Technical Report to the FCC and Industry Canada Regarding Johnson Controls Interiors, L.L.C. Homelink© V
Model: SAHL5B
FCC ID: CB2SAHL5B
IC: 279B- SAHL5B
Emission Designator : 79KL1D
8/30/2012

A report concerning approval for Johnson Controls Homelink® model SAHL5B
Please issue grant immediately upon review.

Measurements Made by:

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1. General Information

1.1. Product Description:

The Johnson Controls Interiors HomeLink® HL5 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 performed according to ANSI C63.4-2003 and KDB 181667. 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 filed with the FCC is dated December 20, 2011, was accepted by the FCC in a letter dated January 10, 2012. The report filled with Industry Canada, dated June 7, 2011, was accepted via a letter dated June 7, 2011. Our OATS is registered with the IC under file number IC# 279B-1.

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: CB2SAHL5B. The Industry Canada certification number is 279B-SAHL5B. These identifiers will be labeled on the product housing.

The label will be placed on the exterior of the HL5 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 "Users Manual.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 "FCC ID Label Artwork.pdf" attachment.
A diagram showing the location of the label on the assembly is included in the "Label_Location.pdf" 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 1.1meter, 1.4meter and 1.7 meter 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. The table was set at 3 different heights reference to the height of each platform of the vehicle (1.7m, 1.4 m and 1.1m)

4. Block Diagram

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

5. Test Setup Photographs

Test Setup flat 30degree tilt (1.1m height)

Test Setup Flat 10degree tilt (1.7m height)

Test Set Up Flat (1.4m height)

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, 365, and 433MHz at 30%, 50% and 80% duty cycles with test set up of 1.7m, 1.4m and 1.1m off from ground. 1.7m was found to be the worst case. A **worst-case emission of 83.19dBuV/m** occurred with the DUT trained to 288MHz, 30% duty cycle. The worst-case emission Average Level (84.4dBuV/m) remained 1.1**dB below the FCC and IC limits** (73.8 dBuV/m) for this type of device.
- The **worst-case harmonic measurements were harmonics of 288MHz and had amplitudes of 52.2 dBuV/m. They were found at 864MHz, 50% duty cycle and at 1728 MHz**, **at 80% duty cycle**. **A margin of 1.6dB 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 79kHz when the DUT is trained to 310 MHz, 50% duty cycle.
- This device has a worst case digital emission of 38.33dBuV/m at 35.64MHz when set to transmit at 288MHz a margin of 1.67dB to the FCC Class B and relevant IC limit is maintained.
- The output power of the DUT increased by no more than 1.2 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 82.66dBuV/m at 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 worst case receiver spurious emissions measurement was made at the mid-point of the receiver band capability. The highest measurement of 136.43uV/m at 3m, at 1350MHz leaving a margin of 363.57uV/m. The least margin was at 649MHz, in which the emissions were 135.65uV/m, leaving 64.35uV/m of margin.

7.2. Test Equipment Used

Description	Model #	Serial Number	Last Cal Date	Cal Due
EMCO Biconical Antenna [20-300 MHz]	**3110B**	**9906-3309**	**01/26/12**	**01/2014**
EMCO LPA Antenna [200-2000MHz]	**3148**	**9908-1076**	**01/26/12**	**01/2014**
Electro-metrics Double Ridged Guide [1-18GHz]	**RGA-60**	**6147**	**01/02/11**	**1/2013**
Agilent E-series EMC Analyzer	**E4407B**	**US41192569**	**10/15/09**	**10/2012**
HP Spectrum Analyzer	**8591A**	**S919A00107**	**01/20/10**	**12/2012**

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 1.1m, 1.4m, and 1.7m above the ground plane pursuant to ANSI C63.4 and KDB 181667 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 Flat orientation, but is tilted to reflect the in vehicle position of the device. These orientations are described below in Figure 7.3.1 and in the photo.

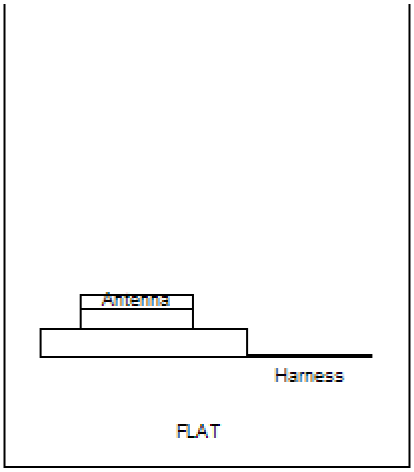


Figure 7.3.1 EUT Orientation

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. The worst case results were provided.

7.4.1.1 DUT Tuned to 288MHz(Fundamental) *1.7meter*

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	Flat	H	30	83.19	-10.46	72.7	73.8	1.1
288	Flat	H	50	78.64	-6.02	72.6	73.8	1.2
288	Flat	H	80	74.20	-1.94	72.3	73.8	**1.6**

*Measurements include Cable corrections and Antenna Factors

7.4.1.2 DUT Tuned to 310MHz (Fundamental) *1.7meter*

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	84.25	-10.5	73.8	75.3	1.5
310	Flat	H	50	80.01	-6.0	74.0	75.3	1.3
310	Flat	H	80	76.12	-1.9	74.2	75.3	**1.1**

* Measurements include Cable corrections and Antenna Factors

7.4.1.3 DUT Tuned to 365MHz (Fundamental) *1.7meter*

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)
365	Flat	H	30	83.4	-10.5	72.9	78.2	5.3
365	Flat	H	50	78.9	-6.0	72.9	78.2	5.3
365	Flat	H	80	74.75	-1.9	72.8	78.2	**5.4**

* Measurements include Cable corrections and Antenna Factors

7.4.1.4 DUT Tuned to 433MHz (Fundamental) *1.7meter*

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	Flat	H	30	83.84	-10.5	73.3	80.8	7.5
433	Flat	H	50	79.76	-6.0	73.8	80.8	7.0
433	Flat	H	80	74.29	-1.9	72.4	80.8	**8.4**

* Measurements include Cable corrections and Antenna Factors

7.4.1.4.1 288MHz (Harmonics) *1.7meter*

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	57.21	-10.5	46.7	53.8	7.1
576	Flat	H	50	53.32	-6.0	47.3	53.8	6.5
576	Flat	H	80	48.56	-1.9	46.7	53.8	7.1
864	Flat	V	30	61.32	-10.5	50.8	53.8	3.0
864	Flat	V	50	58.23	-6.0	52.2	53.8	1.6
864	Flat	V	80	53.94	-1.9	52.0	53.8	1.8
1152	Flat	H	30	53.23	-10.5	42.7	53.8	11.1
1152	Flat	V	50	50.74	-6.0	44.7	53.8	9.1
1152	Flat	V	80	46.85	-1.9	45.0	53.8	8.9

1440	Flat	V	30	52.23	-10.5	41.7	53.8	12.1
1440	Flat	V	50	50.85	-6.0	44.9	53.8	9.0
1440	Flat	V	80	47.29	-1.9	45.4	53.8	8.4
1728	Flat	H	30	62.52	-10.5	52.0	53.8	1.8
1728	Flat	H	50	58.02	-6.0	52.0	53.8	1.8
1728	Flat	H	80	54.14	-1.9	52.2	53.8	**1.6**
2016	Flat	H	30	48.52	-10.5	38.0	53.8	15.8
2016	Flat	H	50	48.52	-6.0	42.5	53.8	11.3
2016	Flat	H	80	48.52	-1.9	46.6	53.8	7.2
2304	Flat	H	30	58.04	-10.5	47.5	53.8	6.3
2304	Flat	V	50	53.54	-6.0	47.5	53.8	6.3
2304	Flat	V	80	52.66	-1.9	50.8	53.8	3.0
2592	Flat	V	30	49.97	-10.5	39.5	53.8	14.3
2592	Flat	V	50	49.97	-6.0	44.0	53.8	9.8
2592	Flat	V	80	49.97	-1.9	48.1	53.8	5.7
2880	Flat	H	30	51.78	-10.5	41.3	53.8	12.5
2880	Flat	H	50	51.78	-6.0	45.8	53.8	8.0
2880	Flat	H	80	51.78	-1.9	49.9	53.8	3.9

Ambient

* Measurements include Cable corrections and Antenna Factors

7.4.1.4.1.1 310MHz (Harmonics) *1.7meter*

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	V	30	56.36	-10.5	45.9	55.3	9.4
620	Flat	V	50	53.08	-6.0	47.1	55.3	8.2
620	Flat	V	80	47.98	-1.9	46.1	55.3	9.2
930	Flat	H	30	61.25	-10.5	50.8	55.3	4.6
930	Flat	H	50	56.25	-6.0	50.3	55.3	5.1
930	Flat	H	80	52.14	-1.9	50.2	55.3	5.1
1240	Flat	H	30	52.14	-10.5	41.6	54.0	12.4
1240	Flat	H	50	50.26	-6.0	44.3	54.0	9.7
1240	Flat	H	80	48.26	-1.9	46.4	54.0	7.6
1550	Flat	H	30	52.87	-10.5	42.4	54.0	11.6
1550	Flat	V	50	50.33	-6.0	44.3	54.0	9.7
1550	Flat	H	80	48	-1.9	46.1	54.0	7.9
1860	Flat	H	30	59.12	-10.5	48.6	55.3	6.7
1860	Flat	H	50	55.14	-6.0	49.1	55.3	6.2
1860	Flat	H	80	53.46	-1.9	51.6	55.3	3.7
2170	Flat	V	30	49.55	-10.5	39.1	55.3	16.3
2170	Flat	V	50	49.55	-6.0	43.6	55.3	11.8
2170	Flat	V	80	49.55	-1.9	47.7	55.3	7.7
2480	Flat	H	30	60	-10.5	49.5	55.3	5.8
2480	Flat	H	50	57.56	-6.0	51.6	55.3	3.7
2480	Flat	H	80	54.08	-1.9	52.2	55.3	3.1
2790	Flat	H	30	50.22	-10.5	39.7	54.0	14.3
2790	Flat	H	50	50.22	-6.0	44.2	54.0	9.8

2790	Flat	H	80	50.22	-1.9	48.3	54.0	5.7
3100	Flat	H	30	51.23	-10.5	40.7	55.3	14.6
3100	Flat	H	50	51.23	-6.0	45.2	55.3	10.1
3100	Flat	H	80	51.23	-1.9	49.3	55.3	6.0

Measurements include Cable corrections and Antenna Factors

7.4.1.4.2 365 MHz (Harmonics) *1.7meter*

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)
730	Flat	H	30	58.59	-10.5	48.1	58.2	10.1
730	Flat	H	50	54.19	-6.0	48.2	58.2	10.0
730	Flat	H	80	48.37	-1.9	46.4	58.2	11.8
1095	Flat	H	30	59.23	-10.5	48.8	54.0	5.2
1095	Flat	H	50	58.05	-6.0	52.0	54.0	2.0
1095	Flat	H	80	53.68	-1.9	51.7	54.0	2.3
1460	Flat	H	30	59.95	-10.5	49.5	54.0	4.5
1460	Flat	H	50	58.05	-6.0	52.0	54.0	2.0
1460	Flat	H	80	53.68	-1.9	51.7	54.0	2.3
1825	Flat	H	30	53.68	-10.5	43.2	58.2	15.0
1825	Flat	H	50	51.87	-6.0	45.8	58.2	12.4
1825	Flat	H	80	51.68	-1.9	49.7	58.2	8.5
2190	Flat	H	30	56.24	-10.5	45.8	58.2	12.4
2190	Flat	H	50	54.11	-6.0	48.1	58.2	10.1
2190	Flat	H	80	52.15	-1.9	50.2	58.2	8.0
2555	Flat	H	30	54.54	-10.5	44.1	58.2	14.1
2555	Flat	H	50	53.11	-6.0	47.1	58.2	11.1
2555	Flat	H	80	52.58	-1.9	50.6	58.2	7.6
2920	Flat	V	30	60.68	-10.5	50.2	58.2	8.0
2920	Flat	V	50	59.28	-6.0	53.3	58.2	4.9
2920	Flat	V	80	55.90	-1.9	54.0	58.2	4.2
3285	Flat	H	30	45.66	-10.5	35.2	58.2	23.0
3285	Flat	H	50	45.66	-6.0	39.6	58.2	18.6
3285	Flat	H	80	45.66	-1.9	43.7	58.2	14.5
3650	Flat	V	30	46.58	-10.5	36.1	54.0	17.9
3650	Flat	V	50	46.58	-6.0	40.6	54.0	13.4
3650	Flat	V	80	46.58	-1.9	44.6	54.0	9.4

* Measurements include Cable corrections and Antenna Factors

7.4.1.4.3 433 MHz (Harmonics *1.7meter*

Frequency	Orientation	Measurement Polarization	Duty Cycle	Measurement*	Duty Cycle	Average Level	FCC Limit	Margin

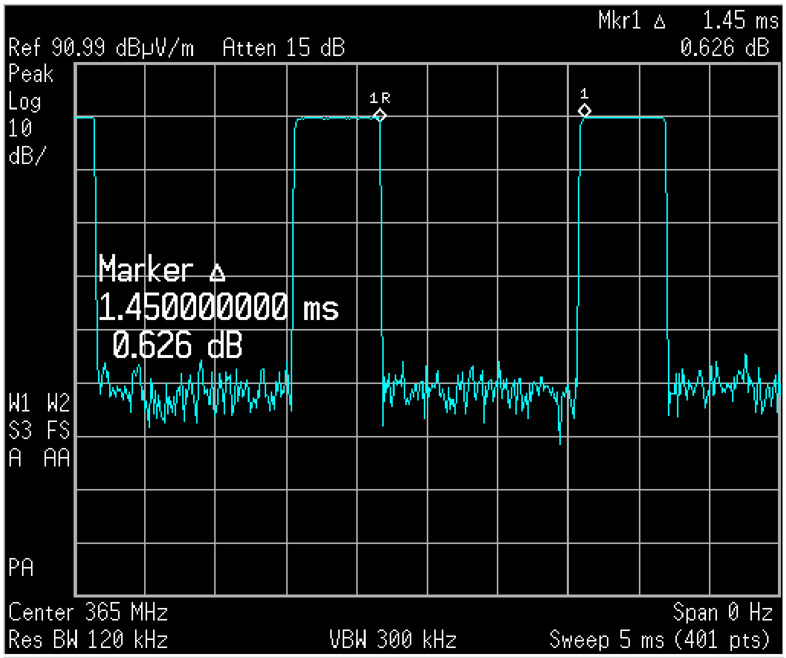
(MHz)	(Flat/End/Side)	(H/V)	(%)	(dBuV/m)	Correction (dB)	(dBuV/m)	(dBuV/m)	(dB)
866	Flat	H	30	59.98	-10.5	49.5	60.8	11.3
866	Flat	H	50	57.31	-6.0	51.3	60.8	9.5
866	Flat	H	80	54.76	-1.9	52.8	60.8	8.0
1299	Flat	H	30	55.86	-10.5	45.4	60.8	15.4
1299	Flat	H	50	53.65	-6.0	47.6	60.8	13.2
1299	Flat	H	80	52.65	-1.9	50.7	60.8	10.1
1732	Flat	H	30	54.77	-10.5	44.3	60.8	16.5
1732	Flat	H	50	53.3	-6.0	47.3	60.8	13.5
1732	Flat	H	80	51.56	-1.9	49.6	60.8	11.2
2165	Flat	H	30	50.01	-10.5	39.6	60.8	21.2
2165	Flat	H	50	50.01	-6.0	44.0	60.8	16.8
2165	Flat	H	80	50.01	-1.9	48.1	60.8	12.7
2598	Flat	H	30	57.49	-10.5	47.0	60.8	13.8
2598	Flat	H	50	55.91	-6.0	49.9	60.8	10.9
2598	Flat	H	80	51.95	-1.9	50.0	60.8	10.8
3031	Flat	V	30	47.19	-10.5	36.7	60.8	24.1
3031	Flat	V	50	47.19	-6.0	41.2	60.8	19.6
3031	Flat	V	80	47.19	-1.9	45.3	60.8	15.5
3464	Flat	H	30	46.4	-10.5	35.9	60.8	24.9
3464	Flat	H	50	46.4	-6.0	40.4	60.8	20.4
3464	Flat	H	80	46.4	-1.9	44.5	60.8	16.3
3897	Flat	H	30	50.23	-10.5	39.8	54.0	14.2
3897	Flat	H	50	50.23	-6.0	44.2	54.0	9.8
3897	Flat	H	80	50.23	-1.9	48.3	54.0	5.7
4330	Flat	V	30	45.32	-10.5	34.9	54.0	19.1
4330	Flat	V	50	45.32	-6.0	39.3	54.0	14.7
4330	Flat	V	80	45.32	-1.9	43.4	54.0	10.6

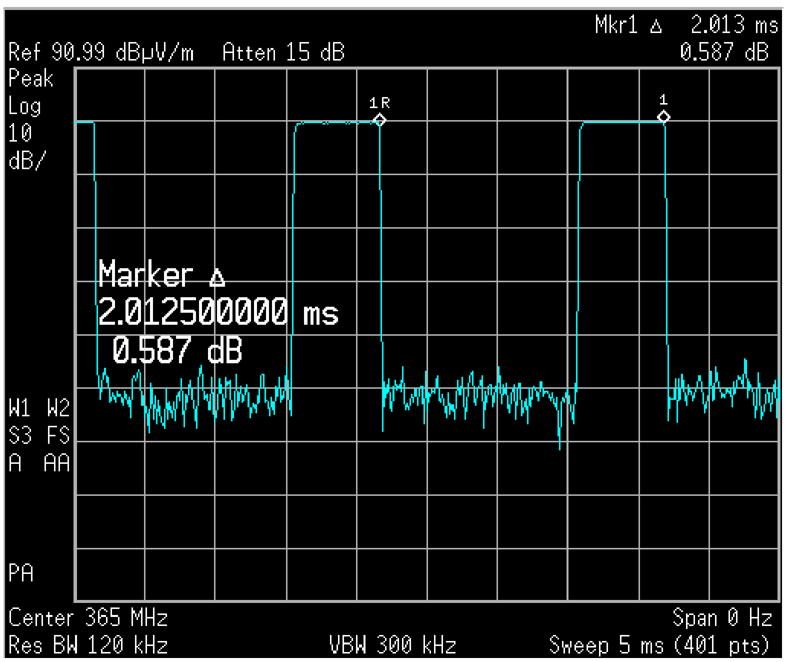
* Measurements include Cable corrections and Antenna Factors

7.4.2 Pulsed Operation

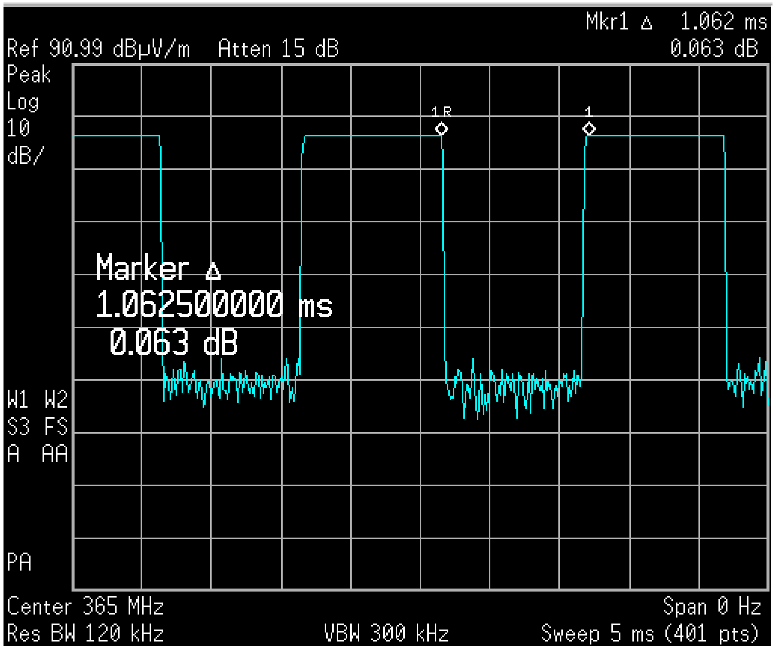
The Homelink© transmitter tested here transmits pulses using amplitude modulation with varying duty cycle. Verification of pulse operation at 30, 50 and 80% duty cycles is provided here. Measurements were taken at 310MHz with the span set to zero on the E4407B spectrum analyzer. The duty cycle is 500Hz.

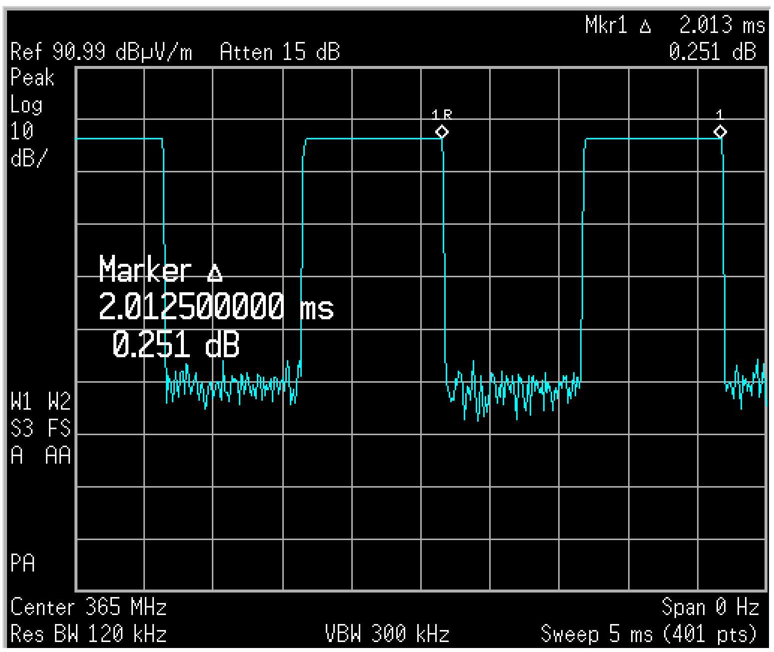
7.4.2.4 30% Duty Cycle



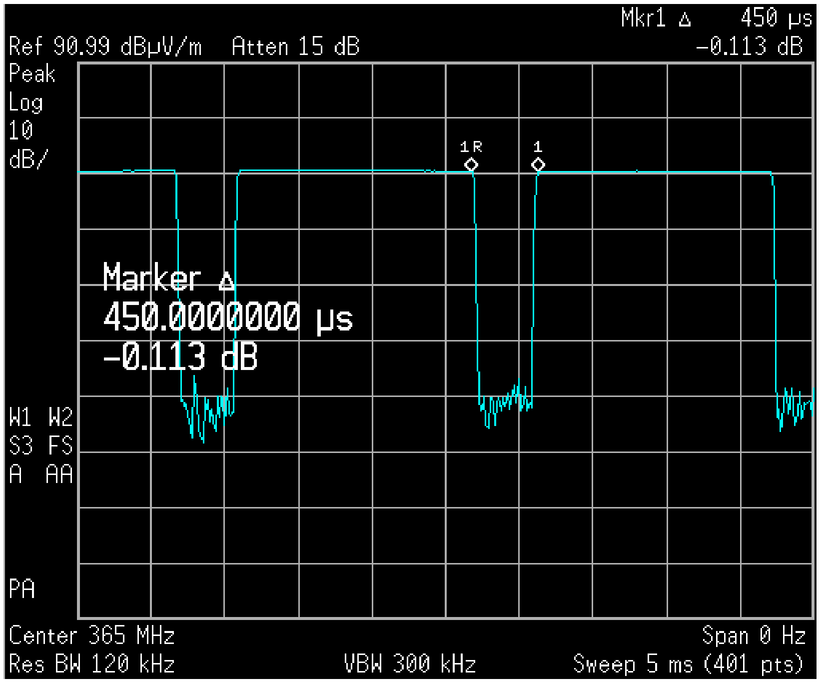


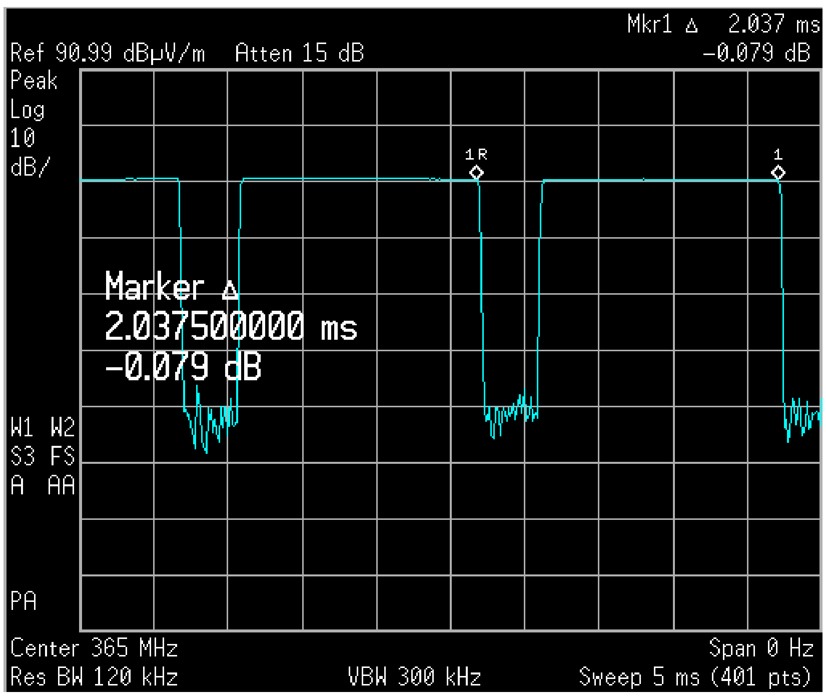
7.4.2.2 50% Duty Cycle





7.4.2.3 80% Duty Cycle





7.4.3 Occupied Bandwidth

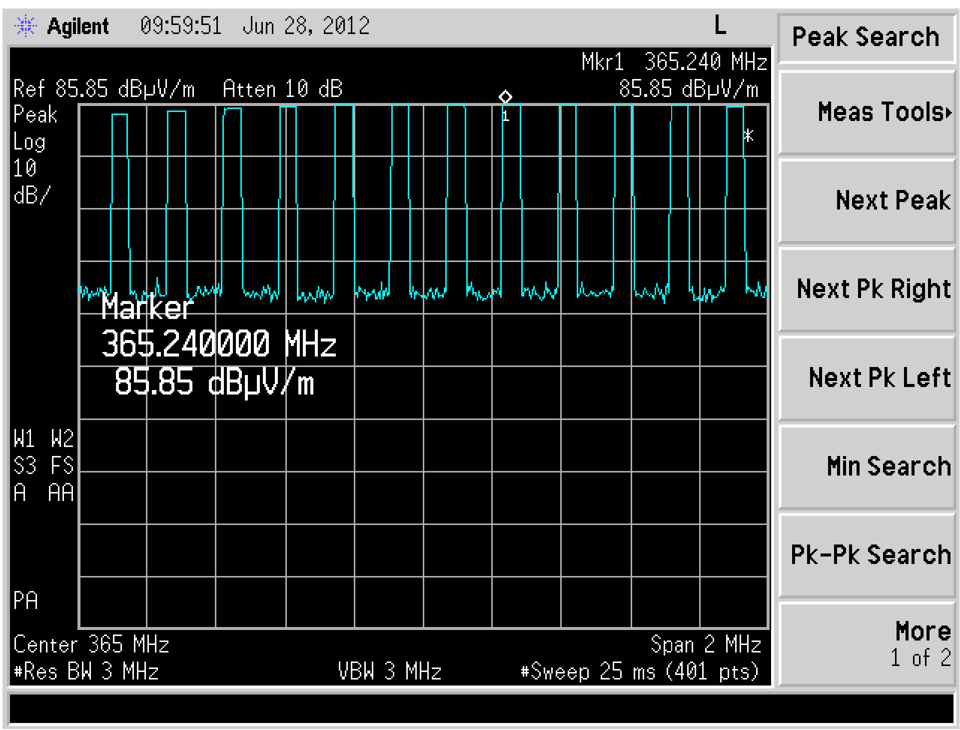
Occupied bandwidth measurements were taken at 288, 310, 365, and 433 MHz. The occupied bandwidth was determined using the 20dB measurement method.

The peak reference level was determined using a 3MHz RBW and a 3MHz VBW. Once the peak reference level was determined, a measurement was also made using 0 span at the peak reference level.

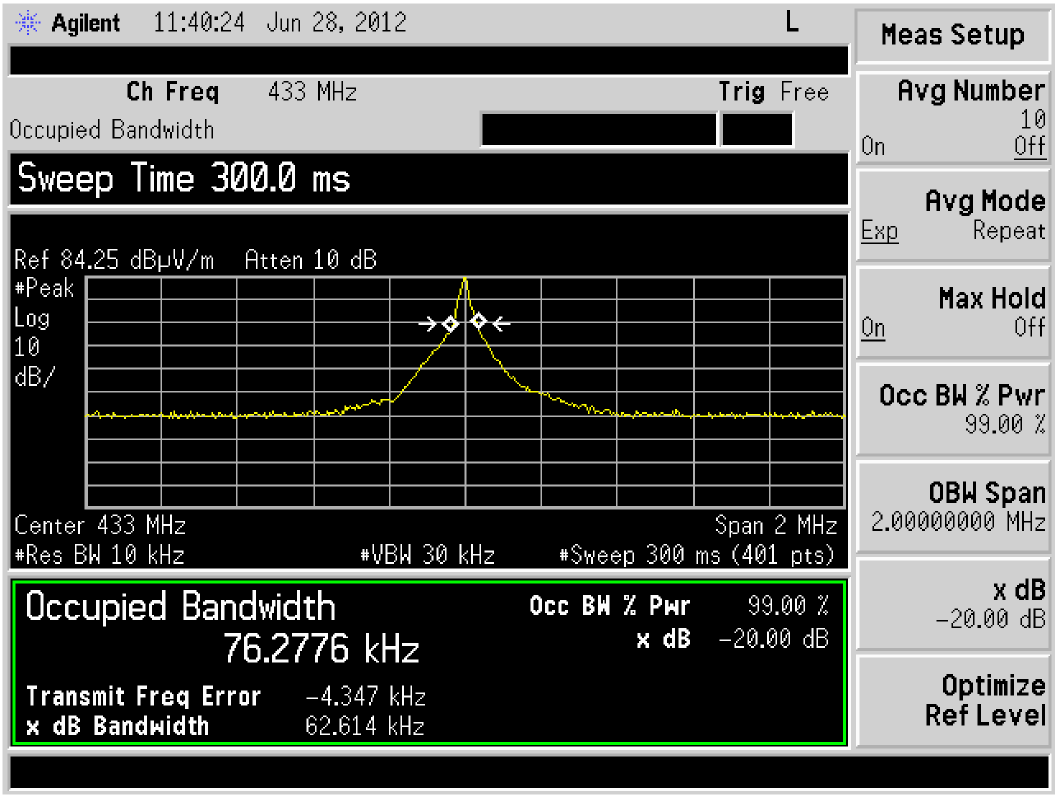
7.4.3.1 Occupied Bandwidth Measurement

Frequency (MHz)	Duty Cycle (%)	Occupied Bandwidth (kHz)	Limit (kHz)
288	30	70	720
	50	71	720
	80	72	720
310	30	78	775
	50	79	775
	80	76	775
365	30	72	1045
	50	70	1045
	80	70	1045
433	30	74	1045
	50	72	1045
	80	74	1045

7.4.3.2 Example of Occupied Bandwidth measurement



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.

Transmitting Frequency (MHz	Frequency (MHz)	DUT Orientation	Antenna Polarization	Field Strength (dBuV/m)	Limit (dBuV/m)	Margin (dB)
288	35.64	Flat	V	38.33	40	1.67
	42.34	Flat	H	30.23	40	9.77
	65.22	Side	H	44.32	40	-4.32
	92.32	Side	V	50.23	40	-10.23
310	41.68	End	V	30.23	40	9.77
	51.23	Flat	H	34.43	40	5.57
	53.44	Side	V	36.43	40	3.57
365	44.56	Side	V	31.22	40	8.78
	454.66	Side	V	33.24	40	6.76
	85.67	E	V	31.22	40	8.78
	112.33	Flat	v	33.65	40	6.35
433	46.77	Flat	H	34.76	40	5.24
	86.56	End	H	37.86	40	2.14
	113.56	Flat	H	30.23	40	9.77
	145.87	Side	H	29.87	40	10.13
	157.87	Flat	V	30.32	40	9.68
	174.89	Side	H	49.77	40	-9.77

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.

7.5 Receiver Spurious Emissions

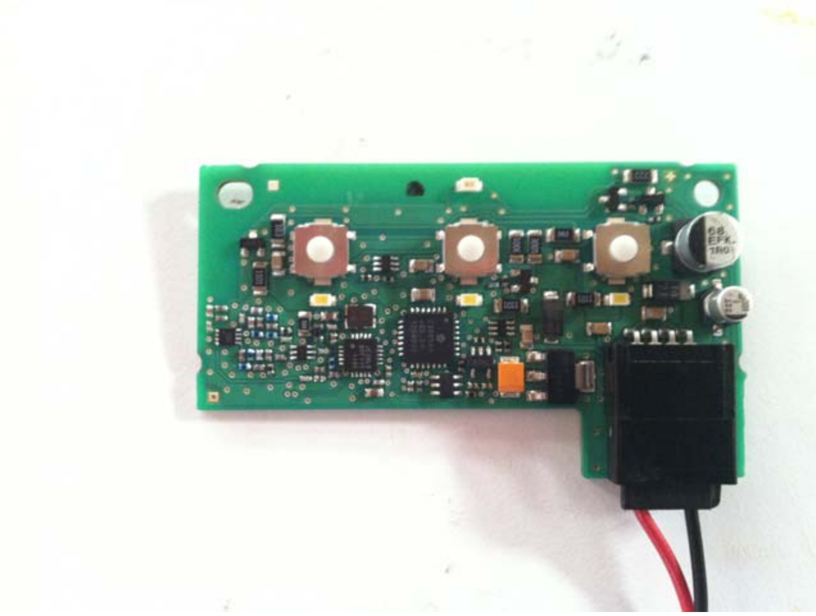
The receiver circuit spurious emissions were measured in accordance to Industry Canada RSS-GEN Issue 3 Section 4.10 and ANSI C63.4-2003.

The band mid point over which the receiver is designed to operate is 368 MHz. The Homelink V is supplied with commands to place it into diagnostic / manufacturing mode, and tune the receiver to the mid point frequency.

The search for spurious emissions was conducted over a range of 286MHz (The lowest oscillator frequency used by the receiver) to 1350 MHz (>3 times the highest tunable frequency of 440MHz)

To determine the orientation of the device at which the worst case emissions would occur, exploratory measurements using a diagnostic command to transmit at the midpoint frequency of 368 MHz. The device was then set to receive using a manufacturing diagnostic command.. Refer to 7.5.1 for setup photograph. The device under test is on its side, with the antenna in horizontal polarization.

7.5.1 Setup Photograph for Receiver spurious emissions



Measurements from 286MHz to 1 GHz were made with the spectrum analyzer using the peak detection method.. The resolution bandwidth setting was 120 kHz. Measurements above 1GHz were made using average detector with 300kHz resolution bandwidth. **At the fundamental frequency, 365 MHz, the receiver spurious emissions measurement was 136.1uV/m at 3m.**

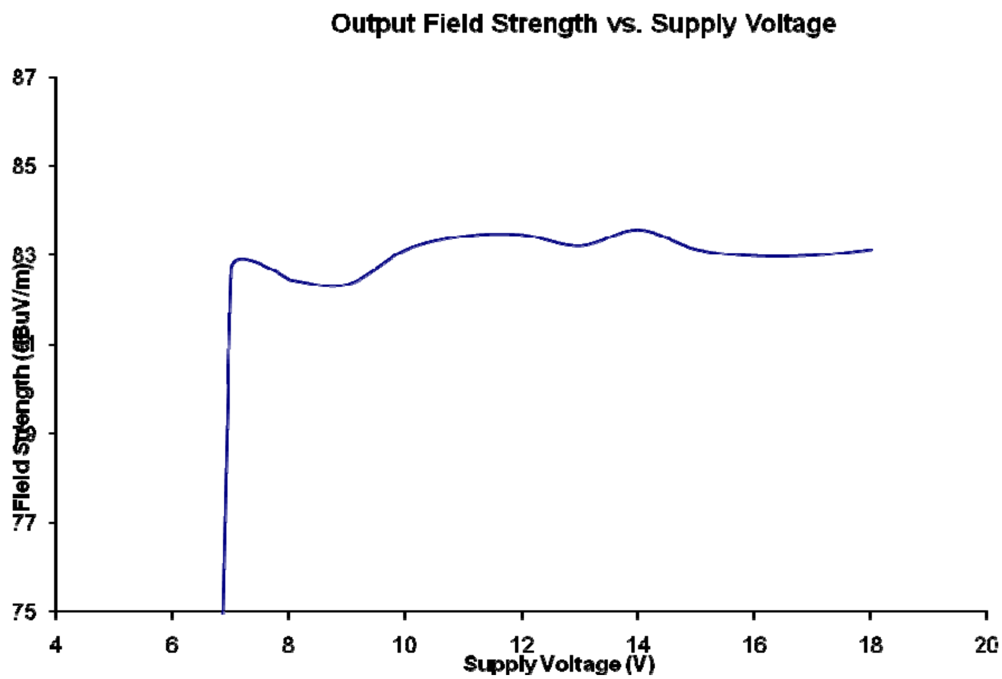
Receive Frequency (MHz)	**Frequency (MHz)**	**DUT Orientation**	**Antenna Polarization**	Field Strength (uV/m)	Limit (uV/m)	Margin (uV/m)
365	296	Side	H	123.77	200	76.23
	323	Side	H	132.56	200	67.44
	377	Side	H	98.23	200	101.77
	379	Side	H	99.12	200	100.88
	649	Side	H	135.65	200	64.35
	999	Side	H	110.23	500	389.77
	1000	Side	H	107.56	500	392.44
	1037	Side	H	105.43	500	394.57
	1040	Side	H	112.23	500	387.77
	1110	Side	H	109.44	500	390.56
	1155	Side	H	112.32	500	387.68
	1195	Side	H	125.66	500	374.34
	1199	Side	H	132.12	500	367.88
	1350	Side	H	136.43	500	363.57

Ambient

7.6 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.

7.6.4.1 Plot of output power over supply voltage



7.6.4.2 Output power as a function of supply voltage

Voltage	Field Strength (dBuV/m)
6	
7	82.66
8	82.44
9	82.34
10	83.12
11	83.42
12	83.45
13	83.21
14	83.56
15	83.12
16	82.98
17	82.99
18	83.12
19	83.22
20	

7.7 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 8, Table 1 and 47 CFR 15.205.

This exercise is described as follows:

HomeLink Operating Frequencies

HomeLink is designed to transmit from 286 – 440 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 was set up to output a 400 Hz square wave with 100% modulation depth and amplitude -5.00 dBm. It was then verified that HomeLink would train to this signal only when it was transmitted at the proper frequencies. Specifically, the various frequencies in the vicinity of the banned region boundaries were tested, and it was verified that HomeLink trained when it saw a signal at a valid frequency, and did not train when it saw a signal at a banned frequency. In the instances where HomeLink trained to a valid frequency, it was then verified that HomeLink transmitted at that same frequency.

One thing that should be noted: HomeLink margin of error is approximately 200 kHz. Therefore it cannot be said that HomeLink will adhere to the specified limits with absolute precision. This is why we guard-banded the FCC banned frequencies 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.

HomeLink V Banned Frequency Testing

Frequency (MHz)	Part 15 Status	Result	Pass/Fail	Comments
285.0	banned	would not train	Pass	
285.5	allowed (guardband region)	would not train	Pass	
286.0	allowed (guardband region)	would not train	Pass	
287.0	allowed	trained	Pass	
319.0	allowed	trained	Pass	
320.0	allowed	trained	Pass	
320.5	allowed	trained	Pass	

321.0	allowed (guardband region)	trained	Pass	
322.0	banned	would not train	Pass	
323.0	banned	would not train	Pass	
324.0	banned	would not train	Pass	
325.0	banned	would not train	Pass	
326.0	banned	would not train	Pass	
327.0	banned	would not train	Pass	
328.0	banned	would not train	Pass	
329.0	banned	would not train	Pass	
330.0	banned	would not train	Pass	
331.0	banned	would not train	Pass	
332.0	banned	would not train	Pass	
333.0	banned	would not train	Pass	
334.0	banned	would not train	Pass	
335.0	banned	would not train	Pass	
336.0	allowed (guardband region)	would not train	Pass	
337.0	allowed (guardband region)	trained	Pass	
338.0	allowed	trained	Pass	
398.0	allowed	trained	Pass	
399.0	allowed (guardband region)	would not train	Pass	While this is a valid frequency, HomeLink guardbands this region to ensure it doesn't train to 399.9 MHz
399.5	allowed (guardband region)	would not train	Pass	While this is a valid frequency, HomeLink guardbands this region to ensure it doesn't train

				to 399.9 MHz
400.0	banned	would not train	Pass	
401.0	banned	would not train	Pass	
402.0	banned	would not train	Pass	
403.0	banned	would not train	Pass	
404.0	banned	would not train	Pass	
405.0	banned	would not train	Pass	
406.0	banned	would not train	Pass	
407.0	banned	would not train	Pass	
408.0	banned	would not train	Pass	
409.0	banned	would not train	Pass	
410.0	banned	would not train	Pass	
410.5	allowed (guardband region)	would not train	Pass	
411.0	allowed (guardband region)	trained	Pass	
411.5	allowed	trained	Pass	
412.0	allowed	trained	Pass	
439.0	allowed	trained	Pass	
440.0	allowed	trained	Pass	
440.5	allowed	would not train	Pass	HomeLink only operates up to 440 MHz
441.0	allowed	would not train	Pass	HomeLink only operates up to 440 MHz
442.0	allowed	would not train	Pass	HomeLink only operates up to 440 MHz

HomeLink V v2.4 Software Operation at 303.5 – 307.5 MHz

HomeLink is designed not to transmit from 304 – 307 MHz in order to avoid harmonics at 608 – 614 MHz, which is a banned region per Part 15.205. When HomeLink trains to a signal in the 304 – 307 MHz region (+/- 0.5 MHz), HomeLink shifts the frequency either down to 303.5 MHz or up to 307.5 MHz, whichever is closer.

To verify this, an Agilent E4421B signal generator was set up to output a 400 Hz square wave with 100% modulation depth and amplitude -5.00 dBm. It was then verified that when HomeLink V (v2.4 code) trained to signals in the 303.5 – 307.5 MHz band, HomeLink would transmit at either 303.5 or 307.5 MHz (+/- 200 kHz).

See the following table for the exact frequencies tested.

Signal Gen Frequency (MHz)	Trained HomeLink Frequency (MHz)	Pass/Fail
303.5	303.5	Pass
304.0	303.5	Pass
304.5	303.5	Pass
305.0	303.5	Pass
305.5	307.5	Pass
306.0	307.5	Pass
306.5	307.5	Pass
307.0	307.5	Pass
307.5	307.5	Pass

7.8 Formulas and Sample Calculations

7.8.1 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)

7.8.2 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:

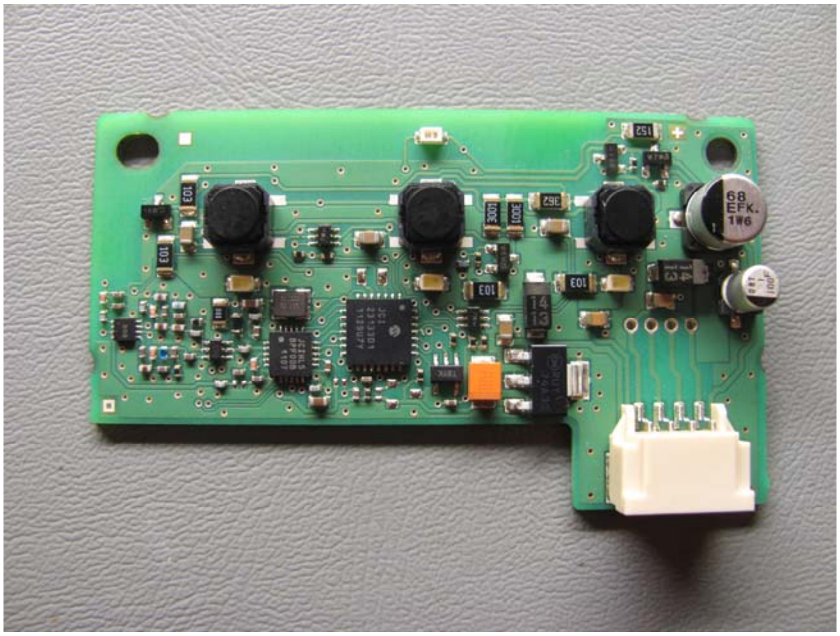
dB limit = 20 * log10(FCC limit uV/m) = 20*log10(41.67*f – 7083.33)
(log10 is used to indicated the use of a base 10 logarithm)

This results in the following limits for the fundamentals:

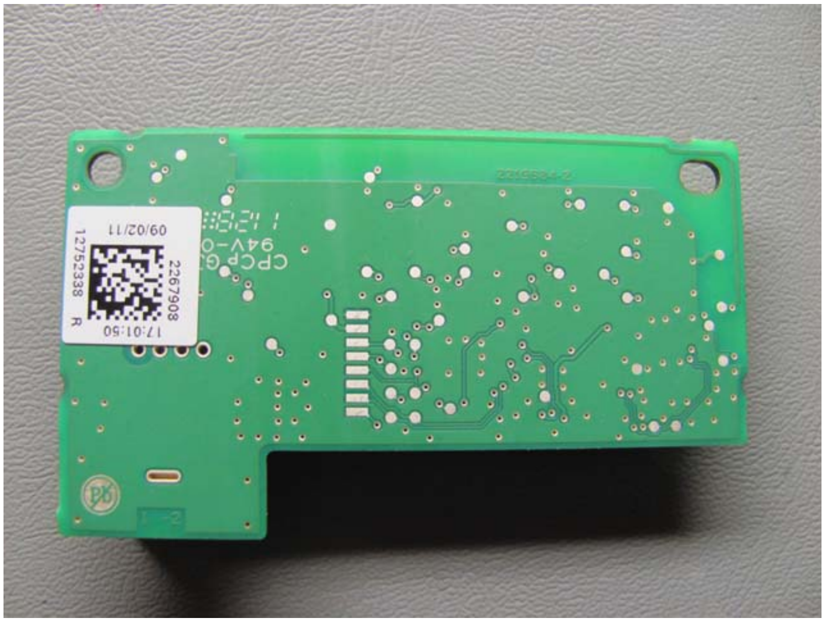
288MHz	20*log10(4917.6)	= 73.8 dBuV/m
310MHz	20*log10(5834.4)	= 75.3 dBuV/m
390MHz	20*log10(9168.0)	= 79.2 dBuV/m
433MHz	20*log10(10959.8)	= 80.8 dBuV/m

8 Photos of Product Tested

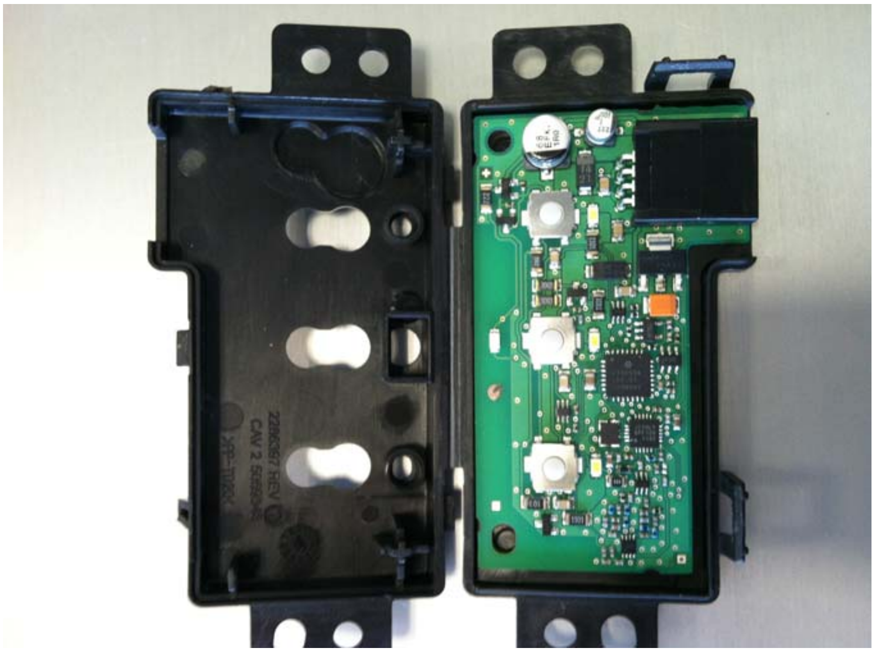
8.1.1 Front View – Printed Circuit Board

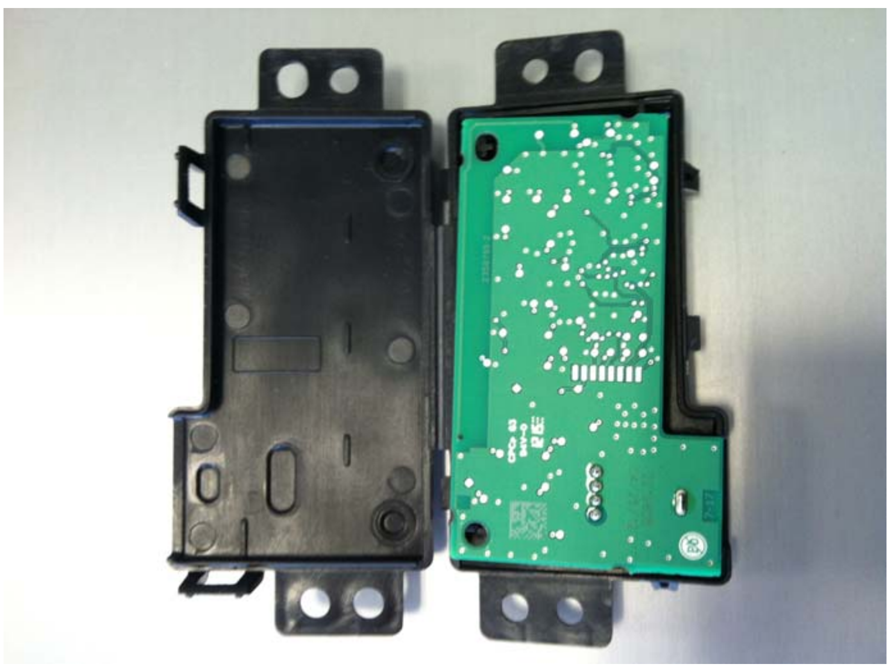


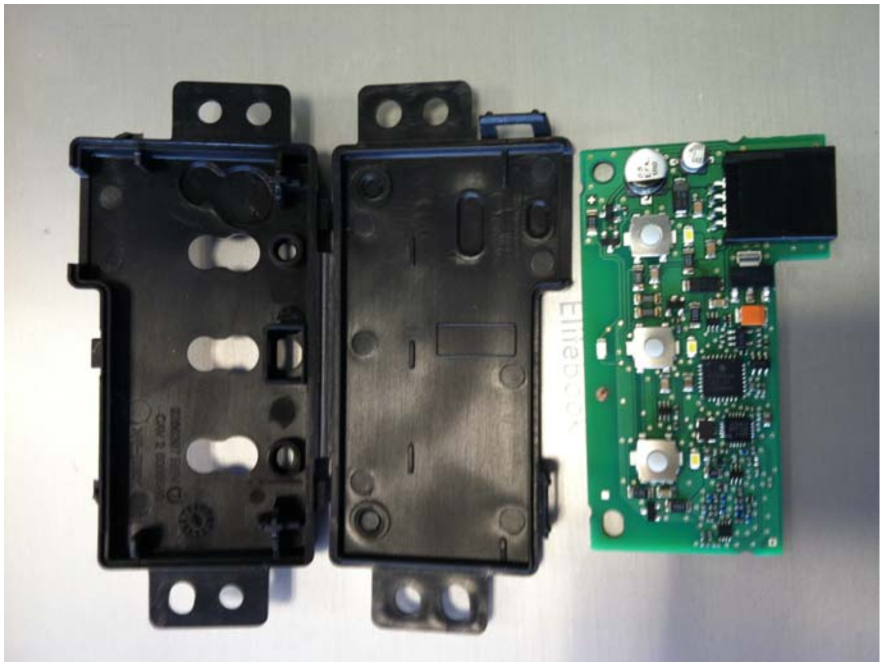
8.1.2 Rear View – Printed Circuit Board.

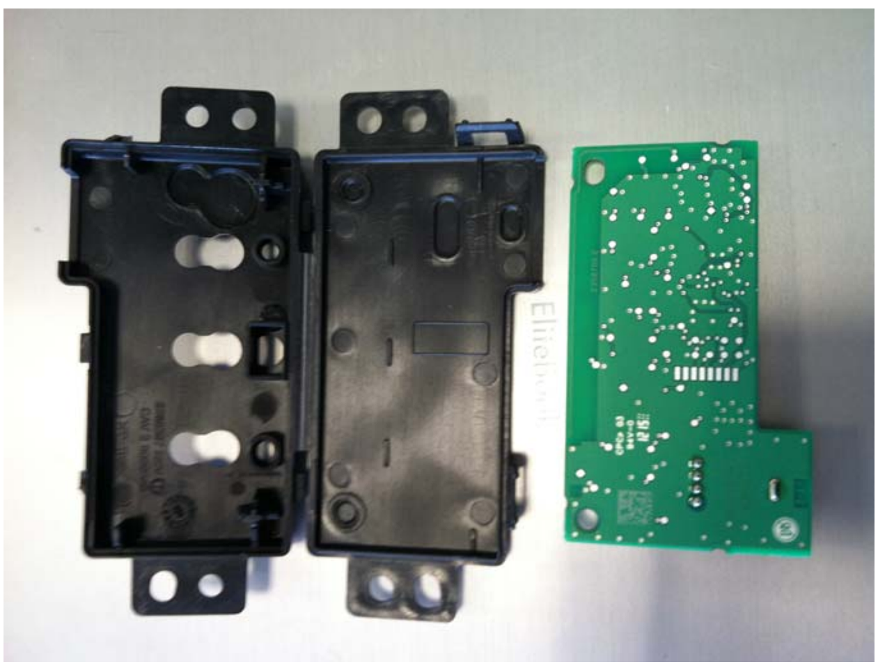


8.1.3 Unit Disassembled



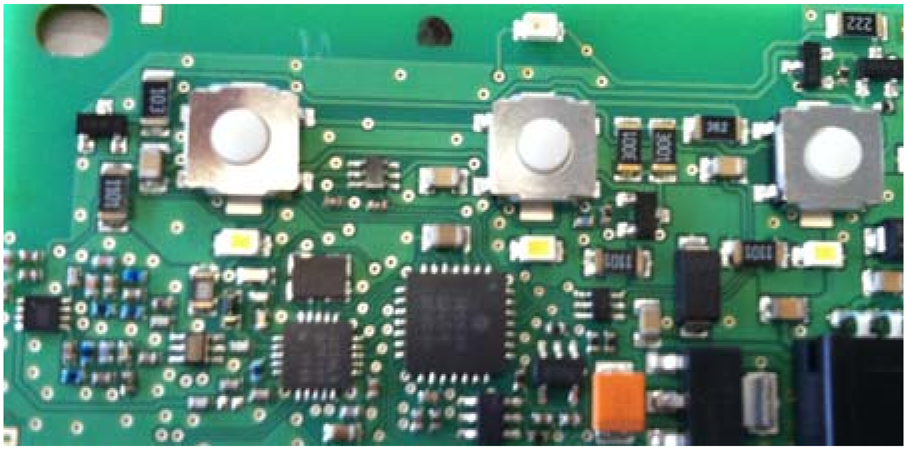






8.2 Housing & PCB Board Internal View

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 79KL1D. Where “79K” 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

Please refer to attachment “Theory_of_operation”

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”.