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Emissions
Test Report

EUT Name: Qolsys Zigbee Radio Card

Model No.: QS-ZB

CFR 47 Part 15.247: 2018 and RSS 247: 2017

Prepared for:

Qolsys Inc.
1900 The Alameda
San Jose, CA 95126
U.S.A

Prepared by:

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Revisions

Revision No.	Date	Reason for Change	Author
0	May 31, 2019	Original Document	BMJ

Note: Latest revision report will replace all previous reports.

Statement of Compliance

Manufacturer:	Qolsys Inc. 1900 The Alameda San Jose, CA 95126
Requester / Applicant:	Qolsys Inc.
Name of Equipment:	Qolsys Zigbee Radio Card
Model No.	QS-ZB
Type of Equipment:	Intentional Radiator
Application of Regulations:	CFR 47 Part 15.247: 2018 and RSS 247: 2017
Test Dates:	21st May, 2019 to May 30th 2019

Guidance Documents:

Emissions: ANSI C63.10-2013 CFR47 part 15.247:2018 and RSS247: 2017

Test Methods:

Emissions: ANSI C63.10-2013

The electromagnetic compatibility test and documented data described in this report has been performed and recorded by TUV Rheinland, in accordance with the standards and procedures listed herein. As the responsible authorized agent of the EMC laboratory, I hereby declare that the equipment described above has been shown to be compliant with the EMC requirements of the stated regulations and standards based on these results. If any special accessories and/or modifications were required for compliance, they are listed in the Executive Summary of this report.

This report must not be used to claim product endorsement by A2LA or any agency of the U.S. Government. This report shall not be reproduced except in full, without the written authorization of TUV Rheinland of North America.

Bernd Jungbluth		Josie Sabado	
Test Engineer	Date May 31, 2019	A2LA Signatory	Date May 31, 2019

Testing Cert #3331.02 **US1131** **2932M-1**

1 Executive Summary

1.1 Scope

This report is intended to document the status of conformance with the requirements of the CFR 47 Part 15.247: 2018 and RSS 247: 2017 based on the results of testing performed on 21st May, 2019 to May 30th 2019 on the Qolsys Zigbee Radio Card Model QS-ZB manufactured by Qolsys Inc.. This report only applies to the specific samples tested under the stated test conditions. It is the responsibility of the manufacturer to assure that additional production units of this model are manufactured with identical or EMI equivalent electrical and mechanical components. This report is further intended to document changes and modifications to the EUT throughout its life cycle. All documentation will be included as a supplement.

1.2 Purpose

Testing was performed to evaluate the EMC performance of the EUT in accordance with the applicable requirements, procedures, and criteria defined in the application of regulations and application of standards listed in this report. The 2400 MHz to 2483.5 MHz frequency band is covered in this document.

1.3 Summary of Test Results

Table 1: Summary of Test Results

Test	Test Method ANSI C63.4	Worse Case (Measured)	Result
AC Power Conducted Emission	CFR47 15.207, RSS-GEN Sect.8.8	N/A – EUT is battery operated	**N/A**
DTS Bandwidth (6dB)	CFR47 15.247 (a)(2), RSS 247 Sect. 5.2(a)	1.7 MHz	**Complied**
Maximum Output Power	CFR47 15.247 (b), RSS 247 Sect. 5.4 (d)	11.0 dBm (peak)	**Complied**
Peak Power Spectral Density	CFR47 15.247 (e), RSS 247 Sect. 5.2	-4.35 dBm/3KHz	**Complied**
Out of Band Emissions	CFR47 15.247 (d), RSS 247 Sect.5.5	31 dB margin @ 2483.5 MHz	**Complied**
Transmit Radiated Spurious Emissions	CFR47 15.247 (d), RSS 247 Sect.5.5	44.8 dB @ 4819.3 MHz (Average)	**Complied**

1.4 Special Accessories

No special accessories were necessary in order to achieve compliance.

1.5 Equipment Modifications

None

2 Laboratory Information

2.1 Accreditations & Endorsements

2.1.1 US Federal Communications Commission

TUV Rheinland of North America at 1279 Quarry Ln, Pleasanton, CA 94566 is recognized by the commission for performing testing services for the general public on a fee basis. These laboratory test facilities have been fully described in reports submitted to and accepted by the FCC (US1131). The laboratory scope of accreditation includes: Title 47 CFR Parts 15, 18, and 90. The accreditation is updated every 3 years.

2.1.2 NIST / A2LA

TUV Rheinland of North America EMC test facilities are accredited by the American Association for Laboratory Accreditation (A2LA). The laboratories have been assessed and accredited by A2LA in accordance with ISO Standard 17025:2005 (Testing Certificate #3331.02). The Scope of Laboratory Accreditation includes emission and immunity testing. The accreditations are updated annually.

1.1.1 Canada – Industry Canada

The Pleasanton 5-meter Semi-Anechoic Chamber, Registration No. 2932M-1, has been accepted by Industry Canada to perform testing to 3 and 5 meters based on the test procedures described in ANSI C63.4-2014. The Fremont 10-meter Semi-Anechoic Chamber, Registration No. 2932D-1, has been accepted by Industry Canada to perform testing to 3 and 10 meters based on the test procedures described in ANSI C63.4-2014.

2.1.3 Acceptance by Mutual Recognition Arrangement

The United States has an established agreement with specific countries under the Asia Pacific Laboratory Accreditation Corporation (APLAC) Mutual Recognition Arrangement. Under this agreement, all TUV Rheinland at 1279 Quarry Ln, Pleasanton, CA 94566 test results and test reports within the scope of the laboratory NIST / A2LA accreditation will be accepted by each member country.

2.2 Test Facilities

All of the test facilities are located at 1279 Quarry Lane, Pleasanton, California 94566, USA.

2.2.1 Emission Test Facility

The Semi-Anechoic chamber and AC Line Conducted measurement facility used to collect the radiated and conducted data has been constructed in accordance with ANSI C63.7:1992. The site has been measured in accordance with and verified to comply with the theoretical normalized site attenuation requirements of ANSI C63.4-2014, at a test distance of 3 and 5 meters. The site is listed with the FCC and accredited by A2LA (Lab Code Testing Cert #3331.02). The 3/5-meter semi-anechoic chamber used to collect the radiated data has been verified to comply with the theoretical normalized site attenuation requirements of ANSI C63.4-2014, at a test distance of 3 meter and 5 meters. A report detailing this site can be obtained from TUV Rheinland of North America.

2.2.2 EMC Software - Pleasanton

Manufacturer	Name	Version	Test Type
Rohde & Schwarz	EMS32	10.40.10	Radiated Emissions
EMISoft	Vasona	5.0	Radiated Emissions

2.3 Measurement Uncertainty

Two types of measurement uncertainty are expressed in this report, per *ISO Guide To The Expression Of Uncertainty In Measurement*, 1st Edition, 1995.

The Combined Standard Uncertainty is the standard uncertainty of the result of a measurement when that result is obtained from the values of a number of other quantities; it is equal to the positive square root of the sum of the variances or co-variances of these other quantities, weighted according to how the measurement result varies with changes in these quantities. The term *standard uncertainty* is the result of a measurement expressed as a standard deviation.

2.3.1 Sample Calculation – radiated & conducted emissions

The field strength is calculated by subtracting the Amplifier Gain and adding the Cable Loss and Antenna Correction Factor to the measured reading. The basic equation is as follows:

Field Strength (dBμV/m) = RAW - AMP + CBL + ACF

Where: RAW = Measured level before correction (dBμV)

AMP = Amplifier Gain (dB)

CBL = Cable Loss (dB)

ACF = Antenna Correction Factor (dB/m)

$$\mu V/m = 10^{\frac{dB\mu V/m}{20}}$$

Sample radiated emissions calculation @ 30 MHz

Measurement +Antenna Factor–Amplifier Gain+Cable loss=Radiated Emissions (dBuV/m)

25 dBuV/m + 17.5 dB – 20 dB + 1.0 dB = 23.5 dBuV/m

2.3.2 Measurement Uncertainty

Per CISPR 16-4-2	**U_{lab}**	**U_{cispr}**
Radiated Disturbance @ 10 meters		
30 – 1,000 MHz	2.25 dB	4.51 dB
Radiated Disturbance @ 3 meters		
30 – 1,000 MHz	2.26 dB	4.52 dB
1 – 6 GHz	2.12 dB	4.25 dB
6 – 18 GHz	2.47 dB	4.93 dB
Conducted Disturbance @ Mains Terminals		
150 kHz – 30 MHz	1.09 dB	2.18 dB

Disturbance Power		
30 MHz – 300 MHz	3.92 dB	4.3 dB

Measurement Uncertainty – Radio Testing

The estimated combined standard uncertainty for frequency error measurements is ± 3.88 Hz
The estimated combined standard uncertainty for carrier power measurements is ± 0.7 dB.
The estimated combined standard uncertainty for adjacent channel power measurements is ± 1.47 dB.
The estimated combined standard uncertainty for modulation frequency response measurements is ± 0.46 dB.
The estimated combined standard uncertainty for transmitter conducted emission measurements is ± 2.06 dB

The expanded uncertainty at a level of 95% confidence is obtained by multiplying the combined standard uncertainty by a coverage factor of 2. Compliance criteria are not based on measurement uncertainty.

2.4 Calibration Traceability

All measurement instrumentation is traceable to the National Institute of Standards and Technology (NIST). Measurement method complies with ANSI/NCSL Z540-1-1994 and ISO Standard 17025:2005. Equipment calibration records are kept on file at the test facility.

3 Product Information

3.1 Product Description

The Qolsys Zigbee Radio Card Model QS-ZB manufactured by Qolsys Inc. is a IEEE 802.15.4 ZigBee module. The module is intended to work within the 2.4GHz frequency band and utilizes a single antenna transceiver chain.

3.2 Equipment Configuration

A description of the equipment configuration is given in the Test Plan Section (Section 6). The EUT was tested as called for in the test standard and was configured and operated in a manner consistent with its intended use. The EUT was connected to rated power and allowed to reach intended operating conditions. The placement of the EUT system components was guided by the test standard and selected to represent typical installation conditions.

In the case of an EUT that can operate in more than one configuration, preliminary testing was performed to determine the configuration that produced maximum radiation.

The final configuration was selected to produce the worst case radiation for emissions testing.

3.3 Operating Mode

A description of the operation mode is given in the Test Plan Section (Section 6).

The final operating mode was selected to produce the worst case radiation for emissions testing.

3.4 Unique Antenna Connector

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 CFR47 Parts 15.211, 15.213, 15.217, 15.219, or 15.221.

3.4.1 Results

The Qolsys Zigbee Radio Card employs a single embedded chip antenna. An additional test sample with a temporary u.fl connector was supplied for the purpose of conducted testing

The antenna is utilized by the applicant as representative implementation for the certification of the module. The antenna is declared is inaccessible for the end user for later internal module integrations.

The antenna has a declared maximum gain of 1 dBi.

4 Emissions

Testing was performed in accordance with CFR 47 Part 15.247. These test methods are listed under the laboratory's A2LA Scope of Accreditation. This test measures the levels emanating from the EUT, thus evaluating the potential for the EUT to cause radio frequency interference to other electronic devices. Procedures described in section 8 of the standard were used.

4.1 Output Power Requirements

The maximum output power requirement is the maximum equivalent isotropic radiated power delivering at the transmitting antenna under specified conditions of measurements in the presence of modulation.

The maximum output power and harmonics shall not exceed CFR47 Part 15.247 (b)

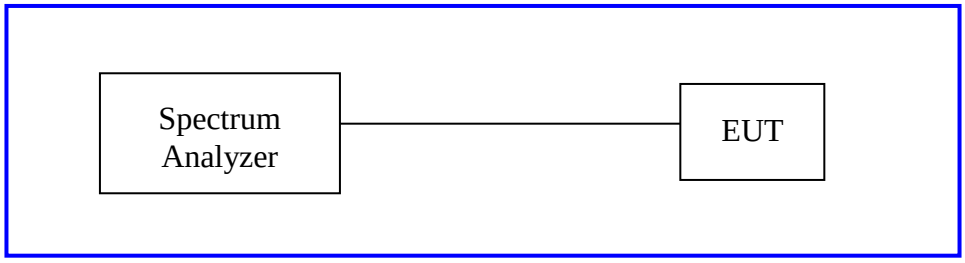
The maximum transmitted powers are:

Band 2400-2483.5 MHz: 1 W

4.1.1 Test Method

The ANSI C63.10-2013 Section 11.9.1.1. Conducted method was used to measure the channel power output. The preliminary investigation was not needed, as the ZigBee implementation runs only one modulation and one power setting. This test was conducted on 3 channels. The result are indicated in the following section. .

Test Setup:



4.1.2 Results

As originally tested, the EUT was found to be compliant to the requirements of the test standard(s).

Table 2: RF Output Power at the Antenna Port – Test Results – IEEE 802.15.4 - ZigBee

Test Conditions: Conducted Measurement, Normal Temperature				
Antenna Type: Chip antenna		**Power Setting:** FW default: Powerlevel 97; power: 104		
Max. Directional Gain: 1 dBi				
Signal State: Modulated				
Ambient Temp.: 21° C			**Relative Humidity:**35.8%	
RF Output Power – IEEE 802.15.4 - ZigBee				
Voltage	**Operating Channel (MHz)**	**Measured Peak Power [dBm]**	**Limit [dBm]**	**Margin [dB]**
Nominal	2405	11.0	30.0	19.0
	2445	10.8	30.0	19.2
	2480	10.8	30.0	19.2
Note: All insertion loss corrections are accounted for in the measurement plots.				

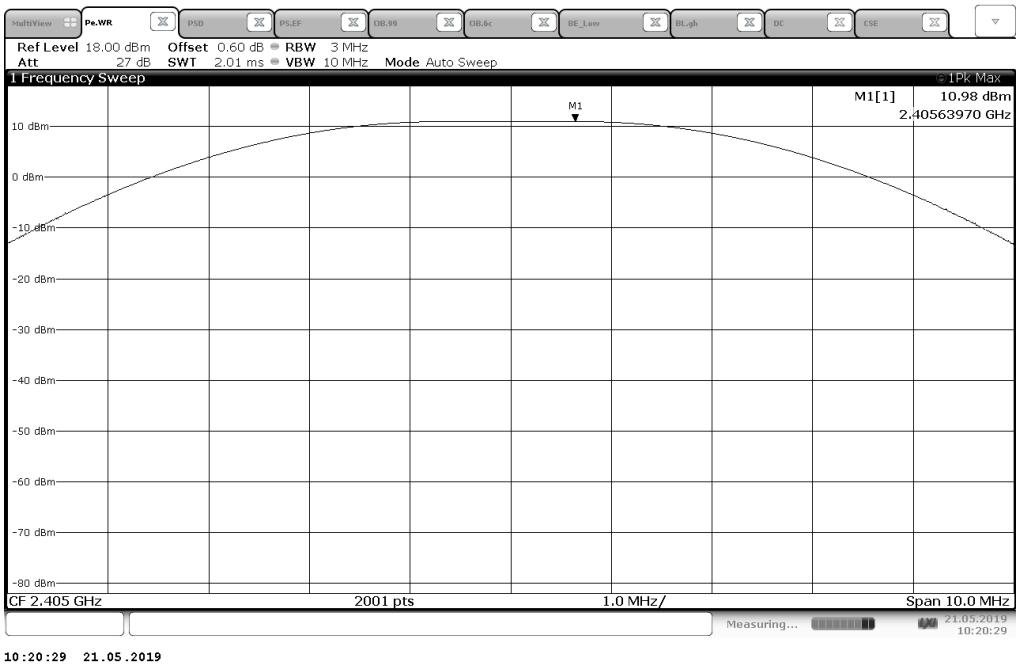


Figure 1 : Peak Output Power – IEEE 802.15.4 - ZIGBEE – 2405MHz

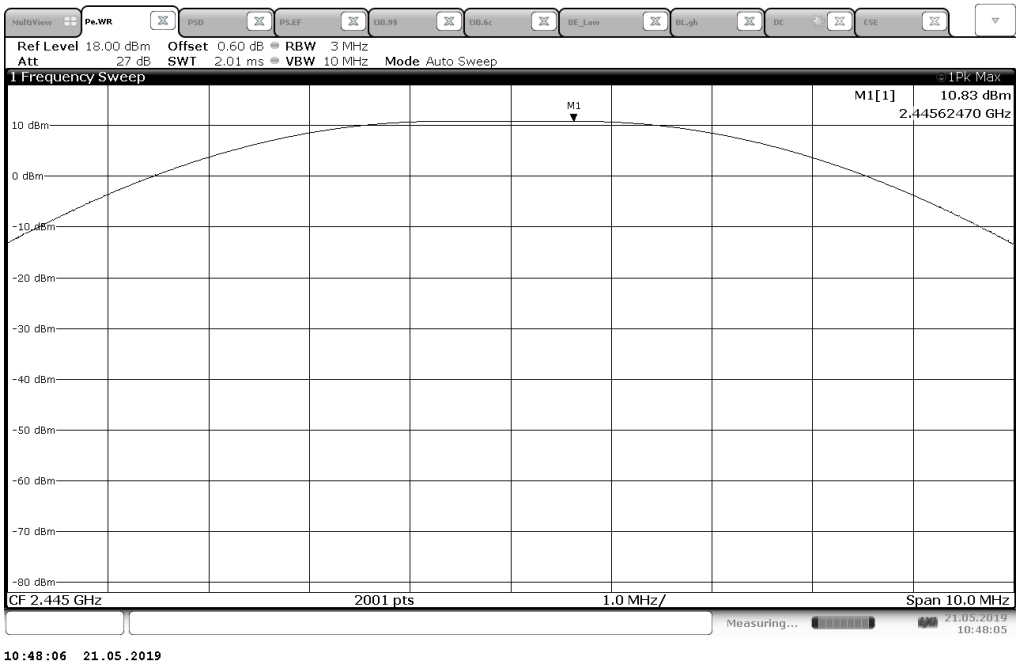


Figure 2 : Peak Output Power – IEEE 802.15.4 - ZIGBEE – 2445MHz

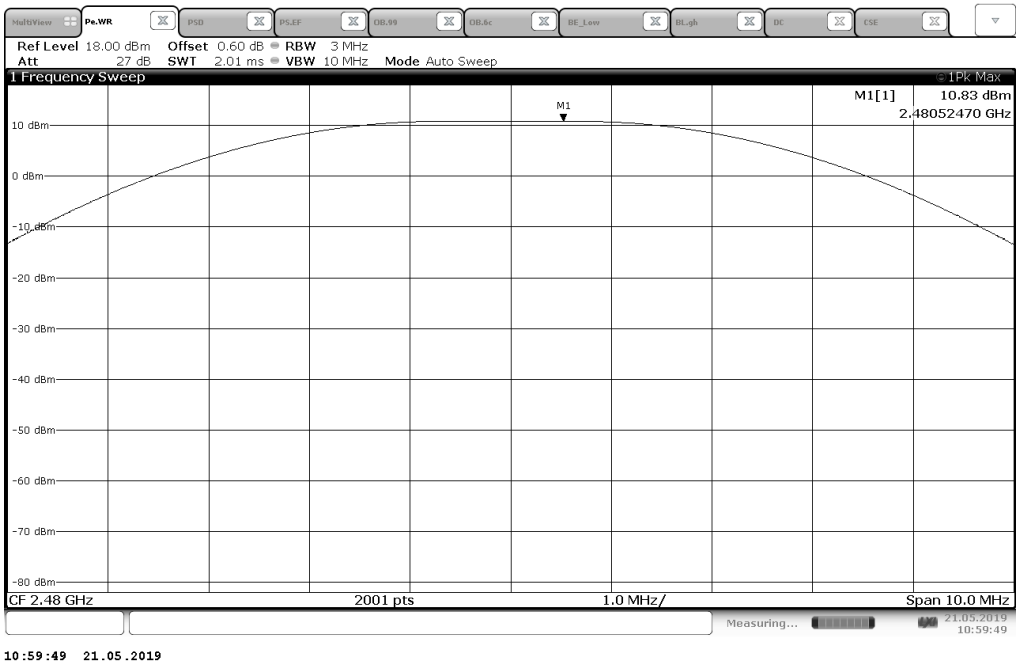


Figure 3 : Peak Output Power – IEEE 802.15.4 - ZIGBEE – 2480MHz

4.2 DTS Bandwidth (6dB)

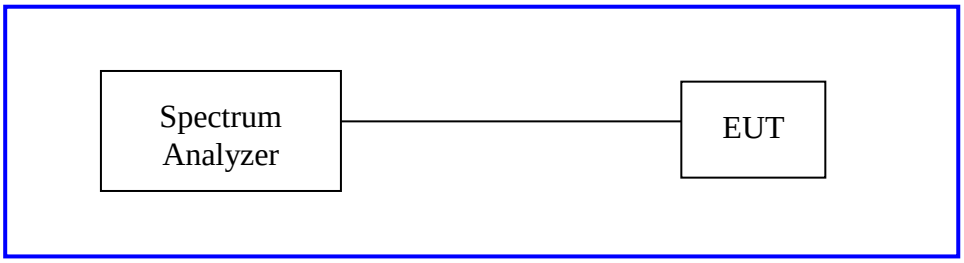
The occupied bandwidth is measured at an amplitude level reduced from the reference level by a specified ratio. The reference level is the level of the highest amplitude signal observed from the transmitter at the fundamental frequency.

The minimum 6 dB bandwidth shall be at least 500 kHz.

4.2.1 Test Method

The conducted method was used to measure the occupied bandwidth and 6 dB bandwidth according to ANSI C63.10:2013 Section 6.9.3 and 11.8.1, respectively. The measurement was performed with modulation per CFR47 15.247(a) (2). Measurements were performed on 3 channels in each operating frequency range; 2400 MHz to 2483.5 MHz.

Test Setup:



4.2.2 Results

As originally tested, the EUT was found to be compliant to the requirements of the test standard(s).

Table 3: Occupied Bandwidth – Test Results – IEEE 802.15.4 - ZigBee

Test Conditions: Conducted Measurement, Normal Temperature			
Antenna Type: whip antenna		**Power Setting:** FW default: Powerlevel 97; power: 104	
Signal State: Modulated			
Ambient Temp.: 21° C		**Relative Humidity:**35.8%	
Bandwidth for IEEE 802.15.4 - ZigBee			
Freq. (MHz)	**6dB Bandwidth (MHz)**	**Limit (MHz)**	**Margin (MHz)**
2405	1.7	0.5	-1.2
2445	1.7	0.5	-1.2
2480	1.7	0.5	-1.2

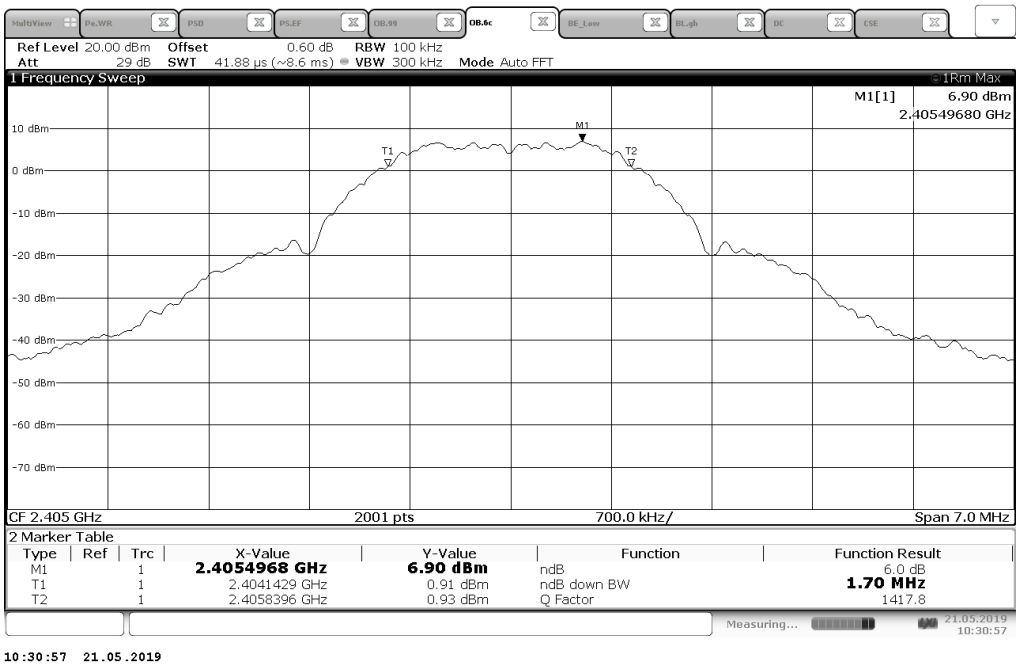


Figure 4 : 6dBc Bandwidth – IEEE 802.15.4 - ZIGBEE – 2405MHz

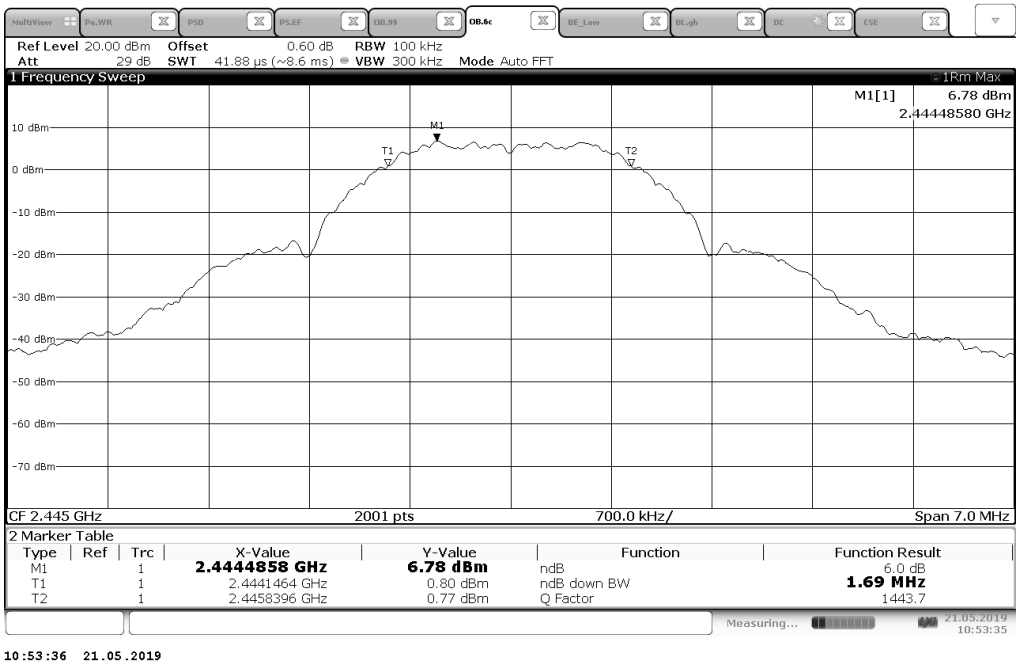


Figure 5 : 6dBc Bandwidth – IEEE 802.15.4 - ZIGBEE – 2445MHz

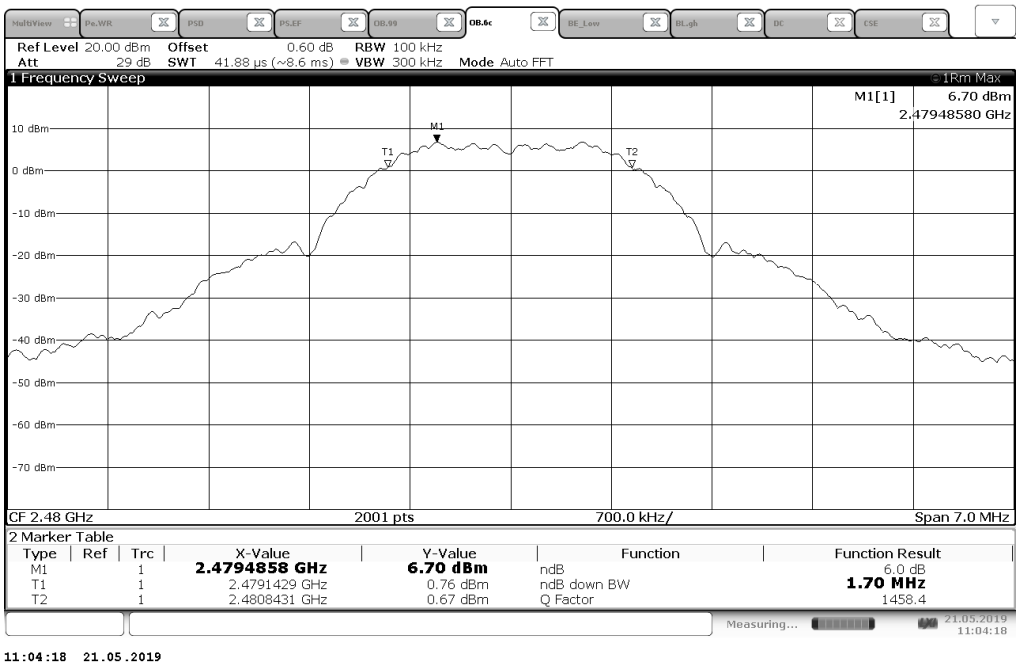


Figure 6 : 6dBc Bandwidth – IEEE 802.15.4 - ZIGBEE – 2480MHz

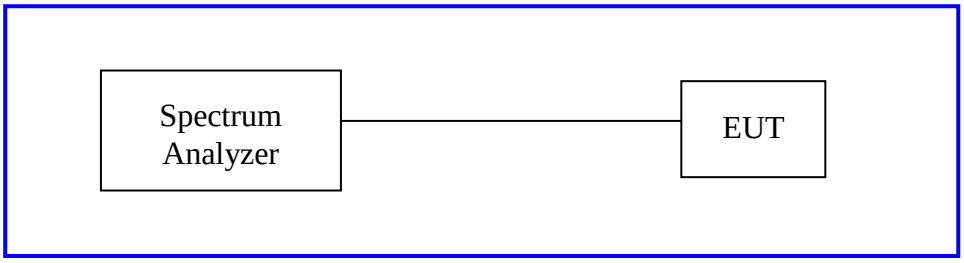
4.3 Peak Power Spectral Density

According to the CFR47 Part 15.247 (e) and RSS 247 Sect.5.2.2, 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.

4.3.1 Test Method

The conducted method was used to measure the channel power output per ANSI C63.10-2013 Section 11.10.2. The measurement was performed with modulation per CFR47 Part 15.247 (e) and RSS 247 Sect.5.2.2.

Test Setup:



4.3.2 Results

As originally tested, the EUT was found to be compliant to the requirements of the test standard(s).

Table 4: Peak Power Spectral Density – Test Results – IEEE 802.15.4 - ZigBee

Test Conditions: Conducted Measurement, Normal Temperature			
Antenna Type: whip antenna		**Power Setting:** FW default: Powerlevel 97; power: 104	
Signal State: Modulated			
Ambient Temp.: 21° C		**Relative Humidity:**35.8%	
Peak Power Spectral Density – IEEE 802.15.4 - ZigBee			
Freq. (MHz)	**Measured PSD [dBm/3kHz]**	**Limit [dBm/3kHz]**	**Margin [dB]**
2405	-4.35	8	12.35
2445	-4.46	8	12.46
2480	-4.49	8	12.49
Note: All insertion loss corrections are accounted for in the measurement plots.			

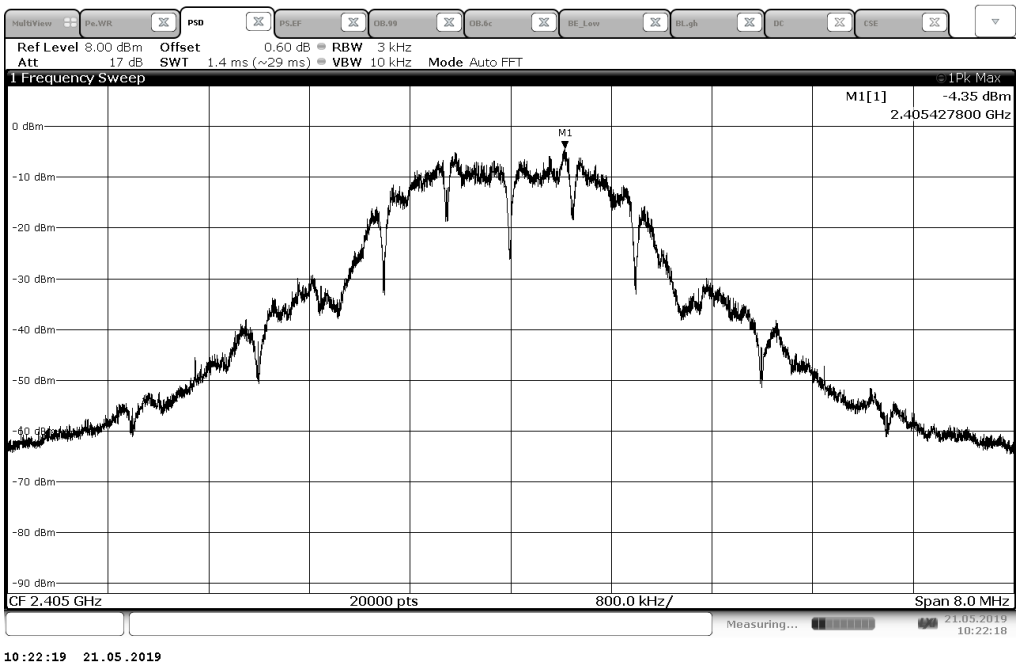


Figure 7: Power Spectral Density – IEEE 802.15.4 - ZIGBEE – 2405 MHz

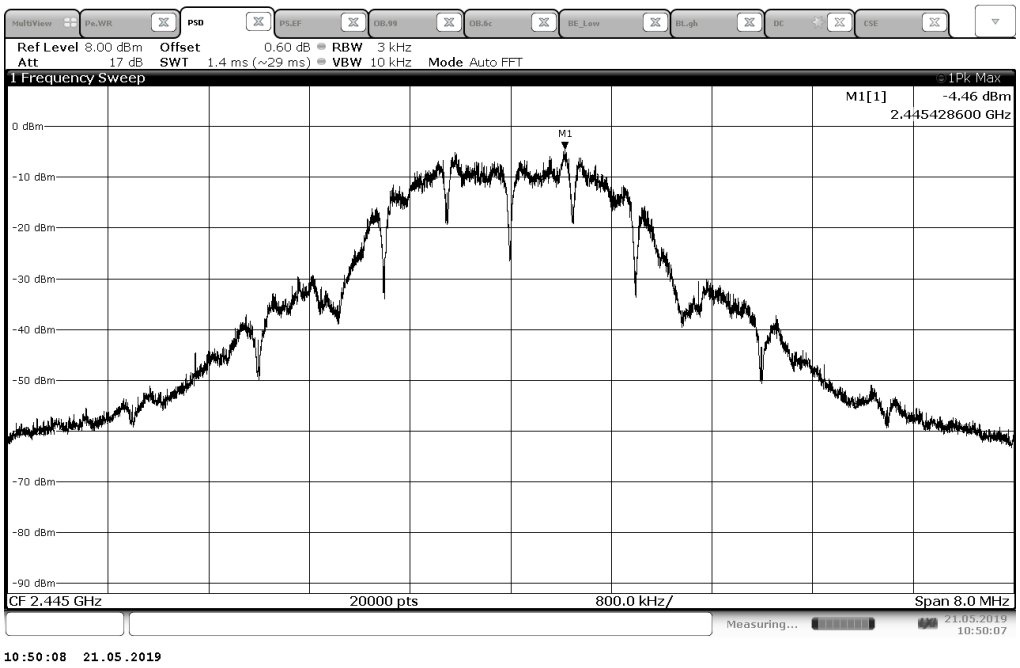


Figure 8: Power Spectral Density – IEEE 802.15.4 - ZIGBEE – 2445 MHz

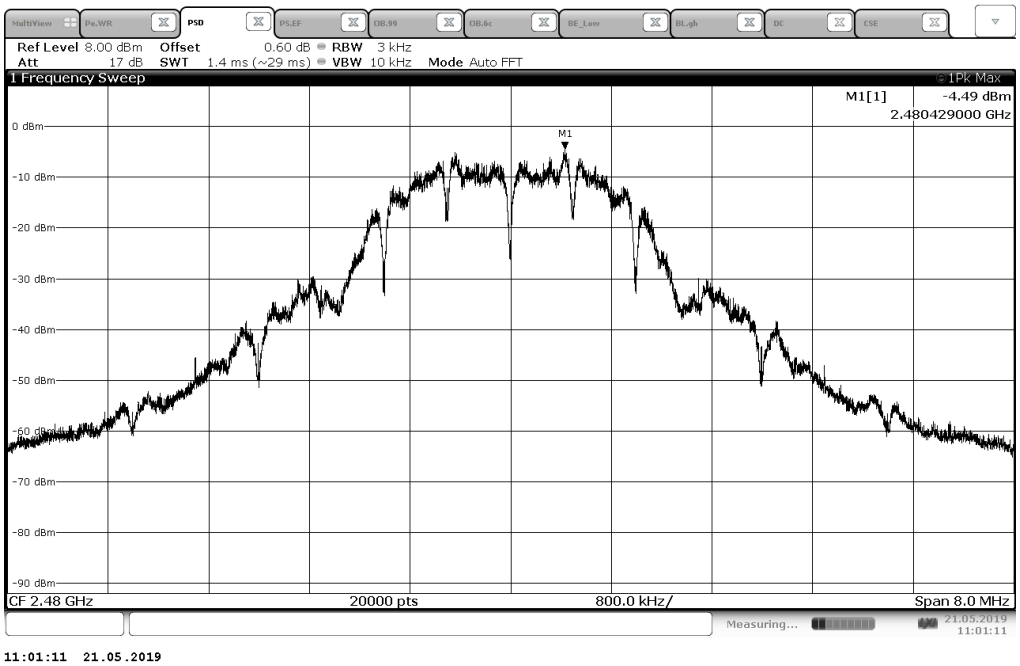


Figure 9: Power Spectral Density – IEEE 802.15.4 - ZIGBEE – 2480 MHz

4.4 Out of Band Emissions- Non-Restricted and Restricted Bands

Transmitter spurious emissions are emissions outside the frequency range of the equipment when the equipment is in transmitting mode; per requirement of CFR47 15.205, 15.209, 15.247(d).

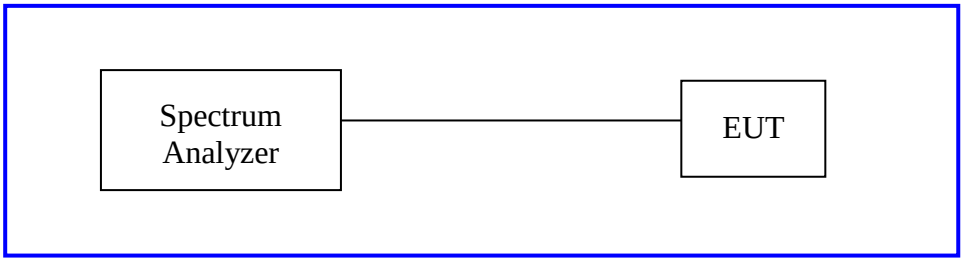
4.4.1 Test Method

The conducted method and radiated method was used to measure the undesirable emission requirement for non-restricted bands. The radiated method was used to measure the undesirable emission requirement for non-restricted bands. The measurement was performed with modulation.

Duty Cycle Measurements were performed according to ANSI 63.10 Section 11.6. Measurements for emissions in nonrestricted frequency bands were performed according to ANSI 63.10-2013 sections 6.10.4 and 11.11.

The utilized test setup for radiated measurements is identical to the described setup for radiated spurious emissions.

4.4.2 Test Setup:



4.4.3 Duty Cycle

The duty cycle of the EUT while operating in each supported mode was measured. Applicable corrections have been applied to emissions measured while operating in modes with a duty cycle less than 98%. Application of the appropriate corrections are in accordance with ANSI 63.10 Section 11.

Mode	Continuous (>98%)	DC Constant?	On Time per period (ms)	Off Time per period (ms)	Period (ms)	Duty Cycle	Duty Cycle Correction Factor (dB)
ZigBee	YES	Yes	100	0	100	1	0

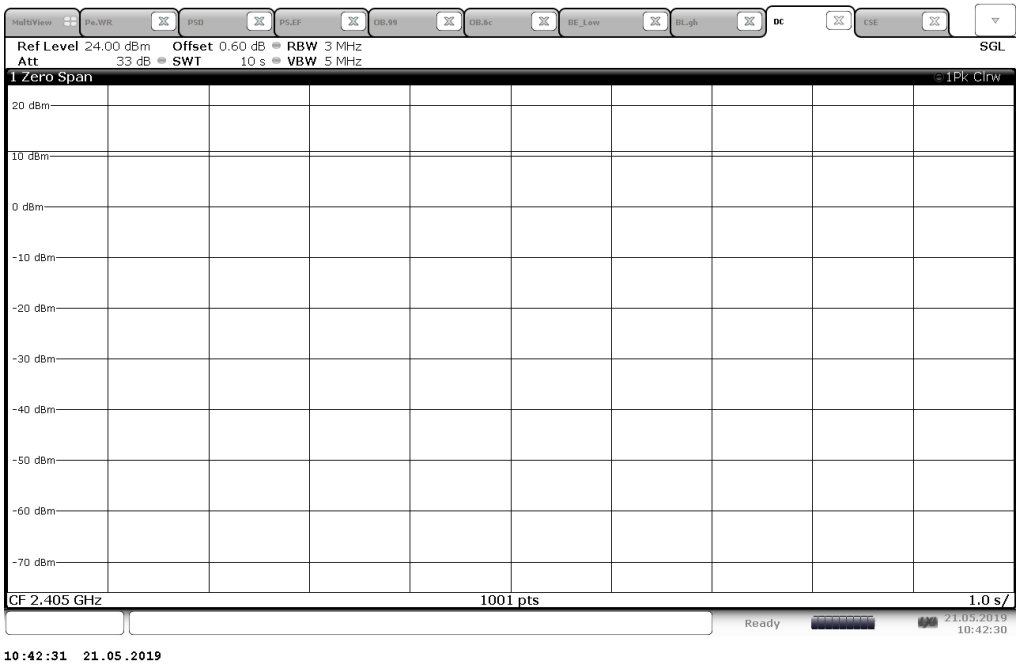


Figure 10: Duty Cycle – IEEE 802.15.4 - ZigBee – 2405 MHz
Note: DC time domain measurement

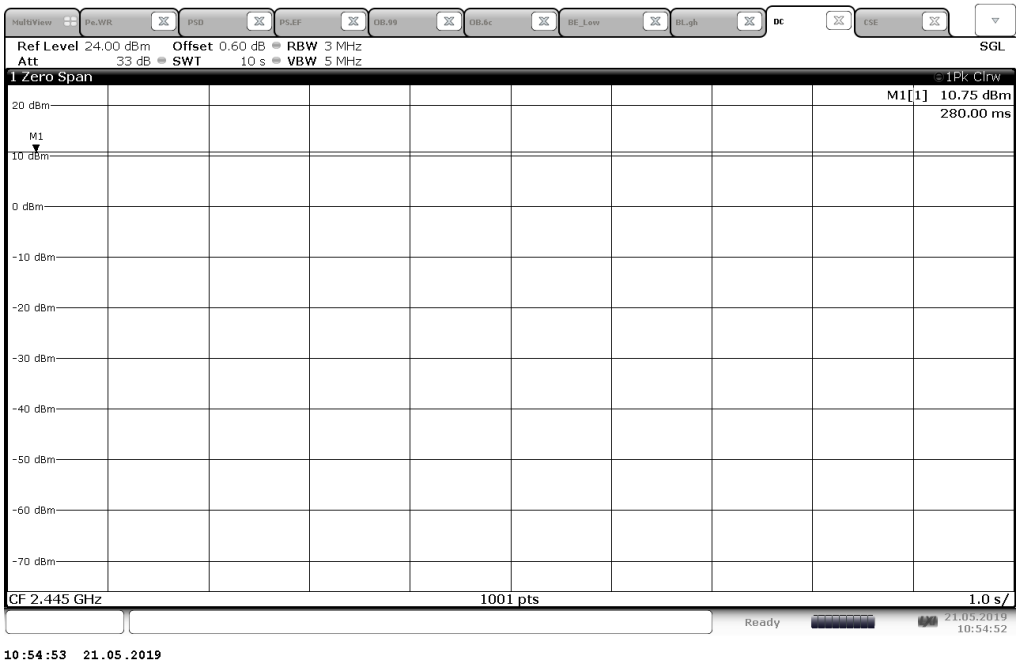


Figure 11: Duty Cycle – IEEE 802.15.4 - ZigBee – 2445 MHz
Note: DC time domain measurement

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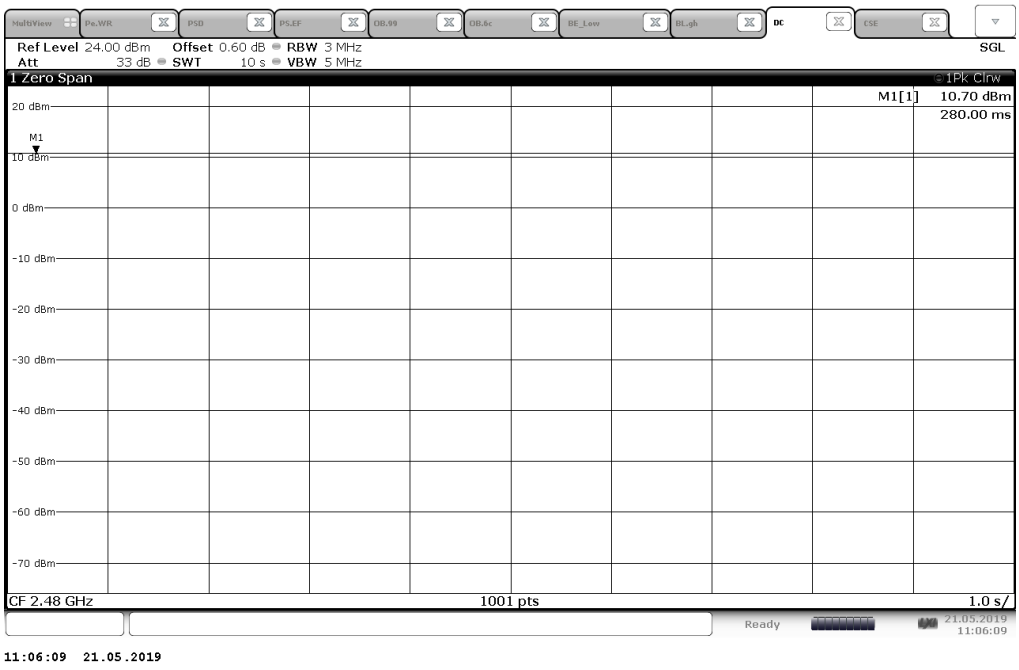

Figure 12: Duty Cycle – IEEE 802.15.4 - ZigBee – 2480 MHz
Note: DC time domain measurement

4.4.4 Results

As originally tested, the EUT was found to be compliant to the requirements of the test standard(s).

4.4.5 Conducted Test results

Table 5: Out of Band Emissions including the Band-Edge – Test Results – IEEE 802.15.4 - ZigBee

Test Conditions: Conducted Measurement, Normal Temperature						
Antenna Type: Chip antenna			**Power Setting:** Power Setting: FW default: Powerlevel 97; power: 104			
Max. Directional Gain: 1 dBi						
Signal State: Modulated						
Ambient Temp.: 21° C			**Relative Humidity:**35.8%			
Non-Restricted Frequency Band Edge Emissions – IEEE 802.15.4 - ZigBee						
Operating Freq. (MHz)	**Measured Freq. (MHz)**	**Measured (dBm)**	**100 kHz RBW Ref Power (dBm)**	**Limit (dBm)**	**Margin (dB)**	**Result**
2405	2400.0	-48.15	6.39	-13.61	-34.54	Pass
2480	2483.5	-45.01	6.39	-13.61	-31.0	Pass
Non-Restricted Frequency Band Emissions – IEEE 802.15.4 - ZigBee						
2405	13535	-44.82	6.39	-13.61	-31.21	Pass
2445	20218	-44.38	6.65	-13.35	-31.03	Pass
2480	18797	-45.66	6.39	-13.61	-32.05	Pass
Note: 1. The stated limits are 20dBc relative to the max output measured with 100kHz bandwidth						

4.4.6 Conducted Plots

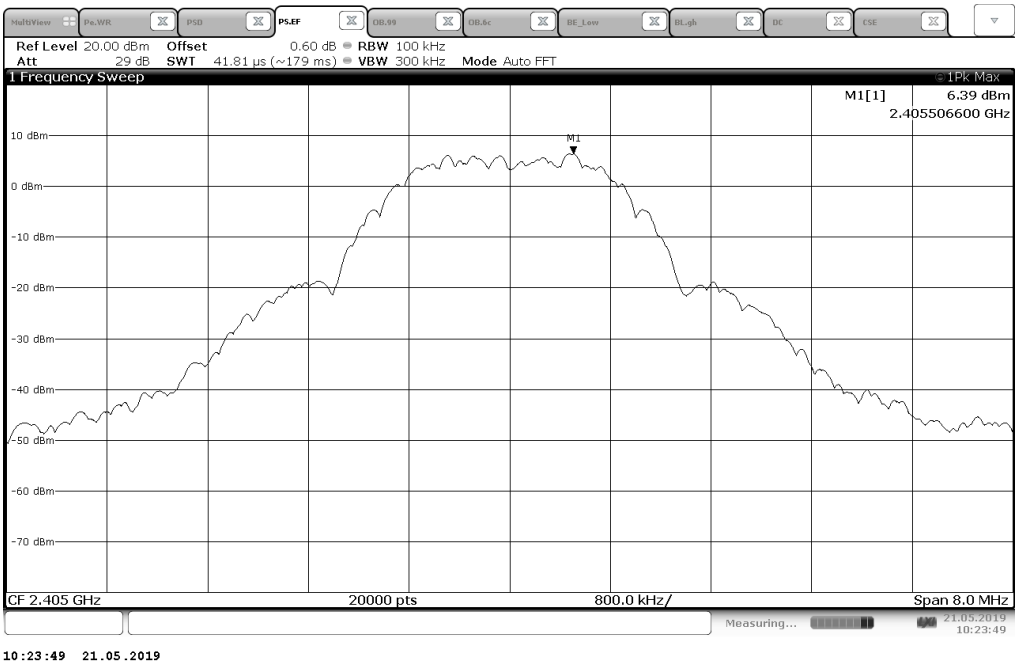

Figure 13 Reference Level – 100kHz RBW power – IEEE 802.15.4 - ZigBee – 2405 MHz

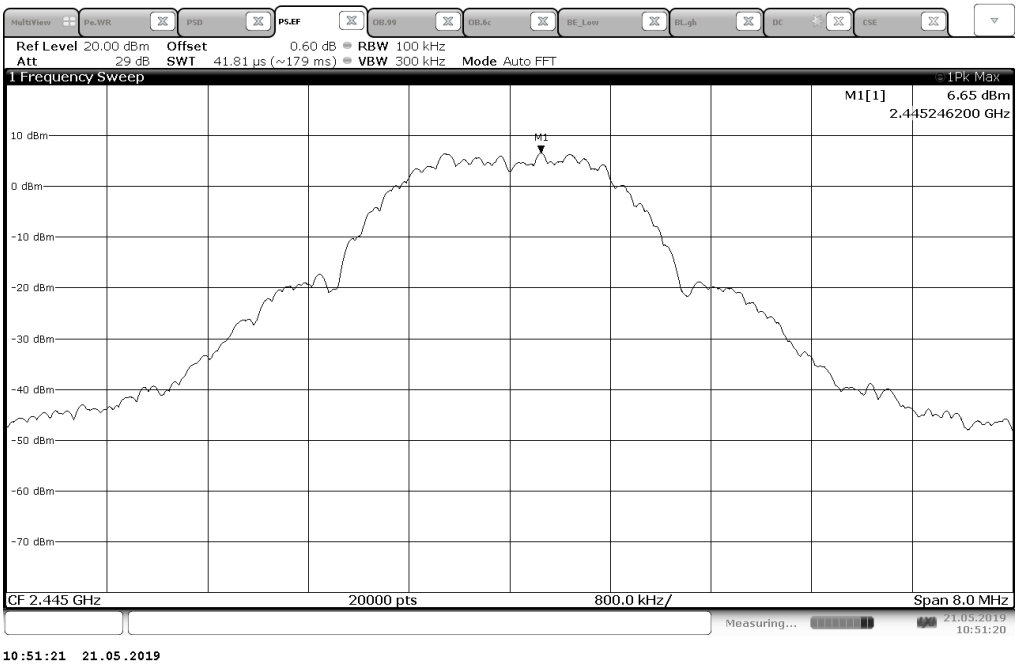

Figure 14: Reference Level – 100kHz RBW power – IEEE 802.15.4 - ZigBee – 2445 MHz

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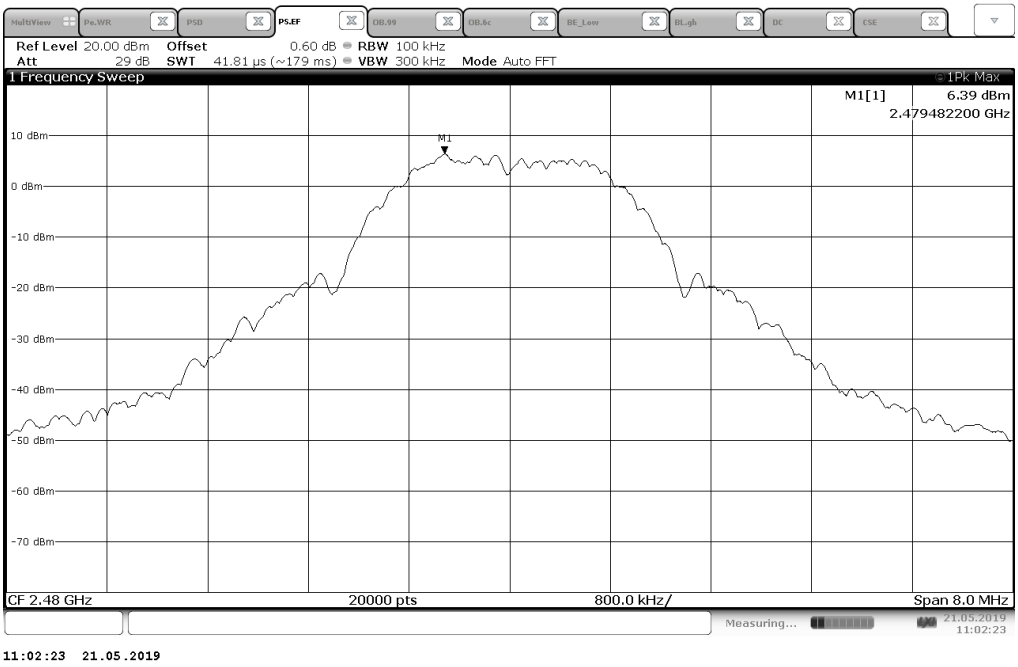

Figure 15: Reference Level – 100kHz RBW power – IEEE 802.15.4 - ZigBee – 2480 MHz

Figure 16: Lower Band Edge – IEEE 802.15.4 - ZIGBEE – 2405 MHz

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Tel: (925) 249-9123, Fax: (925) 249-9124

Figure 17: Upper Band Edge – IEEE 802.15.4 - ZIGBEE – 2480 MHz

1279 Quarry Lane, Ste. A, Pleasanton, CA 95466
Tel: (925) 249-9123, Fax: (925) 249-9124

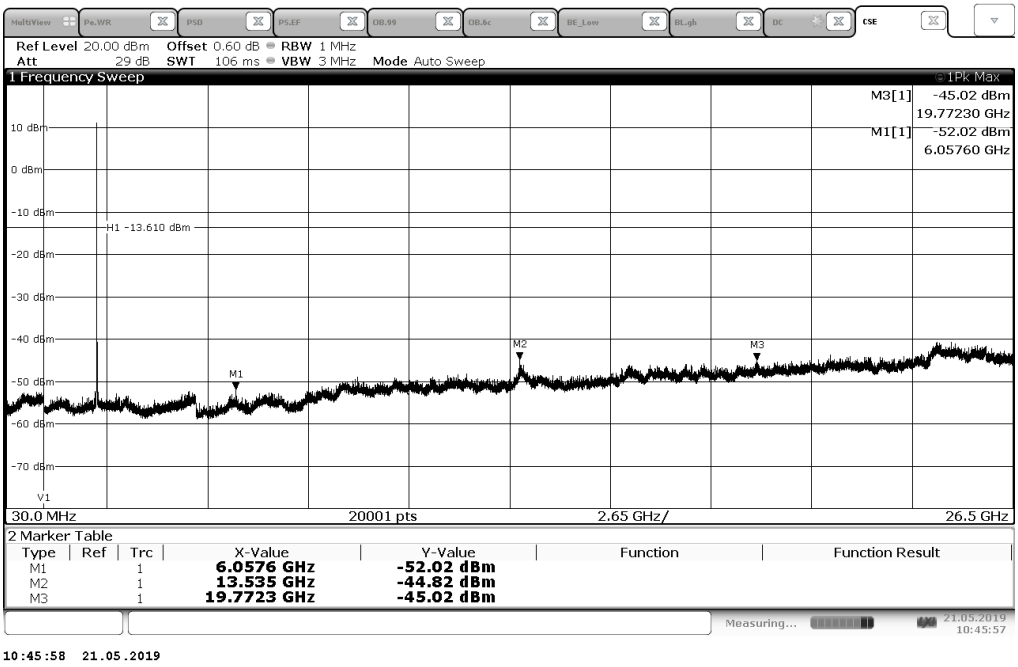


Figure 18: Conducted Emissions – IEEE 802.15.4 - ZIGBEE – 2405 MHz

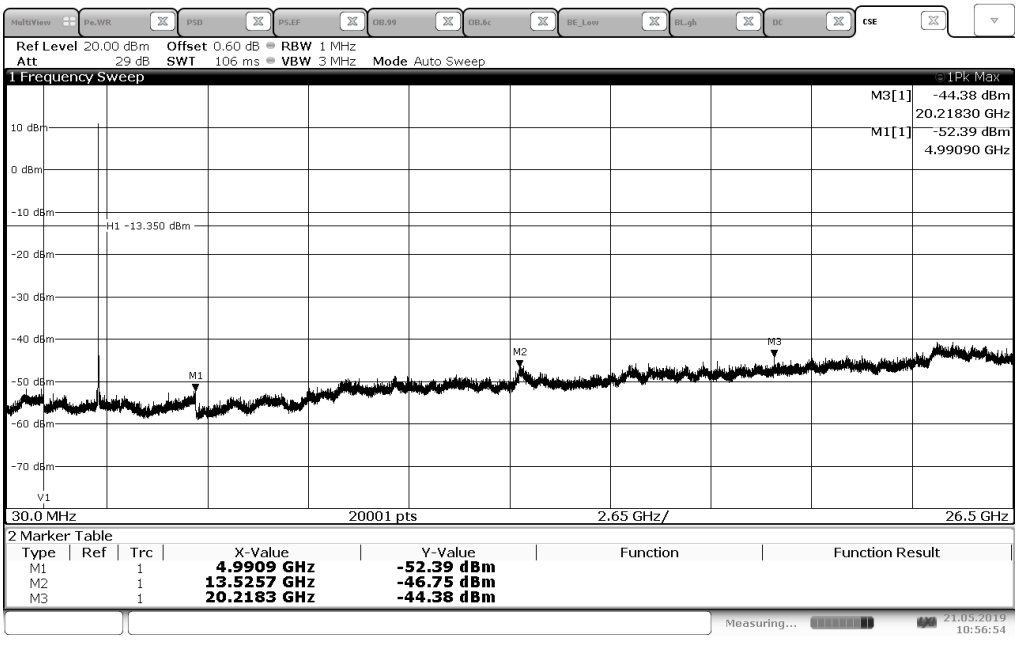


Figure 19: Conducted Emissions – IEEE 802.15.4 - ZIGBEE – 2445 MHz

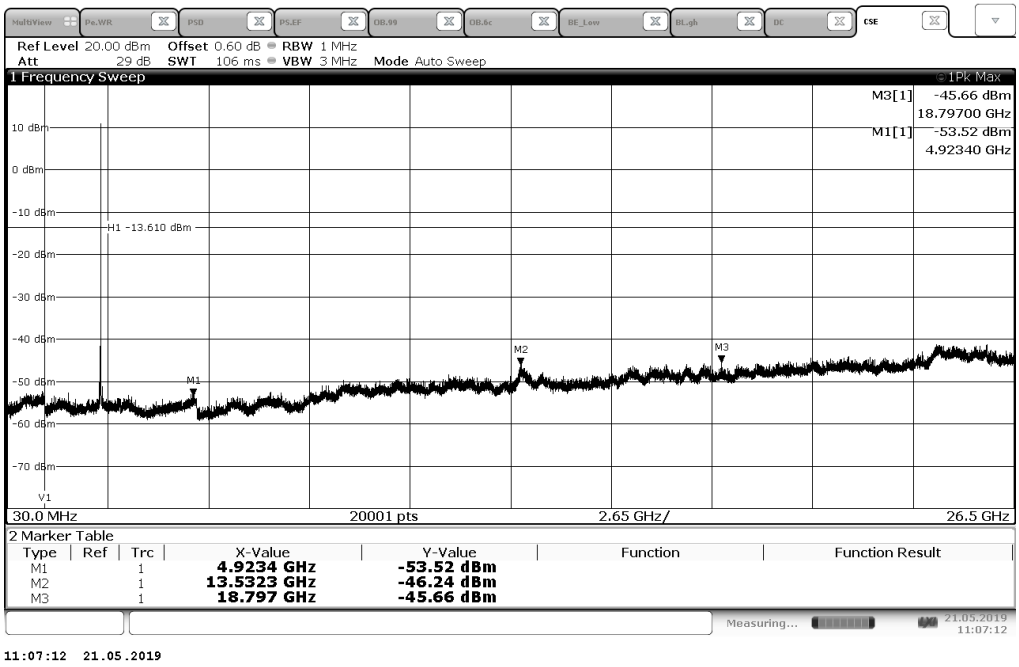


Figure 20: Conducted Emissions – IEEE 802.15.4 - ZIGBEE – 2480 MHz

4.4.7 Radiated Plots

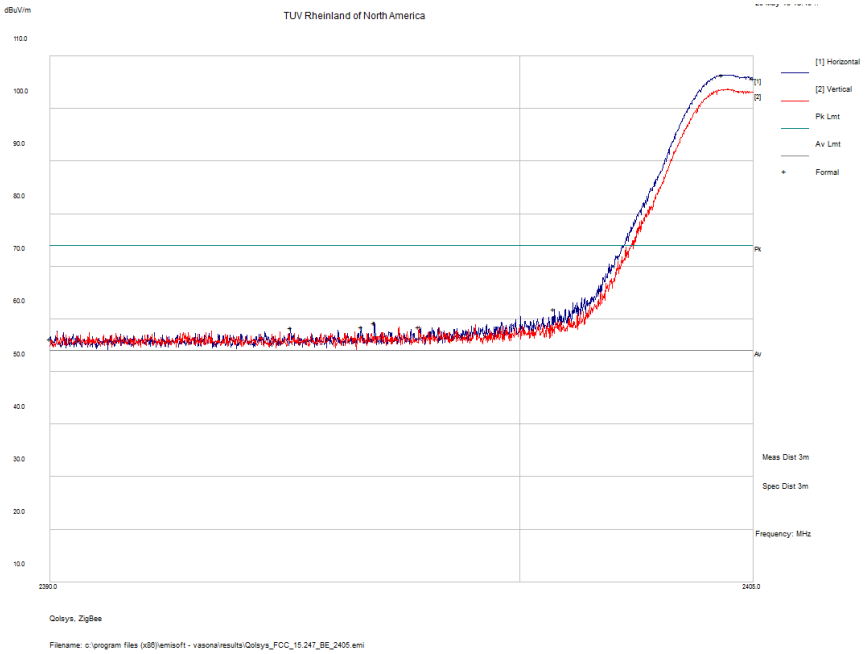


Figure 21: Lower Band Edge (Radiated) – IEEE 802.15.4 - ZIGBEE – 2405 MHz – Peak detector

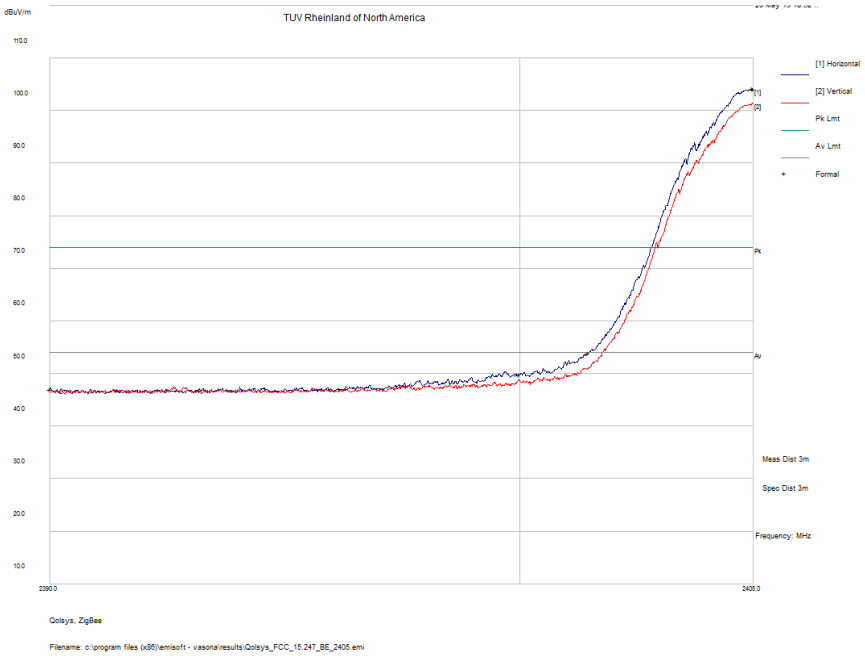


Figure 22: Lower Band Edge (Radiated) – IEEE 802.15.4 - ZIGBEE – 2405 MHz – Average Detector

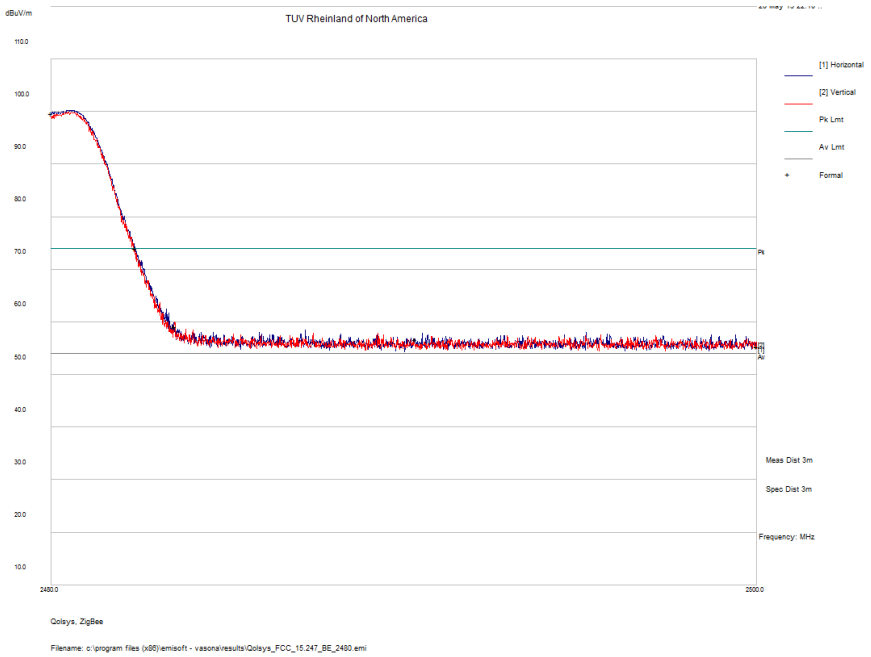


Figure 23: Lower Band Edge (Radiated) – IEEE 802.15.4 - ZIGBEE – 2480 MHz – Peak detector

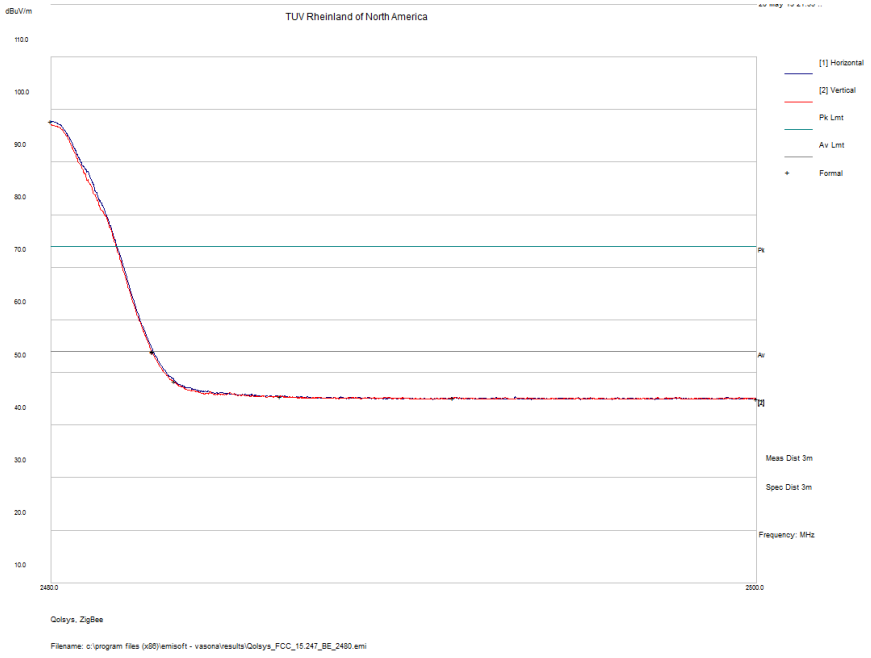


Figure 24: Lower Band Edge (Radiated) – IEEE 802.15.4 - ZIGBEE – 2480 MHz – Average Detector

4.5 Transmit Radiated Spurious Emissions

Transmitter spurious emissions are emissions outside the frequency range of the equipment when the equipment is in transmit mode; per requirement of CFR47 15.205, 15.209, 15.247(d).

4.5.1 Test Methodology

4.5.1.1 Preliminary Test

A test program that controls instrumentation and data logging was used to automate the preliminary RF emissions test procedure. The frequency range of interest was divided into sub-ranges. For each sub-range peak emission data was recorded and plotted while the turntable was rotated 360° in 90° steps and the measurement antenna was rotated in horizontal and vertical antenna polarization. For scan rage 9 kHz to 30 MHz, the measurement is executed with an active loop antenna in 0° and 90° orientation.

Preliminary emission profile testing was performed inside a semi-anechoic chamber. The EUT was placed on a non-conductive table 80 cm above the floor for emissions less than 1 GHz and 150cm above the floor for emissions greater than 1 GHz. The EUT was positioned as shown in the setup photographs. The measurement antenna was placed at a distance of 3m.

4.5.1.2 Final Test

Final testing was performed on an NSA compliant test site.

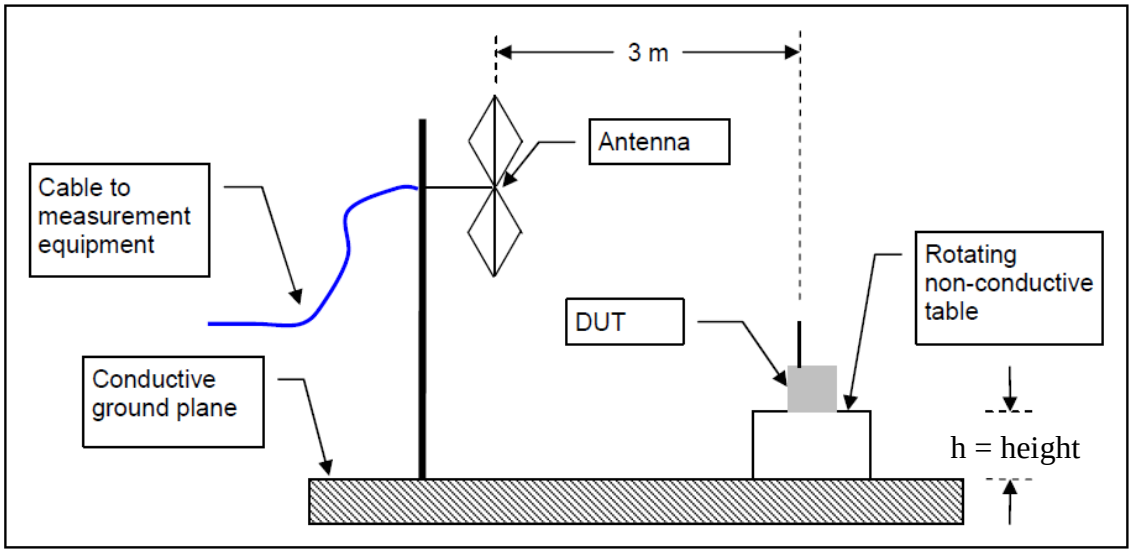
For each frequency measured in scan range 30 MHz to 25 GHz, the peak emission was maximized by manipulating the receiving antenna from 1 to 4 meters above the ground plane and placing it at the position that produced the maximum signal strength reading. The turntable was then rotated through 360° while observing the peak signal and placing the EUT at the position that produced maximum radiation. Preliminary emissions within 10 dB of the limit were measured.

The final scans were performed on the worst EUT axis for three operating channels in the operating mode with the highest power.

4.5.1.3 Deviations

None.

Test Setup:



Where h = 80cm for <1GHz and 150cm for >1GHz

4.5.2 Transmitter Spurious Emission Limit

The spurious emissions of the transmitter shall not exceed the values in CFR47 Part 15.205, 15.209.

Frequency (MHz)	Field strength (microvolts/meter)	Measurement distance (meters)
0.009-0.490	2400/F(kHz)	300
0.490-1.705	24000/F(kHz)	30
1.705-30.0	30	30
30-88	100 **	3
88-216	150 **	3
216-960	200 **	3
Above 960	500	3

All harmonics and spurious emission which are outside of the restricted band shall be 20dB below the in-band emission.

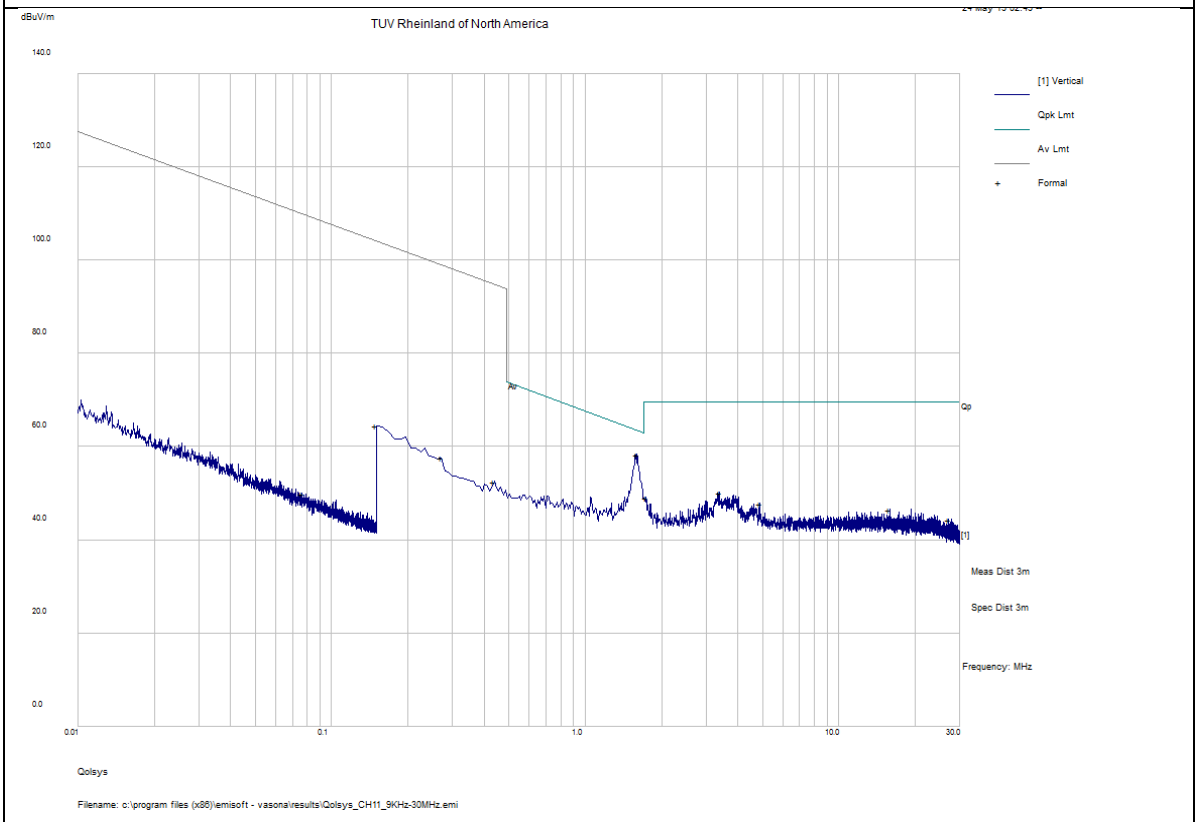
4.5.3 Test Results

The final measurement data was taken under the worst case operating modes, configurations, and/or cable positions. It also reflects the results including any modifications and/or special accessories listed in Sections 1.4 and test plan.

As originally tested, the EUT was found to be compliant to the requirements of the test standard(s).

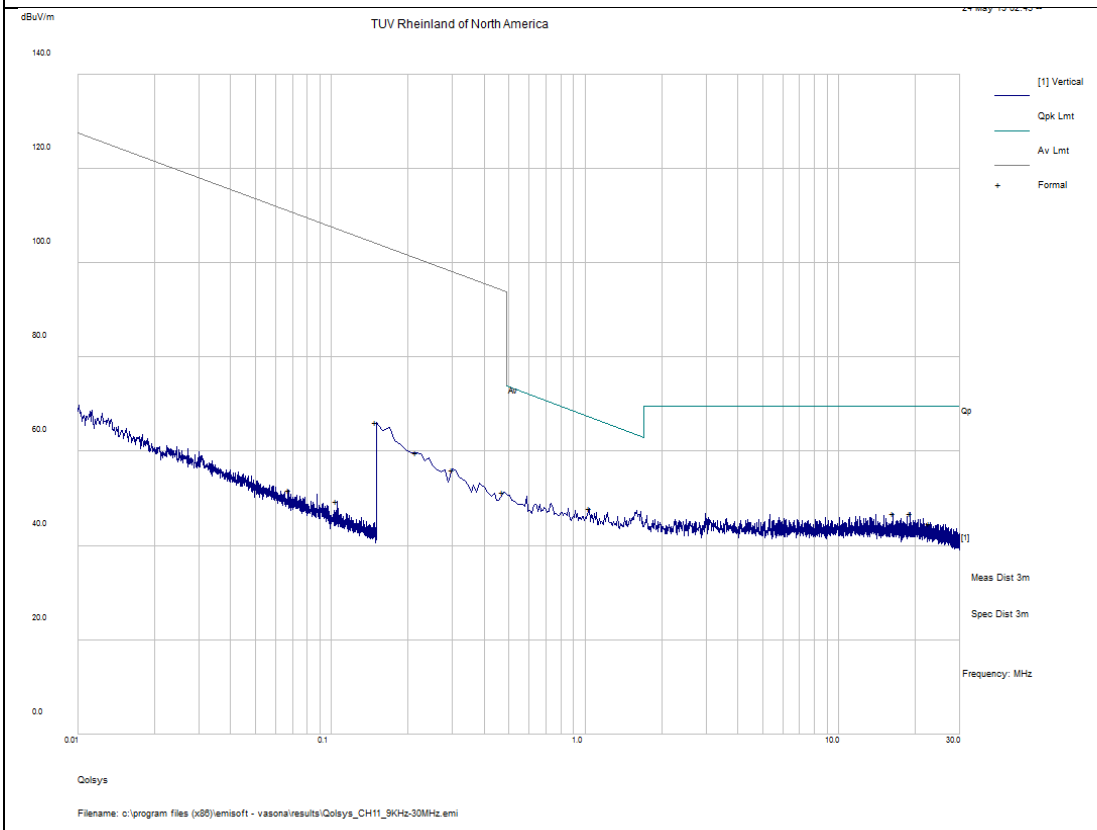
Radiated spurious emissions - FCC 15.247 Transmitter – 9kHz – 30 MHz:

Radiated Emissions – 9 kHz – 30 MHz - Transmit at 2405 MHz (Low Channel)			
EUT Name	Qolsys Zigbee Radio Card	**Temp / Hum in**	21° C / 36%rh
EUT Model	QS-ZB	**Line AC / Freq**	N/A – Battery operated
EUT Config.	2405MHz	**RBW / VBW**	Setting: 9 kHz to 150 kHz: RBW = 200Hz, VBW = 1kHz 150 kHz to 30 MHz: RBW = 9kHz, VBW = 30kHz
Standard	CFR47 Part 15.247	**Performed by**	Abraham Avalos
Antenna:	0 degree	**Dist/Ant Used**	3m/ Active Loop



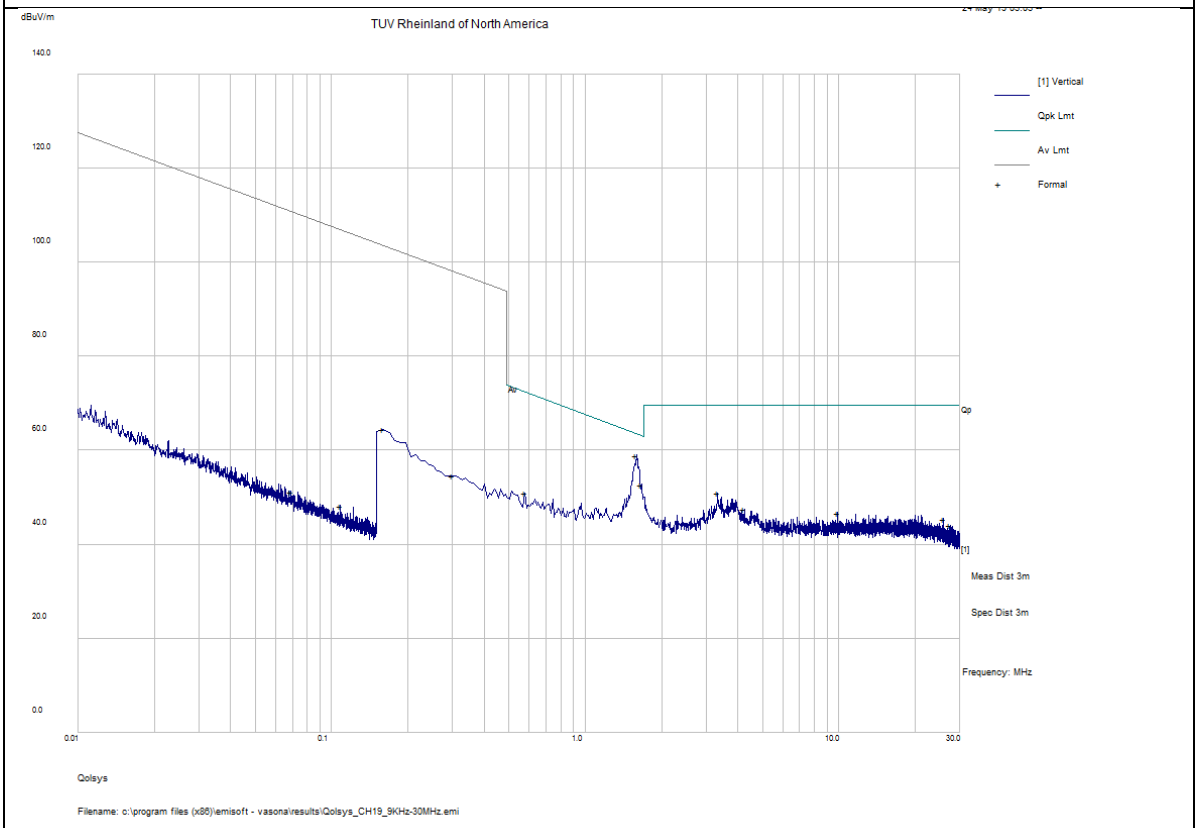
Note: Peak emissions below AVG\QP limit. No final measurement executed for <30 MHz.

Radiated Emissions – 9 kHz – 30 MHz - Transmit at 2405 MHz (Low Channel)			
EUT Name	Qolsys Zigbee Radio Card	**Temp / Hum in**	21° C / 36%rh
EUT Model	QS-ZB	**Line AC / Freq**	N/A – Battery operated
EUT Config.	2405MHz	**RBW / VBW**	Setting: 9 kHz to 150 kHz: RBW = 200Hz, VBW = 1kHz 150 kHz to 30 MHz: RBW = 9kHz, VBW = 30kHz
Standard	CFR47 Part 15.247	**Performed by**	Abraham Avalos
Antenna:	90 degree	**Dist/Ant Used**	3m/ Active Loop



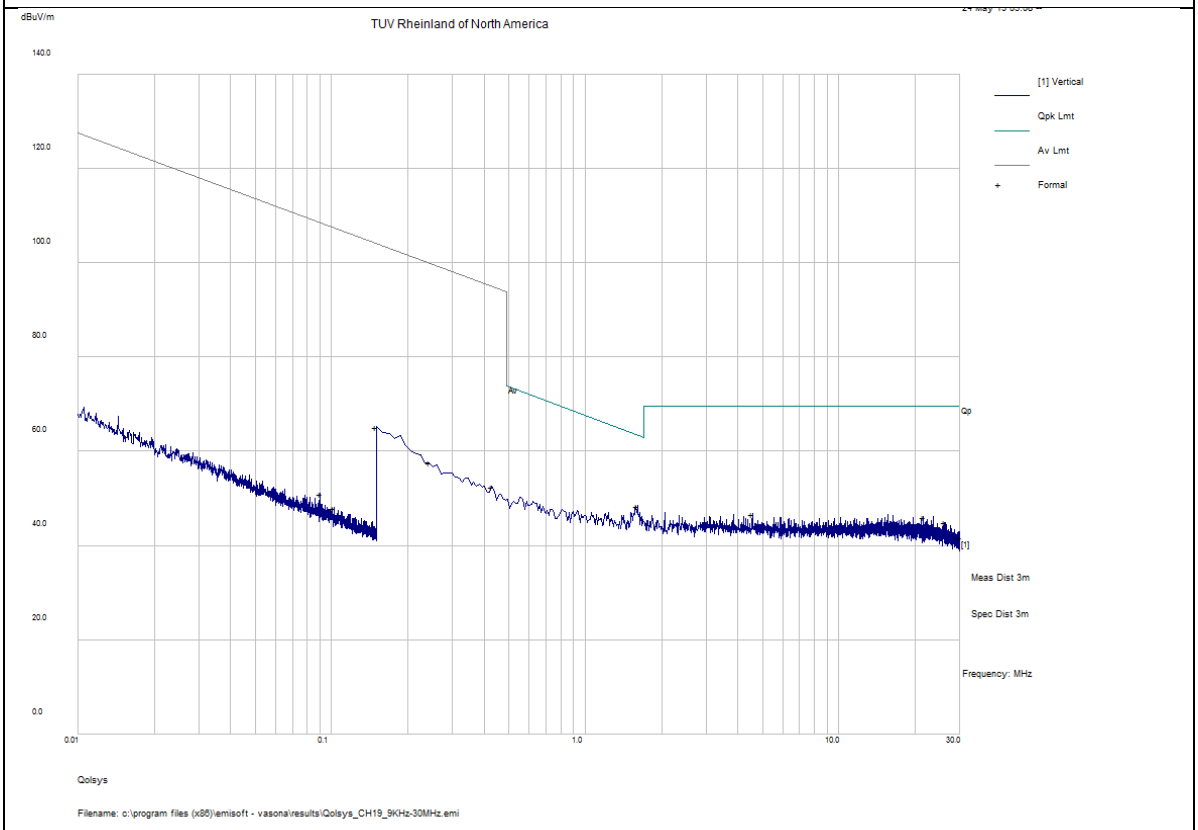
Note: Peak emissions below AVG\QP limit. No final measurement executed for <30 MHz.

Radiated Emissions – 9 kHz – 30 MHz - Transmit at 2445 MHz (Mid Channel)			
EUT Name	Qolsys Zigbee Radio Card	**Temp / Hum in**	21° C / 36%rh
EUT Model	QS-ZB	**Line AC / Freq**	N/A – Battery operated
EUT Config.	2445MHz	**RBW / VBW**	Setting: 9 kHz to 150 kHz: RBW = 200Hz, VBW = 1kHz 150 kHz to 30 MHz: RBW = 9kHz, VBW = 30kHz
Standard	CFR47 Part 15.247	**Performed by**	Abraham Avalos
Antenna:	0 degree	**Dist/Ant Used**	3m/ Active Loop



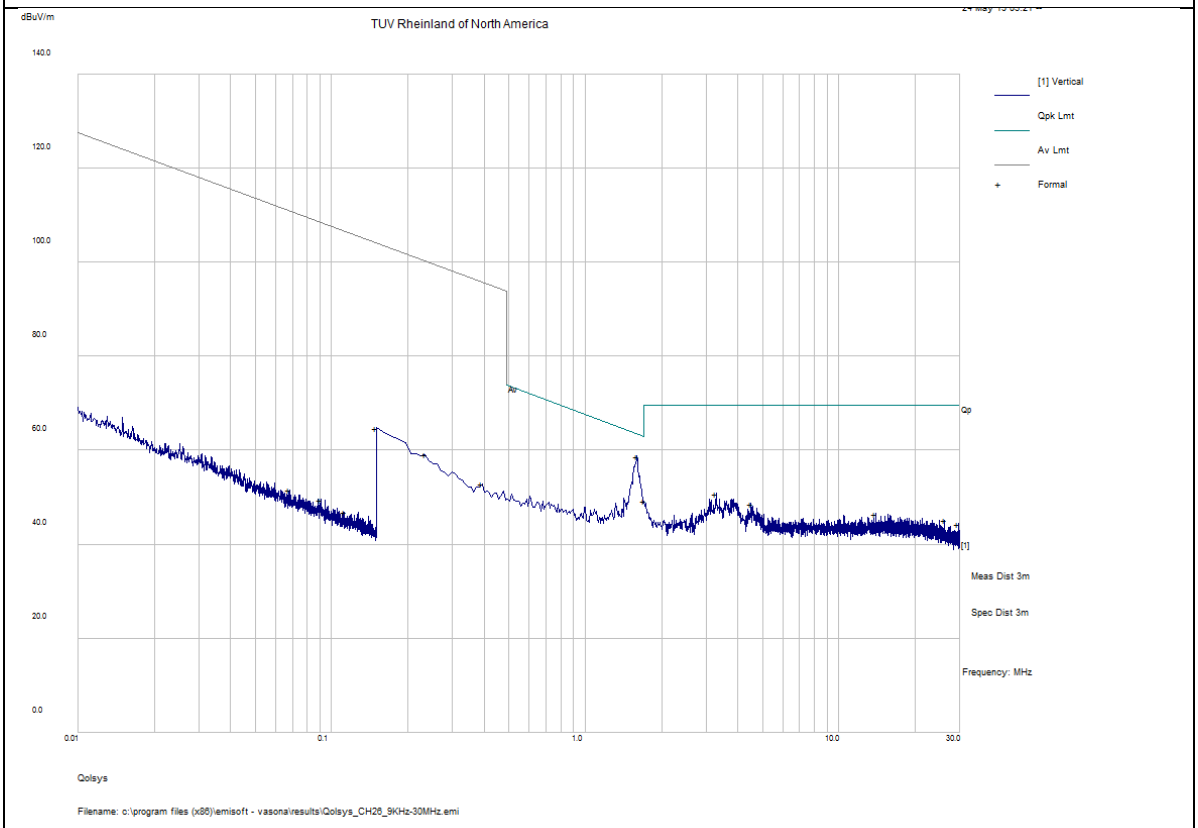
Note: Peak emissions below AVG\QP limit. No final measurement executed for <30 MHz.

Radiated Emissions – 9 kHz – 30 MHz - Transmit at 2445 MHz (Mid Channel)			
EUT Name	Qolsys Zigbee Radio Card	**Temp / Hum in**	21° C / 36%rh
EUT Model	QS-ZB	**Line AC / Freq**	N/A – Battery operated
EUT Config.	2445MHz	**RBW / VBW**	Setting: 9 kHz to 150 kHz: RBW = 200Hz, VBW = 1kHz 150 kHz to 30 MHz: RBW = 9kHz, VBW = 30kHz
Standard	CFR47 Part 15.247	**Performed by**	Abraham Avalos
Antenna:	90 degree	**Dist/Ant Used**	3m/ Active Loop



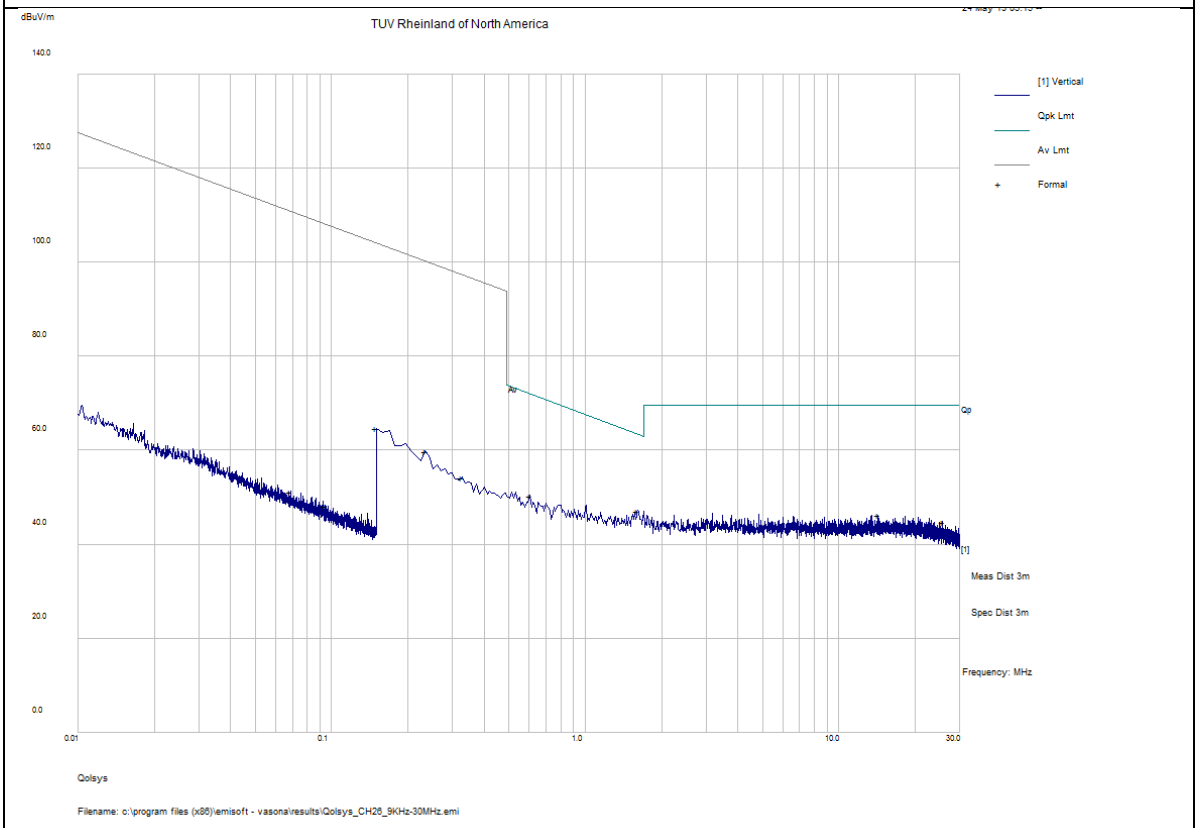
Note: Peak emissions below AVG\QP limit. No final measurement executed for <30 MHz.

Radiated Emissions – 9 kHz – 30 MHz - Transmit at 2480 MHz (High Channel)			
EUT Name	Qolsys Zigbee Radio Card	**Temp / Hum in**	21° C / 36%rh
EUT Model	QS-ZB	**Line AC / Freq**	N/A – Battery operated
EUT Config.	2480MHz	**RBW / VBW**	Setting: 9 kHz to 150 kHz: RBW = 200Hz, VBW = 1kHz 150 kHz to 30 MHz: RBW = 9kHz, VBW = 30kHz
Standard	CFR47 Part 15.247	**Performed by**	Abraham Avalos
Antenna:	0 degree	**Dist/Ant Used**	3m/ Active Loop



Note: Peak emissions below AVG\QP limit. No final measurement executed for <30 MHz.

Radiated Emissions – 9 kHz – 30 MHz - Transmit at 2480 MHz (High Channel)			
EUT Name	Qolsys Zigbee Radio Card	**Temp / Hum in**	21° C / 36%rh
EUT Model	QS-ZB	**Line AC / Freq**	N/A – Battery operated
EUT Config.	2480MHz	**RBW / VBW**	Setting: 9 kHz to 150 kHz: RBW = 200Hz, VBW = 1kHz 150 kHz to 30 MHz: RBW = 9kHz, VBW = 30kHz
Standard	CFR47 Part 15.247	**Performed by**	Abraham Avalos
Antenna:	90 degree	**Dist/Ant Used**	3m/ Active Loop

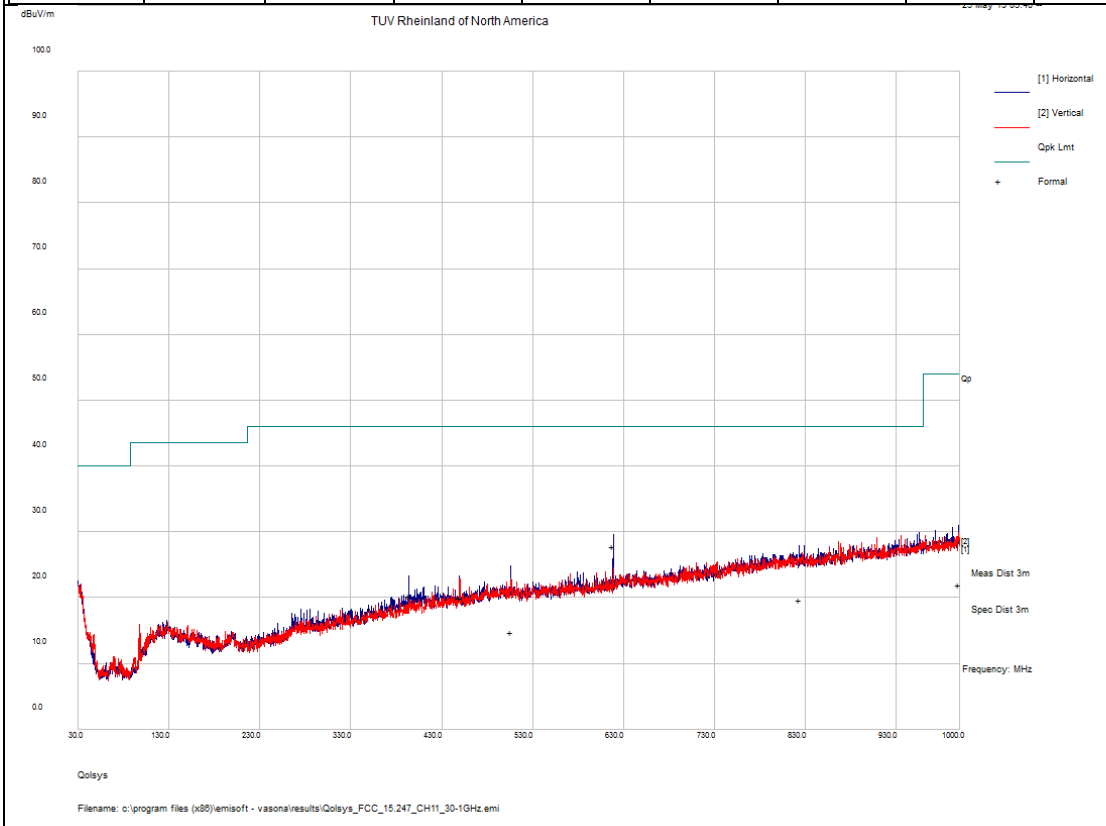


Note: Peak emissions below AVG\QP limit. No final measurement executed for <30 MHz.

Radiated spurious emissions - FCC 15.247 Transmitter – 30 MHz – 1 GHz:

Radiated Emissions - 30MHz– 1 GHz Transmit at 2405 MHz (Low Channel)			
EUT Name	Qolsys Zigbee Radio Card	**Temp / Hum in**	21° C / 36%rh
EUT Model	QS-ZB	**Line AC / Freq**	N/A – Battery operated
EUT Config.	2405MHz - Horizontal	**RBW / VBW**	100KHz/ 300KHz
Standard	CFR47 Part 15.247	**Performed by**	Abraham Avalos
		Dist/Ant Used	3m/ JB3

Frequency	Level	Detector	Polarity	Height	Azimuth	Limit	Margin	Result
MHz	dBuV/m		H/V	cm	deg	dBuV/m	dB	
393.71	20.33	QP	H	245	360	46.00	-25.67	Pass
450.01	19.94	QP	H	183	252	46.00	-26.06	Pass
506.42	14.71	QP	H	266	0	46.00	-31.29	Pass
618.69	27.82	QP	H	117	316	46.00	-18.18	Pass
823.36	19.71	QP	H	200	84	46.00	-26.29	Pass
998.72	22.00	QP	H	105	196	54.00	-32.00	Pass

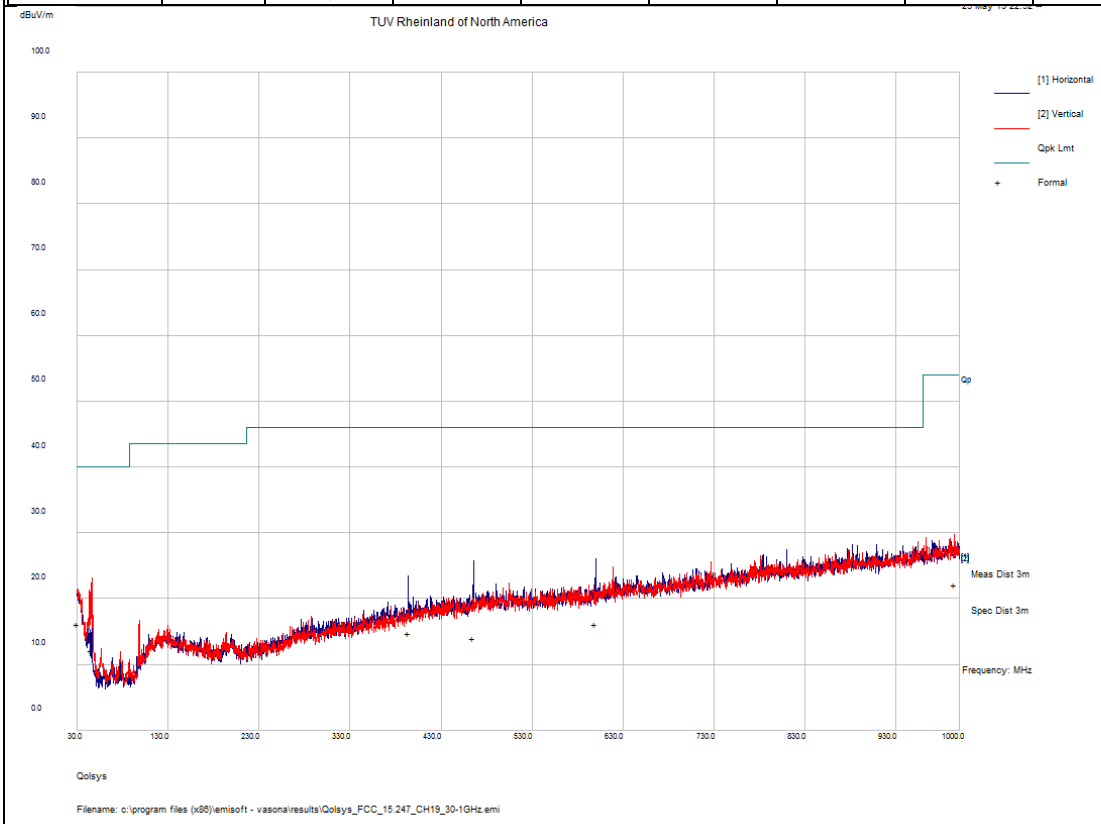


Note: -

Radiated Emissions - 30MHz– 1 GHz Transmit at 2445 MHz (Mid Channel)

EUT Name	Qolsys Zigbee Radio Card	**Temp / Hum in**	21° C / 36%rh
EUT Model	QS-ZB	**Line AC / Freq**	N/A – Battery operated
EUT Config.	2445 MHz - Horizontal	**RBW / VBW**	100KHz/ 300KHz
Standard	CFR47 Part 15.247	**Performed by**	Abraham Avalos
		Dist/Ant Used	3m/ JB3

Frequency	Level	Detector	Polarity	Height	Azimuth	Limit	Margin	Result
MHz	dBuV/m		H/V	cm	deg	dBuV/m	dB	
30.56	16.21	QP	V	160	74	40.00	-23.79	Pass
45.97	12.18	QP	V	109	130	40.00	-27.82	Pass
393.94	14.73	QP	H	271	166	46.00	-31.27	Pass
465.72	14.03	QP	H	315	164	46.00	-31.97	Pass
599.97	16.13	QP	H	198	92	46.00	-29.87	Pass
994.34	22.09	QP	V	226	296	54.00	-31.91	Pass

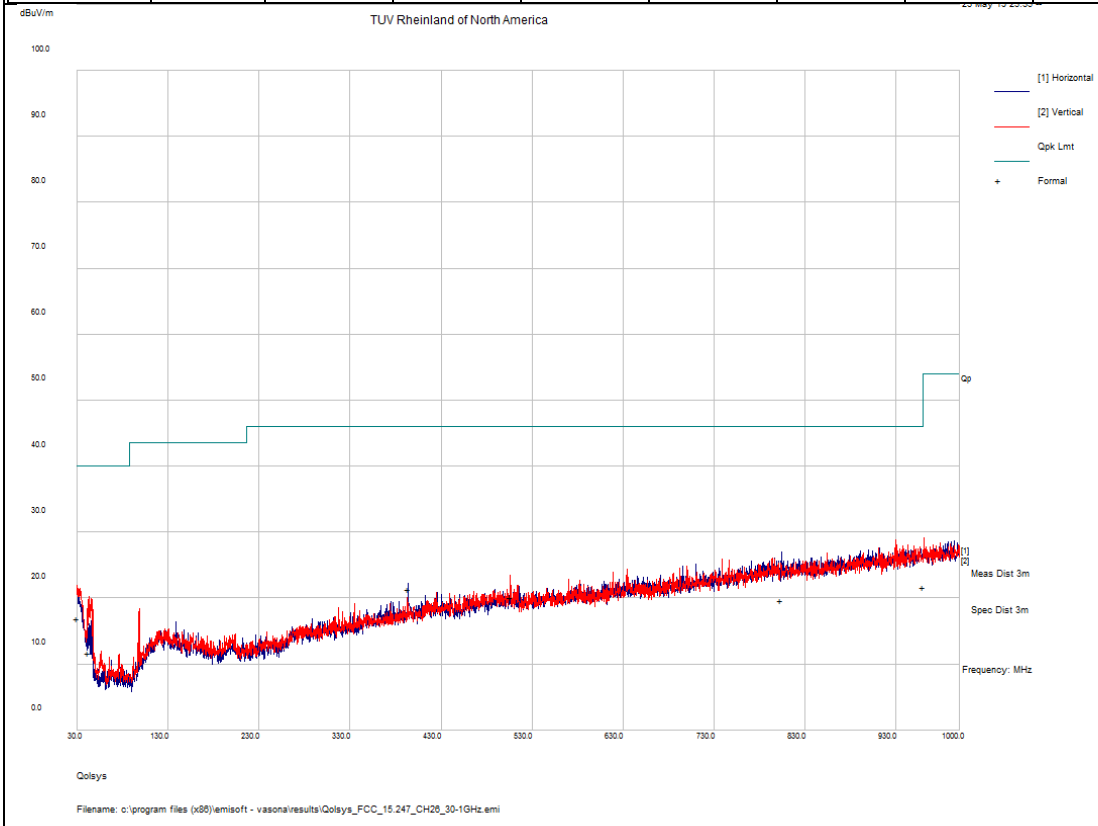


Note: -

Radiated Emissions - 30MHz– 1 GHz Transmit at 2480 MHz (High Channel)

EUT Name	Qolsys Zigbee Radio Card	**Temp / Hum in**	21° C / 36%rh
EUT Model	QS-ZB	**Line AC / Freq**	N/A – Battery operated
EUT Config.	2480 MHz - Horizontal	**RBW / VBW**	100KHz/ 300KHz
Standard	CFR47 Part 15.247	**Performed by**	Abraham Avalos
		Dist/Ant Used	3m/ JB3

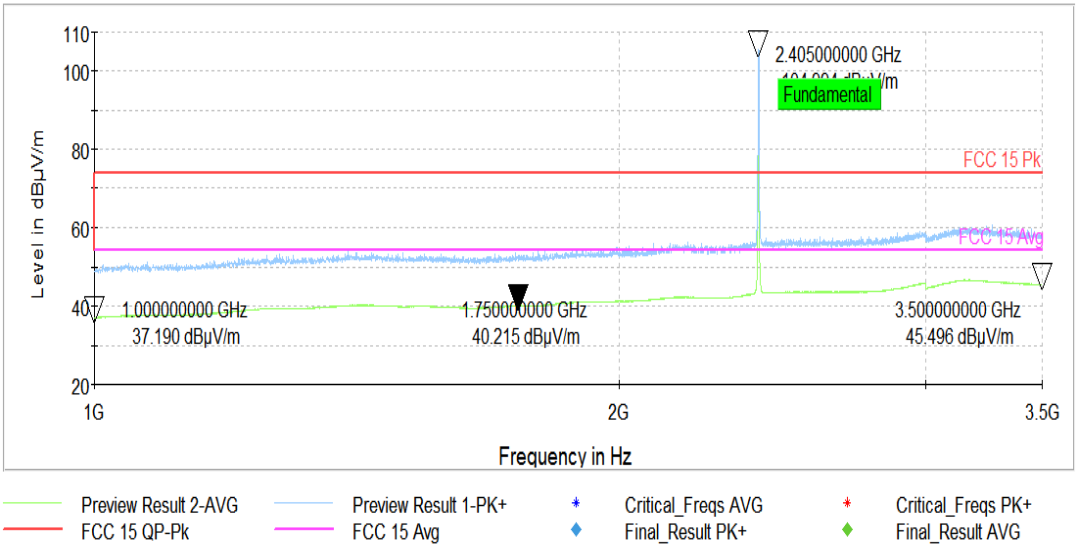
Frequency	Level	Detector	Polarity	Height	Azimuth	Limit	Margin	Result
MHz	dBuV/m		H/V	cm	deg	dBuV/m	dB	
30.00	16.86	QP	V	324	248	40.00	-23.14	Pass
43.10	11.66	QP	V	172	86	40.00	-28.35	Pass
393.73	21.44	QP	H	113	324	46.00	-24.56	Pass
506.22	20.10	QP	H	148	38	46.00	-25.91	Pass
803.95	19.65	QP	H	309	136	46.00	-26.35	Pass
960.48	21.63	QP	V	243	0	54.00	-32.37	Pass



Note: -

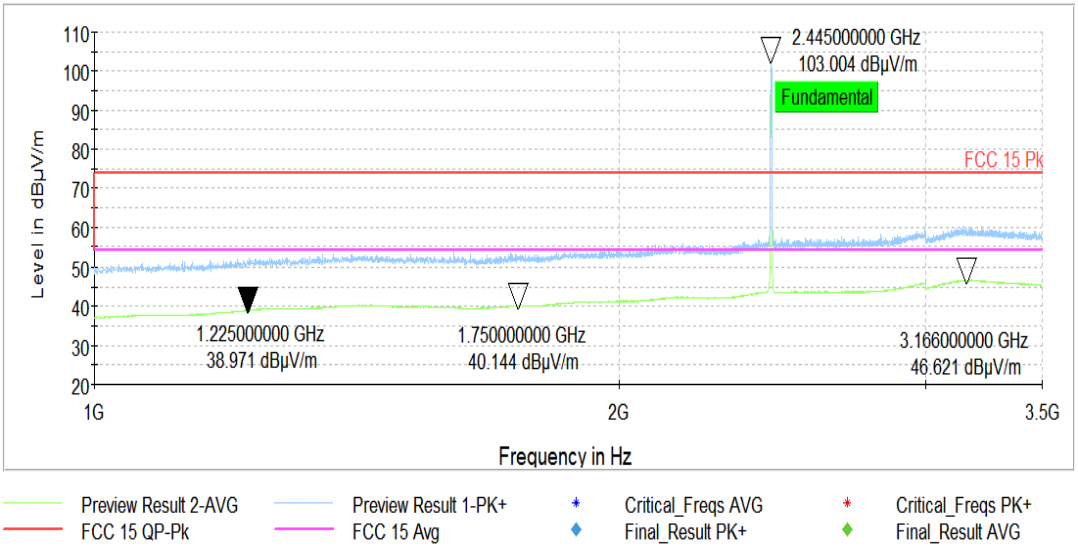
Radiated spurious emissions - FCC 15.247 Transmitter – 1 GHz – 3.5 GHz:

Radiated Emissions – 1 GHz-3.5GHz Transmit at 2405 MHz (Low Channel)			
EUT Name	Qolsys Zigbee Radio Card	**Temp / Hum in**	21° C / 37%rh
EUT Model	QS-ZB	**Line AC / Freq**	N/A – Battery operated
EUT Config.	2405MHz	**RBW / VBW**	1 MHz/ 3 MHz
Standard	CFR47 Part 15.247	**Performed by**	Abraham Avalos
		Dist/Ant Used	3m/ EMCO 3115



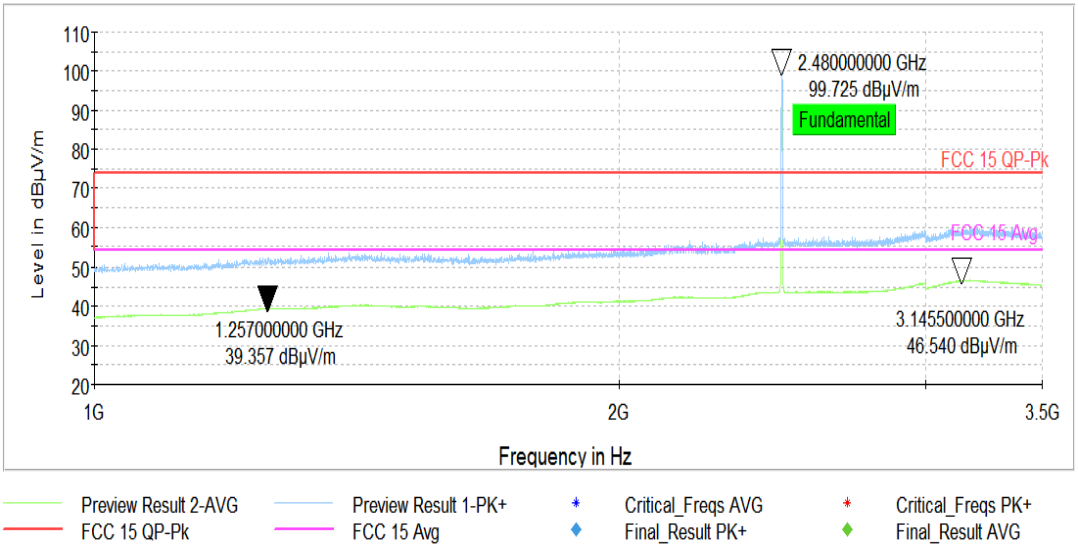
Note: No Emissions identified via peak detector within 6dB of the limits. No final measurements executed.

Radiated Emissions - 1 GHz-3.5GHz Transmit at 2445 MHz (Mid Channel)			
EUT Name	Qolsys Zigbee Radio Card	**Temp / Hum in**	21° C / 37%rh
EUT Model	QS-ZB	**Line AC / Freq**	N/A – Battery operated
EUT Config.	2445MHz	**RBW / VBW**	1 MHz/ 3 MHz
Standard	CFR47 Part 15.247	**Performed by**	Abraham Avalos
		Dist/Ant Used	3m/ EMCO 3115



Note: No Emissions identified via peak detector within 6dB of the limits. No final measurements executed.

Radiated Emissions - 1 GHz-3.5GHz Transmit at 2480 MHz (High Channel)			
EUT Name	Qolsys Zigbee Radio Card	**Temp / Hum in**	21° C / 37%rh
EUT Model	QS-ZB	**Line AC / Freq**	N/A – Battery operated
EUT Config.	2480 MHz	**RBW / VBW**	1 MHz/ 3 MHz
Standard	CFR47 Part 15.247	**Performed by**	Abraham Avalos
		Dist/Ant Used	3m/ EMCO 3115



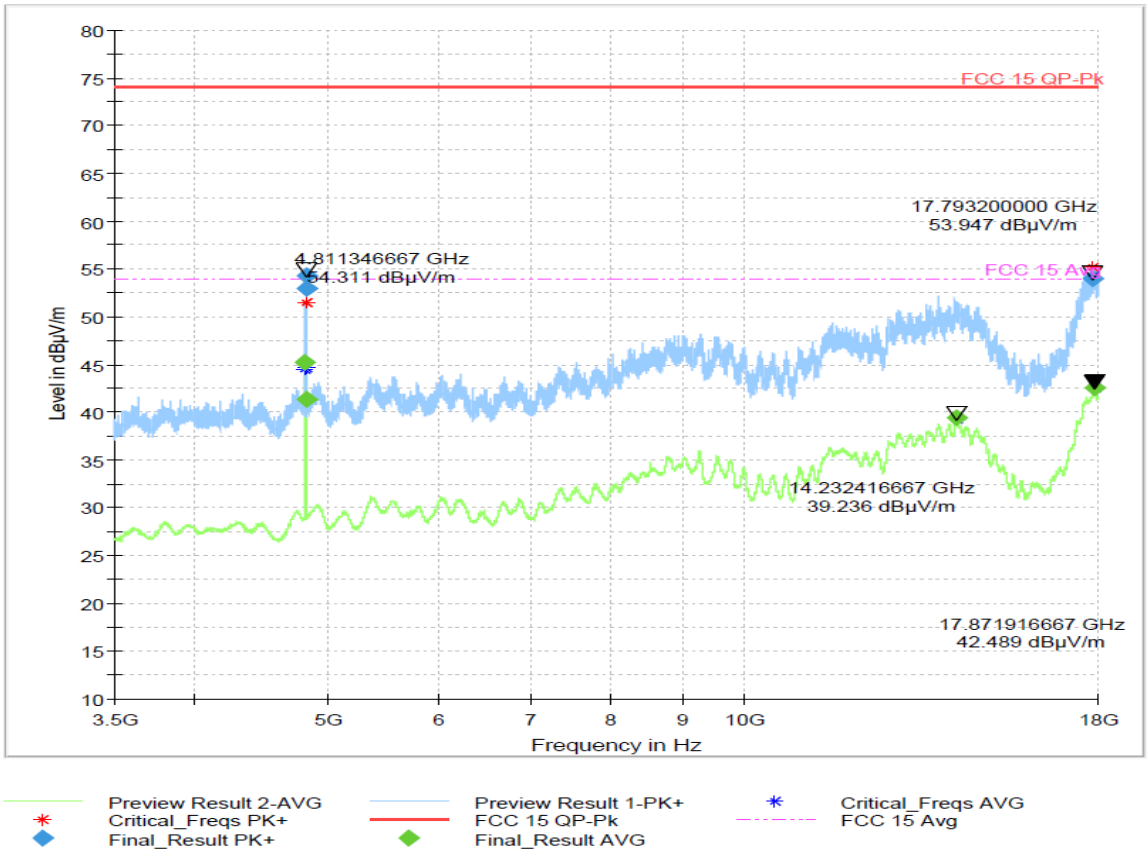
Note: No Emissions identified via peak detector within 6dB of the limits. No final measurements executed.

Radiated spurious emissions - FCC 15.247 Transmitter – 3.5 GHz – 18 GHz:

Radiated Emissions - 3.5 – 18 GHz Transmit at 2405MHz			
EUT Name	Qolsys Zigbee Radio Card	**Temp / Hum in**	21° C / 36%rh
EUT Model	QS-ZB	**Line AC / Freq**	N/A – Battery operated
EUT Config.	2405MHz	**RBW / VBW**	1 MHz/ 3 MHz
Standard	CFR47 Part 15.247	**Performed by**	Abraham Avalos
		Dist/Ant Used	3m/EMCO3115

Final_Result

Frequency (MHz)	MaxPeak (dBµV/m)	Average (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Meas. Time (ms)	Bandwidth (kHz)	Height (cm)	Pol	Azimuth (deg)	Elevation (deg)
4808.906667	---	45.29	54.00	8.71	500.0	1000.000	126.0	V	128.0	0.0
4811.000000	---	41.30	54.00	12.70	500.0	1000.000	381.0	V	125.0	0.0
4811.143333	52.93	---	74.00	21.07	500.0	1000.000	100.0	V	145.0	0.0
4811.346667	54.31	---	74.00	19.69	500.0	1000.000	107.0	V	148.0	0.0
14227.476667	---	39.36	54.00	14.64	500.0	1000.000	400.0	V	164.0	339.0
17793.200000	53.95	---	74.00	20.05	500.0	1000.000	236.0	V	114.0	164.0
17871.896667	---	42.58	54.00	11.42	500.0	1000.000	338.0	V	45.0	211.0

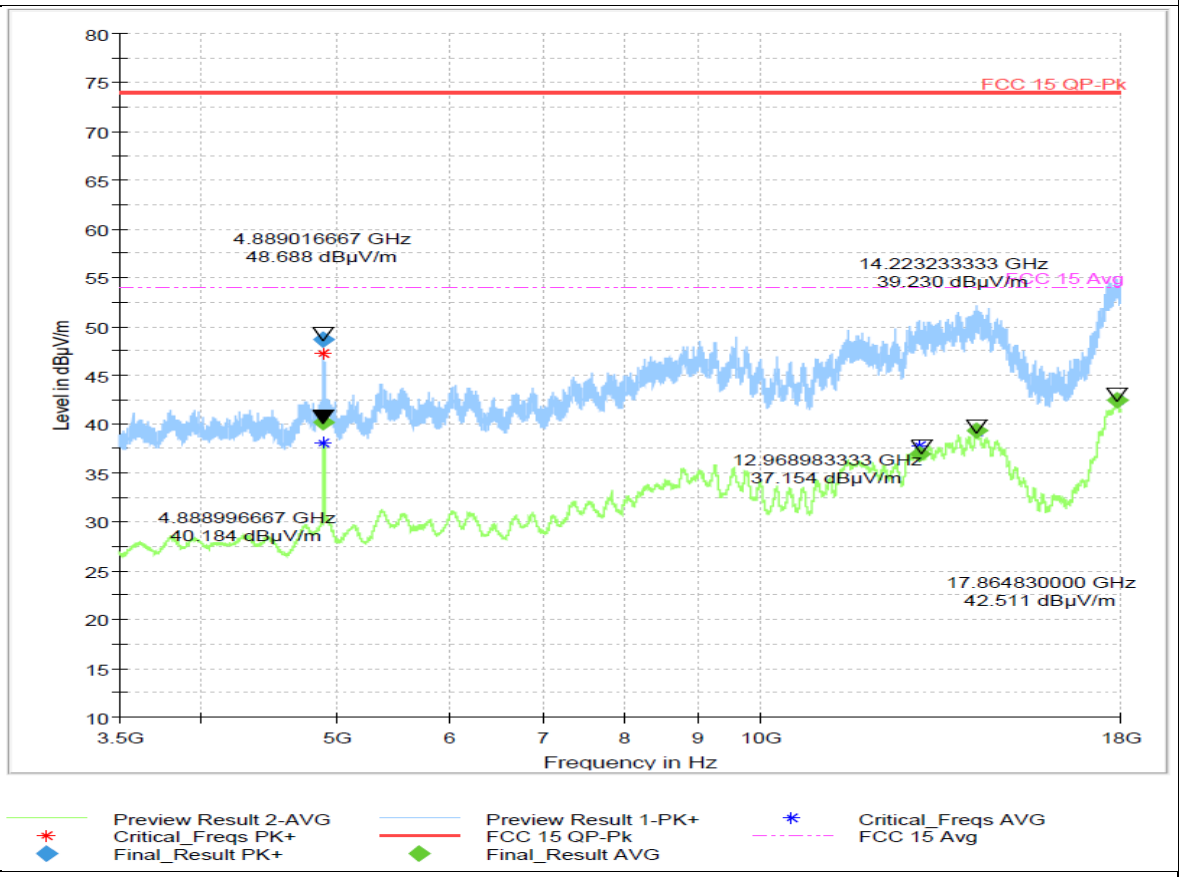


Note:

Radiated Emissions - 3.5 - 18 GHz Transmit at 2445 MHz (Mid Channel)			
EUT Name	Qolsys Zigbee Radio Card	**Temp / Hum in**	21° C / 36%rh
EUT Model	QS-ZB	**Line AC / Freq**	N/A – Battery operated
EUT Config.	2445MHz	**RBW / VBW**	1 MHz/ 3 MHz
Standard	CFR47 Part 15.247	**Performed by**	Abraham Avalos
		Dist/Ant Used	3m/EMCO3115

Final_Result

Frequency (MHz)	MaxPeak (dBµV/m)	Average (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Meas. Time (ms)	Bandwidth (kHz)	Height (cm)	Pol	Azimuth (deg)	Elevation (deg)
4888.996667	---	40.18	54.00	13.82	500.0	1000.000	122.0	V	147.0	356.0
4889.016667	48.69	---	74.00	25.31	500.0	1000.000	145.0	V	146.0	357.0
12933.420000	---	36.99	54.00	17.01	500.0	1000.000	196.0	H	125.0	360.0
14224.263333	---	39.32	54.00	14.68	500.0	1000.000	400.0	V	357.0	196.0
17864.830000	---	42.51	54.00	11.49	500.0	1000.000	299.0	H	341.0	221.0

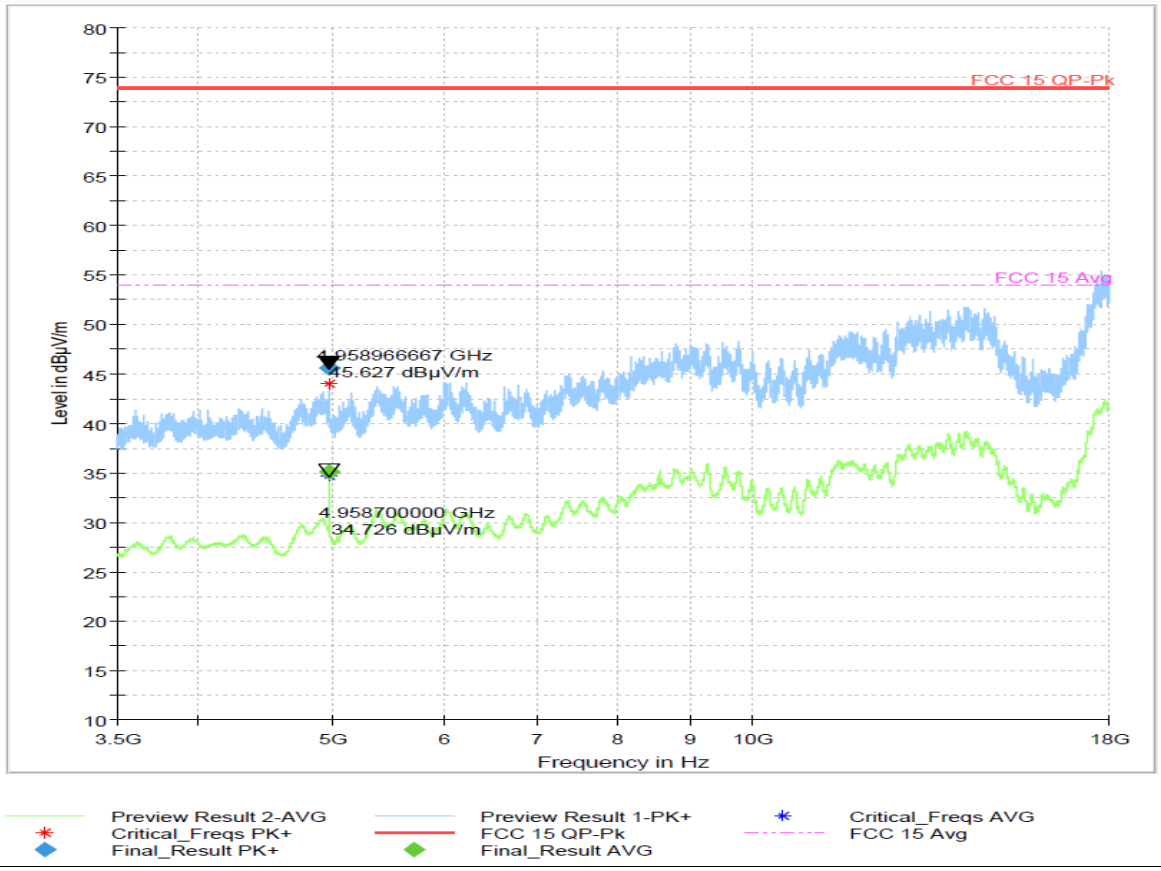


Note:

Radiated Emissions - 3.5 – 18 GHz Transmit at 2480 MHz (High Channel)			
EUT Name	Qolsys Zigbee Radio Card	**Temp / Hum in**	21° C / 36%rh
EUT Model	QS-ZB	**Line AC / Freq**	N/A – Battery operated
EUT Config.	2480MHz	**RBW / VBW**	1 MHz/ 3 MHz
Standard	CFR47 Part 15.247	**Performed by**	Abraham Avalos
		Dist/Ant Used	3m/EMCO3115

Final_Result

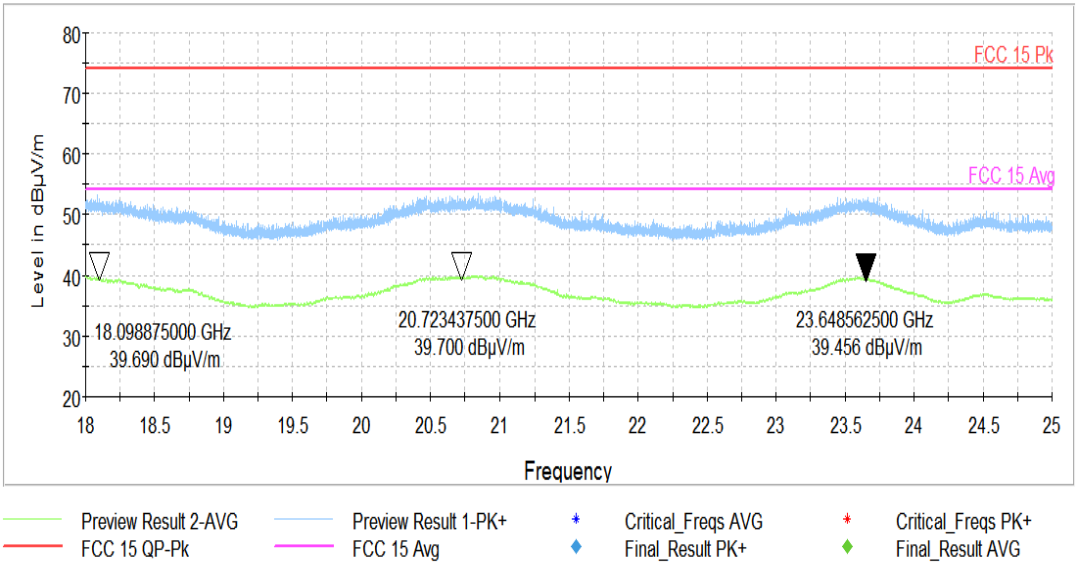
Frequency (MHz)	MaxPeak (dBµV/m)	Average (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Meas. Time (ms)	Bandwidth (kHz)	Height (cm)	Pol	Azimuth (deg)	Elevation (deg)
4958.966667	45.63	---	74.00	28.37	500.0	1000.000	285.0	V	180.0	6.0
4959.070000	---	35.10	54.00	18.90	500.0	1000.000	264.0	V	176.0	15.0



Note:

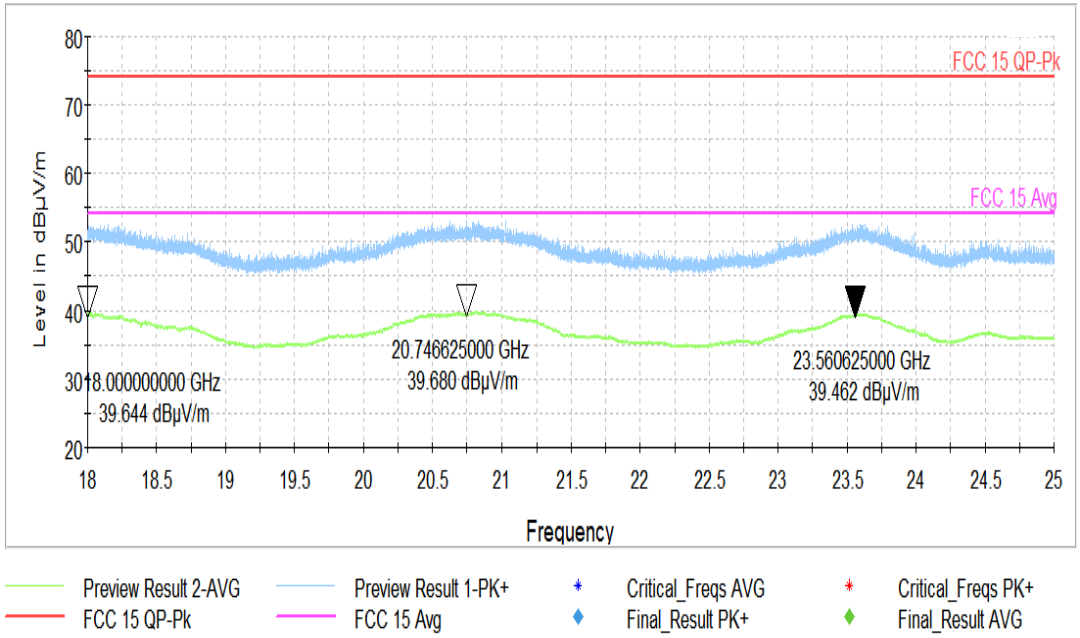
Radiated spurious emissions - FCC 15.247 Transmitter – 18 GHz – 25 GHz:

Radiated Emissions - 18-25 GHz Transmit at 2405 MHz (Low Channel)			
EUT Name	Qolsys Zigbee Radio Card	**Temp / Hum in**	21° C / 37%rh
EUT Model	QS-ZB	**Line AC / Freq**	N/A – Battery operated
EUT Config.	2405MHz	**RBW / VBW**	1 MHz/ 3 MHz
Standard	CFR47 Part 15.247	**Performed by**	Abraham Avalos
		Dist/Ant Used	1m – AHA-840



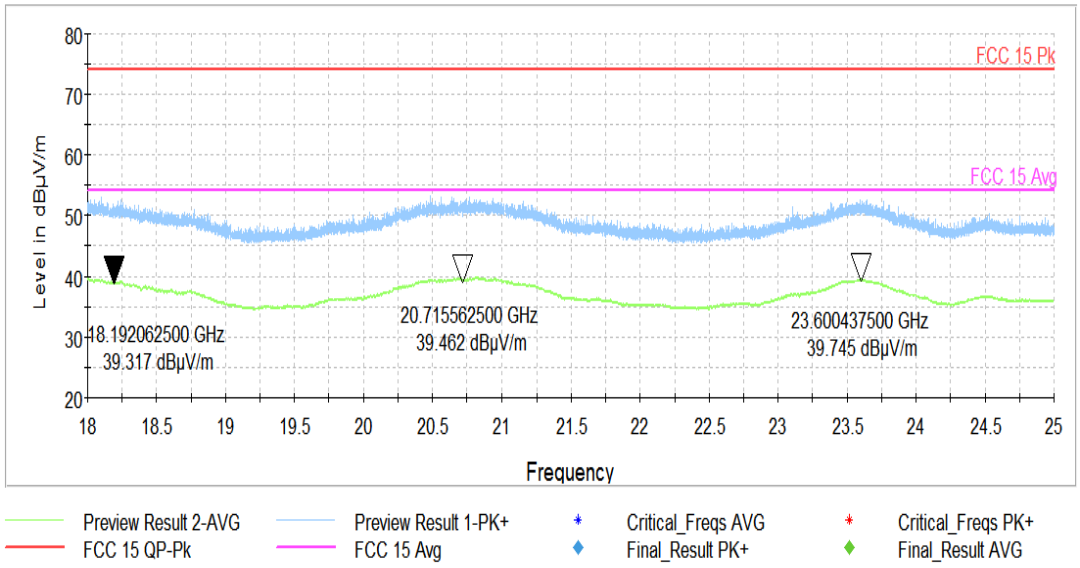
Note:

Radiated Emissions - 18-25 GHz Transmit at 2445 MHz (Mid Channel)			
EUT Name	Qolsys Zigbee Radio Card	**Temp / Hum in**	21° C / 37%rh
EUT Model	QS-ZB	**Line AC / Freq**	N/A – Battery operated
EUT Config.	2445MHz	**RBW / VBW**	1 MHz/ 3 MHz
Standard	CFR47 Part 15.247	**Performed by**	Abraham Avalos
		Dist/Ant Used	1m – AHA-840



Note:

Radiated Emissions - 18-25 GHz Transmit at 2480 MHz (High Channel)			
EUT Name	Qolsys Zigbee Radio Card	**Temp / Hum in**	21° C / 37%rh
EUT Model	QS-ZB	**Line AC / Freq**	N/A – Battery operated
EUT Config.	2480MHz	**RBW / VBW**	1 MHz/ 3 MHz
Standard	CFR47 Part 15.247	**Performed by**	Abraham Avalos
		Dist/Ant Used	1m – AHA-840



Note:

4.6 AC Conducted Emissions

Testing was performed in accordance with ANSI C63.4: 2014. These test methods are listed under the laboratory's A2LA Scope of Accreditation.

This test measures RF emissions emanating from the EUT's AC input port, thus evaluating the potential for the EUT to cause radio frequency interference to other electronic devices.

The AC conducted emissions of equipment under test shall not exceed the values in CFR47 Part 15.207.

4.6.1 Test Methodology

A test program that controls instrumentation and data logging was used to automate the AC Power Line Conducted emission test procedure. The frequency range of interest was divided into sub-ranges such as to yield a frequency resolution of 9 kHz. Each phase and neutral of the AC power line were measured with respect to ground. Measurements were performed using a set of 50μH / 50Ω LISNs.

Testing is performed in Lab 5. The setup photographs clearly identify which site was used. The vertical ground plane used in the semi-anechoic chamber is a 2m x 2m solid aluminum frame and panel, and it is bonded to the horizontal ground plane.

In the case of tabletop equipment, the EUT is placed on a 1.0m x 1.5m non-conductive table 80cm above the ground plane and 40cm from a vertical ground reference plane. The rear of the EUT was positioned flush with the backside of the table and directly over the LISNs. The power and I/O cables were routed over the edge of the table and bundled approximately 40cm from the ground plane. Support equipment was powered from a separate LISN.

4.6.1.1 Deviations

There were no deviations from this test methodology.

4.6.2 Test Results

Not Applicable, the EUT is battery operated via a development board.

5 Test Equipment List

5.1 Equipment List

Note: Equipment is characterized before use.

Equipment	Manufacturer	Model #	Serial/Inst #	Last Cal mm/dd/yyyy	Next Cal mm/dd/yyyy
Spectrum Analyzer	Rohde & Schwarz	FSW67	104088	06/11/2018	06/11/2019
EMI Receiver	Rohde & Schwarz	ESIB40	5000-3090823415	09/20/2018	09/20/2019
Bilog Antenna	Sunol Sciences	JB3	A102606	08/01/2018	08/01/2020
Horn Antenna	EMCO	3115	9211-3969	05/16/2017	05/16/2019* (08/16/2019) (s. Note 1)
Amplifier	Sonoma	310N	185616	01/16/2019	01/16/2020
Active loop antenna	Emco	6502	00062531	06/08/2018	06/08/2019
Maturo Control Unit	Maturo	SCU	246/20571216	N/A	
Maturo EUT Positioner	Maturo	TD1.5-10kg	087/20571216	N/A	
Amplifier	Miteq	AMF-7D-01001800-30-10p-L	2074297	N/A (See Note)	
DC Block	Mini-Circuits	UNAT-1+	VUU83701027	N/A (See Note)	
3.5 GHz High Pass Filter	Hewlett Packard	84300-80038	820004	N/A (See Note)	

Note: No calibration required. Path loss correction characterized internal.
Note 1: Equipment under laboratory designated extended calibration cycle of 3 month extension

6 EMC Test Plan

6.1 Introduction

This section provides a description of the Equipment Under Test (EUT), configurations, operating conditions, and performance acceptance criteria. It is an overview of information provided by the manufacturer so that the test laboratory may perform the requested testing.

6.2 Customer

Table 6: Customer Information

Company Name	Qolsys Inc.
Address	1900 The Alameda
City, State, Zip	San Jose, CA 95126
Country	USA
Applicant name	Walt Wallach
E-mail	Walt.Wallach@qolsys.com
Phone	+1 855-476-5797

6.3 Equipment Under Test (EUT)

The information provided in the following table should be listed as it should appear in the final report. For those products that have only a model name, list the model number as *non-applicable* and vice-versa.

Table 7 – EUT Designation

Product Name	Qolsys Zigbee Radio Card
Model Number	QS-ZB
Product Description	The Qolsys Zigbee Radio Card Model QS-ZB is a radio module utilizing an IEEE 802.15.4 radio based on communication ZigBee technology.

6.4 Product Specifications

Table 8: EUT Specifications

EUT Specification	
Operating Voltage	N/A – Host PCB powered
Number of Antenna Feeds	Transmit: 1 Receive: 1
Product Marketing Name (PMN)	Qolsys Zigbee Radio Card
FW Version	6.4.1
HW Version	X1
Radio Evaluated	IEEE 802.15.4 - ZigBee
Transmit Frequency Band	2400-2483.5MHz
Max. Power Output for Technology	10.98 dBm (Measured peak, Conducted)
Antenna Gain	1 dBi
Antenna Type	Internal embedded chip antenna
Modulation Type	O-QPSK
Type of Equipment	☐ Table Top ☐ Wall-mount ☐ Floor standing cabinet ☒ Other: Module

Table 9: Antenna Information

Number	Antenna Type	Description	Max Gain (dBi)
1	Internal	Embedded chip antenna	1

able 10: Interface Specifications

Interface Type	Cabled with what type of cable?	Is the cable shielded?	Maximum potential length of the cable?	Metallic (M), Coax (C), Fiber (F), or Not Applicable?
USB	USB	No	3m	Not Applicable
Note: USB cable connected to auxiliary host. Removed after configuration before radiated testing.				

Table 11: Support Equipment

Equipment	Manufacturer	Model	Used for
Laptop	Lenovo	T480 Thinkpad	EUT configuration via Putty serial\USB interface connection for module operational mode configuration.
Host Auxiliary IQ Panel 2	Qolsys Inc.	QS-IQPANEL2 FW Version: 2.3.0 HW Version: REV H	Host device for EUT - Module
Note: None.			

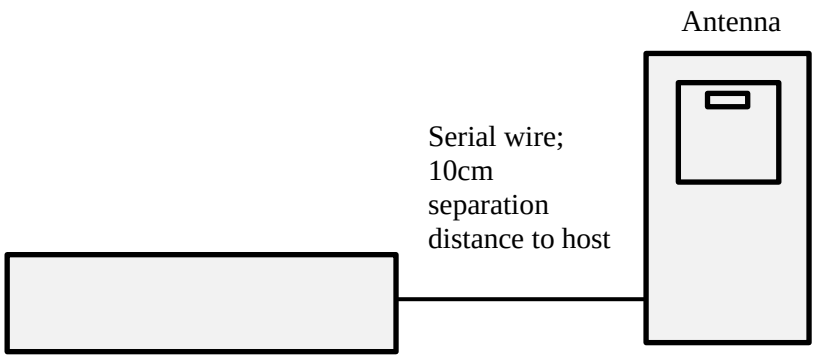
Table 12: Description of Sample used for Testing

Device	Serial	RF Connection	Comment
Qolsys Zigbee Radio Card	N/A	Temporary u.fl	Conducted testing
Qolsys Zigbee Radio Card	N/A	Intended embedded chip antenna	Radiated testing

Table 13: Accessory Equipment

Equipment	Manufacturer	Model	Serial	Comment
-	-	-	-	-

1.1.1 Block Diagram



IQ Panel 2 Host

Vertical Orientation

6.5 EUT Configuration:

The EUT's 802.15.4 radio was stimulated for continuous modulated transmission on all applicable channels via terminal command sets.

6.6 Testing Notes:

Following example configuration indicates the utilized commands:

- *busybox microcom -s 115200 /dev/ttyHSL4*
- *rx 0*
- *config2p4GHz802154*
- *setDebugMode 1*
- *freqOverride 2405000000*
- *setDebugMode 0*
- *SetTxStream 1*

The Firmware implemented power configuration is not changed from the supplied FW default: Powerlevel 97; power: 104 configuration, which is declared by the manufacturer as representative for the final implementation.

END OF REPORT