March 31, 2006

Technical Report to the FCC and Industry Canada Regarding Johnson Controls Interiors, L.L.C. Homelink© III
Model: CB2SAHL4
FCC ID: CB2SAHL4
IC:279B-SAHL4
Emission Designation : 105KL1D
3/31/2006

A report concerning approval for Johnson Controls Homelink® model CB2SAHL4.
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 “hl_block_diag.pdf”
- Theory/Description of Operation “theory_op.pdf”
- Schematics attachment “schematics.pdf”

Measurements Made by:

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Report and Application Prepared by
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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 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 18, 2005 and with the IC on December 27, 2005. 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. 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: CB2SAHL4. The Industry Canada certification number is 279B-SAHL4. These identifiers will be embossed 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 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.

Photograph of Test Setup

4. Block Diagram

See attachment block diagram attachment.

5. Test Setup Photographs

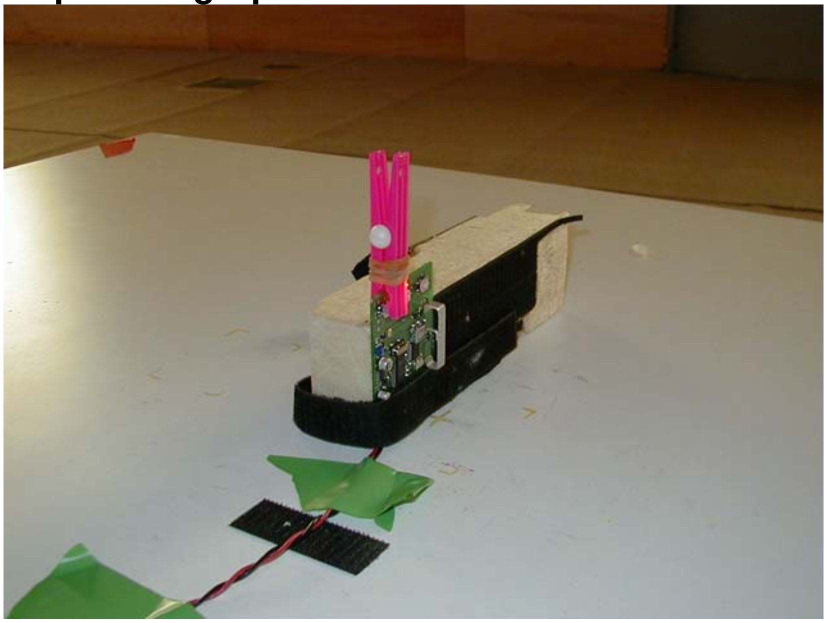


Figure 5.1. Test Setup DUT End Orientation

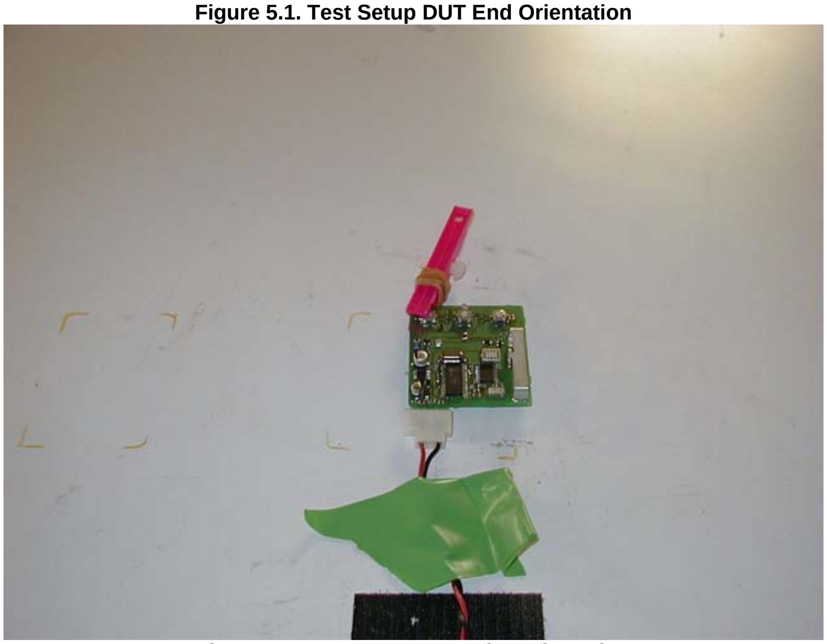


Figure 5.1. Test Setup DUT Flat Orientation

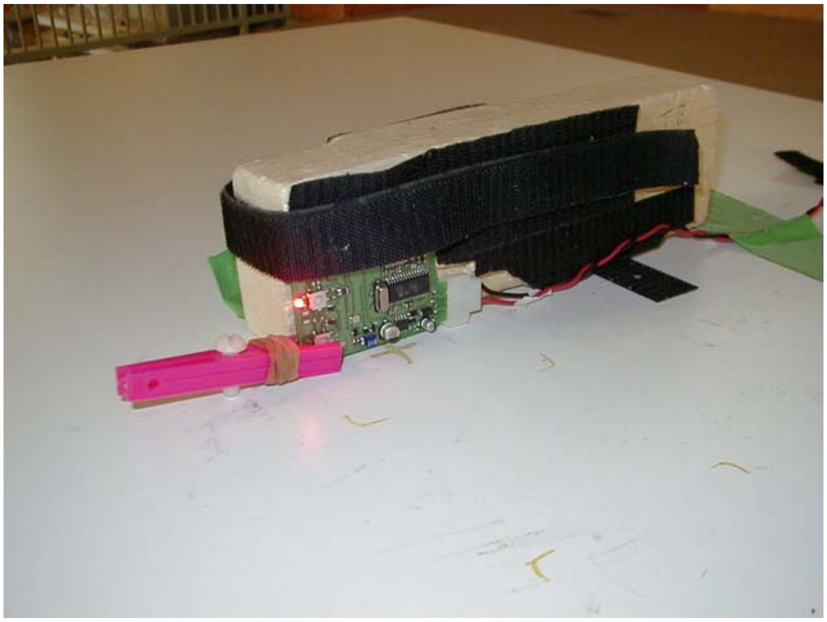


Figure 5.1. Test Setup DUT Side Orientation

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 433 MHz at 30, 50 and 80% duty cycles. A **worst-case emission of 78.9 dBuV/m** occurred with the DUT trained to 433 MHz, 80% duty cycle. The worst-case emission remained **1.9 dB below the IC and FCC limits** (73.8 dBuV/m) for this type of device.
- The **worst-case harmonic measurement of 47.9 dBuV/m** was found at 1152 MHz, the fourth harmonic of 309.3 MHz at 80% duty cycle. **A margin of 5.9 dB to the prescribed FCC and IC limits 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 105 kHz when the DUT is trained to 433 MHz, 30% duty cycle.
- This device has a worst-case Class B emission of 22.3 dBuV/m at 85 MHz when set to transmit at 433 MHz a margin of 17.7 dB to the Class B limit is maintained.
- The output power of the DUT varied by no more than 0.65 dB when the input voltage was varied from 6 to 18 Volts. The device does not operate when the input voltage is below 7V.
- 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 288 MHz, 30% duty cycle the field strength of the pulses average 320 uV/m over 100 msec. This represents a margin on 23.7 dB to the FCC and IC limits.

7.2. Test Equipment Used

Description	Model #	Serial Number	Last Cal Date	Cal Due
EMCO Biconical Antenna (20-300 MHz)	3110B	9906-3309	7/15/05	7/15/07
EMCO LPA Antenna (200-2000MHz)	3148	9908-1076	7/14/05	7/14/07
Electro-metrics Double Ridged Guide (1-18GHz)	RGA-60	6147	1/07/05	1/7/07
A.H. Systems Bicon Antenna	SAS-540	599	8/1/05	8/1/06
Agilent E-series EMC Analyzer	E4407B	US41192569	10/18/05	10/18/06
HP Spectrum Analyzer	8591A	S919A00107	10/17/05	10/17/06
Rohde & Schwarz EMI Test Receiver 7GHz	EMI 7	1088.749.07	7/26/05	7/26/06

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.

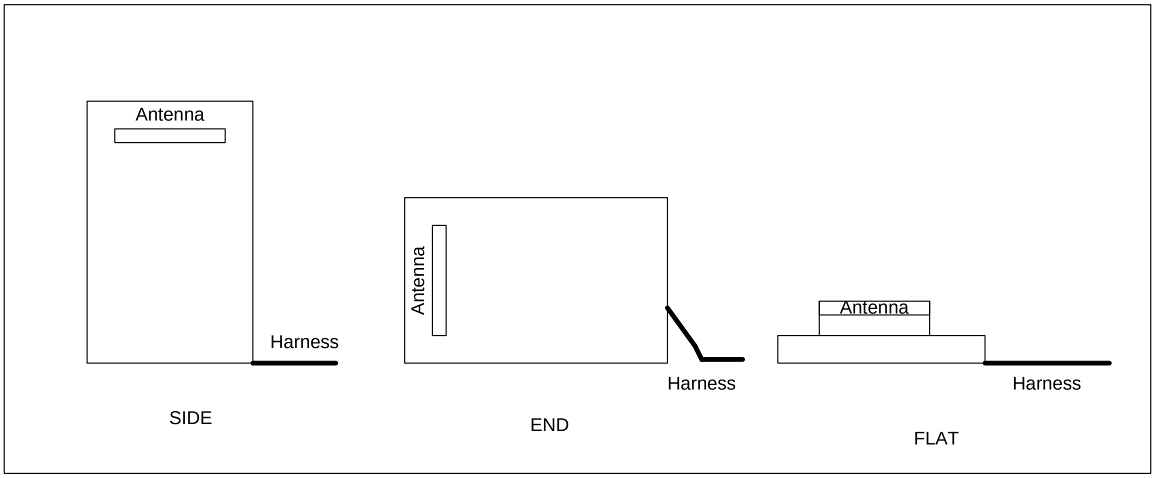


Figure 7.3.1 EUT Orthogonal Orientations

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	79.52	-10.46	69.1	73.8	4.8
288	Side	H	50	76.94	-6.02	70.9	73.8	2.9
288	Side	H	80	73.84	-1.94	71.9	73.8	**1.9**

* Measurements include Cable corrections and Antenna Factors

7.4.1.2. DUT Tuned to 310MHz (Fundamental) *Measured at 309.3 MHz due to ambients*

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)
309.3	Side	H	30	81	-10.5	70.5	75.3	4.7
309.3	Side	H	50	77.65	-6.0	71.6	75.3	3.6
309.3	Side	H	80	75.21	-1.9	73.3	75.3	**2.0**

* 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	87.07	-10.5	76.6	80.8	4.2
433	End	V	50	83.77	-6.0	77.7	80.8	3.0
433	End	V	80	80.88	-1.9	78.9	80.8	**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	V	30	55.85	-10.5	45.4	53.8	8.4
576	Side	V	50	44.75	-6.0	38.7	53.8	15.1
576	Side	H	80	40.33	-1.9	38.4	53.8	15.4
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	Flat	V	30	54.25	-10.5	43.8	53.8	10.0
1152	End	V	50	51.37	-6.0	45.3	53.8	8.5
1152	Flat	V	80	49.84	-1.9	47.9	53.8	**5.9**
1440	Flat	H	30	46.32	-10.5	35.9	53.8	18.0
1440	Flat	H	50	44.56	-6.0	38.5	53.8	15.3
1440	Flat	H	80	43.57	-1.9	41.6	53.8	12.2
1728	Flat	H	30	50.98	-10.5	40.5	53.8	13.3
1728	Flat	H	50	48.99	-6.0	43.0	53.8	10.9
1728	Flat	H	80	48.24	-1.9	46.3	53.8	7.5
2016	Flat	V	30	46.02	-10.5	35.6	53.8	18.3
2016	Flat	V	50	45.21	-6.0	39.2	53.8	14.6
2016	Flat	V	80	45.17	-1.9	43.2	53.8	10.6
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)
618.6	Side	V	30	45.52	-10.5	35.1	55.3	20.2
618.6	Side	V	50	42.26	-6.0	36.2	55.3	19.0
618.6	Side	V	80	39.29	-1.9	37.4	55.3	17.9
927.9	End	V	30	Ambient	-10.5	N/A	55.3	N/A
927.9	End	V	50	Ambient	-6.0	N/A	55.3	N/A
927.9	End	V	80	Ambient	-1.9	N/A	55.3	N/A
1237.2	End	V	30	48.42	-10.5	38.0	54.0	16.0
1237.2	End	V	50	47.25	-6.0	41.2	54.0	12.8
1237.2	End	V	80	47.4	-1.9	45.5	54.0	**8.5**
1546.5	End	V	30	52.64	-10.5	42.2	54.0	11.8
1546.5	End	H	50	47.56	-6.0	41.5	54.0	12.5
1546.5	Flat	V	80	45.66	-1.9	43.7	54.0	10.3
1855.8	End	V	30	Ambient	-10.5	N/A	55.3	N/A
1855.8	End	V	50	Ambient	-6.0	N/A	55.3	N/A
1855.8	End	V	80	Ambient	-1.9	N/A	55.3	N/A
2165.1	End	V	30	42.65	-10.5	32.2	55.3	23.1
2165.1	End	V	50	Noise	-6.0	N/A	55.3	N/A
2165.1	End	V	80	Noise	-1.9	N/A	55.3	N/A
2474.4	Side	V	30	42.31	-10.5	31.9	55.3	23.4
2474.4	Flat	V	50	Noise	-6.0	N/A	55.3	N/A
2474.4	End	V	80	Noise	-1.9	N/A	55.3	N/A
2783.7	Side	H	30	43.68	-10.5	33.2	54.0	20.8
2783.7	End	V	50	Noise	-6.0	N/A	55.3	N/A
2783.7	End	V	80	Noise	-1.9	N/A	55.3	N/A
3093	Side	V	30	Noise	-10.5	N/A	55.3	N/A
3093	Side	V	50	Noise	-6.0	N/A	55.3	N/A
3093	Side	V	80	Noise	-1.9	N/A	55.3	N/A

Ambient Noise

* Measurements include Cable corrections and Antenna Factors

7.4.1.6. 433 MHz (Harmonics)

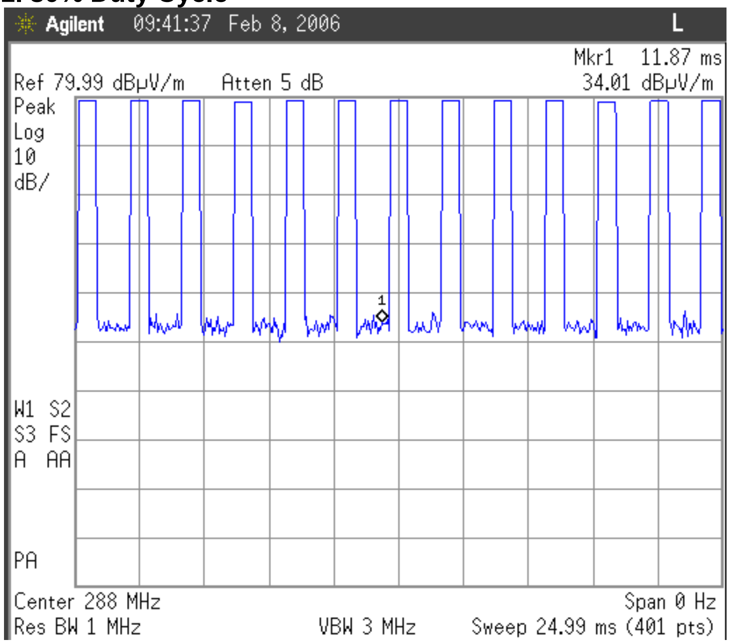
Frequency (MHz)	Orientation (Flat/End/Side)	Measurement Polarization (H/V)	Duty Cycle (%)	Measurement* (dBuV/m)	Duty Cycle Correction (dB)	Average Level (dBuV/m)	FCC Limit (dBuV/m)	Margin (dB)
866	End	V	30	60.34	-10.5	49.9	60.8	10.9
866	Side	V	50	58.21	-6.0	52.2	60.8	**8.6**
866	Side	H	80	49.24	-1.9	47.3	60.8	13.5
1299	Side	V	30	52.63	-10.5	42.2	60.8	18.6
1299	Side	V	50	52.2	-6.0	46.2	60.8	14.6
1299	Side	V	80	51.73	-1.9	49.8	60.8	11.0
1732	Flat	V	30	Noise	-10.5	Noise	54.0	Noise
1732	Flat	V	50	Noise	-6.0	Noise	54.0	Noise
1732	Flat	V	80	Noise	-1.9	Noise	54.0	Noise
2165	Side	V	30	Noise	-10.5	Noise	60.8	Noise
2165	Side	V	50	Noise	-6.0	Noise	60.8	Noise
2165	Side	V	80	Noise	-1.9	Noise	60.8	Noise
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

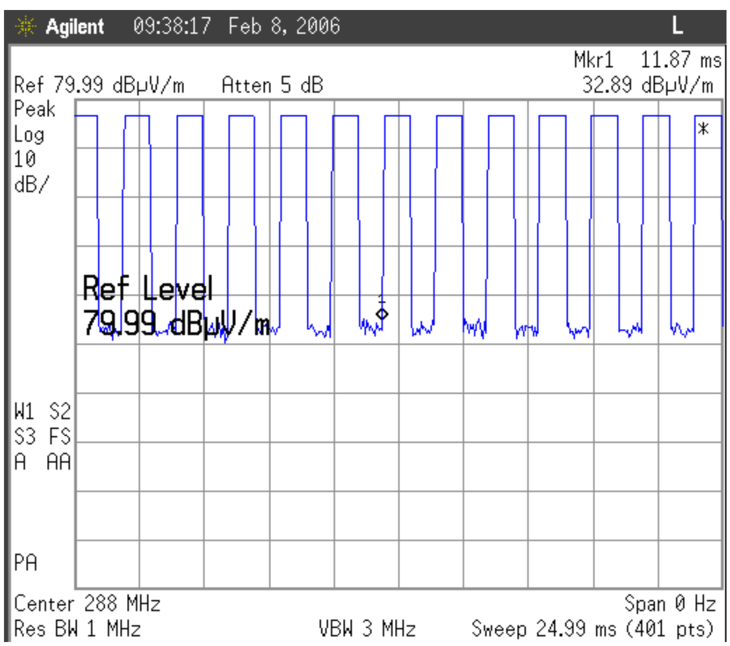
7.4.2. Pulsed Operation

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 288MHz with the span set to zero on the E7407B spectrum analyzer.

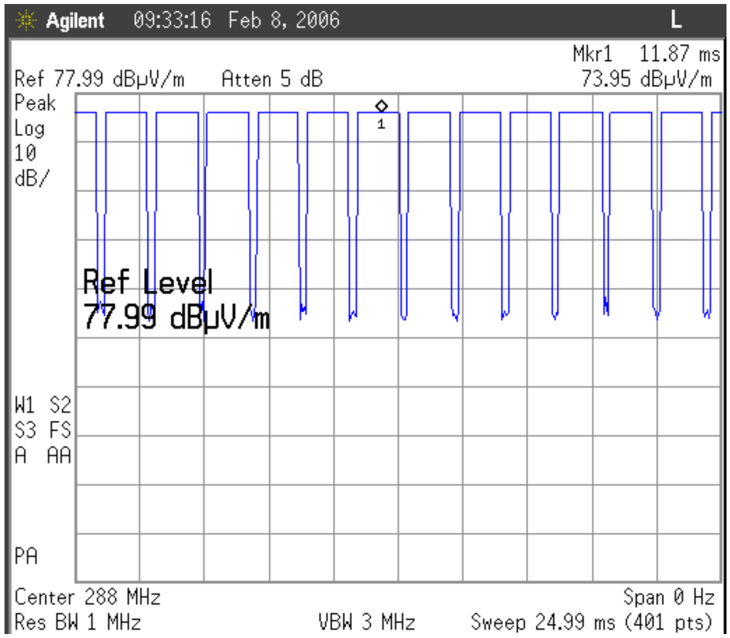
7.4.2.1. 30% Duty Cycle



7.4.2.2. 50% Duty Cycle



7.4.2.3. 80% Duty Cycle



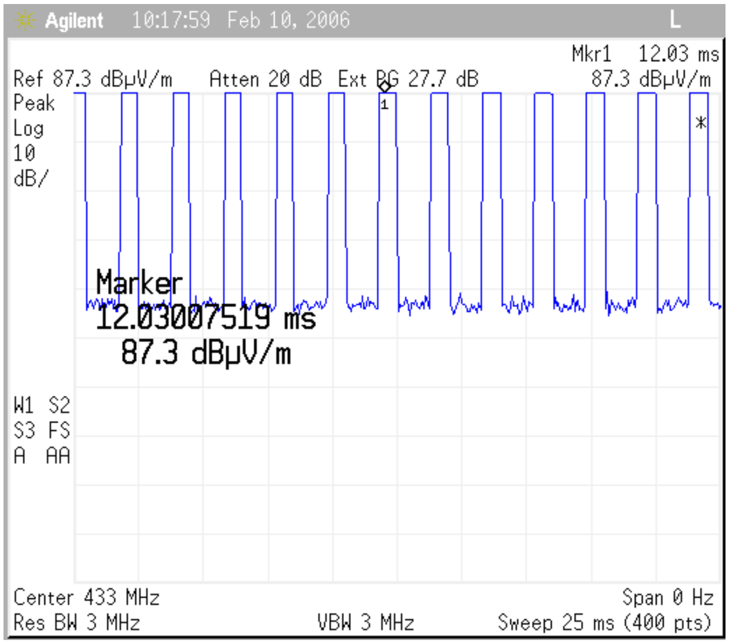
7.4.3. Occupied Bandwidth

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

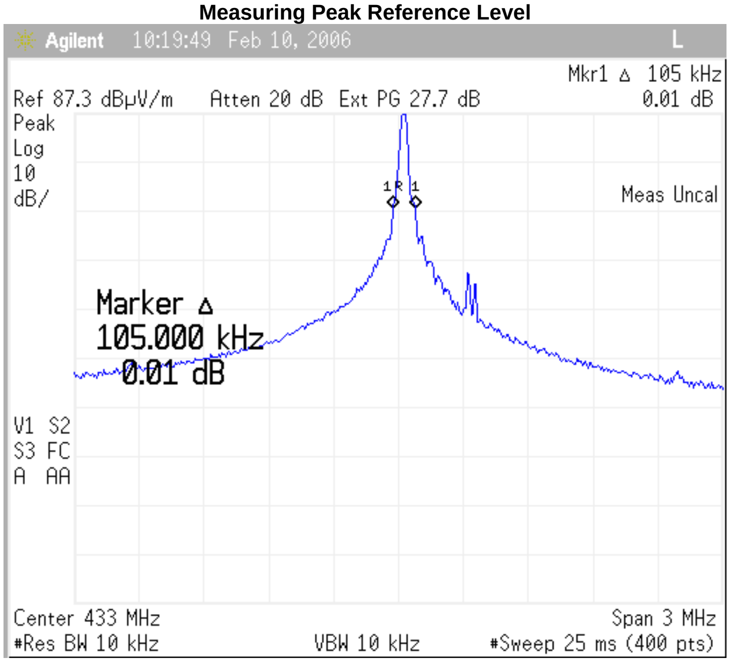
Frequency (MHz)	Duty Cycle (%)	Occupied Bandwidth (kHz)	Limit (kHz)
288	30	85	720
	50	83	720
	80	86	720
310	30	66	775
	50	69	775
	80	78	775
433	30	105	1045
	50	105	1045
	80	90	1045

7.4.3.1. Occupied Bandwidth Measurement

7.4.3.2. Example of Occupied Bandwidth measurement (288MHz 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 7.4.4.4

Measurement settings:

- Resolution BW 120kHz
- Video Bandwidth: 300kHz
- Detector: Peak

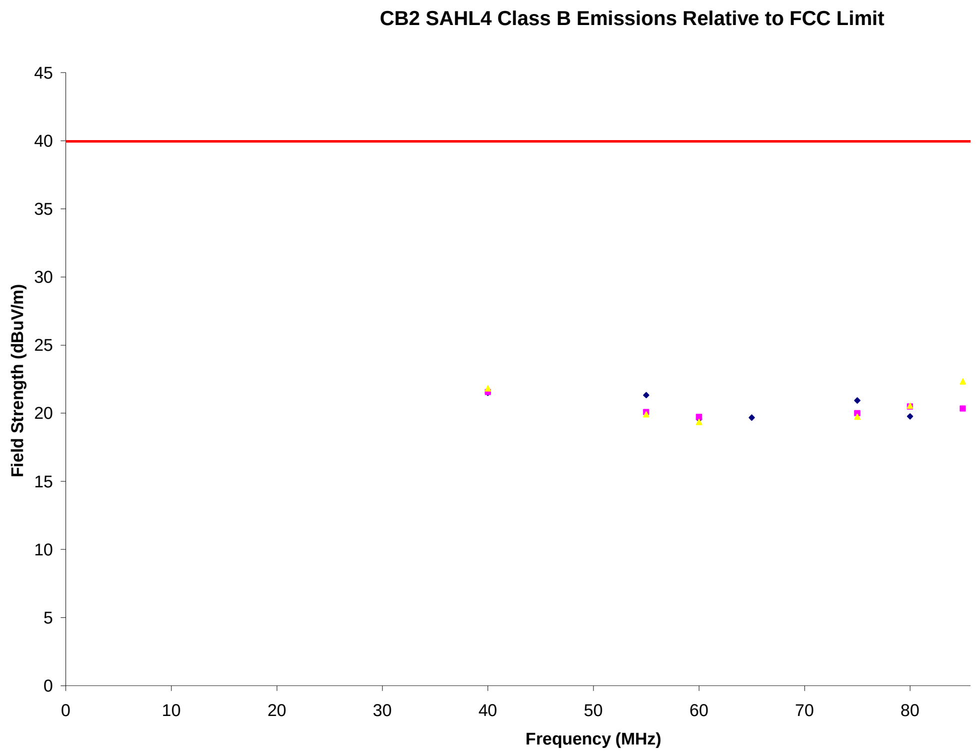
Note: Pre-scan measurements were made in a semi-anechoic chamber using a Rohde & Schwarz EMI Test Receiver 7GHz. The semi-anechoic chamber and test receiver are part of the Johnson Control Electronics Validation Group.

7.4.4.1. Summary of Emissions Measurements Taken on OATS

Transmit Frequency (MHz)	Frequency (MHz)	Measurement (dBuV/m)	Limit (dBuV/m)	Margin (dB)
288	40	21.5	40	18.5
	55	21.33	40	18.67
	60	19.57	40	20.43
	65	19.68	40	20.32
	75	20.94	40	19.06
	80	19.77	40	20.23
	95	21.89	40	18.11
310	40	21.55	40	18.45
	55	20.09	40	19.91
	60	19.72	40	20.28
	75	20	40	20
	80	20.49	40	19.51
	85	20.34	40	19.66
	95	21.38	40	18.62
433	40	21.82	40	18.18
	55	19.92	40	20.08
	60	19.36	40	20.64
	75	19.74	40	20.26
	80	20.55	40	19.45
	85	22.34	40	17.66
	95	22.31	40	17.69

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. Local ambient measurements are not present on scatter-plot.

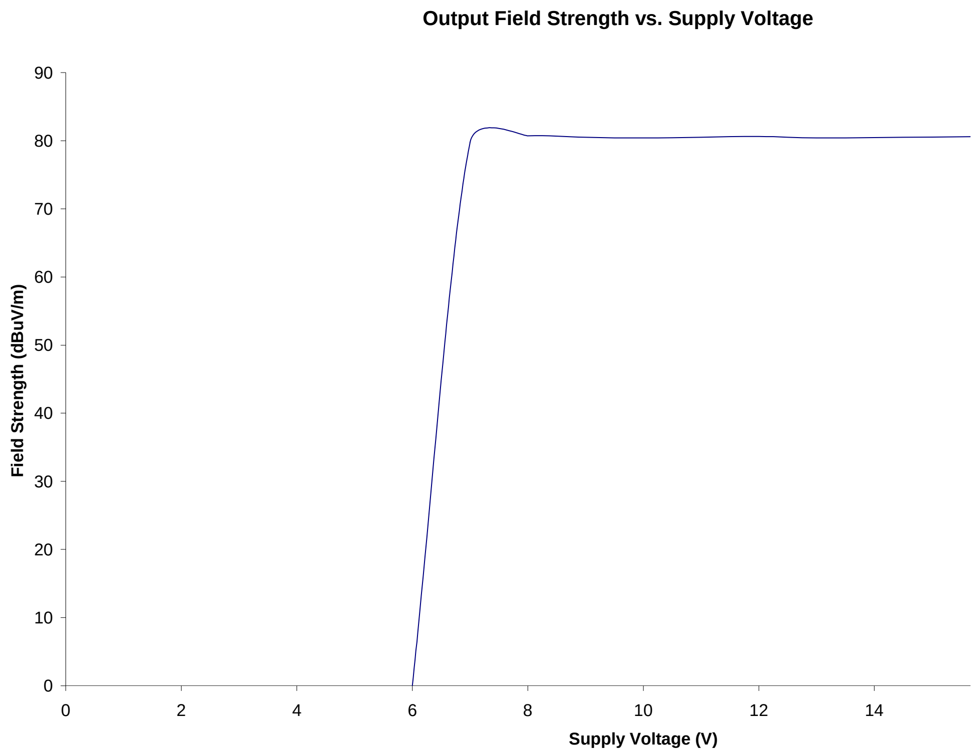
7.4.4.2. Plot of Class B Emissions relative to FCC Limit



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. 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	No Op
7	79.8
8	80.73
9	80.51
10	80.41
11	80.52
12	80.63
13	80.41
14	80.46
15	80.54
16	80.57
17	80.31
18	80.52

7.4.6. Verification of Non-Operation in Restricted Bands

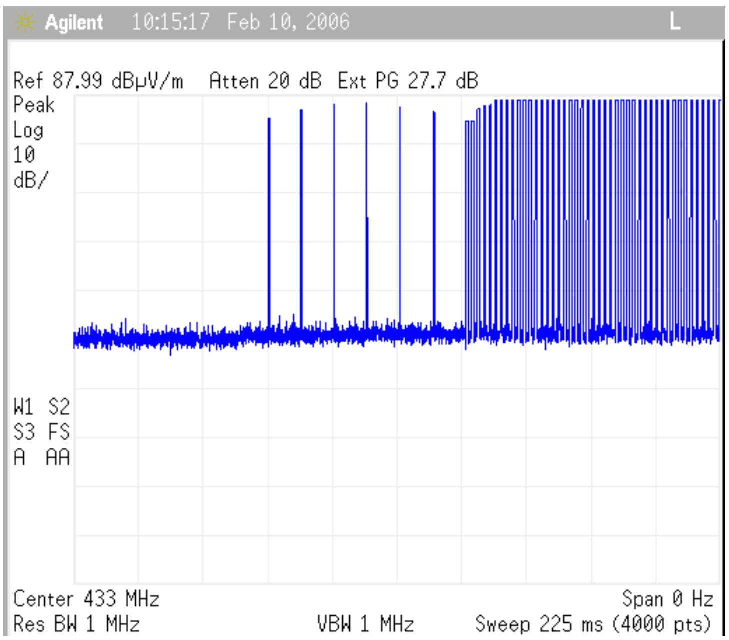
An exercise was undergone to verify that the device was not able to learn and thereby transmit in a restricted band. During this exercise it was found that the device firmware prevents the device from learning any frequency within 1MHz of any restricted band listed in 47 CFR 15.205.

7.4.7. Verification of De-activation after 5 seconds

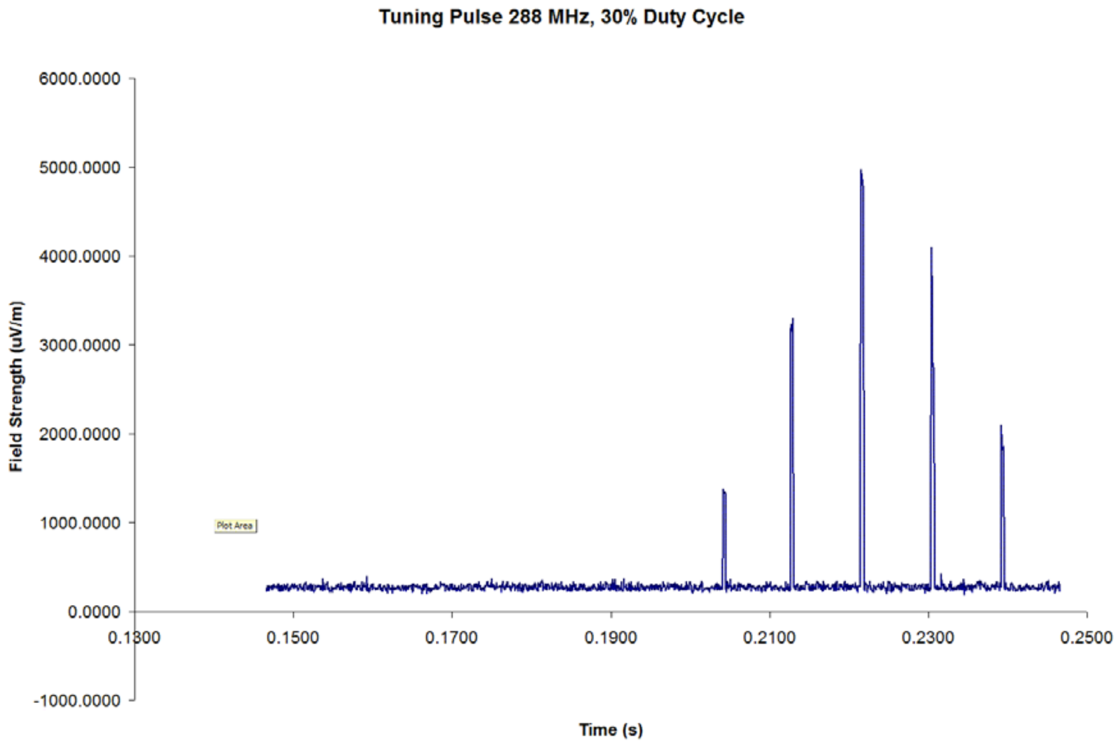
This device stops transmitting once the activation button in depressed.

7.4.8. Tuning Pulse Measurements

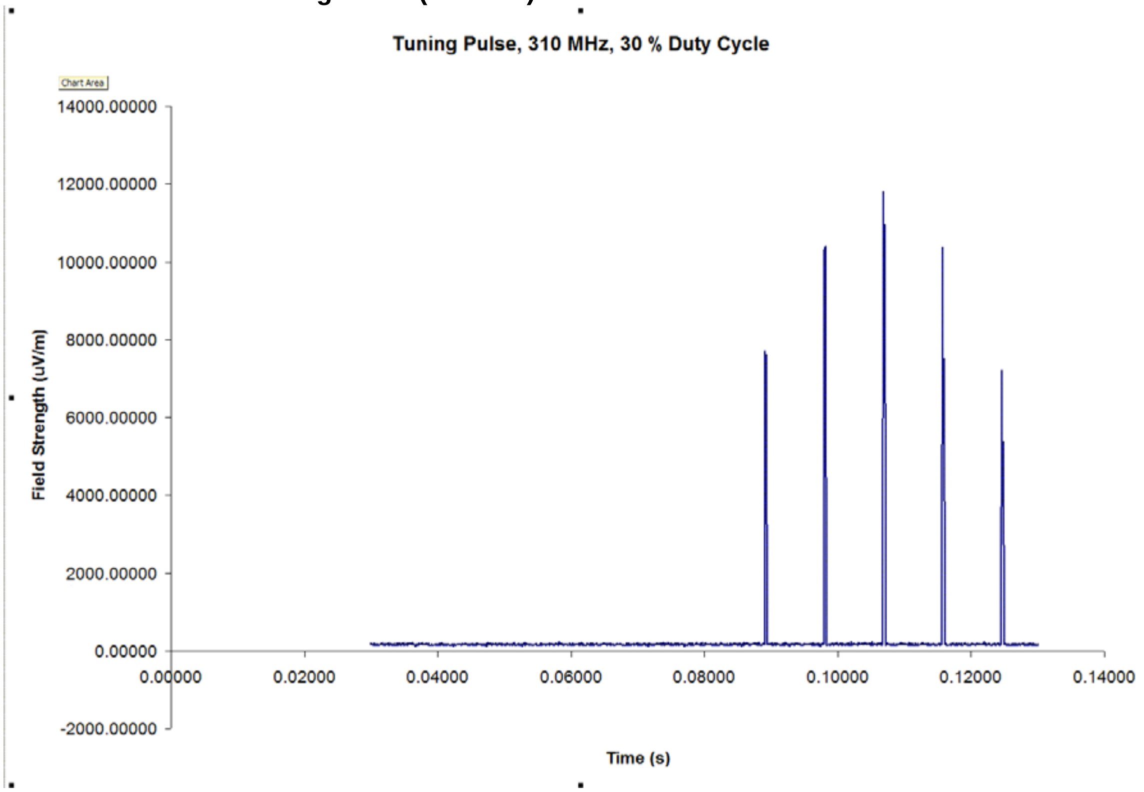
This device uses pulses to tune the antenna prior to transmission. Measurements of these tuning pulses over 100 msec windows show that these pulses are below the FCC limits for operation in this band. A summary of measurements is presented in section 7.4.8.7. Tuning pulse measurements were taken at 288, 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 7.4.8.7.



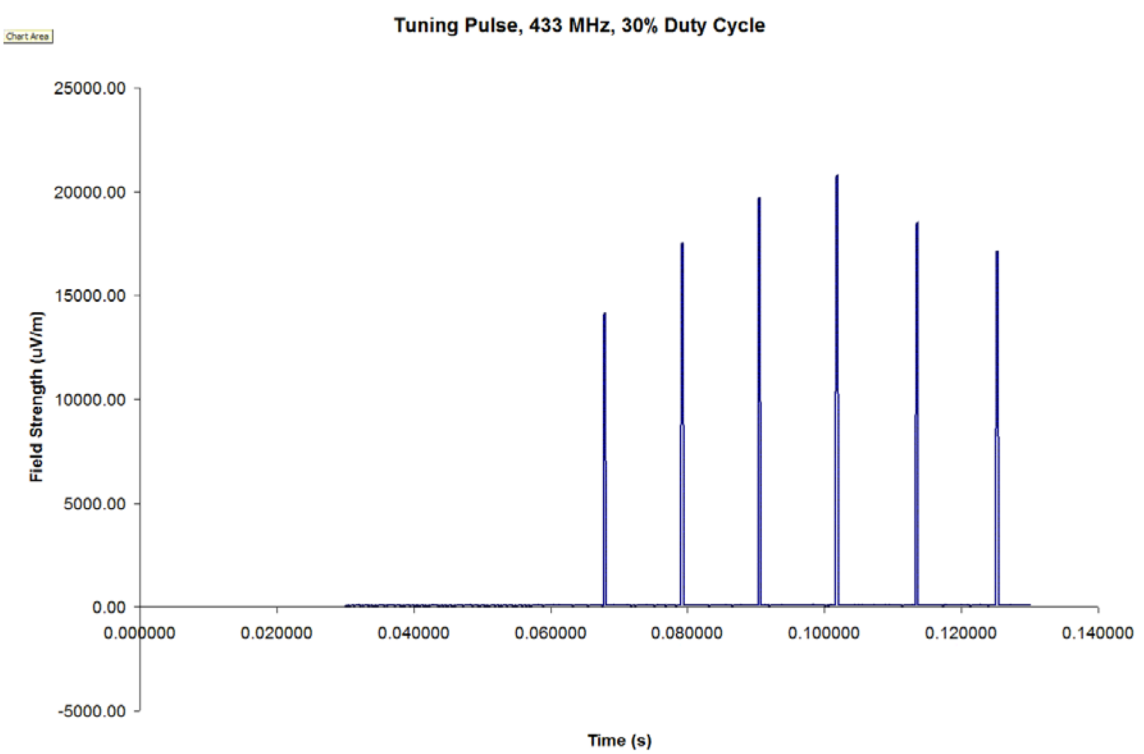
7.4.8.1. Tuning Pulse (288MHz)



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	320	4915	23.7
310	302	5831	25.7
433	426	10958	28.2

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 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 and IC limits from 15.231 and RSS-210.

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. Front View

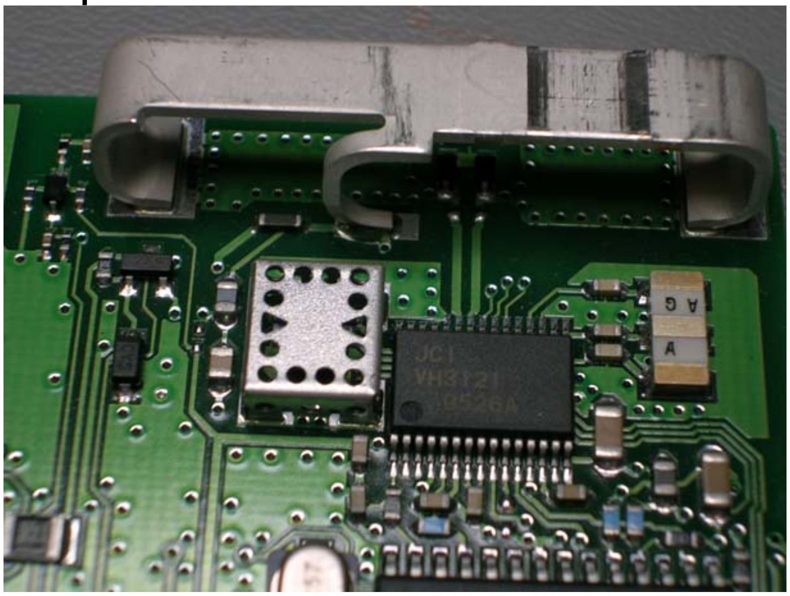
8.2. Rear View

8.3. Homelink© Board Internal Pictures

8.3.1. Front of Board

8.3.2. Rear of Board

8.3.3. Close-up of RF Section



9. Other Attachments and Description

9.1. User Manual

Please refer to attachment “user_manual.pdf”.

9.2. Theory of Operation

Stand Alone HomeLink® Module Description of Operation

The HomeLink® transmitter is a radio frequency transceiver device whose primary function is to determine both frequency and bit code format of typical garage door remote control devices and identically re-transmit them to the original garage door opener receiver.

The on-board microcontroller maintains the operational frequency band as 288MHz to 420MHz, excluding forbidden bands of 303.5 to 305.5MHz, 322 to 335.4MHz and 399.9 to 410 MHz by at least 1 MHz spacing.

The “training” operation is performed by scanning the legal frequencies with a single conversion superheterodyne receiver, looking for valid garage door opener bit code formats. After the training sequence, the frequency, bit code and attenuator setting is stored in non-volatile memory (NVM). The IF of the superheterodyne receiver section is 10.7MHz.

On subsequent power ups, the NVM data is recalled. The VCO is set on the desired RF carrier frequency. The antenna is coarse tuned by sweeping twice around the expected tuning point. It is the fine tuned with 9 pulses. The voltage controlled oscillator (VCO) is then modulated with the appropriate garage door opener bit code from the NVM.

In addition to being frequency and data format adaptive. The HomeLink® transmitter also adjusts the RF amplitude level based upon the duty cycle. During the training sequence, the duty factor of the incoming bit code format is evaluated by the microcontroller determining the greatest amount of on-time in a 100 mS window. The duty factor is then used to adjust the output power in a range of 80% (1.9 dB) to a maximum limit to 30% (10.5 dB) duty cycle. A 9 bit attenuator is adjusted by a closed loop power control algorithm in the microcontroller.

Also, the microcontroller adjusts the output level as a result of the learned frequency of operation. The firmware maintains information relative to the allowable field intensity limits. As the allowable limit increase with frequency of operation the microcontroller adjusts the output level to increase with the increase in transmit frequency.

9.3. Emission Designation

According to TRC-43, the emission designation for this product is 150KL1D. Where “105K” is the highest measured occupied bandwidth (105 kHz), “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. Schematics/ Tuning Information

Programming the Homelink © III
(Tuning Information)

To clear memory:

1. Press the two outside buttons until the indicator LED flashes. This indicates the memory values have been cleared.
2. Holding the hand-held transmitter to be copied 3-6 inches from the Homelink © III and simultaneously, activate the hand-held transmitter and one of the Homelink © III buttons until the indicator LED flashes rapidly. The frequency and bit pattern information are now stored in the Homelink © III non-volatile memory (NVM). At this point the Homelink © III can be used as a substitute from for the Original transmitter.

When a Homelink © III button is pressed four things happen:

1. A Voltage Controlled Oscillator (VCO) is set to desired RF carrier frequency (recalled from the NVM).
2. The antenna is coarse tuned by sweeping twice around the expected tuning point.
3. The antenna is fine tuned by 9 pulses of approximately 210 uS in duration with 11 mS off.
4. The VCO is then modulated with the appropriate garage door opener bit code from the NVM.

Schematics have been submitted with this report as the file “schematics.pdf”