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Measured Radio Frequency Emissions
From

DELPHI Bluetooth Transceiver
FCC ID: L2C0052TR
IC: 3234A-0052TR

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Summary
Tests for compliance with FCC Regulations, CFR 47, Part 15 and with Industry Canada RSS-210/Gen, were performed on a Delphi, FCC ID: L2C0052TR, IC: 3432A-0052TR. This device under test (DUT) is subject to the rules and regulations as a Transceiver.

In testing completed on February 22, 2013, the DUT tested met the allowed specifications for radiated emissions by 11.9 dB. AC Power line conducted emissions are not subject to regulation as the DUT is powered by a 12 VDC vehicular power system.

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1 Introduction

This Delphi Transceiver was tested for compliance with FCC Regulations, Part 15, adopted under Docket 87-389, April 18, 1989 as subsequently amended, and with Industry Canada RSS-210/Gen, Issue 8. Tests were performed at the University of Michigan Radiation Laboratory Willow Run Test Range following the procedures described in ANSI C63.4-2003 "Methods of Measurement of Radio-Noise Emissions from Low-Voltage Electrical and Electronic Equipment in the Range of 9 kHz to 40 GHz" and FCC Public Notice DA 00-705. The Site description and attenuation characteristics of the Open Site facility are on file with FCC Laboratory, Columbia, Maryland (FCC Reg. No: 91050) and with Industry Canada, Ottawa, ON (File Ref. No: IC 2057A-1).

2 Test Procedure and Equipment Used

The pertinent test equipment commonly used in our facility for measurements is listed in Table 2.1 below. The middle column identifies the specific equipment used in these tests. The quality system employed at the University of Michigan Radiation Laboratory Willow Run Test Range has been established to ensure all equipment has a clearly identifiable classification, calibration expiry date, and that all calibrations are traceable to national standards.

Table 2.1 Test Equipment.

Test Instrument	Used	Manufacturer/Model	Q Number
Spectrum Analyzer (9kHz-26GHz)	X	Hewlett-Packard 8593E, SN: 3412A01131	HP8593E1
Spectrum Analyzer (9kHz-6.5GHz)	X	Hewlett-Packard 8595E, SN: 3543A01546	JDB8595E
Power Meter		Hewlett-Packard, 432A	HP432A1
Harmonic Mixer (26-40 GHz)		Hewlett-Packard 11970A, SN: 3003A08327	HP11970A1
Harmonic Mixer (40-60 GHz)		Hewlett-Packard 11970U, SN: 2332A00500	HP11970U1
Harmonic Mixer (75-110 GHz)		Hewlett-Packard 11970W, SN: 2521A00179	HP11970W1
Harmonic Mixer (140-220 GHz)		Pacific Millimeter Prod., GMA, SN: 26	PMPGMA1
S-Band Std. Gain Horn	X	S/A, Model SGH-2.6	SBAND1
C-Band Std. Gain Horn	X	University of Michigan, NRL design	CBAND1
XN-Band Std. Gain Horn	X	University of Michigan, NRL design	XNBAND1
X-Band Std. Gain Horn		S/A, Model 12-8.2	XBAND1
X-band horn (8.2- 12.4 GHz)		Narda 640	XBAND2
X-band horn (8.2- 12.4 GHz)	X	Scientific Atlanta , 12-8.2, SN: 730	XBAND3
K-band horn (18-26.5 GHz)	X	FXR, Inc., K638KF	KBAND1
Ka-band horn (26.5-40 GHz)		FXR, Inc., U638A	KABAND1
U-band horn (40-60 GHz)		Custom Microwave, HO19	UBAND1
W-band horn(75-110 GHz)		Custom Microwave, HO10	WBAND1
G-band horn (140-220 GHz)		Custom Microwave, HO5R	GBAND1
Bicone Antenna (30-250 MHz)	X	University of Michigan, RLBC-1	LBBIC1
Bicone Antenna (200-1000 MHz)	X	University of Michigan, RLBC-2	HBBIC1
Dipole Antenna Set (30-1000 MHz)	X	University of Michigan, RLDP-1,-2,-3	UMDIP1
Dipole Antenna Set (30-1000 MHz)		EMCO 3121C, SN: 992 (Ref. Antennas)	EMDIP1
Active Rod Antenna (30 Hz-50 MHz)		EMCO 3301B, SN: 3223	EMROD1
Active Loop Antenna (30 Hz-50 MHz)		EMCO 6502, SN:2855	EMLOOP1
Ridge-horn Antenna (300-5000 MHz)	X	University of Michigan	UMRH1
Amplifier (5-1000 MHz)	X	Avantek, A11-1, A25-1S	AVAMP1
Amplifier (5-4500 MHz)	X	Avantek	AVAMP2
Amplifier (4.5-13 GHz)	X	Avantek, AFT-12665	AVAMP3
Amplifier (6-16 GHz)		Trek	TRAMP1
Amplifier (16-26 GHz)	X	Avantek	AVAMP4
LISN Box		University of Michigan	UMLISN1
Signal Generator		Hewlett-Packard 8657B	HPSG1

3 Device Under Test

3.1 Description and Block Diagram

The DUT is a 2402-2480 MHz Bluetooth transceiver designed for automotive/vehicular applications, and as such it is powered by a 12 VDC source. For testing, a generic harness was provided by the manufacturer.

Device	[Make], Model	[S/N],P/N	EMC Consideration
Sample 1	[DELPHI], L2C0052TR	-	Normal Operating Sample
Sample 2	[DELPHI], L2C0052TR	-	Modified for conducted RF output

Cable	[Make], Model	Length	EMC Consideration
Harness	[DELPHI]	1.5 m	-

3.2 Variants & Samples

There is only a single variant of this module. Two samples were provided, one normal operating sample and a modified unit that had the internal antenna disabled and a short cable and SMA connector attached for conducted antenna measurement purposes. The DUT has only one SMT antenna on the PCB.

3.3 Modes of Operation

The different operating modes (data-mode, acquisition-mode) of a Bluetooth device do not influence the channel spacing or peak output power. There is only one transmitter which is driven by identical input parameters concerning these values. The tuner included in this application also contains broadcast receivers, which are subject to emissions verification testing. No other transceivers are employed within the DUT.

3.4 EMI Relevant Modifications

No modifications were made to the DUT by this laboratory during testing.

3.5 Exemptions

The DUT is permanently installed in a transportation vehicle. As such, digital emissions are exempt from regulation (per FCC 15.103(a) and IC correspondence on ICES-003).

4 Emission Limits

4.1 Radiated Emission Limits

Since the DUT is a spread spectrum device, wherein the radiated emissions are subject to emissions limits in the restricted bands The applicable frequencies, through ten harmonics, are given below in Table 4.1. Emission limits from digital circuitry are specified in Table 4.2.

Table 4.1. Tx. Radiated Emission Limits (FCC: 15.247/15.209; IC: RSS-210e A2.9).

Frequency (MHz)	Fundamental Ave. Elim (3m)		Spurious* Ave. Elim (3m)	
	(µV/m)	dB (µV/m)	(µV/m)	dB (µV/m)
2400-2483.5	---		---	
2310-2390 2483.5-2500 4500-5250	Restricted Bands		500	54.0
7250-7750 14470-14500 17700-21400 22010-23120 23600-24000	Restricted Bands		500	54.0

1) Emissions radiated outside of the specified frequency bands shall meet the general radiated emission limits in Section 15.209 (Class B).
2) Peak field strength of any emission above 1GHz shall not exceed the maximum permitted average limits specified above by more than 20 dB under any condition of modulation. (FCC 15.35)

Table 4.2. Spurious Emission Limits (FCC: 15.33, .35, .109/209; IC: RSS-210 2.7, T2)

Freq. (MHz)	Elim (3m) µV/m	Elim dB(µV/m)
30-88	100	40.0
88-216	150	43.5
216-960	200	46.0
960-2000	500	54.0

Note: Average readings apply above 1000 MHz (1 MHz BW), Quasi-Peak readings apply to 1000 MHz (120 kHz RBW), PRF of intentional emissions > 20 Hz for QPK to apply.

5 Measurement Procedures

5.1 Semi-Anechoic Chamber Radiated Emissions

To become familiar with the radiated emission behavior of the DUT, the device is first studied and measured in our shielded semi-anechoic chamber. In the chamber there is a set-up similar to that of an outdoor 3-meter site, with a turntable, an antenna mast, and a ground plane. Instrumentation includes spectrum analyzers and other equipment as needed.

The DUT is laid on the test table as shown in the included block diagram and/or photographs. A shielded loop antenna is employed when studying emissions from 9 kHz to 30 MHz. Above 30 MHz and below 250 MHz a biconical antenna is employed. Above 250 MHz a ridge or and standard gain horn antennas are used. The spectrum analyzer resolution and video bandwidths are set so as to measure the DUT emission without decreasing the emission bandwidth (EBW) of the device. Emissions are studied for all orientations (3-axes) of the DUT and all test antenna polarizations. In the chamber, spectrum and modulation characteristics of intentional carriers are recorded. Receiver spurious emissions are measured with an appropriate carrier signal applied. Associated test data is presented in subsequent sections.

5.2 Outdoor Radiated Emissions

After measurements are performed indoors, emissions on our outdoor 3-meter Open Area Test Site (OATS) are made, when applicable. If the DUT connects to auxiliary equipment and is table or floor standing, the configurations prescribed in ANSI C63.4 are employed. Alternatively, an on-table layout more representative of actual use may be employed if the resulting emissions appear to be worst-case in such a configuration. Any intentionally radiating elements are placed on the test table flat, on their side, and on their end (3-axes) and worst case emissions are recorded. For each configuration the DUT is rotated 360 degrees about its azimuth and the receive antenna is raised and lowered between 1 and 4 meters to maximize radiated emissions from the device. Receiver spurious emissions are measured with an appropriate carrier signal applied. For devices with intentional emissions below 30 MHz, our shielded loop antenna at a 1 meter receive height is used. Low frequency field extrapolation to the regulatory limit distance is employed as needed. Emissions between 30 MHz and 1 GHz are measured using tuned dipoles and/or biconical antennas. Care is taken to ensure that the RBW and VBW used meet the regulatory requirements, and that the EBW of the DUT is not reduced. The Photographs included in this report show the Test Setup.

5.3 Radiated Field Computations

To convert the dBm values measured on the spectrum analyzer to dB(μV/m), we use expression

$$E3(dB\mu V/m) = 107 + PR + KA - KG + KE - CF$$

where

PR	=	power recorded on spectrum analyzer, dBm, measured at 3 m
KA	=	antenna factor, dB/m
KG	=	pre-amplifier gain, including cable loss, dB
KE	=	duty correction factor, dB
CF	=	distance conversion (employed only if limits are specified at alternate distance), dB

When presenting the data at each frequency, the highest measured emission under all of the possible DUT orientations (3-axes) is given.

5.4 Indoor Power Line Conducted Emissions

When applicable, power line conducted emissions are measured in our semi-anechoic chamber. If the DUT connects to auxiliary equipment and is table or floor standing, the configurations prescribed in ANSI C63.4 are employed. Alternatively, an on-table layout more representative of actual use may be employed if the resulting emissions appear to be worst-case in such a configuration.

The conducted emissions measured with the spectrum analyzer and recorded (in dBμV) from 0-2 MHz and 2-30 MHz for both the ungrounded (Hi) and grounded (Lo) conductors. The spectrum analyzer is set to peak-hold mode in order to record the highest peak throughout the course of functional operation. Only when the emission exceeds or is near the limit are quasi-peak and average detection used.

5.5 Supply Voltage Variation

Measurements of the variation in the fundamental radiated emission were performed with the supply voltage varied by no less than 85% and 115% of the nominal rated value. For battery operated equipment, tests are performed using a new battery, and worst case emissions are re-checked with a new battery.

6 Test Results

6.1 Radiated Emissions

6.1.1 20 dB Bandwidth (15.247(a)(1)(ii))

For this test, the DUT was put in a test mode for continuous data transmission (hopping disabled). The DUT was placed in front of the horn antenna oriented for maximum radiation. The 20-dB bandwidth was measured for low, mid, and high channels used by the DUT employing the highest data rate modulation available. The resulting measured data is below, and plots are shown in Figure 6.1.

Channel	Frequency	20 dB BW
1	2.402 GHz	1250 kHz
39	2.441 GHz	1280 kHz
79	2.480 GHz	1285 kHz

6.1.2 Carrier Frequency Separation (15.247(a)(1))

For this test, the DUT was put in a test mode for data transmission (hopping enabled) with a minimum packet length. The DUT was placed in front of the horn antenna at the location of maximum radiation. The Carrier Frequency Separation was measured for low, mid, and high channels used by the DUT. A minimum carrier separation of 25 kHz, or two-thirds of the 20 dB bandwidth of the hopping channel, whichever is greater, is required. The resulting measured data is below, and plots are shown in Figure 6.2.

Channel	Frequency	Separation	Limit (min)
1-2	2.402-2.403 GHz	1025 kHz	833.3 kHz
39	2.440-2.441 GHz	985 kHz	853.3 kHz
79	2.479-2.480 GHz	1005 kHz	886.7 kHz

6.1.3 Number of Hopping Frequencies (15.247(a)(1)(ii))

For this test, the DUT was put in a test mode for data transmission (hopping enabled). The DUT was placed in front of the horn antenna at the location of maximum radiation. The total number of hopping channels must be 75 or greater. The number of measured channels is below, and are shown in Figure 6.3.

Frequency Range	Number of Channels	Total	Limit
2402.0 – 2429.5	28		
2429.5 – 2454.5	25	79	>75
2455.0 – 2483.5	26		

6.1.4 Single-Channel Dwell Time (15.247(a)(1)(ii)) and Peak-to-Average Ratio (15.35(b))

For this test, the DUT was put in a test mode for data transmission (hopping enabled). The DUT was placed in front of the horn antenna at the location of maximum radiation. The limit for total average dwell time in a single channel must be less than 0.4 sec in a 31.6 sec (79 x 0.4 sec) period. The dwell time was measured at low, mid, and high channels and the results are listed below. Sample plots are shown in Figure 6.4.

Channel	Frequency	Num. Pulses	Active Time	Total	Limit (max)
1	2.402 GHz	345/31.6 sec	0.166 ms	0.0575 sec	0.4 sec
39	2.441 GHz	378/31.6 sec	0.166 ms	0.0627sec	0.4 sec
79	2.480 GHz	316/31.6 sec	0.166 ms	0.0525 sec	0.4 sec

The measured dwell time may not indicate the actual single channel dwell time of the DUT. A dwell time of 0.3797 seconds within a 30 second period in data mode is independent from the packet type (packet length) for all Bluetooth devices. Therefore, Bluetooth devices comply with the FCC dwell time requirements. Furthermore, the measured ratio between peak and average field strength is always greater than 20 dB for a Bluetooth device in a 100 ms window, and this was verified in our measurements.

6.1.5 Peak Output Power (15.247(b))

For this test, the DUT was put in a test mode for data transmission (hopping disabled). Peak power measurements were made using 3 MHz RBW and 3 MHz VBW on the Spectrum Analyzer. The power was measured from the RF port of DUT (a modified module was provided from the manufacturer for this purpose; the antenna is not generally removable). Table 6.1(b) presents the results. The maximum peak output power limit is 30dBm (1 Watt).

6.1.6 Potential Health Hazard EM Radiation Level

The following table summarizes the power density at a distance of 20 cm from the device as calculated from FCC OET Bulletin 65.

Table 6.3 Potential Health Hazard Radiation Level

Ant.	Ant.Gain (dBi)	Po (mW)	EIRP (mW)	S (mW/cm^2)
PCB	-2.5	1.48	0.832	0.00017

The following equations were used in calculating the operating distance (R).

$$EIRP(mW) = Po(mW) \cdot 10^{\frac{Gain(dB)}{10}} \quad \text{and} \quad S(mW/cm^2) = \frac{EIRP(mW)}{4 \cdot \Pi \cdot R(cm)^2}, \; R = 20 \text{ cm}$$

6.1.7 RF Antenna Spurious Emissions (15.247(c))

For this test, the DUT was put in a test mode for data transmission (hopping disabled). The spectrum analyzer was connected where the antenna attaches to the system. The frequency was swept from 0 to 25.6 GHz. The DUT was measured on the lowest, middle, and highest channels. See Figure 6.5. In all cases, the noise/spurious is at least 30 dB below the carrier. (Limit -20.0 dB below carrier).

6.1.8 Band Edge Emissions (15.247(c))

For this test, the DUT was put in a test both hopping and non-hopping test modes. The spectrum analyzer was connected where the antenna attaches to the system. The DUT was measured for low and high channels used in the system. Figures 6.6 and 6.7 show the band edge emissions, as summarized below.

Not Hopping	<u>Channel</u>	<u>Band Edge</u>	<u>Attenuation</u>	<u>Limit(max)</u>
	1	2400.0 MHz	45.8 dBc	> 20 dBc
	79	2483.5 MHz	47.7 dBc	> 20 dBc
Hopping	<u>Channel</u>	<u>Band Edge</u>	<u>Attenuation</u>	<u>Limit(max)</u>
	1	2400.0 MHz	46.7 dBc	> 20 dBc
	79	2483.5 MHz	42.1 dBc	> 20 dBc

6.2 Conducted Emissions

6.2.1 AC Power Line Conducted Emissions (FCC 15.270)

These tests do not apply, since the DUT is powered from a 12 VDC battery.

Table 6.1(a) Highest Emissions Measured

Restricted Band Radiated Emissions											Delphi BT Tuner; FCC/IC
#	Freq. MHz	Ant. Used	Ant. Pol.	Pr dBm	Det.* Used	Ka dB/m	Kg dB	E3** dBμV/m	E3lim dBμV/m	Pass dB	Comments
1	2390.0	Horn S	H/V	-77.2	Pk	21.5	- 1.5	32.8	54.0	21.2	Low Channel, 2402 MHz
2	2390.0	Horn S	H/V	-76.9	Pk	21.5	- 1.5	33.1	54.0	20.9	Mid Channel, 2441 MHz
3	2390.0	Horn S	H/V	-76.8	Pk	21.5	- 1.5	33.2	54.0	20.8	High Channel, 2480 MHz
4	2483.5	Horn S	H/V	-76.5	Pk	21.5	- 1.5	33.5	54.0	20.5	Low, noise
5	2483.5	Horn S	H/V	-75.9	Pk	21.5	- 1.5	34.1	54.0	19.9	Mid
6	2483.5	Horn S	H/V	-70.1	Pk	21.5	- 1.5	39.9	54.0	14.1	High
7	4804.0	Horn C	H/V	-65.1	Pk	24.6	16.3	30.2	54.0	23.8	Low
8	4882.0	Horn C	H/V	-65.4	Pk	24.6	15.9	30.3	54.0	23.7	Mid
9	4960.0	Horn C	H/V	-65.7	Pk	24.6	15.6	30.3	54.0	23.7	High
10	7206.0	Horn XN	H/V	-62.2	Pk	25.1	16.6	33.3	N/A	-	Low, noise
11	7323.0	Horn XN	H/V	-62.2	Pk	25.2	16.6	33.4	54.0	20.6	Mid, noise
12	7440.0	Horn XN	H/V	-62.3	Pk	25.3	16.6	33.4	54.0	20.6	High, noise
13	9608.0	Horn X	H/V	-63.3	Pk	27.8	15.4	36.1	N/A	-	Low, noise
14	9764.0	Horn X	H/V	-63.0	Pk	27.9	15.3	36.6	N/A	-	Mid, noise
15	9920.0	Horn X	H/V	-63.6	Pk	28.0	15.1	36.3	N/A	-	High, noise
16	12010.0	Horn X	H/V	-63.3	Pk	31.7	13.3	42.1	54.0	**11.9**	Low, noise
17	12205.0	Horn X	H/V	-64.0	Pk	31.8	13.2	41.6	54.0	12.4	Mid, noise
18	12400.0	Horn X	H/V	-63.9	Pk	32.0	13.2	41.8	54.0	12.2	High, noise
19	14412.0	Horn Ku	H/V	-63.3	Pk	33.2	13.8	43.0	N/A	-	Low, noise
20	14646.0	Horn Ku	H/V	-64.0	Pk	33.3	14.0	42.4	N/A	-	Mid, noise
21	14880.0	Horn Ku	H/V	-63.9	Pk	33.4	14.1	42.4	N/A	-	High, noise
22	16814.0	Horn Ku	H/V	-63.3	Pk	34.6	14.9	43.4	N/A	-	Low, noise
23	17087.0	Horn Ku	H/V	-64.0	Pk	34.8	14.9	43.0	N/A	-	Mid, noise
24	17360.0	Horn Ku	H/V	-63.9	Pk	35.0	14.8	43.2	N/A	-	High, noise
25	19216.0	Horn K	H/V	-63.5	Pk	32.2	32.0	23.7	54.0	30.3	Low, noise
26	19528.0	Horn K	H/V	-61.2	Pk	32.3	32.0	26.1	54.0	27.9	Mid, noise
27	19840.0	Horn K	H/V	-60.8	Pk	32.3	32.0	26.5	54.0	27.5	High, noise
28	21618.0	Horn K	H/V	-57.8	Pk	32.7	32.0	29.9	N/A	-	Low, noise
29	21969.0	Horn K	H/V	-55.2	Pk	32.8	32.0	32.6	N/A	-	Mid, noise
30	22320.0	Horn K	H/V	-55.1	Pk	32.8	32.0	32.7	54.0	21.3	High, noise
31	24020.0	Horn Ka	H/V	-55.7	Pk	33.2	32.0	32.5	N/A	-	Low, noise
32	24410.0	Horn Ka	H/V	-54.9	Pk	33.3	32.0	33.4	N/A	-	Mid, noise
33	24800.0	Horn Ka	H/V	-54.8	Pk	33.3	32.0	33.5	N/A	-	High, noise
34											
35	* Peak measured with 3 MHz RBW and 3 MHz VBW, Avg. more than 20 dB below Peak.										
36	** 20 dB maximum permissible duty cycle applied.										
37											

Meas. 02/19/2013; U of Mich.

Table 6.1(b) Highest Emissions Measured

Conducted Peak Output Power											Delphi BT Tuner; FCC/IC
#	Freq. MHz	Ant. Used	Ant. Pol.	Pr dBm	Det.* Used	Ka dB/m	Kg dB	P (Pk) dBm	Plim dBm	Pass dB	Comments
1	2402.0	Cond	H/V	1.30	Pk	0.0	0.0	1.3	30.0	28.7	Lowest channel, conducted
2	2441.0	Cond	H/V	1.10	Pk	0.0	0.0	1.1	30.0	28.9	Middle channel, conducted
3	2480.0	Cond	H/V	1.70	Pk	0.0	0.0	**1.7**	30.0	28.3	Highest channel, conducted
4											
Radiated Peak Power											
#	Freq. MHz	Ant. Used	Ant. Pol.	Pr dBm	Det.* Used	Ka dB/m	Kg dB	E3 (Pk) dBμV/m	EIRP (Pk) dBm	Comp. Antenna Gain dBi	Comments
5	2402.0	Horn S	H/V	-39.1	Pk	21.5	- 1.5	90.9	-4.3	- 5.6	Lowest channel, radiated
6	2441.0	Horn S	H/V	-36.2	Pk	21.5	- 1.5	93.8	-1.4	**- 2.5**	Middle channel, radiated
7	2480.0	Horn S	H/V	-36.2	Pk	21.5	- 1.5	93.8	**-1.4**	- 3.1	Highest channel, radiated
8	* Peak measured with 3 MHz RBW and 3 MHz VBW										
9, 10	Note: The different operating modes (data-mode, acquisition-mode) of this Bluetooth device do not influence the output power. There is only one transmitter which is driven by identical input with regard to this parameter.										
Spurious Emissions (Rx. and Tx.)											
#	Freq. MHz	Ant. Used	Ant. Pol.	Pr* dBm	Det.* Used	Ka dB/m	Kg dB	E3** dBμV/m	E3lim dBμV/m	**Pass** dB	Comments
11	1518.0	R-Horn	H/V	-65.8	Pk	21.3	28.1	34.5	54.0	19.5	max all, noise
12	1588.0	R-Horn	H/V	-65.9	Pk	21.5	28.1	34.5	54.0	19.5	max all, noise
13	1616.0	R-Horn	H/V	-64.3	Pk	21.6	28.1	36.2	54.0	17.8	max all, noise
14	1652.5	R-Horn	H/V	-64.8	Pk	21.7	28.1	35.8	54.0	18.2	max all, noise
15	1755.0	R-Horn	H/V	-65.1	Pk	21.9	28.1	35.7	54.0	18.3	max all, noise
16	1855.0	R-Horn	H/V	-66.1	Pk	22.1	28.1	34.9	54.0	19.1	max all, noise
17	1902.0	R-Horn	H/V	-67.4	Pk	22.3	28.1	33.7	54.0	20.3	max all, noise
18	2303.8	R-Horn	H/V	-67.2	Pk	23.3	26.4	36.7	54.0	17.3	max all, noise
19	2348.8	R-Horn	H/V	-67.5	Pk	23.4	26.4	36.5	54.0	17.5	max all, noise
20	3316.0	R-Horn	H/V	-68.5	Pk	26.4	23.3	41.6	54.0	**12.4**	max all, noise
21	3515.0	R-Horn	H/V	-69.9	Pk	27.0	23.2	40.9	54.0	13.1	max all, noise
22											
23											
24											
28											
29	* Note: Rx LO sweeps 1602-1656 MHz. Emissions below 1 GHz are considered Digital Emissions										
30											
Digital Radiated Emissions*											
#	Freq. kHz	Ant. Used	Ant. Pol.	Pr dBm	Det. Used	Ka dB/m	Kg dB	E3 dBμV/m	E3lim dBμV/m	Pass dB	Comments
28											
29											
30											
31	* For devices used in transportation vehicles, digital emissions are exempt per FCC 15.103(a), ICES-003/RSS-GEN										

Meas. 02/19/2013; U of Mich.

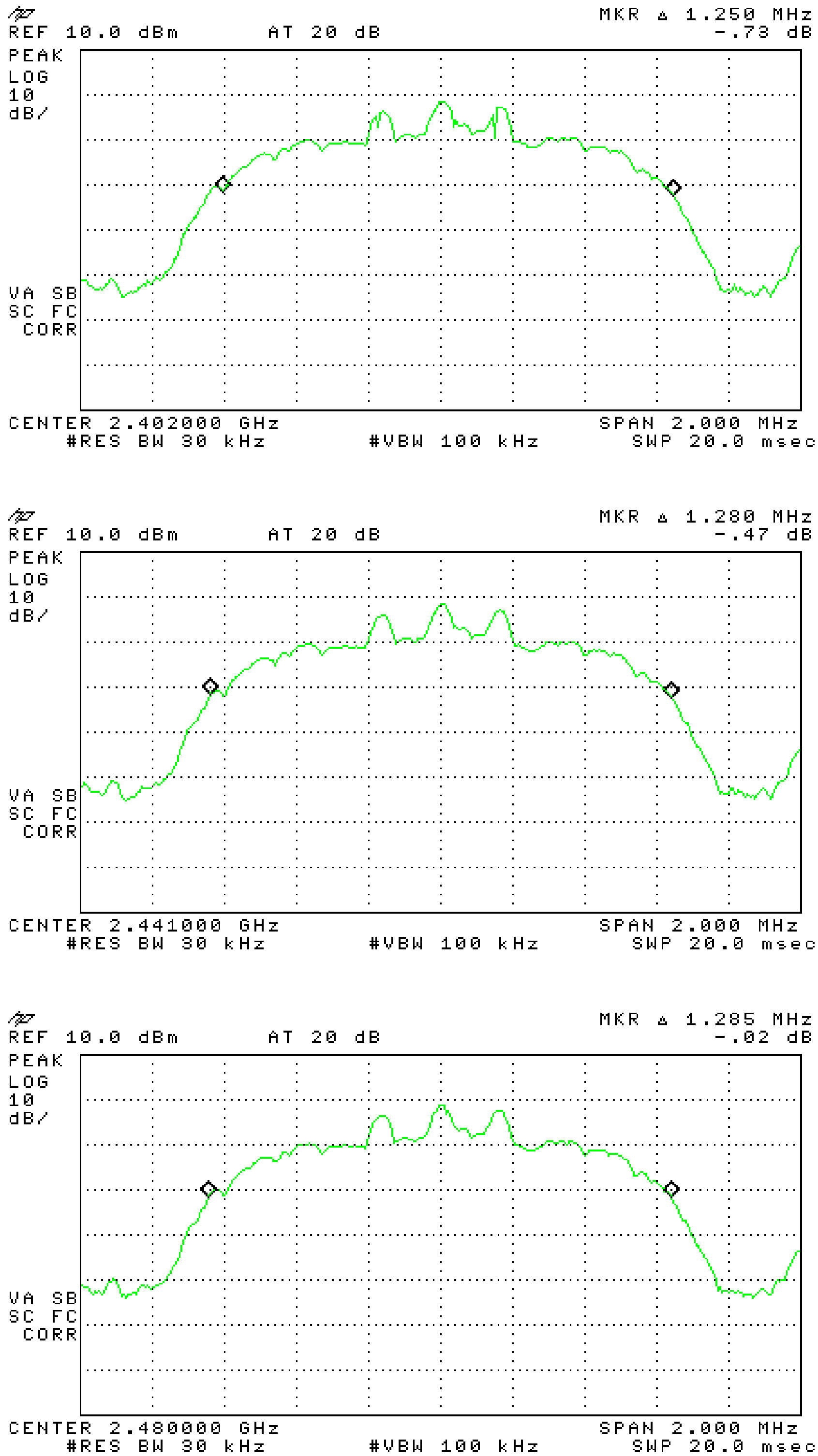


Figure 6.1 Measurement of channel 20 dB bandwidth. (top) Low Channel, (middle) Middle Channel, (bottom) High Channel

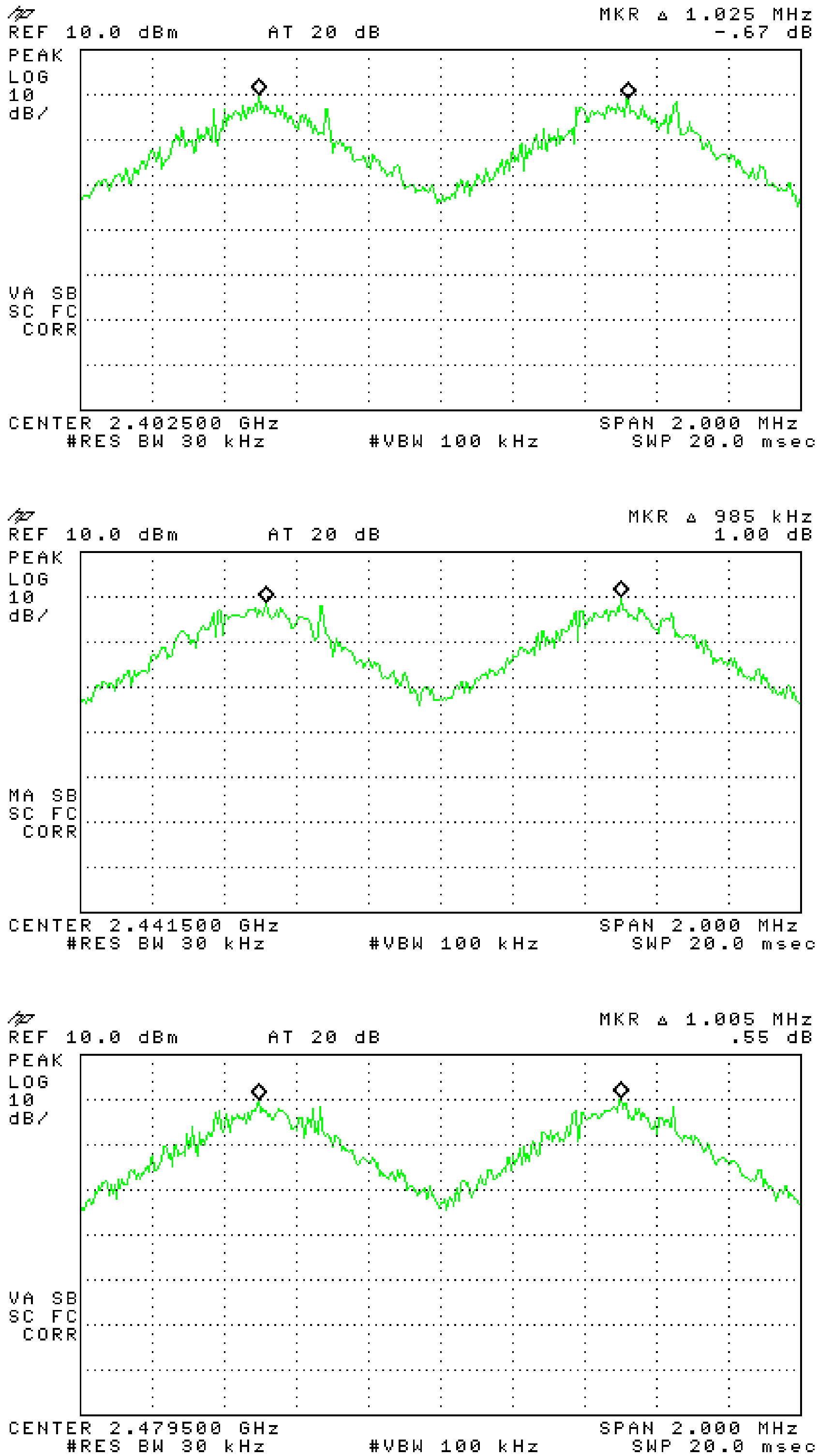
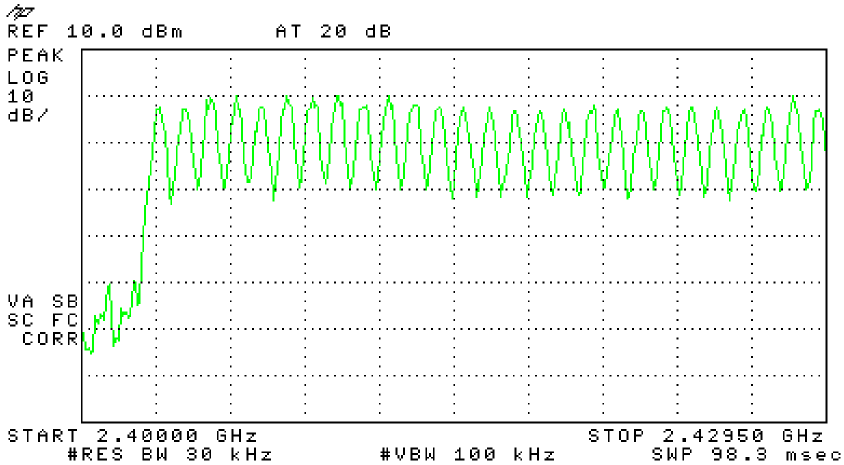
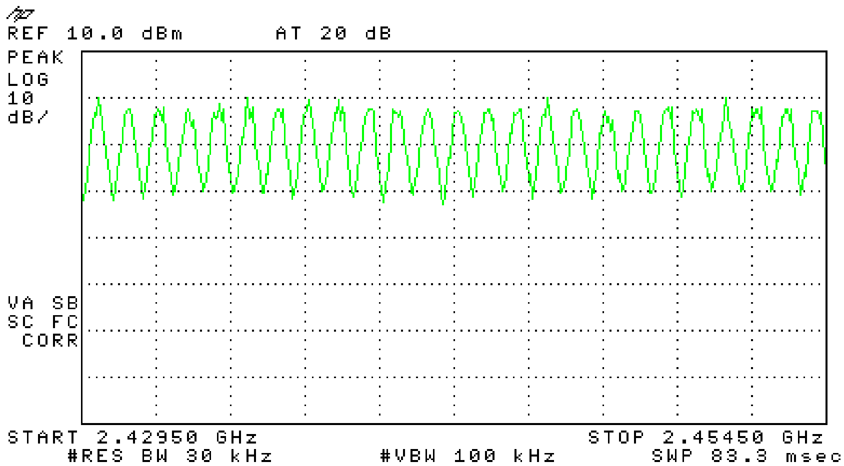


Figure 6.2 Carrier Frequency Separation.
(top) Low Channel, (middle) Middle Channel, (bottom) High Channel





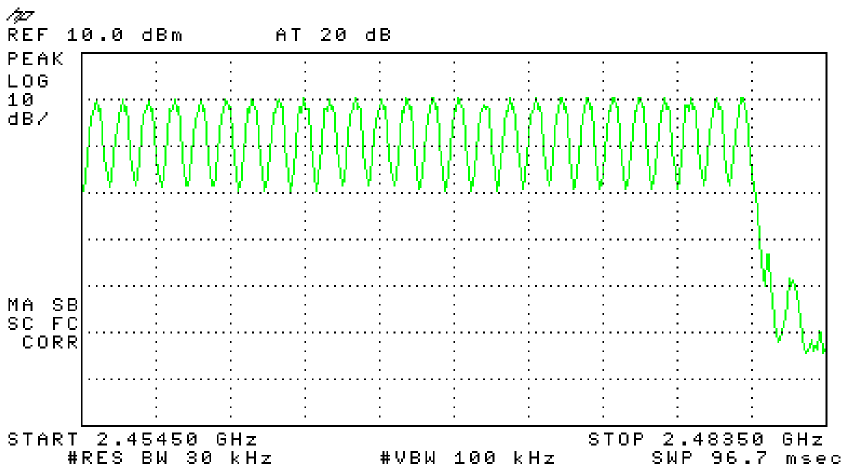
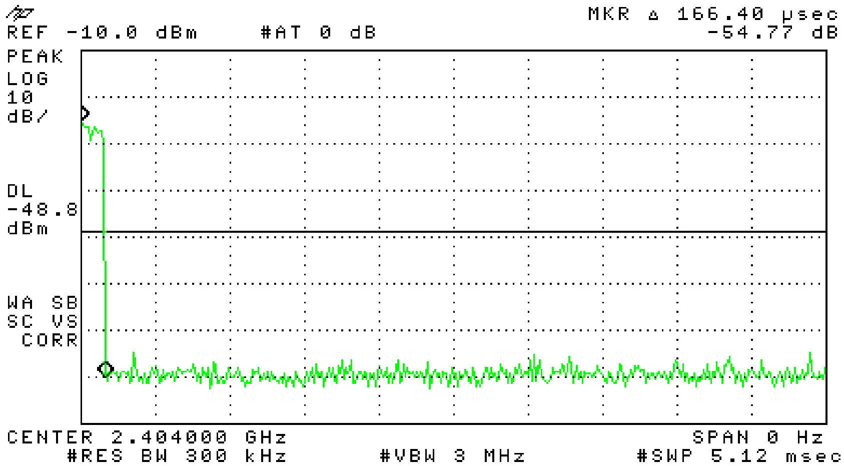


Figure 6.3 Number of Hopping Frequencies.
(top) low, (middle) middle, (bottom) high portion of band



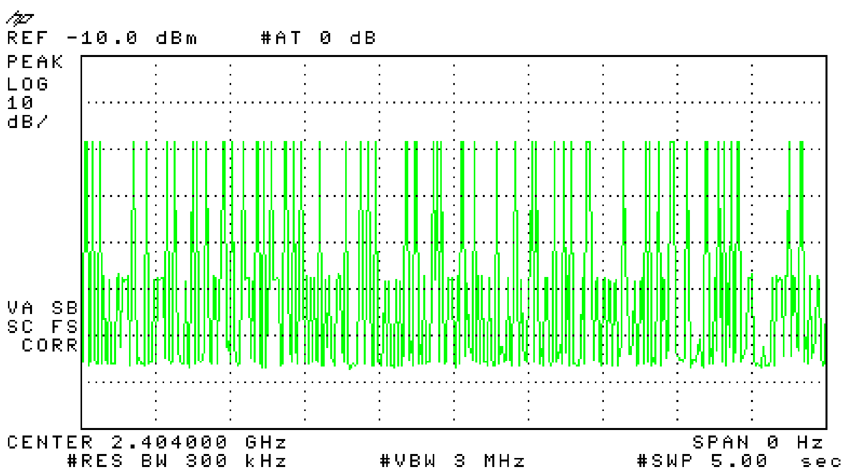
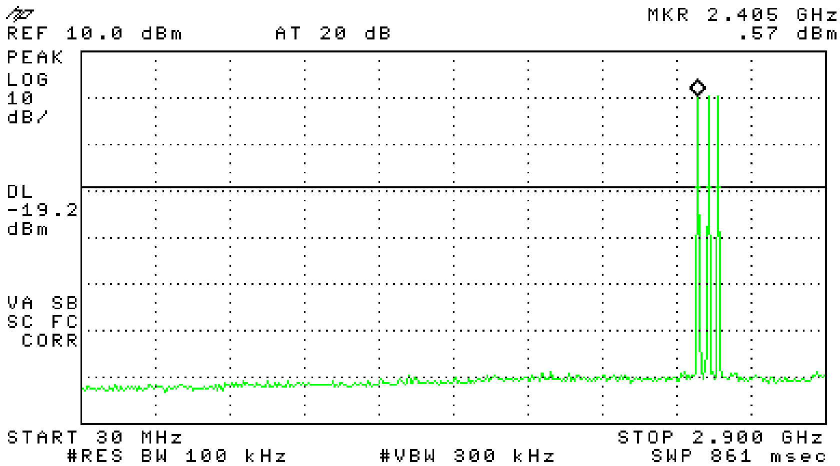
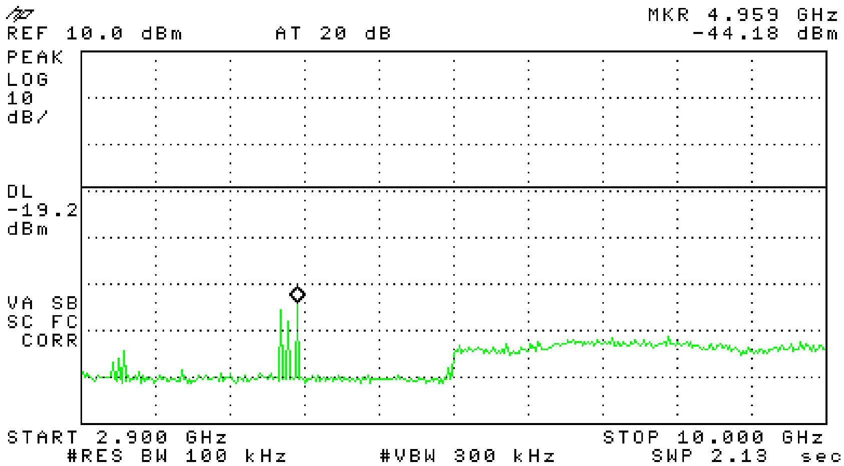


Figure 6.4 Single Channel Dwell Time. (top) Measured Pulse Width, (bottom) 1 of 7 5 second sample windows. (only represenatative plots shown)





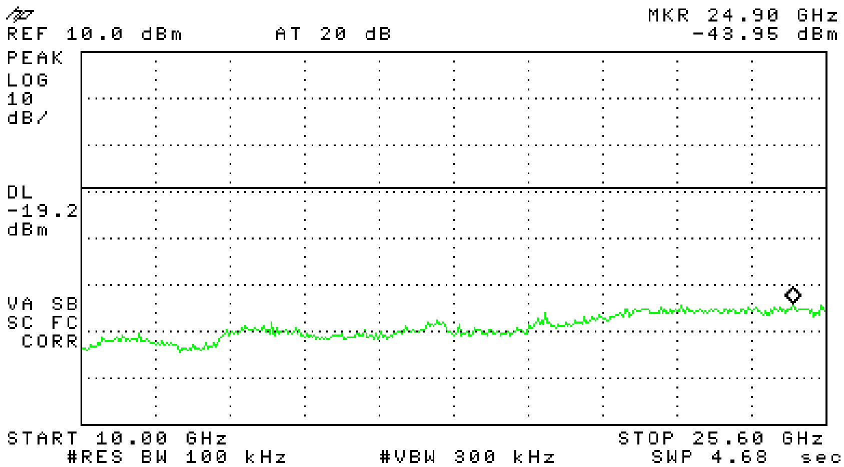
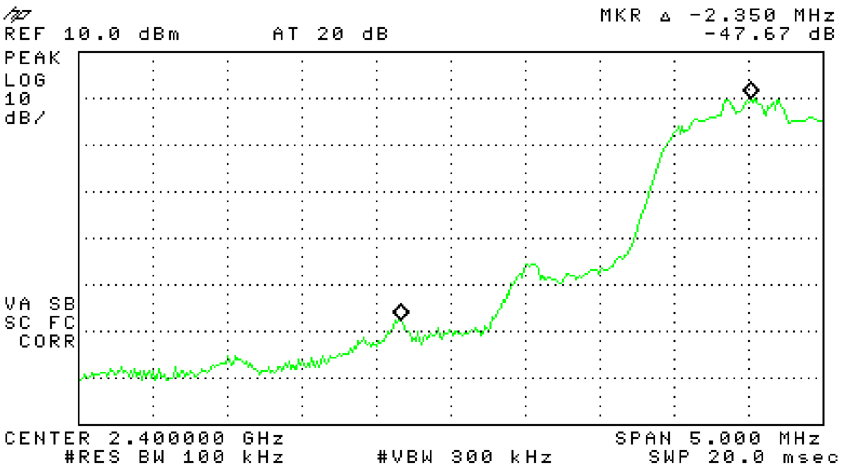


Figure 6.5 Antenna Conducted Spurious Emissions.
(low, mid, and high channels)



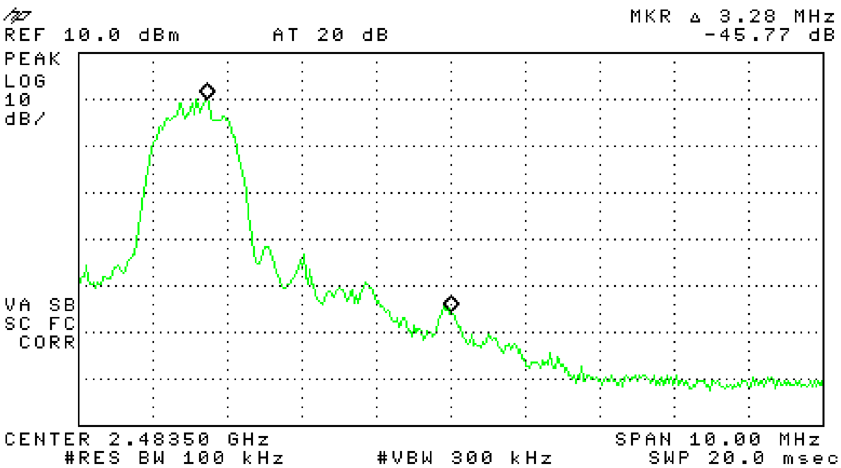


Figure 6.6 Band edge emissions – NOT HOPPING.
(top) Low Channel, (bottom) High Channel

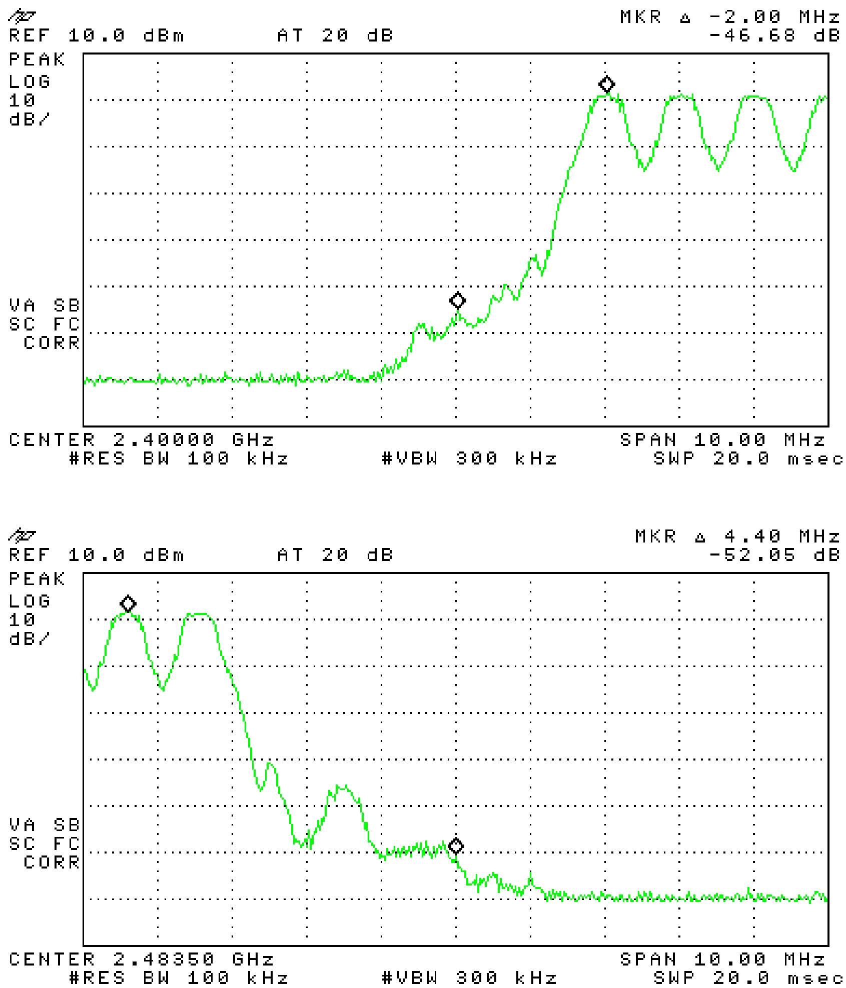


Figure 6.7 Band edge emissions - HOPPING.
(top) Low Channel, (bottom) High Channel

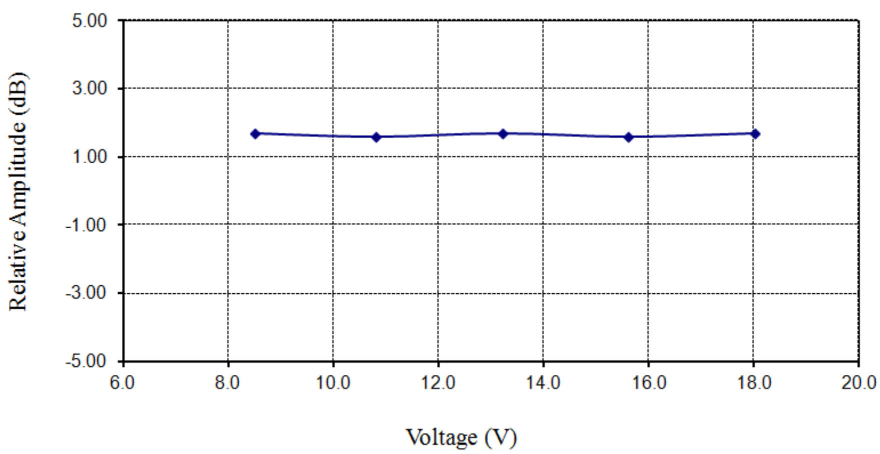
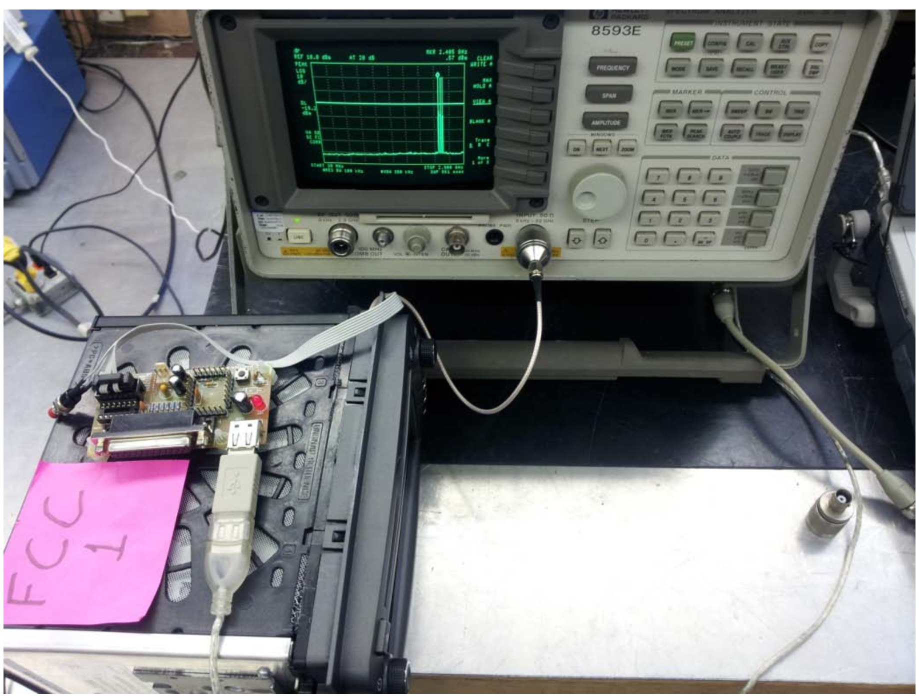


Figure 6.8 Voltage Variation (center channel, CW)

Photograph 6.1: Test Setup



Photograph 6.2: Test Setup