NetBotz Wireless Sensor

Report of Intentional Radiator Testing

Prepared for

Vincent Hawxhurst
Schneider Electric IT Corporation
85 Rangeway Road
North Billerica, MA 01862

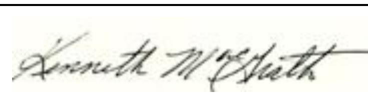
Applicable Models	***NBWS100H*** ***NBWS100T***
Test Date	**February 4–18, 2014**
Tested & Reviewed By	**Ken MacGrath, Manager, George Corriea, Test Engineer, Ed Ramshaw, Test Engineer**
Signature	

Table of Contents

Table of Contents (continued)

1.0 GENERAL INFORMATION

1.1 Product Description

EUT: NetBotz Wireless Sensor
Manufacturer: Schneider Electric
Applicable Models: NBWS100H
NBWS100T

EUT Technical Specifications:

A) Operation Frequency: 2405 – 2475 MHz, 15 channels

1. Low Channel #11, 2.405 GHz
2. Mid Channel #18, 2.440 GHz
3. High Channel #25, 2.475 GHz

B) Rated output power: 0.8mW (-0.9 dBm) (based on test results, ref: 5.3)

C) Modulation type: IEEE 802.15.4-2006 Modulation Format (see Appendix A)

D) Antenna Designation: 2.4GHz Molex Surface Mount Device (SMD) On-ground Antenna, 3.0 dBi, Non-User Replaceable (Fixed), refer to antenna specification for details (see Appendix B).

E) Power Supply: 3.0VDC Lithium coin battery (e.g., CR2477 or other)

F) This report documents the results for Model NBWS100H which is a wireless sensor that measures temperature and humidity. For temperature only the humidity measuring sensor is removed, the results will be identical and the Model number becomes NBWS100T.

G) FCC ID: SNSNBWS100
IC: 3351C-NBWS100

1.2 Applicable Documents and Standards

This test report is based on the following standards.

Intentional Radiators:

- FCC CFR 47, Part 15, Subpart C, Section 15.247
- Industry Canada RSS-210, Annex A8.2, Digital Modulation Systems
- ANSI C63.10: 2013
- FCC KDB 558074

Unintentional Radiators:

- EN55022: 2006, Information Technology Equipment, Class B
- FCC CFR47, Part 15, Subpart B, Digital Devices, Class B
- ICES-003, Issue 5, August 2012, Information Technology Equipment, Class B
- AS/NZS CISPR 22: 2006, Information Technology Equipment, Class B

1.3 Test Dates

February 4 - March 25, 2014

1.4 Test Methodology

Only radiated testing was performed because the EUT is battery operated. Testing was done according to the procedures in ANSI C63.4 (2003). Radiated testing was performed at an antenna-to-EUT distance of 3-meters.

1.5 Test Facility

The Open Area Test Site (OATS) and ferrite lined shielded chamber used to collect the radiated data is located at Core Compliance Testing Services, 79 River Road, Hudson, NH. The OATS is constructed and calibrated to meet the FCC requirements of ANSI C63.4: 2003, MP5, and OST-55. The test facility is listed with the FCC (registration number 792478) and ISO 17025 accredited by A2LA (2778.01).

1.6 Test Equipment List

All equipment used in the testing process has up to date calibrations traceable to the National Institute of Standards and Technology (NIST). Refer to the Table 1 on the following page for a complete list of equipment used during the test.

Test Equipment list is on the following page.

Table 2: Test Equipment

Asset #	Description	Manufacturer	Model	Serial Number	Calibration Date	Calibration Due Date
3	Preamplifier 8447F OPT H64	Agilent/HP	8447F-H64	3113A07400	12/26/13	12/26/15
15	Horn Antenna	EMCO	3115	9906-5841	2/06/13	2/06/15
126	Horn Antenna	A.H.Systems	SAS-571	782	5/11/13	5/11/15
19	Pre amplifier	HP/Agilent	08449B	3008A01322	12/26/13	12/26/14
20	Low Loss Cable	Andrew	ETS1-50T	0081108339	05/17/13	05/17/14
30	Semi-Anechoic chamber	Keene Ray Proof	N/A	8298	03/30/13	03/30/14
46	Antenna	Chase	CBL6111	2602	12/20/13	12/20/14
103	Antenna	A.H.Systems	SAS-200/562B	216	3/18/14	3/18/15
51,52	Receiver	Rohde & Schwarz	ESMI	845364/009	2/06/13	2/06/14
109	Alternative Open Area Test Site	Strongwell	10 Meter	None	12/15/12	12/15/15
123	Spectrum Analyzer	HP	E4405B	US39440317	12/26/13	12/26/14

All equipment used for testing has been calibrated according to methods and procedures defined by the National Institute of Standards and Technology (NIST).

1.7 Measurement Uncertainty

The measurement uncertainty of radiated emissions data is 5.1 dB based on the test equipment used and the OATS site attenuation data.

1.8 Equipment Modifications

Not applicable.

2.0 System Test Configuration

2.1 EUT Configuration

The EUT configuration for testing was based on the standards' requirements and was operated in a manner which intends to maximize its emissions characteristics in a continuous, transmit application. Constant transmit is not an intended mode of operation and although it produced maximum emissions, the battery was quickly drained, leading to intermittent and lower emissions levels. After assuring that a dc supply would not compromise test results, an external power supply was utilized. The testing was done on the EUT with no enclosure because testing proved that the enclosure had an insignificant affect on the measured emissions data and testing with the external supply was needed to keep the transmitter at maximum power and a constantly on state throughout the testing. The small enclosure did not permit attachment of the external power supply leads.

The EUT was placed on a 1.5m high polystyrene support for all testing.

2.2 EUT Exercise

The EUT has been tested under operating conditions and was programmed to allow it to remain in continuous transmitting mode.

The EUT was operated as follows:

Transmit Channel	Transmit Freq. (MHz)	Transmit Power Level (dBm)	FCC Test Mode	Modulation	Tone
0x0B (Chan. 11)	2405	4.5 (max)	01 (continuous transmit)	0x00 (ON) and 0x01 (OFF)	0 kHz
0x12 (Chan. 18)	2440	4.5 (max)	01 (continuous transmit)	0x00 (ON) and 0x01 (OFF)	0 kHz
0x19 (Chan. 25)	2475	4.5 (max)	01 (continuous transmit)	0x00 (ON) and 0x01 (OFF)	0 kHz

2.3 Test Procedures

Conducted Emissions

Not applicable.

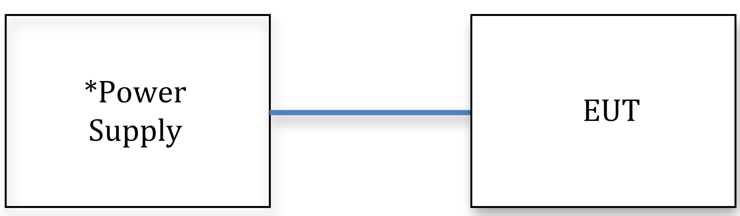
Radiated Emissions

Preliminary testing was done in a ferrite lined shielded enclosure for frequency identification from the EUT.. All final measurements were done on the OATS.

The EUT was placed on a 1.5m high polystyrene support, which is on a turntable per ANSI C63.10, clause 6.3.1.. The turntable was rotated 360 degrees to determine the position of maximum emission level.. The EUT is set 3m away from the receiving antenna which was varied from 1m to 4m in height during the final OATS measurements, to find the highest emissions level.. Each frequency of emission was maximized by changing the polarization of receiving antenna both horizontal and vertical.. In order to find out the maximum emissions, the relative positions of the transmitter (EUT) was rotated through three orthogonal axes according to the requirements in ANSI C63.10, clause 5.10.1.

2.4 Configuration of EUT

During the radiated prescans, it was found that the batteries would drain very quickly in the continuous, full power, transmit mode. This is an abnormal operation for this product but was needed for testing purposes. An external DC power supply was used in place of the battery for most of the testing in this report.



*Power Supply: TTi (Thurlby Thandar Instruments), TSX3510P Programmable DC PSU set at 3.0VDC.

3.0 Summary Of Test Results

Table 2, Test Summary

Rules	Description Of Test	Result
FCC 15.207(a)	Conducted Emission	*N/A*
FCC 15.247(b)(3)	Peak Output Power (1 W)	*Pass*
FCC 15.247(a)(2), IC RSS-210, A8.2	6dB Bandwidth (≥500kHz)	*Pass*
FCC 15.247(d)	100 KHz Bandwidth Of Frequency Band Edges	*Pass*
FCC 15.209(a) through (f) FCC Part 15, Subpart B, Class B, EN55022/CISPR22 Class B, ICES-003 Class B	Unintentional/Spurious Emissions	*Pass*
FCC 15.247(e), IC RSS-210, A8.2	Peak Power Density (8dBm/3kHz)	*Pass*
FCC 15.203	Antenna Requirement	*Pass*

4.0 Peak Output Power Measurement

4.1 Applicable Standard

CFR 47, Part 15.247 (b) (3).. For systems using digital modulation techniques in the 2400 – 2483.5 MHz band, the maximum peak conducted output power is 1.0 Watt.

4.2 Measurement Procedure

Place the EUT on the 1.5 M polystyrene stand and set it in transmitting mode.

Utilizing the radiated emissions method, the EUT was set up on a three meter OATS.. The field strength was maximized by rotating the turntable and adjusting the antenna height.. Measurements were further optimized for vertical and horizontal polarization of the receive antenna.

The peak field strength for each transmit frequency was recorded.

To convert field strength at 3 meters to power in Watts, the following formula was

Used: $P = (E \times d)^2 / (30 \times G)$

Where: P = Power in Watts
E = Field strength in V/m
d = Measurement distance in meters
G = Numeric Gain of Antenna (numeric gain was <6 dBi so a G factor of 1 was used)

Repeat the above procedures for each of the low, mid and high frequency channels.

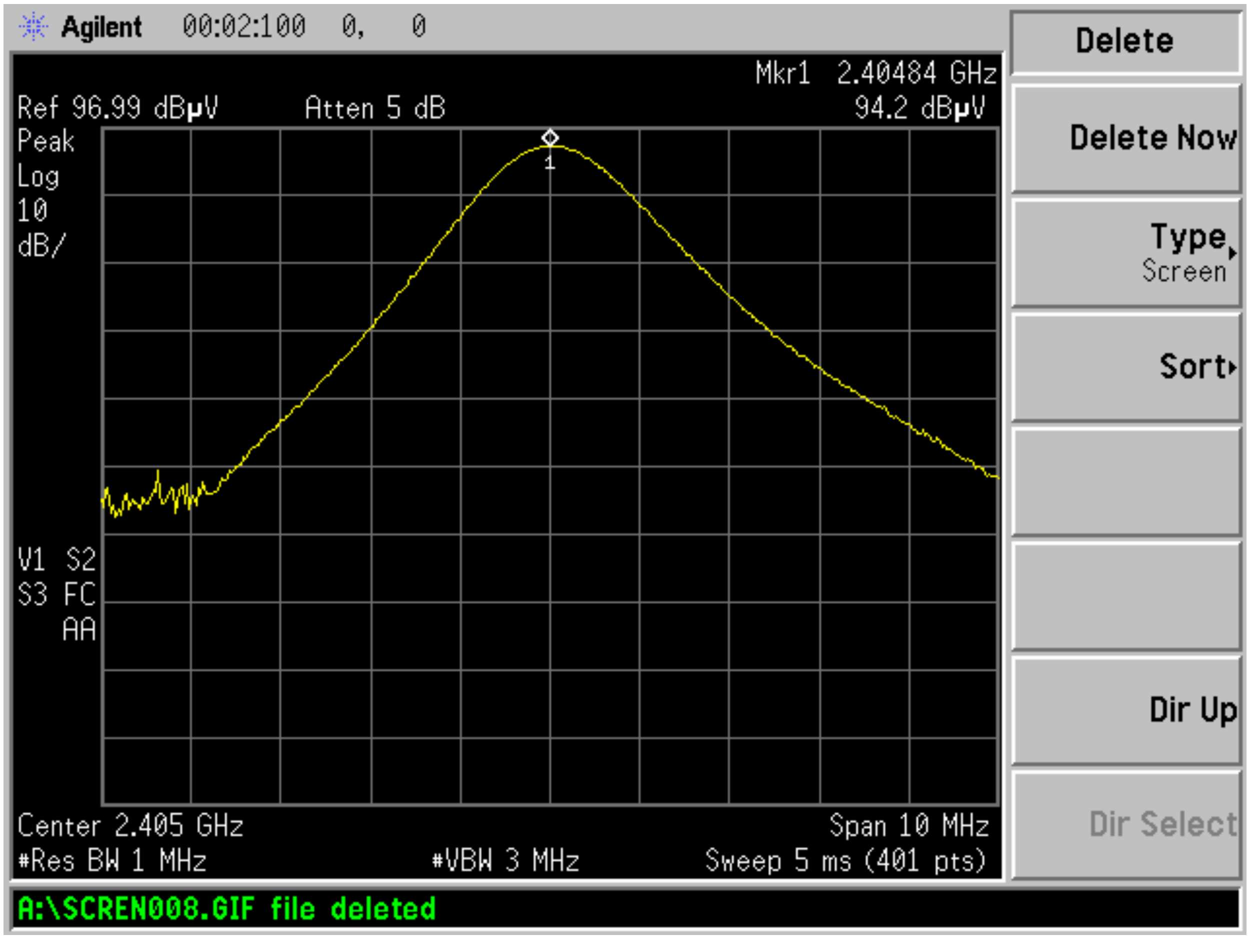
4.3 Measurement Results

Maximum Conducted Output Power						
Channel	**Channel Frequency (GHz)**	***Field Strength (dBμV/m)**	**Field Strength (μV/m)**	**Limit (mW)**	**Power Calculation (mW)**	**Result**
Low	2.405	93.5	47,315	1,000	0.67	*Pass*
Middle	2.440	92.9	44,157	1,000	0.59	*Pass*
High	2.475	94.3	51,880	1,000	0.81	*Pass*

*Field strength includes cable loss, preamplifier gain, and antenna factor as shown below each of the following plots.

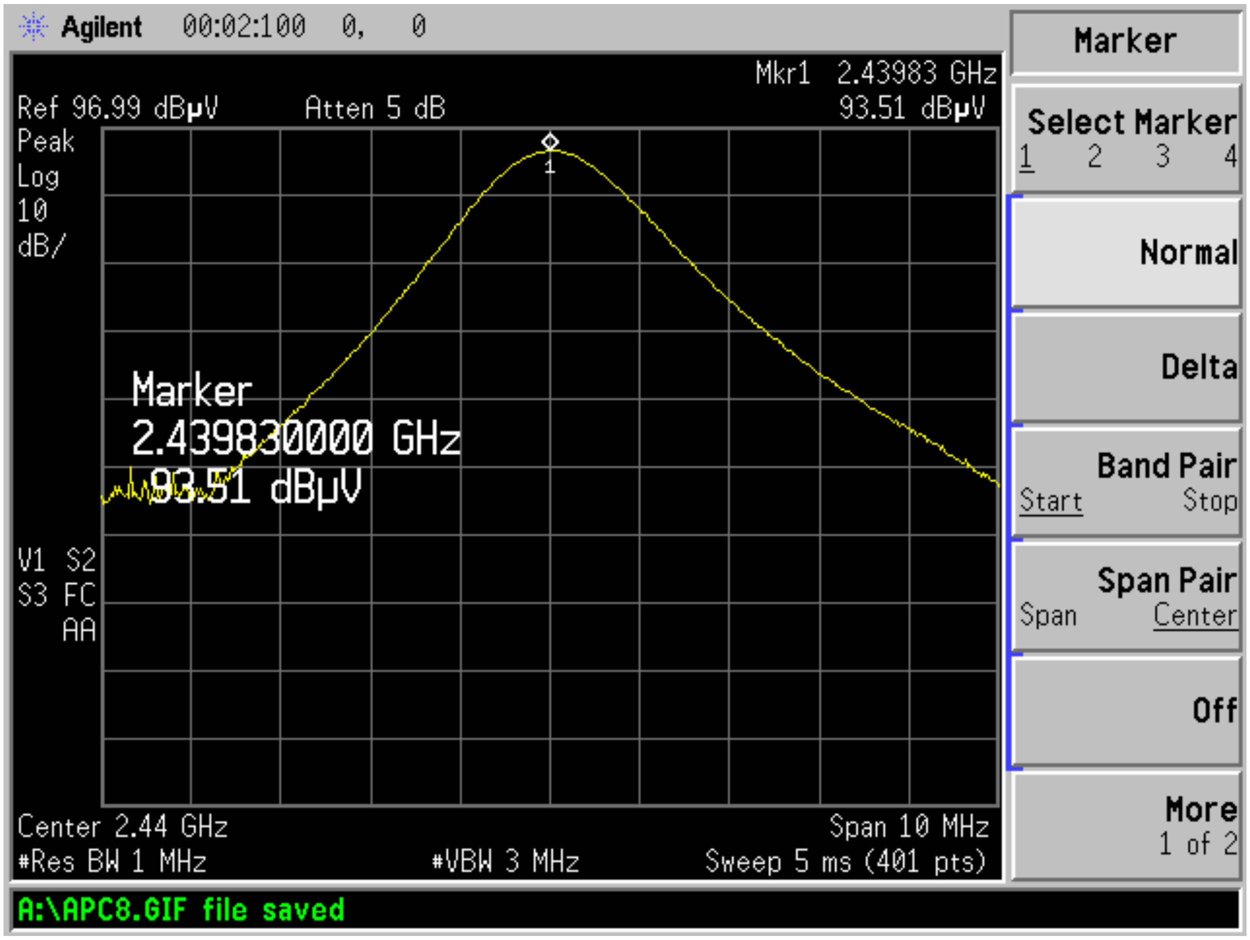
Data plots for low, mid and high channels

Peak Power Output Data Plot (CH 11, Low)



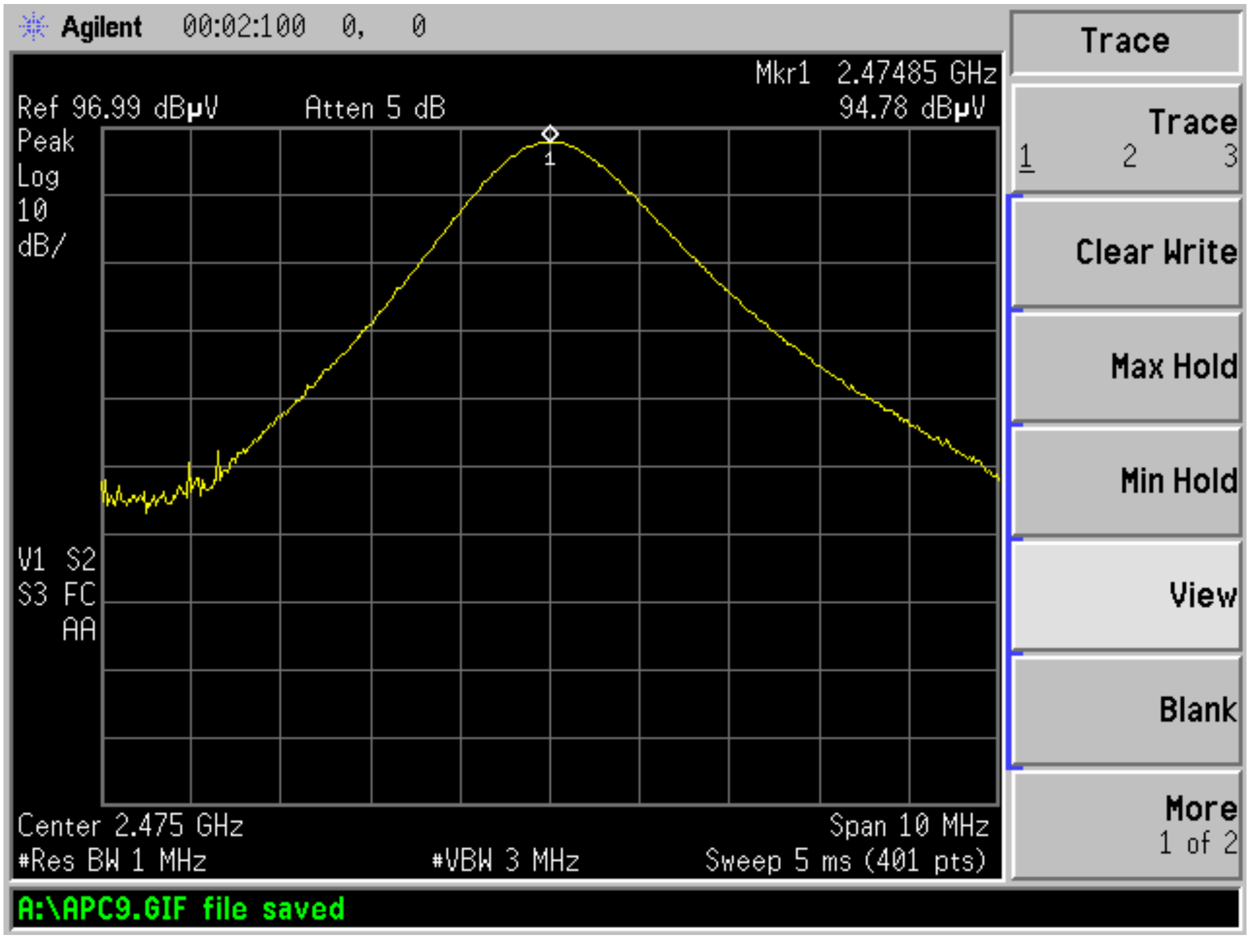
Channel	Channel Frequency (MHz)	Reading (dBμV)	Cable Loss (dB)	Preamp Gain (dB)	Antenna Factor (dB)	Field Strength (dBμV/m)
11	2.405	94.2	8.1	-36.9	28.1	93.5

Peak Power Output Data Plot (CH 18, Mid)



Channel	Channel Frequency (MHz)	Reading (dBμV)	Cable Loss (dB)	Preamp Gain (dB)	Antenna Factor (dB)	Field Strength (dBμV/m)
18	2.440	93.5	8.1	-36.9	28.2	92.9

Peak Power Output Data Plot (CH 25, High)



Channel	Channel Frequency (MHz)	Reading (dBµV)	Cable Loss (dB)	Preamp Gain (dB)	Antenna Factor (dB)	Field Strength (dBµV/m)
25	2.475	94.8	8.2	-36.9	28.2	94.3

5.0 6dB BANDWIDTH

5.1 Applicable Standard

In accordance with FCC CFR 47, Part 15.247 (a)(2) and Industry Canada RSS-210, A8 and A8.2, systems using digital modulation techniques may operate in the 2400-2483.5 MHz band. The minimum 6 dB bandwidth shall be at least 500 kHz.

5.2 Measurement Procedure

Measure the maximum width of the emission that is constrained by the frequencies associated with the two outermost amplitude points that are attenuated by 6 dB, relative to the peak of the fundamental frequency.

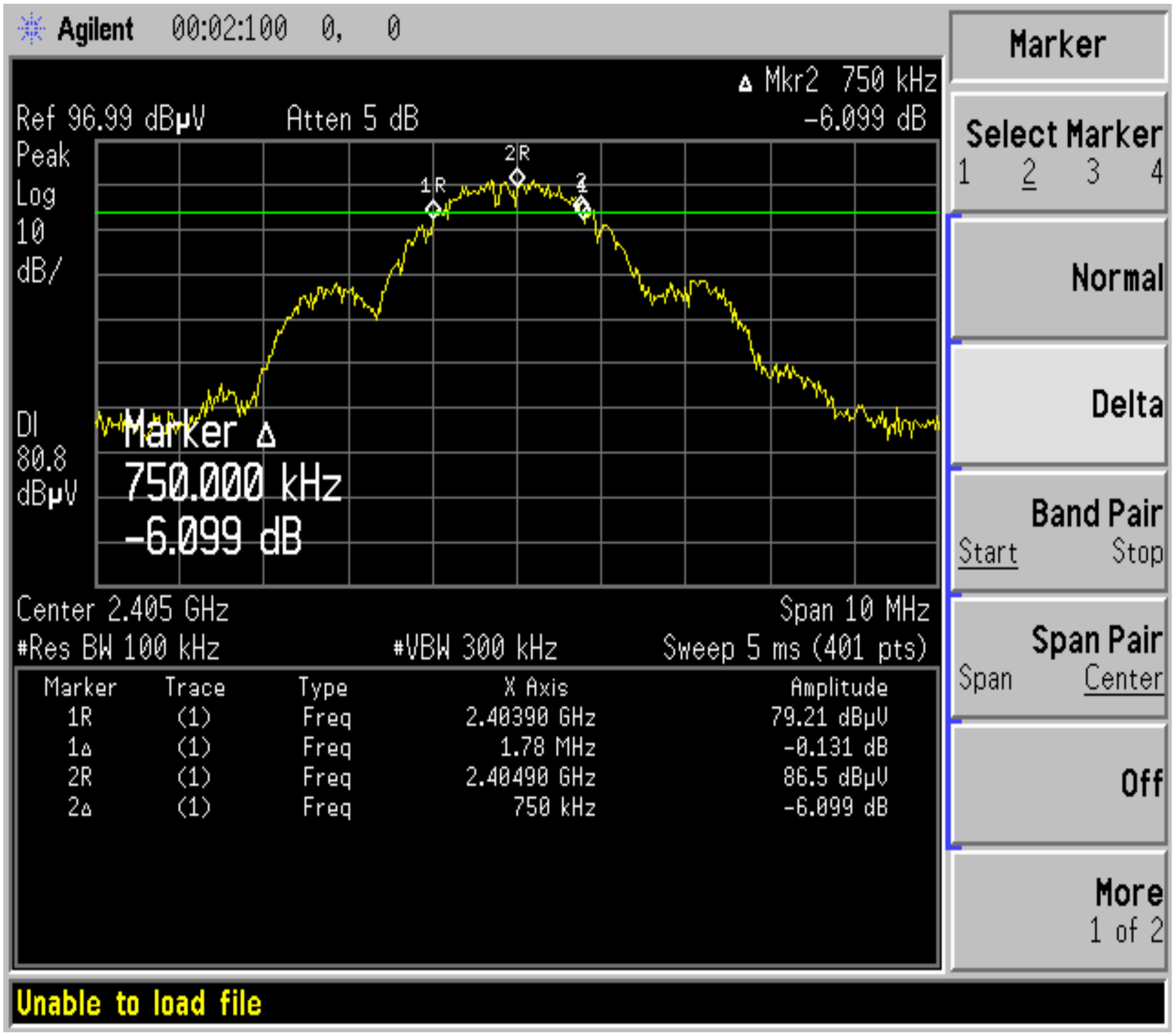
These measurements were performed at the low, mid, and high channel frequencies.

5.3 Measurement Result

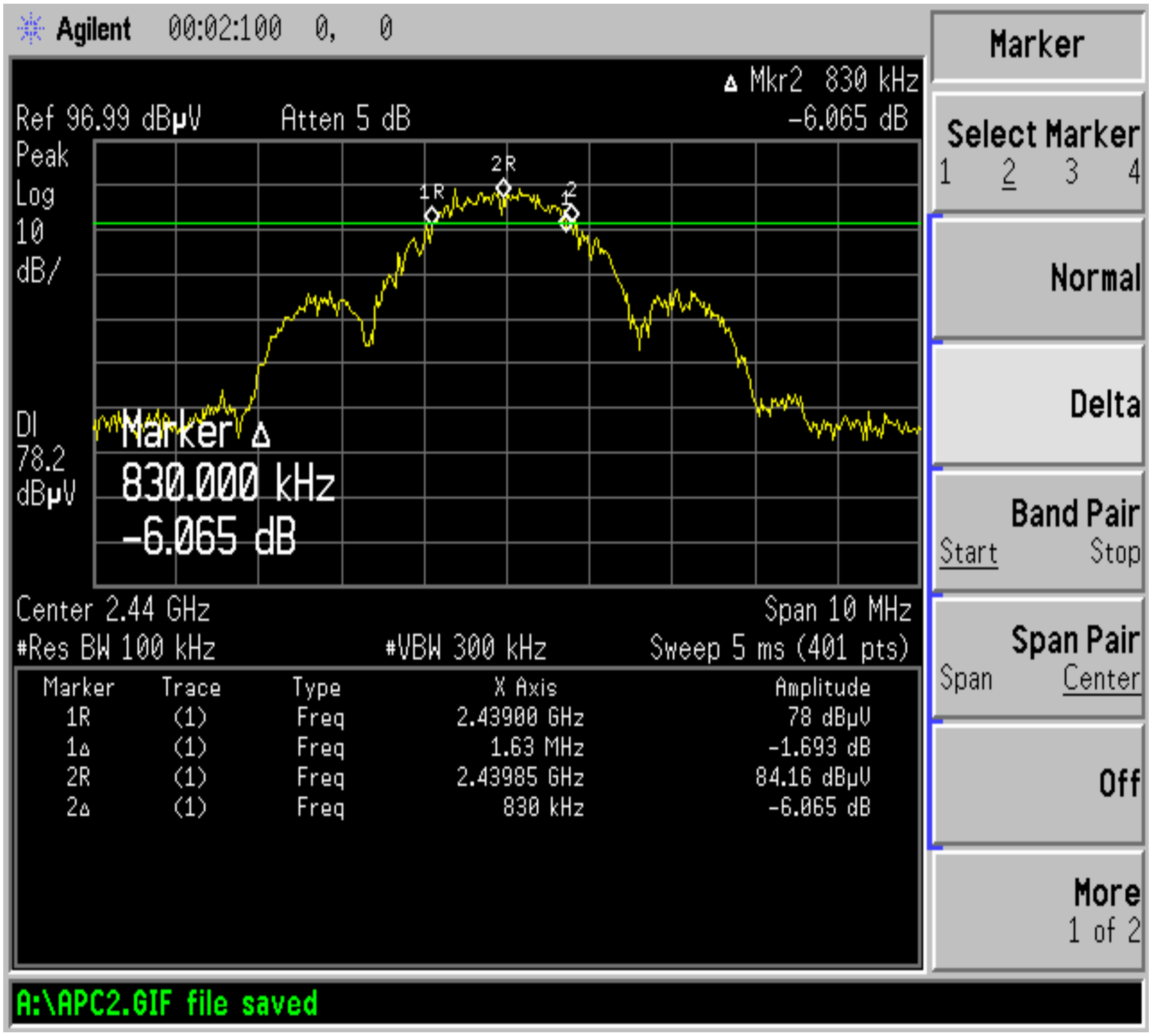
Channel	Bandwidth (MHz)
11, Low	1.78
18, Mid	1.63
25, High	1.78

Data plots for low, mid and high channels

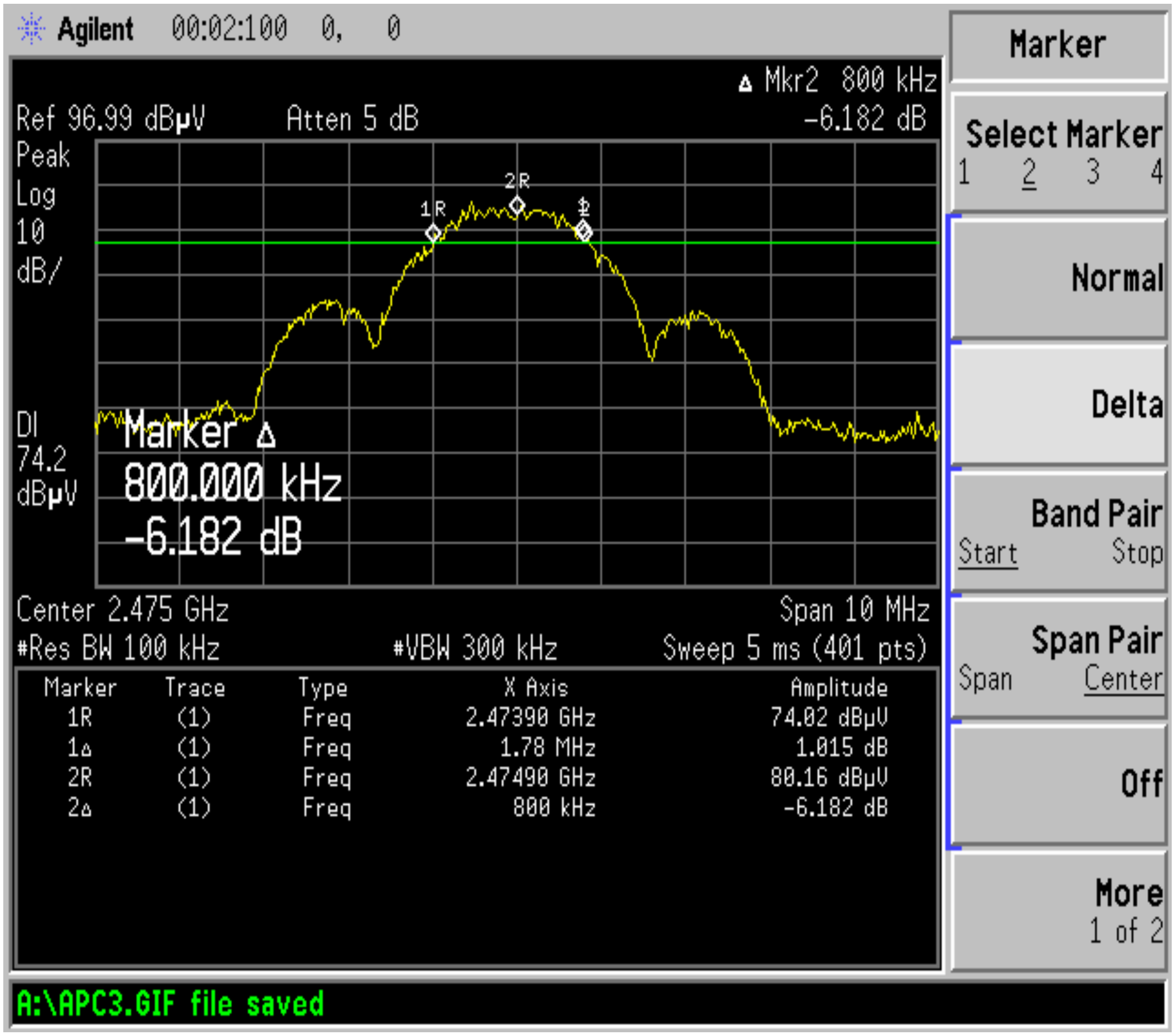
6dB Bandwidth Data Plot (CH 11, Low)



6dB Bandwidth Data Plot (CH 18, Mid)



6dB Bandwidth Data Plot (CH 25, High)



6.0 100KHz BANDWIDTH OF BAND EDGES MEASUREMENT

6.1 Standard Applicable

According to 15.247(d), in any 100 KHz bandwidth outside the frequency bands in which the digitally modulated intentional radiator is operating, the radio frequency power that is produced by the intentional radiator shall be at least 20dB below that in the 100KHz bandwidth within the band that contains the highest level of the desired power. In addition, radiated emissions, which fall in the restricted bands, as defined in 15.205(a), must also comply with the radiated emission limits specified in 15.209(a).

6.2 Measurement Procedure

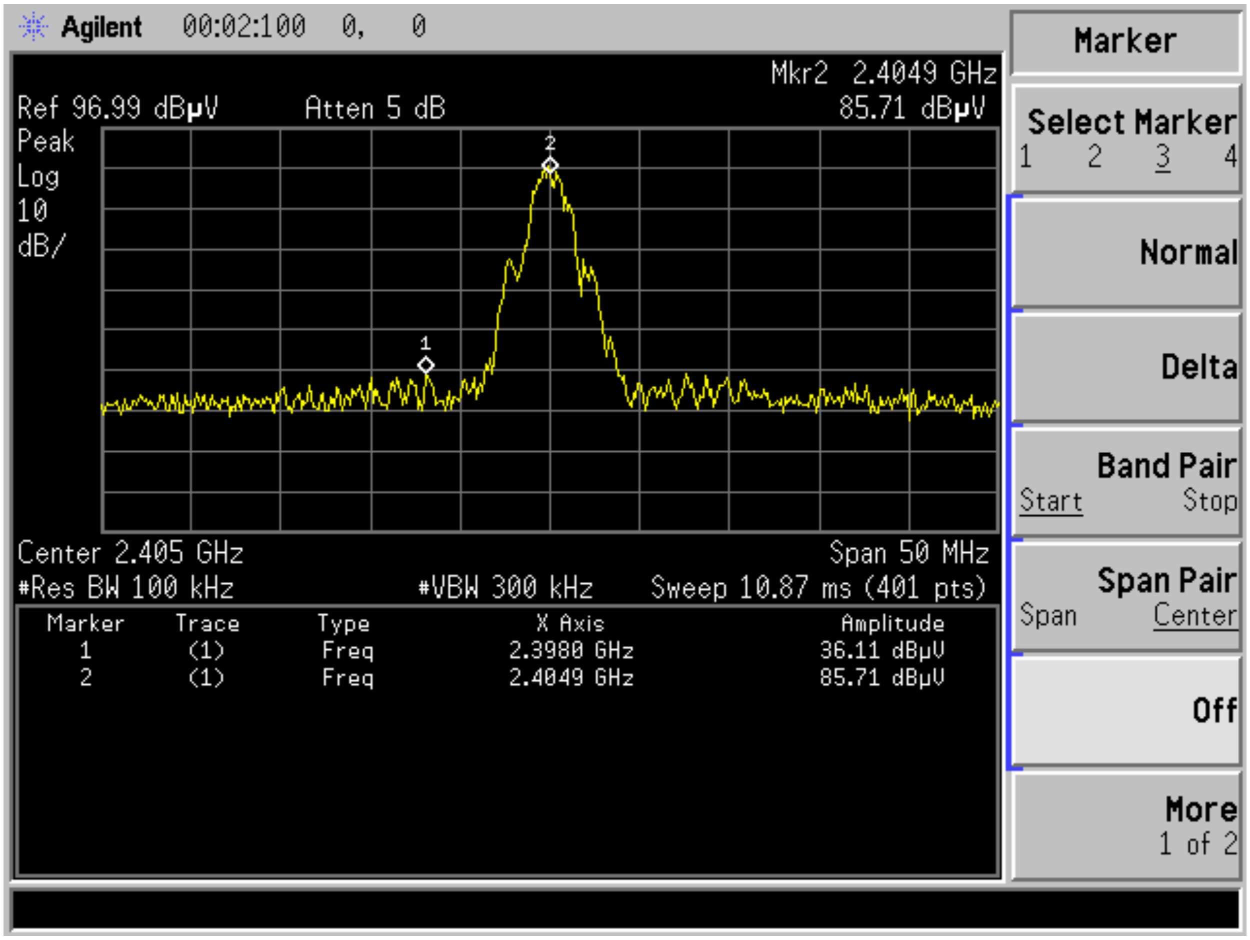
- Place the EUT on the 1.5 meter polystyrene stand and set it in transmitting mode with modulation.
- Set the center frequency of the spectrum analyzer to the operating frequency.
- Set the spectrum analyzer RBW= 100kHz, VBW=300KHz, Span=50MHz, Sweep Auto
- Mark the peak, 2.405 GHz, Lo Channel # 11 and record the maximum level.
- Set the delta marker to next lower frequency of spurious emission and record peak.
- Repeat the above procedures at 2.475 GHz, Hi Channel # 25 and measure the next highest spurious emission and record the level.

6.3 Measurement Result

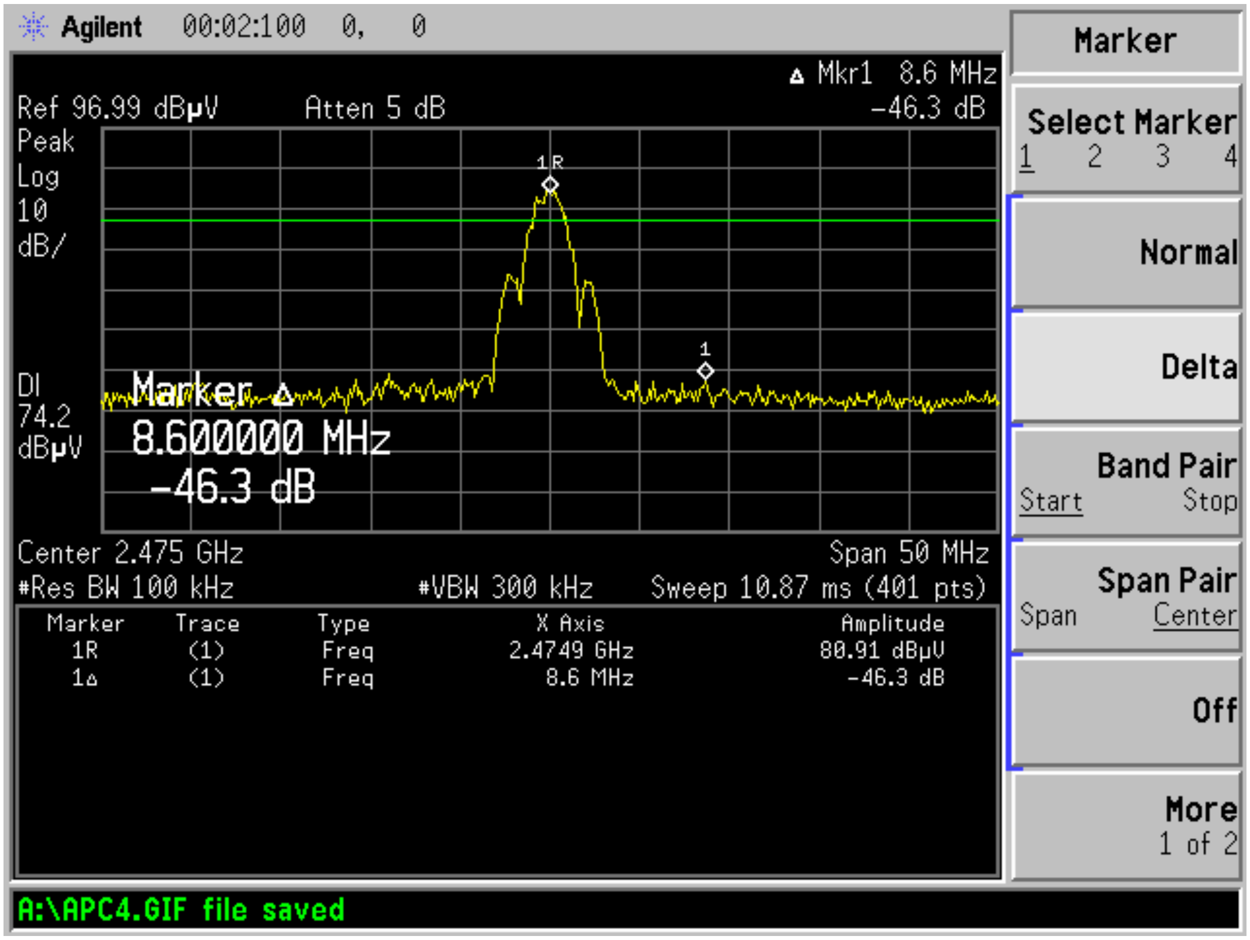
Refer to attached spectrum analyzer data charts.

Data plots for low, mid and high channels

100kHz Band Edge Measurement Data (CH-11, Low)



100kHz Band Edge Measurement Data (CH 25, High)



7.0 UNINTENTIONAL/SPURIOUS RADIATED EMISSION PRESCAN TEST

7.1 EUT Setup

The radiated emissions prescan testing was performed in the 3 meter ferrite lined shielded chamber.

The EUT was placed on an 80 cm high wooden table for all measurements between 9kHz and 1000MHz. For testing above 1GHz, the EUT was set on the 1.5 meter polystyrene stand and the power supply was placed at the base of the stand, on the turntable.

7.2 Measurement Procedure

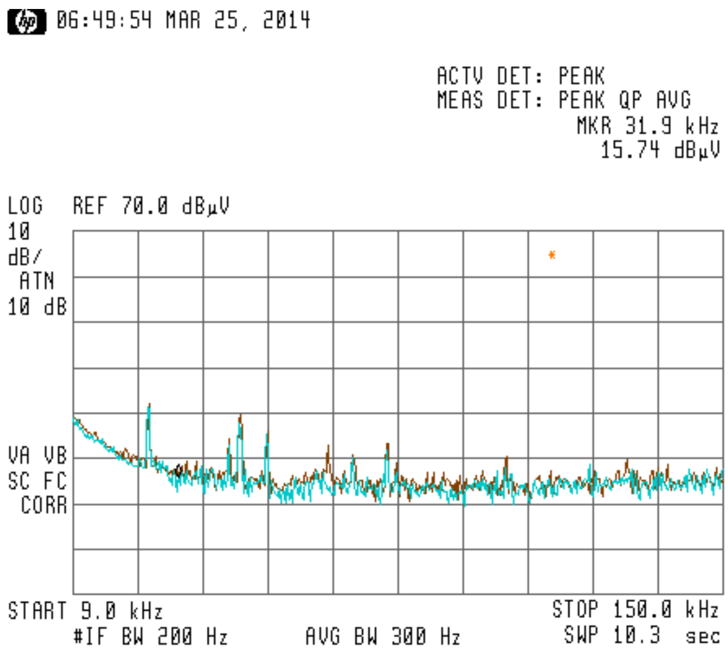
- Prescans from 9kHz to 13GHz were done in the ferrite-lined shielded chamber for EUT frequency identification. These scans are exploratory emission tests only that are voluntarily submitted.
- The turntable was rotated 360 degrees to determine the position of maximum emission level at the transmit frequency. Scans from 1-13GHz were done at this azimuth angle at both horizontal and vertical receive antenna polarization.
- In the 30-1000MHz range, the EUT prescans were done at 0°, 90°, 180°, and 270° turntable angles.
- Emissions were measured with the EUT transmitting at the low, mid, and high frequencies.

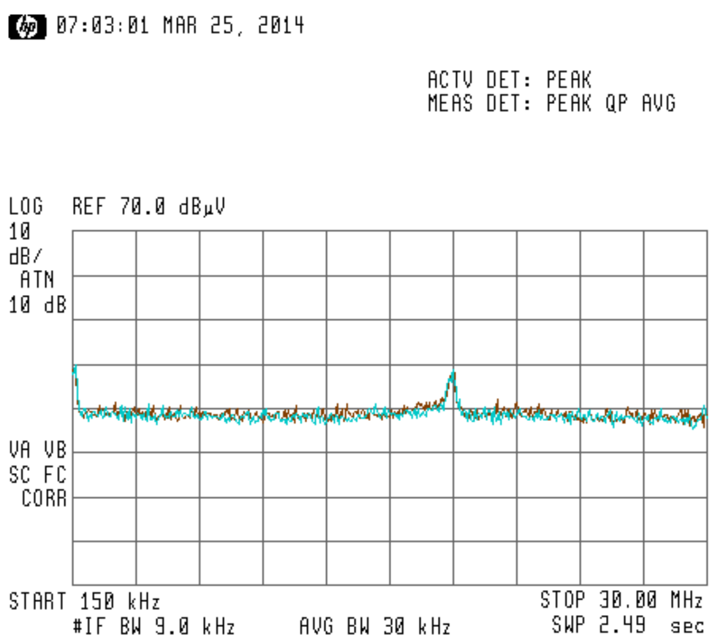
7.3 Measurement Results

The following plots show a summary of the prescan data that was collected.

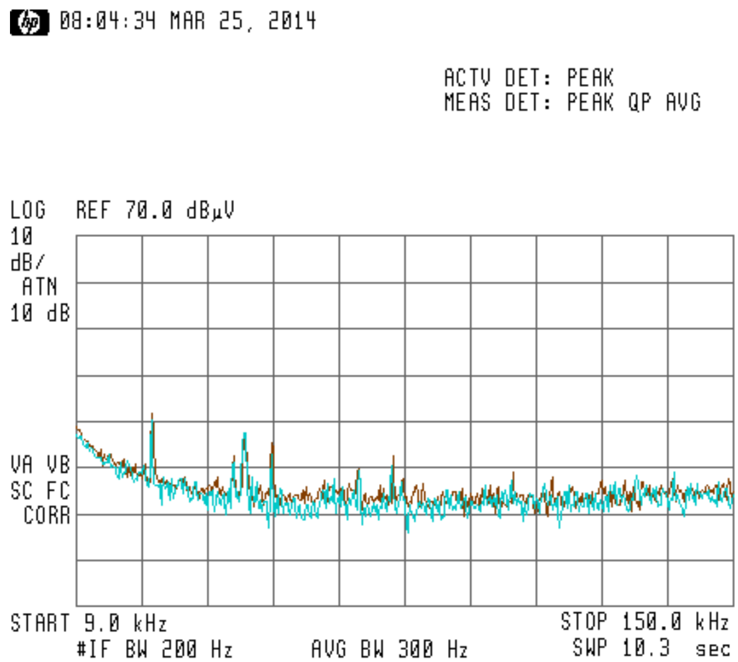
Summary of Prescan Data

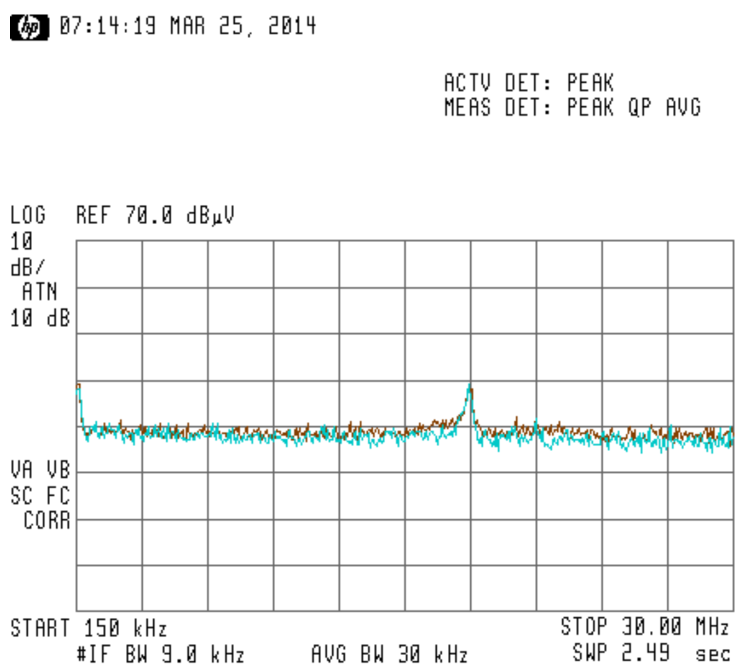
9kHz – 30MHz Scan
EUT Channel 11
EUT: Blue Trace
Ambient: Brown Trace



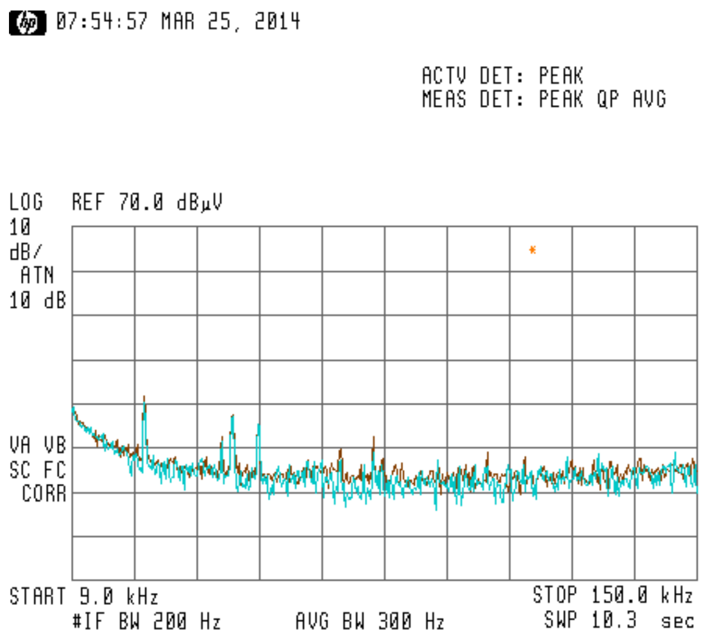


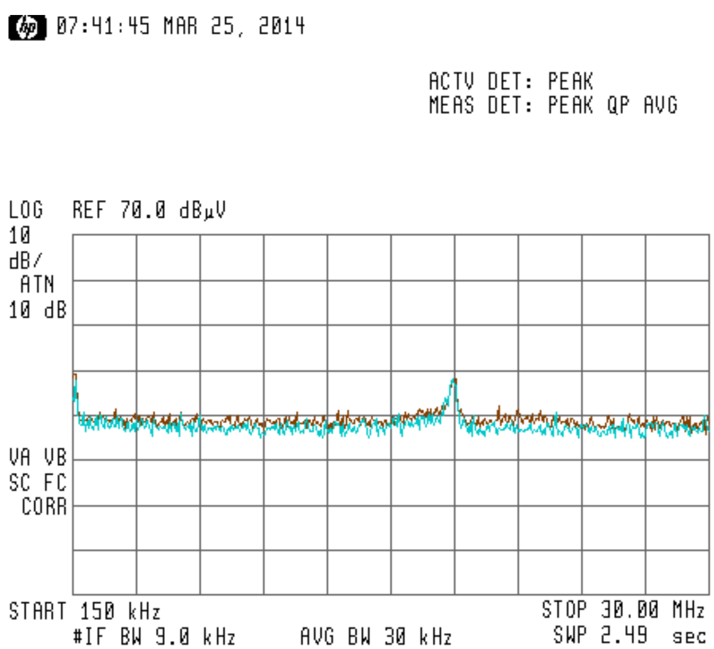
9kHz – 30MHz Scan
EUT Channel 18
EUT:Blue Trace
Ambient: Brown Trace

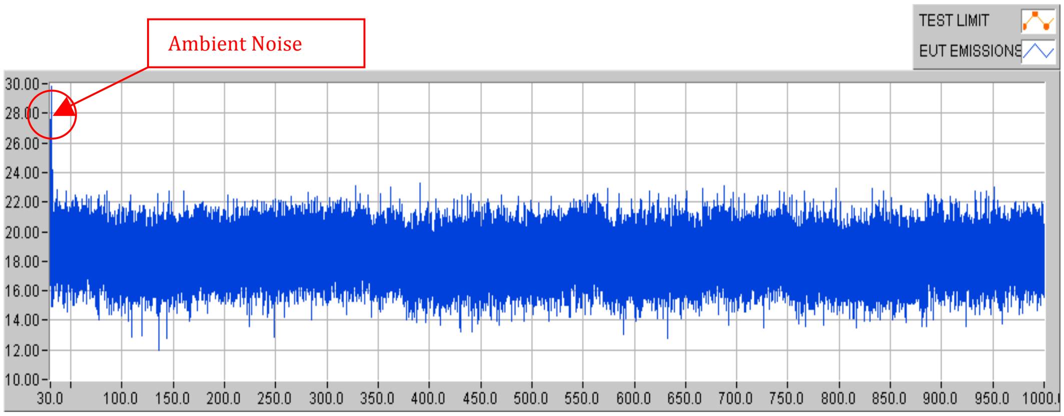


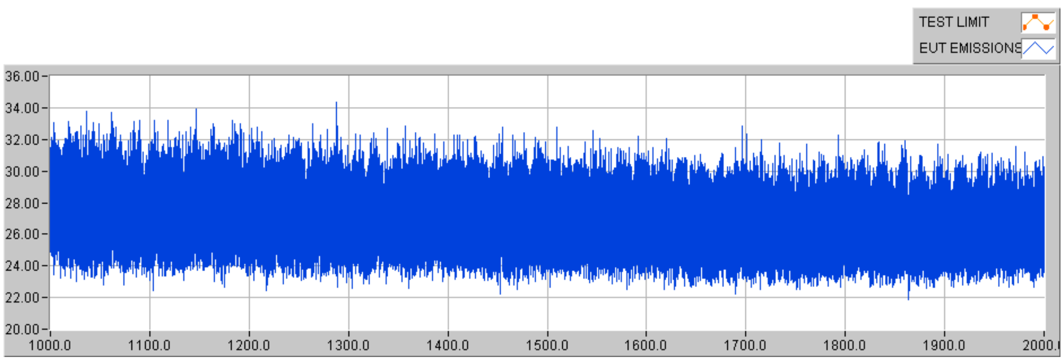


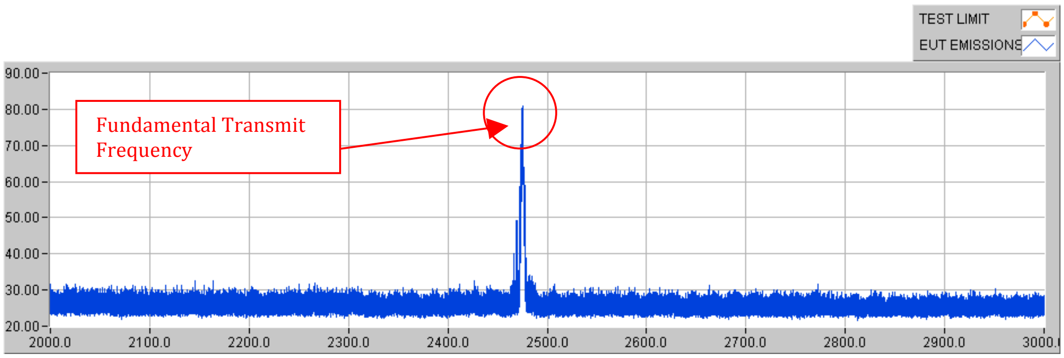
9kHz – 30MHz Scan
EUT Channel 25
EUT:Blue Trace
Ambient: Brown Trace

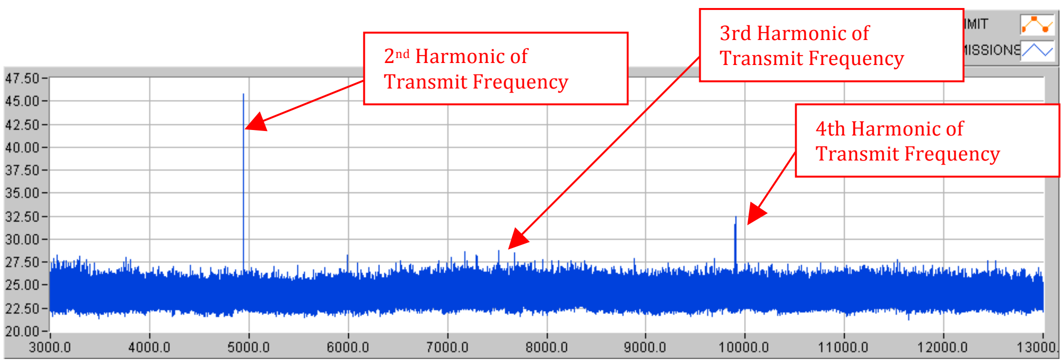





Ambient Noise
TEST LIMIT
EUT EMISSIONS
30.00
28.00
26.00
24.00
22.00
20.00
18.00
16.00
14.00
12.00
10.00
30.0
100.0
150.0
200.0
250.0
300.0
350.0
400.0
450.0
500.0
550.0
600.0
650.0
700.0
750.0
800.0
850.0
900.0
950.0
1000.0


TEST LIMIT
EUT EMISSIONS
36.00
34.00
32.00
30.00
28.00
26.00
24.00
22.00
20.00
1000.0
1100.0
1200.0
1300.0
1400.0
1500.0
1600.0
1700.0
1800.0
1900.0
2000.0


TEST LIMIT
EUT EMISSIONS
Fundamental Transmit Frequency
90.00
80.00
70.00
60.00
50.00
40.00
30.00
20.00
2000.0
2100.0
2200.0
2300.0
2400.0
2500.0
2600.0
2700.0
2800.0
2900.0
3000.0


2nd Harmonic of Transmit Frequency
3rd Harmonic of Transmit Frequency
4th Harmonic of Transmit Frequency
47.50
45.00
42.50
40.00
37.50
35.00
32.50
30.00
27.50
25.00
22.50
20.00
3000.0
4000.0
5000.0
6000.0
7000.0
8000.0
9000.0
10000.0
11000.0
12000.0

8.0 UNINTENTIONAL/SPURIOUS RADIATED EMISSION TEST

8.1 Standard Applicable

Emissions outside the authorized bands shall not exceed the general radiated emission limits specified in 15.209(a), and according to 15.33(a)(1), for an intentional radiator operating below 10GHz, the frequency range of measurements shall encompass the tenth harmonic of the highest fundamental frequency or 40GHz, whichever is lower.

8.2 EUT Setup

The radiated emission tests were performed on the 3 meter open area test site, in accordance with ANSI C63.4-2003.

The EUT was placed on an 80 cm high wooden table for all measurements between 9kHz and 1000MHz. For testing above 1GHz, the EUT was set on a 1.5 meter polystyrene stand and the power supply was placed at the base of the stand, on the turntable.

8.3 Measurement Procedure

- The EUT/stand was placed on a turntable, which is flush with the ground plane.
- The turntable was rotated 360 degrees to determine the position of maximum emission level.
- The EUT was 3m away from the receiving antenna which was varied from 1m to 4m to obtain the maximum emissions level.
- The data was recorded at the six highest emissions to ensure EUT compliance.
- Each emission was maximized by changing the polarization of receiving antenna both horizontal and vertical.
- Emissions were measured with the EUT transmitting at the low, mid, and high frequencies.

8.4 Test SETUP

Refer to photos beginning on page 41.

8.5 Field Strength Calculation

The field strength is calculated by adding the Antenna Factor and Cable Factor and subtracting the Amplifier Gain and Duty Cycle Correction Factor (if any) from the measured reading. The basic equation is as follows:

$$FS = RA + AF + CL - AG$$

Where: FS = Field Strength
CL = Cable Attenuation Factor (Cable Loss)
RA = Reading Amplitude
AG = Amplifier Gain
AF = Antenna Factor

8.6 Duty Cycle Correction Factor

A duty cycle correction factor has been calculated and used to determine the average field strength from the peak field strength as given on the following pages.

Duty Cycle Calculation:
Manufacturer statement and calculations provided:

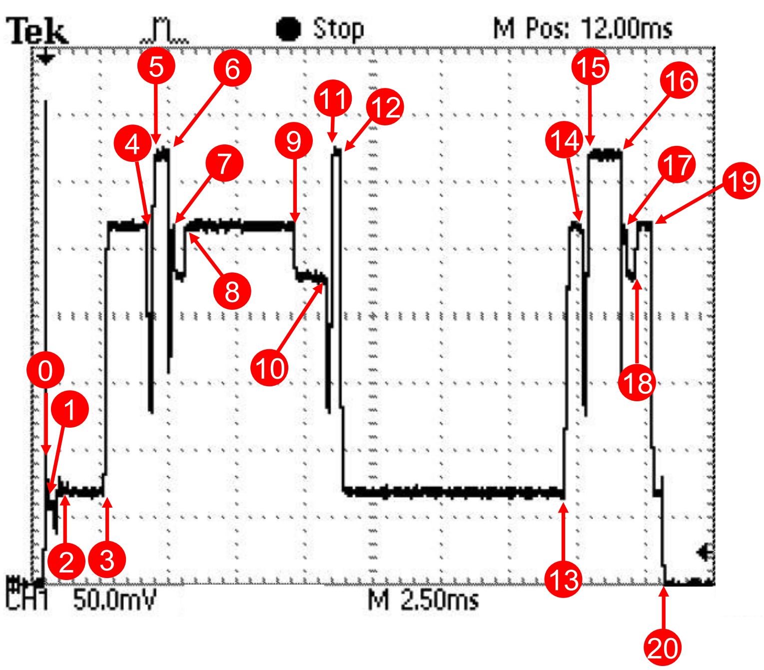
IEEE 802.15.4-2003 is used for application with low power consumption and in normal operation mode the TX duty cycle is much less than 1%. However, calculations have been made to show the maximum theoretical TX on time is 9%. This time is based on a total transmit on time of 2.08ms out of a 23.04ms block, see figure 8.6 (on the following page). *In normal operation this block will only occur once every 30 seconds; therefore, this duty cycle is much more conservative than actual operation. This approval however, is based on ZigBee or any other protocols ensuring a maximum TX duty cycle of 9%.*

Duty Cycle Correction Factor (ref: ANSI C63.10, 7.5)
$\delta(dB) = 20\log(\Delta) = 20 \log (0.09) = -20.9$ dB

Figure 8.6

Hardware:	CC2530EM (1 dBm output power)
Method:	Measuring voltage over a 10Ohm resistor; hence, 50mV translate into 5mA
Software running:	ZigBee PRO, End Device, SampleLight, HA profile, polling every 5000ms - **toggling Light**
Measure points:	See figure below

			Voltage (mV)		Current (mA)		Time (ms)
Before 0	Power Mode 2				0.001	AN071	
Point 0 to 1	Power mode start up sequence.		120		12		0.2
Point 1 to 2	MCU in active mode running on 16MHz clock		60		6		0.25
Point 2 to 3	MCU running on 32 MHz clock		70		7		1.7
Point 3 to 4	CMSA/CA algorithm. Radio in RX mode		270		27		1.85
Point 4 to 5	Switch from RX to TX		140		14		0.28
Point 5 to 6	Packet transmission (Data Request). Radio in TX mode (output power 1dBm)		330		33		**0.6**
Point 6 to 7	Switch from TX to RX		250		25		0.2
Point 7 to 8	Receiving the MAC Acknowledgement from Coordinator		230		23		0.48
Point 8 to 9	Radio in RX mode (processing MAC ACK and then waiting for the packet)		270		27		3.9
Point 9 to 10	Receiving the Toggle Light command		230		23		1.2
Point 10 to 11	Switch from RX to TX		140		14		0.28
Point 11 to 12	Transmitting MAC Acknowledgement. Radio in TX mode (output power 1dBm)		330		33		**0.32**
Point 12 to 13	Processing incoming Toggle Light message (e.g. toggling the light)		70		7		8.2
Point 13 to 14	CMSA/CA algorithm. Radio in RX mode		270		27		0.6
Point 14 to 15	Switch from RX to TX		140		14		0.28
Point 15 to 16	Packet transmission (Toggle response). Radio in TX mode (output power 1dBm		330		33		**1.16**
Point 16 to 17	Switch from TX to RX		250		25		0.2
Point 17 to 18	Receiving the MAC Acknowledgement from Coordinator		230		23		0.4
Point 18 to 19	Radio remaining in RX mode and processing the MAC ACK		270		27		0.48
Point 19 to 20	Processing and shut down.		70		7		0.46
After 20	Power Mode 2				0.001	AN071	
							23.04
						Transmit:	**2.08**
							9.0%



8.7 Measurement Result – Radiated Emissions Data Tables

The data tables on the following page show the Radiated Emissions test results.

Table A1: FCC 15.209 Radiated Emissions 9kHz – 30MHz

Company: Schneider Electric
Test Engineer: K. MacGrath
Model: NBWS100H
Test Date: March 25, 2014
Test Configuration: Channel 11, Max power level, Modulation applied
Power: 3VDC External power supply

Freq. (MHz)	Detector QP or AVG	3 m Reading (dBuV)	Cable Loss (dB)	AF includes E Factor (dB)	Net (dBuV/m)	FCC 15.209 Limit at 3m (dBuV/m)	Margin (dB)
0.032	AVG	-5.5	0.0	80.0	74.5	117.5	-43.0
0.064	AVG	-8.7	0.0	73.0	64.3	111.5	-47.2
0.096	QP	-5.3	0.0	68.5	63.2	108.0	-44.8
0.128	AVG	-11.4	0.0	67.0	55.6	105.5	-49.9
0.150	AVG	2.8	0.1	65.0	67.9	104.1	-36.2
30.0	QP	-2.2	0.4	26.5	24.7	40.0	-15.3

Scanned from 9 kHz to 30 MHz on 3 Meter OATS. Compared data to FCC 15.209 limits.
RBW=200Hz from 9kHz to 150kHz (Ref: CISPR 16-1-1, 5.2.1)
RBW=9kHz from 150kHz to 30MHz (Ref: CISPR 16-1-1, 5.2.1)

Detectors used
Quasi-peak (QP) for all except as follows:
Average (AVG) 9-90kHz
Average (AVG) 110-490kHz

Antenna: Magnetic Loop (Asset #103)

Table 1: FCC Part 15 Class B Radiated Emissions

Company: Schneider Electric-APC
Test Engineers: ER and GC
Model: NBWS100H
Serial No.: N/A
Test Date: February 7, 2014
Test Configuration: Worst case of Battery powered, 3VDC, or using External 3VDC Power Supply
Transmitting on Channel 11 (2.4048 GHz) with modulation applied.

30-1000MHz Spurious Radiated Emissions Results

Turntable/ Height	Polarity (V or H)	Frequency (MHz)	Reading (dBuV)	Cable Loss (dB)	A.F. (dB)	Net (dBuV/m)	FCC Part 15 EN55022 Class B Limit @ 3m (dBuV/m)	Margin (dB)
0/1	Vpk	32.0	8.1	0.4	19.7	28.2	40.0	-11.8
0/1	Vpk	64.0	22.3	0.9	6.0	29.2	40.0	-10.8
0/1	V	128.0	10.0	1.3	12.7	24.0	43.5	-19.5
0/1	V	256.0	7.0	1.8	13.0	21.8	46.0	-24.2
0/2	V	288.0	8.4	1.9	13.6	23.9	46.0	-22.1
0/1.6	H	448.0	8.9	2.4	17.1	28.4	46.0	-17.6

1-26 GHz Spurious Radiated Emissions Results, Peak

Turntable/ Height	Polarity (V or H)	Frequency (MHz)	Reading (dBuV)	Cable Loss (dB)	Preamp Gain (dB)	A.F. (dB)	Net (dBuV/m)	FCC Part 15 EN55022 Class B Limit @ 3m (dBuV/m)	Margin (dB)
180/1.3	Vpk	4809.7	50.0	12.1	-36.4	32.6	58.3	73.9	-15.6
0/1.6	Hpk	7211.6	41.5	14.6	-36.5	35.7	55.3	73.9	-18.6
90/1.5	Hpk	9617.4	38.1	17.2	-37.2	37.4	55.5	73.9	-18.4

1-26 GHz Spurious Radiated Emissions Results, Average (using Duty Cycle correction factor)

Turntable/ Height	Polarity (V or H)	Frequency (MHz)	Reading (dBuV)	Cable Loss (dB)	Preamp Gain (dB)	A.F. (dB)	Duty Cycle Correction Factor (dB)	Net (dBuV/m)	FCC Part 15 EN55022 Class B Limit @ 3m (dBuV/m)	Margin (dB)
180/1.3	Vpk	4809.7	50.0	12.1	-36.4	32.6	-20.9	37.4	53.9	-16.5
0/1.6	Hpk	7211.6	41.5	14.6	-36.5	35.7	-20.9	34.4	53.9	-19.5
90/1.5	Hpk	9617.4	38.1	17.2	-37.2	37.4	-20.9	34.6	53.9	-19.3

Notes: Did complete scans in the ferrite-lined shielded chamber.
Checked transmitter harmonics to the 10^{th} harmonic (26 GHz).
Cable Loss: Sum of 8-meter plus 25-meter cables
Measurements below 30-1000MHz: RBW=120kHz, QP
Measurements above 1GHz: RBW=1MHz, VBW=3MHz, Peak

Duty Cycle Calculation:
Manufacturer statement:
IEEE 802.15.4-2003 are used for application with low power consumption and in normal operation mode the TX duty cycle is much less than 1 %. However, calculations have been made to show the maximum theoretical TX on time is 9%. This is based on a total transmit on time of 2.08ms out of a 23.04ms block. In normal operation this block will only occur once every 30 seconds; therefore, this duty cycle is much more conservative than actual operation. This approval however, is based on ZigBee or any other protocols ensuring a maximum TX duty cycle of 9%.

Duty Cycle Correction Factor (ref: ANSI C63.10, 7.5)
$\delta(\text{dB}) = 20\log(\Delta) = 20\log(0.09) = -20.9$ dB

Table A1: FCC 15.209 Radiated Emissions 9kHz – 30MHz

Company:	Schneider Electric
Test Engineer:	K. MacGrath
Model:	NBWS100H
Test Date:	March 25, 2014
Test Configuration:	Channel 18, Max power level, Modulation applied
Power:	3VDC External power supply

Freq. (MHz)	Detector QP or AVG	3 m Reading (dBuV)	Cable Loss (dB)	AF includes E Factor (dB)	Net (dBuV/m)	FCC 15.209 Limit at 3m (dBuV/m)	Margin (dB)
0.032	AVG	-2.7	0.0	80.0	77.3	117.5	-40.2
0.064	AVG	-4.4	0.0	73.0	68.6	111.5	-42.9
0.096	QP	-8.5	0.0	68.5	60.0	108.0	-48.0
0.128	AVG	-10.2	0.0	67.0	56.8	105.5	-48.7
0.150	AVG	3.1	0.1	65.0	68.2	104.1	-35.9
30.0	QP	-2.3	0.4	26.5	24.6	40.0	-15.4

Scanned from 9 kHz to 30 MHz on 3 Meter OATS. Compared data to FCC 15.209 limits.
RBW=200Hz from 9kHz to 150kHz (Ref: CISPR 16-1-1, 5.2.1)
RBW=9kHz from 150kHz to 30MHz (Ref: CISPR 16-1-1, 5.2.1)

Detectors used
Quasi-peak (QP) for all except as follows:
Average (AVG) 9-90kHz
Average (AVG) 110-490kHz

Antenna: Magnetic Loop (Asset #103)

Table 1: FCC Part 15 Class B Radiated Emissions

Company: Schneider Electric-APC
Test Engineer: ER and GC
Model: NBWS100H
Serial No.: N/A
Test Date: February 7, 2014
Test Configuration: Worst case of Battery powered, 3VDC, or using External 3VDC Power Supply
Transmitting on Channel 18 (2.440 GHz) with modulation applied.

30-1000MHz Spurious Radiated Emissions Results

Turntable/ Height	Polarity (V or H)	Frequency (MHz)	Reading (dBuV)	Cable Loss (dB)	A.F. (dB)	Net (dBuV/m)	FCC Part 15 EN55022 Class B Limit @ 3m (dBuV/m)	Margin (dB)
0/1	Vpk	32.0	7.0	0.4	19.7	27.1	40.0	-12.9
0/1	Vpk	64.0	22.8	0.9	6.0	29.7	40.0	-10.3
0/1	V	128.0	9.8	1.3	12.7	23.8	43.5	-19.7
0/1	V	256.0	7.3	1.8	13.0	22.1	46.0	-23.9
0/1	H	288.0	8.6	1.9	13.6	24.1	46.0	-21.9
0/1.6	H	448.0	11.2	2.4	17.1	30.7	46.0	-15.3

1-26 GHz Spurious Radiated Emissions Results, Peak

Turntable/ Height	Polarity (V or H)	Frequency (MHz)	Reading (dBuV)	Cable Loss (dB)	Preamp Gain (dB)	A.F. (dB)	Net (dBuV/m)	FCC Part 15 EN55022 Class B Limit @ 3m (dBuV/m)	Margin (dB)
180/1.4	Vpk	4879.6	53.9	12.3	-36.4	32.8	62.6	73.9	-11.3
0/1.15	Hpk	7319.3	40.7	14.7	-36.5	36.2	55.1	73.9	-18.8
90/1.5	Hpk	9757.2	36.1	17.3	-37.2	37.5	53.7	73.9	-20.2

1-26 GHz Spurious Radiated Emissions Results, Average (using Duty Cycle correction factor)

Turntable/ Height	Polarity (V or H)	Frequency (MHz)	Reading (dBuV)	Cable Loss (dB)	Preamp Gain (dB)	A.F. (dB)	Duty Cycle Correction Factor (dB)	Net (dBuV/m)	FCC Part 15 EN55022 Class B Limit @ 3m (dBuV/m)	Margin (dB)
180/1.4	Vpk	4879.6	53.9	12.1	-36.2	32.8	-20.9	41.7	53.9	-12.2
0/1.15	Hpk	7319.3	40.7	14.6	-36.4	36.2	-20.9	34.2	53.9	-19.7
90/1.5	Hpk	9757.2	36.1	17.2	-37.1	37.5	-20.9	32.8	53.9	-21.1

Notes: Did complete scans in the ferrite-lined shielded chamber.
Checked transmitter harmonics to the 10^{th} harmonic (26 GHz).
Cable Loss: Sum of 8-meter plus 25-meter cables
Measurements below 30-1000MHz: RBW=120kHz, QP
Measurements above 1GHz: RBW=1MHz, VBW=3MHz, Peak

Duty Cycle Calculation:
Manufacturer statement:
IEEE 802.15.4-2003 are used for application with low power consumption and in normal operation mode the TX duty cycle is much less than 1 %. However, calculations have been made to show the maximum theoretical TX on time is 9%. This is based on a total transmit on time of 2.08ms out of a 23.04ms block. In normal operation this block will only occur once every 30 seconds; therefore, this duty cycle is much more conservative than actual operation. This approval however, is based on ZigBee or any other protocols ensuring a maximum TX duty cycle of 9%.

Duty Cycle Correction Factor (ref: ANSI C63.10, 7.5)
$\delta(dB) = 20\log(\Delta) = 20 \log (0.09) = -20.9$ dB

Table A1: FCC 15.209 Radiated Emissions 9kHz – 30MHz

Company:	Schneider Electric
Test Engineer:	K. MacGrath
Model:	NBWS100H
Test Date:	March 25, 2014
Test Configuration:	Channel 25, Max power level, Modulation applied
Power:	3VDC External power supply

Freq. (MHz)	Detector QP or AVG	3 m Reading (dBuV)	Cable Loss (dB)	AF includes E Factor (dB)	Net (dBuV/m)	FCC 15.209 Limit at 3m (dBuV/m)	Margin (dB)
0.032	AVG	0.4	0.0	80.0	80.4	117.5	-37.1
0.064	AVG	-4.4	0.0	73.0	68.6	111.5	-42.9
0.096	QP	-8.8	0.0	68.5	59.7	108.0	-48.3
0.128	AVG	-10.6	0.0	67.0	56.4	105.5	-49.1
0.150	AVG	3.2	0.1	65.0	68.3	104.1	-35.8
30.0	QP	-2.4	0.4	26.5	24.5	40.0	-15.5

Scanned from 9 kHz to 30 MHz on 3 Meter OATS. Compared data to FCC 15.209 limits.
RBW=200Hz from 9kHz to 150kHz (Ref: CISPR 16-1-1, 5.2.1)
RBW=9kHz from 150kHz to 30MHz (Ref: CISPR 16-1-1, 5.2.1)

Detectors used
Quasi-peak (QP) for all except as follows:
Average (AVG) 9-90kHz
Average (AVG) 110-490kHz

Antenna: Magnetic Loop (Asset #103)

Table 1: FCC Part 15 Class B Radiated Emissions

Company: Schneider Electric-APC
Test Engineer: ER and GC
Model: NBWS100H
Serial No.: N/A
Test Date: February 6, 2014
Test Configuration: Worst case of Battery powered, 3VDC, or using External 3VDC Power Supply
Transmitting on Channel 25 (2.475 GHz) with modulation applied.

30-1000MHz Spurious Radiated Emissions Results

Turntable/ Height	Polarity (V or H)	Frequency (MHz)	Reading (dBuV)	Cable Loss (dB)	A.F. (dB)	Net (dBuV/m)	FCC Part 15 EN55022 Class B Limit @ 3m (dBuV/m)	Margin (dB)
0/1	Vpk	32.0	5.9	0.4	19.7	26.0	40.0	-14.0
0/1	Vpk	64.0	12.6	0.9	6.0	19.5	40.0	-20.5
0/1	V	128.0	7.5	1.3	12.7	21.5	43.5	-22.0
0/1	V	256.0	6.2	1.8	13.0	21.0	46.0	-25.0
0/1	V	288.0	7.1	1.9	13.6	22.6	46.0	-23.4
0/1.6	H	448.0	6.6	2.4	17.1	26.1	46.0	-19.9

1-26 GHz Spurious Radiated Emissions Results, Peak

Turntable/ Height	Polarity (V or H)	Frequency (MHz)	Reading (dBuV)	Cable Loss (dB)	Preamp Gain (dB)	A.F. (dB)	Net (dBuV/m)	FCC Part 15 EN55022 Class B Limit @ 3m (dBuV/m)	Margin (dB)
180/1.1	Vpk	4949.7	55.1	12.3	-36.4	32.8	63.8	73.9	-10.1
0/1.15	Hpk	7424.3	40.0	14.8	-36.6	36.5	54.7	73.9	-19.2
90/1.5	Hpk	9899.2	40.1	17.5	-37.2	37.5	57.9	73.9	-16.0

1-26 GHz Spurious Radiated Emissions Results, Average (using Duty Cycle correction factor)

Turntable/ Height	Polarity (V or H)	Frequency (MHz)	Reading (dBuV)	Cable Loss (dB)	Preamp Gain (dB)	A.F. (dB)	Duty Cycle Correction Factor (dB)	Net (dBuV/m)	FCC Part 15 EN55022 Class B Limit @ 3m (dBuV/m)	Margin (dB)
180/1.1	Vpk	4949.7	55.1	12.3	-36.4	32.8	-20.9	42.9	53.9	-11.0
0/1.15	Hpk	7424.3	40.0	14.8	-36.6	36.5	-20.9	33.8	53.9	-20.1
90/1.5	Hpk	9899.2	40.1	17.5	-37.2	37.5	-20.9	37.0	53.9	-16.9

Notes: Did complete scans in the ferrite-lined shielded chamber.
Checked transmitter harmonics to the 10^{th} harmonic (26 GHz).
Cable Loss: Sum of 8-meter plus 25-meter cables
Measurements below 30-1000MHz: RBW=120kHz, QP
Measurements above 1GHz: RBW=1MHz, VBW=3MHz, Peak

Duty Cycle Calculation:
Manufacturer statement:
IEEE 802.15.4-2003 are used for application with low power consumption and in normal operation mode the TX duty cycle is much less than 1 %. However, calculations have been made to show the maximum theoretical TX on time is 9%. This is based on a total transmit on time of 2.08ms out of a 23.04ms block. In normal operation this block will only occur once every 30 seconds; therefore, this duty cycle is much more conservative than actual operation. This approval however, is based on ZigBee or any other protocols ensuring a maximum TX duty cycle of 9%.

Duty Cycle Correction Factor (ref: ANSI C63.10, 7.5)
$\delta(\text{dB}) = 20\log(\Delta) = 20 \log (0.09) = -20.9$ dB

9.0 Peak Power Spectral Density

9.1 Applicable Standard

According to 15.247(e), for digitally modulated systems, the peak power spectral density conducted from the intentional radiator to the antenna shall not be greater than 8 dBm in any 3kHz band during any time of continuous transmission.

9.2 Measurement Procedure

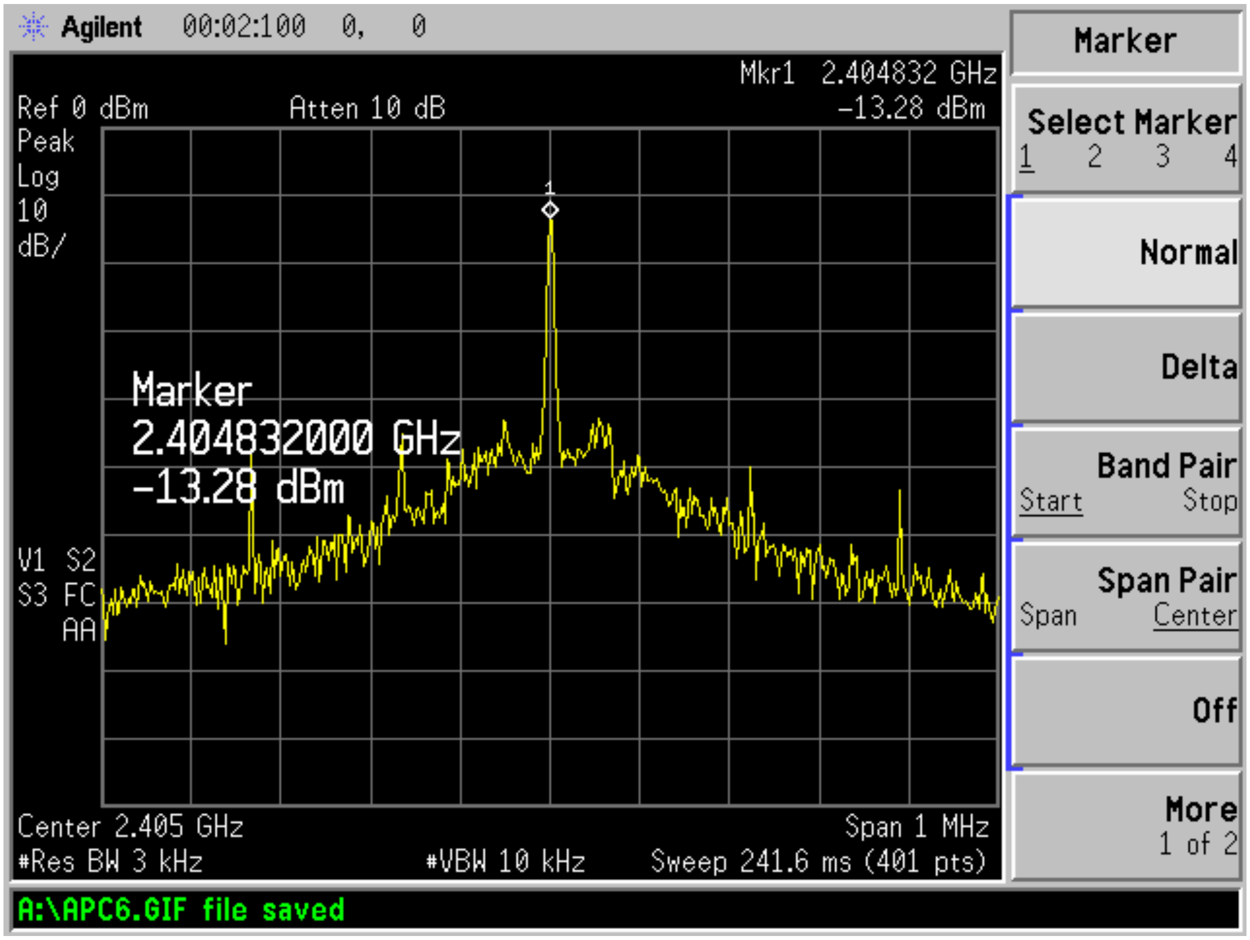
- Place the EUT on the table and set it for continuous transmit mode without modulation.
- Set the spectrum analyzer RBW = 3KHz, VBW = 10KHz, Span = 1MHz, Sweep = Auto.
- Record the maximum reading.
- Repeat above procedures for low, mid and high frequency channels.

9.3 Measurement Result

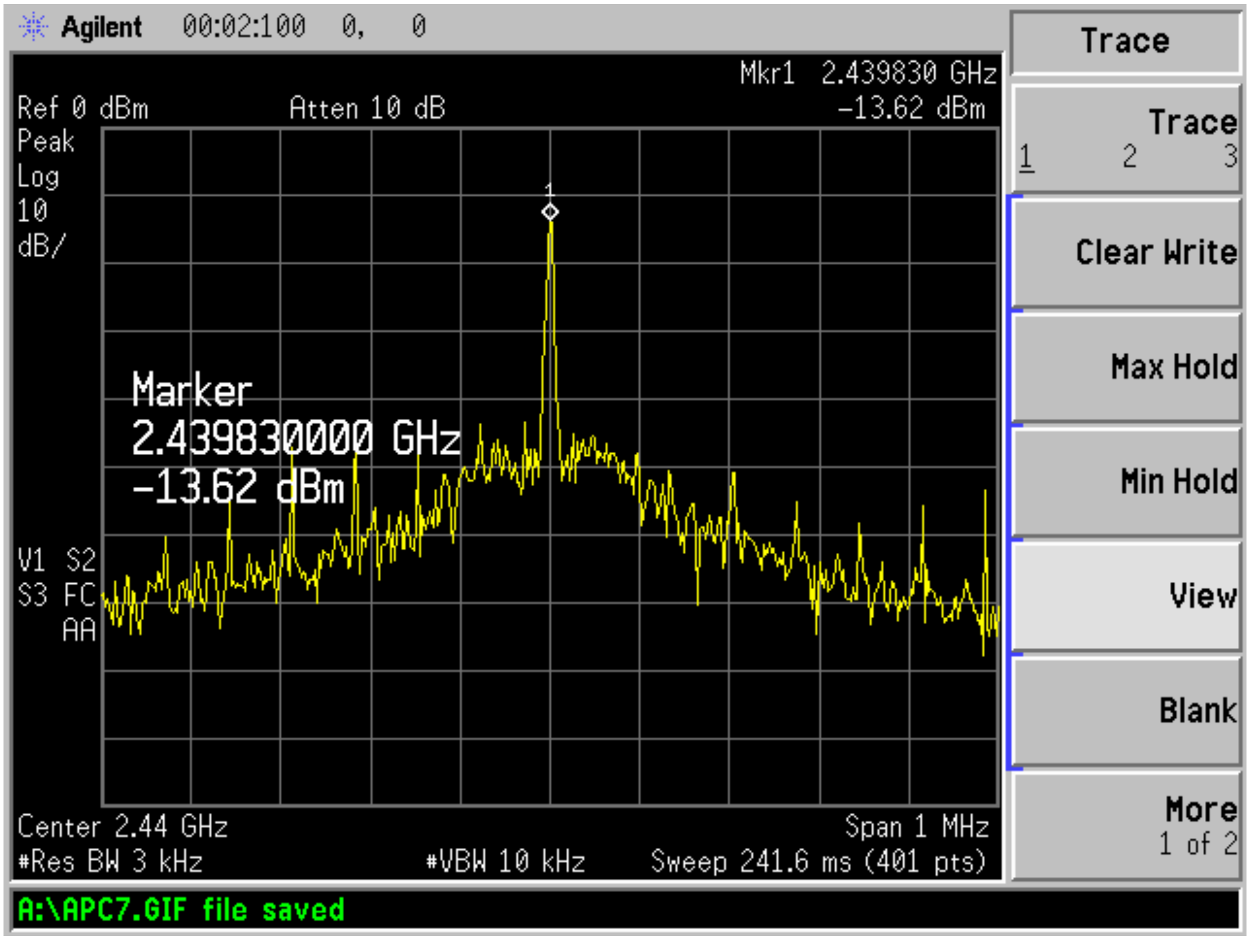
CH	Channel Frequency (GHz)	Maximum Limit (dBm)	RF Power Density Reading (dBm)
Low	2.405	8	-13.3
Mid	2.440	8	-13.6
High	2.475	8	-12.3

Data plots for low, mid and high channels

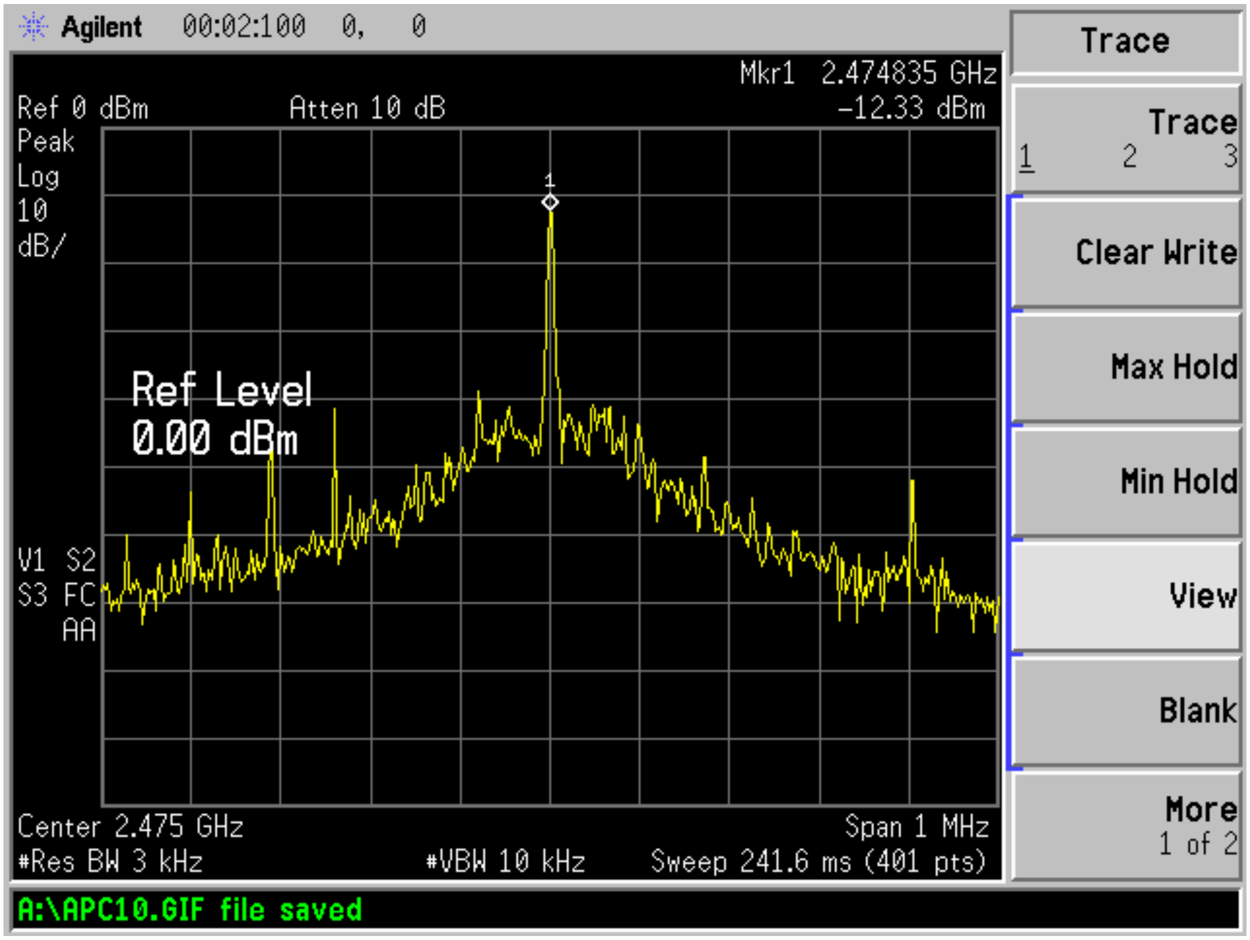
Power Spectral Density Test Plot (CH 11, Low)



Power Spectral Density Test Plot (CH-18, Mid)



Power Spectral Density Test Plot (CH-25, High)



10.0 ANTENNA REQUIREMENT

10.1 Applicable Standard

For an intentional radiator device, according to 15.203, an intentional radiator shall be designed to ensure that no antenna other than furnished by the responsible party shall be used with the device.

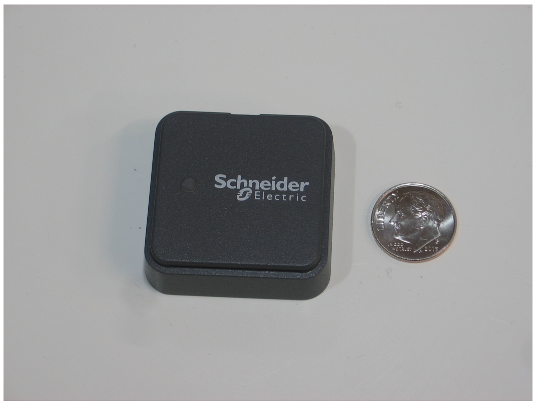
And according to 15.247(4)(1), system operating in the 2400-2483.5MHz bands that are used exclusively for fixed, point-to-point operations may employ transmitting antennas with directional gain greater than 6dBi provided the maximum peak output power of the intentional radiator is reduced by 1 dB for every 3 dB that the directional gain of the antenna exceeds 6 dBi.

10.2 Antenna Connected Construction

The directional gain of the antenna used for transmitting is 3 dBi, and the antenna is permanently mounted to the EUT with no consideration of replacement.

Photographs

NetBotz Wireless Sensor



EUT case (top)

EUT case (bottom)

EUT complete

Additional Photographs can be found in separate documents:

NBWS100 Tsup.pdf
NBWS100 Intpho.pdf
NBWS100 Extpho.pdf.

Appendix A *– EUT Modulation Specification*

IEEE 802.15.4-2006 Modulation Format
(ref: Texas Instruments Literature Number: SWRU191E, Revised January 2014)

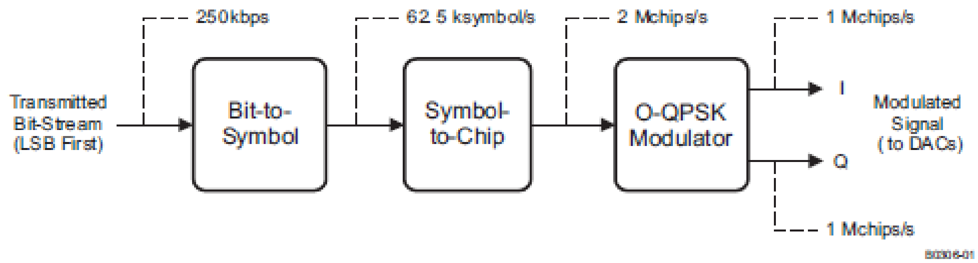


Figure 23-1. Modulation

Table 23-2. IEEE 802.15.4-2006 Symbol-to-Chip Mapping

Symbol	Chip Sequence (C0, C1, C2, ... , C31)
0	1 1 0 1 1 0 0 1 1 1 0 0 0 0 1 1 0 1 0 1 0 0 1 0 0 0 1 0 1 1 1 0
1	1 1 1 0 1 1 0 1 1 0 0 1 1 1 0 0 0 0 1 1 0 1 0 1 0 0 1 0 0 0 1 0
2	0 0 1 0 1 1 1 0 1 1 0 1 1 0 0 1 1 1 0 0 0 0 1 1 0 1 0 1 0 0 1 0
3	0 0 1 0 0 0 1 0 1 1 1 0 1 1 0 1 1 0 0 1 1 1 0 0 0 0 1 1 0 1 0 1
4	0 1 0 1 0 0 1 0 0 0 1 0 1 1 1 0 1 1 0 1 1 0 0 1 1 1 0 0 0 0 1 1
5	0 0 1 1 0 1 0 1 0 0 1 0 0 0 1 0 1 1 1 0 1 1 0 1 1 0 0 1 1 1 0 0
6	1 1 0 0 0 0 1 1 0 1 0 1 0 0 1 0 0 0 1 0 1 1 1 0 1 1 0 1 1 0 0 1
7	1 0 0 1 1 1 0 0 0 0 1 1 0 1 0 1 0 0 1 0 0 0 1 0 1 1 1 0 1 1 0 1
8	1 0 0 0 1 1 0 0 1 0 0 1 0 1 1 0 0 0 0 0 0 1 1 1 0 1 1 1 1 0 1 1
9	1 0 1 1 1 0 0 0 1 1 0 0 1 0 0 1 0 1 1 0 0 0 0 0 0 1 1 1 0 1 1 1
10	0 1 1 1 1 0 1 1 1 0 0 0 1 1 0 0 1 0 0 1 0 1 1 0 0 0 0 0 0 1 1 1
11	0 1 1 1 0 1 1 1 1 0 1 1 1 0 0 0 1 1 0 0 1 0 0 1 0 1 1 0 0 0 0 0
12	0 0 0 0 0 1 1 1 0 1 1 1 1 0 1 1 1 0 0 0 1 1 0 0 1 0 0 1 0 1 1 0
13	0 1 1 0 0 0 0 0 0 1 1 1 0 1 1 1 1 0 1 1 1 0 0 0 1 1 0 0 1 0 0 1
14	1 0 0 1 0 1 1 0 0 0 0 0 0 1 1 1 0 1 1 1 1 0 1 1 1 0 0 0 1 1 0 0
15	1 1 0 0 1 0 0 1 0 1 1 0 0 0 0 0 0 1 1 1 0 1 1 1 1 0 1 1 1 0 0 0

The modulation format is offset – quadrature phase shift keying (O-QPSK) with half-sine chip shaping. This is equivalent to MSK modulation. Each chip is shaped as a half-sine, transmitted alternately in the I and Q channels with one-half chip-period offset. This is illustrated for the zero-symbol in Figure 23-2.

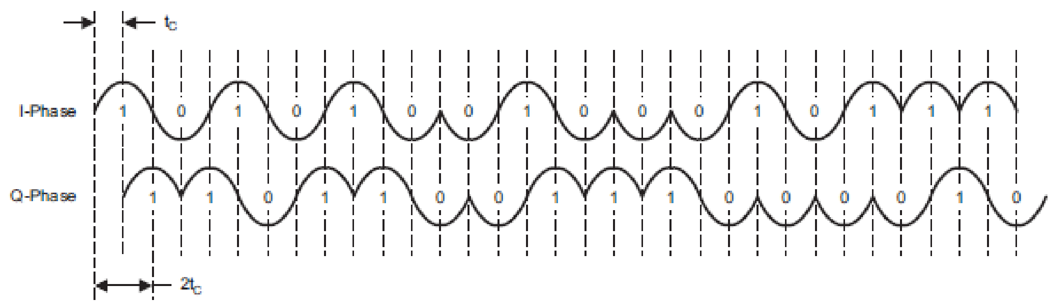


Figure 23-2. I/Q Phases When Transmitting a Zero-Symbol Chip Sequence, t_c = 0.5 μs

END OF TEST REPORT