Nemko-CCL, Inc.
1940 West Alexander Street
Salt Lake City, UT 84119
801-972-6146

Test Report

Certification

Test Of: 27087

Lowes Iris™ HT8 Timer

FCC ID: ML6HT8ZB001

Test Specifications:

FCC PART 15, Subpart C

Test Report Serial No: 237824-3.1

Applicant:
Orbit Irrigation Product Inc.
845 N. Overland Rd.
North Salt Lake, UT 84054
U.S.A

Date of Test: May 28, 2013

Report Issue Date: June 3, 2013

Accredited Testing Laboratory By:

NVLAP Lab Code 100272-0

CERTIFICATION OF ENGINEERING REPORT

This report has been prepared by Nemko-CCL, Inc. to document compliance of the device described below with the requirements of Federal Communications Commission (FCC) Part 15, Subpart C. This report may be reproduced in full, partial reproduction may only be made with the written consent of the laboratory. The results in this report apply only to the sample tested.

- Applicant: Orbit Irrigation Product Inc.
- Manufacturer: VPI Engineering
- Brand Name: Orbit
- Model Number: 27087
- Model Name: Lowes Iris™ HT8 Timer
- FCC ID: ML6HT8ZB001

On this 3rd day of June 2013, I, individually and for Nemko-CCL, Inc., certify that the statements made in this engineering report are true, complete, and correct to the best of my knowledge, and are made in good faith.

Although NVLAP has recognized that the Nemko-CCL, Inc. EMC testing facilities are in good standing, this report must not be used to claim product certification, approval, or endorsement by NVLAP, NIST, or any agency of the federal government.

Nemko-CCL, Inc.

Tested by: Norman P. Hansen
Test Technician

Reviewed by: Thomas C. Jackson
General Manager

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SECTION 1.0 CLIENT INFORMATION

1.1 Applicant:

Company Name:	Orbit Irrigation Product Inc. 845 N. Overland Rd. North Salt Lake, UT 84054 U.S.A.
Contact Name:	Stuart Eyring
Title:	Executive Vice President

1.2 Manufacturer:

Company Name:	VPI Manufacturing 11814 S. Election Rd., Suite 200 Draper, UT 84020 U.S.A
Contact Name:	Jason Stewart
Title:	Director of Manufacturing

SECTION 2.0 EQUIPMENT UNDER TEST (EUT)

2.1 Identification of EUT:

Brand Name: Orbit
Model Number: 27087
Model Name: Lowes Iris^{TM} HT8 Timer
Serial Number: None

2.2 Description of EUT:

The 27087 is a device that is used to control water flow thru a garden hose. The 27087 has a Zigbee transceiver that interfaces the Iris^{TM} system that controls a flow valve. An LCD display and dial are also provided on the 27087 for manual setting controls. Power is provided by 2 AA batteries.

The 27087 Zigbee transceivers use 16 channels in the 2400 to 2483.5 MHz frequency range. See the table of frequencies below.

Channel	Frequency (MHz)	Channel	Frequency (MHz)	Channel	Frequency (MHz)	Channel	Frequency (MHz)
11	2405	15	2425	19	2445	23	2465
12	2410	16	2430	20	2450	24	2470
13	2415	17	2435	21	2455	25	2475
14	2420	18	2440	22	2460	26	2480

This report covers the circuitry of the devices subject to FCC Part 15, Subpart C. The circuitry of the device subject to FCC Subpart B was found to be compliant and is covered in Nemko-CCL, Inc. report 237824-2.

2.3 EUT and Support Equipment:

The FCC ID numbers for all the EUT and support equipment used during the test are listed below:

Brand Name Model Number Serial Number	FCC ID Number or Compliance	Description	Name of Interface Ports / Interface Cables
BN: Orbit MN: 27087 (Note 1) SN: None	ML6HT8ZB001	Hose controller with transceiver	See Section 2.4

2.4 Interface Ports on EUT:

There are no interface ports on the EUT.

2.5 Modification Incorporated/Special Accessories on EUT:

The following modifications were made to the EUT by the Client during testing to comply with the specification. This report is not complete without an accompanying signed attestation, that the product will have all of the documented modifications incorporated into the product when manufactured and placed on the market.

1. In order for channel 26, operating at 2480 MHz, to comply with emission limits for emissions in the restricted bands at the upper band edge, the power setting was reduced from +4 to -3. Channels 11 – 25 will be set to transmit at +4. This change will be incorporated in manufacturing firmware and cannot be changed by users of the device.

SECTION 3.0 TEST SPECIFICATION, METHODS & PROCEDURES

3.1 Test Specification:

Title: FCC PART 15, Subpart C (47 CFR 15)
15.203 and 15.247

Limits and methods of measurement of radio interference characteristics of radio frequency devices.

Purpose of Test: The tests were performed to demonstrate initial compliance.

3.2 Methods & Procedures:

3.2.1 §15.203 Antenna Requirement

An intentional radiator shall be designed to ensure that no antenna other than that furnished by the responsible party shall be used with the device. The use of a permanently attached antenna or of an antenna that uses a unique coupling to the intentional radiator shall be considered sufficient to comply with the provisions of this Section. The manufacturer may design the unit so that a broken antenna can be replaced by the user, but the use of a standard antenna jack or electrical connector is prohibited. This requirement does not apply to carrier current devices or to devices operated under the provisions of Sections 15.211, 15.213, 15.217, 15.219, or 15.221. Further, this requirement does not apply to intentional radiators that must be professionally installed, such as perimeter protection systems and some field disturbance sensors, or to other intentional radiators which, in accordance with Section 15.31(d), must be measured at the installation site. However, the installer shall be responsible for ensuring that the proper antenna is employed so that the limits in this Part are not exceeded.

3.2.2 §15.247 Operation within the bands 902 – 928 MHz, 2400 – 2483.5 MHz, and 5725 – 5850 MHz

(a) Operation under the provisions of this Section is limited to frequency hopping and digitally modulated intentional radiators that comply with the following provisions:

(1) Frequency hopping systems shall have hopping channel carrier frequencies separated by a minimum of 25 kHz or the 20 dB bandwidth of the hopping channel, whichever is greater. Alternatively, frequency hopping systems operating in the 2400 – 2483.5 MHz band may have hopping channel carrier frequencies that are separated by 25 kHz or two-thirds of the 20 dB bandwidth of the hopping channel, whichever is greater, provided the systems operate with an output power no greater than 125 mW. The system shall hop to channel frequencies that are selected at the system hopping rate from a pseudorandomly ordered list of hopping frequencies. Each frequency must be used

equally on the average by each transmitter. The system receivers shall have input bandwidths that match the hopping channel bandwidths of their corresponding transmitters and shall shift frequencies in synchronization with the transmitted signals.

(i) For frequency hopping systems operating in the 902-928 MHz band: if the 20 dB bandwidth of the hopping channel is less than 250 kHz, the system shall use at least 50 hopping frequencies and the average time of occupancy on any frequency shall not be greater than 0.4 seconds within a 20 second period; if the 20 dB bandwidth of the hopping channel is 250 kHz or greater, the system shall use at least 25 hopping frequencies and the average time of occupancy on any frequency shall not be greater than 0.4 seconds within a 10 second period. The maximum allowed 20 dB bandwidth of the hopping channel is 500 kHz.

(ii) Frequency hopping systems operating in the 5725-5850 MHz band shall use at least 75 hopping frequencies. The maximum 20 dB bandwidth of the hopping channel is 1 MHz. The average time of occupancy on any frequency shall not be greater than 0.4 seconds within a 30 second period.

(iii) Frequency hopping systems in the 2400-2483.5 MHz band shall use at least 15 non-overlapping channels. The average time of occupancy on any channel shall not be greater than 0.4 seconds within a period of 0.4 seconds multiplied by the number of hopping channels employed. Frequency hopping systems may avoid or suppress transmissions on a particular hopping frequency provided that a minimum of 15 non-overlapping channels are used.

(2) Systems using digital modulation techniques may operate in the 902 - 928 MHz, 2400 - 2483.5 MHz, and 5725 - 5850 MHz bands. The minimum 6 dB bandwidth shall be at least 500 kHz.

(b) The maximum peak output power of the intentional radiator shall not exceed the following:

(1) For frequency hopping systems operating in the 2400-2483.5 MHz band employing at least 75 non-overlapping hopping channels, and all frequency hopping systems in the 5725-5850 MHz band: 1 watt. For all other frequency hopping systems are in the 2400-2483.5 MHz band: 0.125 watts.

(2) For frequency hopping systems operating in the 902-928 MHz band: 1 watt for systems employing at least 50 hopping channels; and, 0.25 watts for systems employing less than 50 hopping channels, but at least 25 hopping channels, as permitted under paragraph (a)(1)(i) of this section.

(3) For systems using digital modulation in the 902-928 MHz, 2400-2483.5 MHz, and 5725 – 5850 MHz bands: 1 watt. As an alternative to a peak power measurement, compliance with the Conducted Output Power is defined as the total transmit power

delivered to all antennas and antenna elements averaged across all symbols in the signaling alphabet when the transmitter is operating at its maximum power control level. Power must be summed across all antennas and antenna elements. The average must not include any time intervals during which the transmitter is off or is transmitting at a reduced power level. If multiple modes of operation are possible (e.g., alternative modulation methods), the maximum conducted output power is the highest total transmit power occurring in any mode.

(4) The conducted output power limit specified in paragraph (b) of this section is based on the use of antennas with directional gains that do not exceed 6 dBi. Except as shown in paragraph (c) of this section, if transmitting antennas of directional gain greater than 6 dBi are used, the conducted power from the intentional radiator shall be reduced below the stated values in paragraphs (b)(1), (b)(2), and (b)(3) of this section, as appropriate, by the amount in dB that the directional gain of the antenna exceeds 6 dBi.

(c) Operation with directional antenna gains greater than 6 dBi.

(1) Fixed point-to-point operation:

(i) Systems operating in the 2400-2483.5 MHz band that are used exclusively for fixed, point-to-point operations may employ transmitting antennas with directional gain greater than 6 dBi provided the maximum peak output power of the intentional radiator is reduced by 1 dB for every 3 dB that the directional gain of the antenna exceeds 6 dBi.

(ii) Systems operating in the 5725-5850 MHz band that are used exclusively for fixed, point-to-point operations may employ transmitting antennas with directional gain greater than 6 dBi without any corresponding reduction in transmitter peak output power.

(iii) Fixed, point-to-point operation, as used in paragraphs (b)(4)(i) and (b)(4)(ii) of this section, excludes the use of point-to-multipoint systems, omnidirectional applications, and multiple co-located intentional radiators transmitting the same information. The operator of the spread spectrum or digitally modulated intentional radiator or, if the equipment is professionally installed, the installer is responsible for ensuring that the system is used exclusively for fixed, point-to-point operations. The instruction manual furnished with the intentional radiator shall contain language in the installation instructions informing the operator and the installer of this responsibility.

(2) In addition to the provisions in paragraphs (b)(1), (b)(3), (b)(4) and (c)(1)(i) of this section, transmitters operating in the 2400-2483.5 MHz band that emit multiple directional beams, simultaneously or sequentially, for the purpose of directing signals to individual receivers or to groups of receivers provided the emissions comply with the following:

(i) Different information must be transmitted to each receiver.

(ii) If the transmitter employs an antenna system that emits multiple directional beams but does not emit multiple directional beams simultaneously, the total output power conducted to the array or arrays that comprise the device, i.e., the sum of the power supplied to all antennas, antenna elements, staves, etc. and summed across all carriers or frequency channels, shall not exceed the limit specified in paragraph (b)(1) or (b)(3) of this section, as applicable. However, the total conducted output power shall be reduced by 1 dB below the specified limits for each 3 dB that the directional gain of the antenna /antenna array exceeds 6 dBi. The directional antenna gain shall be computed as follows:

(A) The directional gain shall be calculated as the sum of 10 log (number of array elements or staves) plus the directional gain of the element or stave having the highest gain.

(B) A lower value for the directional gain than that calculated in paragraph (c)(2)(ii)(A) of this section will be accepted if sufficient evidence is presented, e.g., due to shading of the array or coherence loss in the beamforming.

(iii) If a transmitter employs an antenna that operates simultaneously on multiple directional beams using the same or different frequency channels, the power supplied to each emission beam is subject to the power limit specified in paragraph (c)(2)(ii) of this section. If transmitted beams overlap, the power shall be reduced to ensure that their aggregate power does not exceed the limit specified in paragraph (c)(2)(ii) of this section. In addition, the aggregate power transmitted simultaneously on all beams shall not exceed the limit specified in paragraph (c)(2)(ii) of this section by more than 8 dB.

(iv) Transmitters that emit a single directional beam shall operate under the provisions of paragraph (c)(1) of this section.

(d) In any 100 kHz bandwidth outside the frequency band in which the spread spectrum or digitally modulated intentional radiator is operating, the radio frequency power that is produced by the intentional radiator shall be at least 20 dB below that in the 100 kHz bandwidth within the band that contains the highest level of the desired power, based on either an RF conducted or a radiated measurement, provided the transmitter demonstrates compliance with the peak conducted power limits. If the transmitter complies with the conducted power limits based on the use of RMS averaging over a time interval, as permitted under paragraph (b)(3) of this section, the attenuation required under this paragraph shall be 30 dB instead of 20 dB. Attenuation below the general limits specified in Section 15.209(a) is not required. In addition, radiated emissions which fall in the restricted bands, as defined in Section 15.205(a), must also comply with the radiated emission limits specified in Section 15.209(a) (see Section 15.205(c)).

(e) For digitally modulated systems, the power spectral density conducted from the intentional radiator to the antenna shall not be greater than 8 dBm in any 3 kHz band during any time interval of continuous transmission. This power spectral density shall be determined in accordance with the provisions of paragraph (b) of this section. The same method of determining the conducted output power shall be used to determine the power spectral density.

(f) For the purposes of this section, hybrid systems are those that employ a combination of both frequency hopping and digital modulation techniques. The frequency hopping operation of the hybrid system, with the direct sequence or digital modulation operation turned off, shall have an average time of occupancy on any frequency not to exceed 0.4 seconds within a time period in seconds equal to the number of hopping frequencies employed multiplied by 0.4. The digital modulation operation of the hybrid system, with the frequency hopping turned off, shall comply with the power density requirements of paragraph (d) of this section.

(g) Frequency hopping spread spectrum systems are not required to employ all available hopping channels during each transmission. However, the system, consisting of both the transmitter and the receiver, must be designed to comply with all of the regulations in this section should the transmitter be presented with a continuous data (or information) stream. In addition, a system employing short transmission bursts must comply with the definition of a frequency hopping system and must distribute its transmissions over the minimum number of hopping channels specified in this section.

(h) The incorporation of intelligence within a frequency hopping spread spectrum system that permits the system to recognize other users within the spectrum band so that it individually and independently chooses and adapts its hopsets to avoid hopping on occupied channels is permitted. The coordination of frequency hopping systems in any other manner for the express purpose of avoiding the simultaneous occupancy of individual hopping frequencies by multiple transmitters is not permitted.

(i) Systems operating under the provisions of this section shall be operated in a manner that ensures that the public is not exposed to radio frequency energy levels in excess of the Commission's guidelines. See § 1.1307(b)(1) of this Chapter.

Note: Spread spectrum systems are sharing these bands on a noninterference basis with systems supporting critical Government requirements that have been allocated the usage of these bands, secondary only to ISM equipment operated under the provisions of Part 18 of this Chapter. Many of these Government systems are airborne radiolocation systems that emit a high EIRP which can cause interference to other users. Also, investigations of the effect of spread spectrum interference to U. S. Government operations in the 902-928 MHz band may require a future decrease in the power limits allowed for spread spectrum operation.

3.2.3 Test Procedure

The testing was performed according to the procedures in ANSI C63.4: 2003, 47 CFR Part 15, and 558074 D01 DTS Meas Guidance V03r01 dated April 9, 2013. Testing was performed at the Nemko-CCL, Inc. Wanship open area test site #2, located at 29145 Old Lincoln Highway, Wanship, UT. This site has been registered with the FCC, and was renewed February 15, 2012 (90504). This registration is valid for three years.

Nemko-CCL, Inc. is accredited by National Voluntary Laboratory Accreditation Program (NVLAP); NVLAP Lab Code: 100272-0, which is effective until September 30, 2013.

SECTION 4.0 OPERATION OF EUT DURING TESTING

4.1 Operating Environment:

Power Supply: 3 VDC from 2 AA batteries

4.2 Operating Modes:

The EUT was tested on 3 orthogonal axes while transmitting a constant modulated signal at the upper, middle or lower channel.

4.3 EUT Exercise Software:

VPI software was used to exercise the transmitters.

SECTION 5.0 SUMMARY OF TEST RESULTS

5.1 FCC Part 15, Subpart C

The Zigbee transceiver of the 27087 was subjected to each of the tests shown in the summary table below.

5.1.1 Summary of Tests:

Section	Environmental Phenomena	Frequency Range (MHz)	Result
15.203	Antenna Requirements	Structural requirement	Complied
15.247(a)	Bandwidth Requirement	2400 – 2483.5	Complied
15.247(b)	Peak Output Power	2400 – 2483.5	Complied
15.247(c)	Spurious Emissions	0.032 - 25000	Complied
15.247(d)	Peak Power Spectral Density	2400 – 2483.5	Complied
15.247(e)	Reserved Paragraph	N/A	Not Applicable
15.247(f)	Hybrid System Requirements	2400 – 2483.5	Not Applicable
15.247(g)	Frequency Hopping Channel Usage	2400 – 2438.5	Not Applicable
15.247(h)	Frequency Hopping Intelligence	2400 – 2483.5	Not Applicable

5.2 Result

In the configuration tested, the transceiver complied with the requirements of the specification.

SECTION 6.0 MEASUREMENTS AND RESULTS

6.1 General Comments:

This section contains the test results only. Details of the test methods used and a list of the test equipment used during the measurements can be found in Appendix 1 of this report.

6.2 Test Results

6.2.1 §15.203 Antenna Requirements

The EUT uses a 2.0 dBi, inverted F, trace antenna and is not user replaceable.

RESULT

The EUT complied with the specification.

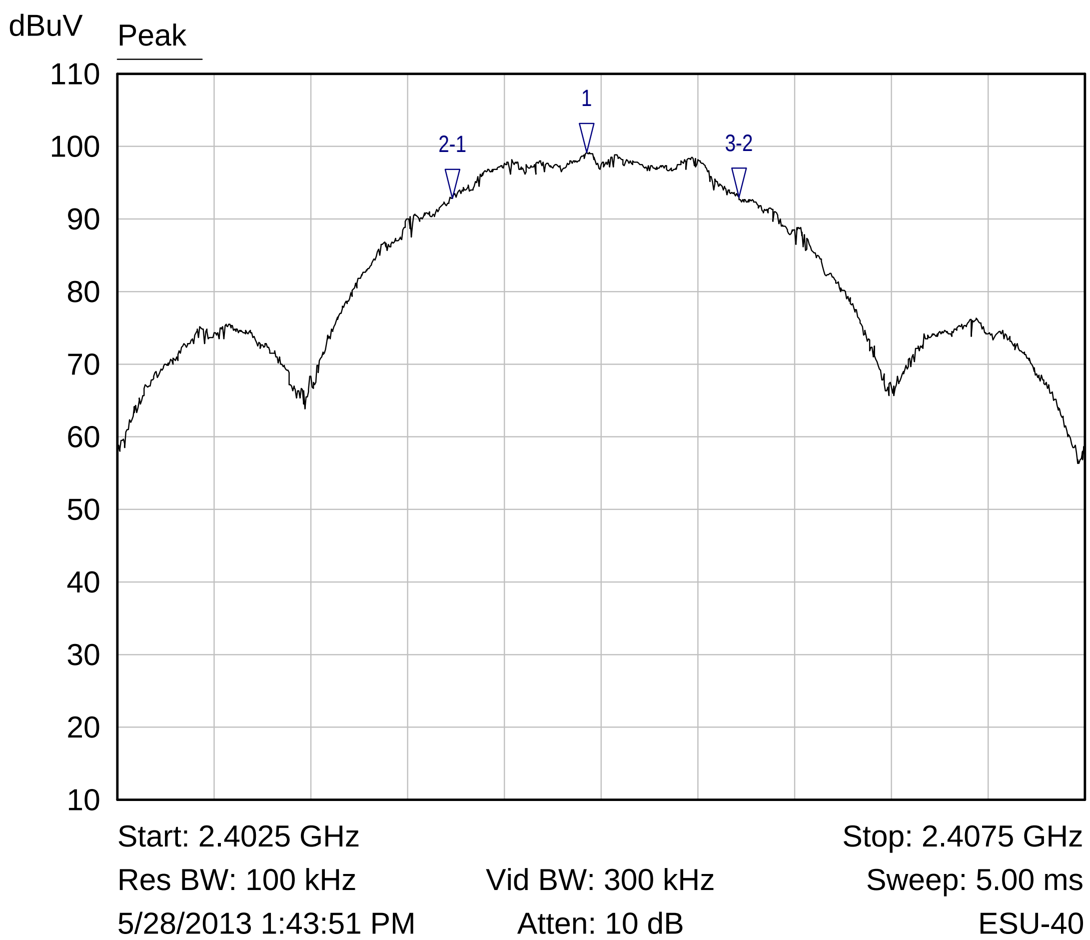
6.2.2 §15.247(a)(2) Emission Bandwidth

Frequency (MHz)	Emission 6dB Bandwidth (kHz)
2405	1480
2440	1525
2480	1550

RESULT

In the configuration tested, the 6 dB bandwidth was greater than 500 kHz; therefore, the EUT complied with the requirements of the specification (see spectrum analyzer plots below).

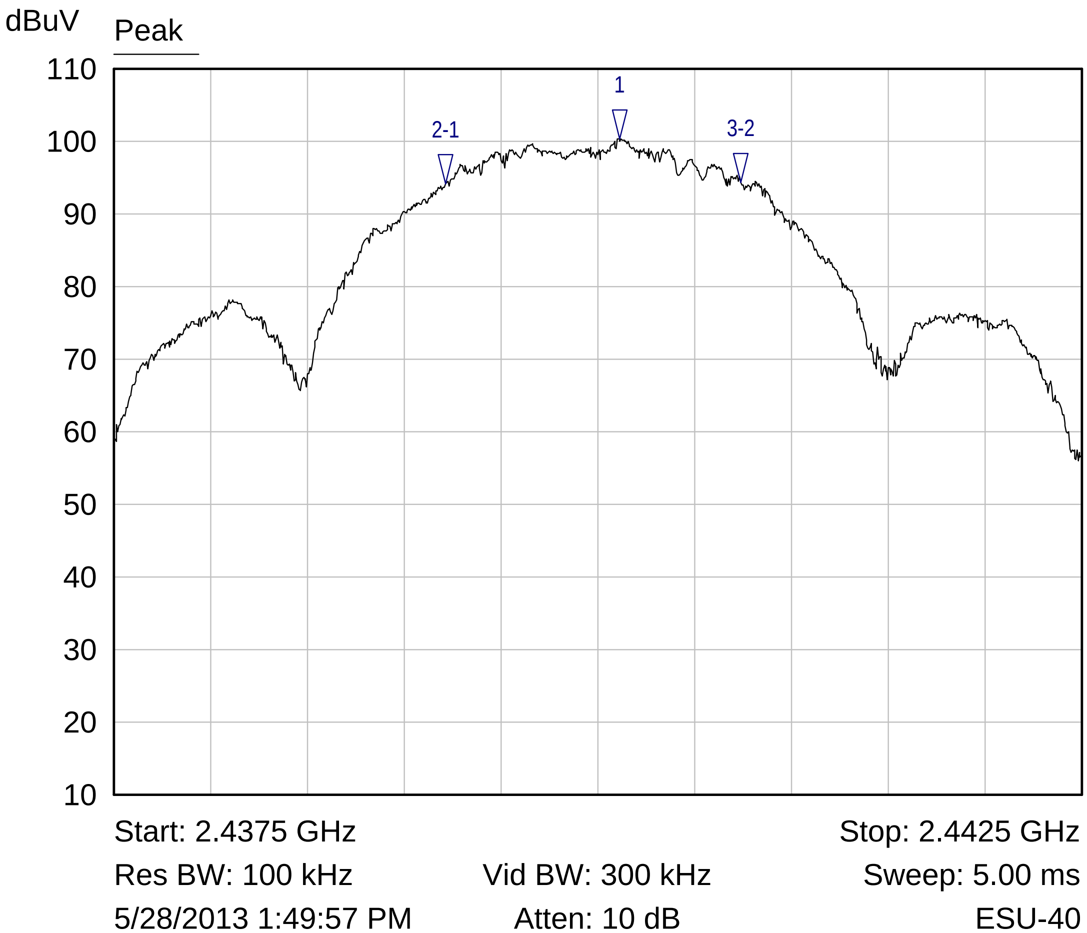
Lower Channel Bandwidth



Mkr	Trace	X-Axis	Value	Notes
1 ∇	Peak	2.4049 GHz	99.20 dBuV	
2-1 ∇	Peak	-695.0000 kHz	-6.37 dB	
3-2 ∇	Peak	1.4800 MHz	0.14 dB	

Band width at +4

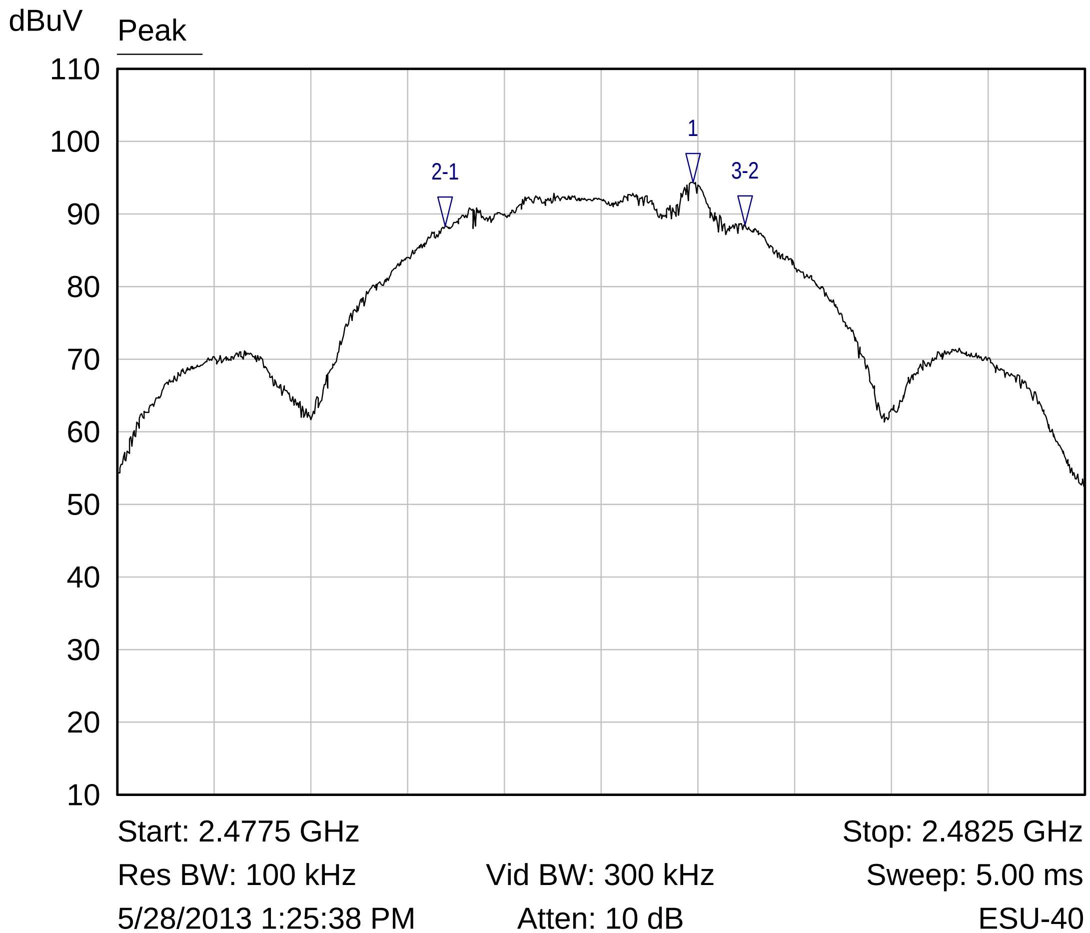
Middle Channel Bandwidth



Mkr	Trace	X-Axis	Value	Notes
1 ▽	Peak	2.4401 GHz	100.34 dBuV	
2-1 ▽	Peak	-895.0000 kHz	-6.10 dB	
3-2 ▽	Peak	1.5250 MHz	0.05 dB	

Band width at +4

Upper Channel Bandwidth



Mkr	Trace	X-Axis	Value	Notes
1 ▽	Peak	2.4805 GHz	94.38 dBuV	
2-1 ▽	Peak	-1.2800 MHz	-6.03 dB	
3-2 ▽	Peak	1.5500 MHz	0.17 dB	

Band width at -3

6.2.3 §15.247(b)(3) Peak Output Power

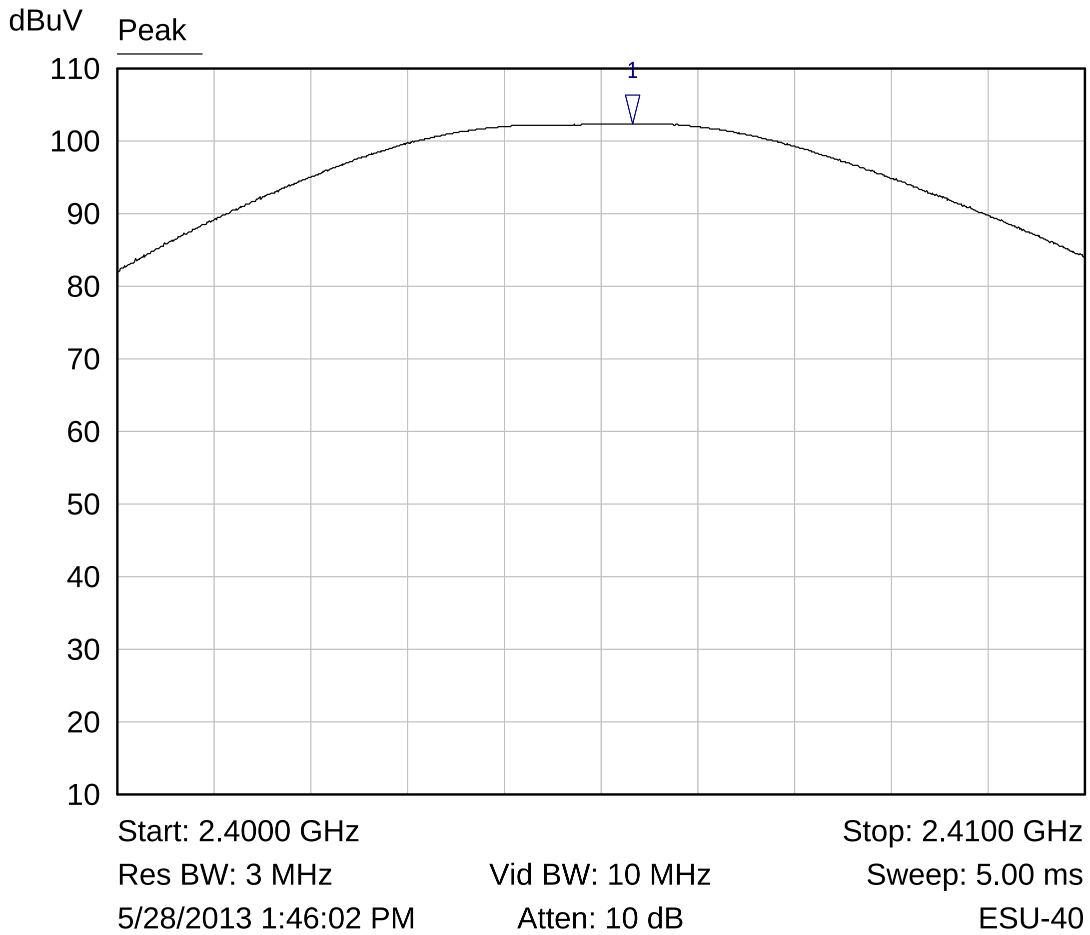
The maximum peak RF output power for this device was 3.28 mW. The maximum peak RF output power was calculated using equation 1.3.1 of KDB 412172 (eirp = $(E \times d)^2 / 30$) to get EIRP in Watts, then Watts was converted to dBm, following the guidance of KDB 558074 paragraph 2.0, the antenna gain in dBi was subtracted to get the maximum transmitter output power in dBm. The limit is 30 dBm (1 Watt) when using antennas with 6 dBi or less gain. Parameters used in the calculations are antenna gain equals 2.0 dBi and a measurement distance (d) of 3 meters. E is the measured field strength in V/m.

Frequency (MHz)	Measured Field Strength (dBμV/m)	Peak RF Output Power to Antenna (dBm)	Peak RF Output Power to Antenna (mW)
2405	102.39	5.16	3.28
2440	103.29	6.06	4.04
2480	96.97	-0.24	0.95

RESULT

In the configuration tested, the RF peak output power was less than 1 Watt; therefore, the EUT complied with the requirements of the specification (see spectrum analyzer plots below).

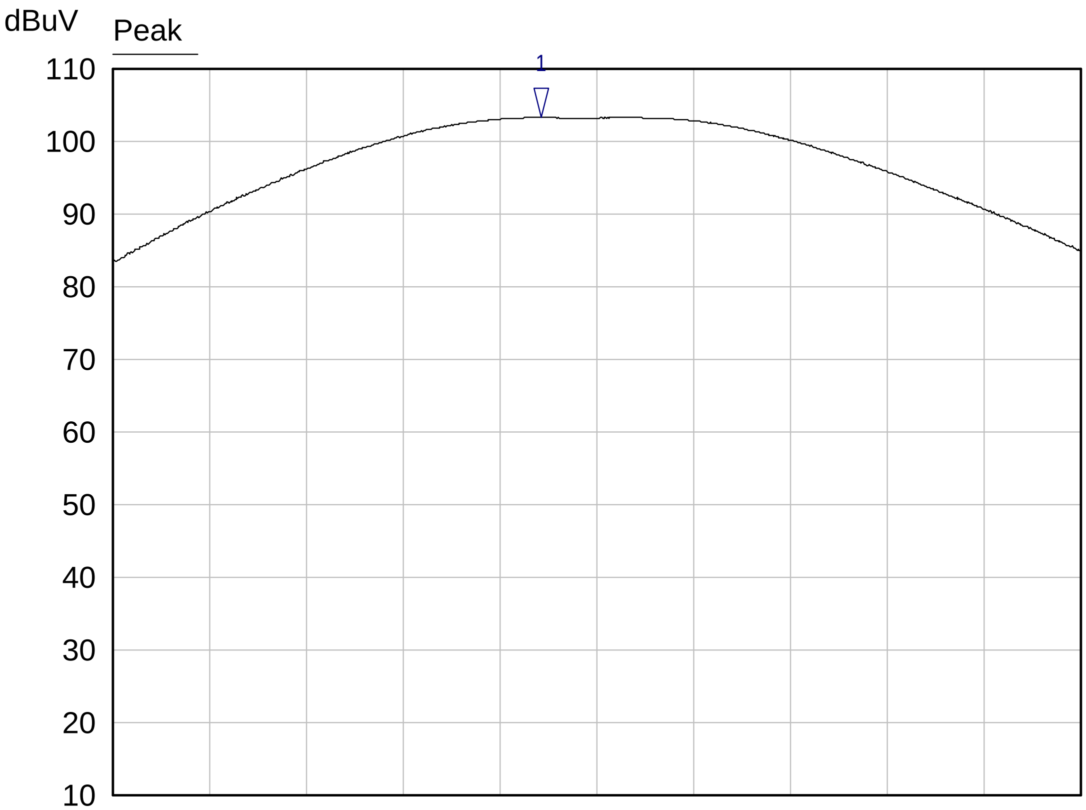
Lower Channel



Mkr	Trace	X-Axis	Value	Notes
1 ∇	Peak	2.4053 GHz	102.39 dBuV	

Output power at +4

Middle Channel

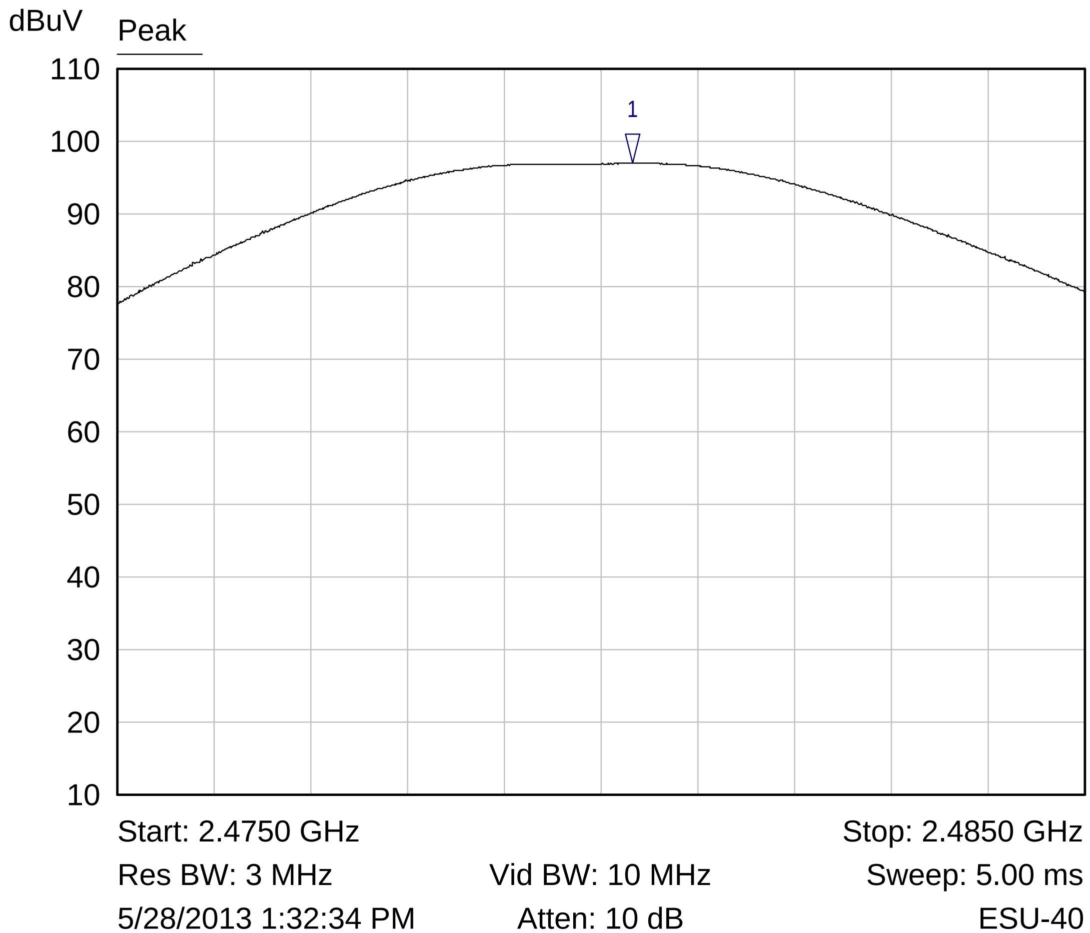


Start: 2.4350 GHz Stop: 2.4450 GHz
Res BW: 3 MHz Vid BW: 10 MHz Sweep: 5.00 ms
5/28/2013 1:51:39 PM Atten: 10 dB ESU-40

Mkr	Trace	X-Axis	Value	Notes
1 ∇	Peak	2.4394 GHz	103.29 dBuV	

Output power at +4

Upper Channel



Mkr	Trace	X-Axis	Value	Notes
1 ▽	Peak	2.4803 GHz	96.97 dBuV	

Output power at -3

6.2.4 §15.247(c) Spurious Emissions

The frequency range from the lowest frequency used in the device to the tenth harmonic of the highest fundamental frequency was investigated to measure any radiated emission. The following tables show measurements of any emission found. The tables show the worst-case emission measured from the EUT. In order to demonstrate compliance at the maximum power setting to be used in the device, all channels were tested for spurious emissions using the +4 setting. For frequencies above 12.5 GHz, a measurement distance of 1 meter was used. The noise floor was a minimum of 6 dB below the limit. Spurious emissions not within the restricted bands must be attenuated 20 dB from the maximum measured fundamental emission. The emissions in the restricted bands must meet the limits specified in **§**15.209. Tabular data for each of the spurious emissions is shown below for each of the units. Plots of the band edges, at channels 11, 25, and 26 at the power settings to be used in production firmware, are also shown.

AVERAGE FACTOR

The EUT operates at a maximum duty cycle of 42.06%. A correction factor of -7.5 dB will be applied to the average detection measurements of emissions exhibiting the same characteristics as the fundamental frequency. For details of the duty cycle calculation, see Appendix 3.

RESULT

All emissions, even those outside the restricted bands of §15.205, met the limits specified in **§**15.209; therefore, the EUT complies with the specification.

Transmitting at the Lowest Frequency (2405 MHz)

Frequency (MHz)	Detection Mode	Antenna Polarity	Receiver Reading (dBμV)	Correction Factor (dB)	Averaging Factor (dB)	Field Strength (dBμV/m)	Limit (dBμV/m)	Margin (dB)
4810.0	Peak	Vertical	14.0	37.7	0.0	51.7	74.0	-22.3
4810.0	Average	Vertical	9.9	37.7	-7.5	40.1	54.0	-13.9
4810.0	Peak	Horizontal	18.1	37.7	0.0	55.8	74.0	-18.2
4810.0	Average	Horizontal	12.5	37.7	-7.5	42.7	54.0	-11.3
7215.0	Peak	Vertical	4.3	42.1	0.0	46.4	74.0	-27.6
7215.0	Average	Vertical	-4.1	42.1	-7.5	30.5	54.0	-23.5
7215.0	Peak	Horizontal	5.5	42.1	0.0	47.6	74.0	-26.4
7215.0	Average	Horizontal	-3.0	42.1	-7.5	31.6	54.0	-22.4
9620.0	Peak	Vertical	7.3	44.7	0.0	52.0	74.0	-22.0
9620.0	Average	Vertical	1.0	44.7	-7.5	38.2	54.0	-15.8
9620.0	Peak	Horizontal	6.5	44.7	0.0	51.2	74.0	-22.8

Frequency (MHz)	Detection Mode	Antenna Polarity	Receiver Reading (dBμV)	Correction Factor (dB)	Averaging Factor (dB)	Field Strength (dBμV/m)	Limit (dBμV/m)	Margin (dB)
9620.0	Average	Horizontal	0.3	44.7	-7.5	37.5	54.0	-16.5
12025.0	Peak	Vertical	0.4	47.2	0.0	40.1	74.0	-33.9
12025.0	Average	Vertical	-9.7	47.2	-7.5	30.0	54.0	-24.0
12025.0	Peak	Horizontal	1.0	47.2	0.0	48.2	74.0	-25.8
12025.0	Average	Horizontal	-9.2	47.2	-7.5	30.5	54.0	-23.5
14430.0	Peak	Vertical	-0.1	50.8	0.0	50.7	74.0	-23.3
14430.0	Average	Vertical	-11.0	50.8	-7.5	32.3	54.0	-21.7
14430.0	Peak	Horizontal	0.3	50.8	0.0	51.1	74.0	-22.9
14430.0	Average	Horizontal	-10.9	50.8	-7.5	32.4	54.0	-21.6
16835.0	Peak	Vertical	-1.3	49.8	0.0	48.5	74.0	-25.5
16835.0	Average	Vertical	-12.2	49.8	-7.5	30.1	54.0	-23.9
16835.0	Peak	Horizontal	-1.6	49.8	0.0	48.2	74.0	-25.8
16835.0	Average	Horizontal	-12.0	49.8	-7.5	30.3	54.0	-23.7

Transmitting at the Middle Frequency (2440 MHz)

Frequency (MHz)	Detection Mode	Antenna Polarity	Receiver Reading (dBμV)	Correction Factor (dB)	Averaging Factor (dB)	Field Strength (dBμV/m)	Limit (dBμV/m)	Margin (dB)
4880.0	Peak	Vertical	13.0	37.9	0.0	50.9	74.0	-23.1
4880.0	Average	Vertical	8.1	37.9	-7.5	38.5	54.0	-15.5
4880.0	Peak	Horizontal	13.4	37.9	0.0	51.3	74.0	-22.7
4880.0	Average	Horizontal	8.5	37.9	-7.5	38.9	54.0	-15.1
7320.0	Peak	Vertical	5.4	42.3	0.0	47.7	74.0	-26.3
7320.0	Average	Vertical	-2.1	42.3	-7.5	32.7	54.0	-21.3
7320.0	Peak	Horizontal	5.1	42.3	0.0	47.4	74.0	-26.6
7320.0	Average	Horizontal	-2.4	42.3	-7.5	32.4	54.0	-21.6
9760.0	Peak	Vertical	7.0	44.8	0.0	51.8	74.0	-22.2
9760.0	Average	Vertical	1.0	44.8	-7.5	38.3	54.0	-15.7
9760.0	Peak	Horizontal	6.6	44.8	0.0	51.4	74.0	-22.6
9760.0	Average	Horizontal	0.4	44.8	-7.5	37.7	54.0	-16.3
12200.0	Peak	Vertical	0.7	47.1	0.0	40.3	74.0	-33.7
12200.0	Average	Vertical	-9.9	47.1	-7.5	29.7	54.0	-24.3
12200.0	Peak	Horizontal	0.5	47.1	0.0	47.6	74.0	-26.4

Frequency (MHz)	Detection Mode	Antenna Polarity	Receiver Reading (dBμV)	Correction Factor (dB)	Averaging Factor (dB)	Field Strength (dBμV/m)	Limit (dBμV/m)	Margin (dB)
12200.0	Average	Horizontal	-9.6	47.1	-7.5	30.0	54.0	-24.0
14640.0	Peak	Vertical	0.2	50.5	0.0	50.7	74.0	-23.3
14640.0	Average	Vertical	-10.2	50.5	-7.5	32.8	54.0	-21.2
14640.0	Peak	Horizontal	0.3	50.5	0.0	50.8	74.0	-23.2
14640.0	Average	Horizontal	-10.4	50.5	-7.5	32.6	54.0	-21.4
17080.0	Peak	Vertical	-2.69	51.3	0.0	48.6	74.0	-25.4
17080.0	Average	Vertical	-12.9	51.3	-7.5	30.9	54.0	-23.1
17080.0	Peak	Horizontal	-1.8	51.3	0.0	49.5	74.0	-24.5
17080.0	Average	Horizontal	-12.5	51.3	-7.5	31.3	54.0	-22.7

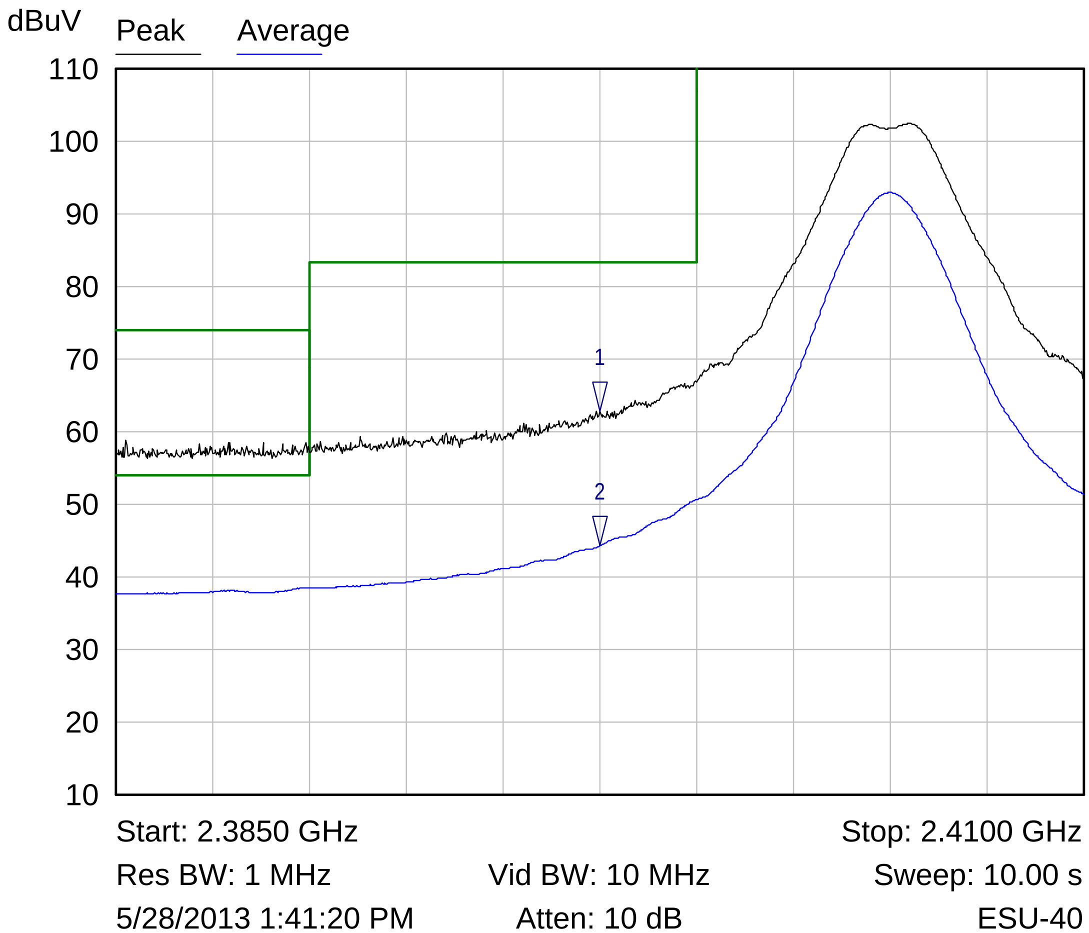
Transmitting at the Highest Frequency (2480 MHz)

Frequency (MHz)	Detection Mode	Antenna Polarity	Receiver Reading (dBμV)	Correction Factor (dB)	Averaging Factor (dB)	Field Strength (dBμV/m)	Limit (dBμV/m)	Margin (dB)
4960.0	Peak	Vertical	12.8	37.9	0.0	50.7	74.0	-23.3
4960.0	Average	Vertical	7.6	37.9	-7.5	38.0	54.0	-16.0
4960.0	Peak	Horizontal	13.0	37.9	0.0	50.9	74.0	-23.1
4960.0	Average	Horizontal	9.1	37.9	-7.5	39.5	54.0	-14.5
7440.0	Peak	Vertical	3.9	42.4	0.0	46.3	74.0	-27.7
7440.0	Average	Vertical	-3.6	42.4	-7.5	31.3	54.0	-22.7
7440.0	Peak	Horizontal	5.0	42.4	0.0	47.4	74.0	-26.6
7440.0	Average	Horizontal	-2.3	42.4	-7.5	32.6	54.0	-21.4
9920.0	Peak	Vertical	8.9	44.9	0.0	53.8	74.0	-20.2
9920.0	Average	Vertical	4.7	44.9	-7.5	42.1	54.0	-11.9
9920.0	Peak	Horizontal	9.6	44.9	0.0	54.5	74.0	-19.5
9920.0	Average	Horizontal	5.2	44.9	-7.5	42.6	54.0	-11.4
12400.0	Peak	Vertical	-0.5	46.7	0.0	38.7	74.0	-35.3
12400.0	Average	Vertical	-10.1	46.7	-7.5	29.1	54.0	-24.9
12400.0	Peak	Horizontal	0.1	46.7	0.0	46.8	74.0	-27.2
12400.0	Average	Horizontal	-10.2	46.7	-7.5	29.0	54.0	-25.0
14880.0	Peak	Vertical	1.0	49.1	0.0	50.1	74.0	-23.9
14880.0	Average	Vertical	-10.7	49.1	-7.5	30.9	54.0	-23.1
14880.0	Peak	Horizontal	-0.4	49.1	0.0	48.7	74.0	-25.3

Frequency (MHz)	Detection Mode	Antenna Polarity	Receiver Reading (dBµV)	Correction Factor (dB)	Averaging Factor (dB)	Field Strength (dBµV/m)	Limit (dBµV/m)	Margin (dB)
14880.0	Average	Horizontal	-10.8	49.1	-7.5	30.8	54.0	-23.2
17360.0	Peak	Vertical	-1.3	51.9	0.0	50.6	74.0	-23.4
17360.0	Average	Vertical	-11.4	51.9	-7.5	33.0	54.0	-21.0
17360.0	Peak	Horizontal	-1.6	51.9	0.0	50.3	74.0	-23.7
17360.0	Average	Horizontal	-11.6	51.9	-7.5	32.8	54.0	-21.2

No other emissions were seen in the restricted bands. Noise floor was greater than 6 dB below the limit.

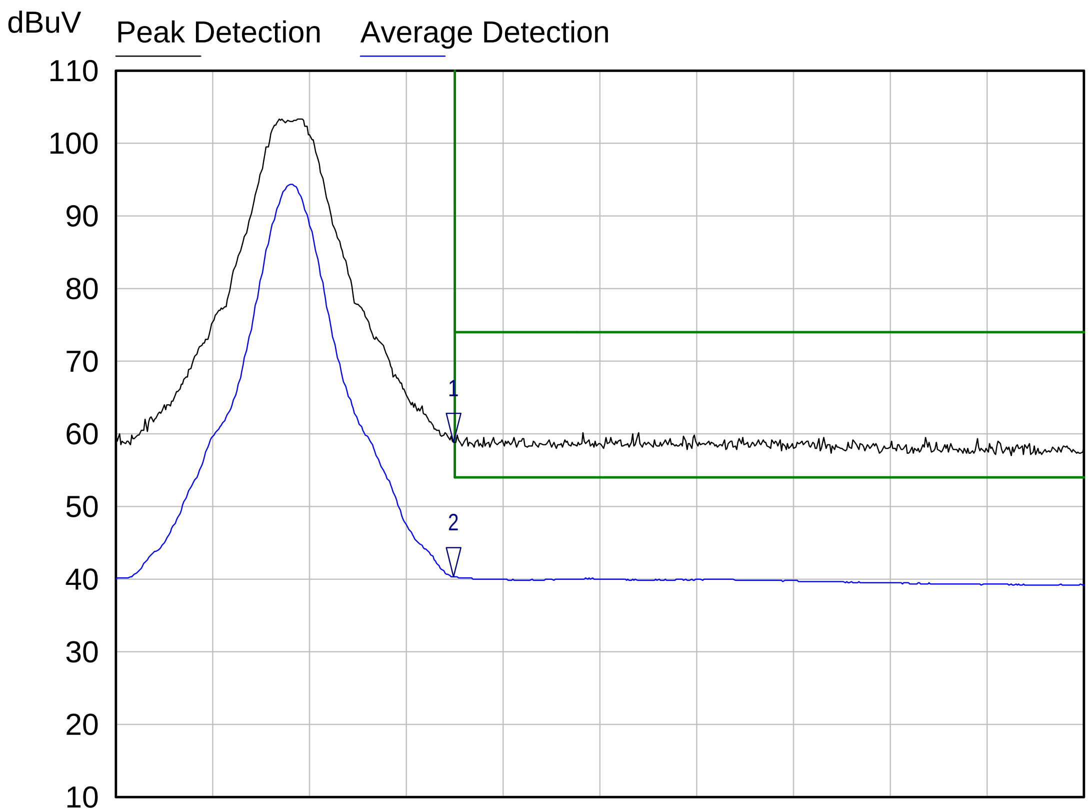
Lower Band Edge



Mkr	Trace	X-Axis	Value	Notes
1 ∇	Peak	2.3975 GHz	62.82 dBuV	
2 ∇	Average	2.3975 GHz	44.27 dBuV	

Band edge at +4

Channel 25 Upper Band Edge



Start: 2.4660 GHz — Stop: 2.5160 GHz

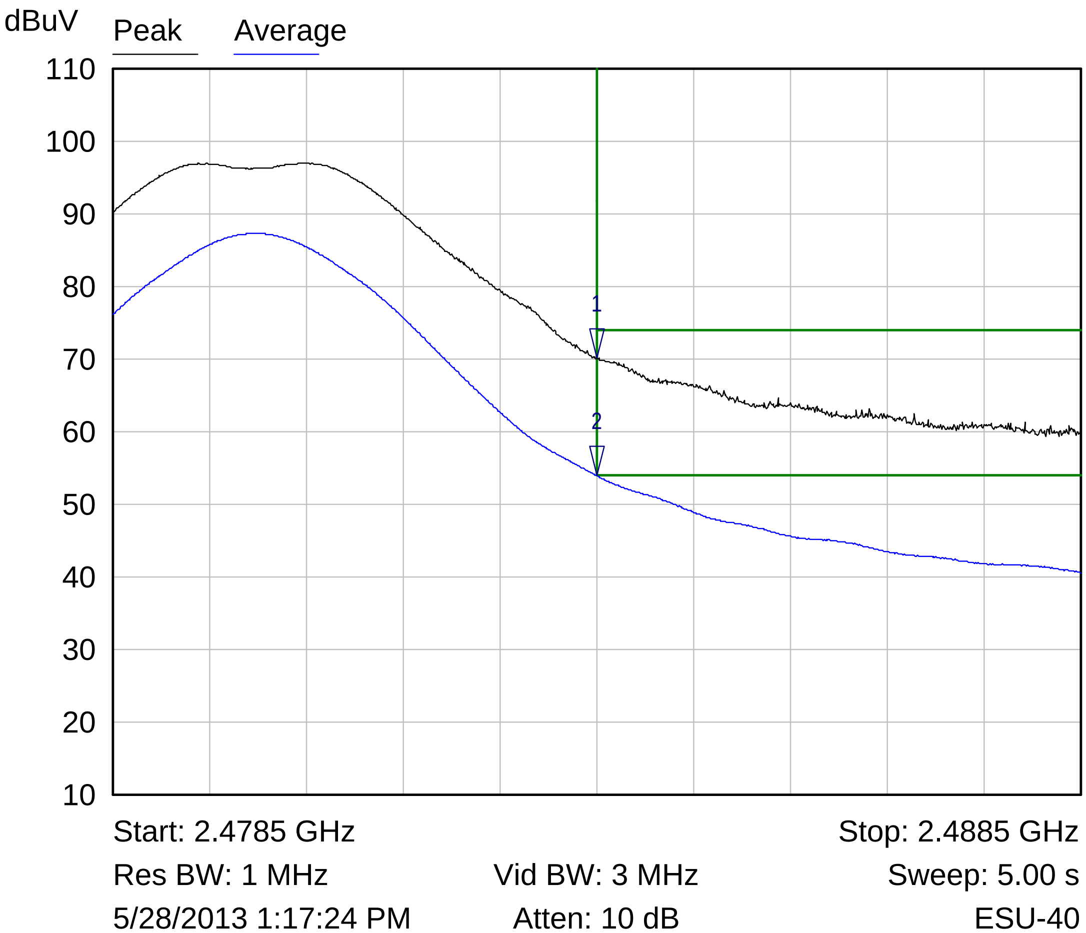
Res BW: 1 MHz — Vid BW: 3 MHz — Sweep: 5.00 s

05/28/2013 1:27:45 PM — Atten: 10 dB — ESU-40

Mkr	Trace	X-Axis	Value	Notes
1 ▽	Peak Detection	2.4835 GHz	58.90 dBuV	
2 ▽	Average Detection	2.4835 GHz	40.31 dBuV	

Channel 25 band edge at +4

Upper Band Edge



Mkr	Trace	X-Axis	Value	Notes
1 ∇	Peak	2.4835 GHz	70.11 dBuV	
2 ∇	Average	2.4835 GHz	53.92 dBuV	

Band edge at -3

6.2.5 §15.247(d) Peak Power Spectral Density

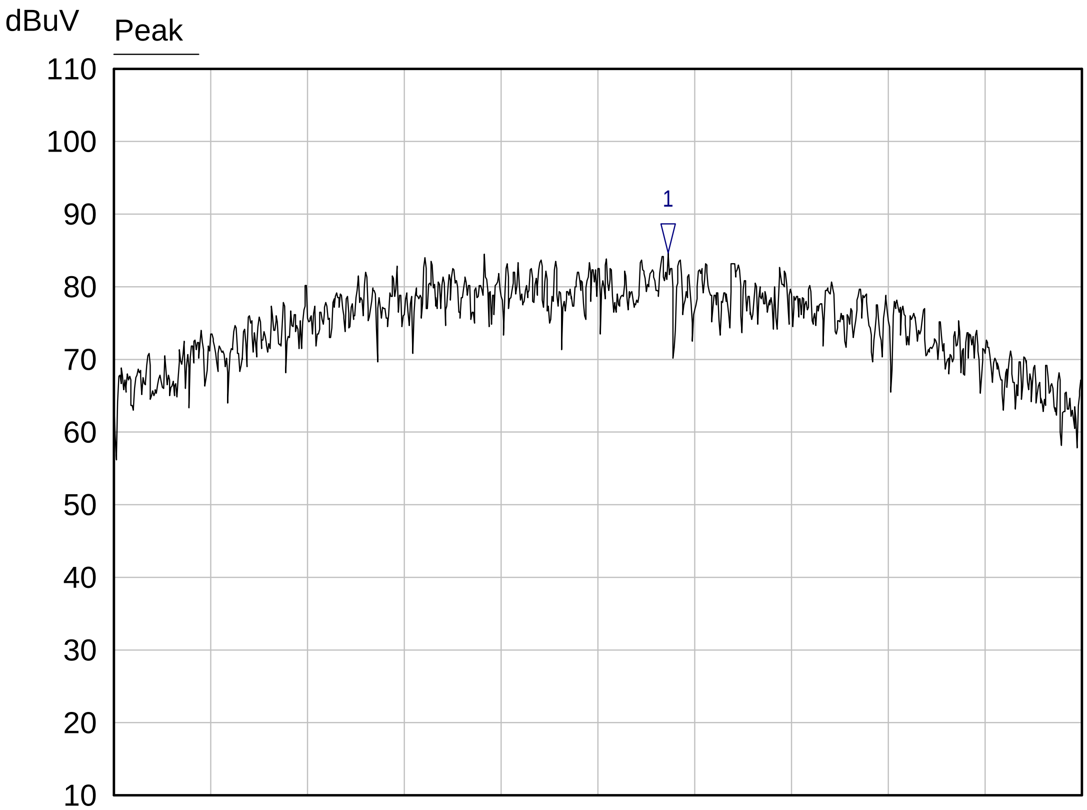
The peak power spectral density conducted from the intentional radiator to the antenna shall not be greater than 8 dBm in any 3 kHz band during any time interval of continuous transmission. The maximum peak RF output power was calculated using equation 1.3.1 of KDB 412172 (eirp = $(E \times d)^2 / 30$) to get EIRP in Watts, then Watts was converted to dBm, following the guidance of KDB 558074, the antenna gain in dBi was subtracted to get the maximum transmitter output power in dBm. Parameters used in the calculations are antenna gain equals 2.0 dBi and a measurement distance (d) of 3 meters. E is the measured field strength in V/m. The plots are shown below and the results of this testing are summarized in the table below.

Frequency (MHz)	Radiated Measurement (dBµV/m)	3 kHz Peak Power Spectral Density (dBm)
2405	84.71	-12.5
2440	85.81	-11.4
2480	81.90	-15.3

RESULT

The EUT complies with the specification.

Lowest Channel

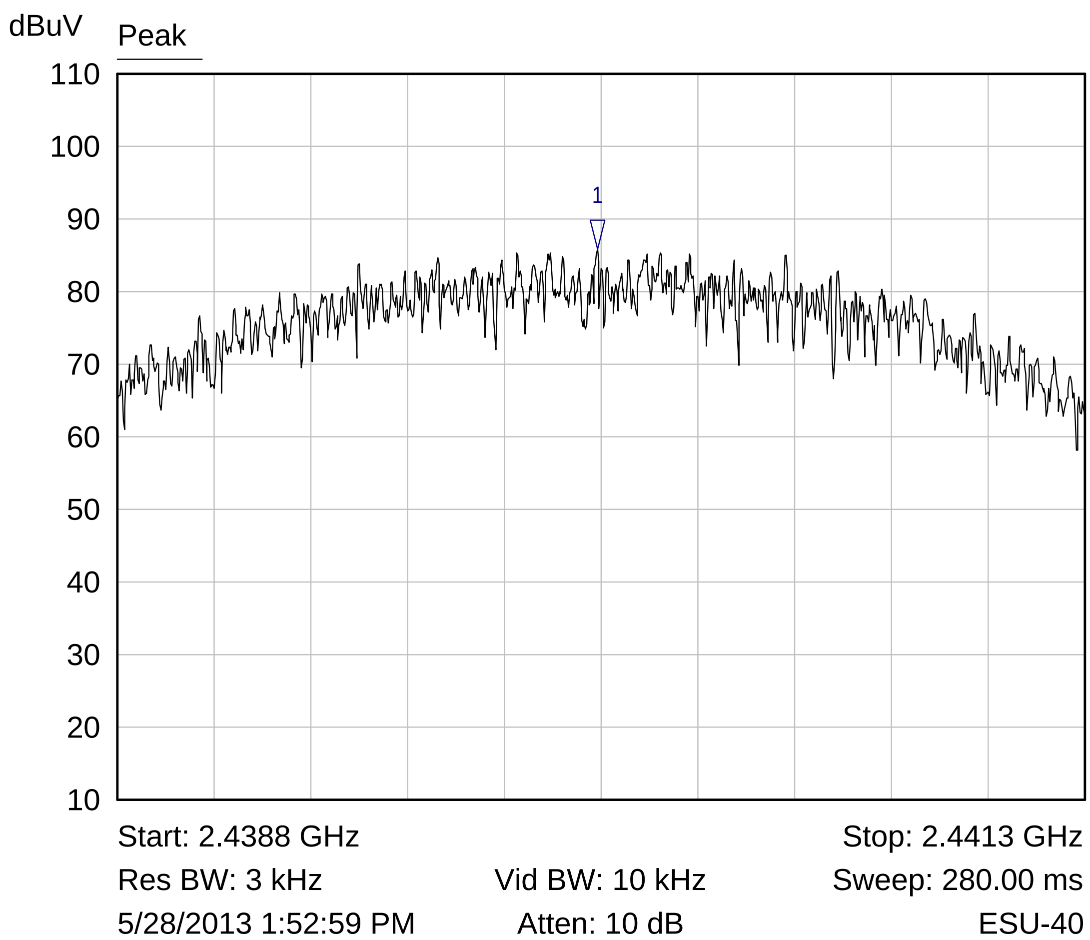


Start: 2.4038 GHz | Stop: 2.4063 GHz
Res BW: 3 kHz | Vid BW: 10 kHz | Sweep: 280.00 ms
5/28/2013 1:47:14 PM | Atten: 10 dB | ESU-40

Mkr	Trace	X-Axis	Value	Notes
1 ▽	Peak	2.4052 GHz	84.71 dBuV	

3 kHz PSD at +4

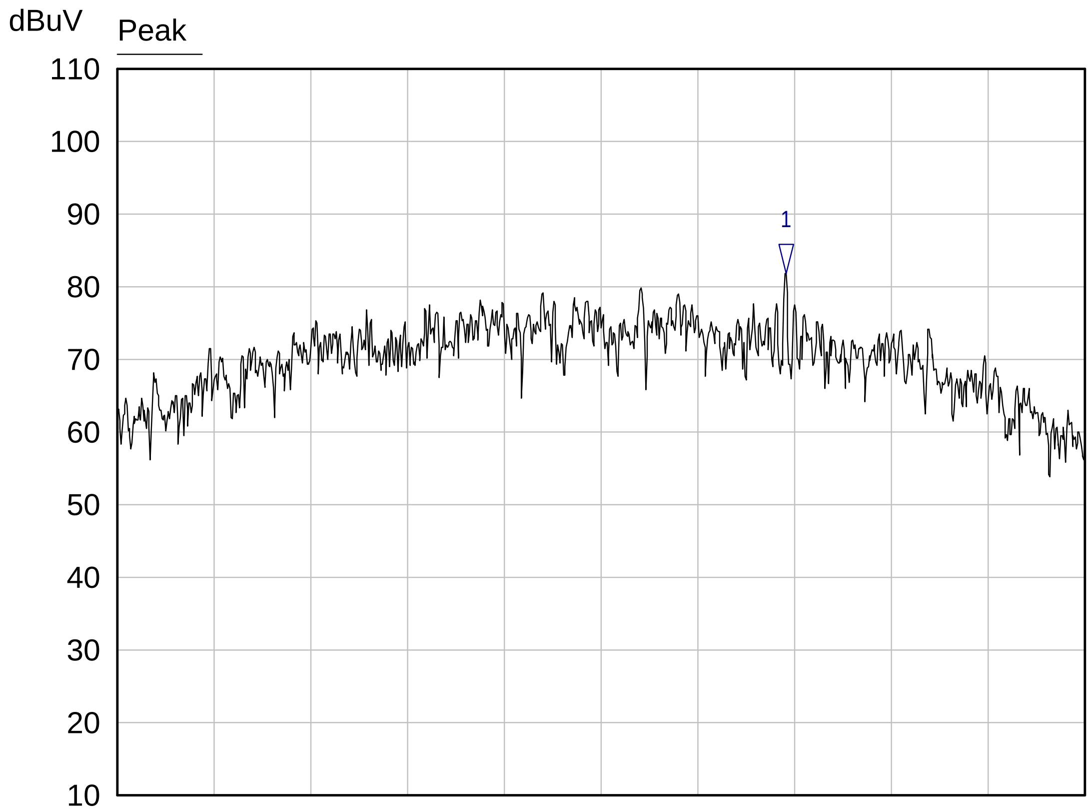
Middle Channel



Mkr	Trace	X-Axis	Value	Notes
1 ▽	Peak	2.4400 GHz	85.81 dBuV	

3 kHz PSD at +4

Upper Channel



Start: 2.4788 GHz Stop: 2.4813 GHz
Res BW: 3 kHz Vid BW: 10 kHz Sweep: 280.00 ms
5/28/2013 1:34:57 PM Atten: 10 dB ESU-40

Mkr	Trace	X-Axis	Value	Notes
1 ▽	Peak	2.4805 GHz	81.90 dBuV	

3 kHz PSD at -3

APPENDIX 1 TEST PROCEDURES AND TEST EQUIPMENT

A1.1 Radiated Emissions

The radiated emissions from the intentional radiator were measured using a spectrum analyzer with a quasi-peak adapter for peak and quasi-peak readings.

A loop antenna was used to measure emissions below 30 MHz. Emission readings more than 20 dB below the limit at any frequency may not be listed in the reported data. For frequencies between 9 kHz and 30 MHz, or the lowest frequency generated or used in the device greater than 9 kHz, and less than 30 MHz, the spectrum analyzer resolution bandwidth was set to 9 kHz and the video bandwidth was set to 30 kHz. For average measurements, the spectrum analyzer average detector was used.

For frequencies above 30 MHz, an amplifier and preamplifier were used to increase the sensitivity of the measuring instrumentation. The quasi-peak adapter uses a bandwidth of 120 kHz, with the spectrum analyzer's resolution bandwidth set at 1 MHz, for readings in the 30 to 1000 MHz frequency ranges. For peak emissions above 1000 MHz the spectrum analyzer’s resolution bandwidth was set to 1 MHz and the video bandwidth was set to 3 MHz. For average measurements above 1000 MHz the spectrum analyzer’s resolution bandwidth was set to 1 MHz and the average detector of the analyzer was used.

A biconilog antenna was used to measure the frequency range of 30 to 1000 MHz and a Double Ridge Guide Horn antenna was used to measure the frequency range of 1 GHz to 18 GHz, and a Pyramidal Horn antenna was used to measure the frequency range of 18 GHz to 25 GHz, at a distance of 3 meters and/or 1 meter from the EUT. The readings obtained by the antenna are correlated to the levels obtained with a tuned dipole antenna by adding antenna factors.

The configuration of the EUT was varied to find the maximum radiated emission. The EUT was connected to the peripherals listed in Section 2.3 via the interconnecting cables listed in Section 2.4. A technician manually manipulated these interconnecting cables to obtain worst-case radiated disturbance. The EUT was rotated 360 degrees, and the antenna height was varied from 1 to 4 meters to find the maximum radiated emission. Where there were multiple interface ports all of the same type, cables are either placed on all of the ports or cables added to these ports until the emissions do not increase by more than 2 dB.

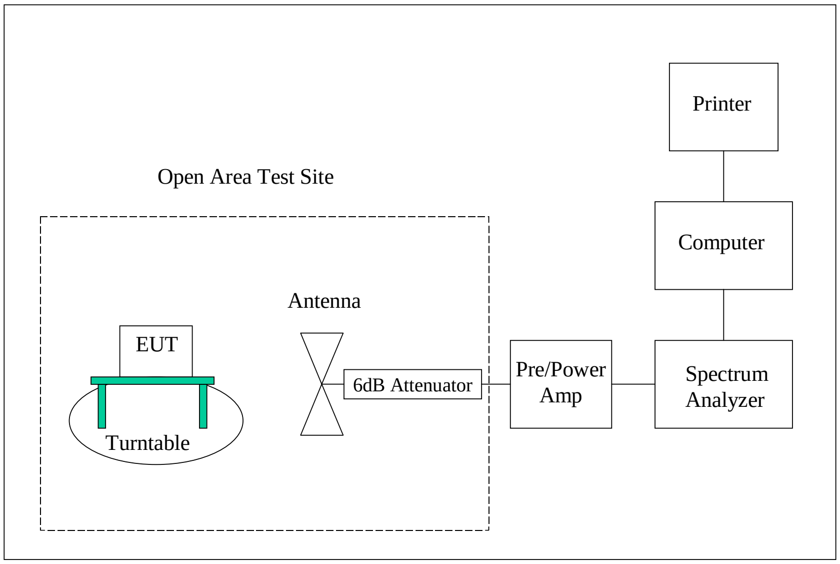
Desktop EUT are measured on a non-conducting table 0.8 meters above the ground plane. The table is placed on a turntable, which is level with the ground plane. For equipment normally placed on floors, the equipment shall be placed directly on the turntable.

For radiated emission testing at 30 MHz or above that is performed at distances closer than the specified distance, an inverse proportionality factor of 20 dB per decade is used to normalize the measured data for determining compliance.

Type of Equipment	Manufacturer	Model Number	Serial Number	Date of Last Calibration	Due Date of Calibration
Wanship Open Area Test Site #2	Nemko-CCL, Inc.	N/A	N/A	12/07/2012	12/07/2013
Test Software	Nemko-CCL, Inc.	Radiated Emissions	Revision 1.3	N/A	N/A
Spectrum Analyzer/Receiver	Rhode & Schwarz	ESU40	100064	07/28/2012	07/28/2013
Spectrum Analyzer	Hewlett Packard	8566B	2230A01711	02/06/2013	02/06/2014
Quasi-Peak Detector	Hewlett Packard	85650A	2043A00137	02/06/2013	02/06/2014
Loop Antenna	EMCO	6502	9111-2675	03/04/2013	03/04/2015
Biconilog Antenna	EMCO	3142	9601-1008	10/10/2012	10/10/2014
Double Ridged Guide Antenna	EMCO	3115	9409-4355	06/06/2012	06/06/2014
Pyramidal Standard Gain Horn	EMC Test System	3160-09	0003-1197	04/10/2009	ICO
High Frequency Amplifier	Miteq	AFS4-01001800-43-10P-4	1096455	05/02/2013	05/02/2014
20’ High Frequency Cable	Microcoax	UFB197C-1-3120-000000	1297	05/02/2013	05/2/2014
3 Meter Radiated Emissions Cable Wanship Site #2	Microcoax	UFB205A-0-4700-000000	1295	05/02/2013	05/2/2014
Pre/Power-Amplifier	Hewlett Packard	8447F	3113A05161	08/27/2012	08/27/2013
6 dB Attenuator	Hewlett Packard	8491A	32835	12/21/2012	12/21/2013

An independent calibration laboratory or Nemko-CCL, Inc. personnel calibrates all the equipment listed above at intervals defined in ANSI C63.4:2003 Section 4.4 following outlined calibration procedures. All measurement instrumentation is traceable to the National Institute of Standards and Technology (NIST). Supporting documentation relative to tractability is on file and is available for examination upon request.

Radiated Emissions Test Setup

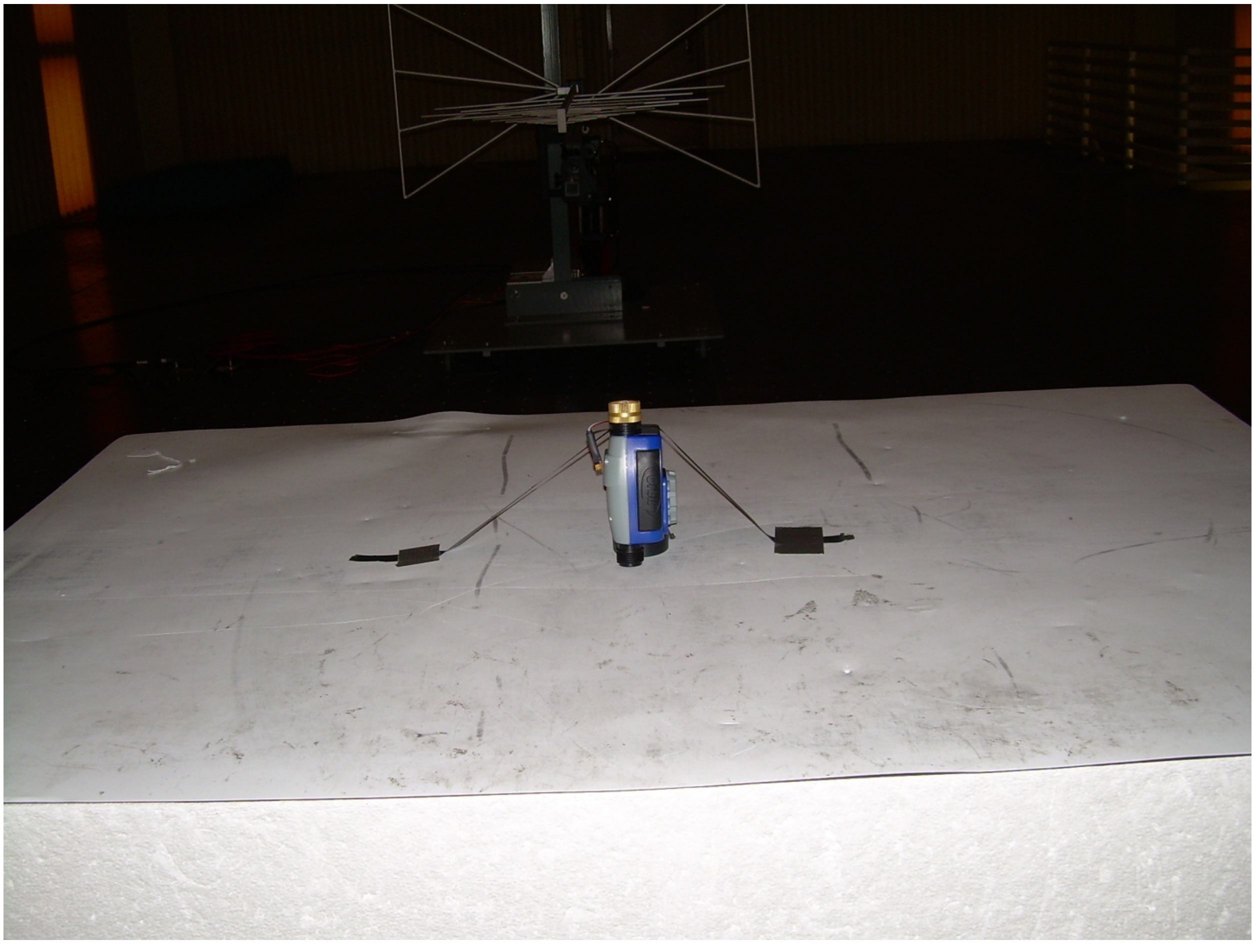


APPENDIX 2 PHOTOGRAPHS

Photograph 1 – View Radiated Test Setup – Flat Placement

Photograph 2 – View Radiated Test Setup – On Edge Placement

Photograph 3 – View Radiated Test Setup – Vertical Placement



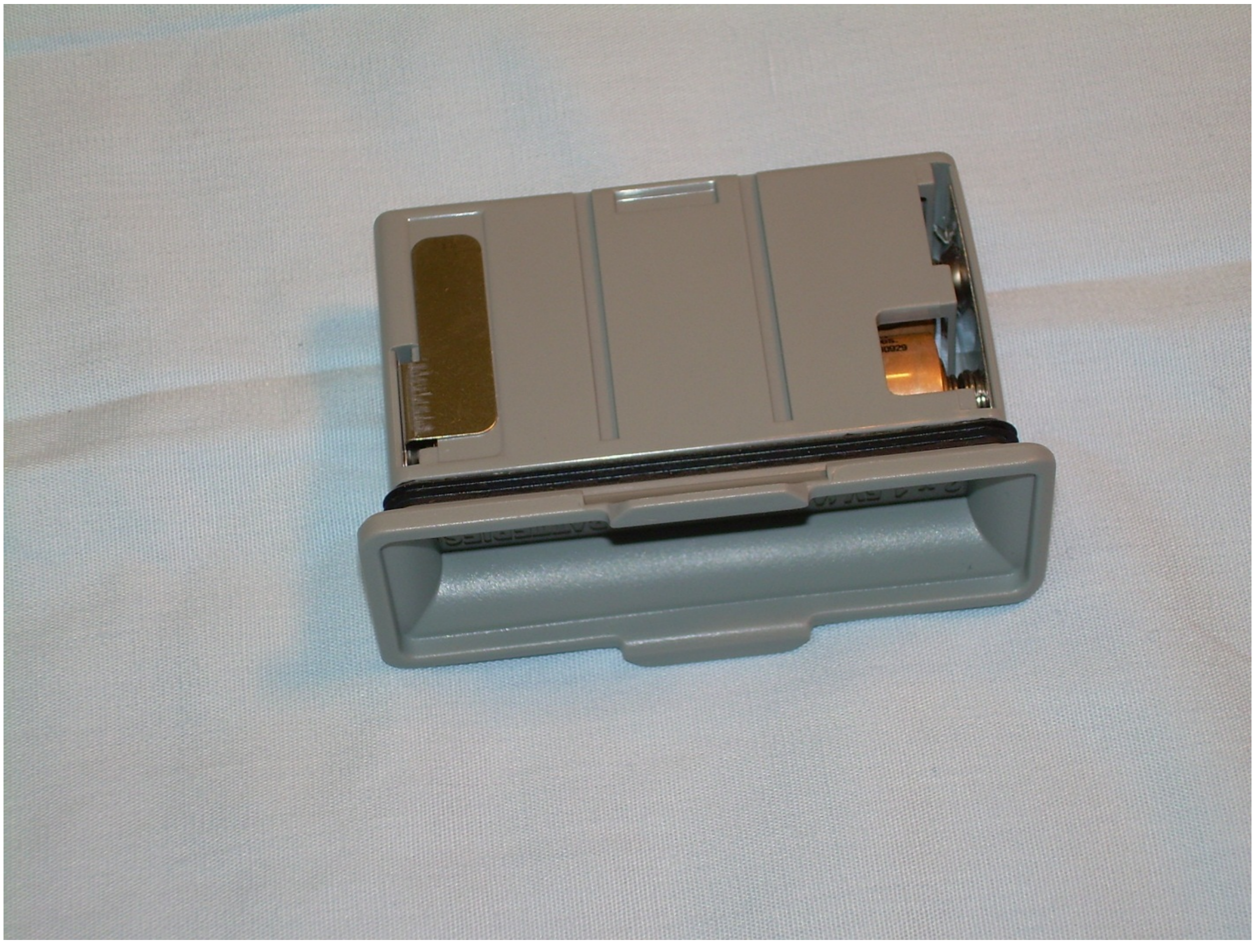
Photograph 4 – Front/Right Side View of the EUT

Photograph 5 – Front/Left Side View of the EUT

Photograph 6 – Back View of the EUT

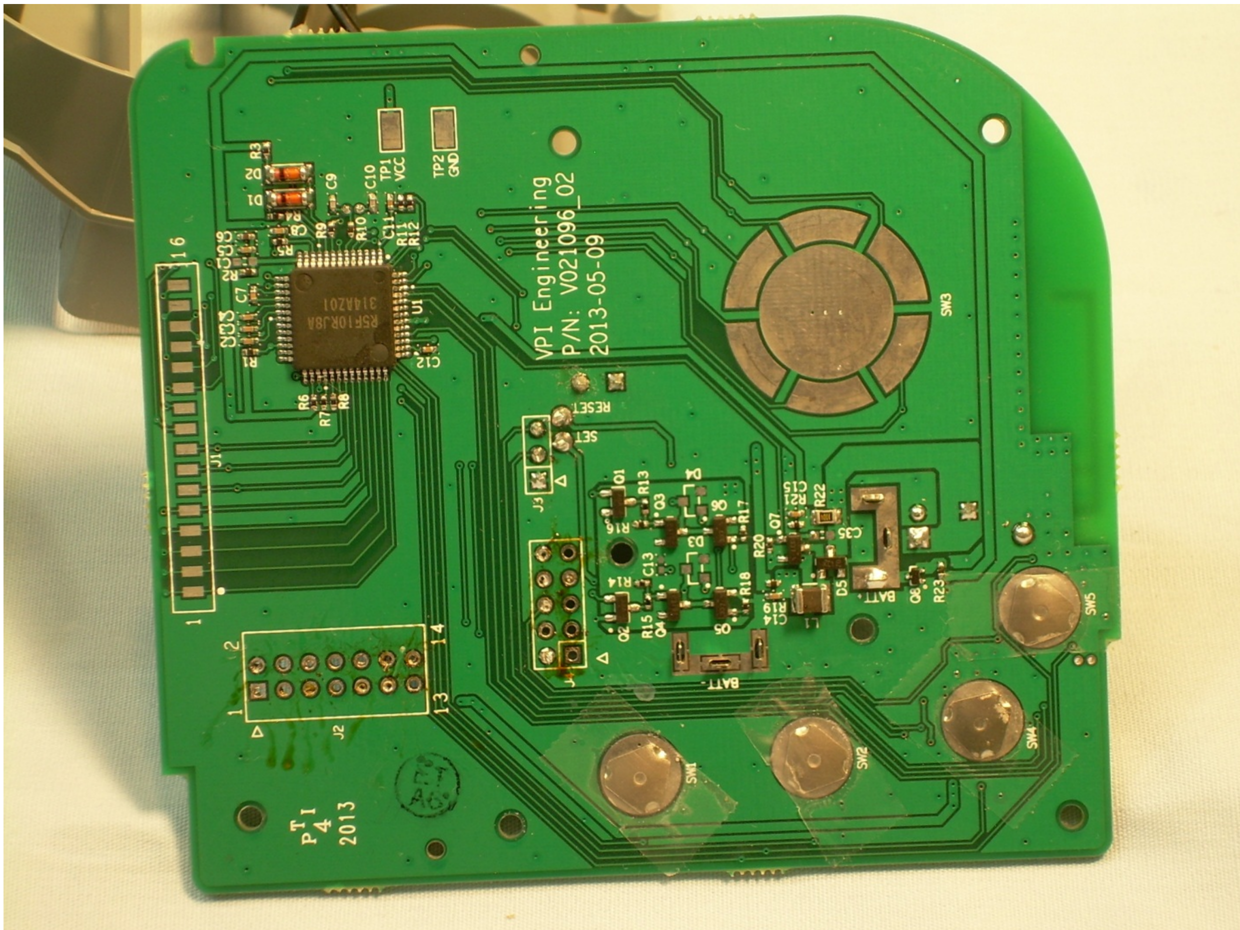
Photograph 7 – View of the Battery Holder – Battery Side

Photograph 8 - View of the Battery Holder – Plastic Side

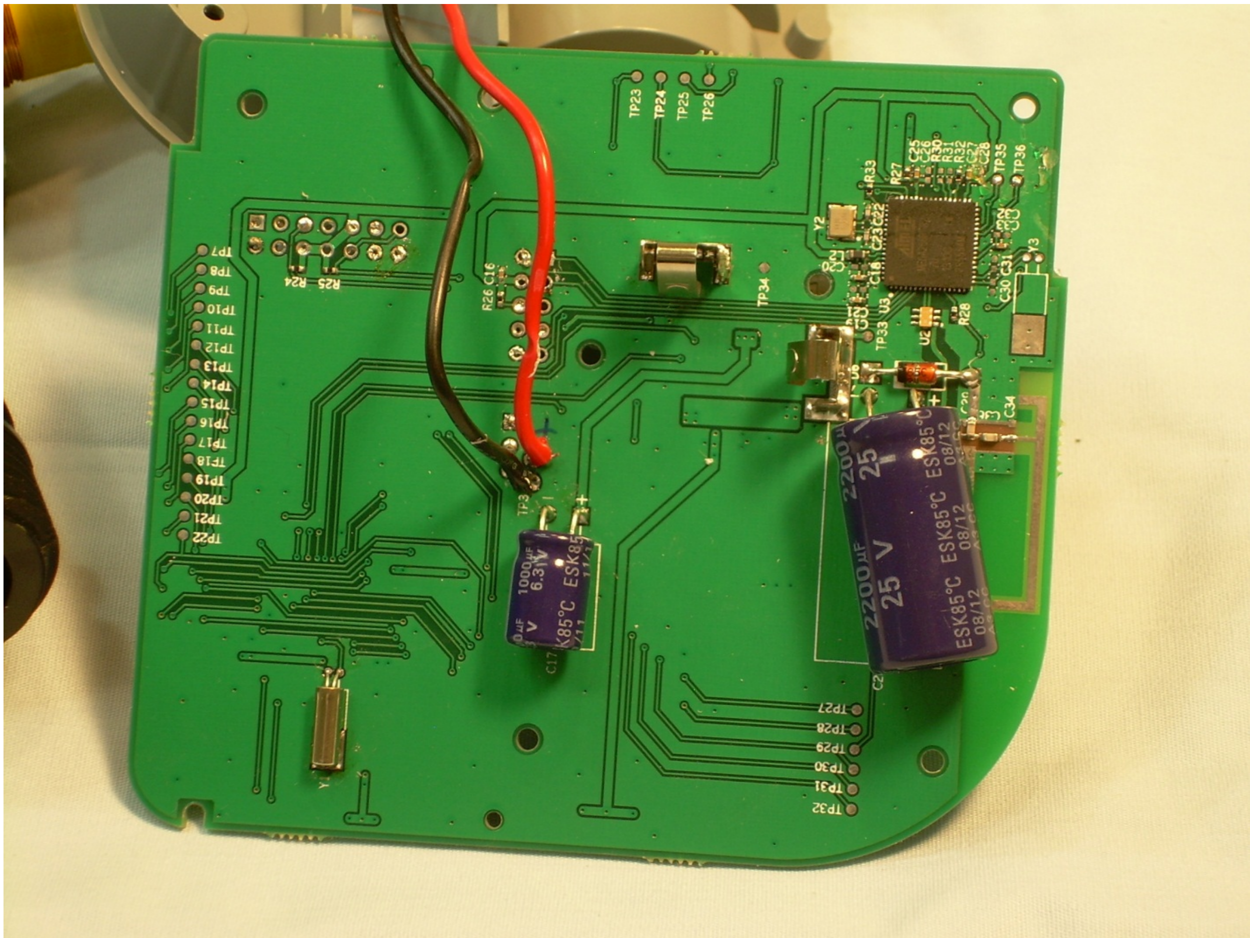


Photograph 9 – View of the Valve Assembly

Photograph 10 – View of the Front Side of the PCB



Photograph 11 – View of the Back Side of the PCB



APPENDIX 3 TRANSMITTER DUTY CYCLE CALCULATIONS

IEEE 802.15.4-2003 2.4 GHz PHY Constants

Data Rate	250000	bits / sec	
	31250	bytes / sec	
Symbols/byte	2	sym / bytes	
Symbol Timing	62500	sym / sec	
	0.000016	sec / sym	
Byte Timing	0.000032	sec / byte	
PHY PSDU	6	bytes	4 Pramble, SPD, Length
Max Length	127	bytes	
Total Packet Length	133	bytes	
Maximum Time TX PKT	0.004256	sec	

Long Frame Scenario:

1) TX Frame — Assume Frame is Data Frame
2) Wait for ACK
3) RX ACK
4) CPU Processing of ACK
5) Wait for Backoff
6) Repeat 1)

MAC-Level Calculation (LIFS)

Long InterFrame Spacing (Slotted w/ ACK)			
Long Frame	127	bytes	
Data Frame Payload	102	bytes	
ACK Frame	5	bytes	
tack	12	sym	
LIFS	40	sym	
Backoff Period	20	sym	
Maximum Backoff	31		Random between 0 and 31
Backoff Required	2		
Backoff Time	300	sym	Average at 15
Transmit Time			
TX Time (Packet)	0.004256		
Total TX Time (sec)	0.004256		
NOT Transmit time (RX or Idle)			
Wait for ACK (tack)	0.000192		
RX Time (ACK)	0.000352		
Backoff Time (tbo)	0.0048		
CPU Processing (tcpu)	0.0002		
CCA Assessment (tcca)	0.000128		
Turn Around Time (RX to TX)	0.000192		
Total Off Time (sec)	0.005864		
Total Time (ttotal)	**0.01012**	**(0.004256 + 0.005864)**	**MAC TX Duty Cycle (On/Total) = 42.06**