A3, A4, B1, B2, B3, B4 & C.
2. Radio Standards Specifications (RSS) in the Category I Equipment Standards List and All Broadcasting Technical Standards (BETS) in Category I Equipment Standards List for Industry Canada.
3. Radio Communication Equipment for Singapore.
4. Radio Equipment Specifications, GMDSS Marine Radio Equipment Specifications, and Fixed Network Equipment Specifications for Hong Kong.
5. Japan MIC Telecommunication Business Law (A1, A2) and Radio Law (B1, B2 and B3).
6. Audio/Video, Battery Charging Systems, Computers, Displays, Enterprise Servers, Imaging Equipment, Set-Top Boxes, Telephony, Televisions, Ceiling Fans, CFLs (Including GU24s),Decorative Light Strings, Integral LED Lamps, Luminaires, Residential Ventilating Fans.

The test site used by BACL Corp. to collect radiated and conducted emissions measurement data is located at its facility in Sunnyvale, California, USA.

The test site at BACL Corp. has been fully described in reports submitted to the Federal Communication Commission (FCC) and Voluntary Control Council for Interference (VCCI). The details of these reports have been found to be in compliance with the requirements of Section 2.948 of the FCC Rules on February 11 and December 10, 1997, and Article 8 of the VCCI regulations on December 25, 1997. The test site also complies with the test methods and procedures set forth in CISPR 22:2008 §10.4 for measurements below 1 GHz and §10.6 for measurements above 1 GHz as well as ANSI C63.4-2009, ANSI C63.4-2009, TIA/EIA-603 & CISPR 24:2010.

The Federal Communications Commission and Voluntary Control Council for Interference have the reports on file and they are listed under FCC registration number: 90464 and VCCI Registration No.: A-0027. The test site has been approved by the FCC and VCCI for public use and is listed in the FCC Public Access Link (PAL) database.

Additionally, BACL Corp. is an American Association for Laboratory Accreditation (A2LA) accredited laboratory (Lab Code 3297-02). The current scope of accreditations can be found at

http://www.a2la.org/scopepdf/3297-02.pdf?CFID=1132286&CFTOKEN=e42a3240dac3f6ba-6DE17DCB-1851-9E57-477422F667031258&jsessionid=8430d44f1f47cf2996124343c704b367816b

2 System Test Configuration

2.1 Justification

The EUT was configured for testing according to TIA-603-D and ASTM E2213-03.

2.2 EUT Exercise Software

Saint Bus Engine 2
Saint Bus Monitor 2

Note: Only channel 172 will be used for this device

2.3 Special Equipment

There were no special accessories were required, included, or intended for use with EUT during these tests.

2.4 Equipment Modifications

No modifications were made to the EUT.

2.5 Local Support Equipment

Manufacturer	Description	Model	Part Number	Calibration Date
Dell	Laptop	Latitude E6410	-	N/A
BK PRECISION	DC Power Supply	E3	N/A	N/A
DELPHI	SAINT 2 Test Box	Version 1.1	N/A	N/A

2.6 EUT Internal Configuration Details

Manufacturer	Description	Model
Delphi	PCB board	28450171A

2.7 Interface Ports and Cables

Cable Description	Length (m)	To	From
RF Cable	<1m	PSA	EUT
USB Cable	1.8m	SAINT 2 Test Box	Laptop

3 Summary of Test Results

Results reported relate only to the product tested.

FCC Rules	Description of Test	Results
FCC §2.1091	RF Exposure	Compliant
FCC §2.1046, §95.639 & ASTM E2213-03 §8.9.1	Output Power	Compliant
FCC §2.1049, §95.633	Emission Bandwidth	Compliant
FCC §95.635 & ASTM E2213-03 §8.9.1	Transmit Spectrum Mask	Compliant
FCC §2.1055 & ASTM E2213-03 §8.9.1	Frequency Stability	Compliant
FCC §2.1051, §95.635 & ASTM E2213-03 §8.9.2	Transmit Spurious Emission-Conducted	Compliant
FCC §95.635, §2.1053 & ASTM E2213-03 §8.9.2	Transmit Spurious Emission-Radiated	Compliant

Note: Only channel 172 will be used for this device

4 FCC §2.1091– RF Exposure

4.1 Applicable Standard

According to FCC §1.1307(b)(1), systems operating under the provisions of this section shall be operated in a manner that ensures that the public is not exposed to radio frequency energy level in excess of the Commission's guidelines.

Limits for General Population/Uncontrolled Exposure

Frequency Range (MHz)	Electric Field Strength (V/m)	Magnetic Field Strength (A/m)	Power Density (mW/cm^2)	Averaging Time (minutes)
Limits for General Population/Uncontrolled Exposure				
0.3-1.34	614	1.63	* (100)	30
1.34-30	824/f	2.19/f	* ($180/f^2$)	30
30-300	27.5	0.073	0.2	30
300-1500	/	/	f/1500	30
1500-100,000	/	/	1.0	30

f = frequency in MHz
* = Plane-wave equivalent power density

4.2 MPE Prediction

Predication of MPE limit at a given distance, Equation from OET Bulletin 65, Edition 97-01

$$S = PG/4\pi R^2$$

Where: S = power density
P = power input to antenna
G = power gain of the antenna in the direction of interest relative to an isotropic radiator
R = distance to the center of radiation of the antenna

4.3 MPE Results

Maximum output power at antenna input terminal (dBm):	19.58
Maximum output power at antenna input terminal (mW):	90.782
Prediction distance (cm):	20
Prediction frequency (MHz):	5860
Maximum Antenna Gain, typical (dBi):	6.4
Maximum Antenna Gain (numeric):	4.365
Power density of prediction frequency at 20 cm (mW/cm^2):	0.079
MPE limit for uncontrolled exposure at prediction frequency (mW/cm^2):	1.0

The device compliances with FCC MPE limit at 20 cm distance.

5 FCC §2.1046, §95.639 & ASTM E 2213-03 §8.9.1 – RF Output Power

5.1 Applicable Standards

FCC §2.1046, §95.639.

According to ASTM E2213-03 §8.9.1, Private OBU operations in Channels 172, 174, 176,178, and 184 shall not exceed 28.8 dBm antenna input power and 33 dBm EIRP. Public safety OBU operations in Channel 172, 174, 176 shall not exceed 28.8 dBm antenna input power and 33 dBm EIRP.

According to ASTM E2213-03 table 9, the Class C device maximum output power should lower than 20dBm

5.2 Test Procedure

TIA-603-D and ASTM E2213-03 8.9.1

5.3 Test Equipment List and Details

Manufacturer	Description	Model No.	Serial No.	Calibration Date	Calibration Interval
Agilent	Analyzer, Spectrum	E4446A	MY48250238	2015-11-12	1 year
-	10dB attenuator	-	-	Each time[1]	N/A
-	SMA Cable	-	#661	Each time[1]	N/A

Statement of Traceability: BACL Corp. *attests that all calibrations have been performed per the A2LA requirements, traceable to the NIST.*

5.4 Test Environmental Conditions

Temperature:	24-26° C
Relative Humidity:	44-46 %
ATM Pressure:	101-102 kPa

The testing was performed by Jimmy Xiao 2016-08-08 at RF site.

5.5 Test Results

Channel	Frequency (MHz)	Conducted Output Power (dBm)	RF Cable Loss (dB)	Output Power @ Antenna (dBm)	Antenna Input Power Limit (dBm)	Antenna Gain (dBi)	E.I.R.P (dBm)	E.I.R.P Limit (dBm)
172	5860	23.32	3.74	19.58	28.8	6.4	25.98	33

Note: the Conducted output power was measured at unit output port, the unit will only use with -3.74dB loss RF cable and 6.4dBi antenna.

6 FCC §2.1049 - Emission Bandwidths

6.1 Applicable Standard

According to FCC §2.1049

6.2 Test Procedure

The transmitter shall be operated at its maximum carrier power measured under normal test conditions. The span of the analyzer shall be set to capture all products of the modulation process, including the emission skirts. The resolution bandwidth shall be set to as close to 1% of the selected span as is possible without being below 1%. The video bandwidth shall be set to 3 times the resolution bandwidth. Video averaging is not permitted. Where practical, a sampling detector shall be used given that a peak or peak hold my produce a wider bandwidth than actual.

The trace data points are recovered and directly summed in linear terms. The recovered amplitude data points, beginning at the lowest frequency, are placed in a running sum until 0.5% of the total is reached and that frequency recorded. The process is repeated for the highest frequency data points. This frequency is recorded. The span between two recorded frequencies is the occupied bandwidth.

6.3 Test Equipment List and Details

Manufacturer	Description	Model No.	Serial No.	Calibration Date	Calibration Interval
Agilent	Analyzer, Spectrum	E4446A	MY48250238	2015-11-12	1 year
-	10dB attenuator	-	-	Each time[1]	N/A
-	SMA Cable	-	#661	Each time[1]	N/A

Statement of Traceability: BACL Corp. *attests that all calibrations have been performed per the A2LA requirements, traceable to the NIST.*

6.4 Test Environmental Conditions

Temperature:	23-25° C
Relative Humidity:	42-46 %
ATM Pressure:	101-102 kPa

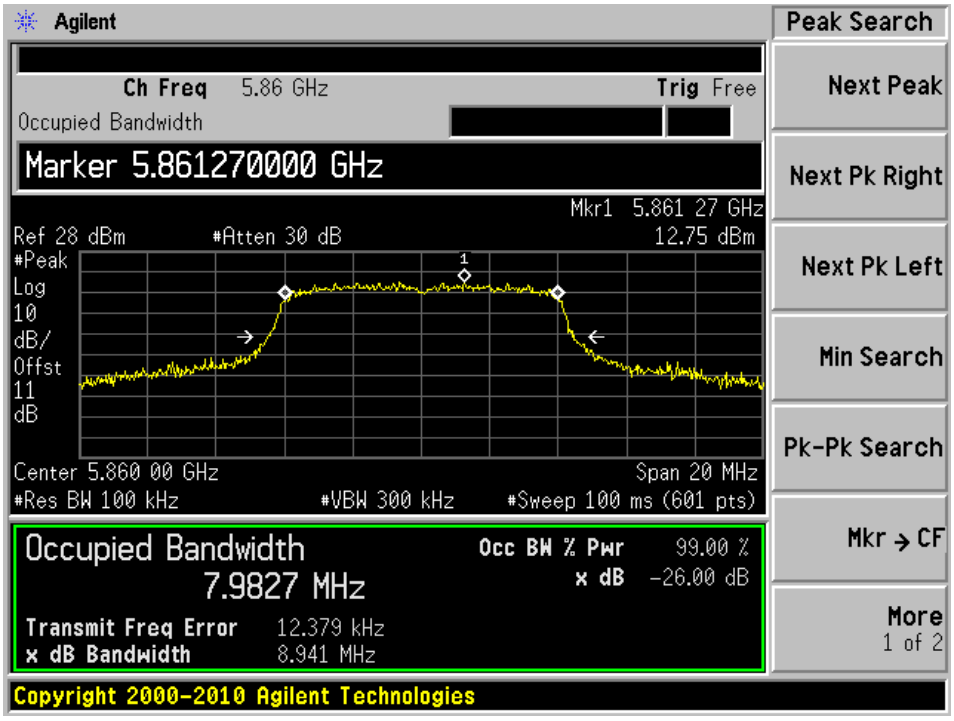
The testing was performed by Jimmy Xiao from 2016-08-08.

6.5 Test Results

Frequency (MHz)	26 dB Emission Bandwidth (MHz)	99% Emission Bandwidth (MHz)
5860	8.941	7.9827

Please refer to the following plot for the test results

5860 MHz



7 FCC §95.635 & ASTM E 2213-03 §8.9.1 – Transmit Spectrum Mask

7.1 Applicable Standards

FCC §95.635, ASTME 2213-03 §8.9.1

TABLE 10 DSRC Spectrum Mask[A]

NOTE—Reduction in Power Spectral Density, dBr.

Class	± 4.5-MHz Offset	± 5.0-MHz Offset	± 5.5-MHz Offset	± 10-MHz Offset	± 15-MHz Offset
Class A	0	-10	-20	-28	-40
Class B	0	-16	-20	-28	-40
Class C	0	-26	-32	-40	-50
Class D	0	-35	-45	-55	-65

[A] From IEEE 802.11a. Copyright 1999 IEEE. All rights reserved.

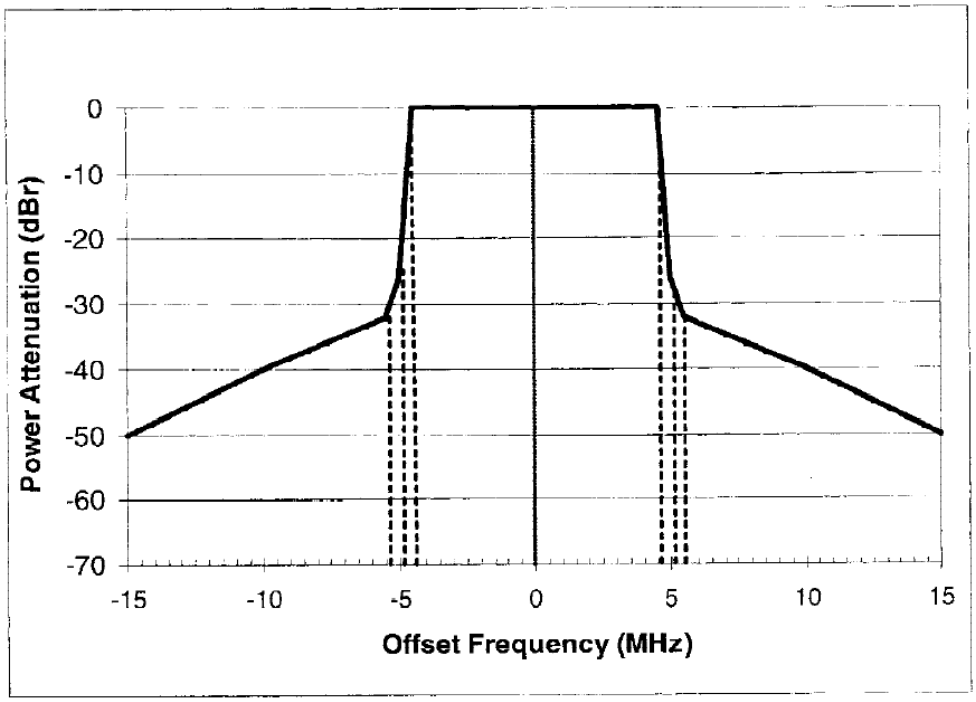


FIG. 14 Class C Transmit Spectrum Mask

7.2 Test Procedure

The DSRC transmitted spectrum mask is relative to the device class of operation. The power in the transmitted spectrum for all DSRC devices shall be −25 dBm or less within 100 kHz outside all channel and band edges. This will be accomplished by attenuating the transmitted signal 100 kHz outside the channel and band edges by 55 + 10log(*P*) dB, where *P* is the total transmitted power in watts. The transmitted spectral density of the transmitted signal for all devices shall fall within the spectral mask, as detailed in Table 10.5 The measurements shall be made using a 100 kHz resolution bandwidth and a 30 kHz video bandwidth.

7.3 Test Equipment List and Details

Manufacturer	Description	Model No.	Serial No.	Calibration Date	Calibration Interval
Agilent	Analyzer, Spectrum	E4446A	MY48250238	2015-11-12	1 year
-	10dB attenuator	-	-	Each time[1]	N/A
-	SMA Cable	-	#661	Each time[1]	N/A

Statement of Traceability: BACL Corp. *attests that all calibrations have been performed per the A2LA requirements, traceable to the NIST.*

7.4 Test Environmental Conditions

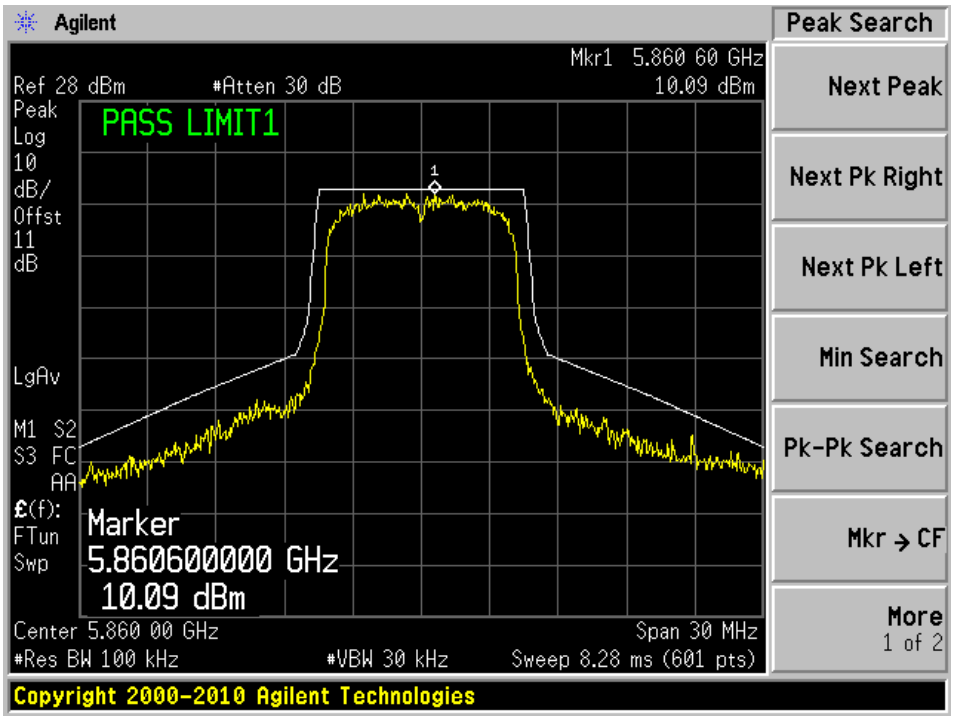
Temperature:	23-25° C
Relative Humidity:	42-46 %
ATM Pressure:	101-102 kPa

The testing was performed by Jimmy Xiao from 2016-08-08.

7.5 Test Results

Please refer to the following plots for the test result

Emission Mask



8 FCC §2.1055 & ASTM E 2213-03 §8.9.4 - Frequency Tolerance

8.1 Applicable Standards

According to FCC §2.1055 and ASTM E2213-03 §8.9.4

8.2 Measurement Procedure

According to ANSI/TIA-D 2010 section 2.2.2, the carrier frequency stability is the ability of the transmitter to maintain an assigned carrier frequency.

The measurement method is as following:

- Operate the equipment in standby conditions for 15 minutes before proceeding.
- Record the carrier frequency of the transmitter as MCF MHz.
- Calculate the ppm frequency error by the following:

  Ppm error = ((MCF/ACF) - 1) * 10^6

  Where

  MCF is the Measured Carrier Frequency in MHz
  ACF is the Assigned Carrier Frequency in MHz

- The value recorded above is the carrier frequency stability.

8.3 Test Equipment List and Details

Manufacturer	Description	Model No.	Serial No.	Calibration Date	Calibration Interval
Agilent	Analyzer, Spectrum	E4446A	MY48250238	2015-11-12	1 year
-	10dB attenuator	-	-	Each time[1]	N/A
-	SMA Cable	-	#661	Each time[1]	N/A
Tenney	Temperature Chamber	TUJR	27445-06	2016-07-09	1 year
BK PRECISION	DC Power Supply	E3	N/A	N/A	N/A
Fluke	Digital Voltmeter	189	N/A	2016-02-05	1 Year

Statement of Traceability: BACL Corp. *attests that all calibrations have been performed per the A2LA requirements, traceable to the NIST.*

8.4 Test Environmental Conditions

Temperature:	22-26° C
Relative Humidity:	42-46 %
ATM Pressure:	101-102 kPa

The testing was performed by Jimmy Xiao from 2016-08-05 at RF site.

8.5 Test Results

Reference Frequency: 5860 MHz

Temperature (°C)	Voltage (V_{DC})	Frequency error		Limit (ppm)
		(kHz)	ppm	
-40	12	5.47	0.93	± 10
-30	12	3.78	0.65	± 10
-20	12	6.42	1.10	± 10
-10	12	5.42	0.92	± 10
0	12	5.08	0.87	± 10
10	12	5.65	0.96	± 10
20	10.8	3.29	0.56	± 10
20	12	11.98	2.04	± 10
20	13.2	14.53	2.48	± 10
30	12	14.20	2.42	± 10
40	12	1.52	0.26	± 10
50	12	5.02	0.86	± 10
60	12	10.67	1.82	± 10
70	12	3.80	0.65	± 10
85	12	6.13	1.05	± 10

Note: The Temperature range was declared by client.

9 FCC §2.1051, §95.635 & ASTM E2213-03 §8.9.2 - Transmit Conducted Spurious Emissions

9.1 Applicable Standard

According to ASTM EN2213-03 §8.9.2.2 The transmitted spectral mask for class A, B, C, and D devices are shown in Figs. 12-15. In addition, all DSRC site installations shall limit the EIRP in the transmitted spectrum to −25 dBm or less in the 100 kHz at the channel edges and the band edges. Additional filtering that supplements the filtering provided by the transmitter may be needed for some antenna/transmitter combinations.

9.2 Measurement Procedure

The DSRC transmitted spectrum mask is relative to the device class of operation. The power in the transmitted spectrum for all DSRC devices shall be −25 dBm or less within 100 kHz outside all channel and band edges. This will be accomplished by attenuating the transmitted signal 100 kHz outside the channel and band edges by 55 + 10log(*P*) dB, where *P* is the total transmitted power in watts. The transmitted spectral density of the transmitted signal for all devices shall fall within the spectral mask, as detailed in Table 10.5 The measurements shall be made using a 100 kHz resolution bandwidth and a 30 kHz video bandwidth.

9.3 Test Equipment List and Details

Manufacturer	Description	Model No.	Serial No.	Calibration Date	Calibration Interval
Agilent	Analyzer, Spectrum	E4446A	MY48250238	2015-11-12	1 year
-	10dB attenuator	-	-	Each time[1]	N/A
-	SMA Cable	-	#661	Each time[1]	N/A

Statement of Traceability: BACL Corp. *attests that all calibrations have been performed per the A2LA requirements, traceable to the NIST.*

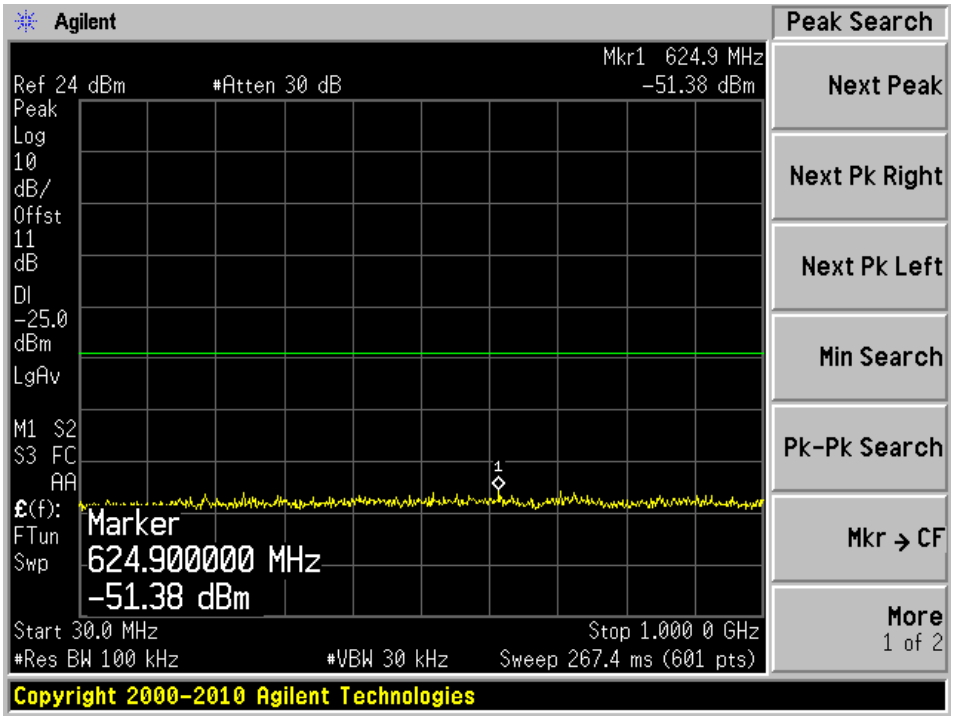
9.4 Test Environmental Conditions

Temperature:	23-25° C
Relative Humidity:	42-46 %
ATM Pressure:	101-102 kPa

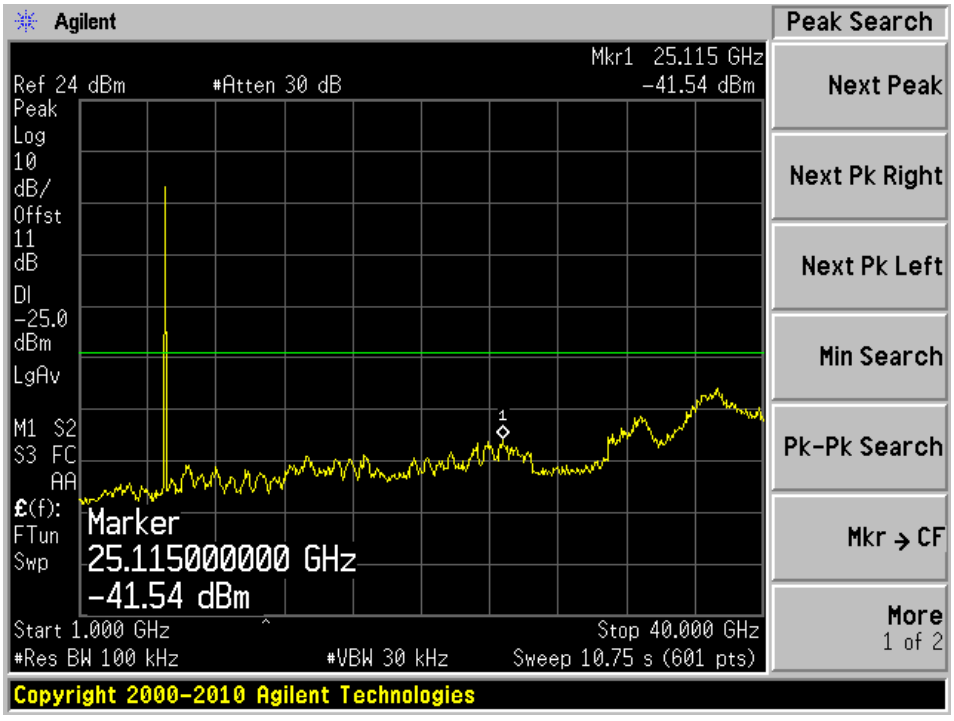
The testing was performed by Jimmy Xiao from 2016-08-08.

9.5 Test Results

30 MHz – 1 GHz



1 GHz – 40 GHz



10 FCC §2.1053 & ASTM E2213-03 §8.9.2 – Field Strength of Spurious Emissions

10.1 Applicable Standard

According to ASTM EN2213-03 §8.9.2.2, the transmitted spectral mask for class A, B, C, and D devices are shown in Figs. 12-15. In addition, all DSRC site installations shall limit the EIRP in the transmitted spectrum to −25 dBm or less in the 100 kHz at the channel edges and the band edges. Additional filtering that supplements the filtering provided by the transmitter may be needed for some antenna/transmitter combinations.

10.2 Measurement Procedure

The DSRC transmitted spectrum mask is relative to the device class of operation. The power in the transmitted spectrum for all DSRC devices shall be −25 dBm or less within 100 kHz outside all channel and band edges. This will be accomplished by attenuating the transmitted signal 100 kHz outside the channel and band edges by $55 + 10\log(P)$ dB, where P is the total transmitted power in watts. The transmitted spectral density of the transmitted signal for all devices shall fall within the spectral mask, as detailed in Table 10.5 The measurements shall be made using a 100 kHz resolution bandwidth and a 30 kHz video bandwidth.

10.3 Test Equipment List and Details

Manufacturer	Description	Model	Serial Number	Calibration Date	Calibration Interval
Agilent	Analyzer, Spectrum	E4440A	US42221851	2016-06-10	1 year
Sunol Science Corp	System Controller	SC99V	122303-1	N/R	N/R
Sunol Sciences	Antenna, Biconi-Log	JB3	A020106-2	2015-07-11	2 Years
Agilent	Amplifier, Pre	8447D	2944A10187	2016-03-20	1 year
HP/ Agilant	Pre Amplifier	8449B OPT HO2	3008A0113	2016-05-19	1year
Sunol Sciences	Antenna, Horn	DRH-118	A052704	2015-03-09	2year
A.R.A.	Antenna, Horn	DRG-118/A	1132	2015-09-21	2 year
HP	Generator, Signal	83650B	3614A00276	2015-08-19	1 year
COM-POWER	Antenna, Dipole	AD-100	721033DB1, 2, 3, 4	2014-11-03	2 year

Statement of Traceability: BACL Corp. *attests that all calibrations have been performed per the A2LA requirements, traceable to the NIST.*

10.4 Test Environmental Conditions

Temperature:	23-26° C
Relative Humidity:	42-46 %
ATM Pressure:	101-102 kPa

The testing was performed by Jimmy Xiao from 2016-08-02.

10.5 Test Results

Freq. (MHz)	S.A. Amp. (dBµV)	Table Azimuth Degrees	Test Antenna		Substitution				Absolute Level (dBm)	FCC	
			Height (m)	Polar (H/ V)	S.G Freq. (MHz)	S.G Level (dBm)	Ant. Gain (dB)	Cable Loss (dB)		Limit (dBm)	Margin (dB)
350	49.37	250	1.8	H	350	-54.80	0	0.21	-55.01	-25	-30.01
350	43.51	147	1.5	V	350	-58.42	0	0.21	-58.63	-25	-33.63
11720	49.45	146	2.1	H	11720	-41.60	11.4	1.84	-32.04	-25	-7.04
11720	49.77	250	2.8	V	11720	-39.76	11.4	1.84	-30.20	-25	-5.20