NORTHWEST EMC

DarCEO Inc.

Drivetrain Health Monitoring System- Sensor

FCC 15.207:2015
FCC 15.247:2015

Report # DARC0001.2

NVLAP Lab Code: 201049-0

CERTIFICATE OF TEST

NORTHWEST EMC
2014-12-10

Last Date of Test: April 24, 2015
DarCEO Inc.
Model: Drivetrain Health Monitoring System- Sensor

Radio Equipment Testing

Standards

Specification	Method
FCC 15.207:2015	ANSI C63.10:2009
FCC 15.247:2015	ANSI C63.10:2009

Results

Method Clause	Test Description	Applied	Results	Comments
6.2	Powerline Conducted Emissions	No	N/A	Not required for a battery powered EUT.
6.5, 6.6	Spurious Radiated Emissions	Yes	Pass	
6.7	Band Edge Compliance	Yes	Pass	
6.7	Spurious Conducted Emissions	Yes	Pass	Radiated Method
6.9.1	Occupied Bandwidth	Yes	Pass	
6.10.2	Output Power	Yes	Pass	
6.11.2	Power Spectral Density	Yes	Pass	
7.5	Duty Cycle	Yes	Pass	

Deviations From Test Standards

None

Approved By:

Jeremiah Darden, Operations Manager

Product compliance is the responsibility of the client; therefore, the tests and equipment modes of operation represented in this report were agreed upon by the client, prior to testing. The results of this test pertain only to the sample(s) tested. The specific description is noted in each of the individual sections of the test report supporting this certificate of test.

REVISION HISTORY

NORTHWEST EMC
REV 2014.10.14

Revision Number	Description	Date	Page Number
00	None		

ACCREDITATIONS AND AUTHORIZATIONS

REV 2015.2.19

United States

FCC - Designated by the FCC as a Telecommunications Certification Body (TCB). Certification chambers, Open Area Test Sites, and conducted measurement facilities are listed with the FCC.

A2LA - Accredited by A2LA to ISO / IEC 17065 as a product certifier. This allows Northwest EMC to certify transmitters to FCC and IC specifications.

NVLAP - Each laboratory is accredited by NVLAP to ISO 17025

Canada

IC - Recognized by Industry Canada as a Certification Body (CB). Certification chambers and Open Area Test Sites are filed with IC.

European Union

European Commission – Validated by the European Commission as a Conformity Assessment Body (CAB) under the EMC directive and as a Notified Body under the R&TTE Directive.

Australia/New Zealand

ACMA - Recognized by ACMA as a CAB for the acceptance of test data.

Korea

MSIP / RRA - Recognized by KCC's RRA as a CAB for the acceptance of test data.

Japan

VCCI - Associate Member of the VCCI. Conducted and radiated measurement facilities are registered.

Taiwan

BSMI – Recognized by BSMI as a CAB for the acceptance of test data.

NCC - Recognized by NCC as a CAB for the acceptance of test data.

Singapore

IDA – Recognized by IDA as a CAB for the acceptance of test data.

Israel

MOC – Recognized by MOC as a CAB for the acceptance of test data.

Hong Kong

OFCA – Recognized by OFCA as a CAB for the acceptance of test data.

Vietnam

MIC – Recognized by MIC as a CAB for the acceptance of test data.

SCOPE

For details on the Scopes of our Accreditations, please visit:
http://www.nwemc.com/accreditations/
http://gsi.nist.gov/global/docs/cabs/designations.html

MEASUREMENT UNCERTAINTY

TMU.2014.12.03

Measurement Uncertainty

When a measurement is made, the result will be different from the true or theoretically correct value. The difference is the result of tolerances in the measurement system that cannot be completely eliminated. To the extent that technology allows us, it has been our aim to minimize this error. Measurement uncertainty is a statistical expression of measurement error qualified by a probability distribution.

A measurement uncertainty estimation has been performed for each test per our internal quality document WP 342. The estimation is used to compare the measured result with its "true" or theoretically correct value. The expanded measurement uncertainty (K=2) for each test is on each data sheet. Our measurement data meets or exceeds the measurement uncertainty requirements of the applicable specification; therefore, the test data can be compared directly to the specification limit to determine compliance. The calculations for estimating measurement uncertainty are based upon ETSI TR 100 028 (or CISPR 16-4-2 as applicable), and are available upon request.

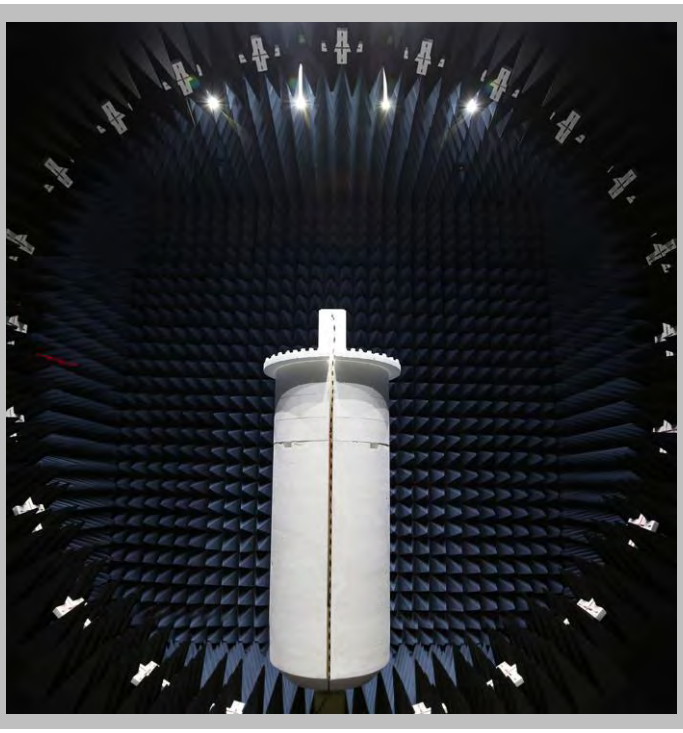
The following table represents the Measurement Uncertainty (MU) budgets for each of the tests that may be contained in this report.

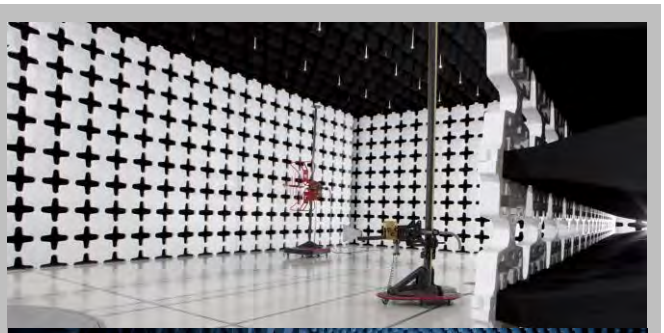
Test	+ MU	- MU
Frequency Accuracy (Hz)	0.0007%	-0.0007%
Amplitude Accuracy (dB)	1.2 dB	-1.2 dB
Conducted Power (dB)	0.3 dB	-0.3 dB
Radiated Power via Substitution (dB)	0.7 dB	-0.7 dB
Temperature (degrees C)	0.7°C	-0.7°C
Humidity (% RH)	2.5% RH	-2.5% RH
Voltage (AC)	1.0%	-1.0%
Voltage (DC)	0.7%	-0.7%
Field Strength (dB)	4.7 dB	-4.7 dB
AC Powerline Conducted Emissions (dB)	2.9 dB	-2.9 dB

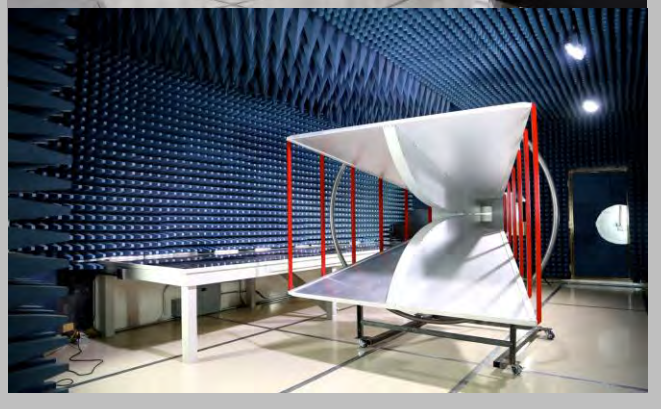
FACILITIES

NORTHWEST EMC
REV 2015.2.19

California	Minnesota	New York	Oregon	Texas	Washington
Labs OC01-13 41 Tesla Irvine, CA 92618 (949) 861-8918	Labs MN01-08, MN10 9349 W Broadway Ave. Brooklyn Park, MN 55445 (612)-638-5136	Labs NY01-04 4939 Jordan Rd. Elbridge, NY 13060 (315) 554-8214	Labs EV01-12 22975 NW Evergreen Pkwy Hillsboro, OR 97124 (503) 844-4066	Labs TX01-09 3801 E Plano Pkwy Plano, TX 75074 (469) 304-5255	Labs NC01-05 19201 120th Ave NE Bothell, WA 9801 (425)984-6600
NVLAP					
NVLAP Lab Code: 200676-0	NVLAP Lab Code: 200881-0	NVLAP Lab Code: 200761-0	NVLAP Lab Code: 200630-0	NVLAP Lab Code:201049-0	NVLAP Lab Code: 200629-0
Industry Canada					
2834B-1, 2834B-3	2834E-1	N/A	2834D-1, 2834D-*2*	2834G-1	2834F-1
BSMI					
SL2-IN-E-1154R	SL2-IN-E-1152R	N/A	SL2-IN-E-1017	SL2-IN-E-1158R	SL2-IN-E-1153R
VCCI					
A-0029	A-0109	N/A	A-0108	A-0201	A-0110
Recognized Phase I CAB for ACMA, BSMI, IDA, KCC/RRA, MIC, MOC, NCC, OFCA					
US0158	US0175	N/A	US0017	US0191	US0157







PRODUCT DESCRIPTION

NORTHWEST EMC 2014-12-10

Client and Equipment Under Test (EUT) Information

Company Name:	DarCEO Inc.
Address:	1675 Samco Road
City, State, Zip:	Rapid City, SD 57702
Test Requested By:	Brian Hemmelman
Model:	Drivetrain Health Monitoring System- Sensor
First Date of Test:	April 21, 2015
Last Date of Test:	April 24, 2015
Receipt Date of Samples:	April 21, 2015
Equipment Design Stage:	Prototype
Equipment Condition:	No Damage

Information Provided by the Party Requesting the Test

Functional Description of the EUT:
The sensor takes capacitance, temperature, accelerometer, etc. data readings periodically and communicates them to the gateway if it is in range. An operator can also get in close proximity to the sensor and trigger readings from it with a handheld RFID unit. The units are designed to go on locomotives. RFID in the sensor is passive.

Testing Objective:
To demonstrate compliance of the 2.4 GHz ISM radios in the Sensor and the Gateway to FCC 15.247 requirements.

CONFIGURATIONS

NORTHWEST EMC 2014-12-10

Configuration DARC0001- 1

Software/Firmware Running during test	
Description	**Version**
DHMS UHF Sensor Configuration	1.0.8.0

EUT			
Description	**Manufacturer**	**Model/Part Number**	**Serial Number**
Sensor 1	GE	84A234628G1	201512001
Sensor 2	GE	84A234628G1	201512006
Sensor 3	GE	84A234628G1	201512008

Peripherals in test setup boundary			
Description	**Manufacturer**	**Model/Part Number**	**Serial Number**
Gateway	GE	84A237140P1	211504015

Remote Equipment Outside of Test Setup Boundary			
Description	**Manufacturer**	**Model/Part Number**	**Serial Number**
RFID Reader	Thing Magic	Vega Reader	540-0012-01 05
Antenna for RFID Reader	MTI Wireless	MT-262024/TRH/A/K	100769

Cables					
Cable Type	**Shield**	**Length (m)**	**Ferrite**	**Connection 1**	**Connection 2**
BNC Coaxial Cable	Yes	1.2m	No	DC Power	Gateway

Configuration DARC0001- 2

Software/Firmware Running during test	
Description	**Version**
DHMS UHF Sensor Configuration	1.0.8.0

EUT			
Description	**Manufacturer**	**Model/Part Number**	**Serial Number**
Sensor 1	GE	84A234628G1	201512001
Sensor 2	GE	84A234628G1	201512006
Sensor 3	GE	84A234628G1	201512008

CONFIGURATIONS

NORTHWEST EMC 2014-12-10

Configuration DARC0001- 6

Software/Firmware Running during test	
Description	**Version**
DHMS UHF Sensor Configuration	1.0.8.0

EUT			
Description	**Manufacturer**	**Model/Part Number**	**Serial Number**
Sensor 4	GE	84A234628G1	2015150066

MODIFICATIONS

NORTHWEST EMC 2014-12-10

Equipment Modifications

Item	Date	Test	Modification	Note	Disposition of EUT
1	4/21/2015	Output Power	Tested as delivered to Test Station.	No EMI suppression devices were added or modified during this test.	EUT remained at Northwest EMC following the test.
2	4/21/2015	Duty Cycle	Tested as delivered to Test Station.	No EMI suppression devices were added or modified during this test.	EUT remained at Northwest EMC following the test.
3	4/22/2015	Occupied Bandwidth	Tested as delivered to Test Station.	No EMI suppression devices were added or modified during this test.	EUT remained at Northwest EMC following the test.
4	4/22/2015	Band Edge Compliance	Tested as delivered to Test Station.	No EMI suppression devices were added or modified during this test.	EUT remained at Northwest EMC following the test.
5	4/22/2015	Power Spectral Density	Tested as delivered to Test Station.	No EMI suppression devices were added or modified during this test.	EUT remained at Northwest EMC following the test.
6	4/24/2015	Spurious Conducted Emissions	Tested as delivered to Test Station.	No EMI suppression devices were added or modified during this test.	EUT remained at Northwest EMC following the test.
7	4/24/2015	Spurious Radiated Emissions	Tested as delivered to Test Station.	No EMI suppression devices were added or modified during this test.	Scheduled testing was completed.

SPURIOUS RADIATED EMISSIONS

Testing was performed using the mode(s) of operation and configuration(s) noted within the report. The individuals and/or the organization requesting the test provided the modes, configurations and settings used to complete the evaluation. The actual test parameters are specified in the test data, this includes items such as investigated frequency range (scanned) and test levels. The testing methods and performance specifications, as well as the test site used for the evaluation are indicated in the test data. The test data represents the configuration / operating mode/ model that produced the highest emission levels as compared to the specification limit.

MODES OF OPERATION

Transmitting OQPSK at High Channel @ 2480.078 MHz.
Transmitting OQPSK at Mid Channel @ 2450.195 MHz.
Transmitting OQPSK at Low Channel @ 2424.7 MHz.

POWER SETTINGS INVESTIGATED

Battery

CONFIGURATIONS INVESTIGATED

DARC0001 - 6

FREQUENCY RANGE INVESTIGATED

Start Frequency	30 MHz	Stop Frequency	26000 MHz

SAMPLE CALCULATIONS

Radiated Emissions: Field Strength = Measured Level + Antenna Factor + Cable Factor - Amplifier Gain + Distance Adjustment Factor + External Attenuation

TEST EQUIPMENT

Description	Manufacturer	Model	ID	Last Cal.	Interval
Spectrum Analyzer	Agilent	N9010A	AFL	6/20/2014	12 mo
Antenna, Biconilog	ETS Lindgren	3143B	AYF	4/7/2014	24 mo
Attenuator, 20dB, 40 GHz	Fairview Microwave	SA4018-20	TQY	2/27/2015	12 mo
TX02 Cable	Northwest EMC	RE 9kHz - 1GHz	TXB	9/22/2014	12 mo
Pre-Amplifier	Miteq	AM-1551	PAH	9/13/2014	12 mo
Antenna, Horn	ETS Lindgren	3115	AJL	9/15/2014	24 mo
TX02 Cable	Northwest EMC	1-8.2 GHz	TXC	9/22/2014	12 mo
Pre-Amplifier	Miteq	AMF-3D-00100800-32-13P	PAJ	9/22/2014	12 mo
Antenna, Horn	ETS Lindgren	3160-07	AJF	NCR	0 mo
Antenna, Horn	ETS Lindgren	3160-08	AJG	NCR	0 mo
Antenna, Double Ridge Guide Horn	A.H. Systems, Inc.	SAS-574	AXW	4/23/2014	24 mo
Cable	Northwest EMC	18-40GHz	TXE	11/21/2014	12 mo
Pre-Amplifier	Miteq	JSDQK42-18004000-60-5P	PAM	11/21/2014	12 mo
TX02 Cable	Northwest EMC	8-18GHz	TXD	10/27/2014	12 mo
Pre-Amplifier	Miteq	AMF-6F-12001800-30-10P	PAL	10/27/2014	12 mo
Pre-Amplifier	Miteq	AMF-6F-08001200-30-10P	PAK	10/27/2014	12 mo
Low Pass Filter, 0 - 1000 MHz	Micro-Tronics	LPM50004	HHV	8/18/2014	12 mo
High Pass Filter, 2.8 - 18 GHz	Micro-Tronics	HPM50111	HHX	8/18/2014	12 mo

MEASUREMENT BANDWIDTHS

Frequency Range (MHz)	Peak Data (kHz)	Quasi-Peak Data (kHz)	Average Data (kHz)
0.01 - 0.15	1.0	0.2	0.2
0.15 - 30.0	10.0	9.0	9.0
30.0 - 1000	100.0	120.0	120.0
Above 1000	1000.0	N/A	1000.0

TEST DESCRIPTION

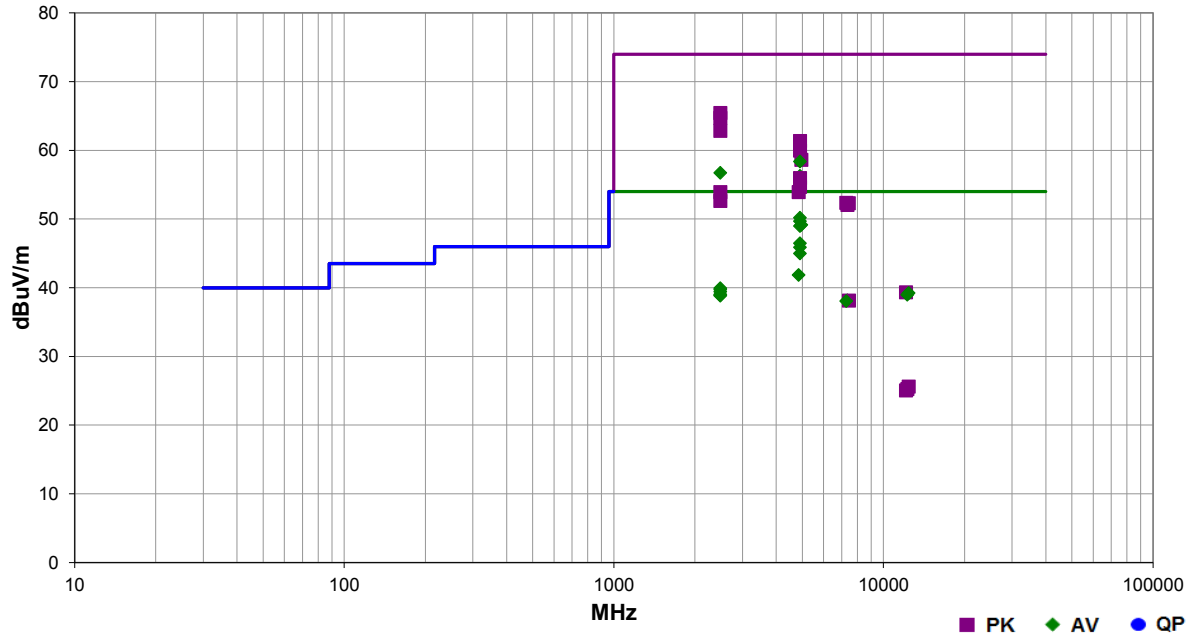
The highest gain of each type of antenna to be used with the EUT was tested. The EUT was configured for low, mid, and high ba nd transmit frequencies. For each configuration, the spectrum was scanned throughout the specified range. In addition, measurem ents were made in the restricted bands to verify compliance. While scanning, emissions from the EUT were maximized by rotating th e EUT on a turntable, adjusting the position of the EUT and the EUT antenna in three orthogonal axis, and adjusting measurement antenna height and polarization. A preamp and high pass filter were used for this test in order to provide sufficient measure ment sensitivity.

SPURIOUS RADIATED EMISSIONS

Work Order:	DARC0001	**Date:**	04/24/15		
Project:	None	**Temperature:**	24.1 °C		
Job Site:	TX02	**Humidity:**	50.5% RH		
Serial Number:	2015150066	**Barometric Pres.:**	1015 mbar	**Tested by:**	Jonathan Kiefer
EUT:	Drivetrain Health Monitoring System- Sensor				
Configuration:	6				
Customer:	DarCEO Inc.				
Attendees:	Brian Hemmelman				
EUT Power:	Battery				
Operating Mode:	Transmitting OQPSK at Low, Mid, High Channel @ 2424.7, 2450.195, 2480.078 MHz				
Deviations:	None				
Comments:	Firmware was updated so one unit could operate at all three channels				

Test Specifications	**Test Method**
FCC 15.247:2015	ANSI C63.10:2009

Run #	51	**Test Distance (m)**	3	**Antenna Height(s)**	1 to 4(m)	**Results**	Pass



Freq (MHz)	Amplitude (dBuV)	Factor (dB)	Antenna Height (meters)	Azimuth (degrees)	Test Distance (meters)	External Attenuation (dB)	Polarity/ Transducer Type	Detector	Distance Adjustment (dB)	Adjusted (dBuV/m)	Spec. Limit (dBuV/m)	Compared to Spec. (dB)	Comments
4900.035	42.1	8.1	3.0	270.0	3.0	0.0	Vert	AV	0.0	50.2	54.0	-3.8	Mid Ch, EUT Horizontal
4899.578	41.6	8.1	1.0	0.0	3.0	0.0	Horz	AV	0.0	49.7	54.0	-4.3	Mid Ch, EUT Vertical
4959.873	40.9	8.2	2.5	0.0	3.0	0.0	Vert	AV	0.0	49.1	54.0	-4.9	High Ch, EUT Horizontal
4899.865	40.9	8.1	3.0	315.0	3.0	0.0	Vert	AV	0.0	49.0	54.0	-5.0	Mid Ch, EUT Vertical
4900.092	38.4	8.1	1.5	90.0	3.0	0.0	Horz	AV	0.0	46.5	54.0	-7.5	Mid Ch, EUT On Side
4899.617	37.8	8.1	2.5	135.0	3.0	0.0	Vert	AV	0.0	45.9	54.0	-8.1	Mid Ch, EUT On Side
2483.500	60.1	-4.7	1.0	309.9	3.0	10.0	Horz	PK	0.0	65.4	74.0	-8.6	High Ch, EUT Vertical
4900.115	36.9	8.1	3.0	270.0	3.0	0.0	Horz	AV	0.0	45.0	54.0	-9.0	Mid Ch, EUT Horizontal
2483.500	59.4	-4.7	1.0	15.9	3.0	10.0	Vert	PK	0.0	64.7	74.0	-9.3	High Ch, EUT Horizontal
2483.500	57.5	-4.7	1.0	296.0	3.0	10.0	Vert	PK	0.0	62.8	74.0	-11.2	High Ch, EUT Vertical
4849.355	33.9	7.9	2.0	0.0	3.0	0.0	Vert	AV	0.0	41.8	54.0	-12.2	Low Ch, EUT Horizontal
4900.013	53.3	8.1	1.0	0.0	3.0	0.0	Horz	PK	0.0	61.4	74.0	-12.6	Mid Ch, EUT Vertical
4899.943	51.9	8.1	3.0	270.0	3.0	0.0	Vert	PK	0.0	60.0	74.0	-14.0	Mid Ch, EUT Horizontal
2483.500	34.6	-4.7	1.0	296.0	3.0	10.0	Vert	AV	0.0	39.9	54.0	-14.1	High Ch, EUT Vertical
2483.500	34.4	-4.7	1.0	309.9	3.0	10.0	Horz	AV	0.0	39.7	54.0	-14.3	High Ch, EUT Vertical
2483.500	34.1	-4.7	1.0	15.9	3.0	10.0	Vert	AV	0.0	39.4	54.0	-14.6	High Ch, EUT Horizontal
2483.500	33.7	-4.7	1.0	105.9	3.0	10.0	Horz	AV	0.0	39.0	54.0	-15.0	High Ch, EUT Horizontal
2483.500	33.6	-4.7	1.0	255.9	3.0	10.0	Horz	AV	0.0	38.9	54.0	-15.1	High Ch, EUT On Side
2483.500	33.5	-4.7	1.0	243.0	3.0	10.0	Vert	AV	0.0	38.8	54.0	-15.2	High Ch, EUT On Side
4959.883	50.4	8.2	2.5	0.0	3.0	0.0	Vert	PK	0.0	58.6	74.0	-15.4	High Ch, EUT Horizontal
4899.915	50.3	8.1	3.0	315.0	3.0	0.0	Vert	PK	0.0	58.4	74.0	-15.6	Mid Ch, EUT Vertical
7351.420	24.8	13.4	1.0	360.0	3.0	0.0	Vert	AV	0.0	38.2	54.0	-15.8	Mid Ch, EUT Horizontal

Freq (MHz)	Amplitude (dBuV)	Factor (dB)	Antenna Height (meters)	Azimuth (degrees)	Test Distance (meters)	External Attenuation (dB)	Polarity/ Transducer Type	Detector	Distance Adjustment (dB)	Adjusted (dBuV/m)	Spec. Limit (dBuV/m)	Compared to Spec. (dB)	Comments
7442.300	24.7	13.4	1.0	279.9	3.0	0.0	Vert	AV	0.0	38.1	54.0	-15.9	High Ch, EUT Horizontal
7274.437	24.7	13.3	3.5	180.0	3.0	0.0	Vert	AV	0.0	38.0	54.0	-16.0	Low Ch, EUT Horizontal
2483.500	51.4	-4.7	1.0	255.9	3.0	10.0	Horz	PK	0.0	56.7	74.0	-17.3	High Ch, EUT On Side
4899.872	48.2	8.1	2.5	135.0	3.0	0.0	Vert	PK	0.0	56.3	74.0	-17.7	Mid Ch, EUT On Side
4899.985	47.9	8.1	1.5	90.0	3.0	0.0	Horz	PK	0.0	56.0	74.0	-18.0	Mid Ch, EUT On Side
4899.938	46.6	8.1	3.0	270.0	3.0	0.0	Horz	PK	0.0	54.7	74.0	-19.3	Mid Ch, EUT Horizontal
4849.272	46.0	7.9	2.0	0.0	3.0	0.0	Vert	PK	0.0	53.9	74.0	-20.1	Low Ch, EUT Horizontal
2483.500	48.6	-4.7	1.0	105.9	3.0	10.0	Horz	PK	0.0	53.9	74.0	-20.1	High Ch, EUT Horizontal
2483.690	47.3	-4.7	1.0	243.0	3.0	10.0	Vert	PK	0.0	52.6	74.0	-21.4	High Ch, EUT On Side
7273.577	39.0	13.3	3.5	180.0	3.0	0.0	Vert	PK	0.0	52.3	74.0	-21.7	Low Ch, EUT Horizontal
7437.750	38.9	13.4	1.0	279.9	3.0	0.0	Vert	PK	0.0	52.3	74.0	-21.7	High Ch, EUT Horizontal
7351.113	38.7	13.4	1.0	360.0	3.0	0.0	Vert	PK	0.0	52.1	74.0	-21.9	Mid Ch, EUT Horizontal
12399.500	26.0	-0.4	1.0	93.0	3.0	0.0	Vert	AV	0.0	25.6	54.0	-28.4	High Ch, EUT Horizontal
12251.630	26.0	-0.7	1.0	211.0	3.0	0.0	Horz	AV	0.0	25.3	54.0	-28.7	Mid Ch, EUT Vertical
12125.250	26.0	-1.0	1.0	145.0	3.0	0.0	Vert	AV	0.0	25.0	54.0	-29.0	Low Ch, EUT Horizontal
12122.930	40.3	-1.0	1.0	145.0	3.0	0.0	Vert	PK	0.0	39.3	74.0	-34.7	Low Ch, EUT Horizontal
12399.720	39.6	-0.4	1.0	93.0	3.0	0.0	Vert	PK	0.0	39.2	74.0	-34.8	High Ch, EUT Horizontal
12251.290	39.7	-0.7	1.0	211.0	3.0	0.0	Horz	PK	0.0	39.0	74.0	-35.0	Mid Ch, EUT Vertical

BAND EDGE COMPLIANCE

XMit 2015.01.14

Testing was performed using the mode(s) of operation and configuration(s) noted within the report. The individuals and/or the organization requesting the test provided the modes, configurations and settings used to complete the evaluation. The actual test parameters are specified in the test data, this includes items such as investigated frequency range (scanned) and test levels. The testing methods and performance specifications, as well as the test site used for the evaluation are indicated in the test data.

TEST EQUIPMENT

Description	Manufacturer	Model	ID	Last Cal.	Interval (mos)
Spectrum Analyzer	Agilent	E4440A	AFD	7/14/2014	12
Near Field Probe	ETS Lindgren	7405	IPS	NCR	0

TEST DESCRIPTION

The spurious RF conducted emissions at the edges of the authorized bands were measured with the EUT set to low and high transmit frequencies in each available band. The channels closest to the band edges were selected. The measurement was made using a radiated method via a near field probe. A reference level offset was used in the analyzer to match the actual radiated EIRP level. The EUT was transmitting at the data rate(s) listed in the datasheet.

The spectrum was scanned below the lower band edge and above the higher band edge.

BAND EDGE COMPLIANCE

NORTHWEST EMC

XMit 2015.01.14

EUT:	Drivetrain Health Monitoring System-Sensor			**Work Order:**	DARC0001
Serial Number:	201512001, 201512006, 201512008			**Date:**	04/22/15
Customer:	DarCEO, Inc.			**Temperature:**	24.0°C
Attendees:	Brian Hemmelman			**Humidity:**	44%
Project:	None			**Barometric Pres.:**	1013 mbar
Tested by:	Jonathan Kiefer	**Power:**	Battery	**Job Site:**	TX09

TEST SPECIFICATIONS	Test Method
FCC 15.247:2015	ANSI C63.10:2009

COMMENTS

Transmitting OQPSK at Low, High Channel @ 2424.7, 2480.078 MHz. The unit was not able to be reconfigured to different channels. Therefore, 2 electrically identical units were tested at Low and High Channel.

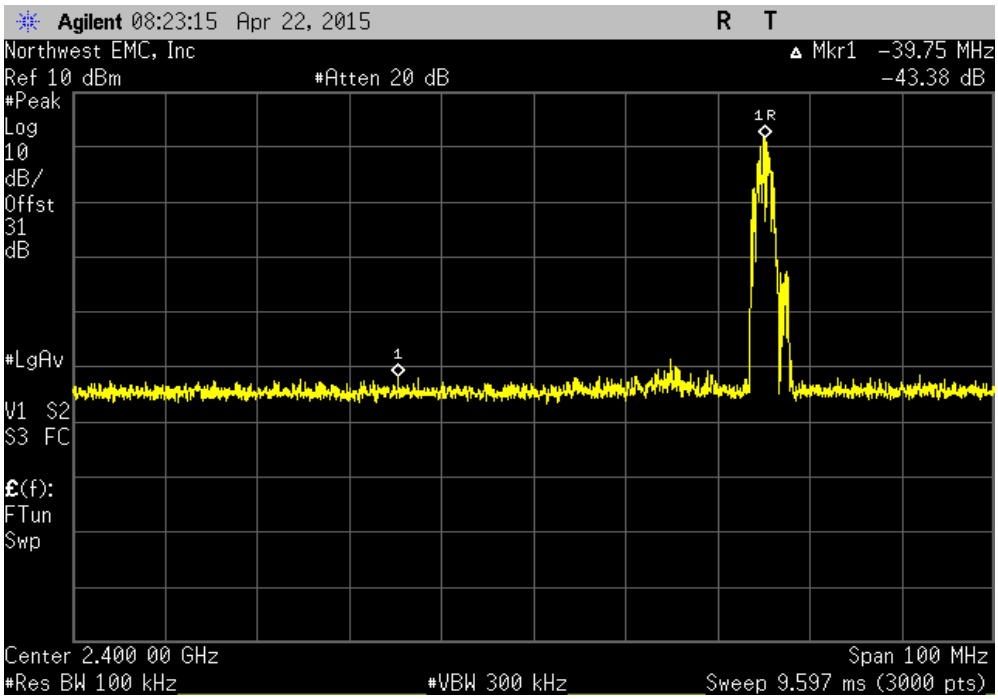
DEVIATIONS FROM TEST STANDARD

None

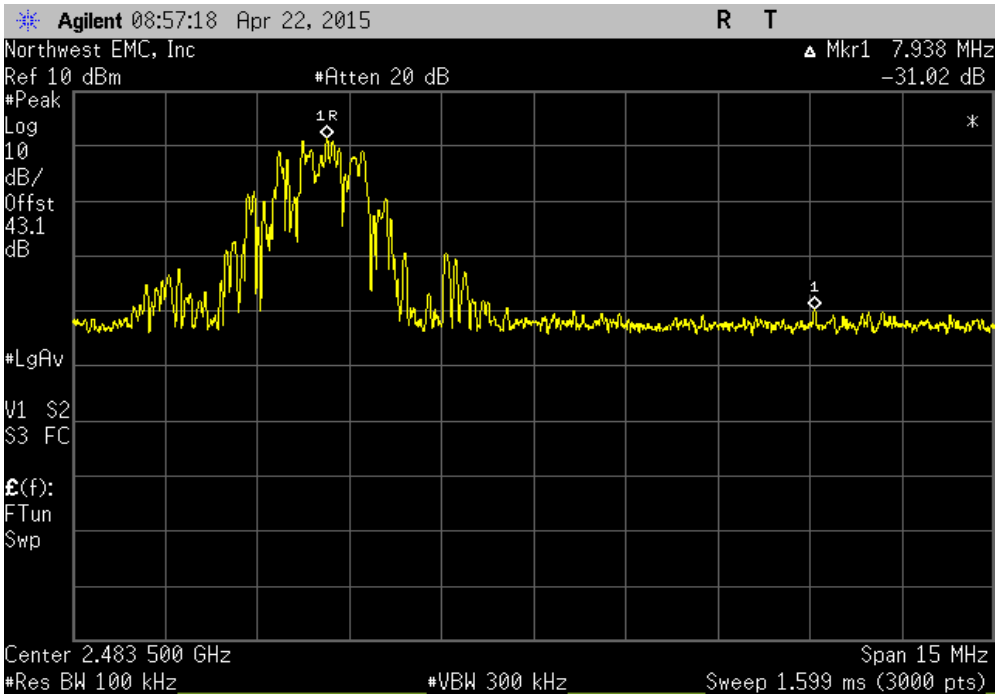
Configuration #	2	Signature

	Value (dBc)	Limit ≤ (dBc)	Result
OQPSK			
Low Channel, 2424.7 MHz	-43.38	-20	Pass
High Channel, 2480.078 MHz	-31.02	-20	Pass

OQPSK, Low Channel, 2424.7 MHz						
				Value (dBc)	Limit ≤ (dBc)	Result
				-43.38	-20	Pass



OQPSK, High Channel, 2480.078 MHz						
				Value (dBc)	Limit ≤ (dBc)	Result
				-31.02	-20	Pass



OCCUPIED BANDWIDTH

NORTHWEST EMC

XMit 2015.01.14

Testing was performed using the mode(s) of operation and configuration(s) noted within the report. The individuals and/or the organization requesting the test provided the modes, configurations and settings used to complete the evaluation. The actual test parameters are specified in the test data, this includes items such as investigated frequency range (scanned) and test levels. The testing methods and performance specifications, as well as the test site used for the evaluation are indicated in the test data.

TEST EQUIPMENT

Description	Manufacturer	Model	ID	Last Cal.	Interval (mos)
Spectrum Analyzer	Agilent	E4440A	AFD	7/14/2014	12
Near Field Probe	ETS Lindgren	7405	IPS	NCR	0

TEST DESCRIPTION

The 6dB occupied bandwidth was measured using 100 kHz resolution bandwidth and 300 kHz video bandwidth.

The EUT was set to the channels and modes listed in the datasheet. The measurement was made using a radiated method via a near field probe. A reference level offset was used in the analyzer to match the actual radiated EIRP level.

OCCUPIED BANDWIDTH

NORTHWEST EMC

XMit 2015.01.14

EUT:	Drivetrain Health Monitoring System-Sensor			Work Order:	DARC0001
Serial Number:	201512001, 201512006, 201512008			Date:	04/22/15
Customer:	DarCEO Inc.			Temperature:	24.0°C
Attendees:	Brian Hemmelman			Humidity:	44%
Project:	None			Barometric Pres.:	1013 mbar
Tested by:	Jonathan Kiefer	Power:	Battery	Job Site:	TX09

TEST SPECIFICATIONS	Test Method
FCC 15.247:2015	ANSI C63.10:2009

COMMENTS

Transmitting OQPSK at Low, Mid, High Channel @ 2424.7, 2450.195, 2480.078 MHz. The unit was not able to be reconfigured to different channels. Therefore, 3 electrically identical units were tested at Low, Mid, and High Channels.

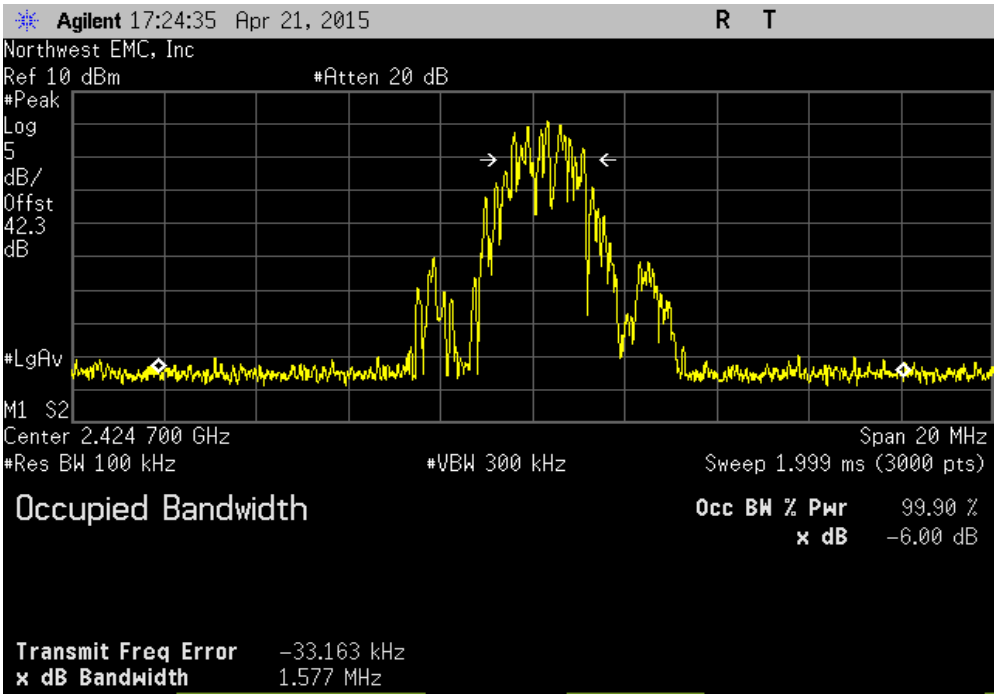
DEVIATIONS FROM TEST STANDARD

None

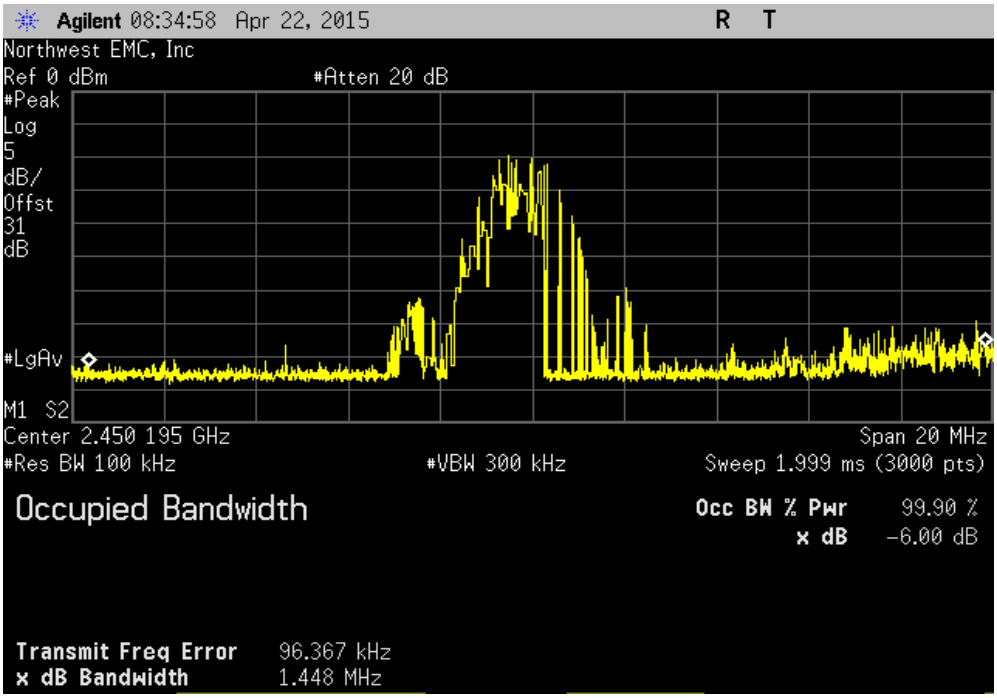
Configuration #	2	Signature

	Value	Limit (>)	Result
OQPSK			
Low Channel, 2424.7 MHz	1.577 MHz	500 kHz	Pass
Mid Channel, 2450.195 MHz	1.448 MHz	500 kHz	Pass
High Channel, 2480.078 MHz	1.814 MHz	500 kHz	Pass

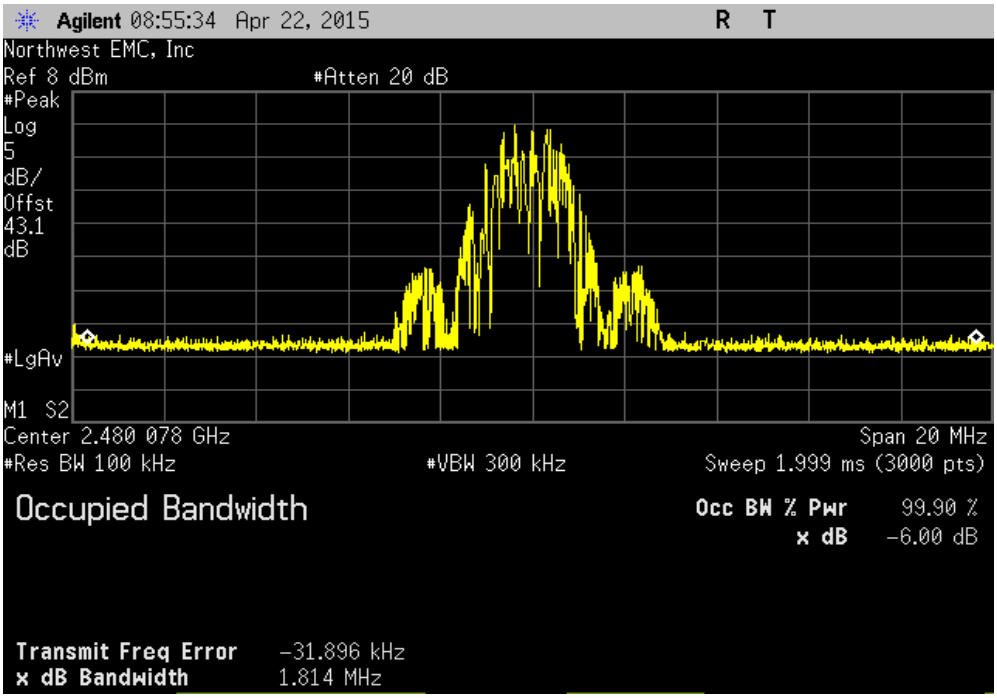
OQPSK, Low Channel, 2424.7 MHz						
				Value	Limit (>)	Result
				1.577 MHz	500 kHz	Pass



OQPSK, Mid Channel, 2450.195 MHz						
				Value	Limit (>)	Result
				1.448 MHz	500 kHz	Pass



OQPSK, High Channel, 2480.078 MHz						
				Value	Limit (>)	Result
				1.814 MHz	500 kHz	Pass



OUTPUT POWER

XMit 2015.01.14

Testing was performed using the mode(s) of operation and configuration(s) noted within the report. The individuals and/or the organization requesting the test provided the modes, configurations and settings used to complete the evaluation. The actual test parameters are specified in the test data, this includes items such as investigated frequency range (scanned) and test levels. The testing methods and performance specifications, as well as the test site used for the evaluation are indicated in the test data.

TEST EQUIPMENT

Description	Manufacturer	Model	ID	Last Cal.	Interval (mos)
TX02 Cable	Northwest EMC	1-8.2 GHz	TXC	9/22/2014	12
Antenna, Horn	ETS	3115	AJN	9/15/2014	24
Spectrum Analyzer	Agilent	N9010A	AFL	6/20/2014	12

TEST DESCRIPTION

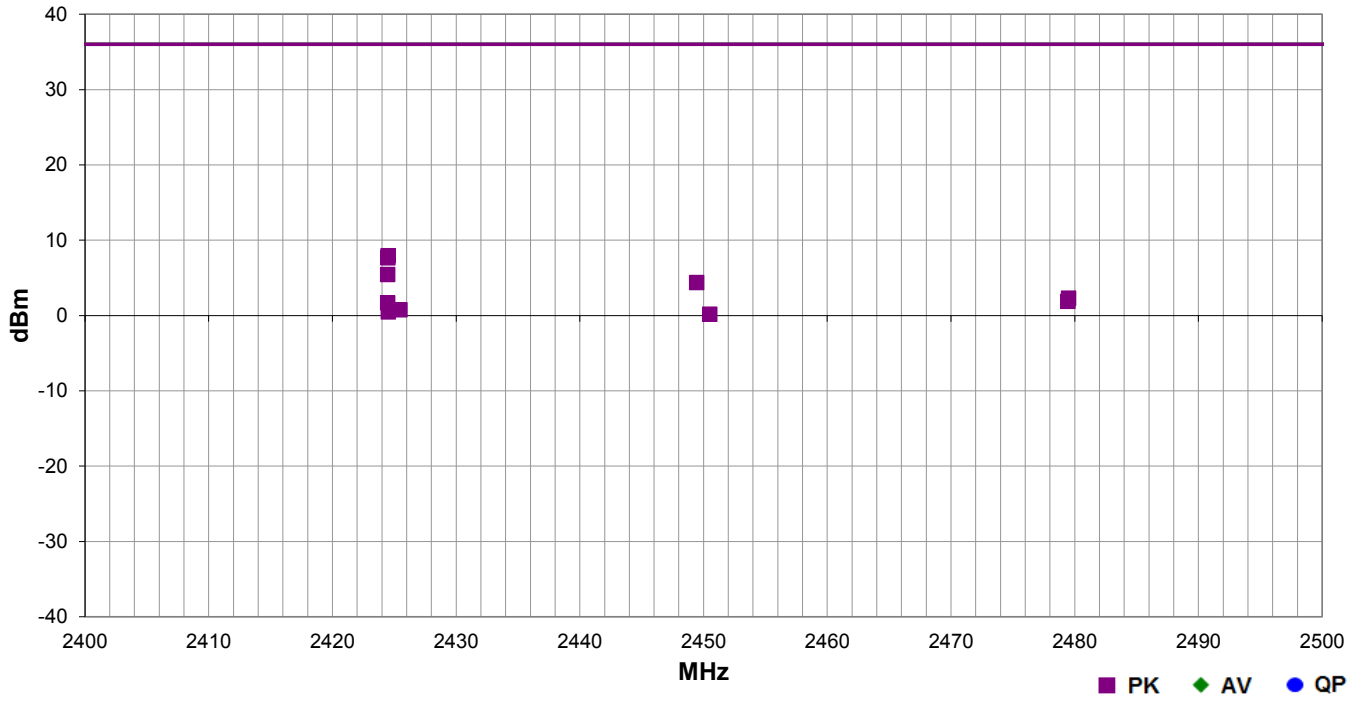
The peak output power was measured with the EUT set to low, medium and high transmit frequencies. A field strength measurement was made of the fundamental with the carrier fully maximized for its highest radiated power. The final data was converted from field strength to a radiated power value using equation 5 found in ANSI C63.10:2009

OUTPUT POWER

Work Order:	DARC0001	**Date:**	04/21/15		
Project:	None	**Temperature:**	23.9 °C		
Job Site:	TX02	**Humidity:**	39.2% RH		
Serial Number:	201512001, 201512006, 201512008	**Barometric Pres.:**	1018 mbar	**Tested by:**	Jonathan Kiefer
EUT:	Drivetrain Health Monitoring System-Sensor				
Configuration:	1				
Customer:	DarCEO Inc.				
Attendees:	Brian Hemmelman				
EUT Power:	Battery				
Operating Mode:	Transmitting OQPSK at Low, Mid, High Channel @ 2424.7, 2450.195, 2480.078 MHz				
Deviations:	None				
Comments:	Radiated method. Worst Case determined to be EUT Horizontal and Rx Antenna Horizontal. The unit was not able to be reconfigured to different channels. Therefore, 3 electrically identical units were tested at Low, Mid, and High Channels. Gateway needed to be within range as firmware was still in development to operate Sensor standalone				

Test Specifications	**Test Method**
FCC 15.247:2015	ANSI C63.10:2009

Run #	9	**Test Distance (m)**	3	**Antenna Height(s)**	1 to 4(m)	**Results**	Pass



	Freq (MHz)	Antenna Height (meters)	Azimuth (degrees)	Polarity/ Transducer Type	Detector	EIRP (Watts)	EIRP (dBm)	Spec. Limit (dBm)	Compared to Spec. (dB)	Comments
	2424.508	2.5	360.0	Horz	PK	6.23E-03	7.9	36.0	-28.1	Low Ch, EUT Horizontal
	2424.492	2.5	90.0	Vert	PK	5.81E-03	7.6	36.0	-28.4	Low Ch, EUT On Side
	2424.467	3.5	270.0	Vert	PK	3.50E-03	5.4	36.0	-30.6	Low Ch, EUT Vertical
	2449.442	2.5	360.0	Horz	PK	2.73E-03	4.4	36.0	-31.6	Mid Ch, EUT Horizontal
	2479.497	2.5	315.0	Vert	PK	1.70E-03	2.3	36.0	-33.7	High Ch, EUT On Side
	2479.455	2.5	180.0	Horz	PK	1.55E-03	1.9	36.0	-34.1	High Ch, EUT Horizontal
	2424.475	2.5	45.0	Horz	PK	1.47E-03	1.7	36.0	-34.3	Low Ch, EUT On Side
	2425.458	2.5	225.0	Horz	PK	1.19E-03	0.8	36.0	-35.2	Low Ch, EUT Vertical
	2450.492	2.5	0.0	Vert	PK	1.04E-03	0.2	36.0	-35.8	Mid Ch, EUT On Side
	2424.525	2.5	225.0	Vert	PK	1.11E-03	0.5	36.0	-35.5	Low Ch, EUT Horizontal

POWER SPECTRAL DENSITY

XMit 2015.01.14

Testing was performed using the mode(s) of operation and configuration(s) noted within the report. The individuals and/or the organization requesting the test provided the modes, configurations and settings used to complete the evaluation. The actual test parameters are specified in the test data, this includes items such as investigated frequency range (scanned) and test levels. The testing methods and performance specifications, as well as the test site used for the evaluation are indicated in the test data.

TEST EQUIPMENT

Description	Manufacturer	Model	ID	Last Cal.	Interval (mos)
Near Field Probe	ETS Lindgren	7405	IPS	NCR	0
Spectrum Analyzer	Agilent	E4440A	AFD	7/14/2014	12

TEST DESCRIPTION

The maximum power spectral density measurements were measured with the EUT set to the required transmit frequencies in each band. The measurement was made using a radiated method via a near field probe. A reference level offset was used in the analyzer to match the actual radiated EIRP level. The EUT was transmitting at the lowest, middle, and maximum data rate for each modulation type available.

Per the procedure outlined in FCC KDB 558074 D01 DTS Measurement Section 10.3, the spectrum analyzer was used as follows:

- RBW = 100 kHz
- VBW = 300 kHz
- Detector = Average
- Trace = Max hold

The observed power level is then scaled to an equivalent value in 3 kHz by adding a Bandwidth Correction Factor (BWCF) where:

BWCF = 10*LOG (3 kHz / 100 kHz) = -15.2 dB

POWER SPECTRAL DENSITY

NORTHWEST EMC

XMit 2015.01.14

EUT:	Drivetrain Health Monitoring System-Sensor			**Work Order:**	DARC0001
Serial Number:	201512001, 201512006, 201512008			**Date:**	04/22/15
Customer:	DarCEO Inc.			**Temperature:**	24.0°C
Attendees:	Brian Hemmelman			**Humidity:**	44%
Project:	None			**Barometric Pres.:**	1013 mbar
Tested by:	Jonathan Kiefer	**Power:**	Battery	**Job Site:**	TX09

TEST SPECIFICATIONS	Test Method
FCC 15.247:2015	ANSI C63.10:2009

COMMENTS

Transmitting OQPSK at Low, Mid, High Channel @ 2424.7, 2450.195, 2480.078 MHz. The unit was not able to be reconfigured to different channels. Therefore, 3 electrically identical units were tested at Low, Mid, and High Channels.

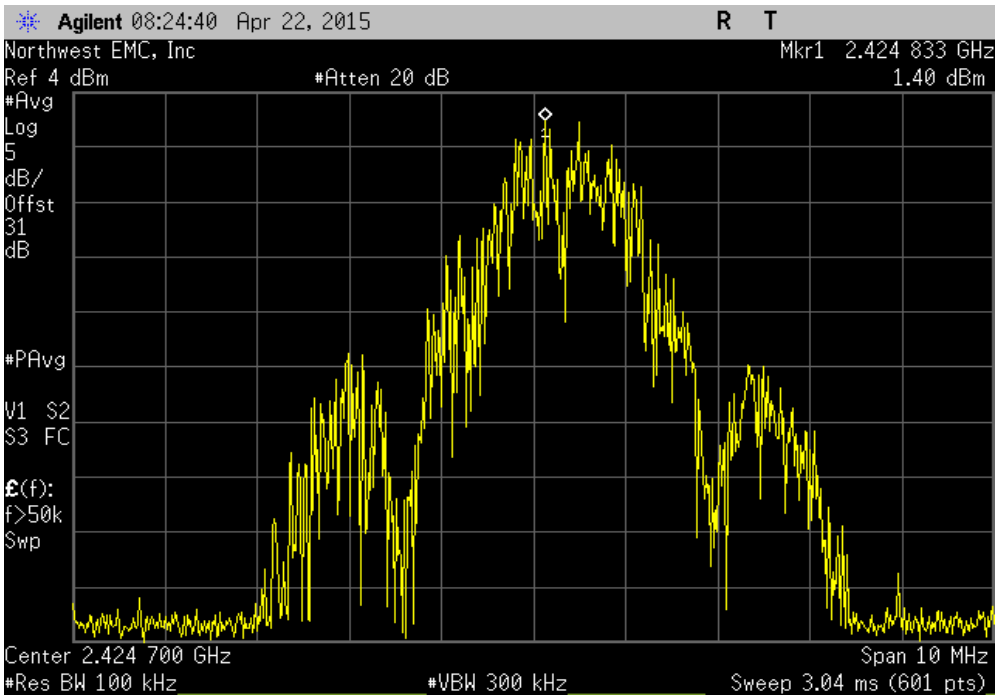
DEVIATIONS FROM TEST STANDARD

None

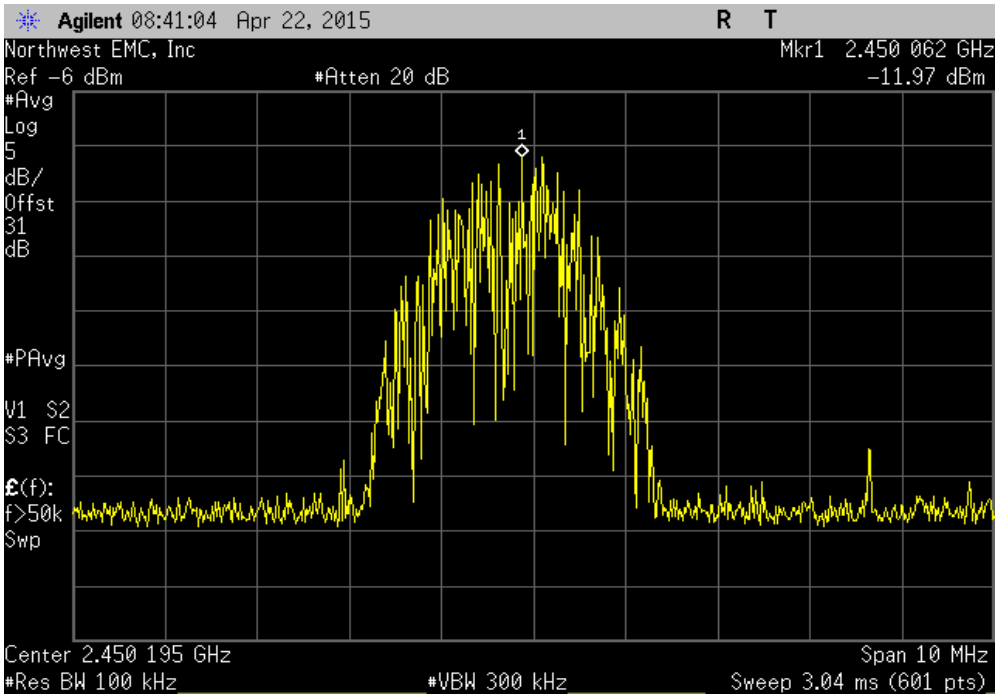
Configuration #	2	*Signature*

	Value dBm/100kHz	dBm/100kHz To dBm/3kHz	Value dBm/3kHz	Limit dBm/3kHz	Results
OQPSK					
Low Channel, 2424.7 MHz	1.405	-15.2	-13.795	8	Pass
Mid Channel, 2450.195 MHz	-11.969	-15.2	-27.169	8	Pass
High Channel, 2480.078 MHz	1.906	-15.2	-13.294	8	Pass

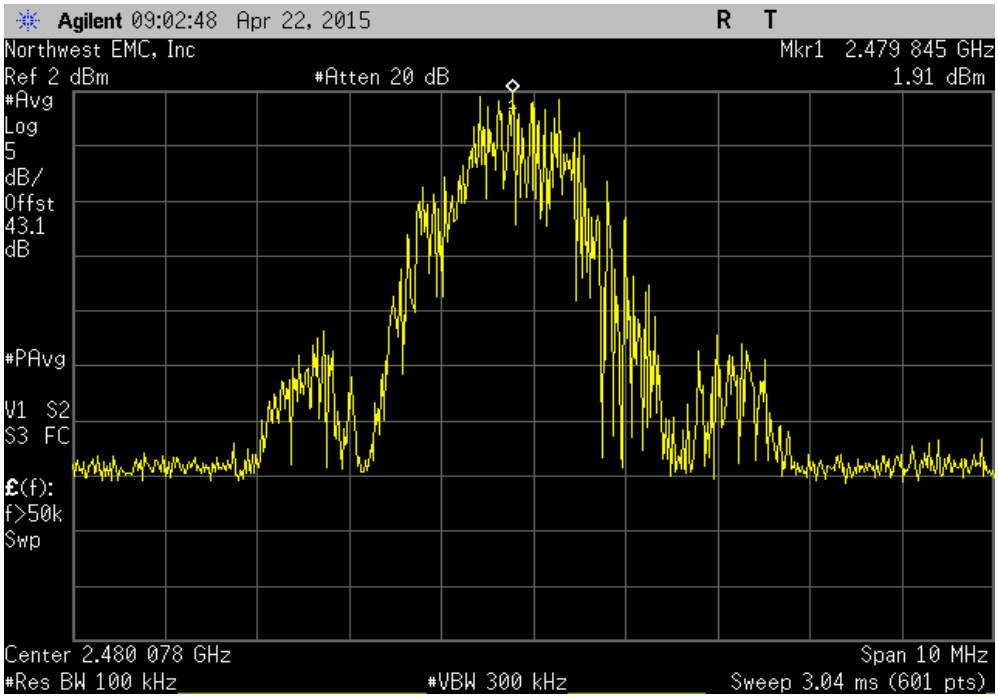
OQPSK, Low Channel, 2424.7 MHz						
		Value dBm/100kHz	dBm/100kHz To dBm/3kHz	Value dBm/3kHz	Limit dBm/3kHz	Results
		1.405	-15.2	-13.795	8	Pass



OQPSK, Mid Channel, 2450.195 MHz						
		Value dBm/100kHz	dBm/100kHz To dBm/3kHz	Value dBm/3kHz	Limit dBm/3kHz	Results
		-11.969	-15.2	-27.169	8	Pass



OQPSK, High Channel, 2480.078 MHz						
		Value dBm/100kHz	dBm/100kHz To dBm/3kHz	Value dBm/3kHz	Limit dBm/3kHz	Results
		1.906	-15.2	-13.294	8	Pass



DUTY CYCLE

XMit 2015.01.14

Testing was performed using the mode(s) of operation and configuration(s) noted within the report. The individuals and/or the organization requesting the test provided the modes, configurations and settings used to complete the evaluation. The actual test parameters are specified in the test data, this includes items such as investigated frequency range (scanned) and test levels. The testing methods and performance specifications, as well as the test site used for the evaluation are indicated in the test data.

TEST EQUIPMENT

Description	Manufacturer	Model	ID	Last Cal.	Interval (mos)
Signal Generator	Agilent	N5171B	TGE	5/16/2014	36
Antenna, Horn	ETS Lindgren	3115	AJL	9/15/2014	24
TX02 Cable	Northwest EMC	1-8.2 GHz	TXC	9/22/2014	12
Spectrum Analyzer	Agilent	N9010A	AFL	6/20/2014	12

TEST DESCRIPTION

The Duty Cycle (x) of the single channel operation of the radio as controlled by the provided test software was measured for each of the EUT operating modes.

The measurements were made using a zero span on the spectrum analyzer to see the pulses in the time domain. The transmit power was set to its default maximum. The duty cycle was measured radiated in the RF chamber.

DUTY CYCLE

NORTHWEST EMC

XMit 2015.01.14

EUT:	Drivetrain Health Monitoring System-Sensor			**Work Order:**	DARC0001
Serial Number:	201512001, 201512006, 201512008			**Date:**	04/21/15
Customer:	DarCEO Inc.			**Temperature:**	24.3°C
Attendees:	Brian Hemmelman			**Humidity:**	42%
Project:	None			**Barometric Pres.:**	1017 mbar
Tested by:	Jonathan Kiefer	**Power:**	Battery	**Job Site:**	TX02

TEST SPECIFICATIONS	Test Method
FCC 15.247:2015	ANSI C63.10:2009

COMMENTS

Radiated method. EUT transmitting in horizontal orientation. Antenna at horizontal position. The unit was not able to be reconfigured to different channels. Therefore, 3 electrically identical units were tested at Low, Mid, and High Channels. Gateway needed to be within range as firmware was still in development to operate Sensor standalone

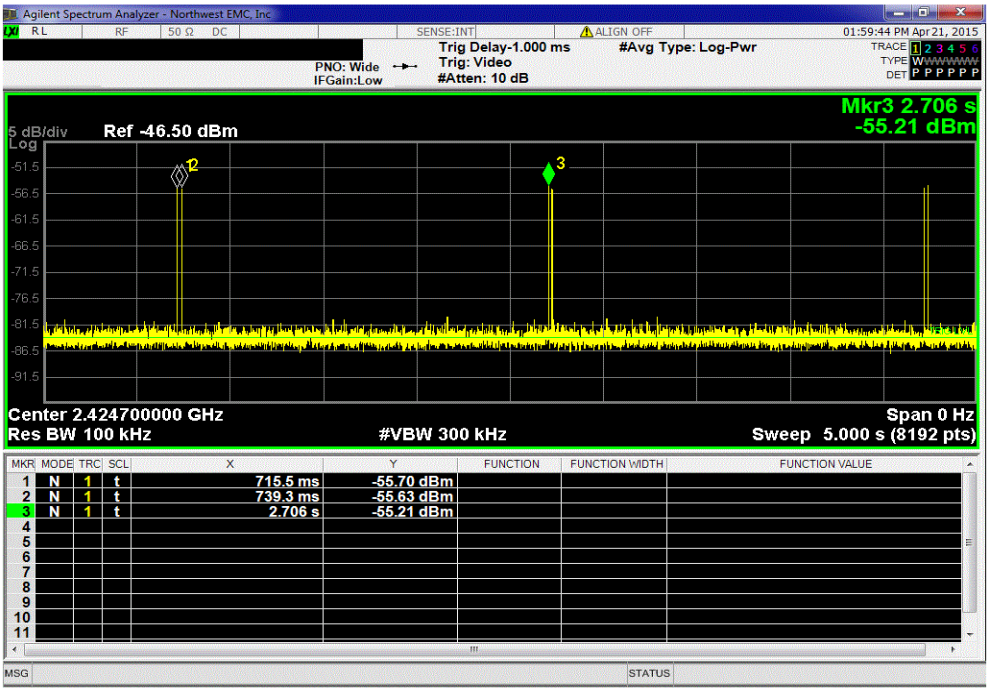
DEVIATIONS FROM TEST STANDARD

None

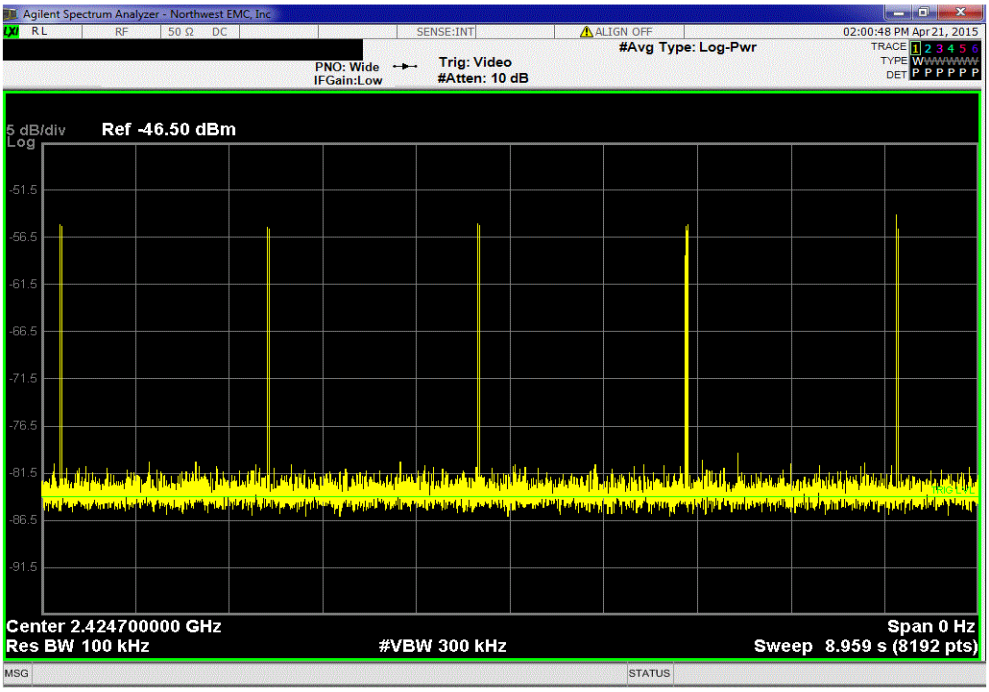
Configuration #	1	Signature

	Pulse Width	Period	Number of Pulses	Value (%)	Limit (%)	Results
OQPSK						
Low Channel, 2424.7 MHz	23.808 ms	1.991 s	1	1.2	N/A	N/A
Low Channel, 2424.7 MHz	N/A	N/A	11	N/A	N/A	N/A
Mid Channel, 2450.195 MHz	21.97 ms	2.008 s	1	1.1	N/A	N/A
Mid Channel, 2450.195 MHz	N/A	N/A	10	N/A	N/A	N/A
High Channel, 2480.078 MHz	13.04 ms	1.998 s	1	0.7	N/A	N/A
High Channel, 2480.078 MHz	N/A	N/A	11	N/A	N/A	N/A

OQPSK, Low Channel, 2424.7 MHz						
	Pulse Width	Period	Number of Pulses	Value (%)	Limit (%)	Results
	23.808 ms	1.991 s	1	1.2	N/A	N/A



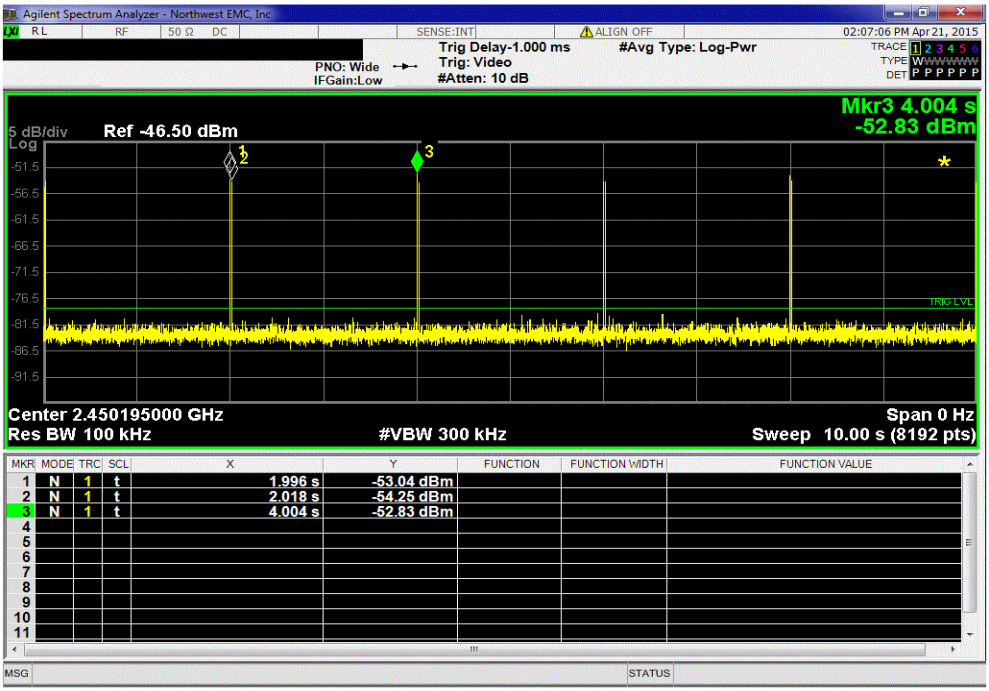
OQPSK, Low Channel, 2424.7 MHz						
	Pulse Width	Period	Number of Pulses	Value (%)	Limit (%)	Results
	N/A	N/A	11	N/A	N/A	N/A



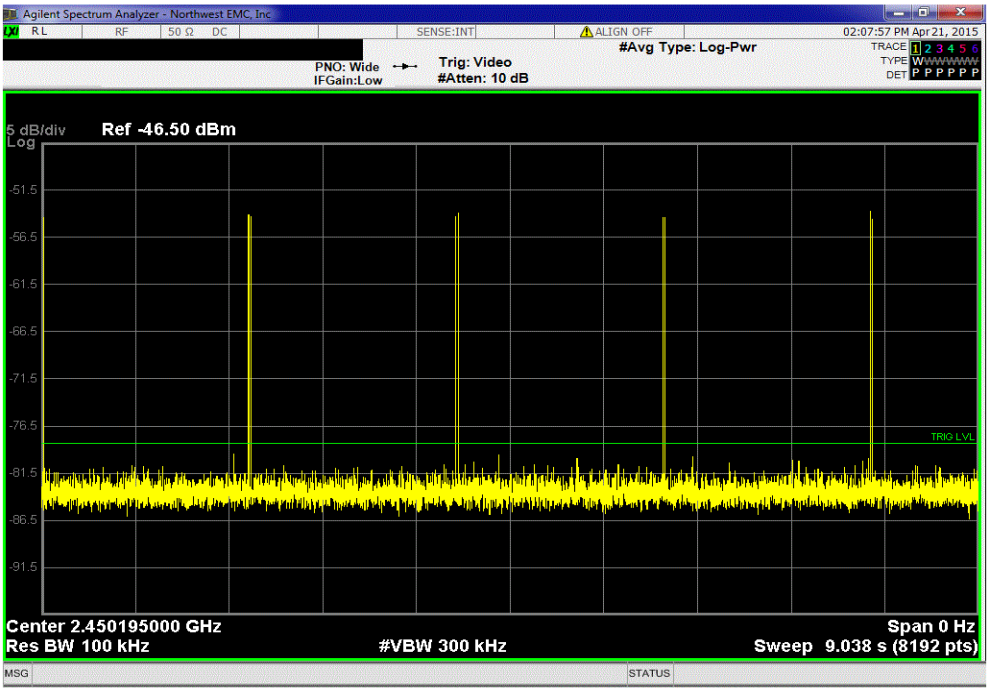
DUTY CYCLE

XMit 2015.01.14

OQPSK, Mid Channel, 2450.195 MHz						
	Pulse Width	Period	Number of Pulses	Value (%)	Limit (%)	Results
	21.97 ms	2.008 s	1	1.1	N/A	N/A



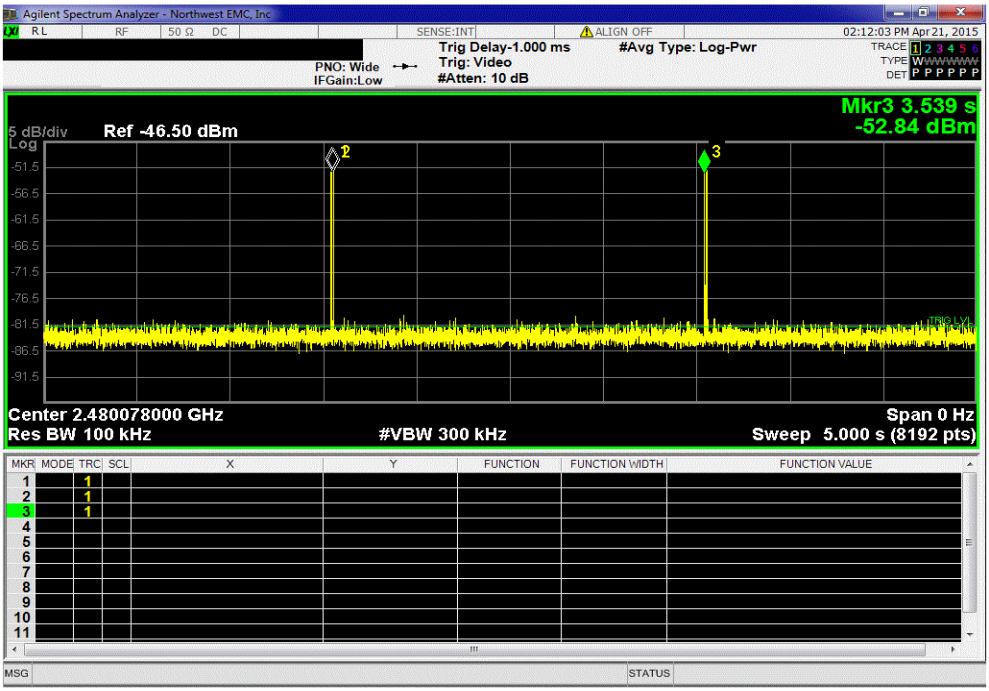
OQPSK, Mid Channel, 2450.195 MHz						
	Pulse Width	Period	Number of Pulses	Value (%)	Limit (%)	Results
	N/A	N/A	10	N/A	N/A	N/A



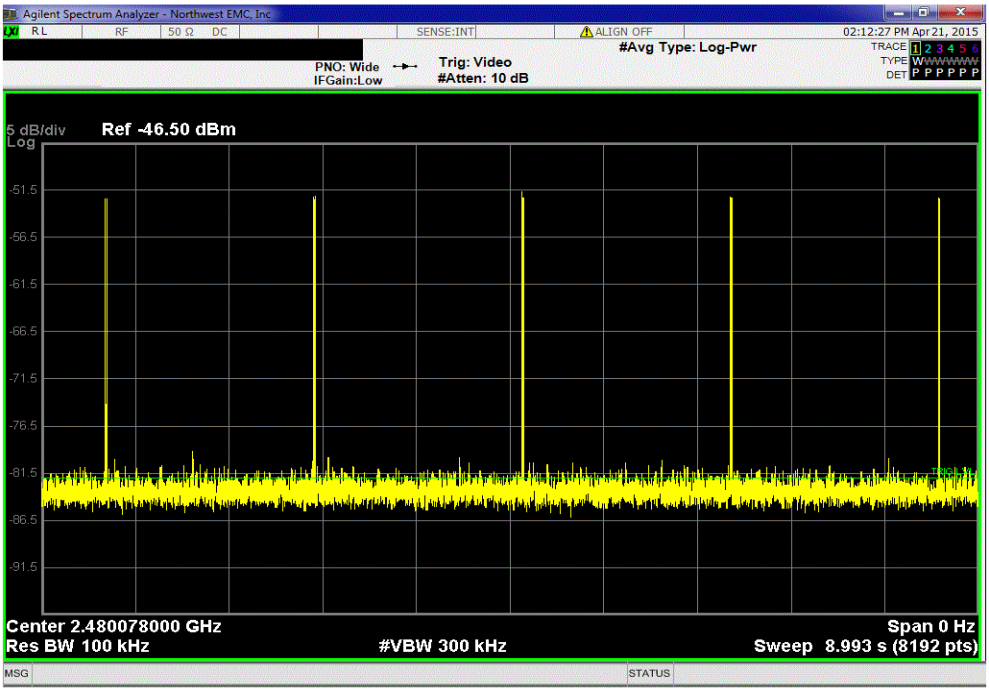
DUTY CYCLE

XMit 2015.01.14

OQPSK, High Channel, 2480.078 MHz						
	Pulse Width	Period	Number of Pulses	Value (%)	Limit (%)	Results
	13.04 ms	1.998 s	1	0.7	N/A	N/A



OQPSK, High Channel, 2480.078 MHz						
	Pulse Width	Period	Number of Pulses	Value (%)	Limit (%)	Results
	N/A	N/A	11	N/A	N/A	N/A



OUT OF BAND EMISSIONS

Testing was performed using the mode(s) of operation and configuration(s) noted within the report. The individuals and/or the organization requesting the test provided the modes, configurations and settings used to complete the evaluation. The actual test parameters are specified in the test data, this includes items such as investigated frequency range (scanned) and test levels. The testing methods and performance specifications, as well as the test site used for the evaluation are indicated in the test data.

TEST EQUIPMENT

Description	Manufacturer	Model	ID	Last Cal.	Interval
High Pass Filter	Micro-Tronics	HPM50111	HHX	8/18/2014	12 mo
Low Pass Filter	Micro-Tronics	LPM50004	HHV	8/18/2014	12 mo
Pre-Amplifier	Miteq	AMF-6F-08001200-30-10P	PAK	10/27/2014	12 mo
Pre-Amplifier	Miteq	AMF-6F-12001800-30-10P	PAL	10/27/2014	12 mo
TX02 Cable	NWEMC	8-18GHz	TXD	10/27/2014	12mo
Pre-Amplifier	Miteq	JSDQK42-18004000-60-5P	PAM	11/21/2014	12 mo
Cable	NWEMC	18-40GHz	TXE	11/21/2014	12 mo
Antenna, Double Ridge Guide Horn	A.H. Systems, Inc.	SAS-574	AXW	4/23/2014	36 mo
Antenna, Horn	ETS Lindgren	3160-08	AJG	NCR	0 mo
Antenna, Horn	ETS Lindgren	3160-07	AJF	NCR	0 mo
Pre-Amplifier	Miteq	AMF-3D-00100800-32-13P	PAJ	9/22/2014	12 mo
TX02 Cable	NWEMC	1-8.2 GHz	TXC	9/22/2014	12 mo
Antenna, Horn	ETS Lindgren	3115	AJL	9/15/2014	24 mo
Pre-Amplifier	Miteq	AM-1551	PAH	9/13/2014	12 mo
TX02 Cable	N/A	RE 9kHz - 1GHz	TXB	9/22/2014	12 mo
Antenna, Biconilog	ETS Lindgren	3143B	AYF	4/7/2014	36 mo
Spectrum Analyzer	Agilent	N9010A	AFL	6/20/2014	12 mo

TEST DESCRIPTION

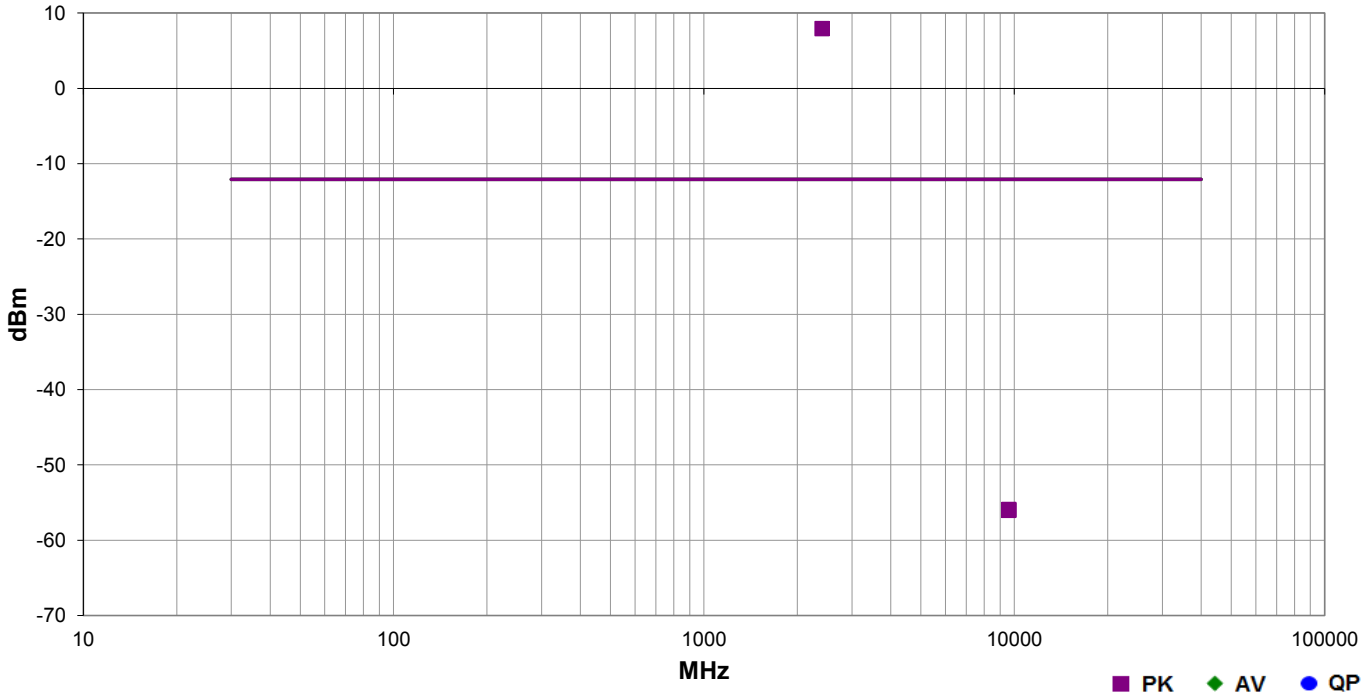
The spurious RF emissions were measured with the EUT set to low, medium and high transmit frequencies. The measurements were made using a radiated setup using an antenna and spectrum analyze with various filters and preamps to sustain an adequate sensitivity and accuracy because the EUT has an integral antenna that doesn't allow direct connection. The EUT was transmitting at the data rate(s) listed in the datasheet. For each transmit frequency, the spectrum was scanned throughout the specified frequency range. Out of band emissions were measured where applicable and compared to the -20 dBc limit in reference to the highest fundamental reading.

OUT OF BAND EMISSIONS

Work Order:	DARC0001	**Date:**	04/24/15		
Project:	None	**Temperature:**	23.9 °C		
Job Site:	TX02	**Humidity:**	39.2% RH		
Serial Number:	201512001, 201512006, 201512008	**Barometric Pres.:**	1018 mbar	**Tested by:**	Jonathan Kiefer
EUT:	Drivetrain Health Monitoring System-Sensor				
Configuration:	1				
Customer:	DarCEO Inc.				
Attendees:	Brian Hemmelman				
EUT Power:	Battery				
Operating Mode:	Transmitting OQPSK at Low, Mid, High Channel @ 2424.7, 2450.195, 2480.078 MHz				
Deviations:	None				
Comments:	Radiated method. Worst Case determined to be EUT Horizontal and Rx Antenna Horizontal. The unit was not able to be reconfigured to different channels. Therefore, 3 electrically identical units were tested at Low, Mid, and High Channels. Gateway needed to be within range as firmware was still in development to operate Sensor standalone				

Test Specifications	**Test Method**
FCC 15.247:2014	ANSI C63.10:2009

Run #	9	**Test Distance (m)**	3	**Antenna Height(s)**	1 to 4(m)	**Results**	Pass



	Freq (MHz)	Antenna Height (meters)	Azimuth (degrees)	Polarity/ Transducer Type	Detector	EIRP (Watts)	EIRP (dBm)	Spec. Limit (dBm)	Compared to Spec. (dB)	Comments
	9609.080	2.5	265.0	Horz	PK	2.55E-09	-55.9	-12.1	-43.8	Low Channel, 1MHz RBW
	9609.080	2.5	270.0	Vert	PK	2.50E-09	-56.0	-12.1	-43.9	Low Channel, 1MHz RBW
	2402.317	2.5	273.0	Horz	PK	6.23E-03	7.9	N/A	N/A	Fundamental Reference

All other Out of Band frequencies greater than -40 dBc from fundamental