May 6, 2009

# Technical Report to the FCC and Industry Canada Regarding Johnson Controls Interiors, L.L.C. Homelink© IV

**Model : CB2610HL4**
**FCC ID : CB2610HL4**
**IC : 279B- 610HL4**
**Emission Designator : 105KL1D**
**03/16/2009**

A report concerning approval for Johnson Controls Homelink® model CB2610HL4
Please issue grant immediately upon review.

Confidentiality applied to the following sections according to 47 CFR 0.459 and RSP-100 section 10:

| | |
|---|---|
| Circuit Block Diagrams, attachment : | "Block Diagram.pdf" |
| Theory/Description of Operation : | "Theory_op.pdf" |
| Schematics attachment : | "Schematics.pdf & part list.pdf" |


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# 1. General Information

## 1.1. Product Description:

The Johnson Controls Interiors HomeLink® HL4 Universal Garage Door Opener is a low-power transceiver OEM device that is installed into an overhead area of the automobile. The installation is provided by trained technicians during the course of the manufacture of the automobile. It is powered by the 12 Volt 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 January 6, 2009, was accepted by the FCC in a letter dated January 08, 2009. The report filled with Industry Canada, dated January 6, 2009, was accepted via a letter dated January 08, 2009. The site was re-certified with the FCC on January 08, 2009 and with the IC on January 08, 2009. 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 (#1425.02) are available from their web site 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: CB2610HL4. The Industry Canada certification number is 279B- 610HL4. These identifiers will be labeled on the product housing.

The label will be placed on the exterior of the HL4 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.

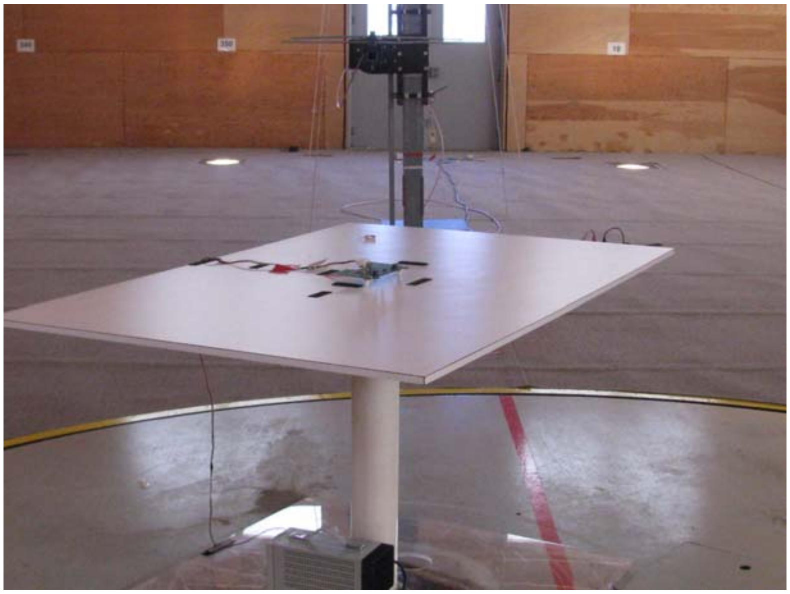
WARNING: The transmitter has been tested and complies with FCC and Industry Canada rules. Changes or modifications not expressly approved by the party responsible for the compliance could void the user's authority to operate the device."

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

The label drawing is included in the "LABEL Drawing_Label_Location" attachment.
A drawing showing the location of the label on the assembly is included in the "LABEL Drawing_Label_Location" attachment.

## 3. Test Configuration

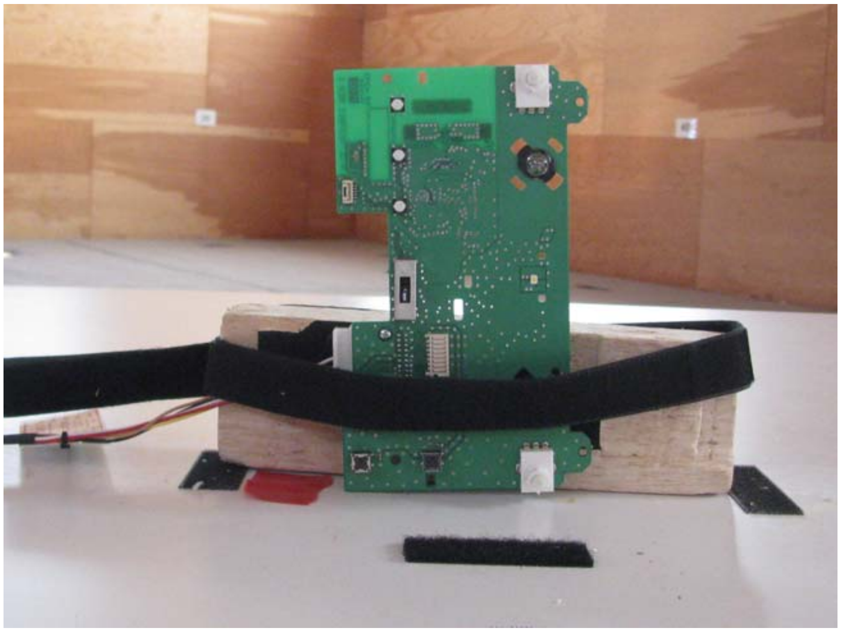
Radiated Emission measurements presented in the report were made in accordance with ANSI C63.4 Figure 9(c). The EUT was placed on a 1 x 1.5m non-metallic table elevated 80cm above a conducting ground plane. The harness was run to the long edge of the table and dropped to a power supply sitting at base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



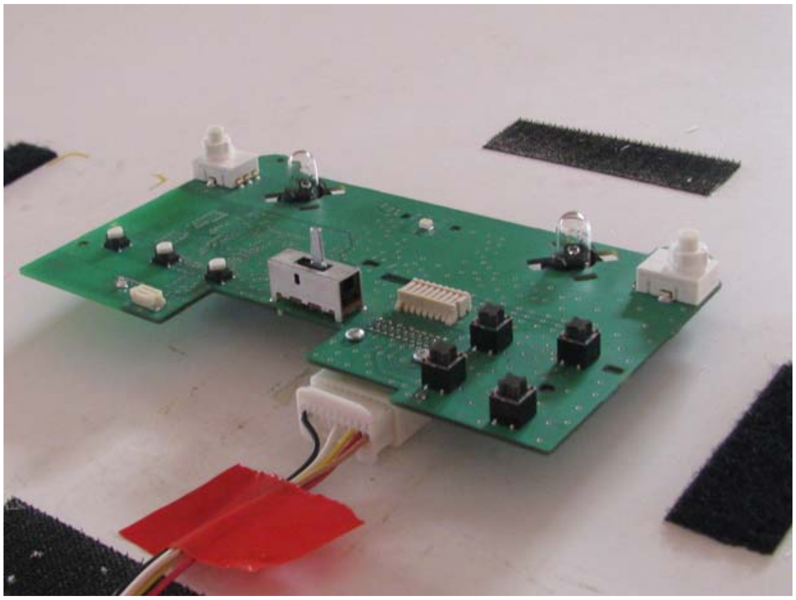
## 4. Block Diagram

For system block diagram please refer to attachment named “hl_block_diag.pdf”

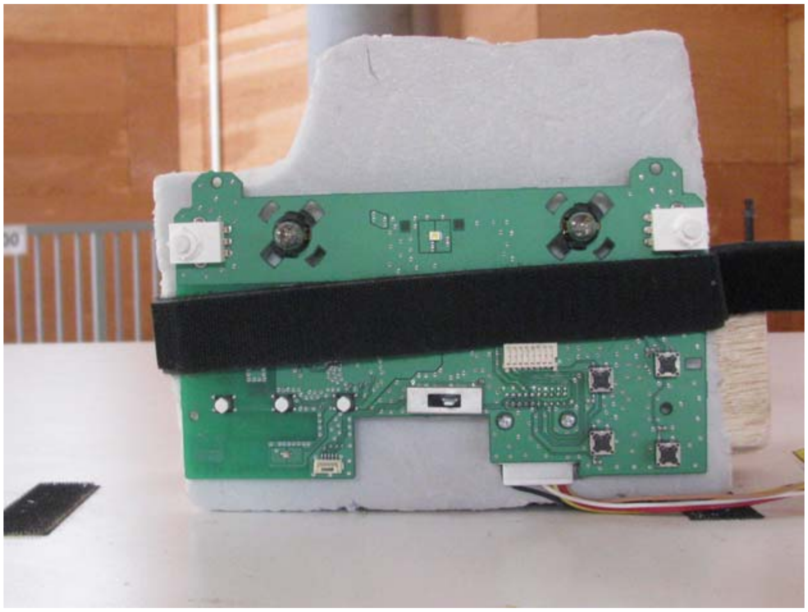
## 5. Test Setup Photographs



Test Setup Side



Test Setup Flat



Test Set Up End

## 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 433MHz at 30%, 50% and 80% duty cycles. A **worst-case emission of 82.83dBuV/m** occurred with the DUT trained to 288MHz, 30% duty cycle. The worst-case emission remained **1.5dB below the FCC and IC limits** (75.3dBuV/m) for this type of device.
- The **worst-case harmonic measurement of 62.86dBuV/m** was found at 576MHz, the second harmonic of 288MHz at 30% duty cycle. **A margin of 1.4dB to the prescribed 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 105kHz when the DUT is trained to 433MHz, 30% duty cycle.
- This device has a worst case digital emission of 41.25dBuV/m at 30MHz when set to transmit at 288MHz a margin of 1.25dB to the FCC Class B and relevant IC limit is maintained.
- The output power of the DUT increased by no more than 0.69 dB when the input voltage was varied from 6 to 18 Volts. The device does not operate when the input voltage is below 7V and power reduced to 88.41dBuV/m at 17V.
- 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 pulses to tune the transmit antenna. At 433MHz, 30% duty cycle the field strength of the pulses average 154uV/m over 100 msec. This represents a margin on 37dB to the IC and FCC limits.

## 7.2. Test Equipment Used

| Description | Model # | Serial Number | Last Cal Date | Cal Due |
|---|---|---|---|---|
| **EMCO Biconical Antenna [20-300 MHz]** | **3110B** | **9906-3309** | **09/14/07** | **09/14/09** |
| **EMCO LPA Antenna [200-2000MHz]** | **3148** | **9908-1076** | **09/14/07** | **09/14/09** |
| **Electro-metrics Double Ridged Guide [1-18GHz]** | **RGA-60** | **6147** | **01/02/09** | **01/02/11** |
| **Agilent E-series EMC Analyzer** | **E4407B** | **US41192569** | **10/04/07** | **10/15/09** |
| **HP Spectrum Analyzer** | **8591A** | **S919A00107** | **10/04/07** | **10/15/09** |

## 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) |
| | :10 kHz (to determine occupied bandwidth) |
| Video Bandwidth | :3 MHz ( to determine peak level) |
| | :30 kHz (to determine occupied bandwidth) |

For the testing, the EUT was placed at the center of a non-conducting table 80cm 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.

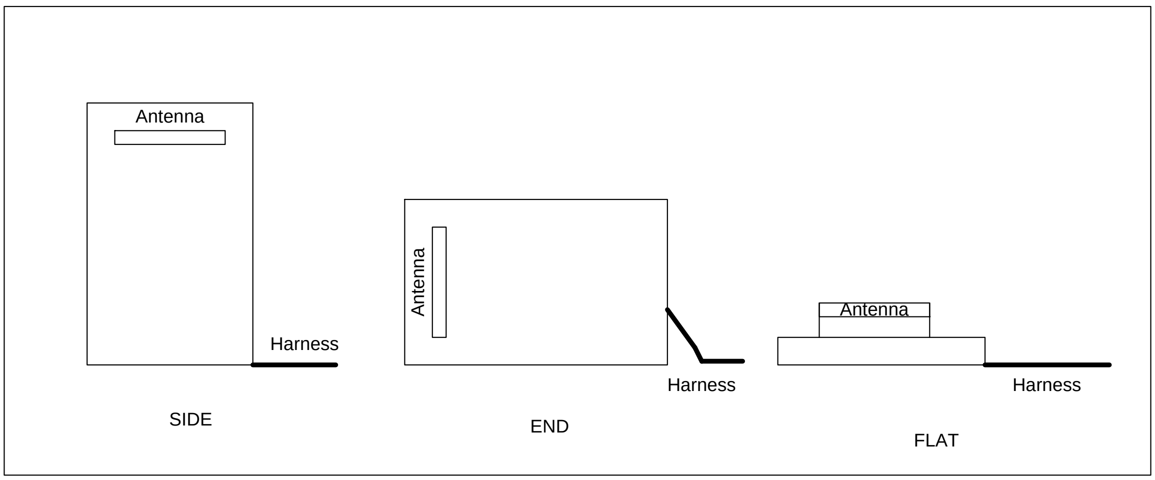



**Figure 7.3.1 EUT Orthogonal Orientations**

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 | 82.83 | -10.46 | 72.4 | 73.8 | 1.5 |
| 288 | Side | H | 50 | 78.30 | -6.02 | 72.3 | 73.8 | 1.6 |
| 288 | Side | H | 80 | 74.30 | -1.94 | 72.4 | 73.8 | **1.5** |

- 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 | Flat | H | 30 | 83.87 | -10.5 | 73.4 | 75.3 | 1.9 |
| 310 | Flat | H | 50 | 78.92 | -6.0 | 72.9 | 75.3 | 2.4 |
| 310 | Flat | H | 80 | 74.94 | -1.9 | 73.0 | 75.3 | **2.3** |

* Measurements include Cable corrections and Antenna Factors

### 7.4.1.3 DUT Tuned to 433MHz (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) |
|---|---|---|---|---|---|---|---|---|
| 433 | End | V | 30 | 89.12 | -10.5 | 78.7 | 80.8 | 2.1 |
| 433 | End | V | 50 | 84.97 | -6.0 | 78.9 | 80.8 | 1.8 |
| 433 | End | V | 80 | 80.95 | -1.9 | 79.0 | 80.8 | **1.8** |

- 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 | Flat | H | 30 | 62.86 | -10.5 | 52.4 | 53.8 | 1.4 |
| 576 | Flat | H | 50 | 52.1 | -6.0 | 46.1 | 53.8 | 7.8 |
| 576 | Side | H | 80 | 48.38 | -1.9 | 46.4 | 53.8 | 7.4 |
| 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 | V | 30 | 50.16 | -10.5 | 39.7 | 53.8 | 14.1 |
| 1152 | End | V | 50 | 48.16 | -6.0 | 42.1 | 53.8 | 11.7 |
| 1152 | End | V | 80 | 48.07 | -1.9 | 46.1 | 53.8 | 7.7 |
| 1440 | Flat | H | 30 | 52.61 | -10.5 | 42.2 | 53.8 | 11.7 |
| 1440 | Flat | H | 50 | 52.53 | -6.0 | 46.5 | 53.8 | 7.3 |
| 1440 | Flat | H | 80 | 51.87 | -1.9 | 49.9 | 53.8 | 3.9 |
| 1728 | Flat | H | 30 | 50.77 | -10.5 | 40.3 | 53.8 | 13.5 |
| 1728 | End | V | 50 | 50.06 | -6.0 | 44.0 | 53.8 | 9.8 |
| 1728 | End | V | 80 | 48.68 | -1.9 | 46.7 | 53.8 | **7.1** |
| 2016 | Flat | H | 30 | 45.08 | -10.5 | 34.6 | 53.8 | 19.2 |
| 2016 | Flat | H | 50 | 44.64 | -6.0 | 38.6 | 53.8 | 15.2 |
| 2016 | Flat | H | 80 | 44.7 | -1.9 | 42.8 | 53.8 | 11.1 |
| 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 |

* Measurements include Cable corrections and Antenna Factors — Noise — Ambient

### 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 | Flat | H | 30 | 58.13 | -10.5 | 47.7 | 55.3 | 7.6 |
| 620 | Flat | H | 50 | 52.15 | -6.0 | 46.1 | 55.3 | 9.2 |
| 620 | Flat | H | 80 | 43.53 | -1.9 | 41.6 | 55.3 | 13.7 |
| 930 | Flat | V | 30 | 45.26 | -10.5 | 34.8 | 55.3 | 20.5 |
| 930 | End | V | 50 | 38.93 | -6.0 | 32.9 | 55.3 | 22.4 |
| 930 | Side | V | 80 | 39.55 | -1.9 | 37.6 | 55.3 | 17.7 |
| 1240 | Flat | V | 30 | 50.14 | -10.5 | 39.7 | 54.0 | 14.3 |
| 1240 | Flat | V | 50 | 46.26 | -6.0 | 40.2 | 54.0 | 13.8 |
| 1240 | Flat | V | 80 | 47.95 | -1.9 | 46.0 | 54.0 | 8.0 |
| 1550 | End | V | 30 | 52.67 | -10.5 | 42.2 | 54.0 | 11.8 |
| 1550 | End | H | 50 | 43.76 | -6.0 | 37.7 | 54.0 | 16.3 |
| 1550 | End | V | 80 | 43.55 | -1.9 | 41.6 | 54.0 | 12.4 |
| 1860 | Side | V | 30 | 56.54 | -10.5 | 46.1 | 55.3 | 9.2 |
| 1860 | Side | V | 50 | 53.62 | -6.0 | 47.6 | 55.3 | 7.7 |
| 1860 | Side | V | 80 | 50.66 | -1.9 | 48.7 | 55.3 | 6.6 |
| 2170 | End | V | 30 | Noise | -10.5 | N/A | 55.3 | N/A |
| 2170 | End | V | 50 | Noise | -6.0 | N/A | 55.3 | N/A |
| 2170 | End | V | 80 | Noise | -1.9 | N/A | 55.3 | N/A |
| 2480 | End | V | 30 | Noise | -10.5 | N/A | 55.3 | N/A |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| 2480 | Flat | V | 50 | Noise | -6.0 | N/A | 55.3 | N/A |
| 2480 | End | V | 80 | Noise | -1.9 | N/A | 55.3 | N/A |
| 2790 | End | V | 30 | Noise | -10.5 | N/A | 55.3 | N/A |
| 2790 | End | V | 50 | Noise | -6.0 | N/A | 55.3 | N/A |
| 2790 | End | V | 80 | Noise | -1.9 | N/A | 55.3 | 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 |

Noise Ambient

Measurements include Cable corrections and Antenna Factors

#### 7.4.1.6 433 MHz (Harmonics)

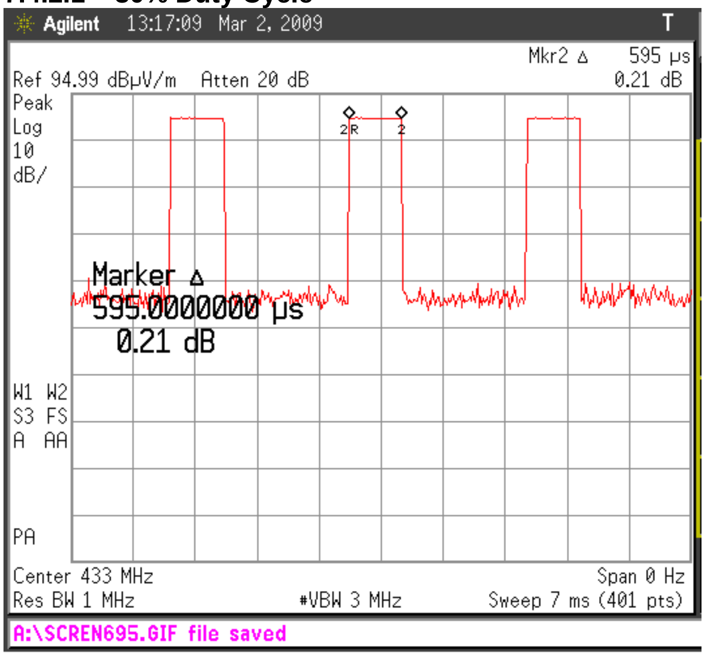
| Frequency (MHz) | Orientation (Flat/End/Side) | Measurement Polarization (H/V) | Duty Cycle (%) | Measurement* (dBuV/m) | Duty Cycle Correction (dB) | Average Level (dBuV/m) | FCC Limit (dBuV/m) | Margin (dB) |
|---|---|---|---|---|---|---|---|---|
| 866 | Side | H | 30 | 57.27 | -10.5 | 46.8 | 60.8 | 14.0 |
| 866 | Side | H | 50 | 53.69 | -6.0 | 47.7 | 60.8 | 13.1 |
| 866 | Side | H | 80 | 51.68 | -1.9 | 49.7 | 60.8 | 11.1 |
| 1299 | Flat | V | 30 | 56.27 | -10.5 | 45.8 | 60.8 | 15.0 |
| 1299 | Flat | V | 50 | 52.56 | -6.0 | 46.5 | 60.8 | 14.3 |
| 1299 | Flat | V | 80 | 50.89 | -1.9 | 49.0 | 60.8 | 11.8 |
| 1732 | Flat | H | 30 | 53.5 | -10.5 | 43.0 | 54.0 | 11.0 |
| 1732 | Flat | H | 50 | 49.65 | -6.0 | 43.6 | 54.0 | 10.4 |
| 1732 | Flat | H | 80 | 48.56 | -1.9 | 46.6 | 54.0 | 7.4 |
| 2165 | Flat | H | 30 | 51.27 | -10.5 | 40.8 | 60.8 | 20.0 |
| 2165 | Flat | H | 50 | 48.75 | -6.0 | 42.7 | 60.8 | 18.1 |
| 2165 | Flat | H | 80 | 47 | -1.9 | 45.1 | 60.8 | 15.7 |
| 2598 | Side | V | 30 | Noise | -10.5 | Noise | 60.8 | Noise |
| 2598 | Side | V | 50 | Noise | -6.0 | Noise | 60.8 | Noise |
| 2598 | Side | V | 80 | Noise | -1.9 | Noise | 60.8 | Noise |
| 3031 | End | V | 30 | Noise | -10.5 | Noise | 60.8 | Noise |
| 3031 | End | V | 50 | Noise | -6.0 | Noise | 60.8 | Noise |
| 3031 | End | V | 80 | Noise | -1.9 | Noise | 60.8 | Noise |
| 3464 | Flat | V | 30 | Noise | -10.5 | Noise | 60.8 | Noise |
| 3464 | Flat | V | 50 | Noise | -6.0 | Noise | 60.8 | Noise |
| 3464 | Flat | V | 80 | Noise | -1.9 | Noise | 60.8 | Noise |
| 3897 | End | V | 30 | Noise | -10.5 | Noise | 54.0 | Noise |
| 3897 | End | V | 50 | Noise | -6.0 | Noise | 60.8 | Noise |
| 3897 | End | V | 80 | Noise | -1.9 | Noise | 60.8 | Noise |
| 4330 | Side | H | 30 | Noise | -10.5 | Noise | 54.0 | Noise |
| 4330 | Side | H | 50 | Noise | -6.0 | Noise | 60.8 | Noise |
| 4330 | Side | H | 80 | Noise | -1.9 | Noise | 60.8 | Noise |

* Measurements include Cable corrections and Antenna Factors

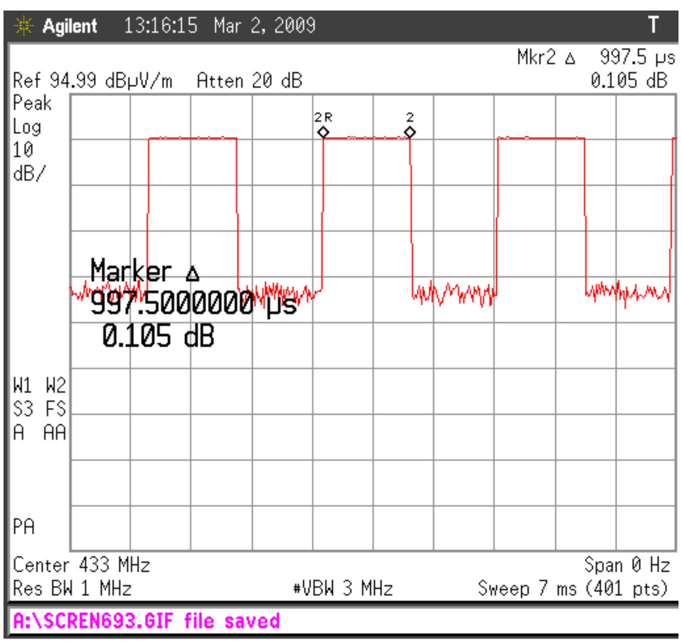
### 7.4.2 Pulsed Operation

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 433MHz with the span set to zero on the E4407B spectrum analyzer. The duty cycle is 500Hz.

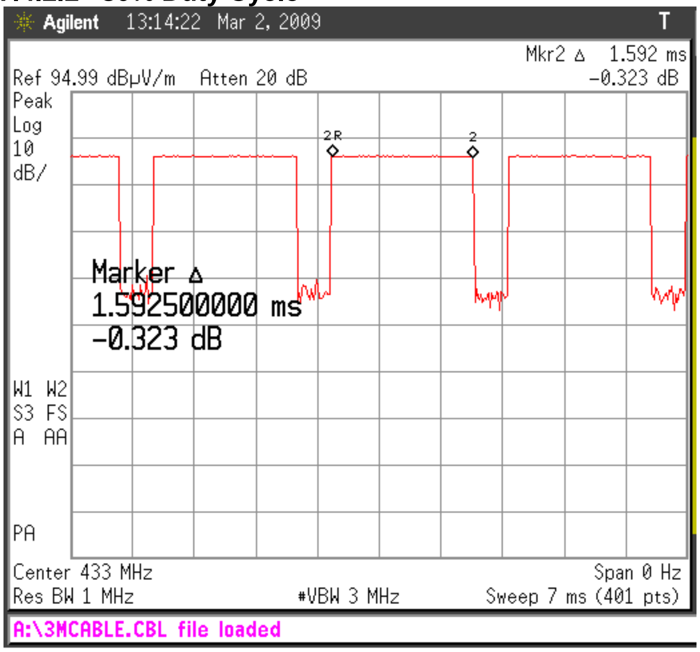
### 7.4.2.1 30% Duty Cycle




**50% Duty Cycle**



#### 7.4.2.2 80% Duty Cycle



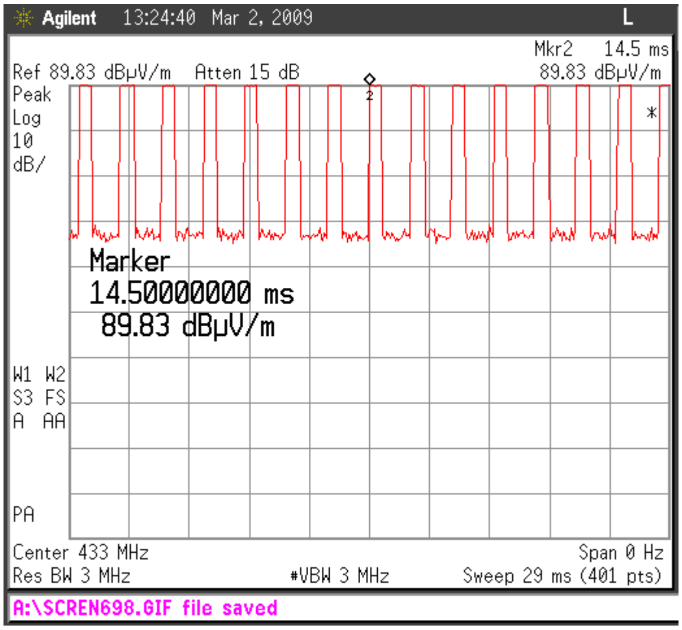

## 7.4.3 Occupied Bandwidth

Occupied bandwidth measurements were taken at 288, 310, and 433 MHz. The occupied bandwidth was determined using the 20dB measurement method.

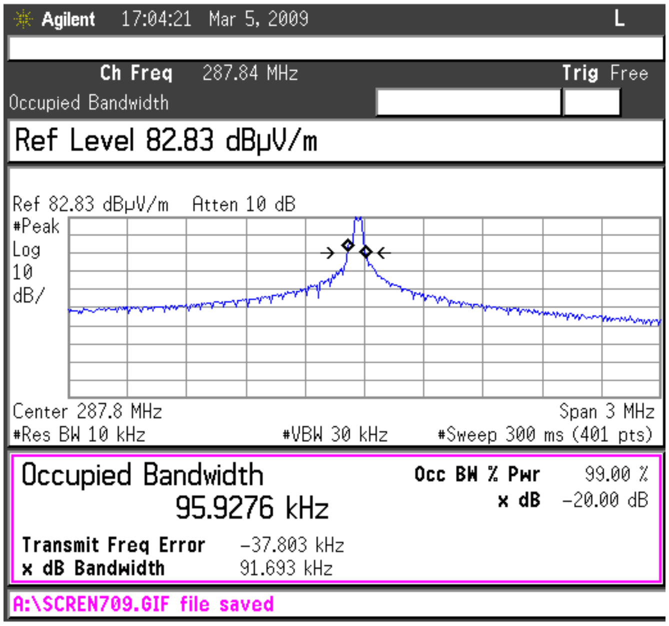
#### 7.4.3.1 Occupied Bandwidth Measurement

| Frequency (MHz) | Duty Cycle (%) | Occupied Bandwidth (kHz) | Limit (kHz) |
|---|---|---|---|
| 288 | 30 | 96 | 720 |
| | 50 | 92 | 720 |
| | 80 | 96 | 720 |
| 310 | 30 | 82 | 775 |
| | 50 | 86 | 775 |
| | 80 | 92 | 775 |
| 433 | 30 | 105 | 1045 |
| | 50 | 95 | 1045 |
| | 80 | 83 | 1045 |

### 7.4.3.2 Example of Occupied Bandwidth measurement (433MHz 30% Duty Cycle)




**Measuring Peak Reference Level**




**Measuring Occupied Bandwidth at –20dB points**

## 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.

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 and IC limits for spurious emissions. A summary is presented below in section 7.4.4.1

Measurement settings:

Resolution BW :20kHz
Video Bandwidth :300kHz
Detector :Peak

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.

#### 7.4.4.1 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 | 30 | Flat | V | 41.25 | 40 | -1.25 |
| | 40.8 | Flat | H | 29.65 | 40 | 10.35 |
| | 61.7 | Side | H | 45.63 | 40 | -5.63 |
| | 89.4 | Side | V | 58.26 | 40 | -18.26 |
| 310 | 40.1 | End | V | 31.22 | 40 | 8.78 |
| | 50.3 | Flat | H | 36.54 | 40 | 3.46 |
| | 51.3 | Side | V | 35.47 | 40 | 4.53 |
| 433 | 47.6 | Flat | H | 35.62 | 40 | 4.38 |
| | 87.4 | End | H | 41.26 | 40 | -1.26 |
| | 113 | Flat | H | 28.99 | 40 | 11.01 |
| | 145.4 | Side | H | 26.84 | 40 | 13.16 |
| | 156.9 | Flat | V | 28.65 | 40 | 11.35 |
| | 175.1 | Side | H | 48.25 | 40 | -8.25 |

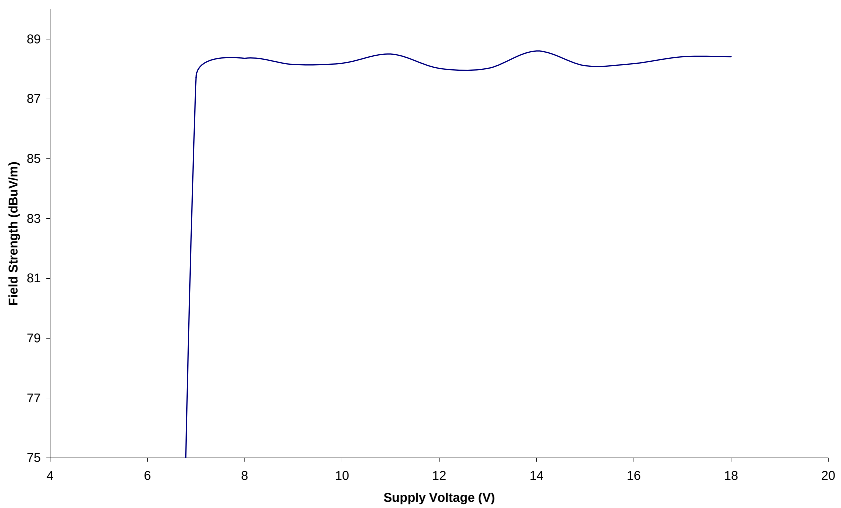
Ambient

Measurements were made using a peak detector with Resolution BW of 120kHz and Video BW of 300kHz. 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 433 MHz, 30% Duty Cycle. Values presented are not corrected for 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

| Voltage | Field Strength (dBuV/m) |
|---|---|
| 6 | 0 |
| 7 | 87.72 |
| 8 | 88.36 |
| 9 | 88.15 |
| 10 | 88.19 |
| 11 | 88.5 |
| 12 | 88.02 |
| 13 | 88.02 |
| 14 | 88.6 |
| 15 | 88.11 |
| 16 | 88.18 |
| 17 | 88.41 |
| 18 | 88.41 |
| 19 | 88.34 |
| 20 | 0 |

### 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 RSS-210 Issue 7, Table 1 and 47 CFR 15.205.

This exercise is described as follows:

## HomeLink® Operating Frequencies

HomeLink® is designed to transmit from 286 – 450 MHz, with the exception of two regions:

- 321 – 336.4 MHz
- 398.9 – 411 MHz

HomeLink® will only transmit at frequencies it is able to train to, therefore to verify HomeLink® does not **transmit** outside the designated regions, we must verify that HomeLink® does not **train** to signals outside the designated regions.

To verify this, an Agilent E4421B signal generator is set to output a 400 Hz square wave with 100% modulation depth and amplitude -5.00 dBm. It is then verified that HomeLink® will train to this signal only when it receives a transmission signal within the proper frequency range. Specifically, various frequencies are tested in the vicinity of the banned region boundaries, and it is verified that HomeLink® trained when it sees a signal at a valid frequency, and does not train when it sees a signal at a banned frequency. In the instances where HomeLink® trains to a valid frequency, it is then verified that HomeLink® transmits at that same frequency.

One thing that should be noted: HomeLink® margin of error is approximately 200 kHz. Therefore it cannot be stated that HomeLink® will adhere to the specified limits with absolute precision. This is why the FCC banned frequencies are guard-banded by 1 MHz. For example, the FCC bans transmissions below 285 MHz. By setting HomeLink®'s lower limit to 286 MHz, we guarantee that HomeLink® will not operate below 285 MHz, and in all likelihood, HomeLink ®will not operate below 285.8 MHz.

See the following table for the exact frequencies tested.

| Frequency (MHz) | Result | Pass/Fail |
|---|---|---|
| 285.0 | would not train | Pass |
| 285.5 | would not train | Pass |
| 286.0 | trained | Pass |
| 287.0 | trained | Pass |
| 319.0 | trained | Pass |
| 320.0 | trained | Pass |
| 320.5 | trained | Pass |
| 321.0 | would not train | Pass |
| 322.0 | would not train | Pass |
| 323.0 | would not train | Pass |
| 324.0 | would not train | Pass |
| 325.0 | would not train | Pass |
| 326.0 | would not train | Pass |
| 327.0 | would not train | Pass |
| 328.0 | would not train | Pass |
| 329.0 | would not train | Pass |
| 330.0 | would not train | Pass |

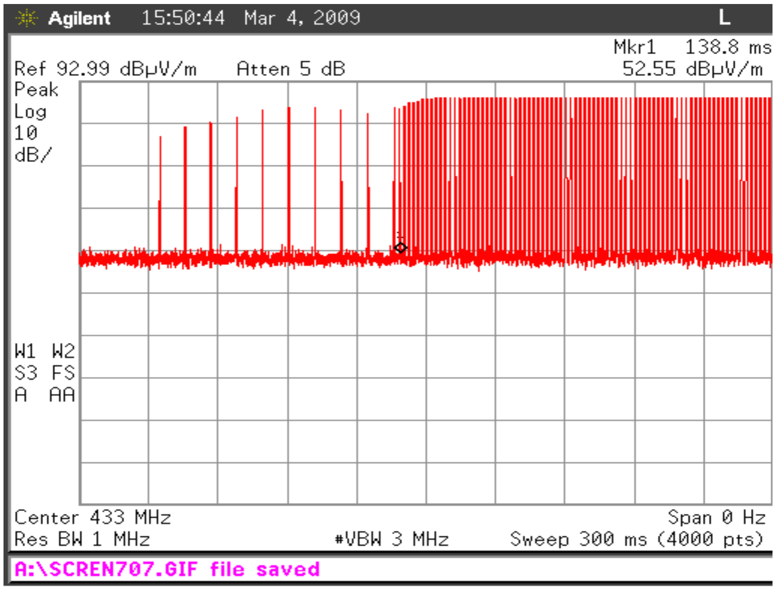
| | | |
|---|---|---|
| **331.0** | **would not train** | **Pass** |
| **332.0** | **would not train** | **Pass** |
| **333.0** | **would not train** | **Pass** |
| **334.0** | **would not train** | **Pass** |
| **335.0** | **would not train** | **Pass** |
| **336.0** | **would not train** | **Pass** |
| **337.0** | **trained** | **Pass** |
| **338.0** | **trained** | **Pass** |
| **398.0** | **trained** | **Pass** |
| **399.0** | **would not train** | **Pass** |
| **400.0** | **would not train** | **Pass** |
| **401.0** | **would not train** | **Pass** |
| **402.0** | **would not train** | **Pass** |
| **403.0** | **would not train** | **Pass** |
| **404.0** | **would not train** | **Pass** |
| **405.0** | **would not train** | **Pass** |
| **406.0** | **would not train** | **Pass** |
| **407.0** | **would not train** | **Pass** |
| **408.0** | **would not train** | **Pass** |
| **409.0** | **would not train** | **Pass** |
| **410.0** | **would not train** | **Pass** |
| **411.0** | **would not train** | **Pass** |
| **411.5** | **trained** | **Pass** |
| **412.0** | **trained** | **Pass** |
| **449.0** | **trained** | **Pass** |
| **450.0** | **trained** | **Pass** |
| **450.5** | **would not train** | **Pass** |
| **451.0** | **would not train** | **Pass** |
| **452.0** | **would not train** | **Pass** |

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

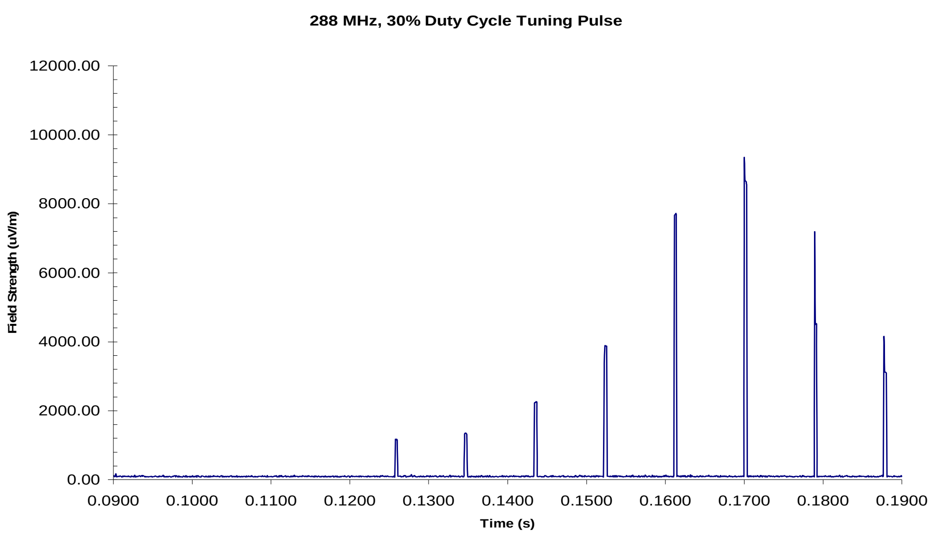
This device stops transmitting once the activation button is released.

### 7.4.8 Tuning Pulse Measurements

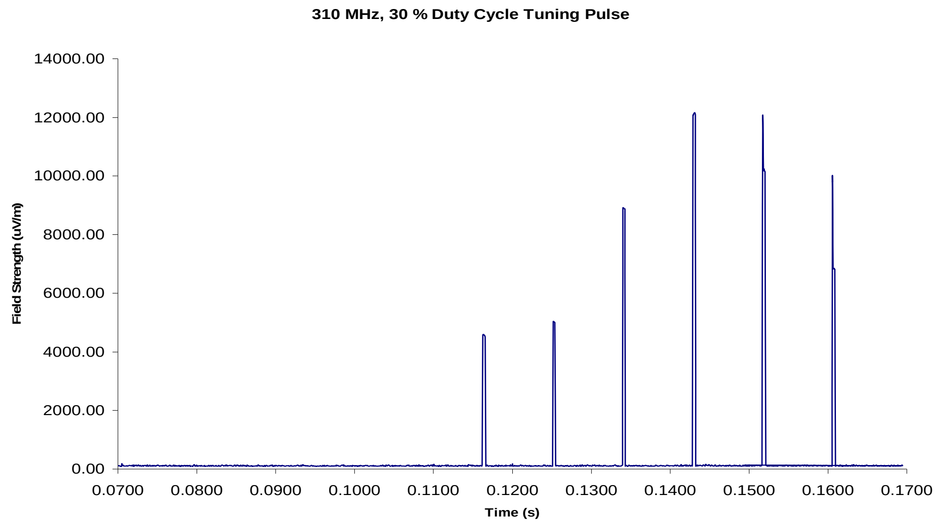
This device uses pulses to tune the antenna prior to transmission. Measurements of these tuning pulses over 100 msec windows show that these pulses are below the FCC limits for operation in this band. A summary of measurements is presented in section 7.4.8.4. Tuning pulse measurements were taken at 288, 310, and 433 MHz at a duty cycle of 30%. Settings in the screen capture below were not used to make the measurements presented in section 7.4.8.4.



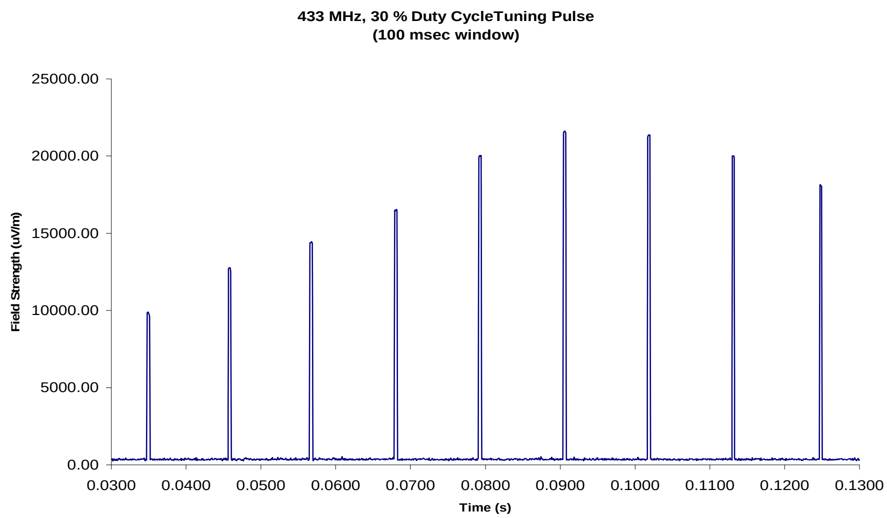

### 7.4.8.1 Tuning Pulse (288MHz)




### 7.4.8.2 Tuning Pulse (310MHz)




### 7.4.8.3 Tuning Pulse (433 MHz)




### 7.4.8.4 Summary of Tuning Pulse Measurements

Measurement Settings:
Resolution Bandwidth : 1MHz
Video Bandwidth : 3 MHz
Sweep Time : 300 msec.
For this measurement 4000 points were recorded and the values averaged over 100 msec. windows that captured the tuning pulse.

| Frequency (MHz) | Average (uV/m) | Limit (uV/m) | Margin (dB) |
|---|---|---|---|
| 288 | 208 | 4915 | 27.5 |
| 310 | 282 | 5831 | 26.3 |
| 433 | 895 | 10958 | **21.8** |

## 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 IC Limits from Table 4, RSS-210 and 47 CFR Part 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:

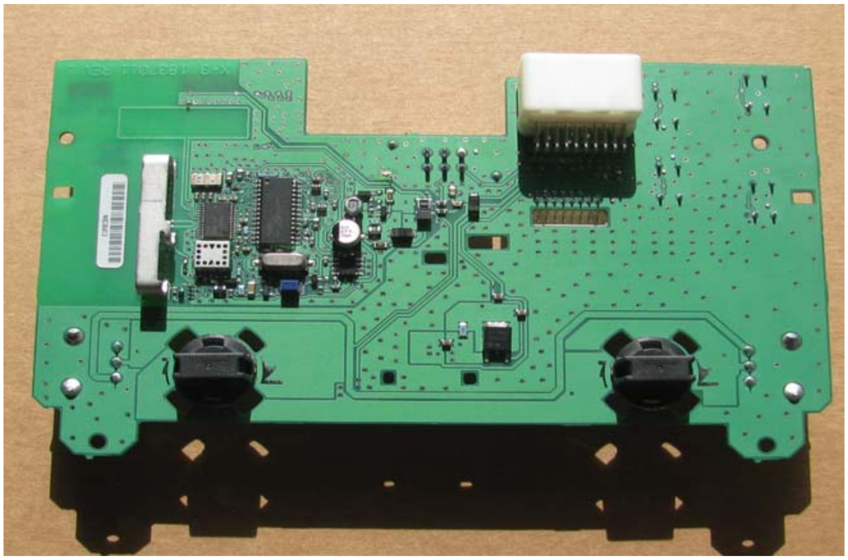
dB limit = 20 * log10( FCC limit uV/m) = 20*log10( 41.67*f – 7083.33)
( log10 is used to indicated the use of a base 10 logarithm)

This results in the following limits for the fundamentals:

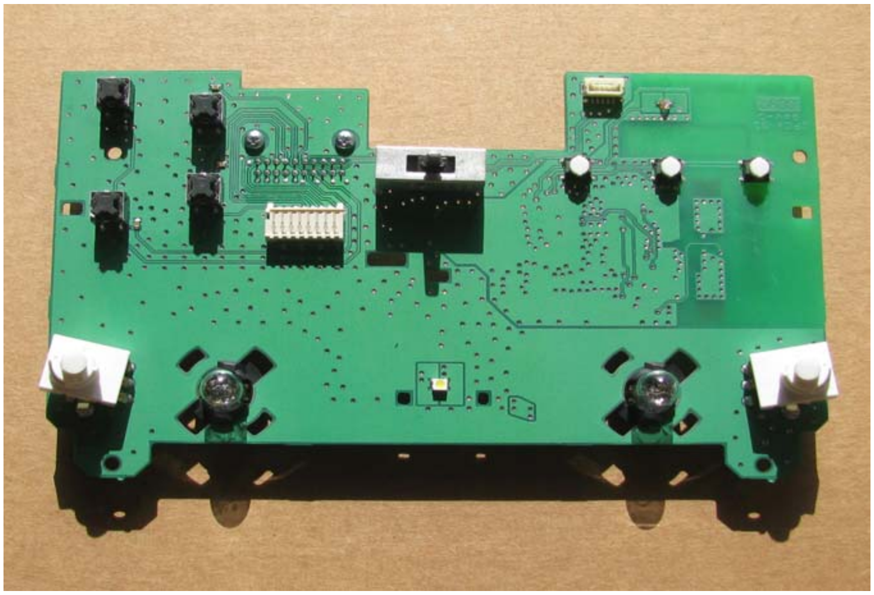
| | | |
|---|---|---|
| 288MHz | 20*log10(4917.6) | = 73.8 dBuV/m |
| 310MHz | 20*log10(5834.4) | = 75.3 dBuV/m |
| 390MHz | 20*log10(9168.0) | = 79.2 dBuV/m |
| 433MHz | 20*log10(10959.8) | = 80.8 dBuV/m |

# 8 Photos of Product Tested

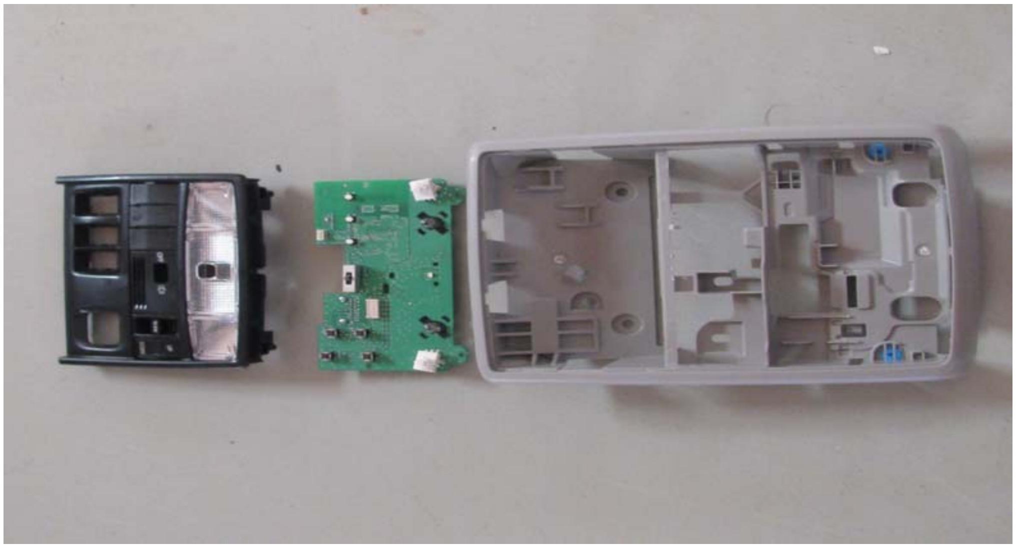
### 8.1.1 Front View

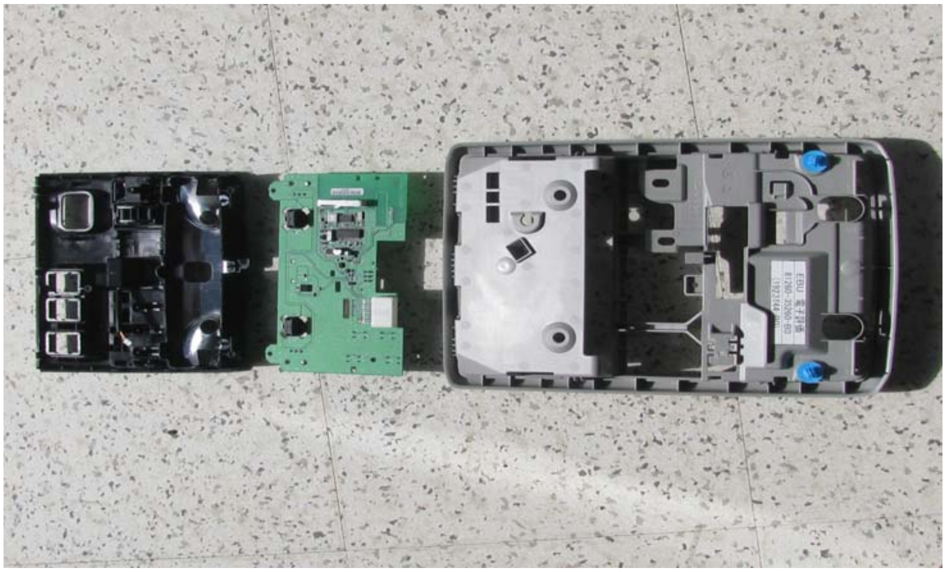


### 8.1.2 Rear View



### 8.1.3 Unit Disassembled



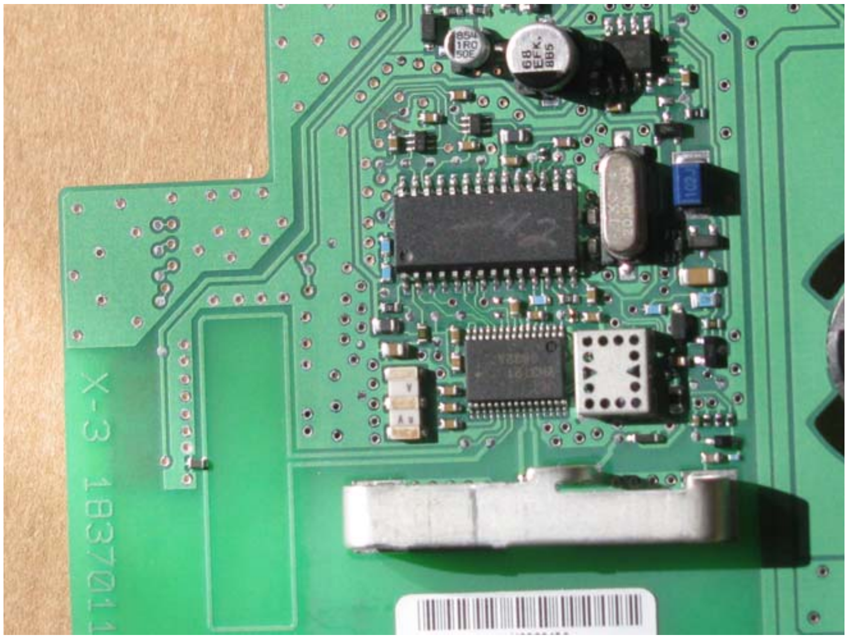


## 8.2 Housing & PCB Board Internal View

May 6, 2009



Figure 8.3 Close-up of Homelink RF Section.



# 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”.

## 9.3 Emission Designation

According to TRC-43, the emission designation for this product is 105KL1D. Where “105K” is the highest measured occupied bandwidth, “L” indicates the device uses pulse width modulation, “1” indicates the modulation as being single channel, digital information and “D” indicates that data is being transmitted

## 9.4 Theory of Operation

For schematics please refer to attachment “Theory_op.pdf”

## 9.5 Label Drawing and Location on Complete Assembly.

For a drawing of the label, refer to attachment “LABEL Drawing_Label_Location.”

For a drawing of the position of the label on the finished assembly refer to

“LABEL Drawing_Label_Location”.