

December 15, 2004



**Technical Report to the FCC Regarding  
Johnson Controls Interiors, L.L.C. Homelink® III  
Model: XKHL3  
FCC ID: CB2XKHL3  
12/15/2004**

A report concerning approval for Johnson Controls Homelink® model XKHL3  
Please issue grant immediately upon review.  
Confidentiality applied to the following sections according to 47 CFR 0.459 and RSP-100:  
Circuit Block Diagrams, attachment "hl\_block\_diag.pdf"  
Theory/Description of Operation "theory\_op.pdf"  
Schematics attachment "schematics.pdf"

Measurements Made by:

A handwritten signature in cursive script, appearing to read "Bolay Elgersma".

Bolay Elgersma  
RF Test Site Technician  
Johnson Controls Interiors, LLC.

Measurements Observed by:

A handwritten signature in cursive script, appearing to read "Jeremy Bos".

Jeremy Bos  
RF Test Site Manager  
Johnson Controls Interiors, LLC.

A handwritten signature in cursive script, appearing to read "Jeremy Bos".

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Report and Application Prepared by  
Jeremy Bos  
RF Test Site Manager  
Johnson Controls Interiors, LLC.

## **1. General Information**

### **1.1. Product Description:**

The Johnson Controls Interiors HomeLink® HL3 Universal Garage Door Opener is a low-power transceiver OEM device that is installed into an overhead console of the automobile. The installation is provided by trained technicians during the course of the manufacture of the automobile. It is powered by the 12volt system of the automobile.

This Universal Garage Door Opener has the capability to

1. Learn the frequency and bit code format of the user's existing garage door remote control devices and
2. Reproduce and transmit the frequency and bit code format to remotely operate the user's garage door.

The unit is designed for the periodic operation of a control signal, which typically activates a garage door opener receiver.

The unit is supplied to the automobile manufacturer without harness. For testing purposes a typical assembly and 2-conductor cable harness were used to power to the unit.

The unit is only operational when the user depresses the control button. It becomes inactive after release of the control button.

The three-button HomeLink® unit replaces up to three hand-held transmitters. In addition to the typical operation of the garage door, the unit will learn the radio frequency codes of other transmitter types to activate entry door locks, estate gates, security systems, and home or office lighting.

The antenna system is an integral part of the unit. It cannot be altered nor replaced by the user. Service of this system is only available from the Automobile Manufacturer's Dealerships and Johnson Controls Interiors, LLC.

### **1.2. Related Grants**

None.

### **1.3. Test Methodology**

Radiated Emissions testing was done according to ANSI C63.4-2003. The power source for this product is a 12V automotive vehicle battery, thus conducted emissions measurements are not required.

The unit is supplied to the automobile manufacturer without harness. For testing purposes a 2-conductor cable harness was used to interface to the unit.

### **1.4. Test Facility**

The Open Area Test Site where these measurements were taken, is located on the grounds of Johnson Controls Automotive Interiors System's Edgar D. Prince Technical Campus, in the city of Holland, county of Ottawa, state of Michigan, United States of America. The site is a fully enclosed 10m weather-protected OATS. All structure materials above the conducting ground-plane are non-metallic and consist of: wood, laminated lumber, fiberglass, glue, plastic, or fiberglass reinforced plastic. The site contains a 15-foot diameter turntable capable of supporting large cars and light trucks under test. Tabletop testing was conducted on a smaller 3m turntable described in the site recertification report. The test site has been fully described in a reports filled with the FCC and Industry Canada. The report filled with the FCC is dated October 19, 1999, was accepted by the FCC in a letter dated December, 20 1999. The report filled with Industry Canada, dated January 31, 2000, was accepted via a letter dated February 29, 2000. The site was re-certified with the FCC on December 27, 2002 and with the IC on January 27, 2003. Our OATS is registered with the IC under file number IC 3593.

### **1.5. Accreditation**

The Johnson Controls, Inc. - Electronics Validation Lab is accredited to ISO 17025 by the American Association for Laboratory Accreditation (A2LA). Our laboratory scope and accreditation certificate (#1869.01) are available from their web site [www.a2la.org](http://www.a2la.org). Our scope of accreditation covers ANSI C63.4 Radiated Emissions at 3m, FCC 47 CFR Part 15, and IC RSS-210.

## **2. Product Labeling**

The FCC Identifier assigned is FCC ID: CB2XKHL3. The Industry Canada certification number is 279B-XKHL3. These identifiers will be embossed on the product housing.

The label will be placed on the exterior of the HL3 housing using an acrylic adhesive that will permanently affix the label.

Because of the small size of the device and because the installation is inside a portion of the automobile, the following statements will appear in the user's manual. Refer to attachment "user\_man.pdf" for the entire text of the user's manual.

"This device complies with Part 15 of the FCC rules and with RSS-210 of the Industry Canada. Operation is subject to the following two conditions:

- (1) This device may not cause harmful interference,
- (2) This device must accept any interference that may be received including interference that may cause undesired operation.

WARNING: The transmitter has been tested and complies with FCC and Industry Canada rules. Changes or modifications not expressly approved by the party responsible for the compliance could void the user's authority to operate the device."

### **2.1. Label Drawing and Location on Product.**

The label drawing as well as a sketch of the label location on product packaging is available in "label.pdf"

## **3. Test Configuration**

Radiated Emissions measurements presented in the report were made in accordance with ANSI C63.4 Figure 9(c). The EUT was placed on a 1 x 1.5m non-metallic table elevated 80cm above a conducting ground plane. The harness was run to the long edge of the table and dropped to a power supply sitting at base of the table.

A picture of the radiated test setup is available as an attachment named "test\_setup.jpg"

#### 4. Block Diagram

For system block diagram please refer to attachment named "hl\_block\_diag.pdf"

#### 5. Test Setup Photographs

For test setup photos please refer to attachment named "end.jpg"

For test setup photos please refer to attachment named "side.jpg"

For test setup photos please refer to attachment named "flat.jpg"

#### 6. Conducted Emissions Measurements

Conducted Measurements are not required for this product.

#### 7. Radiated Emissions Data

##### 7.1. Summary of Results

- Measurements of the transmit output field strength were taken with the DUT trained to 288, 310, and 418 MHz at 30, 50 and 80% duty cycles. A **worst-case emission of 74 dBuV/m** occurred with the DUT trained to 310 MHz, 30% duty cycle. The worst-case emission remained **1.3 dB below the FCC limit** (75.3 dBuV/m) for this type of device.
- The **worst-case harmonic measurement of 53.4 dBuV/m** was found at 1672 MHz, the fifth harmonic of 288 MHz at 30% duty cycle. **A margin of 0.6 dB to the prescribed FCC limit was noted.** When adjusted for the duty cycle.
- This module exhibits pulsed operation characteristics.
- Measurements were taken of the 20dB occupied bandwidth. The transmitter had a maximum occupied bandwidth of 87.6 kHz when the DUT is trained to 418 MHz, 50% duty cycle.
- This device has a worst case Class B emission of 36.6 dBuV/m at 36.87 MHz when set to transmit at 418 MHz a margin of 3.43 dB to the Class B limit is maintained.
- The output power of the DUT varied by no more than 0.2dB when the input voltage was varied from 6 to 18 Volts. The device does not operate when the input voltage is below 8V.
- The device was found to be incapable of operating in restricted bands.
- The device deactivated immediately after the activation button is depressed. Less than 5 sec.
- The device uses coarse and fine pulses to tune the transmit antenna. At 418 MHz, 30% duty cycle the field strength of the pulses average 5166 uV/m over 100 msec. This represents a margin on 5.6 dB to the FCC limit.

##### 7.2. Test Equipment Used

<u>Description</u>	<u>Model #</u>	<u>Serial Number</u>	<u>Last Cal Date</u>	<u>Cal Due</u>
EMCO Biconical Antenna (20- 300 MHz)	3110B	9906-3309	10/21/03	10/21/05
EMCO LPA Antenna (200- 2000MHz)	3148	9908-1076	10/21/03	10/21/05
Electro-metrics Double Ridged Guide (1-	RGA-60	6147	10/21/03	10/21/05

<b>18GHz)</b>				
<b>Agilent E-series EMC Analyzer</b>	<b>E4407B</b>	<b>US41192569</b>	<b>10/26/04</b>	<b>10/26/05</b>
<b>Rohde &amp; Schwarz EMI Test Receiver 7GHz</b>	<b>EMI 7</b>	<b>1088.749.07</b>	<b>7/20/04</b>	<b>7/20/05</b>

**7.3. Test Equipment Setup and Procedure**

Spectrum Analyzer Settings Emissions:

Detector Function: Peak

Resolution Bandwidth: 120kHz (below 1GHz)  
1MHz (above 1GHz)

Video Bandwidth: 300kHz (below 1GHz)  
3MHz (above 1GHz)

Spectrum Analyzer Settings Occupied Bandwidth:

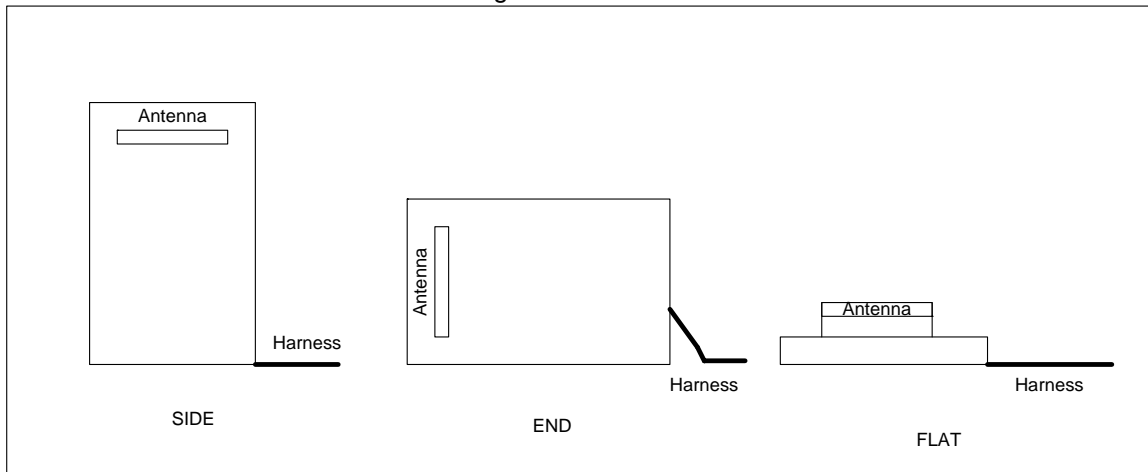
Detector: Peak

Resolution Bandwidth: 3 MHz ( to determine peak level)  
1 kHz (to determine occupied bandwidth)

Video Bandwidth: 3 MHz ( to determine peak level)  
3 kHz (to determine occupied bandwidth)

For the testing, the EUT was placed at the center of a non-conducting table 80 cm above the ground plane pursuant to ANSI C63.4 for stand-alone equipment. The 2-conductor cable harness was routed to the edge of the long side of the table then down to the power supply located on the turntable base.

Equipment is placed in one of the three orthogonal orientations, End, Side, and Flat. These orientations are described below in Figure 7.3.1.



**Figure 7.3.1 EUT Orthogonal Orientations**

While in the prescribed orientation, the vertical antenna positioner sweeps in elevation from 1 to 4m in height until the operator finds the peak. The 3m turntable is then rotated through 360 degrees until a peak is found. The table is stopped at the peak location and the peak in elevation re-verified. Procedure is repeated for applicable orientations/measurement antenna polarizations.

**7.4. Measured Data**

**7.4.1. Measurements of Fundamentals and Harmonics**

Measurements described in this section were taken according to ANSI C63.4-2003 on the Johnson Controls 3m test table.

**7.4.1.1. DUT Tuned to 288MHz (Fundamental)**

Frequency (MHz)	Orientation (Flat/End/Side)	Measurement Polarization (H/V)	Duty Cycle (%)	Measurement* (dBuV/m)	Duty Cycle Correction (dB)	Average Level (dBuV/m)	FCC Limit (dBuV/m)	Margin (dB)
288	Side	H	30	81.50	-10.46	71.0	73.8	2.8
288	Side	H	50	77.25	-6.02	71.2	73.8	2.6
288	Side	H	80	73.33	-1.94	71.4	73.8	<b>2.4</b>

\* Measurements include Cable corrections and Antenna Factors

**7.4.1.2. DUT Tuned to 310MHz (Fundamental)**

Frequency (MHz)	Orientation (Flat/End/Side)	Measurement Polarization (H/V)	Duty Cycle (%)	Measurement* (dBuV/m)	Duty Cycle Correction (dB)	Average Level (dBuV/m)	FCC Limit (dBuV/m)	Margin (dB)
310	Side	H	30	84.43	-10.5	74.0	75.3	<b>1.3</b>
310	Side	H	50	79.66	-6.0	73.6	75.3	1.7
310	Side	H	80	75.47	-1.9	73.5	75.3	1.8

\* Measurements include Cable corrections and Antenna Factors

**7.4.1.3. DUT Tuned to 418MHz (Fundamental)**

Frequency (MHz)	Orientation (Flat/End/Side)	Measurement Polarization (H/V)	Duty Cycle (%)	Measurement* (dBuV/m)	Duty Cycle Correction (dB)	Average Level (dBuV/m)	FCC Limit (dBuV/m)	Margin (dB)
418	End	V	30	88.3	-10.5	77.8	80.3	2.4
418	End	V	50	84.69	-6.0	78.7	80.3	<b>1.6</b>
418	End	V	80	80.37	-1.9	78.4	80.3	1.9

\* Measurements include Cable corrections and Antenna Factors

**7.4.1.4. 288MHz (Harmonics)**

Frequency (MHz)	Orientation (Flat/End/Side)	Measurement Polarization (H/V)	Duty Cycle (%)	Measurement* (dBuV/m)	Duty Cycle Correction (dB)	Average Level (dBuV/m)	FCC Limit (dBuV/m)	Margin (dB)
576	Side	H	30	57.85	-10.5	47.4	53.8	6.4
576	Side	H	50	52.68	-6.0	46.7	53.8	7.2
576	Side	H	80	47.17	-1.9	45.2	53.8	8.6
864	Flat	V	30	Ambient	-10.5	N/A	53.8	N/A
864	Flat	V	50	Ambient	-6.0	N/A	53.8	N/A
864	Flat	V	80	Ambient	-1.9	N/A	53.8	N/A
1152	End	H	30	51.05	-10.5	40.6	53.8	13.2
1152	Flat	H	50	50.52	-6.0	44.5	53.8	9.3
1152	Side	V	80	50.67	-1.9	48.7	53.8	5.1
1440	Side	V	30	53.55	-10.5	43.1	53.8	10.7
1440	Flat	H	50	53.26	-6.0	47.2	53.8	6.6
1440	End	H	80	53.22	-1.9	51.3	53.8	2.6
1728	Flat	H	30	45.38	-10.5	34.9	53.8	18.9
1728	Flat	H	50	45.35	-6.0	39.3	53.8	14.5
1728	Flat	H	80	44.79	-1.9	42.9	53.8	11.0
2016	Side	V	30	45.14	-10.5	34.7	53.8	19.2
2016	Side	V	50	44.89	-6.0	38.9	53.8	15.0
2016	Side	H	80	44.85	-1.9	42.9	53.8	10.9
2304	Side	V	30	Noise	-10.5	N/A	53.8	N/A
2304	Side	V	50	Noise	-6.0	N/A	53.8	N/A
2304	Side	V	80	Noise	-1.9	N/A	53.8	N/A
2592	Flat	V	30	Noise	-10.5	N/A	53.8	N/A
2592	Flat	V	50	Noise	-6.0	N/A	53.8	N/A
2592	Flat	V	80	Noise	-1.9	N/A	53.8	N/A
2880	Flat	V	30	Noise	-10.5	N/A	53.8	N/A
2880	Flat	V	50	Noise	-6.0	N/A	53.8	N/A
2880	Flat	V	80	Noise	-1.9	N/A	53.8	N/A

Ambient

Noise Floor

\* Measurements include Cable corrections and Antenna Factors

**7.4.1.5. 310MHz (Harmonics)**

Frequency (MHz)	Orientation (Flat/End/Side)	Measurement Polarization (H/V)	Duty Cycle (%)	Measurement* (dBuV/m)	Duty Cycle Correction (dB)	Average Level (dBuV/m)	FCC Limit (dBuV/m)	Margin (dB)
620	Side	H	30	59.47	-10.5	49.0	55.3	6.3
620	End	V	50	53.7	-6.0	47.7	55.3	7.6
620	End	V	80	46.32	-1.9	44.4	55.3	10.9
930	Side	H	30	Ambient	-10.5	N/A	55.3	N/A
930	Side	H	50	Ambient	-6.0	N/A	55.3	N/A
930	Side	H	80	Ambient	-1.9	N/A	55.3	N/A
1240	Flat	H	30	50.89	-10.5	40.4	54.0	13.6
1240	Flat	H	50	50.23	-6.0	44.2	54.0	9.8
1240	Flat	H	80	50.11	-1.9	48.2	54.0	5.8
1550	End	V	30	57.21	-10.5	46.8	54.0	7.2
1550	End	V	50	56.46	-6.0	50.4	54.0	3.6
1550	Flat	V	80	55.07	-1.9	53.1	54.0	0.9
1860	Flat	V	30	Ambient	-10.5	N/A	55.3	N/A
1860	Flat	V	50	Ambient	-6.0	N/A	55.3	N/A
1860	Flat	V	80	Ambient	-1.9	N/A	55.3	N/A
2170	End	V	30	43.89	-10.5	33.4	55.3	21.9
2170	End	V	50	43.75	-6.0	37.7	55.3	17.6
2170	End	V	80	42.56	-1.9	40.6	55.3	14.7
2480	End	V	30	44.25	-10.5	33.8	55.3	21.5
2480	Flat	V	50	44.58	-6.0	38.6	55.3	16.8
2480	End	V	80	44.41	-1.9	42.5	55.3	12.8
2790	Side	H	30	Ambient	-10.5	N/A	54.0	N/A
2790	End	V	50	Ambient	-6.0	N/A	54.0	N/A
2790	End	V	80	Ambient	-1.9	N/A	54.0	N/A
3100	Side	V	30	Noise	-10.5	N/A	55.3	N/A
3100	Side	V	50	Noise	-6.0	N/A	55.3	N/A
3100	Side	V	80	Noise	-1.9	N/A	55.3	N/A

Ambient Ambient too strong to take measurement at 930, cell tower.

\* Measurements include Cable corrections and Antenna Factors



**7.4.1.6. 418MHz (Harmonics)**

Frequency (MHz)	Orientation (Flat/End/Side)	Measurement Polarization (H/V)	Duty Cycle (%)	Measurement* (dBuV/m)	Duty Cycle Correction (dB)	Average Level (dBuV/m)	FCC Limit (dBuV/m)	Margin (dB)
836	Flat	H	30	69.56	-10.5	59.1	60.3	1.2
836	Flat	H	50	61.27	-6.0	55.2	60.3	5.0
836	Flat	H	80	53.59	-1.9	51.7	60.3	8.6
1254	Side	V	30	54.31	-10.5	43.9	60.3	16.4
1254	Side	V	50	53.89	-6.0	47.9	60.3	12.4
1254	Side	V	80	53.47	-1.9	51.5	60.3	8.8
1672	Flat	H	30	59.7	-10.5	49.2	54.0	4.8
1672	Flat	H	50	56.8	-6.0	50.8	54.0	3.2
1672	Flat	V	80	55.33	-1.9	53.4	54.0	0.6
2090	Flat	H	30	43.48	-10.5	33.0	60.3	27.3
2090	End	H	50	40.43	-6.0	34.4	60.3	25.9
2090	End	H	80	39.85	-1.9	37.9	60.3	22.4
2508	Side	H	30	44.98	-10.5	34.5	60.3	25.8
2508	Side	H	50	44.88	-6.0	38.9	60.3	21.4
2508	Side	H	80	44.67	-1.9	42.7	60.3	17.6
2926	Flat	V	30	44.42	-10.5	34.0	60.3	26.3
2926	End	H	50	44.27	-6.0	38.2	60.3	22.0
2926	End	H	80	44.39	-1.9	42.5	60.3	17.8
3344	End	V	30	Noise	-10.5	N/A	60.3	N/A
3344	End	V	50	Noise	-6.0	N/A	60.3	N/A
3344	End	V	80	Noise	-1.9	N/A	60.3	N/A
3762	End	V	30	Noise	-10.5	N/A	54.0	N/A
3762	End	V	50	Noise	-6.0	N/A	54.0	N/A
3762	End	V	80	Noise	-1.9	N/A	54.0	N/A
4180	End	V	30	Noise	-10.5	N/A	54.0	N/A
4180	End	V	50	Noise	-6.0	N/A	54.0	N/A
4180	End	V	80	Noise	-1.9	N/A	54.0	N/A

Ambient

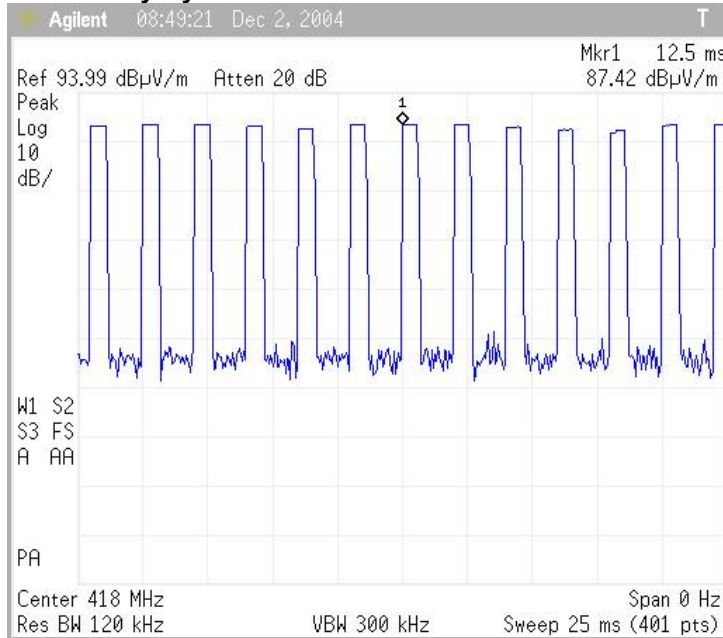
Noise Floor

\* Measurements include Cable corrections and Antenna Factors

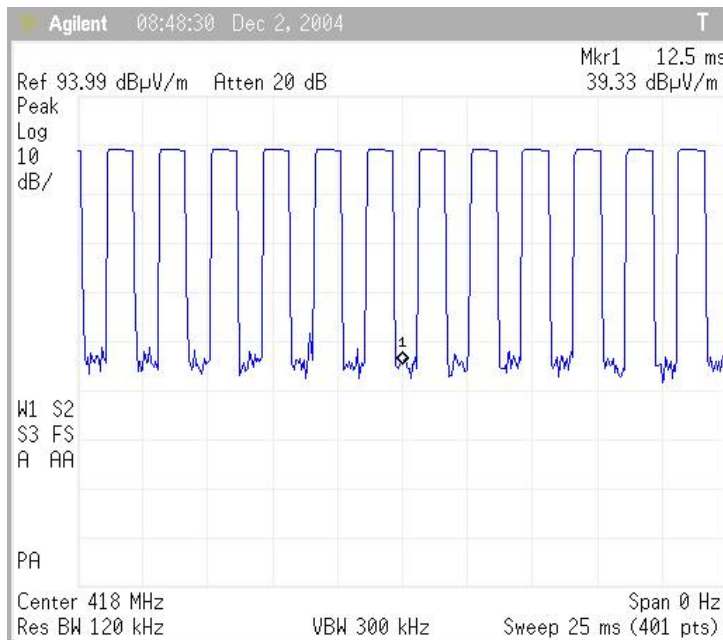
### 7.4.2. Pulsed Operation

The Homelink® transmitter tested here transmits pulses using amplitude modulation with varying duty cycle. Verification of pulse operation at 30, 50 and 80% duty cycles is provided here. Measurements were taken at 310MHz with the span set to zero on the E7407B spectrum analyzer.

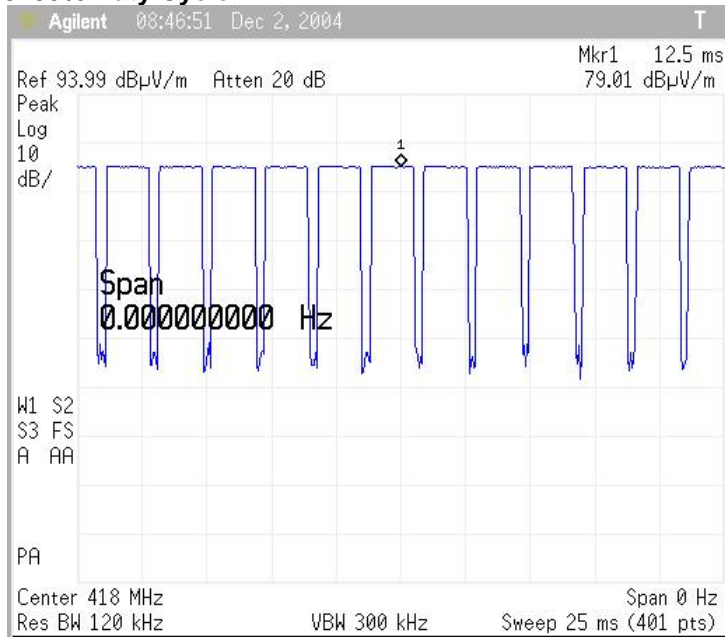
#### 7.4.2.1. 30% Duty Cycle



#### 7.4.2.2. 50% Duty Cycle



**7.4.2.3. 80% Duty Cycle**



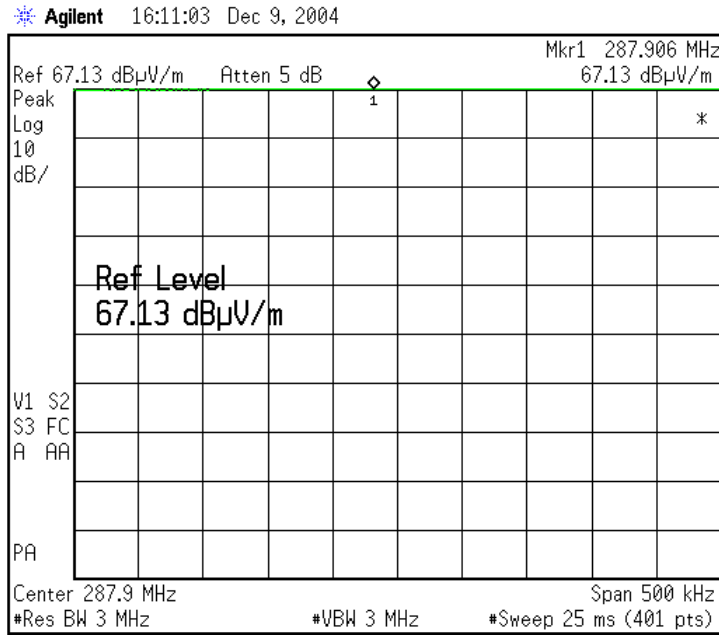
**7.4.3. Occupied Bandwidth**

Occupied bandwidth measurements were taken at 288, 310, and 418 MHz. The occupied bandwidth was determined using the 20dB measurement method.

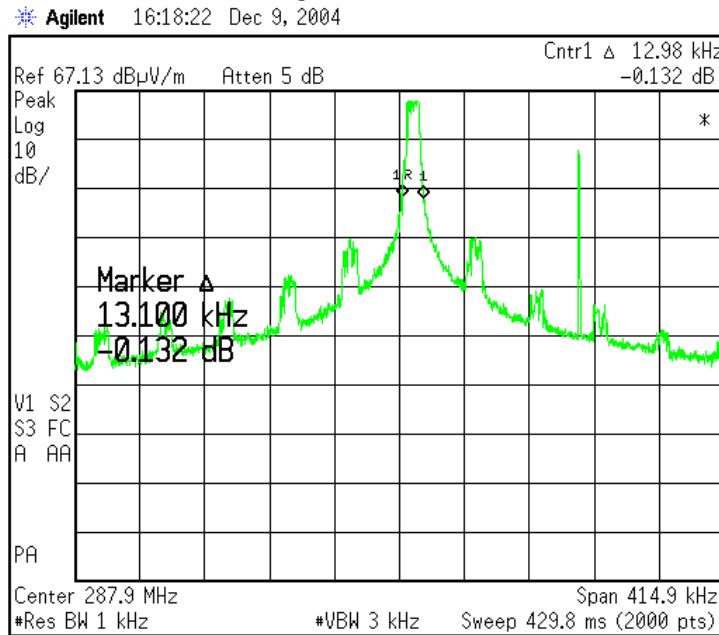
**7.4.3.1. Occupied Bandwidth Measurement**

Frequency (MHz)	Duty Cycle (%)	Occupied Bandwidth (kHz)	Limit (kHz)
288	30	13.1	720
	50	11.3	720
	80	10.6	720
310	30	16.3	775
	50	15	775
	80	16.8	775
418	30	83.1	1045
	50	87.6	1045
	80	82.8	1045

**7.4.3.2. Example of Occupied Bandwidth measurement  
(288MHz 30% Duty Cycle)**



**Measuring Peak Reference Level**



**Measuring Peak Reference Level**

**7.4.4. Emission Spectrum**

Prescan Measurements were taken inside a semi-anechoic chamber to investigate the possibility of other spurious emissions from the DUT. Screen captures presented below in sections 7.4.4.1-3 show the spurious emissions observed with the DUT trained to 288, 310, and 418MHz with a 30% Duty cycle.

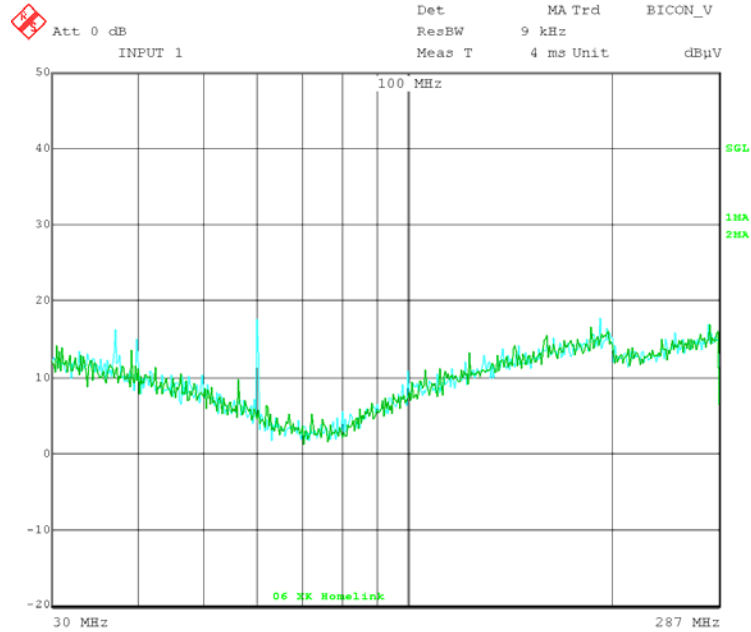
December 15, 2004

A relay was used to reset the DUT, the emissions of the relay (without DUT connected) are shown as the green trace.

Emissions were noted and measured on the JCI OATS, all measurements were found to be near or below the ambient noise level and well below the FCC limits for spurious emissions. A summary is presented below in section 7.4.4.4

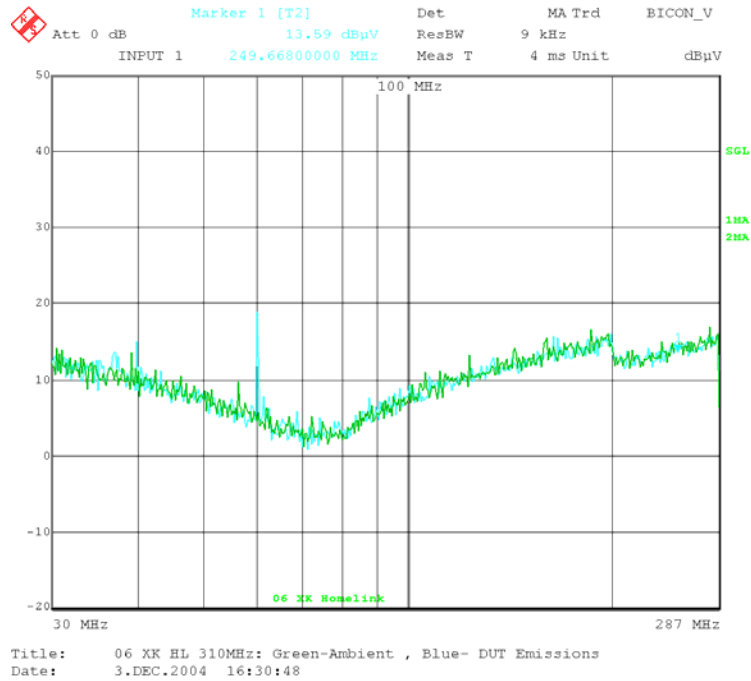
Measurement settings:  
Resolution BW 120kHz  
Video Bandwidth: 300kHz  
Detector: Peak

#### 7.4.4.1. 288 MHz

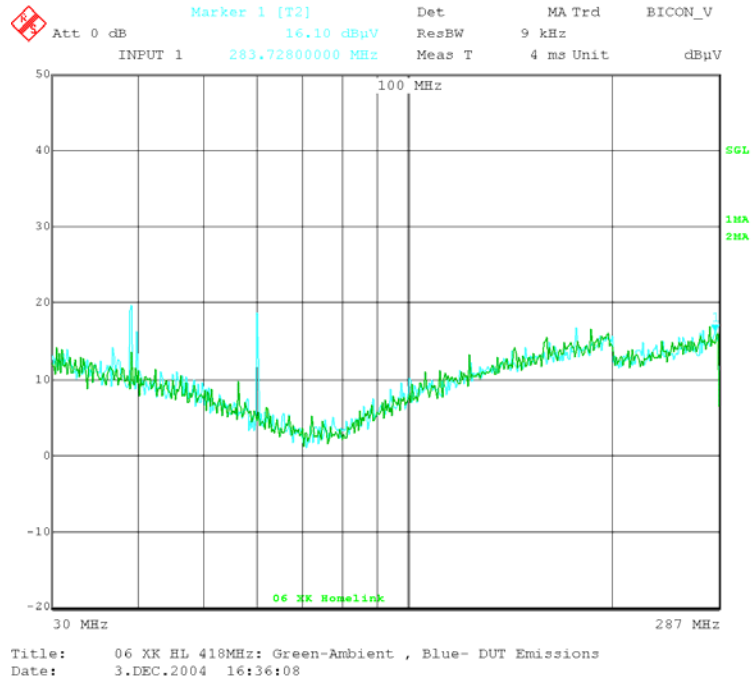


Title: 06 XK HL 288MHz: Green-Ambient , Blue- DUT Emissions  
Date: 3.DEC.2004 16:24:35

### 7.4.4.2. 310 MHz



### 7.4.4.3. 418 MHz



Note: Pre-scan measurements were made in a semi-anechoic chamber using a Rohde & Schwarz EMI Test Receiver 7GHz. The semi-anechoic chamber and test receiver are part of the Johnson Control Electronics Validation Group.

**7.4.4.4. Summary of Emissions Measurements Taken on OATS**

Transmitting Frequency (MHz)	Frequency (MHz)	DUT Orientation	Antenna Polarization	Field Strength (dBuV/m)	Limit (dBuV/m)	Margin (dB)
288	40	Side	V	34.02	40	5.98
	60	End	V	31.03	40	8.97
	192.25	Side	H	30.75	40	9.25
310	37.1	Flat	V	33.75	40	6.25
	40	End	H	31.41	40	8.59
	60	Side	H	28.15	40	11.85
	61.33	Side	V	29.31	40	10.69
418	68.83	Flat	V	28.29	40	11.71
	36.87	End	V	36.57	40	3.43
	39.18	Side	V	34.08	40	5.92
	40	Side	V	33.86	40	6.14
	57.88	End	H	33.29	40	6.71
	97.97	Flat	V	AMBIENT	40	N/A
	177.03	Side	V	AMBIENT	40	N/A
	251.25	Side	H	30.88	40	9.12
272.24	Side	H	30.41	40	9.59	

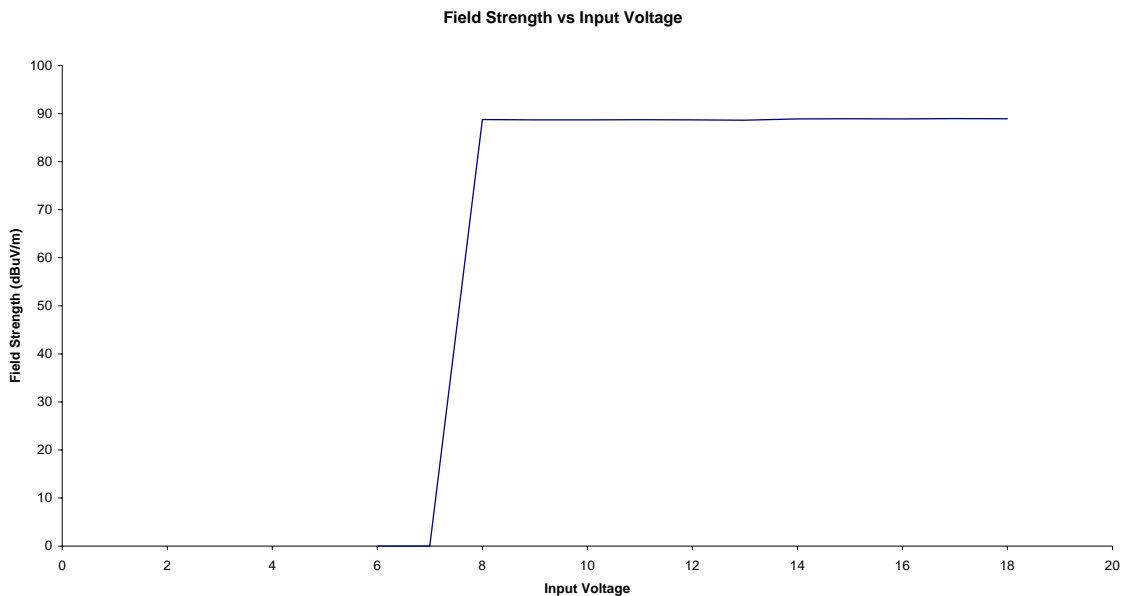
FM and Television Broadcasts present at 97.9 and 177 MHz.

Measurements were made using a peak detector with Resolution BW of 120 kHz and Video BW of 300 kHz. Cable losses and correction factors included in measurement.

**7.4.5. Variation of Supply Voltage**

Measurements of the variation in output field strength due to variation in the supply voltage were taken in accordance with 15.31(e). The DUT was configured to transmit at 310MHz, 30% Duty Cycle.

**7.4.5.1. Plot of output power over supply voltage**



**7.4.5.2. Output power as a function of supply voltage**

<b>Voltage</b>	<b>Field Strength (dBuV/m)</b>
6	No Op
7	No Op
8	88.73
9	88.67
10	88.67
11	88.71
12	88.68
13	88.6
14	88.86
15	88.89
16	88.88
17	88.95
18	88.89

**7.4.6. Verification of Non-Operation in Restricted Bands**

An exercise was undergone to verify that the device was not able to learn and thereby transmit in a restricted band. During this exercise it was found that the device firmware prevents the device from learning any frequency within 1MHz of any restricted band listed in 47 CFR 15.205.

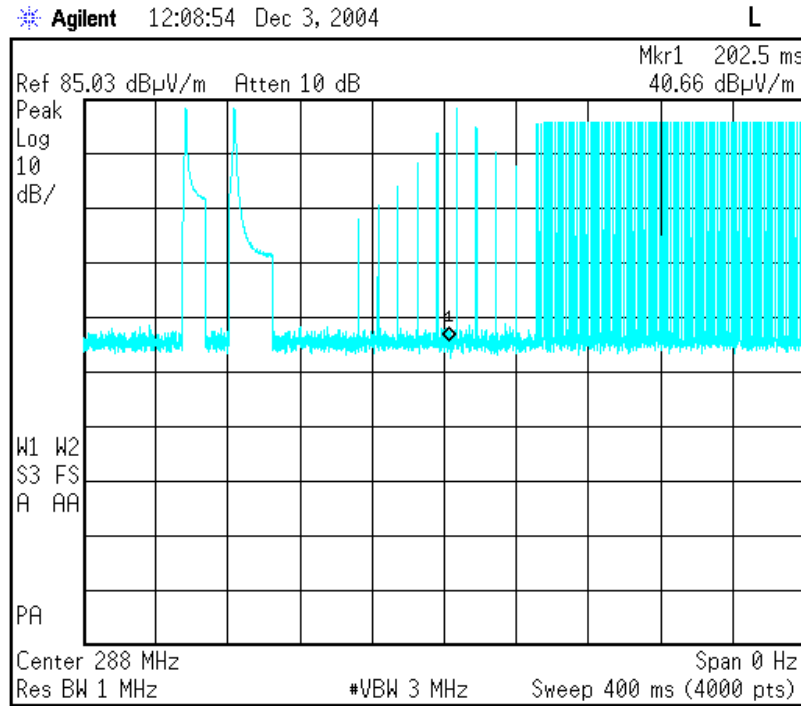
**7.4.7. Verification of De-activation after 5 seconds**

This device stops transmitting once the activation button is depressed.



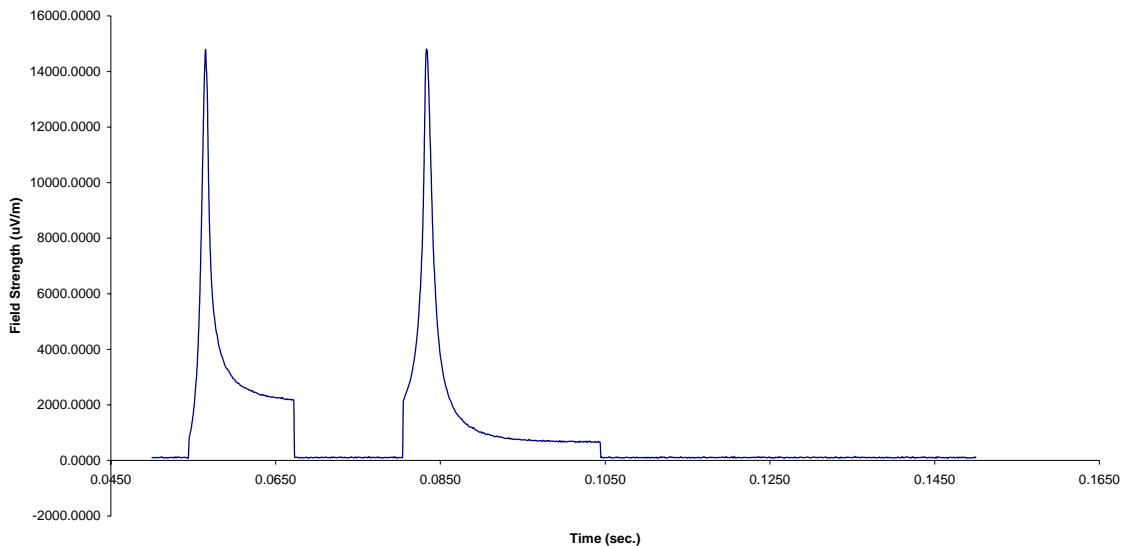
### 7.4.8. Tuning Pulse Measurements

This device uses pulses to tune the antenna prior to transmission. Measurements of these tuning pulses over 400 msec windows show that these pulses are below the FCC limits for operation in this band. A summary of measurements is presented in section 7.4.8.7. Tuning pulse measurements were taken at 288, 310, and 418 MHz at a duty cycle of 30%. Settings in the screen capture below were not used to make the measurements presented in section 7.4.8.7.



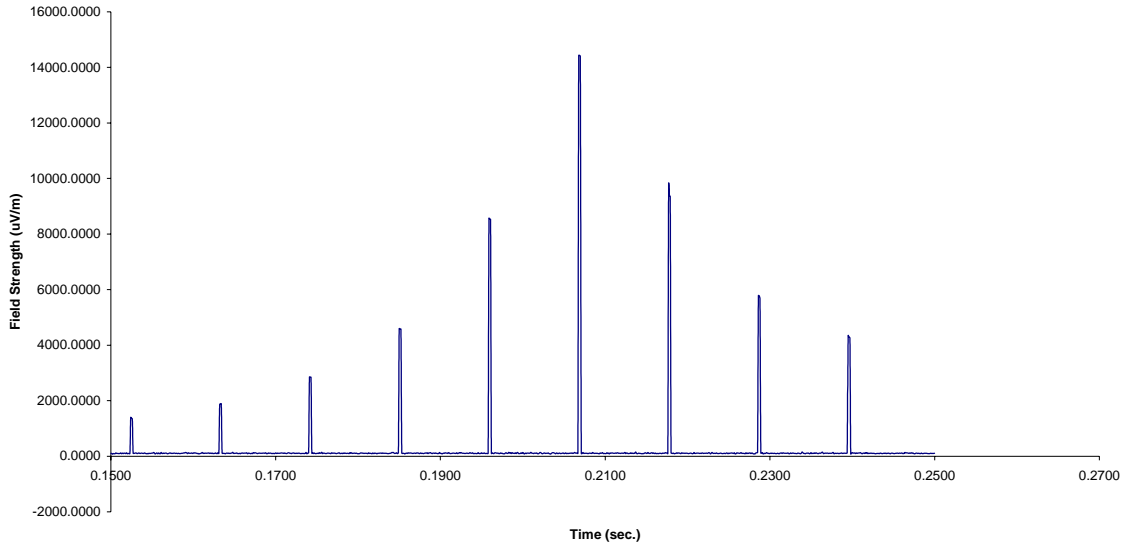
#### 7.4.8.1. Coarse Tuning Pulse (288MHz)

288 MHz, 30 % Duty Cycle Coarse Tuning Pulse



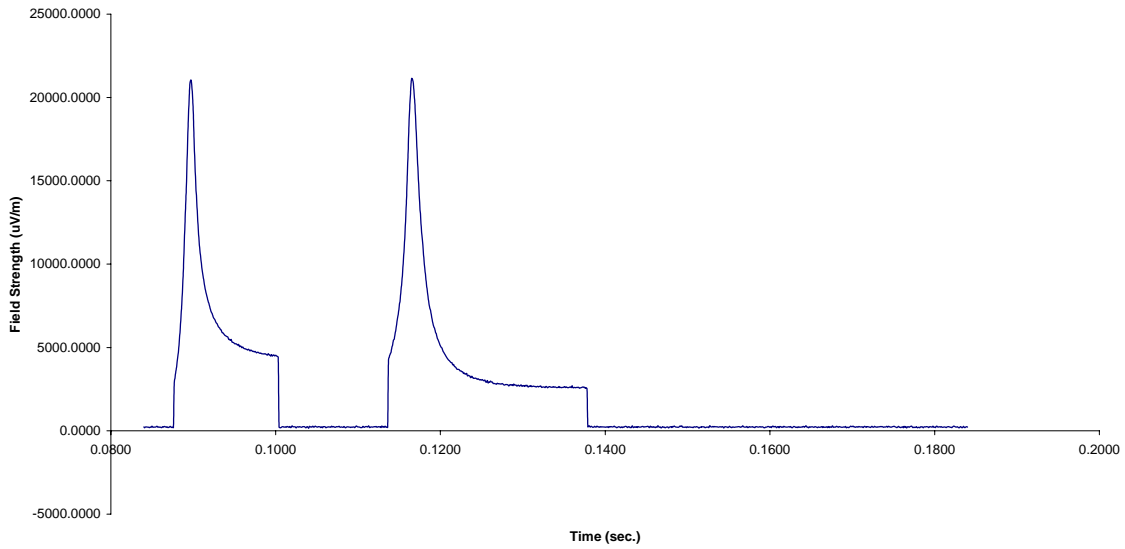
### 7.4.8.2. Fine Tuning Pulse (288MHz)

288 MHz, 30 % Duty Cycle, Fine Tuning Pulse



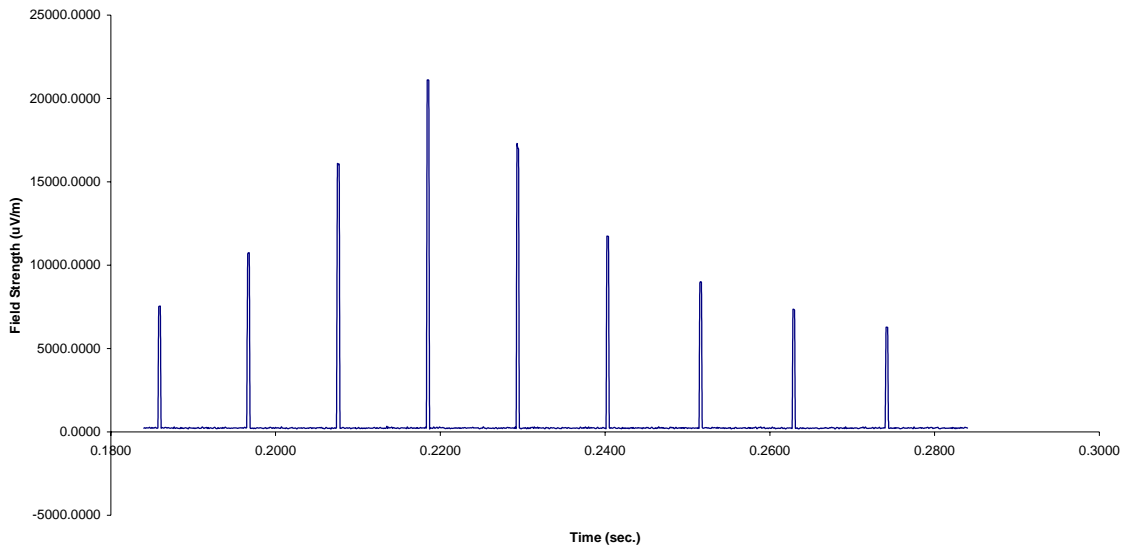
### 7.4.8.3. Coarse Tuning Pulse (310MHz)

310 MHz, 30% Duty Cycle, Coarse Tuning Pulse



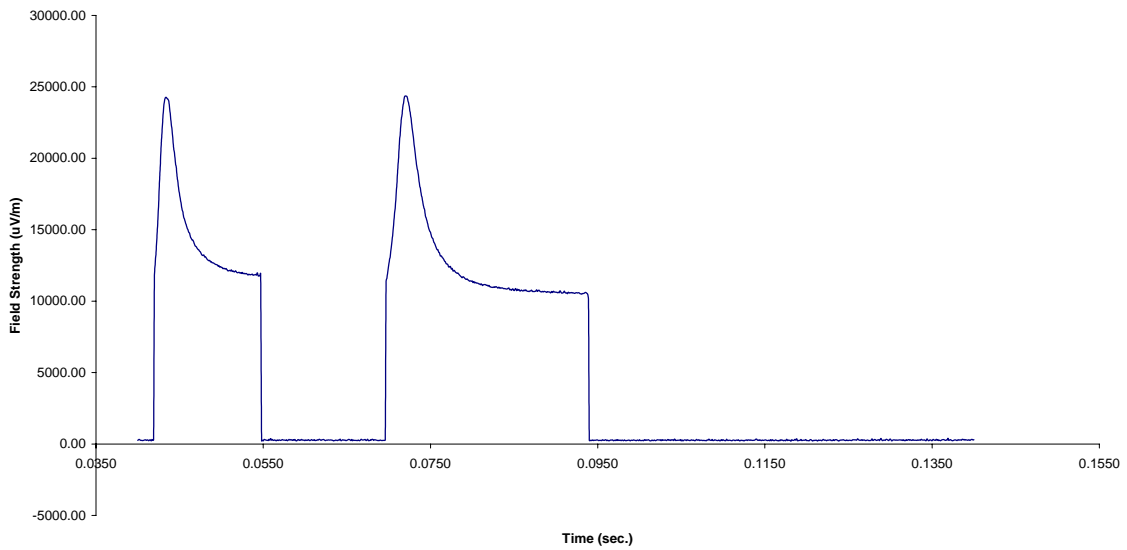
### 7.4.8.4. Fine Tuning Pulse (310MHz)

310 MHz, 30% Duty Cycle, Fine Tuning Pulse

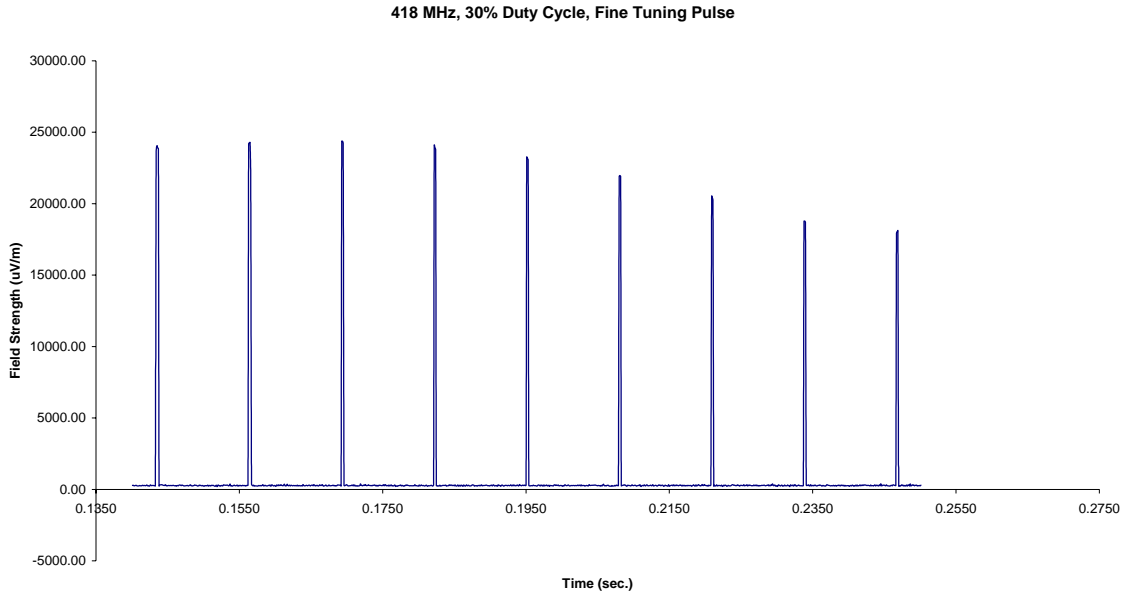


### 7.4.8.5. Coarse Tuning Pulse (418 MHz)

418 MHz, 30% Duty Cycle, Coarse Tuning Pulse



### 7.4.8.6. Fine Tuning Pulse (418MHz)



### 7.4.8.7. Summary of Tuning Pulse Measurements

Measurement Settings:

Resolution Bandwidth: 1MHz

Video Bandwidth: 3 MHz

Sweep Time: 400 msec.

For this measurement 4000 points were recorded and the values averaged over 100 msec. windows that captured either the coarse or fine tuning pulses.

Coarse	Frequency (MHz)	Average (uV/m)	Limit (uV/m)	Margin (dB)
	288	1019	4915	13.7
	310	2255	5831	8.3
	418	5166	9806	<b>5.6</b>

Fine	Frequency (MHz)	Average (uV/m)	Limit (uV/m)	Margin (dB)
	288	264	4915	25.4
	310	544	5831	20.6
	418	851	9806	21.2

## 7.5. Formulas and Sample Calculations

### 7.5.1. Adjustment to account for duty cycle

The spectrum analyzers used for making the measurements in this report automatically corrects for cable correction and antenna factors using values stored in memory taken from the most recent calibration (in the case of antenna factors) and periodic cable loss measurements.

Formula 1:  $FS(dBuV/m) = M(dBuV) + AF(dB/m) + CF(dB)$

The presented field strength is computed by the spectrum analyzer by taking the measured level and adding to it the antenna factor and cable loss corrections. The measurement presented is gathered using the spectrum analyzer's peak-hold capability.

Formula 2:  $Average\ Level(dBuV/m) = Peak\ Level\ (dBuV/m) + duty\ cycle\ factor(dB)$ .

The peak measurement is adjusted to an average level by a duty cycle described below.

The duty cycle factor to apply is determined for the duty cycles of 30%, 50%, and 80% as follows:

For 30% (0.30):  $duty\ cycle\ factor(dB) = 20 * \text{Log}(0.3) = -10.46$

For 50% (0.50):  $duty\ cycle\ factor(dB) = 20 * \text{Log}(0.5) = -6.02$

For 80% (0.80):  $duty\ cycle\ factor(dB) = 20 * \text{Log}(0.8) = -1.94$

Example calculation:

With the EUT programmed with a 30% duty cycle a measurement of 74 dBuV/m is taken (about 5000 uV/m), the adjusted level would be:

$$74 + (-10.46) = 63.54\ dBuV/m\ \text{(example)}$$

#### **7.5.2. Calculation of FCC limits from 15.231.**

The prescribed limit in the range of 260 MHz to 470 MHz is stated as a linear interpolation between 3750 uV/m and 12500 uV/m. The equation used to calculate the limit using this criteria is:

$$FCC\ limit = 41.67 * f - 7083.33$$

(Where 'f' is the measurement frequency in MHz.)

The limit in dBuV/m is then:

$$dB\ limit = 20 * \log_{10}(FCC\ limit\ uV/m) = 20 * \log_{10}(41.67 * f - 7083.33)$$

(log<sub>10</sub> is used to indicate the use of a base 10 logarithm)

This results in the following limits for the fundamentals:

288MHz  $20 * \log_{10}(4917.6) = 73.8\ dBuV/m$

310MHz  $20 * \log_{10}(5834.4) = 75.3\ dBuV/m$

390MHz  $20 * \log_{10}(9168.0) = 79.2\ dBuV/m$

418MHz  $20 * \log_{10}(10334.7) = 80.3\ dBuV/m$

## **8. Photos of Product Tested**

### **8.1. Front View**

Please refer to attachment named "front\_view.jpg"

### **8.2. Rear View**

Please refer to attachment named "rear\_view.jpg"

### **8.3. Unit Disassembled**

Please refer to attachment named "assembly.jpg"

### **8.4. Homelink® Board**

Please refer to attachment named "internal\_front.jpg"

Please refer to attachment named "internal\_rear.jpg"

Please refer to attachment name "closeup.jpg" (Close-up of Homelink section of board).

## **9. Other Attachments and Description**

### **9.1. User Manual**

Please refer to attachment "user\_manual.pdf".

### **9.2. Schematics/ Tuning Information**

For schematics please refer to attachment "schematics.pdf".

For tuning information please refer to attachment "tuning.pdf".

### **9.3. Theory of Operation**

For schematics please refer to attachment "theory\_op.pdf"