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CERTIFICATION TEST REPORT

Manufacturer: **Harsco Rail**
a Division of Harsco Corporation
2401 Edmund Highway
West Columbia, South Carolina 29170

Applicant: **Same as Above**

Product Name: **PT-704 Ranging Radio Module**

Product Description: 2.4 GHz Nanotron Ranging radio module with built-on RF Amplifier circuit and Antenna Switching for use in Ranging Personal Alert Device.

Model: **PT-704**

FCC ID: **2AEO5-PT-704**

Testing Commenced: Nov. 29, 2016

Testing Ended: Jan. 19, 2017

Summary of Test Results: **In Compliance**

The EUT complies with the EMC requirements when manufactured identically as the unit tested in this report, including any required modifications. Any changes to the design or build of this unit subsequent to this testing may deem it non-compliant.

Standards:

- **FCC Part 15 Subpart C, Section 15.247**
- **FCC15.207 - Conducted Limits**
- **FCC Part 15.31(e)**
- **ANSI C63.10:2013**



Order Number: F2LQ9197

Client: Harsco Rail
Model: PT-704

Evaluation Conducted by:

Joe Knepper, EMC Proj. Eng.

Report Reviewed by:

Ken Littell, Director of EMC & Wireless Operations

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1 ADMINISTRATIVE INFORMATION

1.1 Measurement Location:

F2 Labs in Middlefield, Ohio. Site description and attenuation data are on file with the FCC's Sampling and Measurement Branch at the FCC Laboratory in Columbia, MD.

1.2 Measurement Procedure:

All measurements were performed according to the 2013 version of ANSI C63.10 and recommended FCC procedure of measurement of DTS operating under Section 15.247 and in KDB558074. A list of the measurement equipment can be found in Section 6.

1.3 Uncertainty Budget:

The uncertainty in EMC measurements arises from several factors which affect the results, some associated with environmental conditions in the measurement room, the test equipment being used and the measurement techniques adopted. Note: Only measurements listed in the table below which relate to tests included in this Test Report are applicable.

The measurement uncertainty budgets detailed below are calculated from the test and calibration data, and are expressed with a 95% confidence factor using a coverage factor of $k=2$. The Uncertainty for a laboratory are referred to as U_{lab} . For Radiated and Conducted Emissions, the Expanded Uncertainty is compared to the U_{cispr} values to determine if a specific margin is required to deem compliance.

U_{lab}

Measurement Range	Combined Uncertainty	Expanded Uncertainty
Radiated Emissions <1 GHz @ 3m	2.54	5.07dB
Radiated Emissions <1 GHz @ 10m	2.55	5.09dB
Radiated Emissions 1 GHz to 2.7 GHz	1.81	3.62dB
Radiated Emissions 2.7 GHz to 18 GHz	1.55	3.10dB
AC Power Line Conducted Emissions, 150kHz to 30 MHz	1.38	2.76dB
AC Power Line Conducted Emissions, 9kHz to 150kHz	1.66	3.32dB

U_{cispr}

Measurement Range	Expanded Uncertainty
Radiated Emissions <1 GHz @ 3m	5.2dB
Radiated Emissions <1 GHz @ 10m	5.2dB
Radiated Emissions 1 GHz to 2.7 GHz	Under Consideration
Radiated Emissions 2.7 GHz to 18 GHz	Under Consideration
AC Power Line Conducted Emissions, 150kHz to 30 MHz	3.6dB
AC Power Line Conducted Emissions, 9kHz to 150kHz	4.0dB

If U_{lab} is less than or equal to U_{cispr} , then:

- compliance is deemed to occur if no measured disturbance exceeds the disturbance limit;
- non-compliance is deemed to occur if any measured disturbance exceeds the disturbance limit.

If U_{lab} is greater than U_{cispr} in table 1, then:

- compliance is deemed to occur if no measured disturbance, increased by $(U_{lab} - U_{cispr})$, exceeds the disturbance limit;
- non-compliance is deemed to occur if any measured disturbance, increased by $(U_{lab} - U_{cispr})$, exceeds the disturbance limit.



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1.4 Document History

Document Number	Description	Issue Date	Approved By
F2LQ9197-01E	First Issue	Jan. 20, 2017	K. Littell



2 SUMMARY OF TEST RESULTS AND MODIFICATIONS

Test Name	Standard(s)	Results
6dB Occupied Bandwidth	CFR 47 Part 15.247(a)(2) / KDB558074	Complies
Conducted Output Power	CFR 47 Part 15.247(b)(3) / KDB558074	Complies
Voltage Variations	CFR 47 Part 15.31(e)	Complies
Conducted Spurious Emissions	CFR 47 Part 15.247(d) / KDB558074	Complies
Radiated Spurious Emission with 5dBi External Antenna	CFR 47 Part 15.247(d) / Part 15.209 / KDB558074	Complies
Peak Power Spectral Density	CFR 47 Part 15.247(e) / KDB558074	Complies
Frequency Separation	ANSI 63.10 2013 (7.8.2)	Not Applicable
Number of Hopping Frequencies	ANSI 63.10 2013 (7.8.3)	Not Applicable
Dwell Time	ANSI 63.10 2013 (7.8.4)	Not Applicable
Conducted Emissions	CFR 47 Part 15.207(a)	Complies

Modifications Made to the Equipment
None



3 TABLE OF MEASURED RESULTS

Test	2.44 GHz	
Conducted Output Power	5.89mW (7.70dBm)	
Conducted Output Power Limit	1 Watt, (30dBm)	
E.I.R.P. with 5dBi External Antenna	8.43mW (9.26dBm)	
E.I.R.P. Limit	4 Watts, (36.02dBm)	
Peak Power Spectral Density	-35.21dBm	
Peak Power Spectral Density Limit	8dBm	
-6dB Occupied Bandwidth	55.31 MHz	
-6dB Occupied Bandwidth Limit	\geq 500kHz	
Voltage Variations	3.06V(dBm)	-6.41
	3.06V(mW)	0.229
	4.14V(dBm)	7.70
	4.14V(mW)	5.89
Limit		1W 30dBm
E.I.R.P.	3.06V(dBm)	-1.41
	3.06V(mW)	0.723
	4.14V(dBm)	12.7
	4.14V(mW)	18.6

Note: To meet the requirements of 15.31, voltage was varied by $\pm 15\%$ of the nominal voltage. All tests were then performed at the highest output power voltage setting.



Order Number: F2LQ9197

Client: Harsco Rail

Model: PT-704

4 ENGINEERING STATEMENT

This report has been prepared on behalf of Harsco Rail to provide documentation for the testing described herein. This equipment has been tested and found to comply with Part 15.247 of the FCC Rules using ANSI C63.10:2013 and KDB558074 standards. The test results found in this test report relate only to the items tested.



5 EUT INFORMATION AND DATA

5.1 Equipment Under Test:

Product: Radio Module
Model: PT-704
Serial No.: None Specified
FCC ID: 2AEO5-PT-704

5.2 Trade Name:

Harsco Rail

5.3 Power Supply:

Lenovo 42T4418

5.4 Applicable Rules:

CFR 47, Part 15.247, subpart C

5.5 Equipment Category:

Radio Transmitter-DTS

5.6 Antenna:

5dBi External

5.7 Accessories:

N/A

5.8 Test Item Condition:

The equipment to be tested was received in good condition.

5.9 Testing Algorithm:

The EUT was set up in a normal testing manner, powered at 3.6VDC from a test fixture that was powered at 120V/60 Hz. EUT transmitted continuously at 2.44 GHz. The highest emissions were recorded in the data tables.



Order Number: F2LQ9197

Client: Harsco Rail

Model: PT-704

6 LIST OF MEASUREMENT INSTRUMENTATION

Equipment Type	Asset Number	Manufacturer	Model	Serial Number	Calibration Due Date
Shielded Chamber	CL166-E	AlbatrossProjects	B83117-DF435-T261	US140023	May 12, 2017
Temp/Hum. Recorder	CL137	Extech	RH520	CH16992	June 3, 2017
Pre-amplifier	CL153	Keysight Tech.	83006A	MY39500791	June 6, 2017
Antenna	CL175	Sunol Sciences	JB3	A030315	Apr. 1, 2017
Active 18" Loop Antenna	CL163	AH Systems, Inc.	EHA-52B	100	May 2, 2017
Horn Antenna	CL098	Emco	3115	9809-5580	Dec. 10, 2016
Horn Antenna	CL114	AH Systems, Inc.	SAS-572	237	Nov. 17, 2018
Pre-amplifier	CL189	Com-Power	PAM-840A	461303	June 18, 2017
Receiver	CL204	Rohde & Schwarz	ESR7	101714	Aug. 30, 2017
Spectrum Analyzer	0204	Hewlett Packard	HP8591A	31349A02546	Dec. 2, 2016
Software	EMC Analyzer 85712D Rev. A.00.01			Date Verified	Dec. 1, 2016
Transient Limiter	0202	Hewlett Packard	11947A	3107A00729	June 27, 2018
Receiver	CL151	Rohde & Schwarz	ESU40	100319	Nov. 28, 2017
LISN	CL181	Com-Power	LI-125A	191226	June 24, 2018
LISN	CL182	Com-Power	LI-125A	191225	June 24, 2018
Software:	Tile Version 1.0		Software Verified: Nov. 29, 2016		
Software:	EMC 32, Version 5.20.2		Software Verified: Nov. 29, 2016		



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7 FCC PART 15.247(a)(2) – OCCUPIED BANDWIDTH

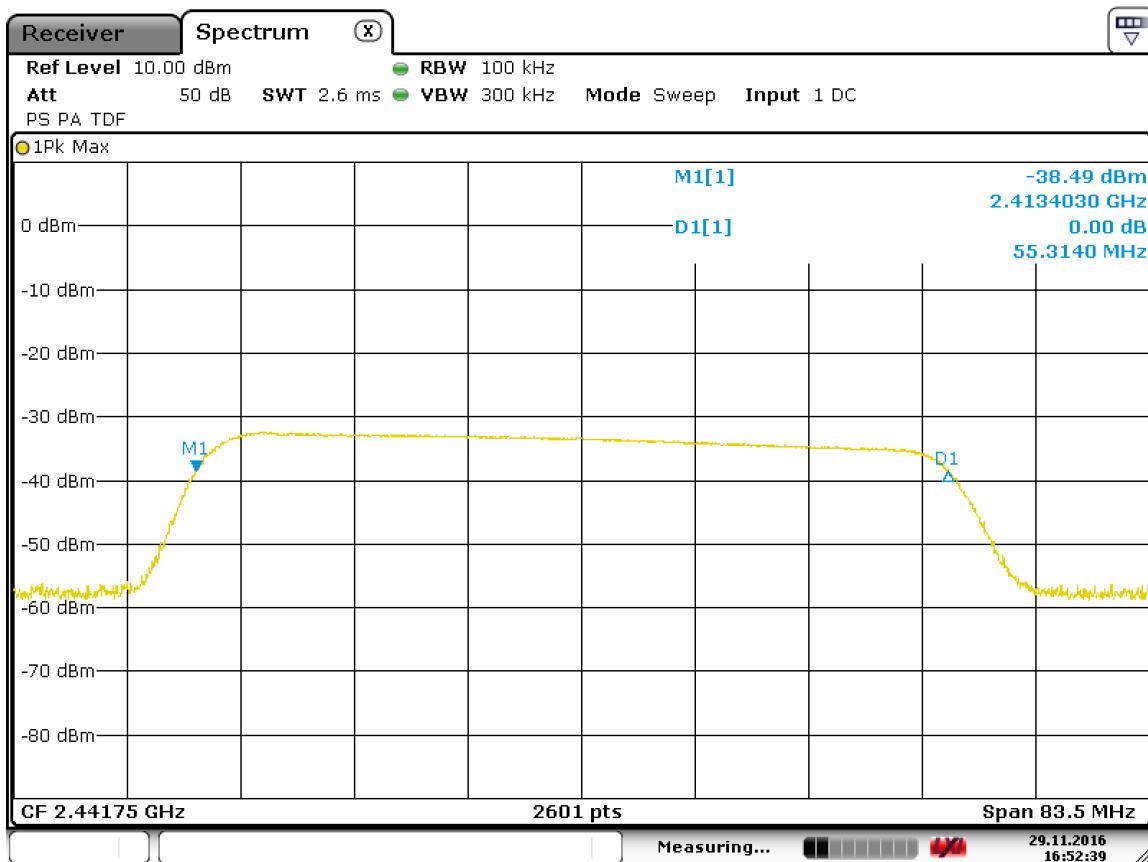
7.1 Requirements:

The 6dB bandwidth shall be greater than 500 kHz.

Bandwidth measurements were made at the 2.44 GHz frequency with the resolution Bandwidth set at 100 kHz (video bandwidth set at 300 kHz) while the span was set at 3MHz. The bandwidth was measured using the analyzer's marker function.

7.2 Occupied Bandwidth Test Data

Test Date:	Nov. 29, 2016	Test Engineer:	J. Knepper
Standards:	CFR 47 Part 15.247(a)(2); KDB558074	Air Temperature:	20.8°C
		Relative Humidity:	48%



Date: 29.NOV.2016 16:52:39



8 FCC PART 15.247(b)(3) – CONDUCTED OUTPUT POWER

The EUT antenna port was fitted with an SMA connector and directly connected to the input of the receiver. The peak power output was measured.

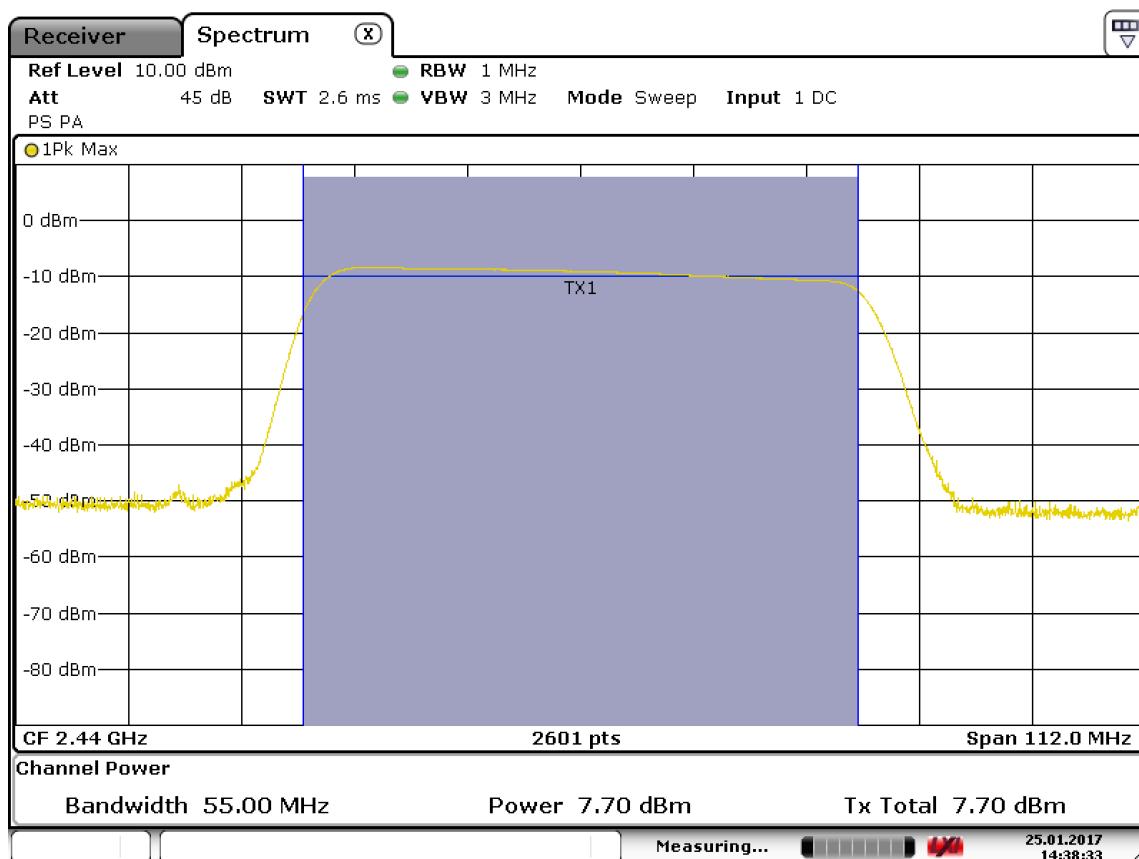
8.1 Requirements:

The peak power output shall be 1 watt (30 dBm) or less when using an antenna with a gain of less than 6dBi. For antennas having a gain of more than 6dBi, the limit is reduced by 1dB for every dB the antenna gain is over 6dBi.

8.2 Conducted Output Power Test Data

Test Date:	Nov. 29, 2016	Test Engineer:	J. Knepper
Standards:	CFR 47 Part 15.247(b)(3); KDB558074	Air Temperature:	20.1°C
		Relative Humidity:	48%

2.44 GHz



Date: 25.JAN.2017 14:38:33



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Client: Harsco Rail

Model: PT-704

9 FCC PART 15.31(e) – VOLTAGE VARIATIONS

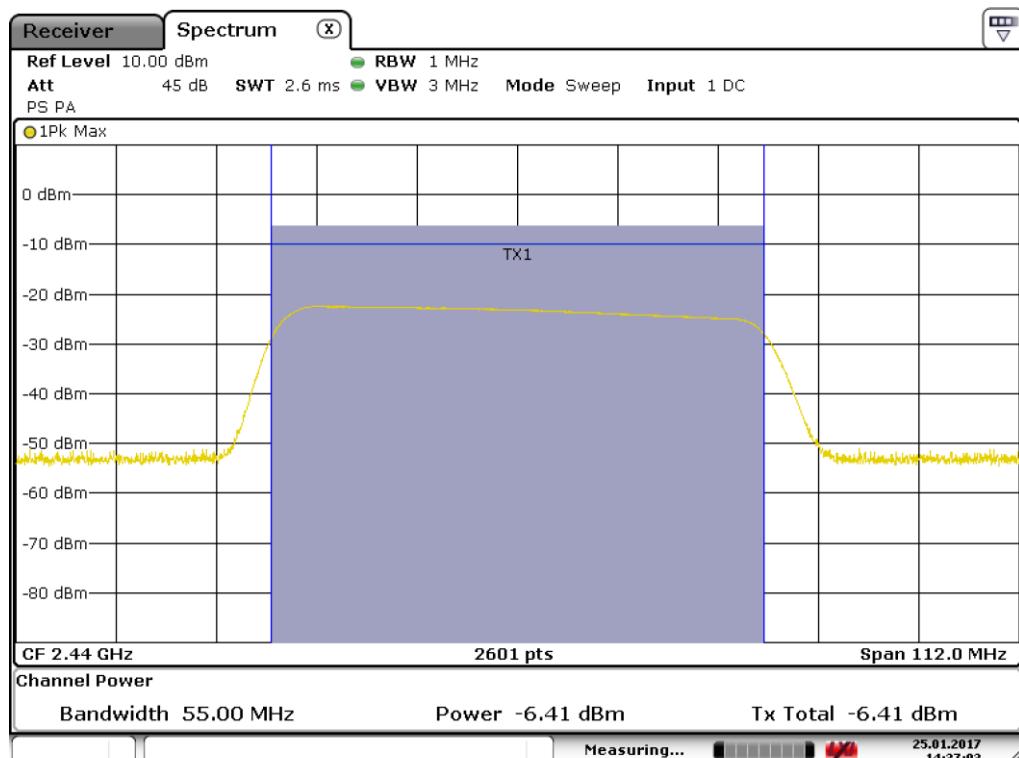
9.1 Requirements

For intentional radiators, measurements of the variation of the input power or the radiated signal level of the fundamental frequency component of the emission, as appropriate, shall be performed with the supply voltage varied $\pm 15\%$ of the nominal rated supply voltage. For battery-operated equipment, the equipment tests shall be performed using a new battery.

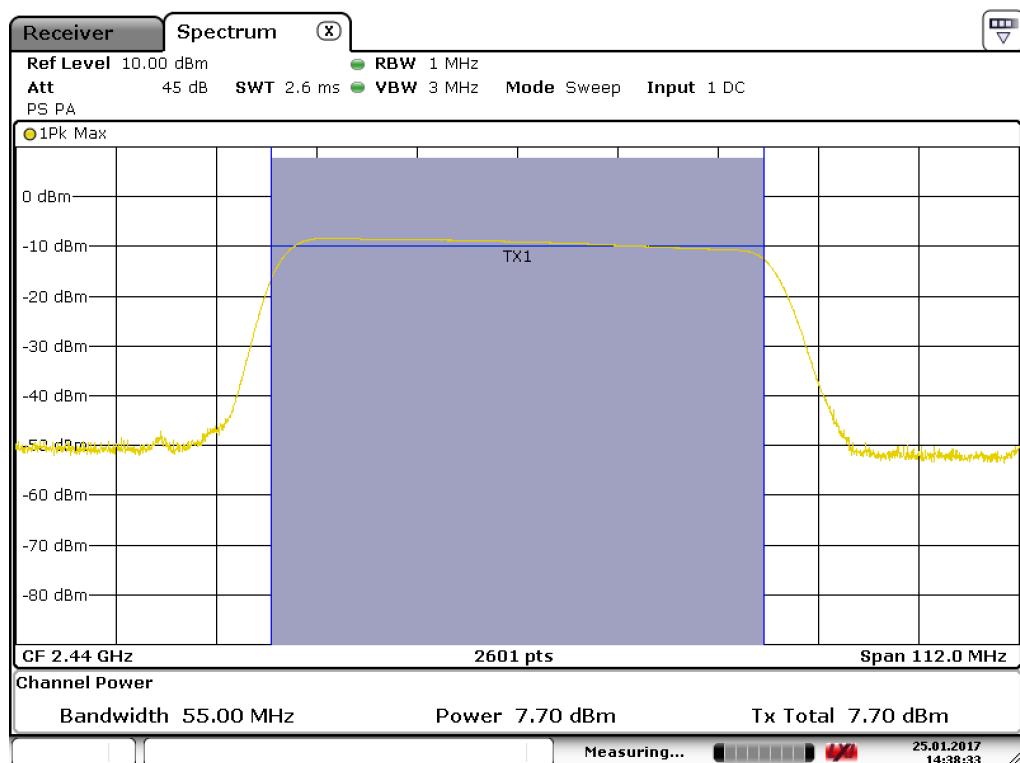
9.2 Voltage Variations Test Data

Test Date(s):	Jan. 19, 2017	Test Engineer:	J. Knepper
Rule:	15.31(e)	Air Temperature:	20.3° C
Test Results:	Complies	Relative Humidity:	48%

3.06V (-15%)



Date: 25.JAN.2017 14:37:02

4.14V (+15%)


Date: 25.JAN.2017 14:38:33



10 FCC Part 15.247(d) – CONDUCTED SPURIOUS EMISSIONS

The following tests were performed to demonstrate compliance.

RF Antenna Conducted Test

The EUT antenna port was fitted with an SMA connector and directly connected to the input of the spectrum analyzer.

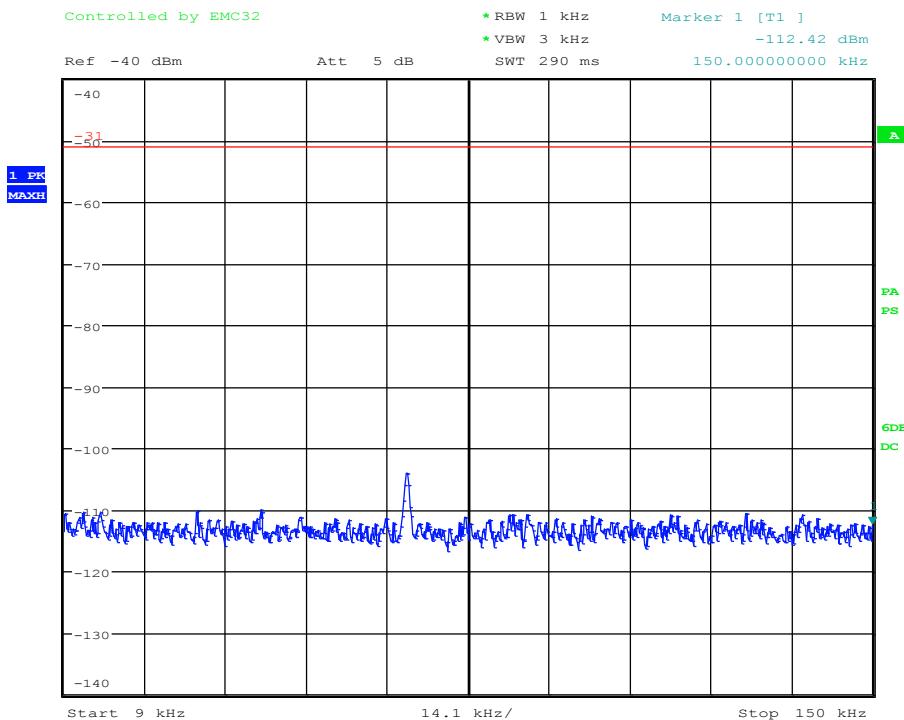
10.1 Requirements:

All Spurious Emissions must be at least 20dB down from the highest emission level measured within the authorized band up through the tenth harmonic. Additionally, 20dB down points were measured for the low and high channels to verify band edge compliance.

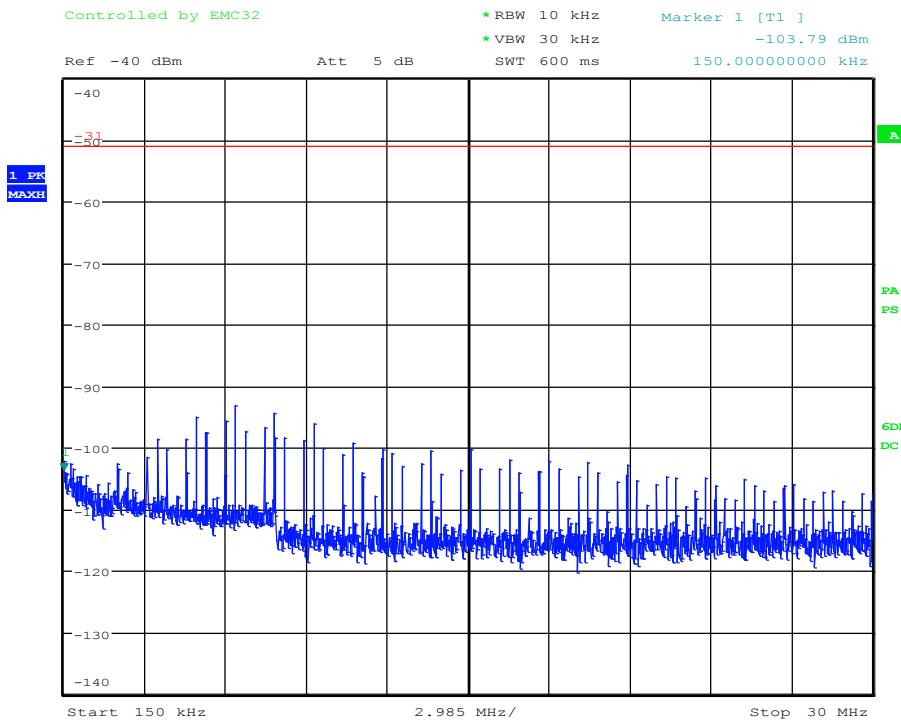
10.2 Conducted Spurious Emissions Test Data

Test Date:	Dec. 2, 2016	Test Engineer:	J. Knepper
Standards:	CFR 47 Part 15.247(d) / Part 15.207 KDB558074	Air Temperature:	21.2°C
		Relative Humidity:	47%

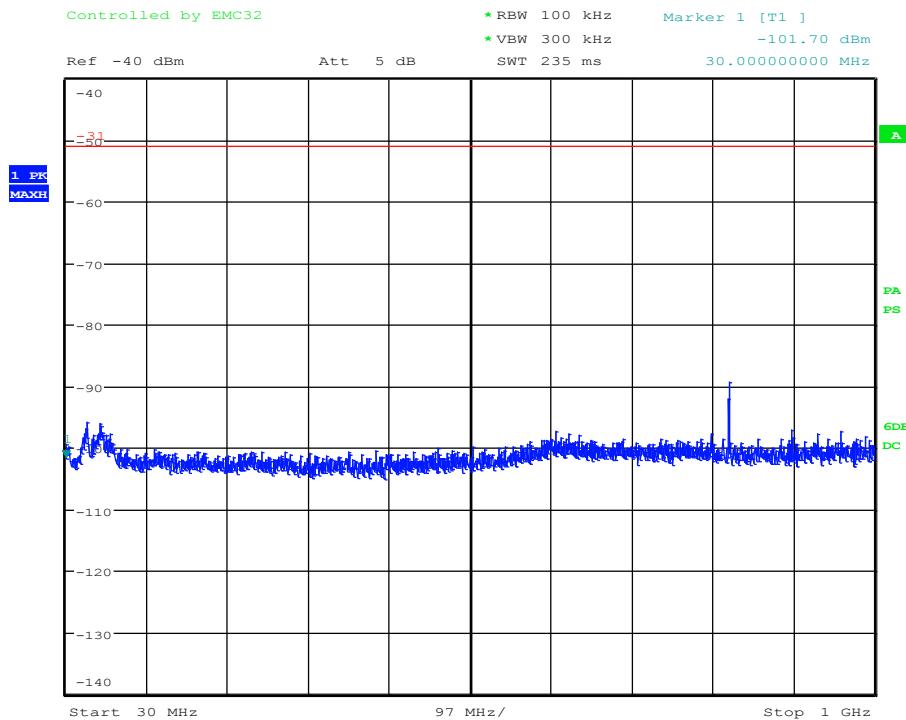
2.44 GHz: 9kHz to 150kHz



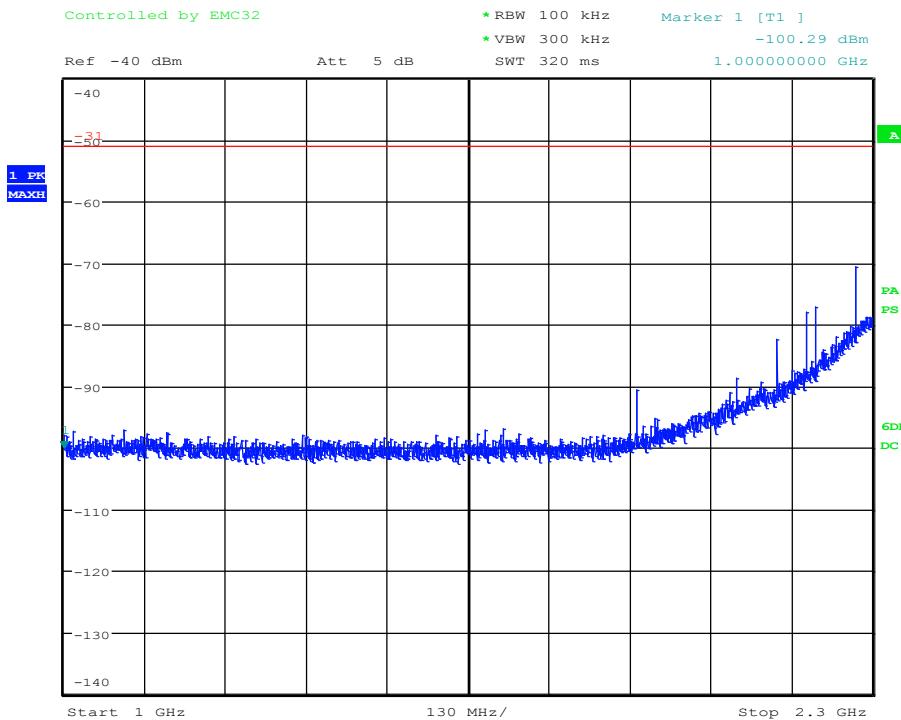
Date: 2.DEC.2016 13:22:35

2.44 GHz: 150kHz to 30 MHz


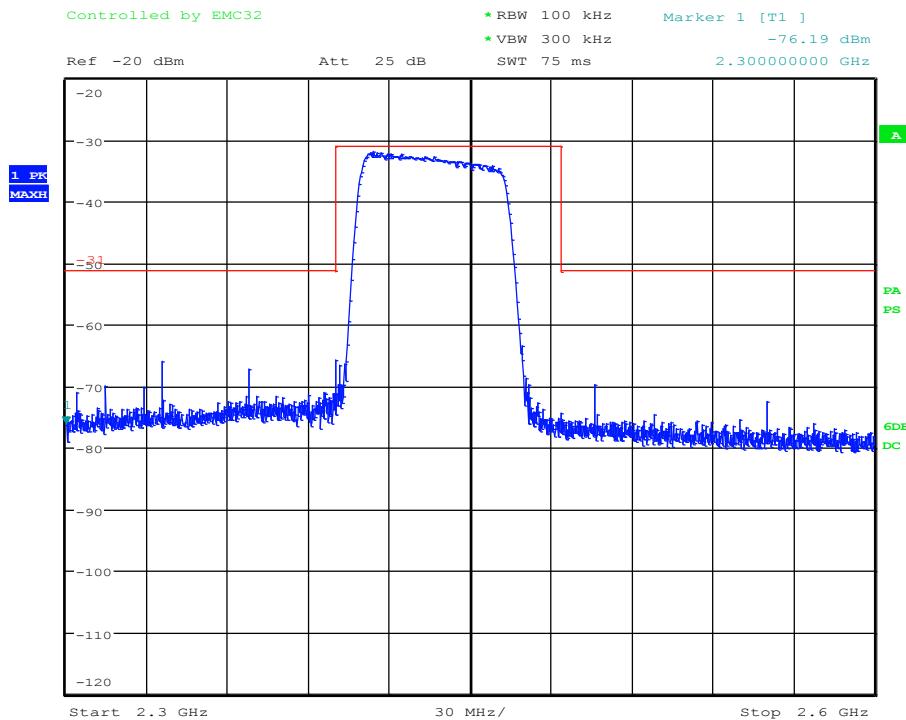
Date: 2.DEC.2016 13:22:59

2.44 GHz: 30 MHz to 1 GHz

Date: 2.DEC.2016 13:23:20

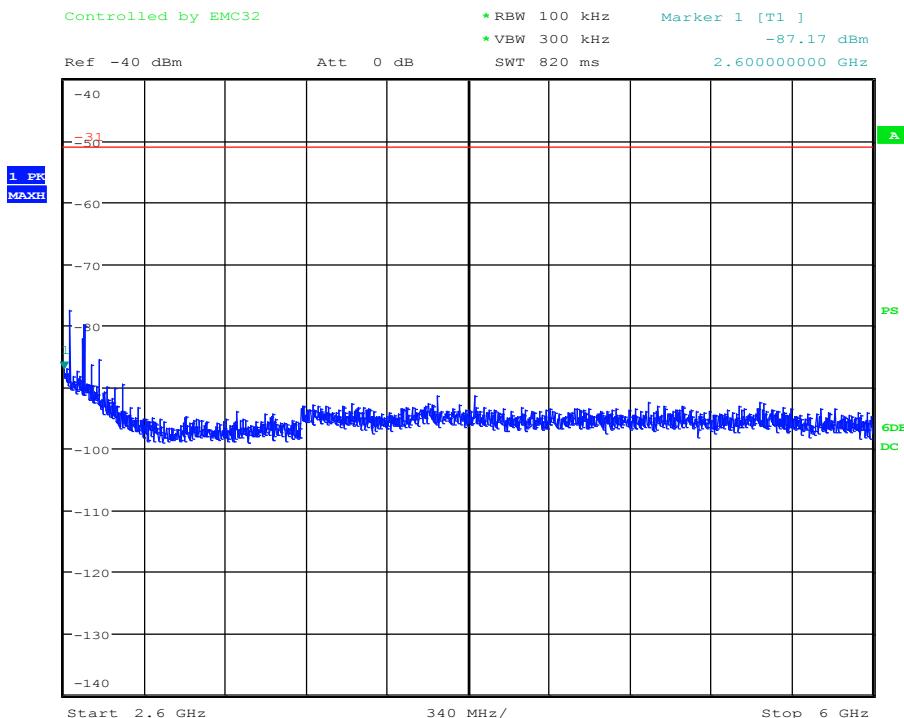
2.44 GHz: 1 GHz to 2.3 GHz

Date: 2.DEC.2016 13:23:33

2.44 GHz: 2.3 GHz to 2.6 GHz

Date: 2.DEC.2016 13:23:48

2.44 GHz: 2.6 GHz to 6 GHz



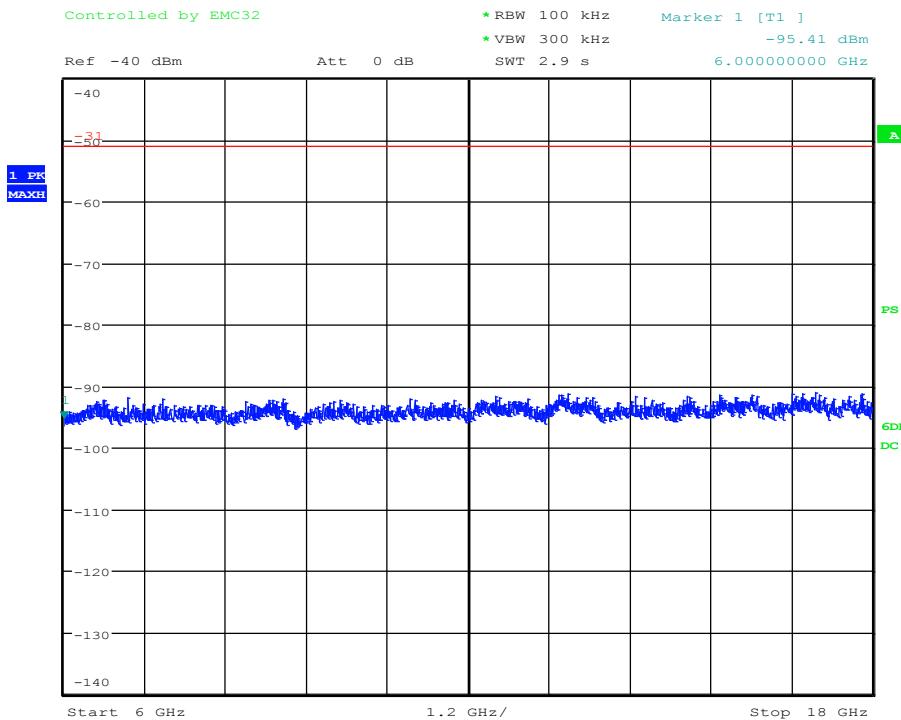
Date: 2.DEC.2016 13:24:15



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Client: Harsco Rail
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2.44 GHz: 6 GHz to 18 GHz



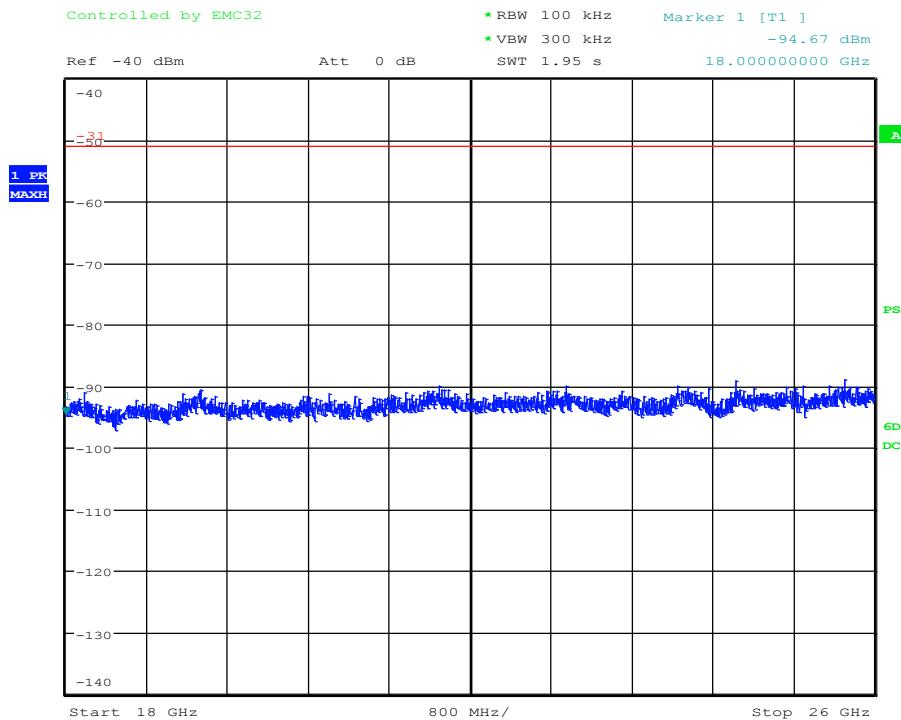
Date: 2.DEC.2016 13:24:46

051816

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2.44 GHz: 18 GHz to 26 GHz

Date: 2.DEC.2016 13:25:05



Order Number: F2LQ9197

Client: Harsco Rail

Model: PT-704

11 RADIATED SPURIOUS EMISSION

The EUT antenna port was fitted with its 5dBi external antenna. Radiated emissions were measured in a Semi-Anechoic Chamber. Each of the three orthogonal positions were examined to determine worst case, and was put in that position for measurements. All emissions generated that fall in the restricted bands per FCC Part 15.205 were examined.

11.1 Requirements:

All emissions that fall in the restricted bands defined in FCC Part 15.205 shall not exceed the maximum field strength listed in FCC Part 15.209(a).



11.2 Radiated Spurious Emission Test Data

Test Date(s):	Nov. 29, 2016	Test Engineer:	J. Knepper
Standards:	CFR 47 Part 15.247(d); Part 15.209 / KDB558074	Air Temperature:	21.2°C
		Relative Humidity:	48%

The equipment was fully exercised with all cabling attached to the EUT and was positioned in a 3-meter semi-anechoic chamber and was rotated through all three orthogonal axes for maximum emissions. While the equipment was energized, the receiving antenna was scanned from 1.0 meter to 4.0 meters in both vertical and horizontal polarities for frequencies above 30MHz, and all three orientations of the loop antenna were scanned to determine worst case emission while the turntable was adjusted 360 degrees to determine the maximum field strength. The tables of measured results can be found below.

Some of the frequencies did not change with the EUT on or off. At those frequencies, the test distance was shortened to 1 meter and still no emissions from the EUT were visible or over the ambient or limit.



Order Number: F2LQ9197

Client: Harsco Rail

Model: PT-704

Measurements

MaxPeak

Frequency (MHz)	Antenna Polarization	Reading (dB μ V)	Cable Loss & Antenna Factor (dB)	Emission (dB μ V/m)	Limit (dB μ V/m)	Margin (dB)
2390.000000	V	35.3	-4.4	30.90	74.0	-43.1
2483.500000	V	36.0	-4.2	31.80	74.0	-42.2
2483.500000	H	35.7	-4.2	31.50	74.0	-42.5
2390.000000	H	35.8	-4.4	31.40	74.0	-42.6

Average

Frequency (MHz)	Antenna Polarization	Reading (dB μ V)	Cable Loss & Antenna Factor (dB)	Emission (dB μ V/m)	Limit (dB μ V/m)	Margin (dB)
2390.000000	V	22.3	-4.4	17.90	54.0	-36.1
2483.500000	V	22.2	-4.2	18.00	54.0	-36.0
2483.500000	H	22.4	-4.2	18.20	54.0	-35.8
2390.000000	H	22.9	-4.4	18.50	54.0	-35.5

QuasiPeak

Frequency (MHz)	Antenna Polarization	Antenna Height (cm)	Azimuth (degrees)	Reading (dB μ V)	Cable Loss & Antenna Factor (dB)	Emission (dB μ V/m)	Limit (dB μ V/m)	Margin (dB)
37.480000	V	100.00	0.00	-3.0	16.1	13.10	40.0	-26.9
73.280000	H	100.00	0.00	23.2	10.6	33.80	40.0	-6.2
75.200000	V	100.00	155.00	9.8	9.9	19.70	40.0	-20.3
108.000000	V	100.00	0.00	1.7	15.7	17.40	43.5	-26.1
137.440000	H	100.00	0.00	2.8	16.7	19.50	43.5	-24.0
149.920000	H	100.00	171.00	16.5	16.0	32.50	43.5	-11.0
169.920000	V	100.00	0.00	-3.3	16.4	13.10	43.5	-30.4
257.560000	V	100.00	0.00	4.2	17.7	21.90	46.0	-24.1
614.000000	H	100.00	0.00	-2.2	26.8	24.60	46.0	-21.4
960.000000	H	100.00	0.00	-1.9	33.0	31.10	54.0	-22.9
960.000000	V	100.00	0.00	-1.9	32.4	30.50	46.0	-15.5



12 FCC PART 15.247(e) – PEAK POWER SPECTRAL DENSITY (PSD)

Peak power spectral density measurements were performed.

12.1 Requirements:

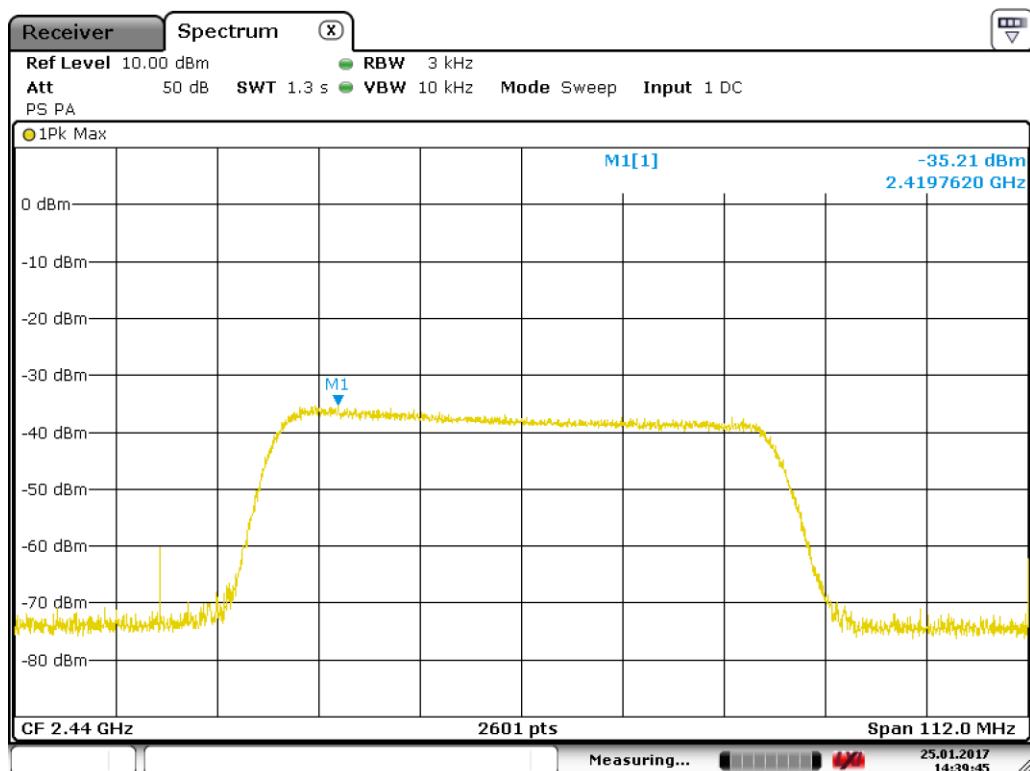
The peak power spectral density shall not exceed +8dBm in any 3 kHz band during any time interval of continuous transmission.

Power spectral density measurements were performed at a resolution bandwidth of 3 kHz (video bandwidth set at 10 KHz).

12.2 Peak Power Spectral Density Test Data

Test Date(s):	Nov. 29, 2016	Test Engineer:	J. Knepper
Standards:	CFR 47 Part 15.247(e); KDB558074	Air Temperature:	20.5°C
		Relative Humidity:	46%

2.44 GHz



Date: 25.JAN.2017 14:39:45



13 CONDUCTED EMISSIONS

13.1 Requirements

In accordance with FCC CFR 47 Part 15.207(a), "Except as shown in paragraphs (b) and (c) of this section, for an intentional radiator that is designed to be connected to the public utility (AC) power line, the radio frequency voltage that is conducted back onto the AC power line on any frequency or frequencies, within the band 150 kHz to 30 MHz, shall not exceed the limits in the following table, as measured using a 50 μ H/50 ohms line impedance stabilization network (LISN). Compliance with the provisions of this paragraph shall be based on the measurement of the radio frequency voltage between each power line and ground at the power terminal. The lower limit applies at the boundary between the frequency ranges.

Frequency of Emission (MHz)	Conducted Limit (dB μ V)	
	Quasi-peak	Average
0.15-0.5	66 to 56*	56 to 46*
0.5-5	56	46
5-30	60	50

*Decreases with the logarithm of the frequency.

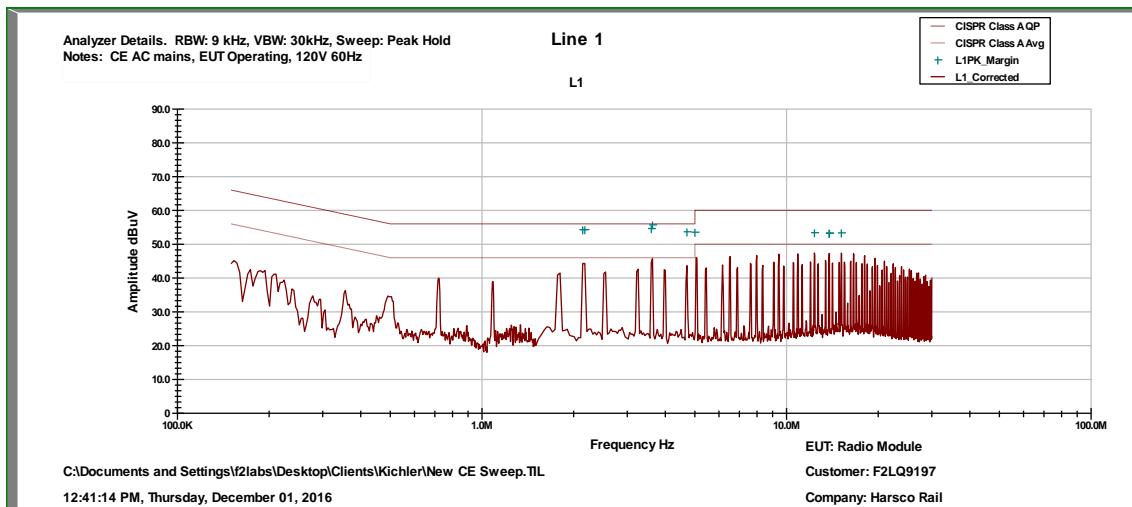
13.2 Procedure

The EUT was placed on a 1.0 x 1.5 meter non-conductive table, 0.8 meter above a horizontal ground plane and 0.4 meter from a vertical ground plane. Power was provided to the EUT through a LISN bonded to a 3 x 2 meter ground plane. The LISN and peripherals were supplied power through a filtered AC power source. The output of the LISN was connected to the input of the receiver via a transient limiter, and emissions in the range 150 kHz to 30 MHz were measured. The measurements were recorded using the quasi-peak and average detectors as directed by the standard, and the resolution bandwidth during testing was 9 kHz. The raw measurements were corrected to allow for attenuation from the LISN, transient limiter and cables.

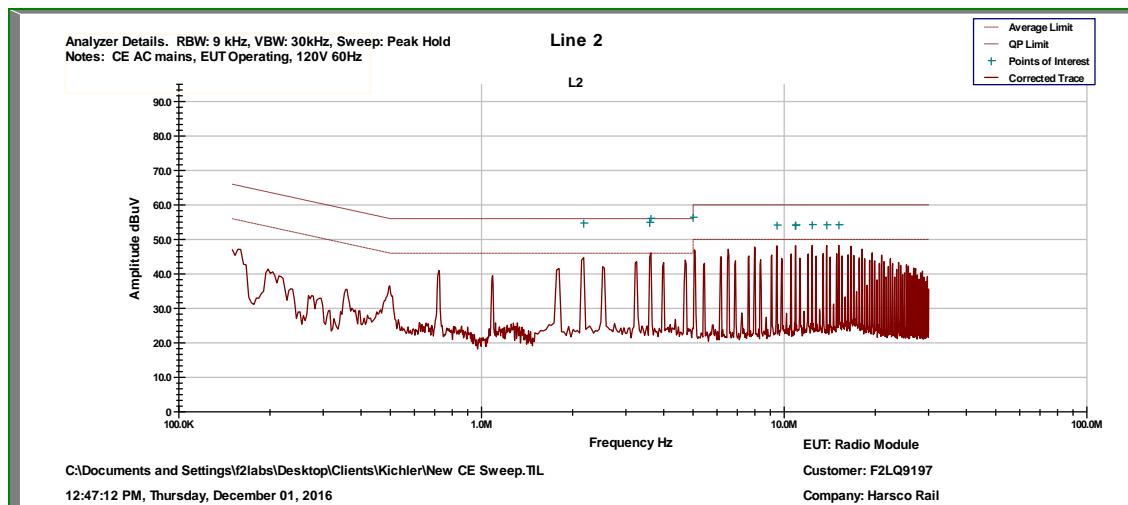
13.3 Conducted Emissions Test Data

Test Date:	Dec. 1, 2016	Test Engineer:	J. Knepper
Rule:	15.207	Air Temperature:	21.2° C
Test Results:	Complies	Relative Humidity:	48%

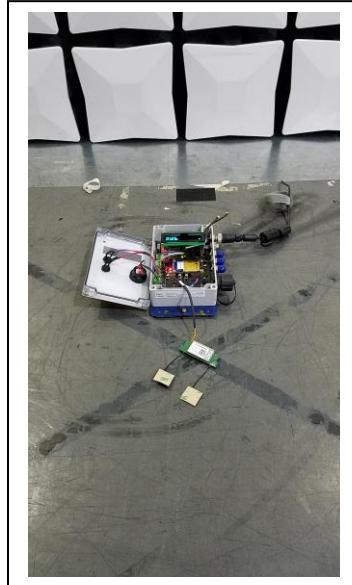
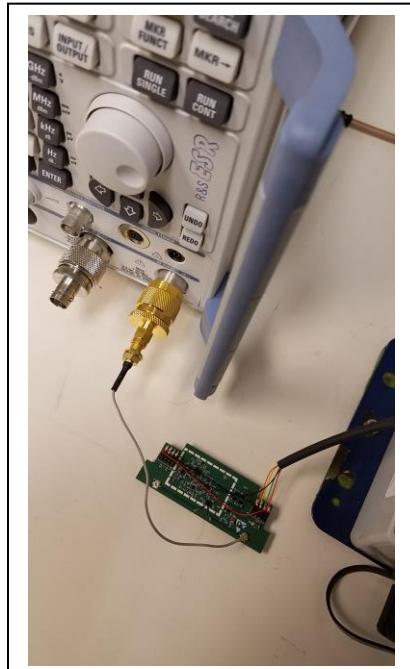
Conducted Test – Line 1: 0.15 MHz to 30.0 MHz



Top Discrete Measurements								
No.	Conductor	Frequency (MHz)	Detector	Level (dB μ V)	Adjustment (dB)	Results (dB μ V)	Limit (dB μ V)	Margin (dB)
1	Line 1	2.14125	Quasi-Peak	11.040	11.000	22.040	56.0	-33.960
		2.14125	Average	2.550	11.000	13.550	46.0	-32.450
2	Line 1	2.175	Quasi-Peak	13.980	11.000	24.980	56.0	-31.02
		2.175	Average	11.343	11.000	22.343	46.0	-23.657
3	Line 1	3.5925	Quasi-Peak	11.630	11.000	22.630	56.0	-33.370
		3.5925	Average	7.855	11.000	18.855	46.0	-27.145
4	Line 1	3.62625	Quasi-Peak	7.570	11.000	18.570	56.0	-37.43
		3.62625	Average	1.838	11.000	12.838	46.0	-33.162
5	Line 1	4.70625	Quasi-Peak	7.570	11.000	18.570	56.0	-37.430
		4.70625	Average	2.610	11.000	13.610	46.0	-32.390
6	Line 1	5	Quasi-Peak	6.770	10.585	17.355	56.0	-38.645
		5	Average	0.407	10.585	10.992	46.0	-35.008
7	Line 1	12.3337	Quasi-Peak	9.540	10.786	20.326	60.0	-39.674
		12.3337	Average	3.255	10.786	14.041	50.0	-35.959
8	Line 1	13.785	Quasi-Peak	9.610	10.903	20.513	60.0	-39.487
		13.785	Average	3.835	10.903	14.738	50.0	-35.262
9	Line 1	13.8188	Quasi-Peak	8.860	10.906	19.766	60.0	-40.234
		13.8188	Average	2.530	10.906	13.436	50.0	-36.564
10	Line 1	15.1125	Quasi-Peak	8.070	11.085	19.155	60.0	-40.845
		15.1125	Average	2.075	11.085	13.160	50.0	-36.840

Conducted Test – Line 2: 0.15 MHz to 30.0 MHz


Top Discrete Measurements								
No.	Conductor	Frequency (MHz)	Detector	Level (dB μ V)	Adjustment (dB)	Results (dB μ V)	Limit (dB μ V)	Margin (dB)
1	Line 2	2.175	Quasi-Peak	17.760	11.000	28.760	56.000	-27.240
		2.175	Average	16.175	11.000	27.175	46.000	-18.825
2	Line 2	3.5925	Quasi-Peak	9.350	11.000	20.350	56.000	-35.650
		3.5925	Average	4.510	11.000	15.510	46.000	-30.490
3	Line 2	3.62625	Quasi-Peak	9.080	11.000	20.080	56.000	-35.920
		3.62625	Average	4.560	11.000	15.560	46.000	-30.440
4	Line 2	5	Quasi-Peak	7.060	10.585	17.645	56.000	-38.355
		5	Average	1.080	10.585	11.665	46.000	-34.335
5	Line 2	9.465	Quasi-Peak	8.180	10.641	18.821	60.000	-41.18
		9.465	Average	2.245	10.641	12.886	50.000	-37.114
6	Line 2	10.8825	Quasi-Peak	8.570	10.676	19.246	60.000	-40.754
		10.8825	Average	2.665	10.676	13.341	50.000	-36.659
7	Line 2	10.9163	Quasi-Peak	8.850	10.677	19.527	60.000	-40.473
		10.9163	Average	3.135	10.677	13.812	50.000	-36.188
8	Line 2	12.3675	Quasi-Peak	8.560	10.789	19.349	60.0	-40.651
		12.3675	Average	3.133	10.789	13.922	50.0	-36.078
9	Line 2	13.8188	Quasi-Peak	8.920	10.906	19.826	60.0	-40.174
		13.8188	Average	3.030	10.906	13.936	50.0	-36.064
10	Line 2	15.15	Quasi-Peak	16.260	11.094	27.354	60.0	-32.646
		15.15	Average	11.943	11.094	23.037	50.0	-26.963

14 PHOTOGRAHPS/EXHIBITS – PRODUCT PHOTOS, TEST SETUPS**Radiated Spurious Emission with 5dBi External Antenna****Conducted Output Power, Peak Power Spectral Density,
Occupied Bandwidth, Voltage Variations and Conducted Spurious Emissions**

Conducted Emissions