# Technical Report to the FCC Regarding
# Johnson Controls Interiors, L.L.C. Homelink© III
# Model: CB2LXHL3
# FCC ID: CB2LXHL3
# Form 731 Confirmation #: EA995996
# 9/12/2003

A report concerning a request for certification of CB2LXHL3.
Please issue grant immediately upon review.
Confidentiality applied to the following sections according to 47 CFR 0.459:
Circuit Block Diagrams, attachment “hl_block_diag.pdf”
Theory/Description of Operation “theory_op.pdf”
Schematics attachment “schematics.pdf”

Measurements Made by:

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

Measurements Observed by:

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

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

This report applies to a request for a new certification for the CB2LXHL3.

## 1.3. Test Methodology

Radiated Emissions testing was done according to ANSI C63.4-1992. 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.

## 2. Product Labeling

The FCC Identifier assigned is FCC ID: CB2LXHL3. The Industry Canada certification number is 279B-LXHL3. These identifier will be imprinted on a 1"X1.5" high temperature polyester matte white label.

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 C63.4-1992 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 “test_setup_end.jpg”
For test setup photos please refer to attachment named “test_setup_side.jpg”
For test setup photos please refer to attachment named “test_setup_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 77.9 dBuV/m occurred with the DUT trained to 418 MHz, 30% duty cycle. The worst-case emission remained 2.3dB below the FCC limit (80.3 dBuV/m) for this type of device.
- The worst-case harmonic measurement of 52.3 dBuV/m was found at 576 MHz, the second harmonic of 288 MHz at 30% duty cycle. A margin of 1.5 dB to the prescribed FCC limit was noted.
- This module exhibits pulsed operation characteristics.
- Measurements were taken of the 20dB occupied bandwidth. The transmitter had a maximum occupied bandwidth of 530 kHz when the DUT is trained to 310 MHz, 30% duty cycle.
- This device has no measurable Class B emissions.
- 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 9V.
- 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 9930 uV/m over 100 msec. This represents a margin on 0.3 dB to the FCC limit.

## 7.2. Test Equipment Used

| Description | Model # | Serial Number | Last Cal Date | Cal Due |
|---|---|---|---|---|
| **EMCO Biconical Antenna (20-300 MHz)** | **3110B** | **9906-3309** | **10/21/02** | **10/21/03** |
| **EMCO LPA Antenna (200-2000MHz)** | **3148** | **9908-1076** | **10/21/02** | **10/21/03** |
| **Electro-metrics Double Ridged Guide (1-18GHz)** | **RGA-60** | **6147** | **10/21/02** | **10/21/03** |
| **Agilent E-series EMC Analyzer** | **E4407B** | **US41192569** | **10/16/02** | **10/16/03** |
| **HP Preamp** | **8447D** | **1937A03135** | **10/09/02** | **10/09/03** |

| | | | | |
|---|---|---|---|---|
| **Rohde & Schwarz EMI Test Receiver 7GHz** | **EMI 7** | **1088.749.07** | **8/7/03** | **8/7/04** |

## 7.3. Test Equipment Setup and Procedure

Spectrum Analyzer Settings:
Detector Function: Peak
Resolution Bandwidth: 120kHz (below 1GHz)
1MHz (above 1GHz)
Video Bandwidth: 300kHZ (below 1GHz)
3MHz (above 1GHz)

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.

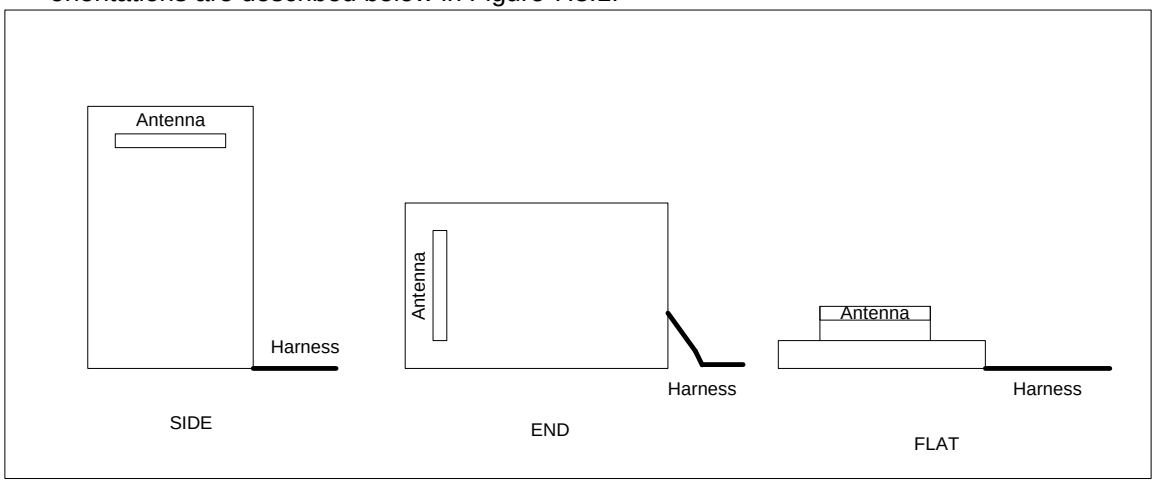



**Figure 7.3.1 EUT Orthogonal Orientations**

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 C63.4-1992 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) | Correction Factor (dB) | Duty Cycle Correction (dB) | Average Level (dBuV/m) | FCC Limit (dBuV/m) | Margin (dB) |
|---|---|---|---|---|---|---|---|---|---|
| 288 | Side | H | 30 | 79.4 | 0 | -10.5 | 68.9 | 73.8 | 4.9 |
| 288 | Side | H | 50 | 75 | 0 | -6.0 | 69.0 | 73.8 | 4.9 |
| 288 | Side | H | 80 | 71.2 | 0 | -1.9 | 69.3 | 73.8 | **4.6** |

* 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) | Correction Factor (dB) | Duty Cycle Correction (dB) | Average Level (dBuV/m) | FCC Limit (dBuV/m) | Margin (dB) |
|---|---|---|---|---|---|---|---|---|---|
| 310 | Side | H | 30 | 82.8 | 0 | -10.5 | 72.3 | 75.3 | **3.0** |
| 310 | Side | H | 50 | 77.9 | 0 | -6.0 | 71.9 | 75.3 | 3.4 |
| 310 | Side | H | 80 | 73.7 | 0 | -1.9 | 71.8 | 75.3 | 3.6 |

* 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) | Correction Factor (dB) | Duty Cycle Correction (dB) | Average Level (dBuV/m) | FCC Limit (dBuV/m) | Margin (dB) |
|---|---|---|---|---|---|---|---|---|---|
| 418 | End | V | 30 | 88.4 | 0 | -10.5 | 77.9 | 80.3 | **2.3** |
| 418 | Side | H | 50 | 83.7 | 0 | -6.0 | 77.7 | 80.3 | 2.6 |
| 418 | Side | H | 80 | 79.6 | 0 | -1.9 | 77.7 | 80.3 | 2.6 |

* 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) | Correction Factor (dB) | Duty Cycle Correction (dB) | Average Level (dBuV/m) | FCC Limit (dBuV/m) | Margin (dB) |
|---|---|---|---|---|---|---|---|---|---|
| 576 | Side | V | 30 | 62.8 | 0 | -10.5 | 52.3 | 53.8 | 1.5 |
| 576 | Side | V | 50 | 55.9 | 0 | -6.0 | 49.9 | 53.8 | 4.0 |
| 576 | Side | V | 80 | 50.1 | 0 | -1.9 | 48.2 | 53.8 | 5.7 |
| 864 | Side | H | 30 | 52.3 | 0 | -10.5 | 41.8 | 53.8 | 12.0 |
| 864 | Side | H | 50 | 52.3 | 0 | -6.0 | 46.3 | 53.8 | 7.6 |
| 864 | Side | H | 80 | 52.3 | 0 | -1.9 | 50.4 | 53.8 | 3.5 |
| 1152 | Flat | H | 30 | 48.7 | 0 | -10.5 | 38.2 | 53.8 | 15.6 |
| 1152 | Flat | H | 50 | 48.7 | 0 | -6.0 | 42.7 | 53.8 | 11.2 |
| 1152 | Flat | H | 80 | 48.7 | 0 | -1.9 | 46.8 | 53.8 | 7.1 |
| 1440 | Flat | H | 30 | 51.8 | 0 | -10.5 | 41.3 | 53.8 | 12.5 |
| 1440 | Flat | H | 50 | 51.8 | 0 | -6.0 | 45.8 | 53.8 | 8.1 |
| 1440 | Flat | H | 80 | 51.8 | 0 | -1.9 | 49.9 | 53.8 | 4.0 |
| 1728 | Side | V | 30 | 51.3 | 0 | -10.5 | 40.8 | 53.8 | 13.0 |
| 1728 | Side | V | 50 | 51.3 | 0 | -6.0 | 45.3 | 53.8 | 8.6 |
| 1728 | Side | V | 80 | 51.3 | 0 | -1.9 | 49.4 | 53.8 | 4.5 |
| 2016 | Side | V | 30 | 48.3 | 0 | -10.5 | 37.8 | 53.8 | 16.0 |
| 2016 | Side | V | 50 | 48.3 | 0 | -6.0 | 42.3 | 53.8 | 11.6 |
| 2016 | Side | V | 80 | 48.3 | 0 | -1.9 | 46.4 | 53.8 | 7.5 |
| 2304 | Side | V | 30 | 48.9 | 0 | -10.5 | 38.4 | 53.8 | 15.4 |
| 2304 | Side | V | 50 | 48.9 | 0 | -6.0 | 42.9 | 53.8 | 11.0 |
| 2304 | Side | V | 80 | 48.9 | 0 | -1.9 | 47.0 | 53.8 | 6.9 |
| 2592 | Side | V | 30 | 49.8 | 0 | -10.5 | 39.3 | 53.8 | 14.5 |
| 2592 | Side | V | 50 | 49.8 | 0 | -6.0 | 43.8 | 53.8 | 10.1 |
| 2592 | Side | V | 80 | 49.8 | 0 | -1.9 | 47.9 | 53.8 | 6.0 |
| 2880 | Side | V | 30 | 50.8 | 0 | -10.5 | 40.3 | 53.8 | 13.5 |
| 2880 | Side | V | 50 | 50.8 | 0 | -6.0 | 44.8 | 53.8 | 9.1 |
| 2880 | Side | V | 80 | 50.8 | 0 | -1.9 | 48.9 | 53.8 | 5.0 |

Ambient

* 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) | Correction Factor (dB) | Duty Cycle Correction (dB) | Average Level (dBuV/m) | FCC Limit (dBuV/m) | Margin (dB) |
|---|---|---|---|---|---|---|---|---|---|
| 620 | End | H | 30 | 62.4 | 0 | -10.5 | 51.9 | 55.3 | 3.4 |
| 620 | End | H | 50 | 55.9 | 0 | -6.0 | 49.9 | 55.3 | 5.4 |
| 620 | End | V | 80 | 51 | 0 | -1.9 | 49.1 | 55.3 | 6.3 |
| 930 | Flat | H | 30 | ambient | 0 | -10.5 | N/A | 55.3 | N/A |
| 930 | Side | H | 50 | ambient | 0 | -6.0 | N/A | 55.3 | N/A |
| 930 | Flat | H | 80 | ambient | 0 | -1.9 | N/A | 55.3 | N/A |
| 1240 | End | H | 30 | 49.9 | 0 | -10.5 | 39.4 | 54.0 | 14.6 |
| 1240 | End | H | 50 | 49.9 | 0 | -6.0 | 43.9 | 54.0 | 10.1 |
| 1240 | End | H | 80 | 49.9 | 0 | -1.9 | 48.0 | 54.0 | 6.0 |
| 1550 | Flat | H | 30 | 53.6 | 0 | -10.5 | 43.1 | 54.0 | 10.9 |
| 1550 | Side | V | 50 | 51.5 | 0 | -6.0 | 45.5 | 54.0 | 8.5 |
| 1550 | Flat | H | 80 | 51.1 | 0 | -1.9 | 49.2 | 54.0 | 4.8 |
| 1860 | Side | V | 30 | 46.6 | 0 | -10.5 | 36.1 | 55.3 | 19.2 |
| 1860 | Side | V | 50 | 46.6 | 0 | -6.0 | 40.6 | 55.3 | 14.7 |
| 1860 | Side | V | 80 | 46.2 | 0 | -1.9 | 44.3 | 55.3 | 11.1 |
| 2170 | Flat | V | 30 | 47.8 | 0 | -10.5 | 37.3 | 55.3 | 18.0 |
| 2170 | Flat | V | 50 | 47.8 | 0 | -6.0 | 41.8 | 55.3 | 13.5 |
| 2170 | Flat | V | 80 | 47.8 | 0 | -1.9 | 45.9 | 55.3 | 9.5 |
| 2480 | End | V | 30 | 49.1 | 0 | -10.5 | 38.6 | 55.3 | 16.7 |
| 2480 | End | V | 50 | 49.5 | 0 | -6.0 | 43.5 | 55.3 | 11.8 |
| 2480 | End | V | 80 | 49.5 | 0 | -1.9 | 47.6 | 55.3 | 7.8 |
| 2790 | Flat | V | 30 | 49.3 | 0 | -10.5 | 38.8 | 54.0 | 15.2 |
| 2790 | Flat | V | 50 | 49.3 | 0 | -6.0 | 43.3 | 54.0 | 10.7 |
| 2790 | Flat | V | 80 | 49.3 | 0 | -1.9 | 47.4 | 54.0 | 6.6 |
| 3100 | Side | V | 30 | 54.9 | 0 | -10.5 | 44.4 | 55.3 | 10.9 |
| 3100 | Side | V | 50 | 54.9 | 0 | -6.0 | 48.9 | 55.3 | 6.4 |
| 3100 | Side | V | 80 | 54.9 | 0 | -1.9 | 53.0 | 55.3 | 2.4 |

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) | Correction Factor (dB) | Duty Cycle Correction (dB) | Average Level (dBuV/m) | FCC Limit (dBuV/m) | Margin (dB) |
|---|---|---|---|---|---|---|---|---|---|
| 836 | Side | V | 30 | 60.5 | 0 | -10.5 | 50.0 | 60.3 | 10.2 |
| 836 | Flat | H | 50 | 51.4 | 0 | -6.0 | 45.4 | 60.3 | 14.9 |
| 836 | Flat | H | 80 | 45.1 | 0 | -1.9 | 43.2 | 60.3 | 17.1 |
| 1254 | Side | V | 30 | 54.1 | 0 | -10.5 | 43.6 | 60.3 | 16.6 |
| 1254 | Side | V | 50 | 50.3 | 0 | -6.0 | 44.3 | 60.3 | 16.0 |
| 1254 | Side | V | 80 | 48.3 | 0 | -1.9 | 46.4 | 60.3 | 13.9 |
| 1672 | Side | V | 30 | 57.4 | 0 | -10.5 | 46.9 | 54.0 | 7.1 |
| 1672 | Side | V | 50 | 52.8 | 0 | -6.0 | 46.8 | 54.0 | 7.2 |
| 1672 | Side | V | 80 | 52.3 | 0 | -1.9 | 50.4 | 54.0 | 3.6 |
| 2090 | Side | V | 30 | 48.2 | 0 | -10.5 | 37.7 | 60.3 | 22.5 |
| 2090 | Side | V | 50 | 48.5 | 0 | -6.0 | 42.5 | 60.3 | 17.8 |
| 2090 | Side | V | 80 | 48.9 | 0 | -1.9 | 47.0 | 60.3 | 13.3 |
| 2508 | End | V | 30 | 49.4 | 0 | -10.5 | 38.9 | 60.3 | 21.3 |
| 2508 | End | V | 50 | 49.4 | 0 | -6.0 | 43.4 | 60.3 | 16.9 |
| 2508 | End | V | 80 | 49.4 | 0 | -1.9 | 47.5 | 60.3 | 12.8 |
| 2926 | Side | V | 30 | 50.7 | 0 | -10.5 | 40.2 | 60.3 | 20.0 |
| 2926 | Side | V | 50 | 50.7 | 0 | -6.0 | 44.7 | 60.3 | 15.6 |
| 2926 | Side | V | 80 | 50.7 | 0 | -1.9 | 48.8 | 60.3 | 11.5 |
| 3344 | End | V | 30 | 54.3 | 0 | -10.5 | 43.8 | 60.3 | 16.4 |
| 3344 | End | V | 50 | 54.3 | 0 | -6.0 | 48.3 | 60.3 | 12.0 |
| 3344 | End | V | 80 | 54.3 | 0 | -1.9 | 52.4 | 60.3 | 7.9 |
| 3762 | Flat | V | 30 | 50.1 | 0 | -10.5 | 39.6 | 54.0 | 14.4 |
| 3762 | Flat | V | 50 | 50.1 | 0 | -6.0 | 44.1 | 54.0 | 9.9 |
| 3762 | Flat | V | 80 | 50.1 | 0 | -1.9 | 48.2 | 54.0 | 5.8 |
| 4180 | Flat | V | 30 | 47.6 | 0 | -10.5 | 37.1 | 54.0 | 16.9 |
| 4180 | Flat | V | 50 | 47.6 | 0 | -6.0 | 41.6 | 54.0 | 12.4 |
| 4180 | Flat | V | 80 | 47.6 | 0 | -1.9 | 45.7 | 54.0 | 8.3 |

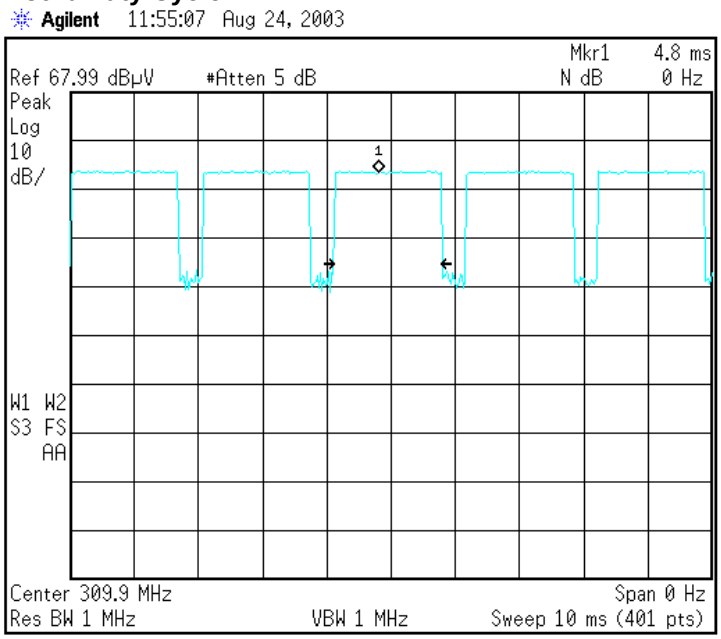
Ambient

* Measurements include Cable corrections and Antenna Factors

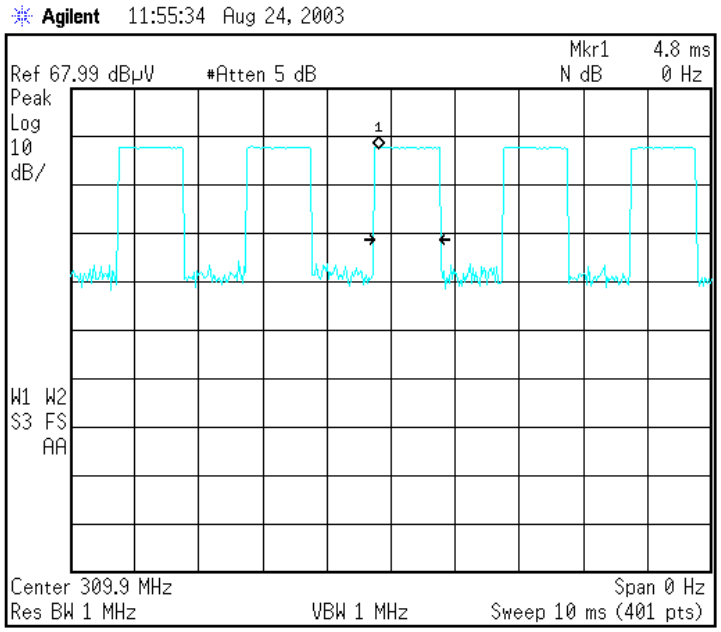
## 7.4.2. Pulsed Operation

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.

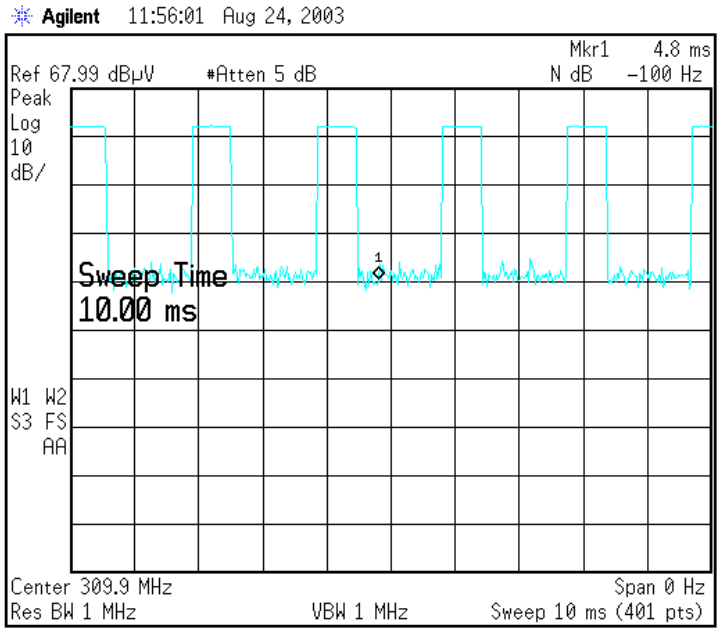
### 7.4.2.1. 30% Duty Cycle




### 7.4.2.2. 50% Duty Cycle



#### 7.4.2.3. 80% Duty Cycle



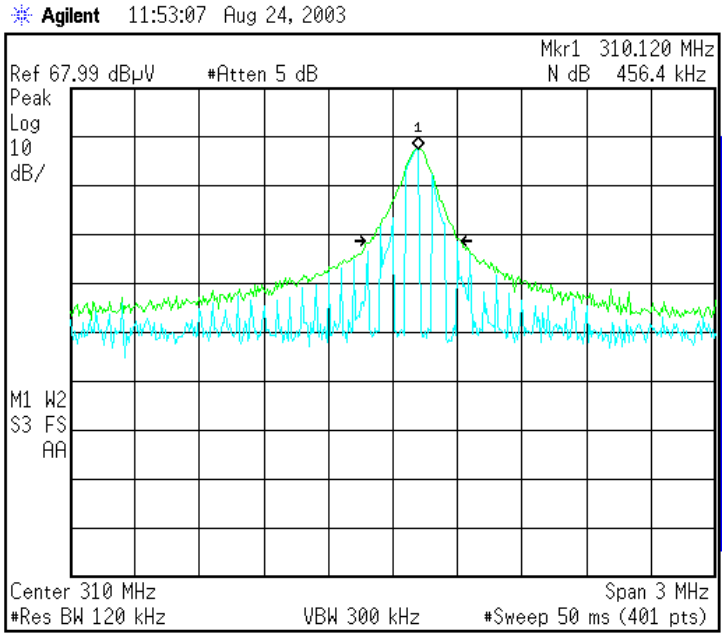

## 7.4.3. Occupied Bandwidth

Occupied bandwidth measurements were taken at 288, 310, and 418 MHz. The occupied bandwidth was determined by finding the points where the signal attenuated 20dB down from the peak. The difference between the two points in frequency was found to be the occupied bandwidth.

#### 7.4.3.1. Occupied Bandwidth Measurements

| Frequency (MHz) | Duty Cycle (%) | Occ BW (MHz) | Limit (Mhz) |
|---|---|---|---|
| 288 | 30 | 0.48 | 0.72 |
| 288 | 50 | 0.49 | 0.72 |
| 288 | 80 | 0.52 | 0.72 |
| 310 | 30 | 0.53 | 0.78 |
| 310 | 50 | 0.46 | 0.78 |
| 310 | 80 | 0.48 | 0.78 |
| 418 | 30 | 0.50 | 1.05 |
| 418 | 50 | 0.49 | 1.05 |
| 418 | 80 | 0.49 | 1.05 |

**7.4.3.2. Example of Occupied Bandwidth measurement (310MHz 50% Duty Cycle)**




## 7.4.4. Emission Spectrum

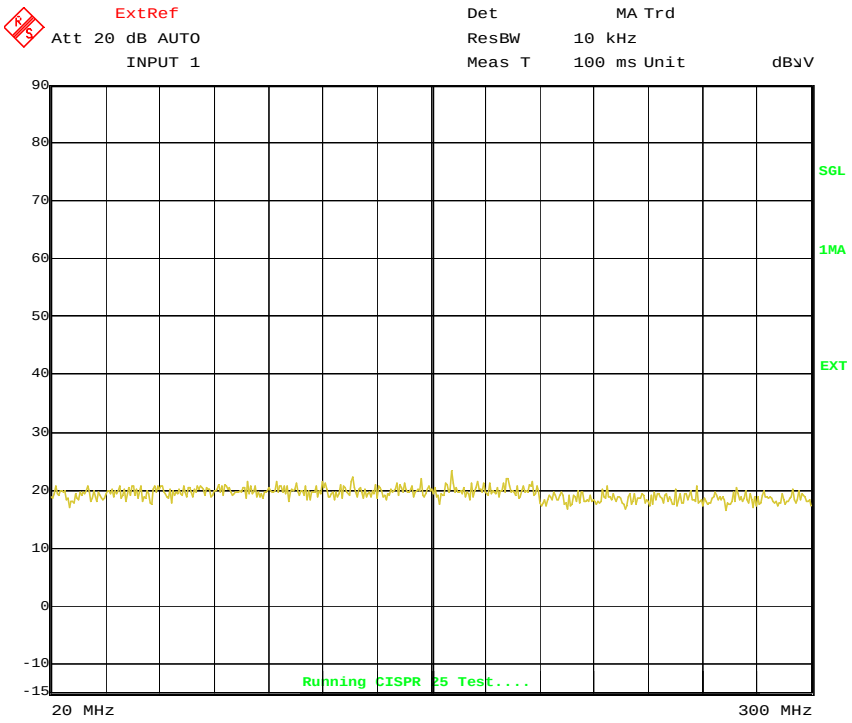
Prescan Measurements were taken inside a semi-anechoic chamber to investigate the possibility of other spurious emissions from the DUT. Screen captures presented below in sections 7.4.4.1-3 show the spurious emissions observed with the DUT trained to 288, 310, and 418MHz with a 30% Duty cycle.

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

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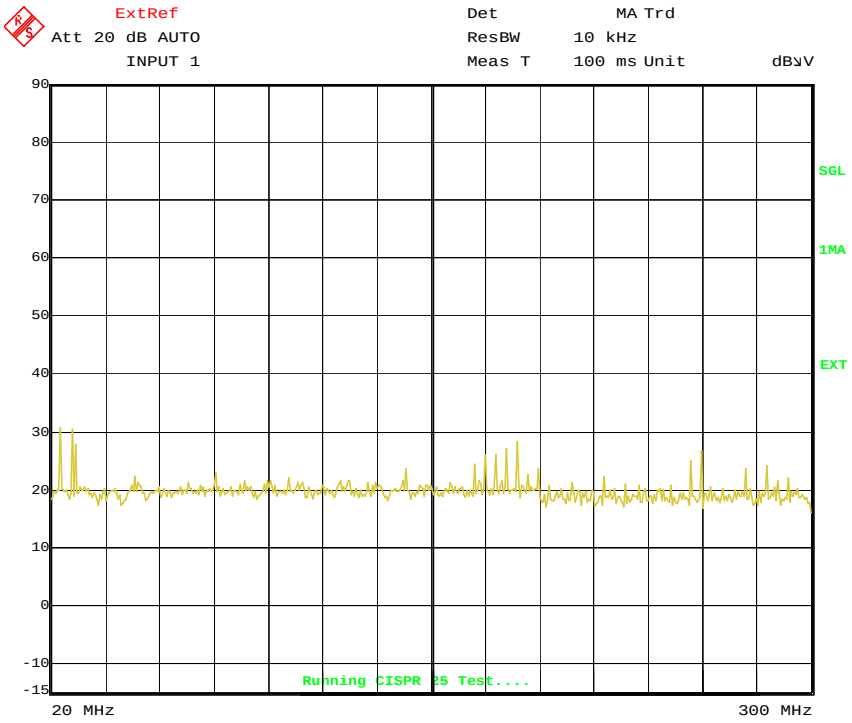
### 7.4.4.2. 310 MHz

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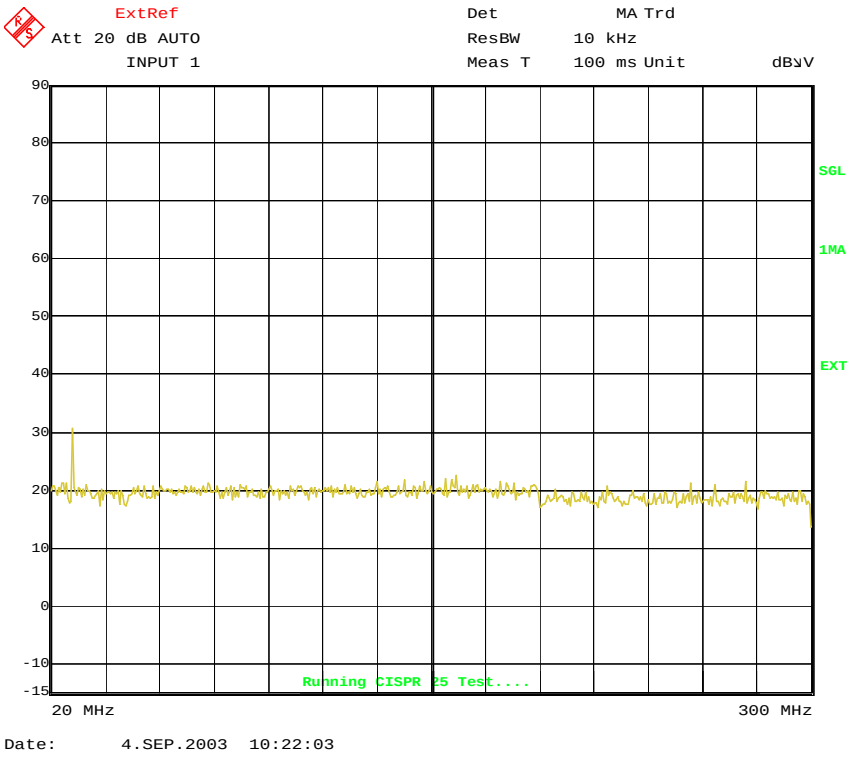
### 7.4.4.3. 418 MHz




Note: Pre-scan measurements were made in a semi-anechoic chamber using a Rohde & Schwarz EMI Test Receiver 7GHz. The semi-anehoic chamber and test receiver are part of the Johnson Control CISPR 25 Electronics Validation Group.

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

| Frequency (MHz) | Polarization (H/V) | Measurement ** (dBuV/m) | Limit (dBuV/m) | Margin (dB) |
|---|---|---|---|---|
| 31.9* | V | 36.9 | 40 | 3.1 |
| 180 | V | 28.8 | 43.5 | 14.7 |
| 184* | V | 52.2 | 43.5 | Ambient |
| 188 | V | 33.83 | 43.5 | 9.67 |
| 192 | V | 30.1 | 43.5 | 13.4 |
| 240 | V | 29 | 43.5 | 14.5 |
| 252 | V | 27.4 | 43.5 | 16.1 |
| 268 | V | 29 | 43.5 | 14.5 |
| 270 | V | 24.2 | 43.5 | 19.3 |
| 284 | V | 30.1 | 43.5 | 13.4 |
| 288 | V | 21.5 | 43.5 | 22 |

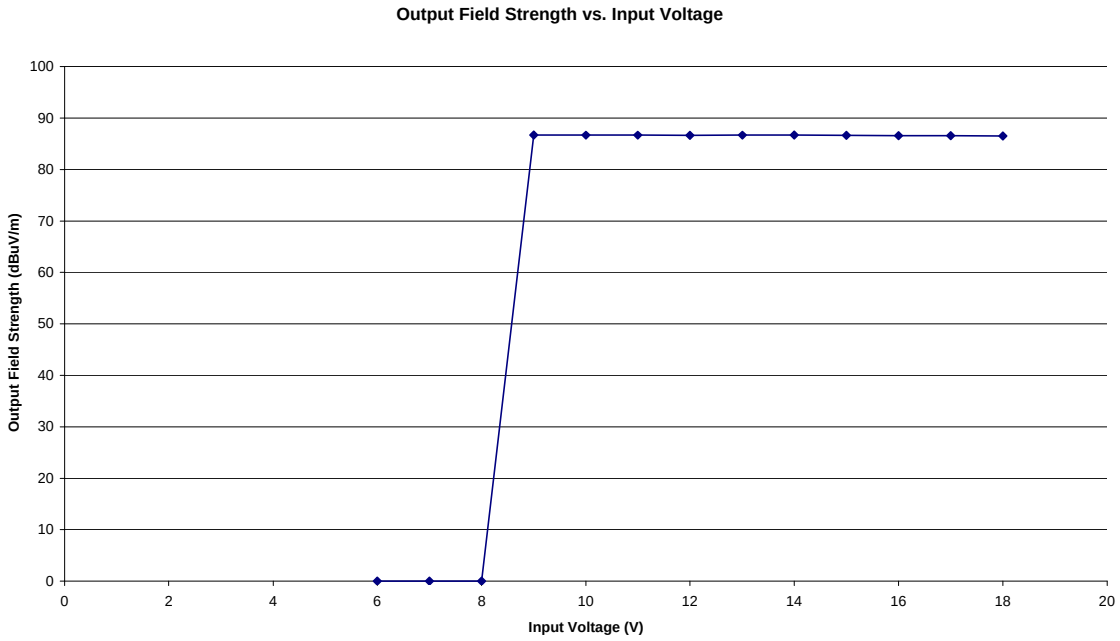
* Strong Ambient present at this frequency
** All Measurements were at or near noise floor

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

| Input Voltage (V) | Peak Value (dBuV/m) |
|---|---|
| 6 | No Op |
| 7 | No Op |
| 8 | No Op |
| 9 | 86.7 |
| 10 | 86.7 |
| 11 | 86.7 |
| 12 | 86.6 |
| 13 | 86.7 |
| 14 | 86.7 |
| 15 | 86.6 |
| 16 | 86.6 |
| 17 | 86.6 |
| 18 | 86.5 |

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

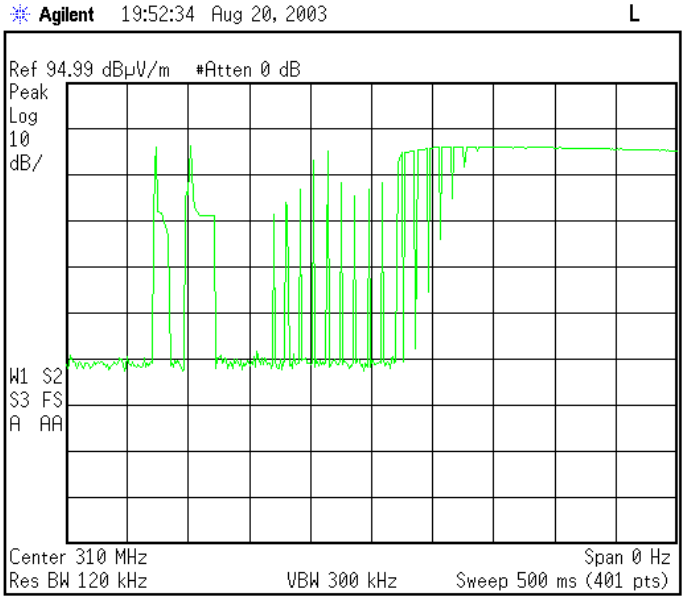
An exercise was undergone to verify that the device was not able to learn and thereby transmit in a restricted band. During this exercise it was found that the device firmware prevents the device from learning any frequency within 1MHz of any restricted band listed in 47 CFR 15.205.

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

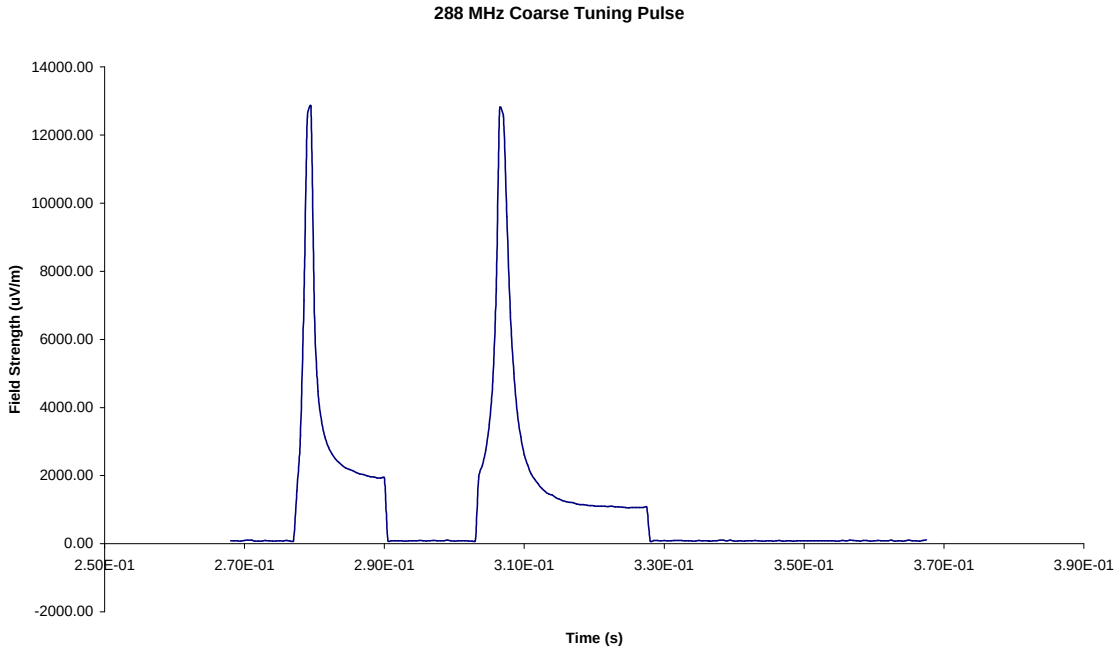
This device stops transmitting once the activation button in depressed.

## 7.4.8. Tuning Pulse Measurements

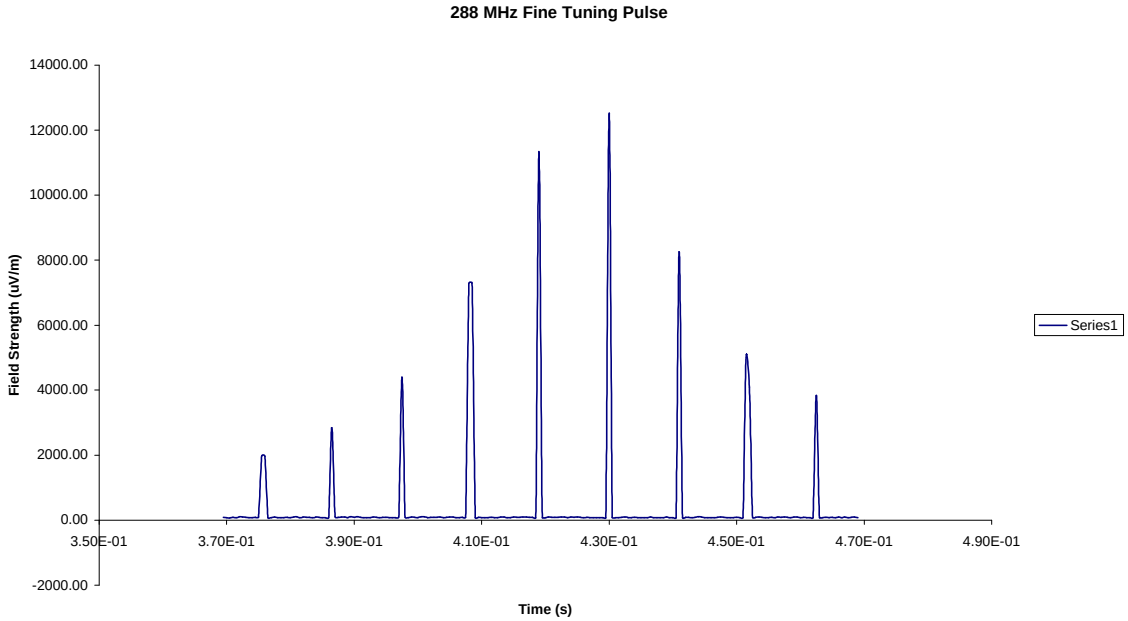
This device uses pulses to tune the antenna prior to transmission. Measurements of these tuning pulses over 500msec windows show that these pulses are below the FCC limits for operation in this band. A summary of measurements is presented in section 7.4.8.7. Tuning pulse measurements were taken at 288, 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.



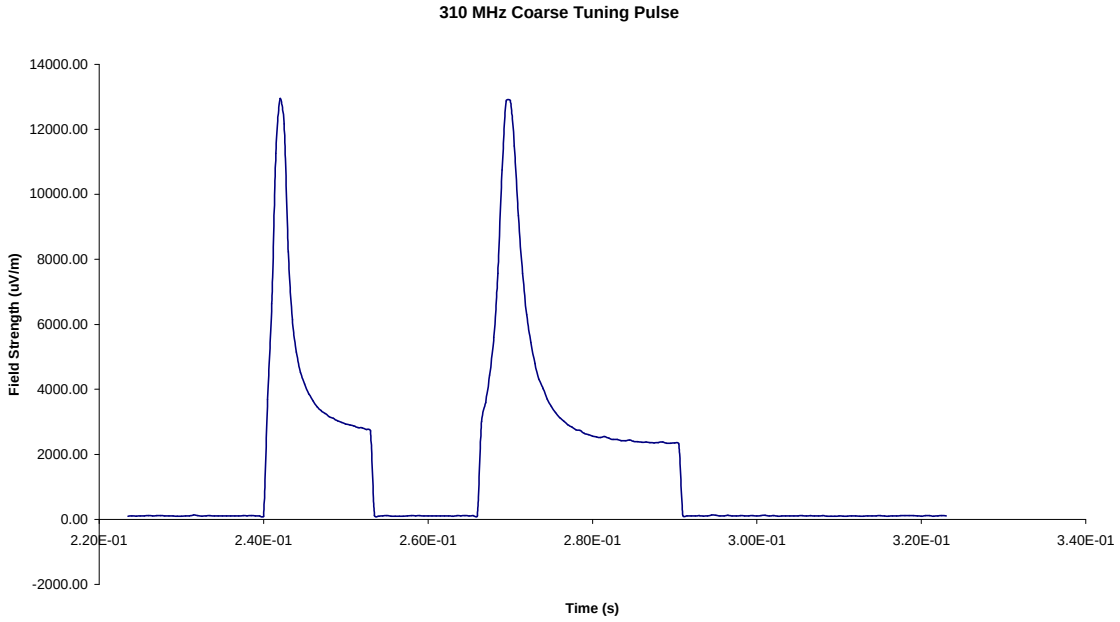

### 7.4.8.1. Coarse Tuning Pulse (288MHz)



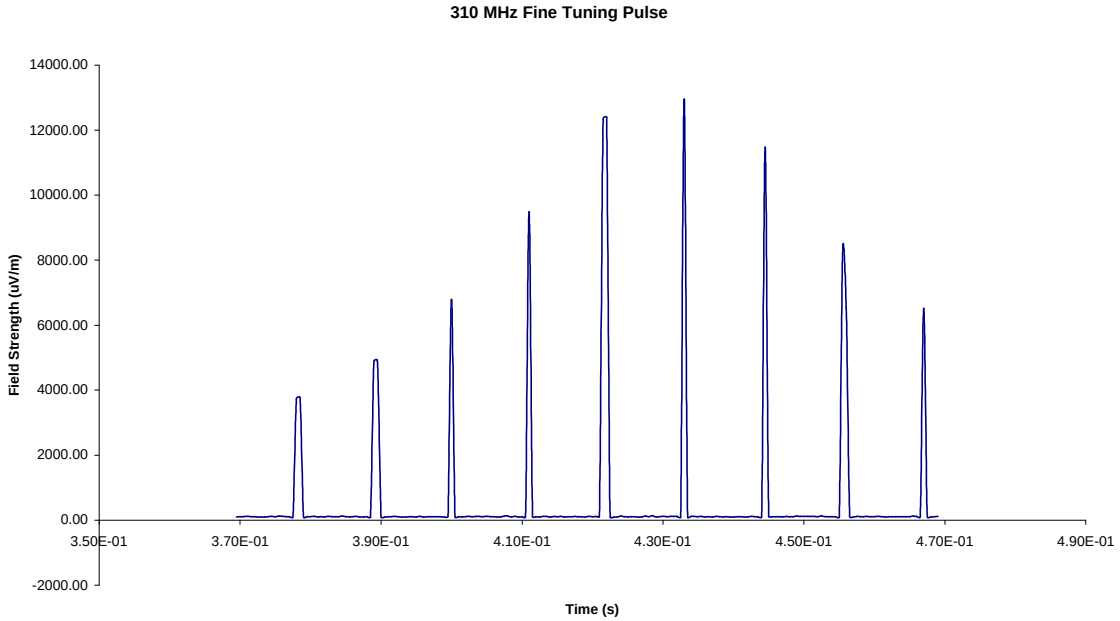
### 7.4.8.2. Fine Tuning Pulse (288MHz)



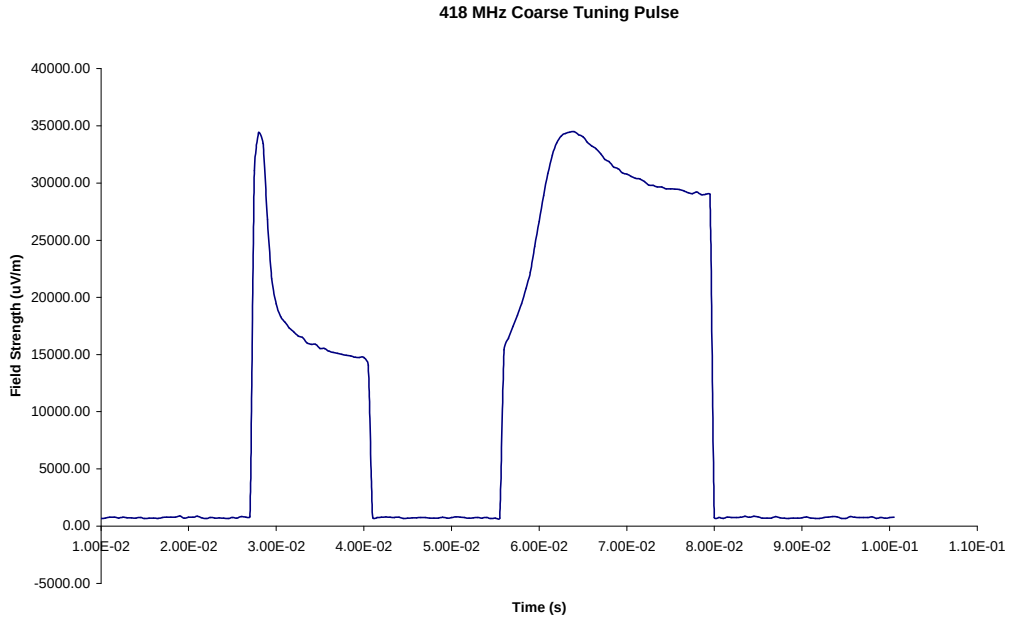

### 7.4.8.3. Coarse Tuning Pulse (310MHz)



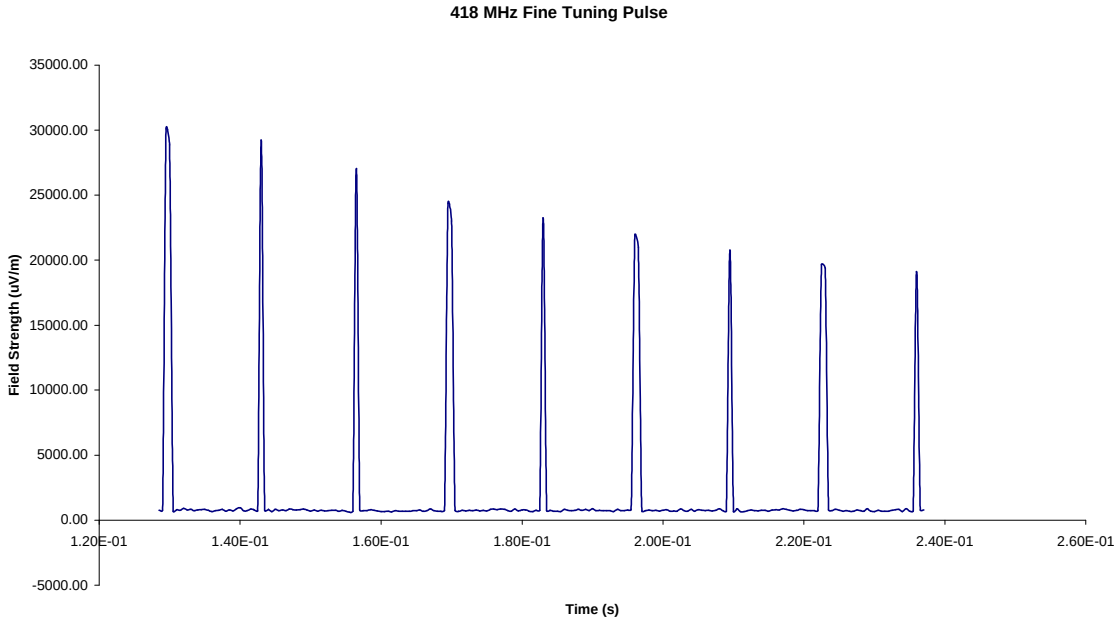
### 7.4.8.4. Fine Tuning Pulse (310MHz)




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



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




#### 7.4.8.7. Summary of Tuning Pulse Measurements

| | Frequency (MHz) | Average (uV/m) | Limit (uV/m) | Margin (dB) |
|---|---|---|---|---|
| Coarse | 288 | 1134 | 4917 | 12.7 |
| | 310 | 1692 | 5833 | 10.7 |
| | 418 | 9930 | 10333 | 0.3 |

| | Frequency (MHz) | Average (uV/m) | Limit (uV/m) | Margin (dB) |
|---|---|---|---|---|
| Fine | 288 | 434 | 4917 | 21.1 |
| | 310 | 621 | 5833 | 19.5 |
| | 418 | 2119 | 10333 | 13.8 |

Measurement Settings:

Resolution Bandwidth: 1MHz
Video Bandwidth: 3 MHz
Sweep Time: 500 msec.

For this measurement 400 points were recorded and the values averaged over 100 msec. windows that captured either the coarse or fine tuning pulses.

## 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 in 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*Log(0.3) = -10.46
For 50% (0.50): duty cycle factor(dB) = 20*Log(0.5) = -6.02
For 80% (0.80): duty cycle factor(dB) = 20*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 (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 is dBuV/m is then:

dB limit = 20 * log10( FCC limit uV/m) = 20*log10( 41.67*f – 7083.33)
( log10 is used to indicated the use of a base 10 logarithm)

This results in the following limits for the fundamentals:

| | |
|---|---|
| 288MHz | 20*log10(4917.6) = 73.8 dBuV/m |
| 310MHz | 20*log10(5834.4) = 75.3 dBuV/m |
| 390MHz | 20*log10(9168.0) = 79.2 dBuV/m |
| 418MHz | 20*log10(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 "d_assym.jpg"

## 8.4. Homelink© Board

Please refer to attachment named "lx_front.jpg"
Please refer to attachment named "lx_back.jpg"
Please refer to attachment name "hl3.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”