Report on the Radio Testing

For

Gyrus Medical Ltd

on

VAPR VUE electrosurgical generator

Report no. TRA-025920-09-45-03E

3rd January 2018

Report Number: TRA-025920-09-45-03E
Issue: E

REPORT ON THE RADIO TESTING OF A
Gyrus Medical Ltd
VAPR VUE electrosurgical generator
WITH RESPECT TO SPECIFICATION
FCC 47CFR 15.247 & IC RSS-247

TEST DATES: 16th Mar - 10th Apr 2017

Tested & Written by: A Wong

A Longley / A Tosif / A Wong
Radio Test Engineers

Approved by:

Digitally signed by John Charters
DN: cn=John Charters, o, ou=Element Materials Technology Ltd., email=john.charters@element.com, c=GB
Reason: I am approving this document
Date: 2018.01.03 10:06:47 Z

J Charters
Department Manager- Radio

Date: 3rd January 2018

1 Revision Record

Issue Number	*Issue Date*	*Revision History*
A	8th May 2017	Original
E	3rd January 2018	Type errors corrected

2 Summary

TEST REPORT NUMBER:	TRA-025920-09-45-03E
WORKS ORDER NUMBER:	TRA-025920-09
PURPOSE OF TEST:	USA: Testing of radio frequency equipment per the relevant authorization procedure of chapter 47 of CFR (code of federal regulations) Part 2, subpart J. Canada: Testing of radio apparatus for TAC (technical acceptance certificate) per subsections 4(2) of the Radiocommunication Act and 21(1) of the Radiocommunication Regulations.
TEST SPECIFICATION(S):	47CFR15.247 & RSS-247
EQUIPMENT UNDER TEST (EUT):	VAPR VUE electrosurgical generator
FCC IDENTIFIER:	2ALZC-225024
EUT SERIAL NUMBER:	AD1720038
MANUFACTURER/AGENT:	Gyrus Medical Ltd
ADDRESS:	Fortran Road St Mellons Cardiff South Glamorgan CF3 0LT
CLIENT CONTACT:	Vincent Corden ☎ 02920 776300 ✉ vincent.corden@olympus-oste.eu
ORDER NUMBER:	334905
TEST DATE:	16th Mar - 10th Apr 2017
TESTED BY:	A Longley / A Tosif / A Wong Element

2.1 Test Summary

Test Method and Description		*Requirement Clause*		*Applicable to this equipment*	*Result / Note*
		RSS	*47CFR15*		
Radiated spurious emissions (restricted bands of operation and cabinet radiation)		Gen, 8.10	15.205	☒	*Pass*
AC power line conducted emissions		Gen, 8.8	15.207	☒	*Pass*
Occupied bandwidth		247, 5.2 (1)	15.247(a)(2)	☒	*Pass*
Conducted carrier power	Peak	247, 5.4 (4)	15.247(b)(3)	☒	*Pass*
	Max.			☐	
Conducted / radiated RF power out-of-band		247, 5.5	15.247(d)	☒	*Pass*
Power spectral density, conducted		247, 5.2 (2)	15.247(e)	☒	*Pass*

Notes:

The results contained in this report relate only to the items tested, in the condition at time of test, and were obtained in the period between the date of initial receipt of samples and the date of issue of the report.

The apparatus was set up and exercised using the configurations, modes of operation and arrangements defined in this report only. Any modifications made are identified in Section 8 of this report.

Particular operating modes, apparatus monitoring methods and performance criteria required by the standards tested to have been performed except where identified in Section 5.2 of this test report (Deviations from Test Standards).

3 Contents

4 Introduction

This report TRA-025920-09-45-03E presents the results of the Radio testing on a Gyrus Medical Ltd, VAPR VUE electrosurgical generator to specification 47CFR15 Radio Frequency Devices and RSS-247 Licence-exempt Radio Apparatus (All Frequency Bands): Category I Equipment.

The testing was carried out for Gyrus Medical Ltd by Element, at the address(es) detailed below.

☒ Element Hull
Unit E
South Orbital Trading Park
Hedon Road
Hull
HU9 1NJ
UK

☐ Element Skelmersdale
Unit 1
Pendle Place
Skemersdale
West Lancashire
WN8 9PN
UK

This report details the configuration of the equipment, the test methods used and any relevant modifications where appropriate.

All test and measurement equipment under the control of the laboratory and requiring calibration is subject to an established programme and procedures to control and maintain measurement standards. The quality management system meets the principles of ISO 9001, and has quality control procedures for monitoring the validity of tests undertaken. Records and sufficient detail are retained to establish an audit trail of calibration records relating to its test results for a defined period. Under control of the established calibration programme, key quantities or values of the test & measurement instrumentation are within specification and comply with the relevant traceable internationally recognised and appropriate standard specifications, which are UKAS calibrated as such where these properties have a significant effect on results. Participation in inter-laboratory comparisons and proficiency testing ensures satisfactory correlation of results conform to Elements own procedures, as well as statistical techniques for analysis of test data providing the appropriate confidence in measurements.

Throughout this report EUT denotes equipment under test.

FCC Site Listing:
Element is accredited for the above sites under the US-EU MRA, Designation number UK0009.

IC Registration Number(s):

Element Hull	3483A
Element North West	3930B

The test site requirements of ANSI C63.4-2014 are met up to 1GHz.

The test site SVSWR requirements of CISPR 16-1-4:2010 are met over the frequency range 1 GHz to 18 GHz.

5 Test Specifications

5.1 Normative References

- FCC 47 CFR Ch. I – Part 15 – Radio Frequency Devices.
- ANSI C63.10-2013 – American National Standard of Procedures for Compliance Testing of Unlicensed Wireless Devices.
- ANSI C63.4-2014 – American National Standard for Methods of Measurement of Radio-Noise Emissions from Low-Voltage Electrical and Electronic Equipment in the Range of 9 kHz to 40 GHz.
- Industry Canada RSS-247, Issue 1, May 2015 – Digital Transmission Systems (DTSs), Frequency Hopping Systems (FHSs) and Licence-Exempt Local Area Network (LE-LAN) Devices
- Industry Canada RSS-Gen, Issue 4, November 2014 – General Requirements for Compliance of Radio Apparatus

5.2 Deviations from Test Standards

There were no deviations from the test standard.

6 Glossary of Terms

§	denotes a section reference from the standard, not this document
AC	Alternating Current
ANSI	American National Standards Institute
BW	bandwidth
C	Celsius
CFR	Code of Federal Regulations
CW	Continuous Wave
dB	decibel
dBm	dB relative to 1 milliwatt
DC	Direct Current
DSSS	Direct Sequence Spread Spectrum
EIRP	Equivalent Isotropically Radiated Power
ERP	Effective Radiated Power
EUT	Equipment under Test
FCC	Federal Communications Commission
FHSS	Frequency Hopping Spread Spectrum
Hz	hertz
IC	Industry Canada
ITU	International Telecommunication Union
LBT	Listen before Talk
m	metre
max	maximum
MIMO	Multiple Input and Multiple Output
min	minimum
MRA	Mutual Recognition Agreement
N/A	Not Applicable
PCB	Printed Circuit Board
PDF	Portable Document Format
Pt-mpt	Point-to-multipoint
Pt-pt	Point-to-point
RF	Radio Frequency
RH	Relative Humidity
RMS	Root Mean Square
Rx	receiver
s	second
SVSWR	Site Voltage Standing Wave Ratio
Tx	transmitter
UKAS	United Kingdom Accreditation Service
V	volt
W	watt
Ω	ohm

7 Equipment under Test

7.1 EUT Identification

- Name: VAPR VUE electrosurgical generator
- Serial Number: AD1720038
- Model Number: 225024
- Software Revision: V1.11
- Build Level / Revision Number: BG

7.2 System Equipment

Equipment listed below forms part of the overall test setup and is required for equipment functionality and/or monitoring during testing. The compliance levels achieved in this report relate only to the EUT and not items given in the following list.

Radio control board
VAPR VUE Wireless Footswitch

7.3 EUT Mode of Operation

7.3.1 Transmission

The mode of operation for Tx tests was as follow.
EUT transmitting permanent modulated carrier on bottom, middle or top channel as required.

7.3.2 Reception

The mode of operation for Rx tests was as follows.
EUT in permanent receive mode on bottom, middle or top channel as required channels.

7.4 EUT Radio Parameters

7.4.1 General

Frequency of operation:	2405 – 2480 MHz
Modulation type(s):	ZigBee
Occupied channel bandwidth(s):	2 MHz
Channel spacing:	5 MHz
Declared output power(s):	5 dBm EIRP
Nominal Supply Voltage:	4.5 V dc

7.4.2 Antennas

Type:	Integral (Laird NanoBlue)
Frequency range:	2405 – 2480 MHz
Impedance:	50 ohms
Gain:	2 dBi

7.5 EUT Description

The EUT is an electro-surgical generator used for tissue management in surgical procedures. It contains a 2.4 GHz ZigBee radio using 2 dBi NanoBlue antenna.

8 Modifications

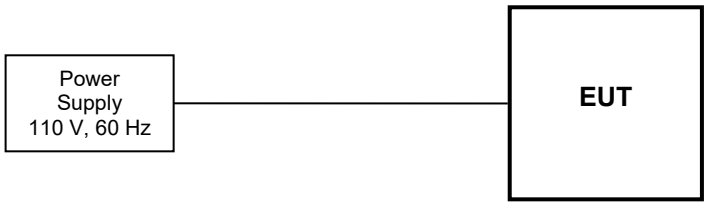
The following modifications were performed during this assessment.

A radio control board was connected to the EUT to facilitate putting the unit into the radio test modes.

9 EUT Test Setup

9.1 Block Diagram

The following diagram shows basic EUT interconnections with cable type and cable lengths identified:



9.2 General Set-up Photograph

The following photograph shows basic EUT set-up:

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10 General Technical Parameters

10.1 Normal Conditions

The EUT was tested under the normal environmental conditions of the test laboratory, except where otherwise stated. The normal power source applied was approx 110 V ac, 60 Hz, from the mains.

10.2 Varying Test Conditions

There are no specific frequency stability requirements for the type of device. The results contained in this report demonstrate that the occupied bandwidth is contained within the authorised band and the manufacturer has declared sufficient frequency stability (refer to section 7.4).

Variation of supply voltage is required to ensure stability of the declared output power. During carrier power testing the following variations were made:

	Category	***Nominal***	***Variation***
☒	Mains	110 V ac +/-2 %	85 % and 115 %
☐	Battery	New battery	N/A

11 Radiated emissions

11.1 Definitions

Spurious emissions
Emissions on a frequency or frequencies, which are outside the necessary bandwidth and the level of which may be reduced without affecting the corresponding transmission of information. Spurious emissions include harmonic emissions, parasitic emissions, intermodulation products and frequency conversion products, but exclude out-of-band emissions.

Restricted bands
A frequency band in which intentional radiators are permitted to radiate only spurious emissions but not fundamental signals.

11.2 Test Parameters

Element Hull	Element Hull
Wireless Lab 2	Wireless Lab 2
Test Standard and Clause:	ANSI C63.10-2013, Clause 6.5 and 6.6
EUT Channels / Frequencies Measured:	2405 MHz / 2440 MHz / 2480 MHz
EUT Channel Bandwidths:	2 MHz
Deviations From Standard:	None
Measurement BW:	30 MHz to 1 GHz: 120 kHz Above 1 GHz: 1 MHz
Measurement Detector:	Up to 1 GHz: quasi-peak Above 1 GHz: RMS average and Peak

Environmental Conditions (Normal Environment)

Temperature: 23 °C	+15 ºC to +35 ºC (as declared)
Humidity: 33 % RH	20 % RH to 75 % RH (as declared)

11.3 Test Limit

Unwanted emissions that fall within the restricted frequency bands shall comply with the limits specified:

General Field Strength Limits for License-Exempt Transmitters at Frequencies above 30 MHz

Frequency (MHz)	***Field Strength (µV/m at 3 m)***
30 to 88	100
88 to 216	150
216 to 960	200
Above 960	500

11.4 Test Method

With the EUT setup as per section 9 of this report and connected as per Figure i, the emissions from the EUT were measured on a spectrum analyzer / EMI receiver.

Radiated electromagnetic emissions from the EUT are checked first by preview scans. Preview scans for all spectrum and modulation characteristics are checked, using a peak detector and where applicable worst-case determined for function, operation, orientation, etc. for both vertical and horizontal polarisations. Pre-scan plots are shown with a peak detector and 100 kHz RBW.

If the EUT connects to auxiliary equipment and is table or floor standing, the configurations prescribed in ANSI C63.10 are followed. Alternatively, a layout closest to normal use (as declared by the provider) is employed, (see EUT setup photographs for more detail).

Emissions between 30 MHz and 1 GHz are measured using calibrated broadband antennas. Emissions above 1 GHz are characterized using standard gain horn antennas. Pre-amplifiers and filters are used where required. Care is taken to ensure that test receiver resolution bandwidth, video bandwidth and detector type(s) meet the regulatory requirements.

For both horizontal and vertical polarizations, the EUT is then rotated through 360 degrees in azimuth until the highest emission is detected. At the previously determined azimuth the test antenna is raised and lowered from 1 to 4 m in height until a maximum emission level is detected, this maximum value is recorded.

Power values measured on the test receiver / analyzer are converted to field strength, FS, in dBµV/m at the regulatory distance, using:

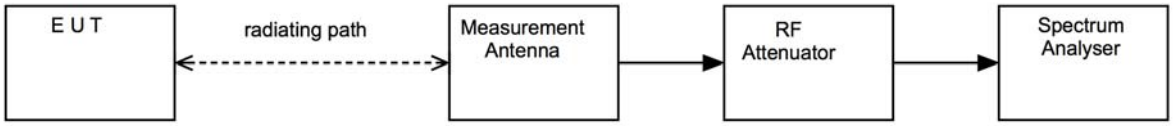
$$FS = PR + CL + AF – PA + DC – CF$$

Where,

PR is the power recorded on the receiver / spectrum analyzer in dBµV;
CL is the cable loss in dB;
AF is the test antenna factor in dB/m;
PA is the pre-amplifier gain in dB (where used);
DC is the duty correction factor in dB (where used, e.g. harmonics of pulsed fundamental);
CF is the distance factor in dB (where measurement distance different to limit distance);

This field strength value is then compared with the regulatory limit.

Figure i Test Setup



11.5 Test Set-up Photograph

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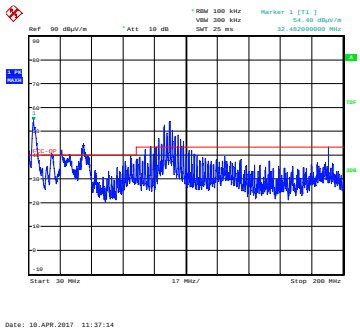
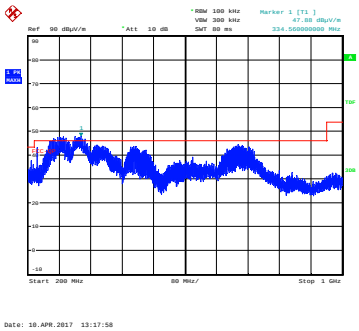
11.6 Test Equipment

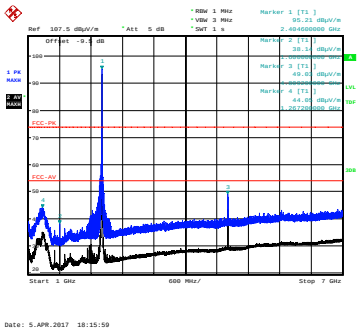
Equipment Type	Manufacturer	Equipment Description	Element No	Due For Calibration
FSU46	R&S	Spectrum Analyser	REF910	05/07/17
3115	EMCO	Horn Antenna	RFG129	09/02/18
8449B	Agilent	Pre-Amp (1 – 26.5GHz)	REF913	02/02/18
ATS	Rainford	Ferrite Lined Chamber	REF886	21/07/17
3109	EMCO	Biconical Antenna	RFG095	17/05/19
3146	EMCO	Log Periodic Antenna	RFG191	17/05/19
310	Sonoma	Pre-Amp (9kHz – 1GHz)	REF927	30/06/18
ESVS20	R&S	EMI Test Receiver	RFG126	23/05/17

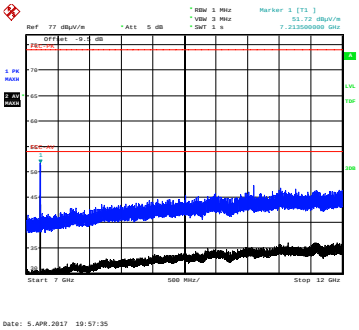
11.7 Test Results

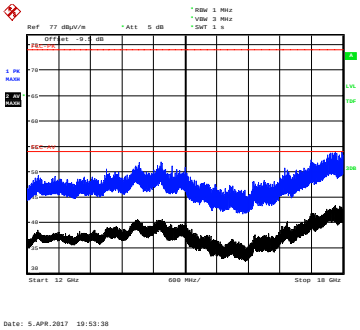
Transmit mode; Channel: 2405 MHz										
Detector	**Freq. (MHz)**	**Meas'd Emission (dBµV)**	**Cable Loss (dB)**	**Antenna Factor (dB/m)**	**Pre-amp Gain (dB)**	**Duty Cycle Corr'n (dB)**	**Distance Extrap'n Factor (dB)**	**Field Strength (dBµV/m)**	**Field Strength (µV/m)**	**Limit (µV/m)**
QP	255.1	62.1	1.7	13.0	32.4	0.00	0.00	44.3	164.6	200.0
QP	275.8	61.7	1.8	13.1	32.4	0.00	0.00	44.1	161.1	200.0
QP	327.5	58.9	1.9	13.5	32.4	0.00	0.00	41.9	125.0	200.0
Av	4809.1	46.7	5.5	32.9	35.4	0.0	-9.5	40.2	101.9	500.0
Pk	7213.7	56.9	6.3	35.9	35.6	0.0	-9.5	53.9	496.5	5000.0
Av	7213.7	48.8	6.3	35.9	35.6	0.0	-9.5	45.8	195.2	500.0

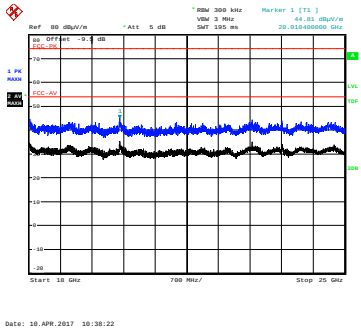


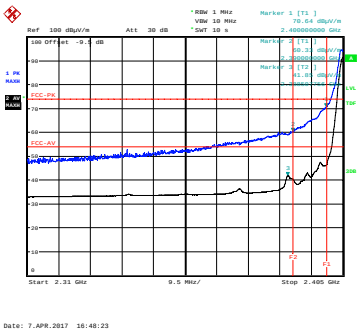




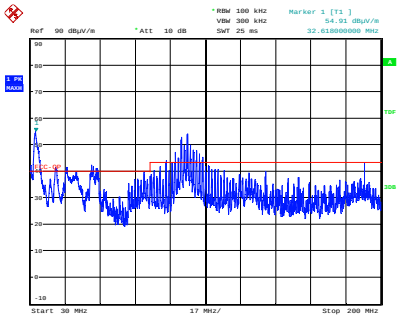








Transmit mode; Channel: 2440 MHz										
Detector	***Freq. (MHz)***	***Meas'd Emission (dBµV)***	***Cable Loss (dB)***	***Antenna Factor (dB/m)***	***Pre-amp Gain (dB)***	***Duty Cycle Corr'n (dB)***	***Distance Extrap'n Factor (dB)***	***Field Strength (dBµV/m)***	***Field Strength (µV/m)***	***Limit (µV/m)***
QP	255.1	62.1	1.7	13.0	32.4	0.00	0.00	44.3	164.6	200.0
QP	275.8	61.7	1.8	13.1	32.4	0.00	0.00	44.1	161.1	200.0
QP	327.5	58.9	1.9	13.5	32.4	0.00	0.00	41.9	125.0	200.0
Av	4879.0	41.9	5.4	33.1	35.4	0.0	-9.5	35.4	59.1	500.0
Pk	7318.6	55.0	6.7	36.1	35.7	0.0	-9.5	52.6	427.9	5000.0
Av	7318.6	46.7	6.7	36.1	35.7	0.0	-9.5	44.3	163.4	500.0



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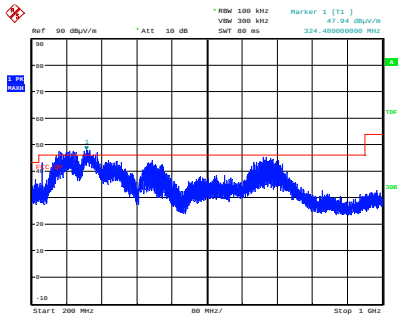

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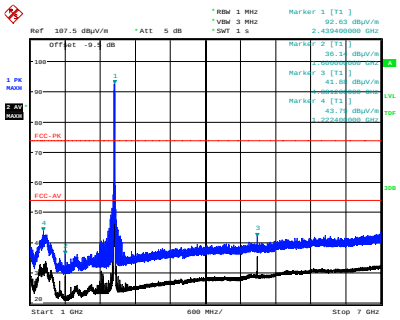

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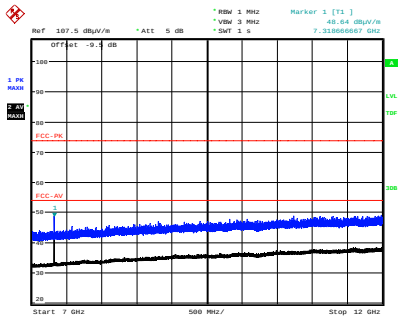

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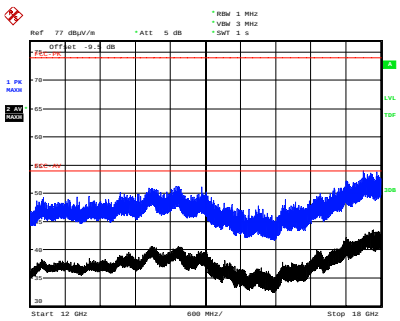

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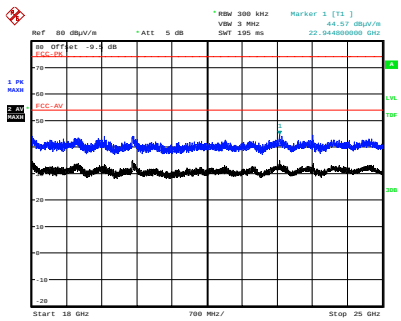

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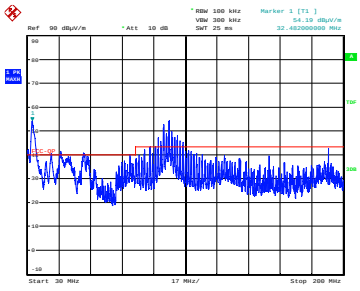
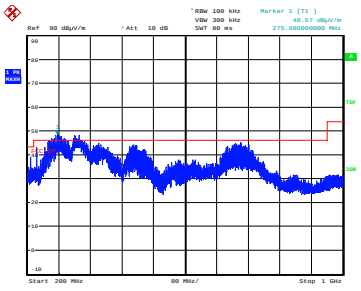
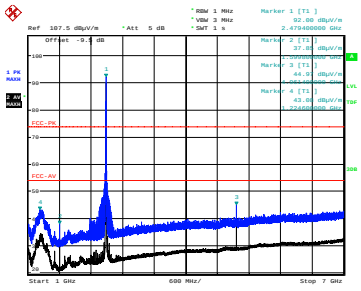
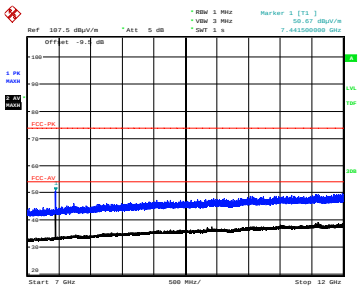
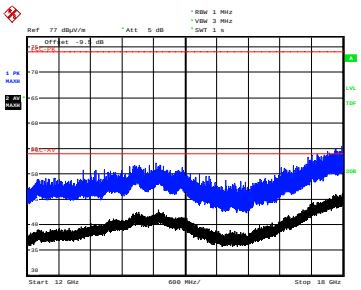
Transmit mode; Channel: 2480 MHz										
Detector	**Freq. (MHz)**	**Meas'd Emission (dBµV)**	**Cable Loss (dB)**	**Antenna Factor (dB/m)**	**Pre-amp Gain (dB)**	**Duty Cycle Corr'n (dB)**	**Distance Extrap'n Factor (dB)**	**Field Strength (dBµV/m)**	**Field Strength (µV/m)**	**Limit (µV/m)**
QP	255.1	62.1	1.7	13.0	32.4	0.00	0.00	44.3	164.6	200.0
QP	275.8	61.7	1.8	13.1	32.4	0.00	0.00	44.1	161.1	200.0
QP	327.5	58.9	1.9	13.5	32.4	0.00	0.00	41.9	125.0	200.0
Av	4959.0	44.5	5.3	33.2	35.4	0.0	-9.5	38.0	79.8	500.0
Pk	7438.6	56.9	6.5	36.3	35.7	0.0	-9.5	54.5	530.7	5000.0
Av	7438.6	48.8	6.5	36.3	35.7	0.0	-9.5	46.4	208.9	500.0

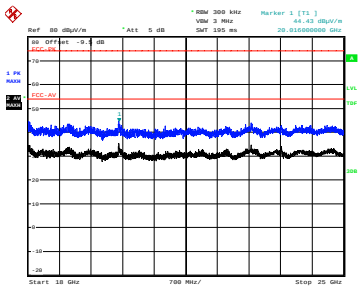


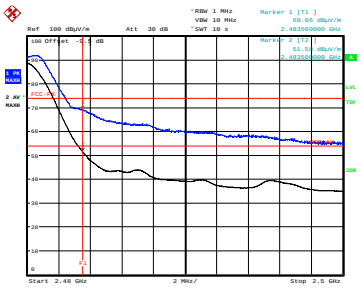




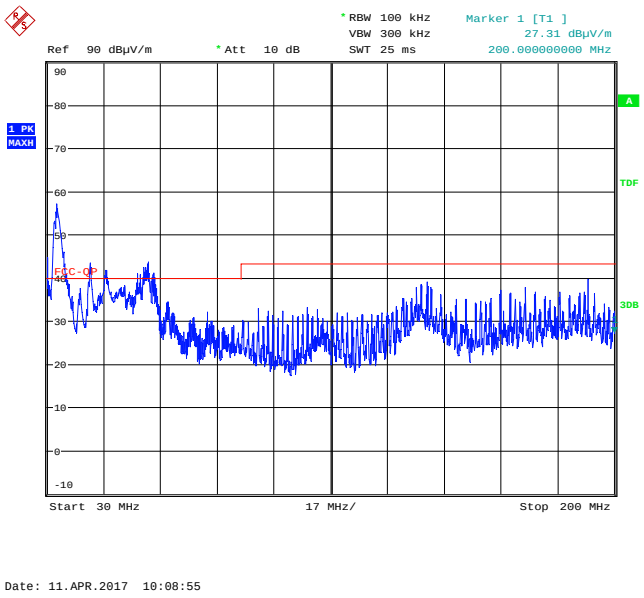








Note: There were some emissions that were coming from the test mode support equipment (i.e. radio control board), so the following plot was taken with the radio control board removed from the EUT.



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12 AC power-line conducted emissions

12.1 Definition

Line-to-ground radio-noise voltage that is conducted from all of the EUT current-carrying power input terminals that are directly (or indirectly via separate transformers or power supplies) connected to a public power network.

12.2 Test Parameters

Test Location:	Element Hull
Test Chamber:	Screen Room 2
Test Standard and Clause:	ANSI C63.10-2013, Clause 6.2
EUT Channels / Frequencies Measured:	Middle Channel only at 2440 MHz
EUT Channel Bandwidths:	2 MHz
EUT Modulation:	ZigBee
Deviations From Standard:	None
Measurement BW:	200 Hz / 9 kHz
Measurement Detectors:	Quasi-Peak / Average

Environmental Conditions (Normal Environment)

Temperature: 20 °C	+15 ºC to +35 ºC (as declared)
Humidity: 50 % RH	20 % RH to 75 % RH (as declared)
Supply: 110 V ac	110 V ac ±10 % (as declared)

12.3 Test Limit

A radio apparatus that is designed to be connected to the public utility (AC) power line shall ensure that the radio frequency voltage, which is conducted back onto the AC power line on any frequency or frequencies within the band 150 kHz to 30 MHz, shall not exceed the limits in Table 3.

Table 3 – AC Power Line Conducted Emission Limits

Frequency (MHz)	***Conducted limit (dBµV)***	
	Quasi-Peak	***Average*** [**]
0.15 to 0.5	66 to 56[*]	56 to 46[*]
0.5 to 5	56	46
5 to 30	60	50

*The level decreases linearly with the logarithm of the frequency.
**A linear average detector is required.

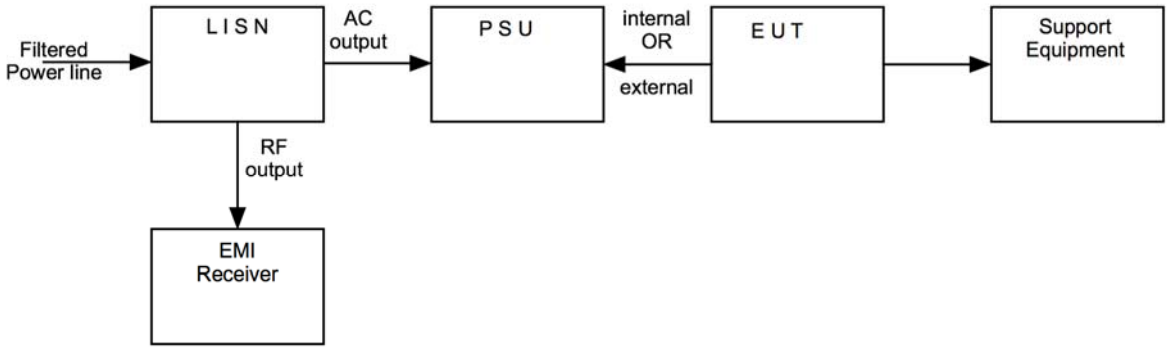
12.4 Test Method

With the EUT setup in a screened room, as per section 9 of this report and connected as per Figure ii, the power line emissions were measured on a spectrum analyzer / EMI receiver.

AC power line conducted emissions from the EUT are checked first by preview scans with peak and average detectors covering both live and neutral lines. A spectrum analyzer is used to determine if any periodic emissions are present.

Formal measurements using the correct detector(s) and bandwidth are made on frequencies identified from the preview scans. Final measurements were performed with EUT set at its maximum duty in transmit and receive modes.

Figure ii Test Setup



12.5 Test Set-up Photograph

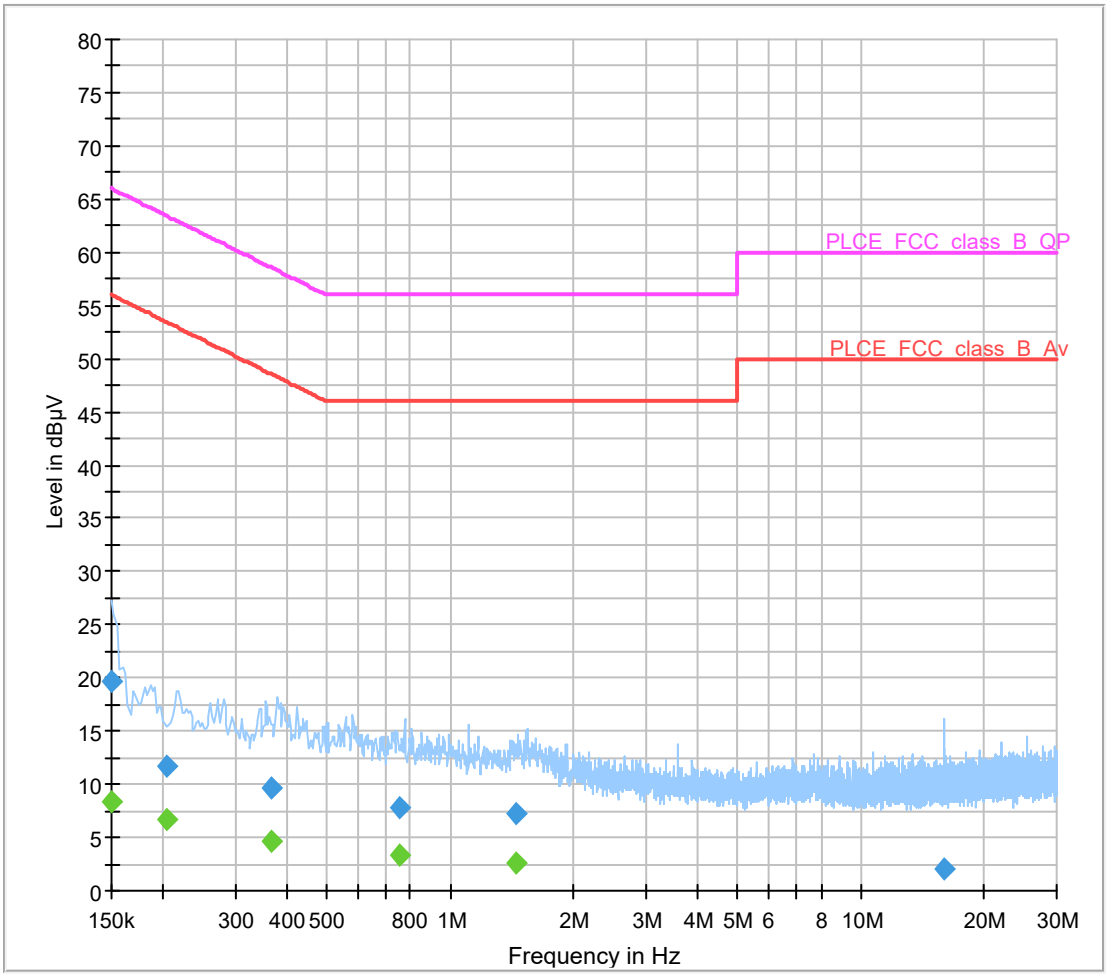
Removed for short term confidentiality

12.6 Test Equipment

Equipment Description	*Manufacturer*	*Equipment Type*	*Element No*	*Last Cal Calibration*	*Calibration Period*	*Due For Calibration*
LISN	R&S	2-Line V network	RFG189	2-8-2016	12-month	2-8-2017
9kHz-7GHz Receiver	R&S	EMI test receiver ESCI7	RFG715	11-10-2016	12-month	11-10-2017
Pulse Limiter	R&S	ESH3-Z2	RFG674	6-4-2017	12-month	6-4-2018
Frequency converter	8559 500VA	Voltage converter	RFG109	N / A	N / A	N / A

12.7 Test Results

The EUT was set to transmit normal ZigBee modulated signal on the middle channel with centre frequency at 2440 MHz.



The Power Line Conducted Emissions results for the complete EUT are reported in its EMC report. The following results are the contribution made by the radio module, tabulated as follows:

Quasi-Peak Detector Results

Frequency (MHz)	Quasi Peak (dBµV)	Meas. Time (ms)	Bandwidth (kHz)	PE	Line	Corr. (dB)	Margin (dB)	Limit (dBµV)
0.150	19.7	15000	0.2	GND	L1	10.2	46.3	66.0
0.205	11.6	15000	9.0	GND	N	10.2	51.8	63.4
0.366	9.6	15000	9.0	GND	N	10.3	49.0	58.6
0.757	7.8	15000	9.0	GND	N	10.4	48.2	56.0
1.443	7.2	15000	9.0	GND	L1	10.5	48.8	56.0
16.023	2.0	15000	9.0	GND	N	11.3	58.0	60.0

Average Detector Results

Frequency (MHz)	Average (dBµV)	Meas. Time (ms)	Bandwidth (kHz)	PE	Line	Corr. (dB)	Margin (dB)	Limit (dBµV)
0.150	8.3	15000	9.0	GND	L1	10.2	47.7	56.0
0.205	6.6	15000	9.0	GND	N	10.2	46.8	53.4
0.366	4.6	15000	9.0	GND	N	10.3	44.0	48.6
0.757	3.3	15000	9.0	GND	N	10.4	42.7	46.0
1.443	2.7	15000	9.0	GND	L1	10.5	43.3	46.0
16.023	-2.9	15000	9.0	GND	N	11.3	52.9	50.0

13 Occupied Bandwidth

13.1 Definition

The emission bandwidth (x dB) is defined as the frequency range between two points, one above and one below the carrier frequency, at which the spectral density of the emission is attenuated x dB below the maximum in-band spectral density of the modulated signal.

13.2 Test Parameters

Test Location:	Element Hull
Test Chamber:	Lab4
Test Standard and Clause:	IC: ANSI C63.10-2013, Clause 6.9 FCC: ANSI C63.10-2013, Clause 11.8
EUT Channels / Frequencies Measured:	Low / Mid / High
EUT Channel Bandwidths:	2 MHz
EUT Test Modulations:	Zigbee
Deviations From Standard:	None
Measurement BW: (IC requirement: 1% to 5% OBW; FCC requirement: 100 kHz)	100 kHz (30 kHz IC)
Spectrum Analyzer Video BW: (requirement at least 3x RBW)	300 kHz (100 kHz IC)
Measurement Span: (requirement 2 to 5 times OBW)	5 MHz
Measurement Detector:	Peak

Environmental Conditions (Normal Environment)

Temperature: 20 °C	+15 ºC to +35 ºC (as declared)
Humidity: 41 % RH	20 % RH to 75 % RH (as declared)

13.3 Test Limit

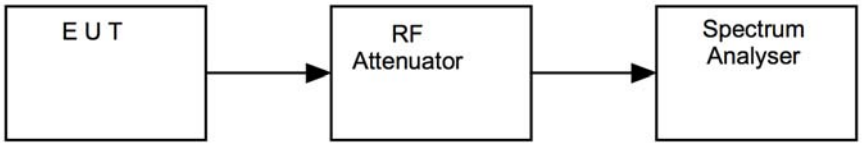
The minimum -6 dB bandwidth shall be at least 500 kHz.

13.4 Test Method

With the EUT setup as per section 9 of this report and connected as per Figure iii, the bandwidth of the EUT was measured on a spectrum analyser.

The measurements were performed with EUT set at its maximum duty. All modulation schemes, data rates and power settings were used to observe the worst-case configuration in each bandwidth.

Figure iii Test Setup

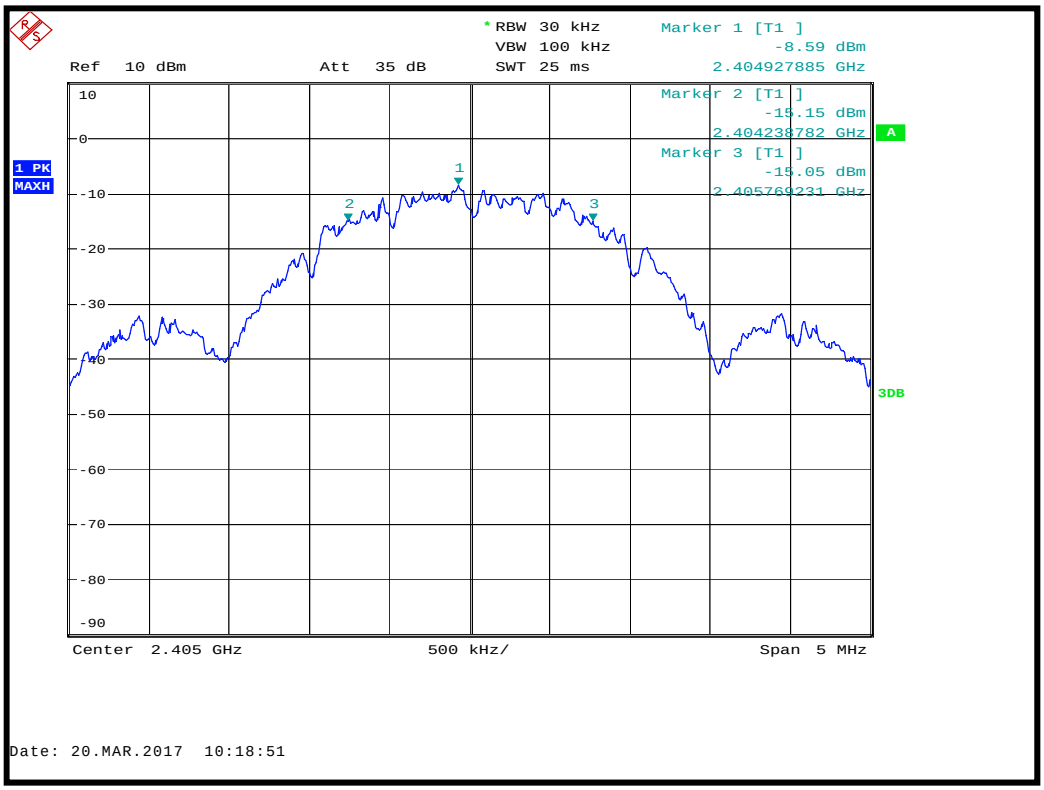


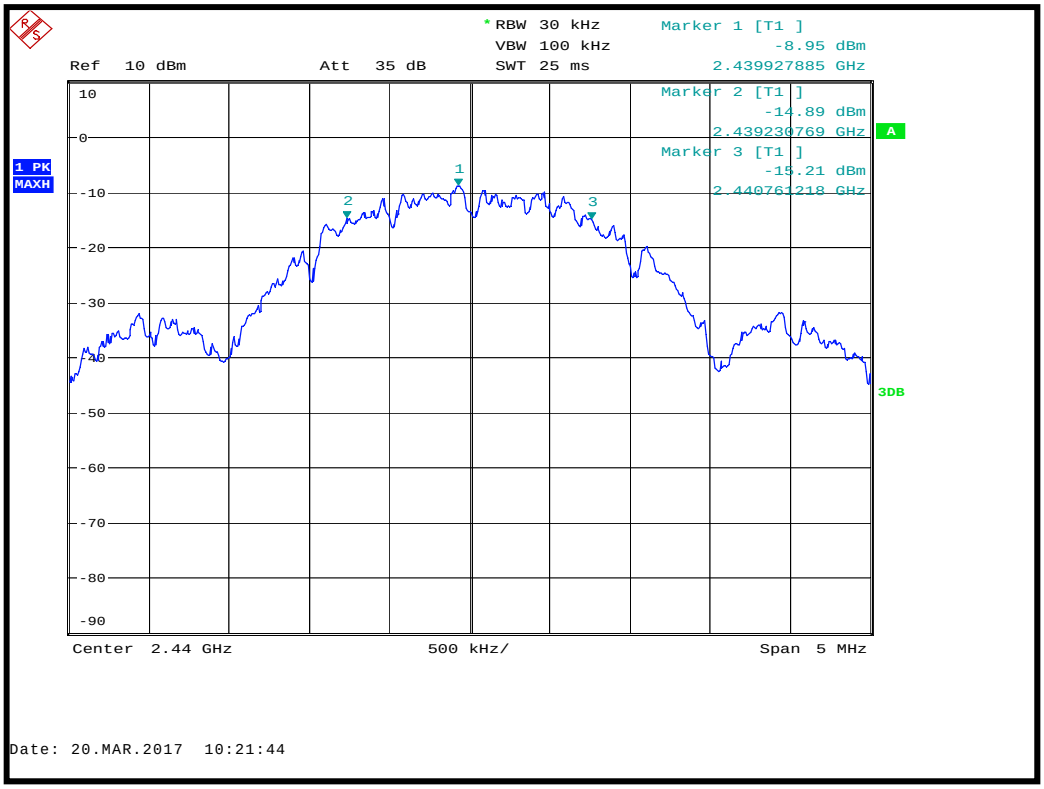
13.5 Test Equipment

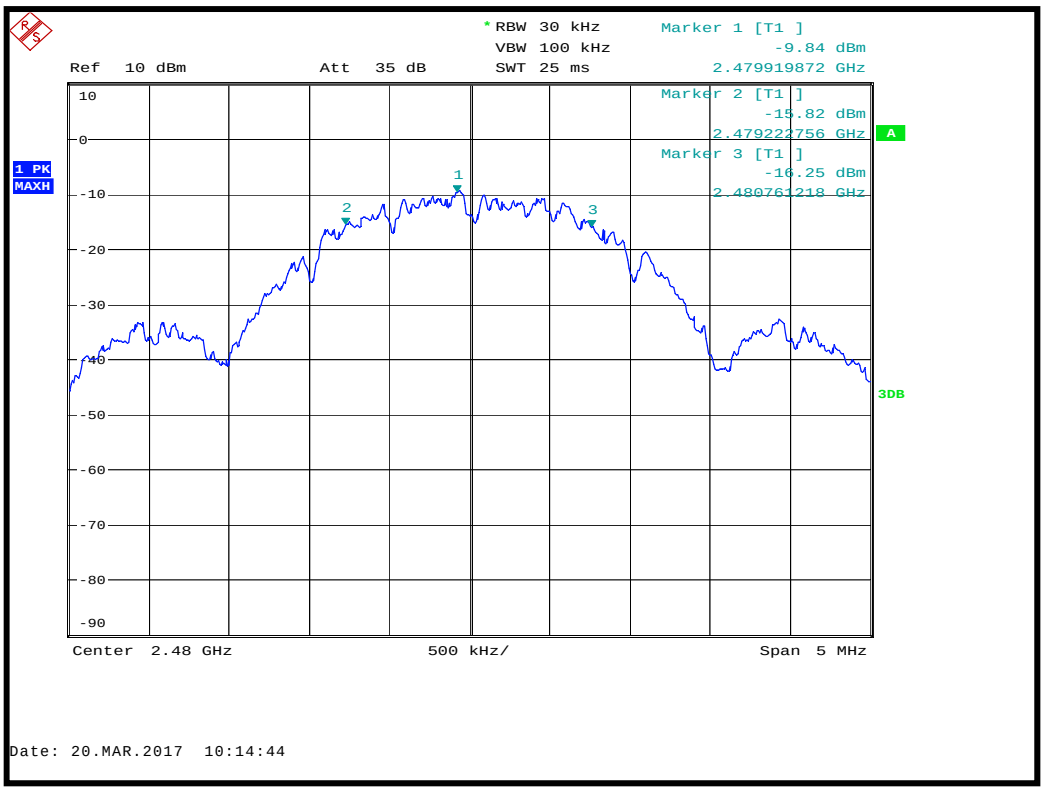
Equipment Type	Manufacturer	Equipment Description	Element No	Due For Calibration
FSU26	R&S	Spectrum Analyser	REF909	02/05/2017

13.6 Test Results

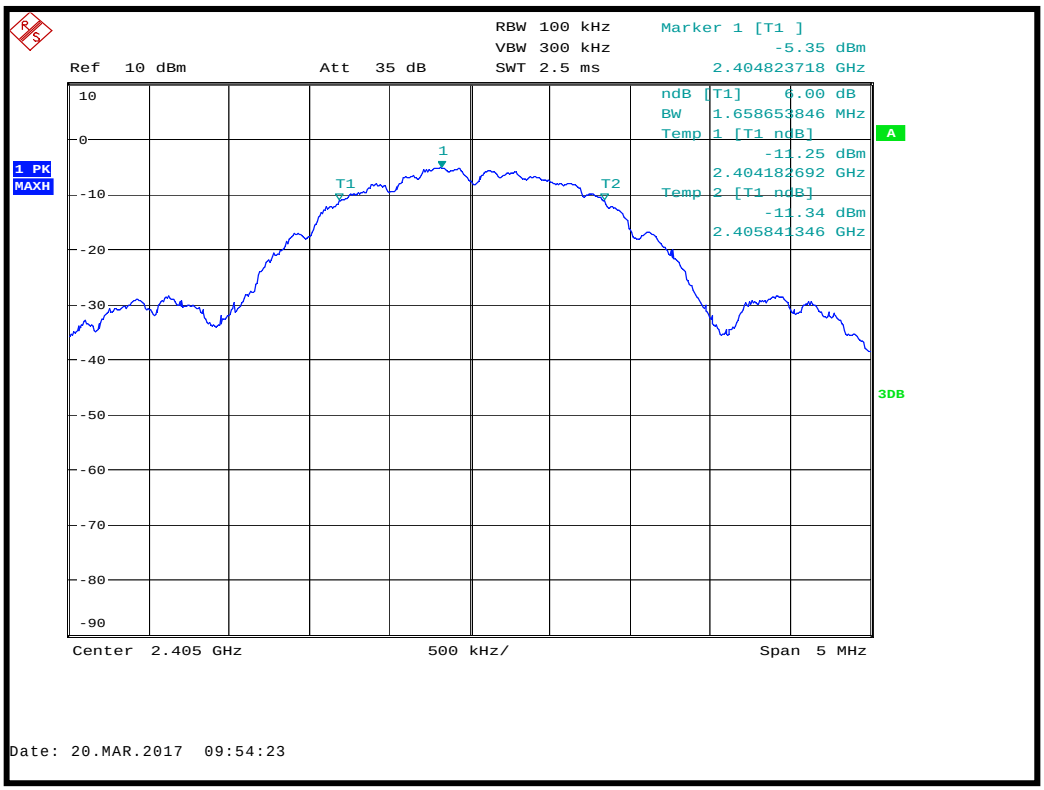
RSS-210. Modulation: Zigbee; Power setting: Full				
Channel Frequency (MHz)	**F_L (MHz)**	**F_H (MHz)**	**6dB Bandwidth (kHz)**	**Result**
2405	2404.238782	2405.769231	1530.449	PASS
2440	2439.230769	2440.761218	1530.449	PASS
2480	2479.222756	2480.761218	1538.462	PASS

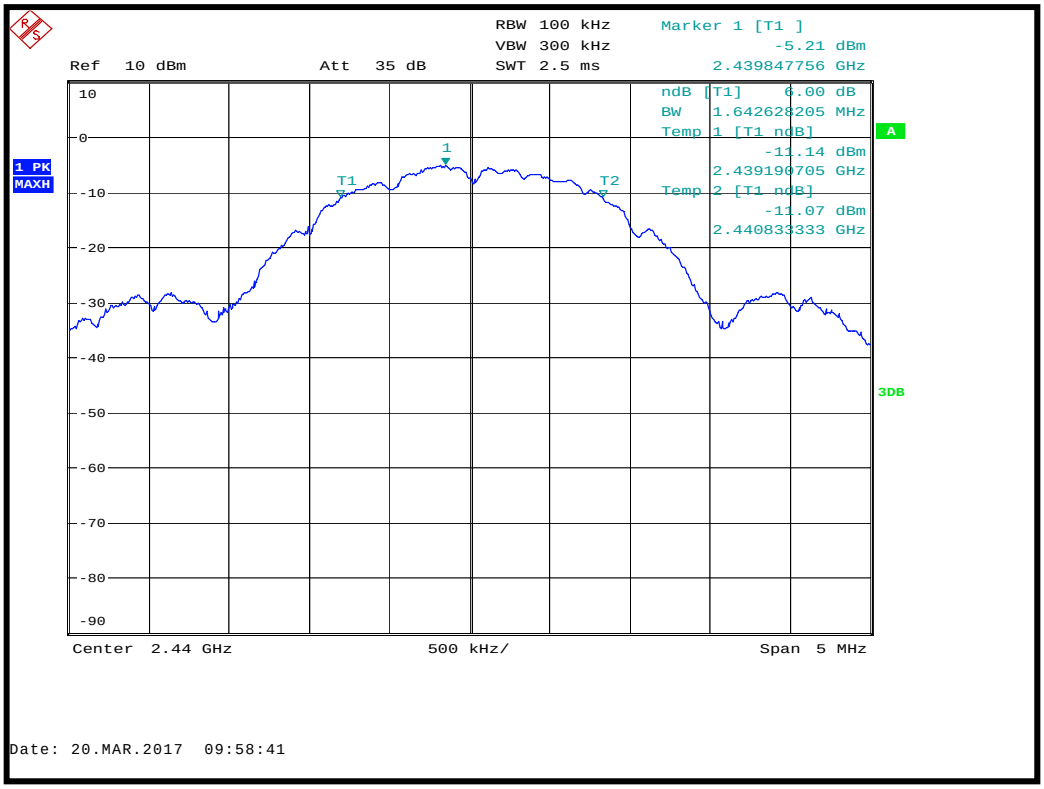


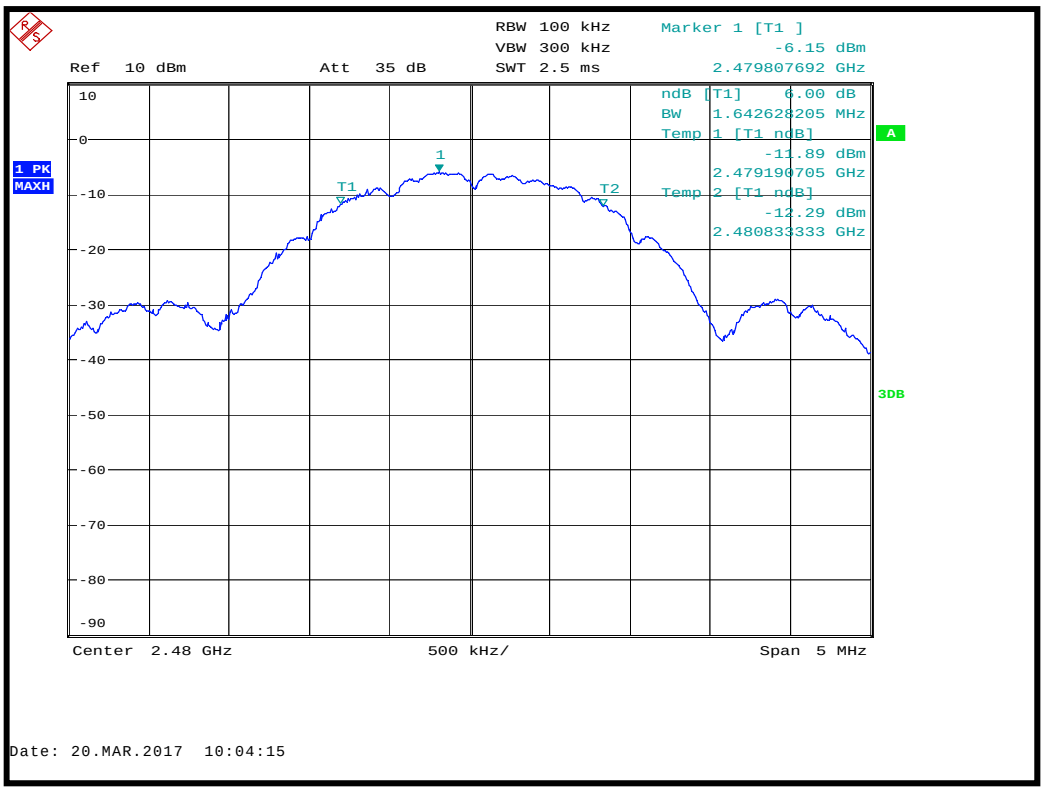

RBW 30 kHz
VBW 100 kHz
SWT 25 ms
Marker 1 [T1]
-8.95 dBm
2.439927885 GHz
Marker 2 [T1]
-14.89 dBm
2.439230769 GHz
Marker 3 [T1]
-15.21 dBm
2.440761218 GHz
Ref 10 dBm
Att 35 dB
1 PK
MAXH
A
3DB
Center 2.44 GHz
500 kHz/
Span 5 MHz
Date: 20.MAR.2017 10:21:44


RBW 30 kHz
VBW 100 kHz
SWT 25 ms
Marker 1 [T1]
-9.84 dBm
2.479919872 GHz
Marker 2 [T1]
-15.82 dBm
2.479222756 GHz
Marker 3 [T1]
-16.25 dBm
2.480761218 GHz
Ref 10 dBm
Att 35 dB
1 PK
MAXH
A
3DB
Center 2.48 GHz
500 kHz/
Span 5 MHz
Date: 20.MAR.2017 10:14:44

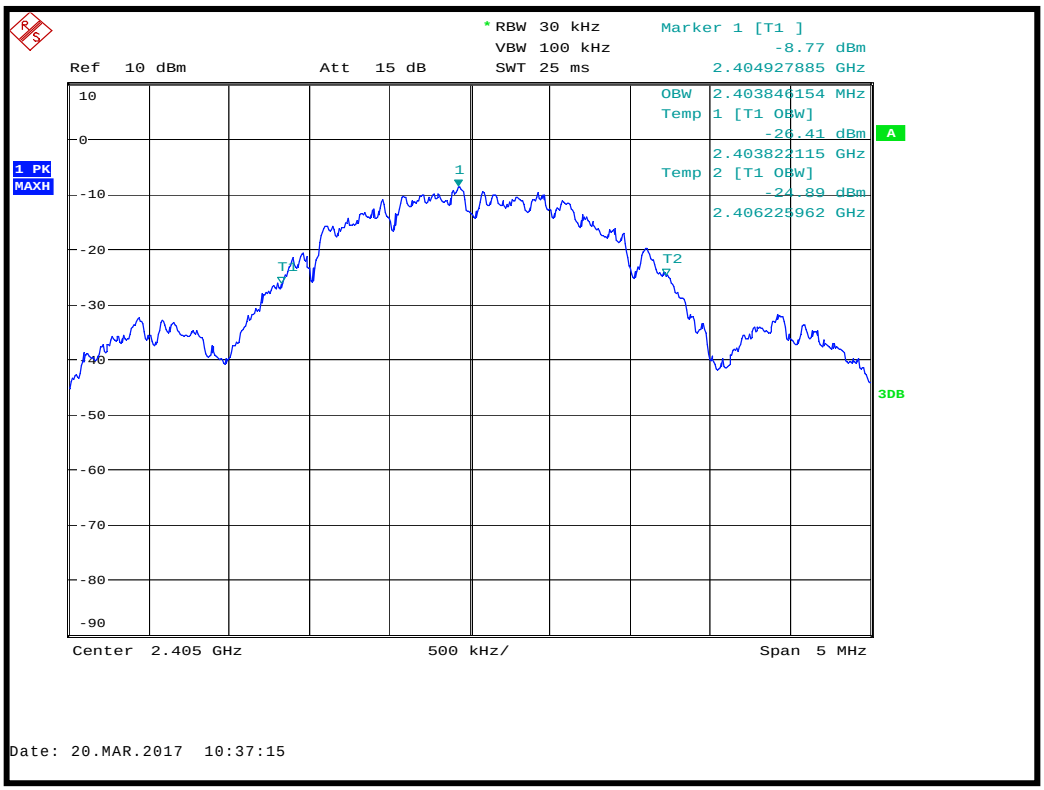
FCC 15.247. Modulation: Zigbee; Power setting: Full				
Channel Frequency (MHz)	**F_L (MHz)**	**F_H (MHz)**	**6dB Bandwidth (MHz)**	**Result**
2405	2404.182692	2405.841346	1.658653846	PASS
2440	2439.190705	2440.833333	1.642628205	PASS
2480	2479.190705	2480.833333	1.642628205	PASS

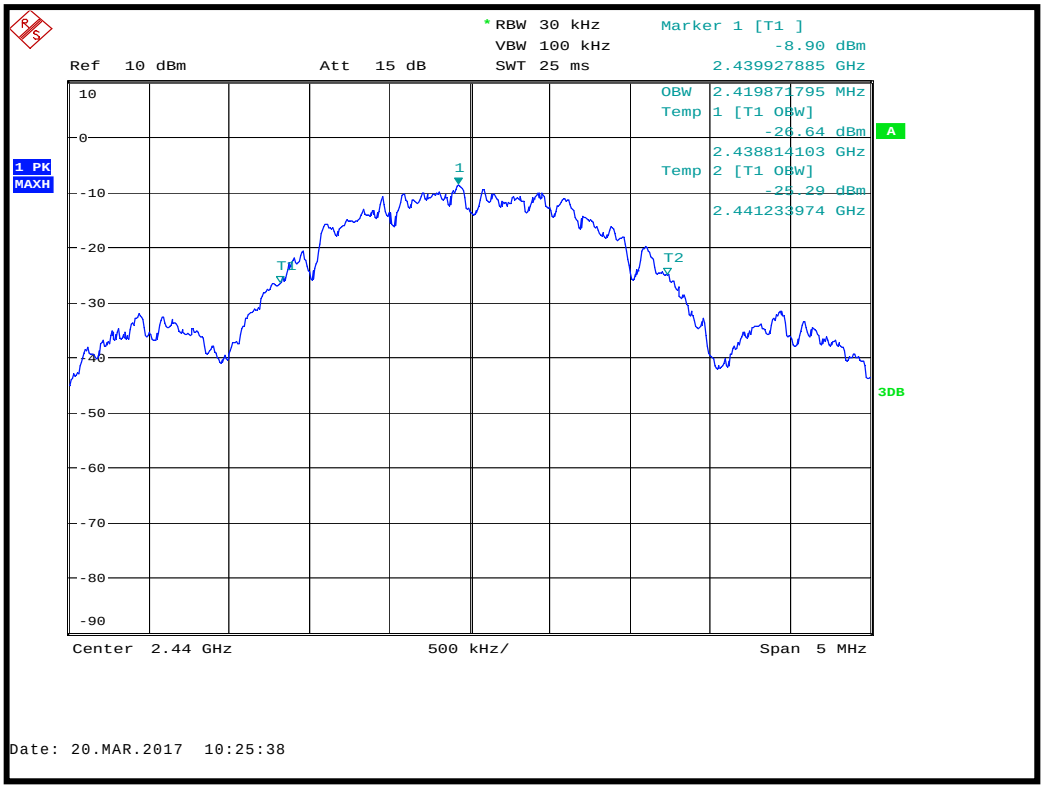


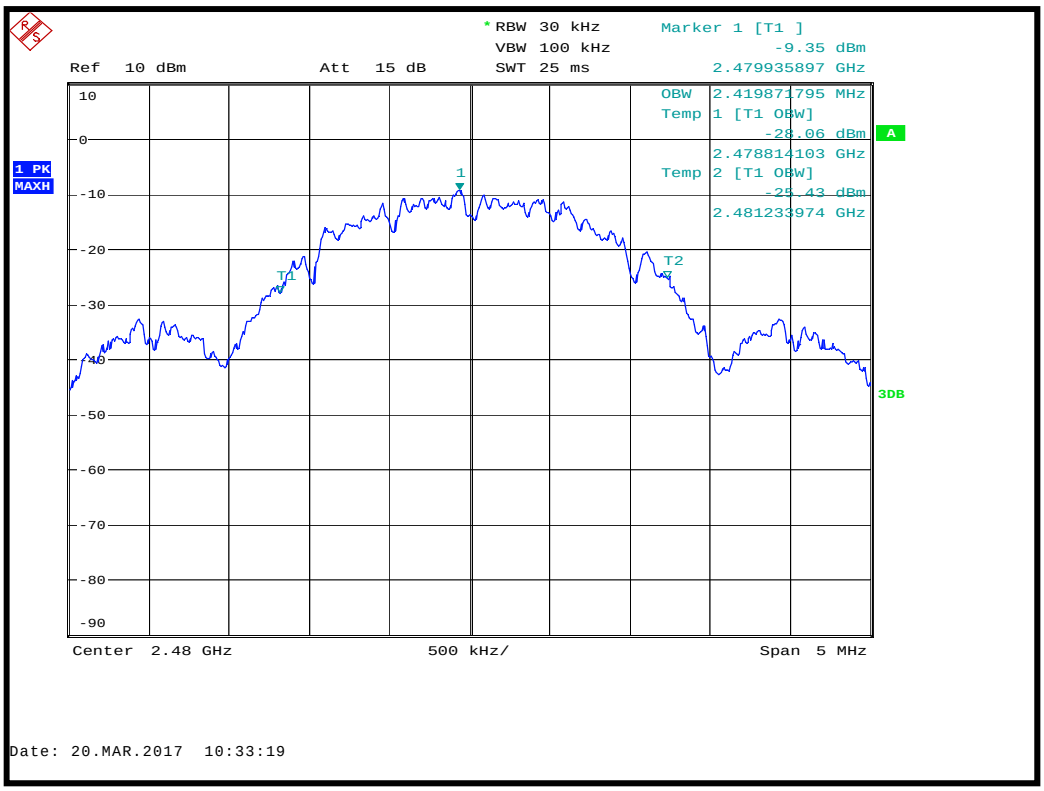

RBW 100 kHz
VBW 300 kHz
SWT 2.5 ms
Marker 1 [T1]
-5.21 dBm
2.439847756 GHz
Ref 10 dBm
Att 35 dB
ndB [T1] 6.00 dB
BW 1.642628205 MHz
Temp 1 [T1 ndB]
-11.14 dBm
2.439190705 GHz
Temp 2 [T1 ndB]
-11.07 dBm
2.440833333 GHz
1 PK
MAXH
A
3DB
Center 2.44 GHz
500 kHz/
Span 5 MHz
Date: 20.MAR.2017 09:58:41


RBW 100 kHz
VBW 300 kHz
SWT 2.5 ms
Marker 1 [T1]
-6.15 dBm
2.479807692 GHz
Ref 10 dBm
Att 35 dB
ndB [T1] 6.00 dB
BW 1.642628205 MHz
Temp 1 [T1 ndB]
-11.89 dBm
2.479190705 GHz
Temp 2 [T1 ndB]
-12.29 dBm
2.480833333 GHz
1 PK
MAXH
A
3DB
Center 2.48 GHz
500 kHz/
Span 5 MHz
Date: 20.MAR.2017 10:04:15

RSS-210. Modulation: Zigbee; Power setting: Full				
Channel Frequency (MHz)	**F_L (MHz)**	**F_H (MHz)**	**99% Bandwidth (MHz)**	**Result**
2405	2403.822115	2406.225962	2.403846154	PASS
2440	2438.814103	2441.233974	2.419871795	PASS
2480	2478.814103	2481.233974	2.419871795	PASS




RBW 30 kHz
VBW 100 kHz
SWT 25 ms
Marker 1 [T1]
-8.90 dBm
2.439927885 GHz
Ref 10 dBm
Att 15 dB
OBW 2.419871795 MHz
Temp 1 [T1 OBW]
-26.64 dBm
2.438814103 GHz
Temp 2 [T1 OBW]
-25.29 dBm
2.441233974 GHz
1 PK
MAXH
A
3DB
Center 2.44 GHz
500 kHz/
Span 5 MHz
Date: 20.MAR.2017 10:25:38


RBW 30 kHz
VBW 100 kHz
SWT 25 ms
Marker 1 [T1]
-9.35 dBm
2.479935897 GHz
Ref 10 dBm
Att 15 dB
OBW 2.419871795 MHz
Temp 1 [T1 OBW]
-28.06 dBm
2.478814103 GHz
Temp 2 [T1 OBW]
-25.43 dBm
2.481233974 GHz
1 PK
MAXH
A
3DB
Center 2.48 GHz
500 kHz/
Span 5 MHz
Date: 20.MAR.2017 10:33:19

14 Maximum peak conducted output power

14.1 Definition

The maximum peak conducted output power is defined as the maximum power level measured with a peak detector using a filter with width and shape of which is sufficient to accept the signal bandwidth.

The maximum 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.

14.2 Test Parameters

Test Location:	Element Hull
Test Chamber:	Lab4
Test Standard and Clause:	ANSI C63.10-2013, Clause 11.9.1
EUT Channels / Frequencies Measured:	Low / Mid / High
EUT Channel Bandwidths:	2 MHz
Deviations From Standard:	None
Measurement BW:	3 MHz
Spectrum Analyzer Video BW: (requirement at least 3x RBW)	10 MHz
Measurement Detector:	Peak
Voltage Extreme Environment Test Range:	Mains Power = 85 % and 115 % of Nominal (FCC only requirement); Battery Power = new battery.

Environmental Conditions (Normal Environment)

Temperature: 20 °C	+15 ºC to +35 ºC (as declared)
Humidity: 41 % RH	20 % RH to 75 % RH (as declared)

14.3 Test Limit

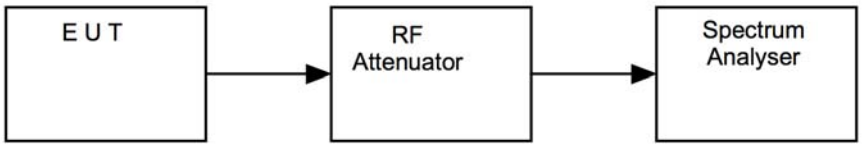
For systems employing digital modulation techniques operating in the bands 902 to 928 MHz, 2400 to 2483.5 MHz and 5725 to 5850 MHz, the maximum peak conducted output power shall not exceed 1 W.

14.4 Test Method

With the EUT setup as per section 9 of this report and connected as per Figure iv, the resolution bandwidth of the spectrum analyser was increased above the EUT occupied bandwidth and the peak emission data noted.

The measurements were performed with EUT set at its maximum duty. All modulation schemes, data rates and power settings were used to observe the worst-case configuration in each bandwidth.

Figure iv Test Setup



14.5 Test Equipment

Equipment Type	Manufacturer	Equipment Description	Element No	Due For Calibration
FSU26	R&S	Spectrum Analyser	REF909	02/05/2017

14.6 Test Results

Modulation: Zigbee; Power setting: Full				
Channel Frequency (MHz)	***Analyzer Level (dBm)***	***Cable loss (dB)***	***Power (mW)***	***Result***
2405	-1.01	0	0.793	PASS
2440	-0.98	0	0.798	PASS
2480	-1.69	0	0.678	PASS

15 Out-of-band and conducted spurious emissions

15.1 Definition

Out-of-band emission.
Emission on a frequency or frequencies immediately outside the necessary bandwidth that results from the modulation process but excluding spurious emissions.

Spurious emission.
Emission on a frequency or frequencies that are outside the necessary bandwidth and the level of which may be reduced without affecting the corresponding transmission of information. Spurious emissions include harmonic emissions, parasitic emissions, intermodulation products, and frequency conversion products, but exclude out-of-band emissions.

15.2 Test Parameters

Test Location:	Element Hull
Test Chamber:	Lab4
Test Standard and Clause:	ANSI C63.10-2013, Clause 11.11
EUT Channels / Frequencies Measured:	Low / Mid / High
EUT Channel Bandwidths:	2 MHz
Deviations From Standard:	None
Measurement BW:	100 kHz
Spectrum Analyzer Video BW: (requirement at least 3x RBW)	300 kHz
Measurement Detector:	Peak
Measurement Range:	30 MHz to 26.5 GHz

Environmental Conditions (Normal Environment)

Temperature: 20 °C	+15 ºC to +35 ºC (as declared)
Humidity: 41 % RH	20 % RH to 75 % RH (as declared)

15.3 Test Limit

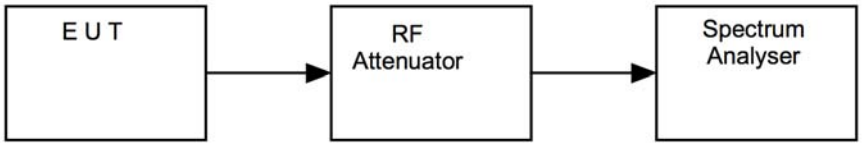
In any 100 kHz bandwidth outside the frequency band in which the spread spectrum or digitally modulated device is operating, the RF power that is produced shall be at least 20 dB below that in the 100 kHz bandwidth within the band that contains the highest level of the desired power, based on either an RF conducted or a radiated measurement, provided that the transmitter demonstrates compliance with the peak conducted power limits. If the transmitter complies with the conducted power limits based on the use of root-mean-square averaging over a time interval, the attenuation required shall be 30 dB instead of 20 dB. Attenuation below the general field strength limits specified in FCC 47CFR15.209(a) / RSS-Gen is not required.

15.4 Test Method

With the EUT setup as per section 9 of this report and connected as per Figure v, the emissions from the EUT were measured on a spectrum analyser.

The measurements were performed with EUT set at its maximum duty. All modulation schemes, data rates and power settings were used to observe the worst case configuration in each bandwidth.

Figure v Test Setup

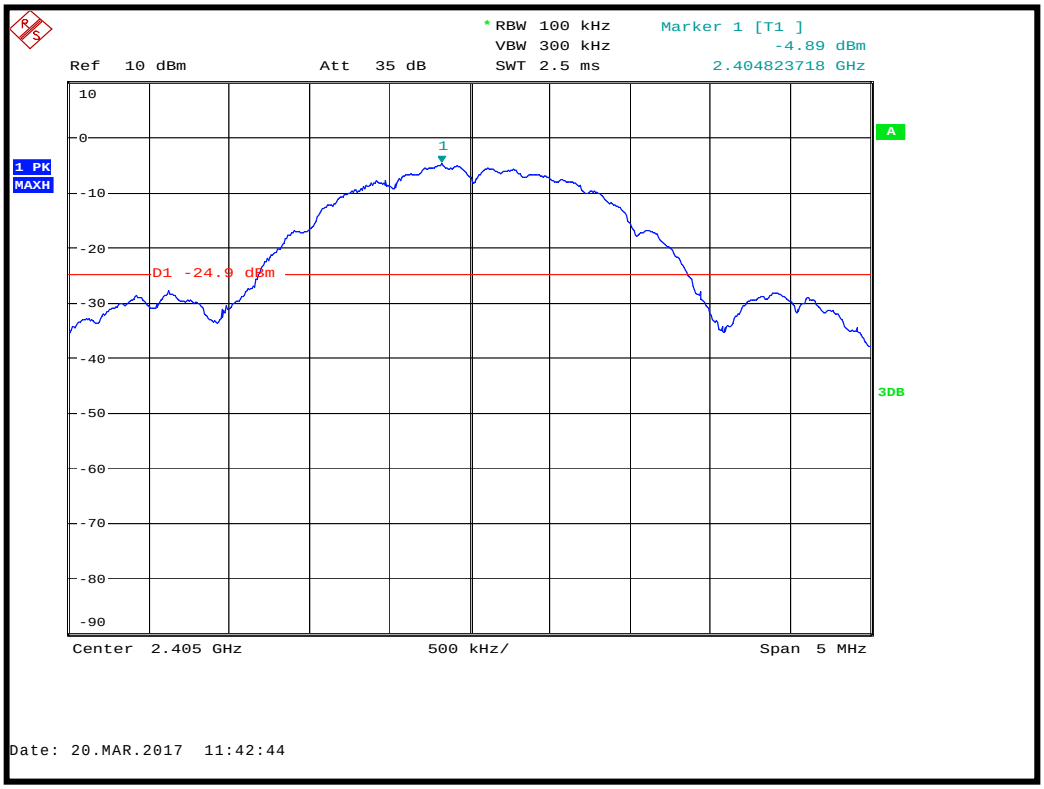


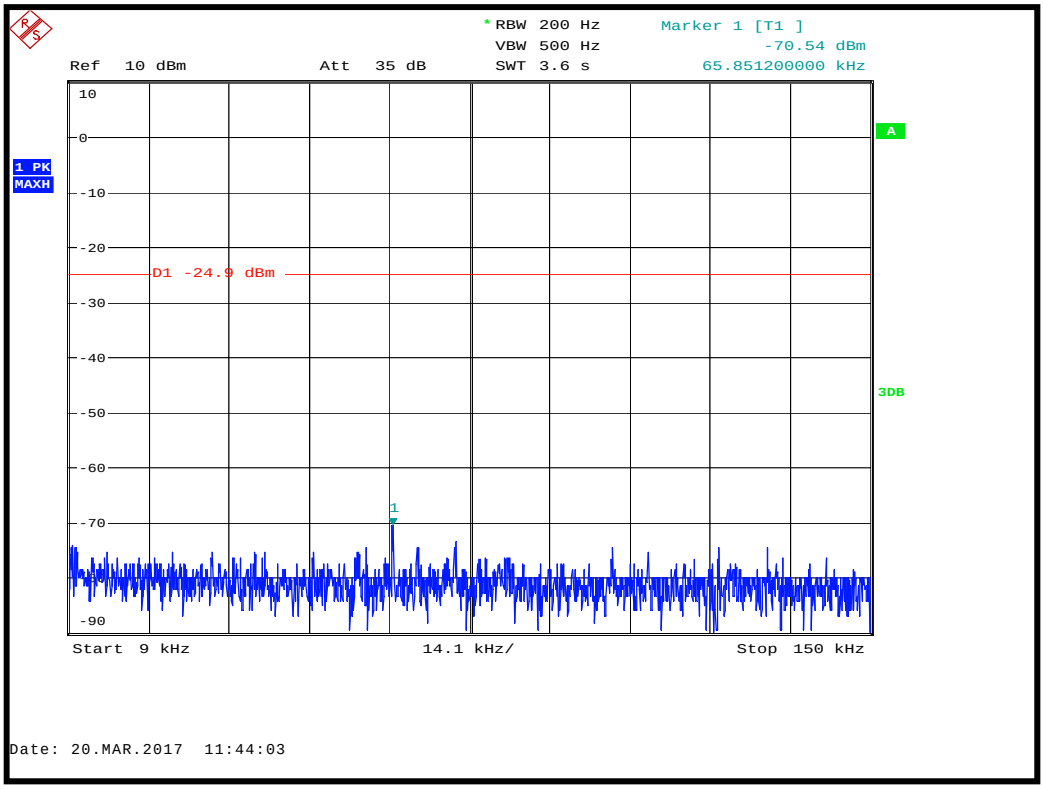
15.5 Test Equipment

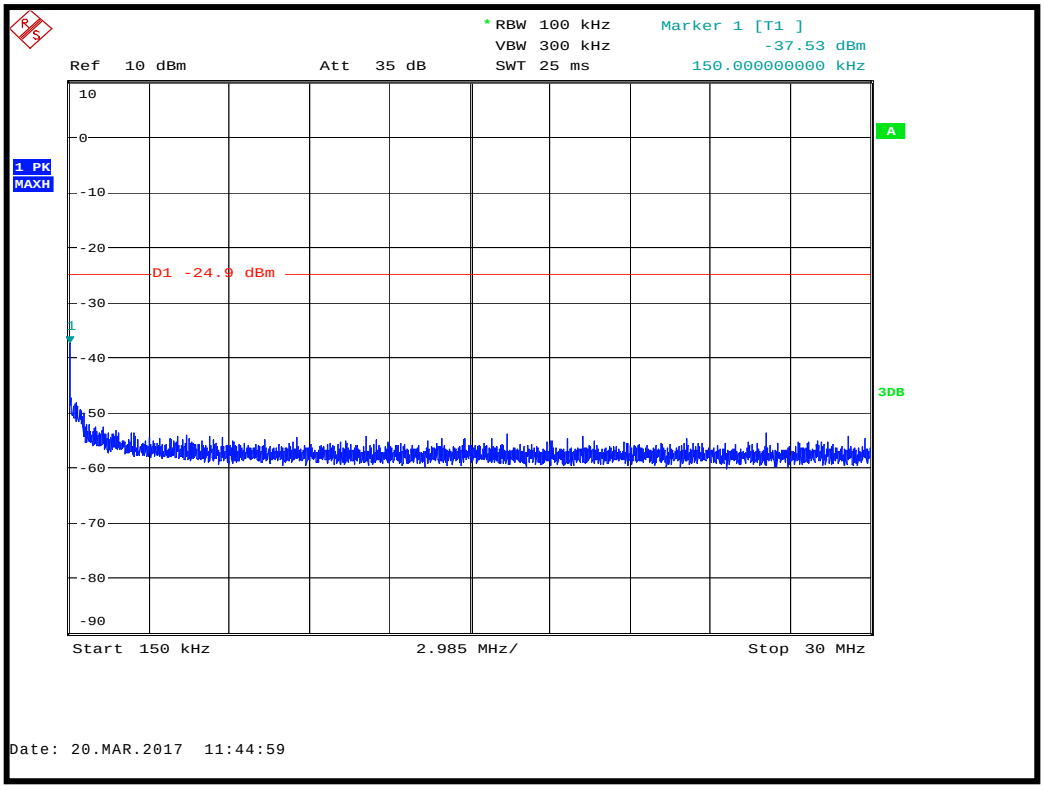
Equipment Type	Manufacturer	Equipment Description	Element No	Due For Calibration
FSU26	R&S	Spectrum Analyser	REF909	02/05/2017

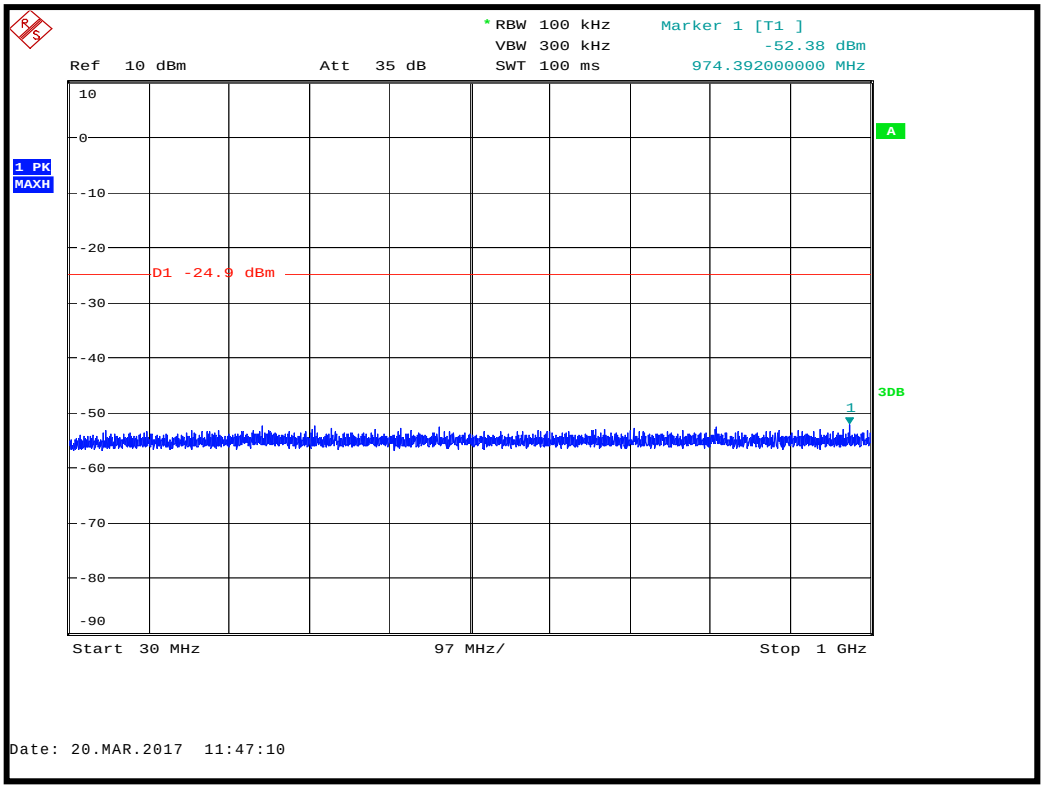
15.6 Test Results

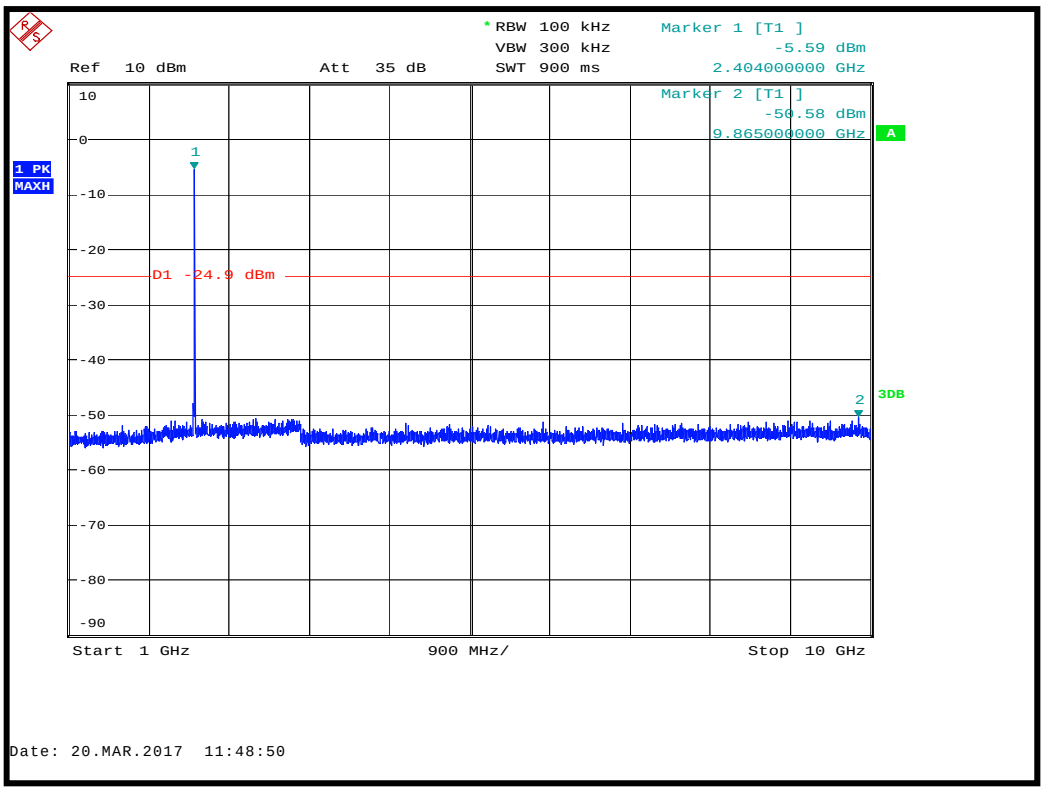
Channel: 2405 MHz; Modulation: Zigbee; Power setting: Full						
Channel Frequency (MHz)	**Emission Frequency (MHz)**	**Analyzer Level (dBm)**	**Emission Level (dBm)**	**Limit (dBm)**	**Margin (dB)**	**Result**
2405	2405	-4.89	-4.89	N/A	N/A	PASS
2405	0.066	-70.54	-70.54	-24.9	-45.64	PASS
2405	0.150	-37.53	-37.53	-24.9	-12.63	PASS
2405	974.392	-52.38	-52.38	-24.9	-27.48	PASS
2405	9865.000	-50.58	-50.58	-24.9	-25.68	PASS
2405	24751.000	-47.08	-47.08	-24.9	-22.18	PASS

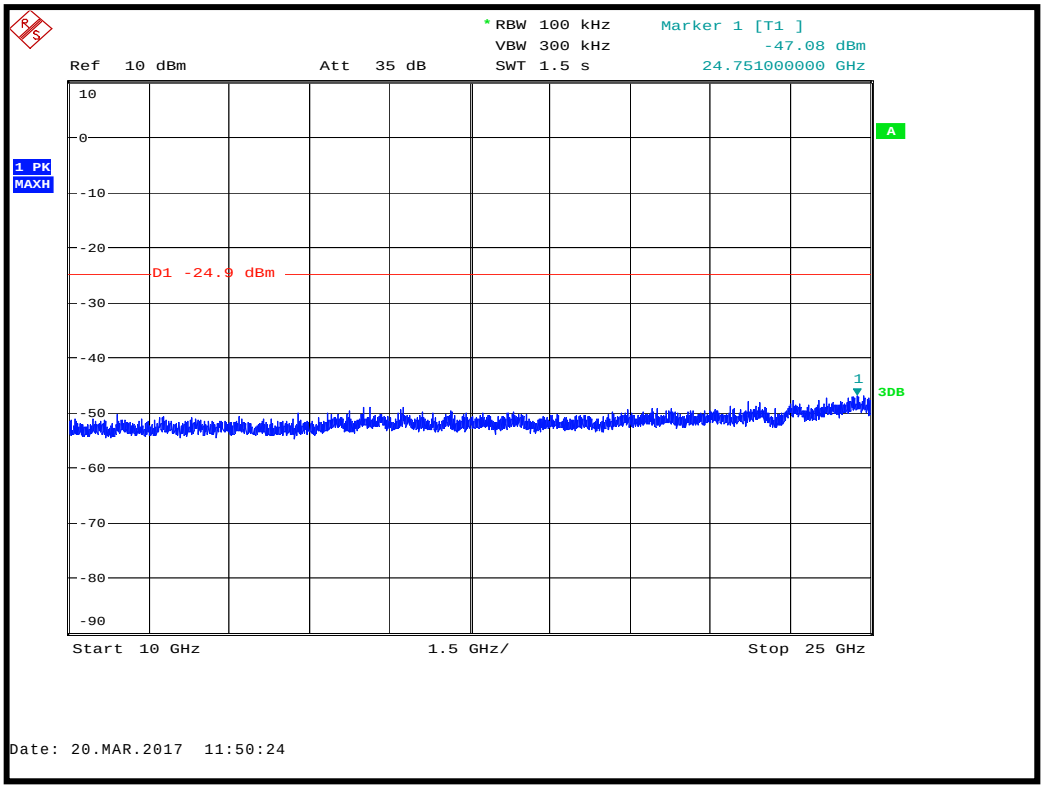


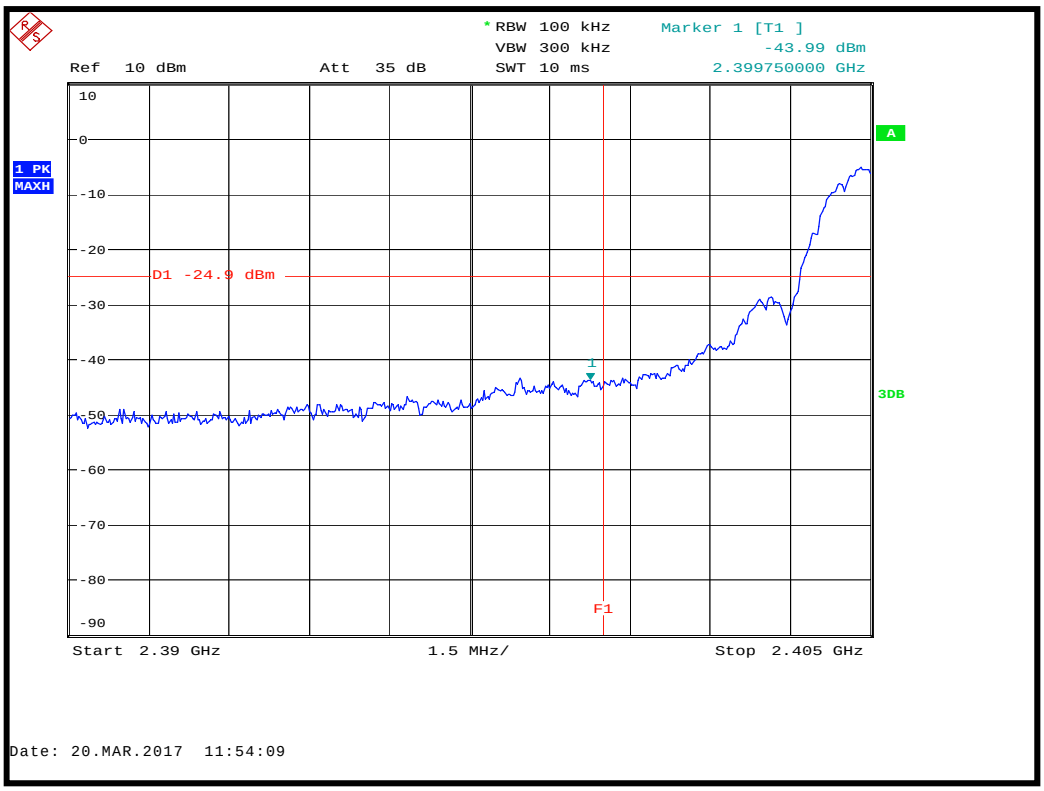

RBW 200 Hz
VBW 500 Hz
SWT 3.6 s
Marker 1 [T1]
-70.54 dBm
65.851200000 kHz
Ref 10 dBm
Att 35 dB
1 PK
MAXH
A
3DB
D1 -24.9 dBm
Start 9 kHz
14.1 kHz/
Stop 150 kHz
Date: 20.MAR.2017 11:44:03


RBW 100 kHz
VBW 300 kHz
SWT 25 ms
Marker 1 [T1]
-37.53 dBm
150.000000000 kHz
Ref 10 dBm
Att 35 dB
1 PK
MAXH
A
3DB
D1 -24.9 dBm
Start 150 kHz
2.985 MHz/
Stop 30 MHz
Date: 20.MAR.2017 11:44:59

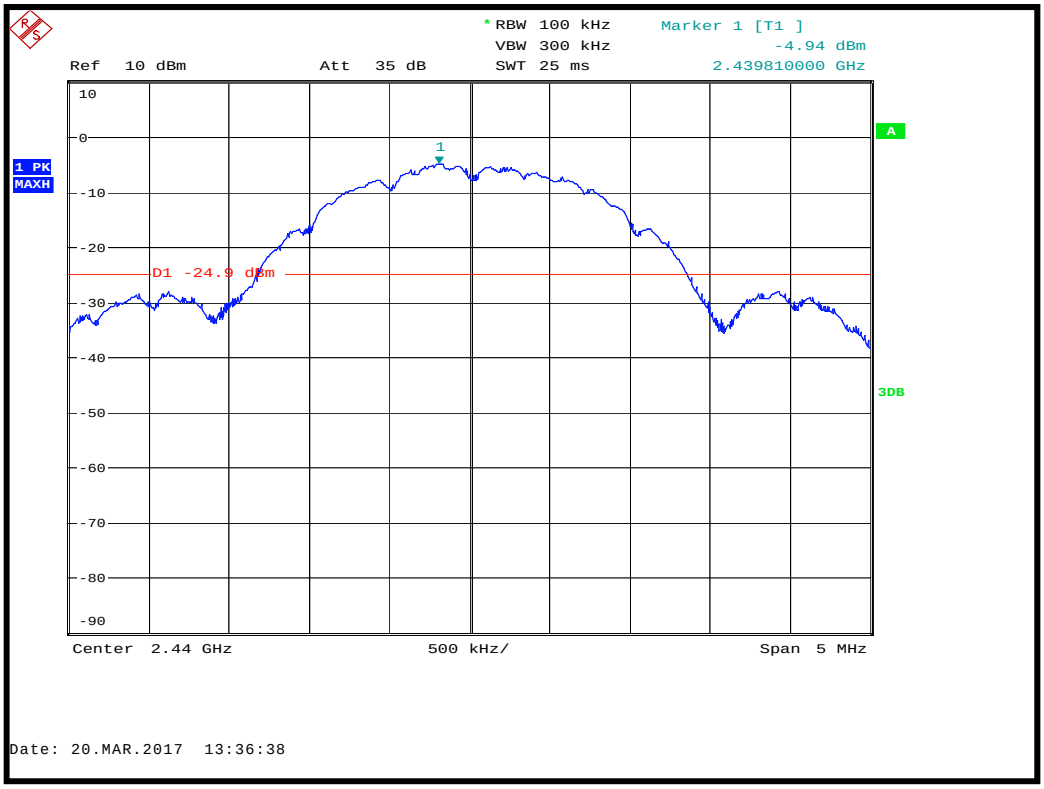

RBW 100 kHz
VBW 300 kHz
SWT 100 ms
Marker 1 [T1]
-52.38 dBm
974.392000000 MHz
Ref 10 dBm
Att 35 dB
1 PK
MAXH
A
3DB
D1 -24.9 dBm
Start 30 MHz
97 MHz/
Stop 1 GHz
Date: 20.MAR.2017 11:47:10

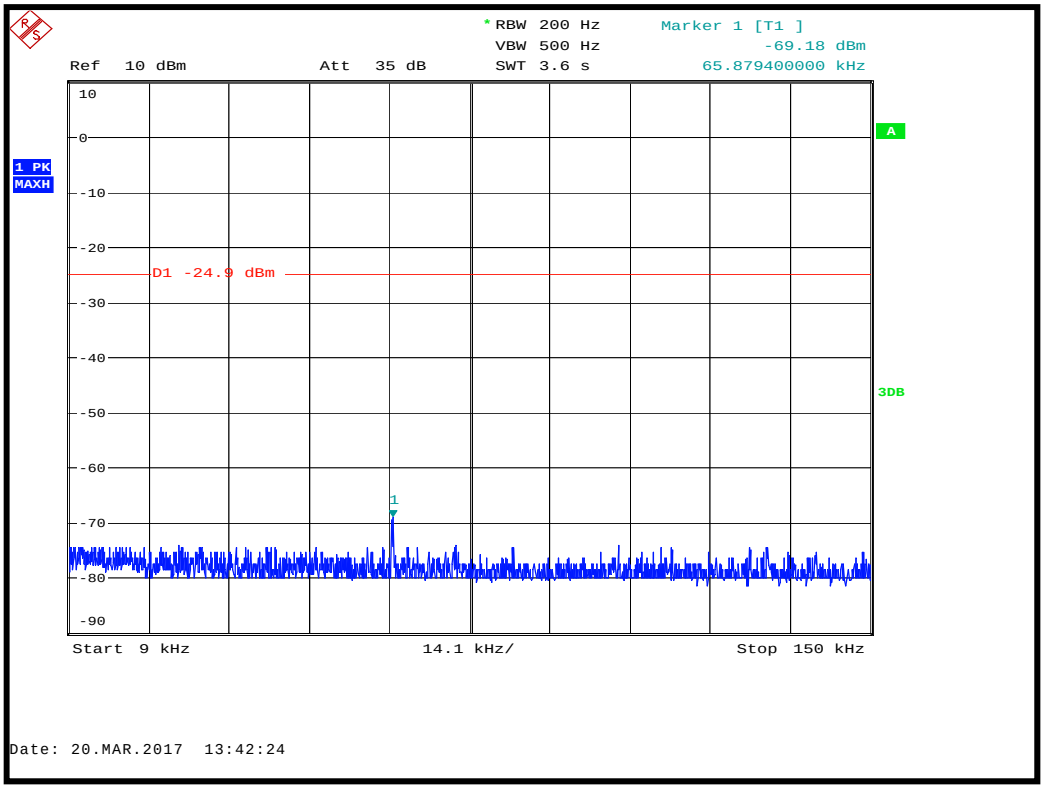

RBW 100 kHz
VBW 300 kHz
SWT 900 ms
Marker 1 [T1]
-5.59 dBm
2.404000000 GHz
Marker 2 [T1]
-50.58 dBm
9.865000000 GHz
Ref 10 dBm
Att 35 dB
1 PK
MAXH
A
3DB
D1 -24.9 dBm
Start 1 GHz
900 MHz/
Stop 10 GHz
Date: 20.MAR.2017 11:48:50

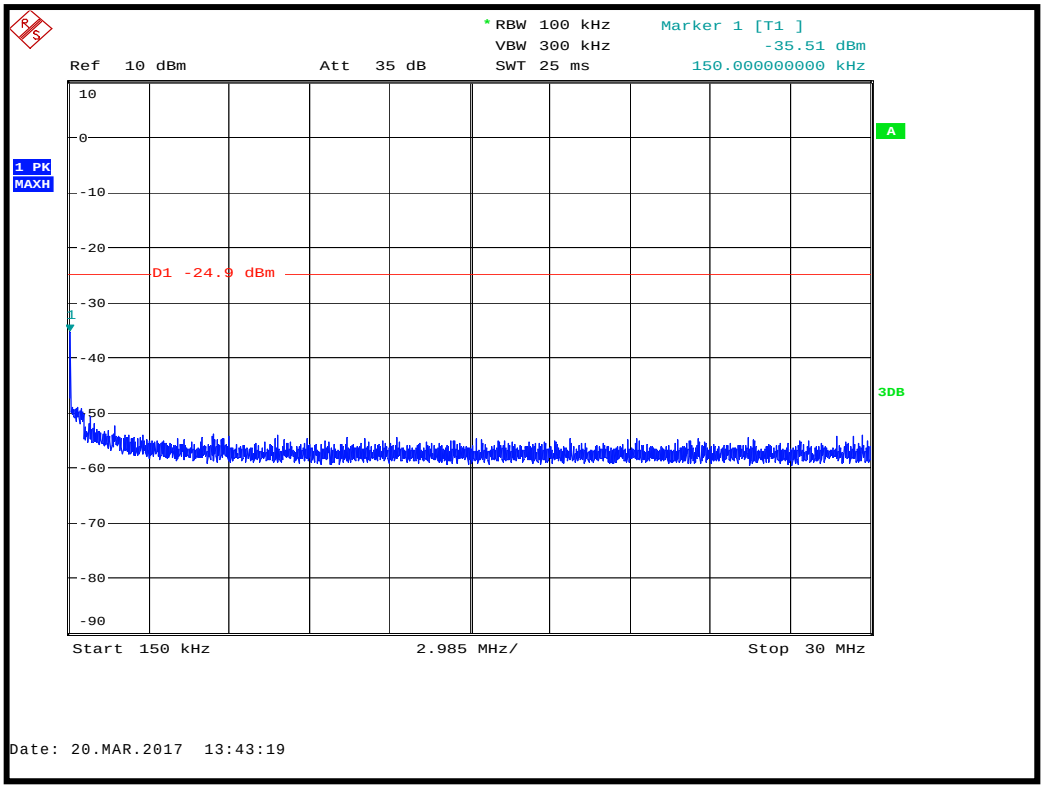

RBW 100 kHz
VBW 300 kHz
SWT 1.5 s
Marker 1 [T1]
-47.08 dBm
24.751000000 GHz
Ref 10 dBm
Att 35 dB
1 PK
MAXH
A
D1 -24.9 dBm
3DB
Start 10 GHz
1.5 GHz/
Stop 25 GHz
Date: 20.MAR.2017 11:50:24

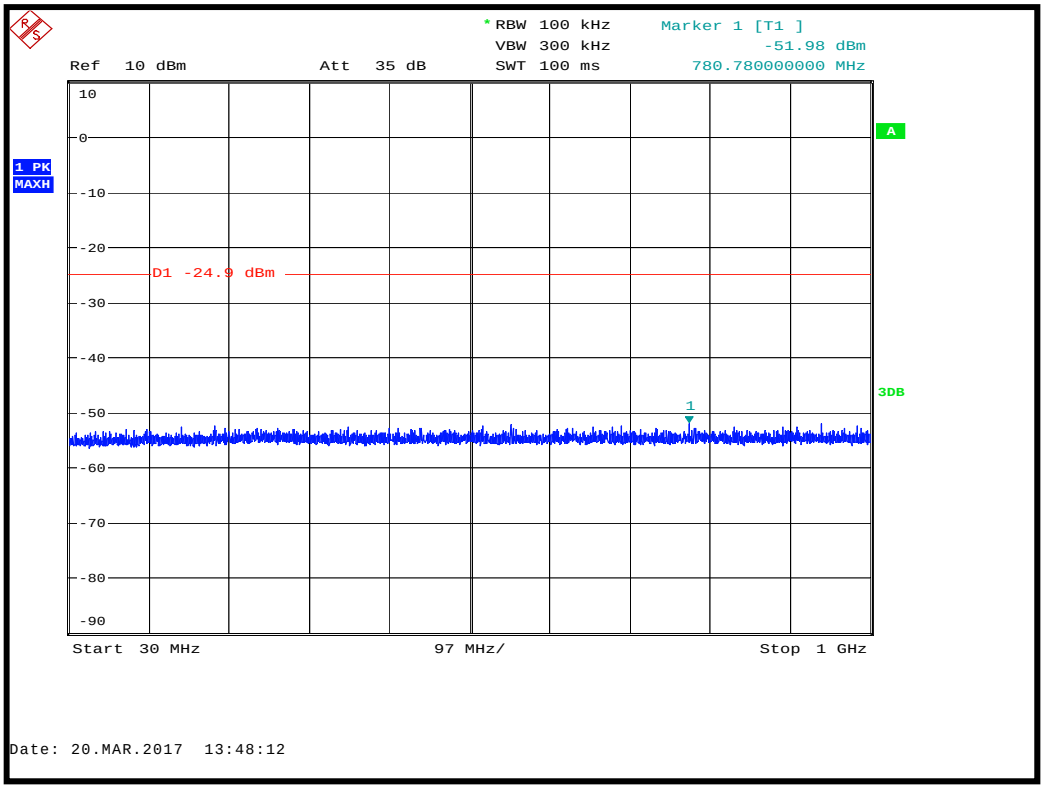

RBW 100 kHz
VBW 300 kHz
SWT 10 ms
Marker 1 [T1]
-43.99 dBm
2.399750000 GHz
Ref 10 dBm
Att 35 dB
1 PK
MAXH
A
D1 -24.9 dBm
3DB
F1
Start 2.39 GHz
1.5 MHz/
Stop 2.405 GHz
Date: 20.MAR.2017 11:54:09

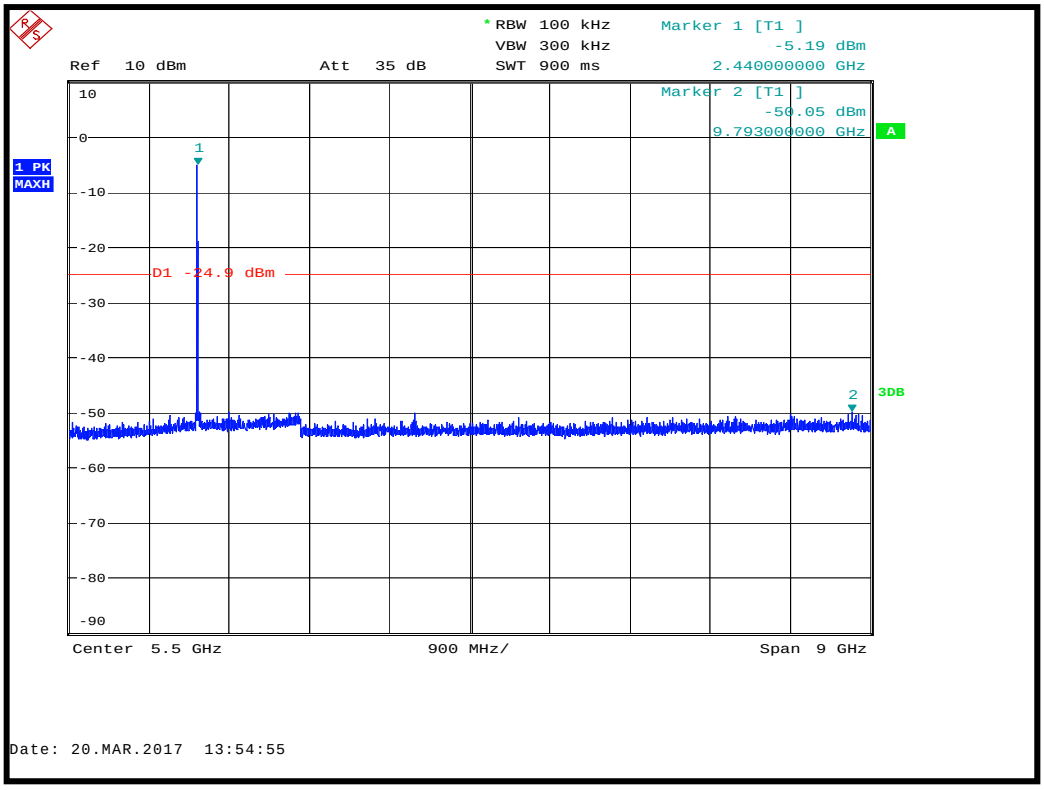
Channel: 2440 MHz; Modulation: Zigbee; Power setting: Full						
Channel Frequency (MHz)	**Emission Frequency (MHz)**	**Analyzer Level (dBm)**	**Emission Level (dBm)**	**Limit (dBm)**	**Margin (dB)**	**Result**
2440	2440	-4.94	-4.94	N/A	N/A	PASS
2440	0.066	-69.18	-69.18	-24.9	-44.28	PASS
2440	0.150	-35.51	-35.51	-24.9	-10.61	PASS
2440	780.780	-51.98	-51.98	-24.9	-27.08	PASS
2440	9793.000	-50.05	-50.05	-24.9	-25.15	PASS
2440	24289.000	-46.81	-46.81	-24.9	-21.91	PASS

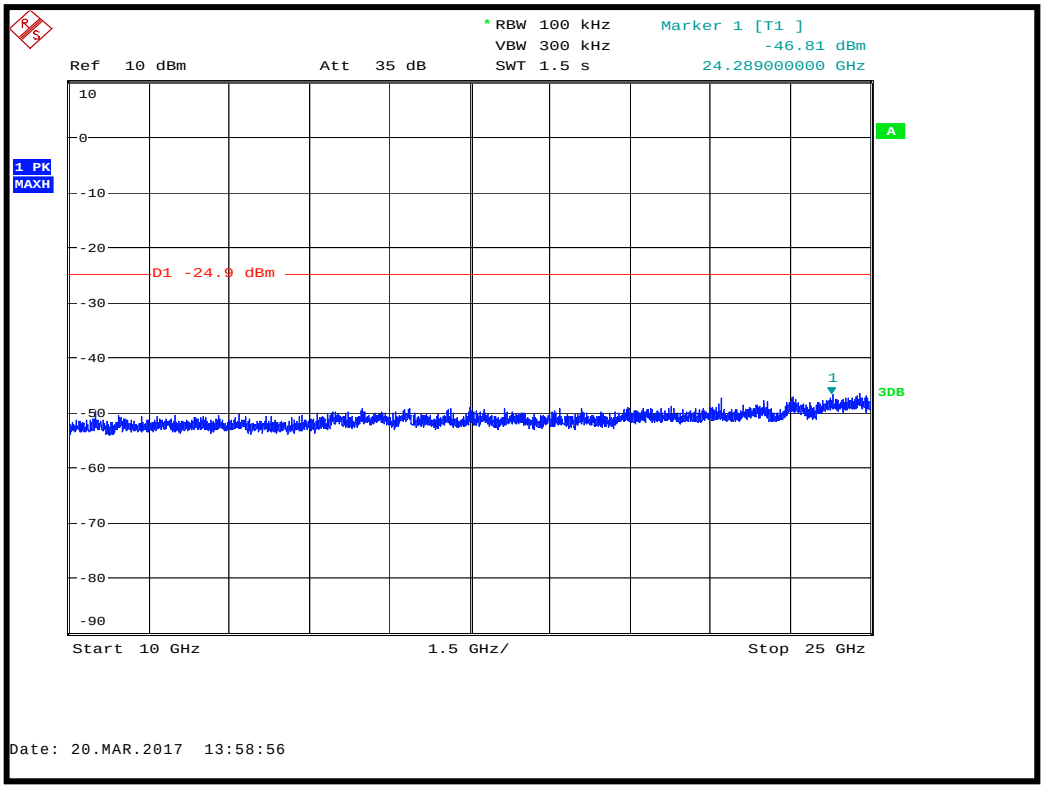



RBW 200 Hz
VBW 500 Hz
SWT 3.6 s
Marker 1 [T1]
-69.18 dBm
65.879400000 kHz
Ref 10 dBm
Att 35 dB
1 PK
MAXH
A
3DB
D1 -24.9 dBm
Start 9 kHz
14.1 kHz/
Stop 150 kHz
Date: 20.MAR.2017 13:42:24

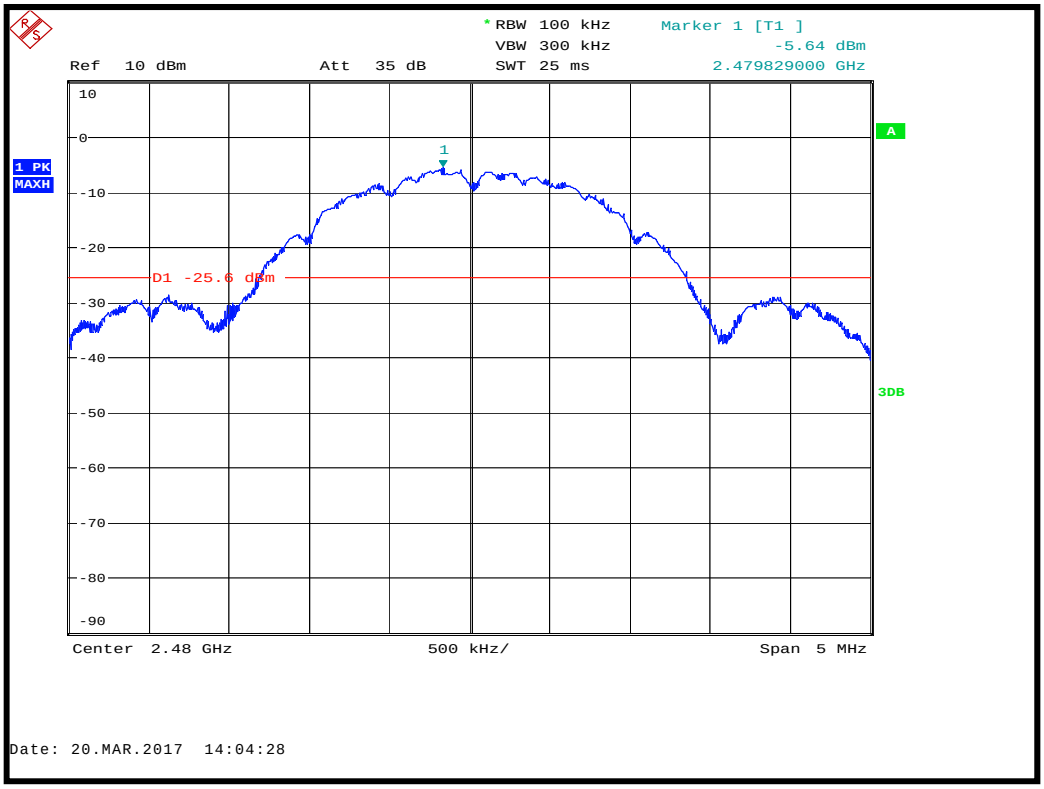

RBW 100 kHz
VBW 300 kHz
SWT 25 ms
Marker 1 [T1]
-35.51 dBm
150.000000000 kHz
Ref 10 dBm
Att 35 dB
1 PK
MAXH
A
3DB
D1 -24.9 dBm
Start 150 kHz
2.985 MHz/
Stop 30 MHz
Date: 20.MAR.2017 13:43:19

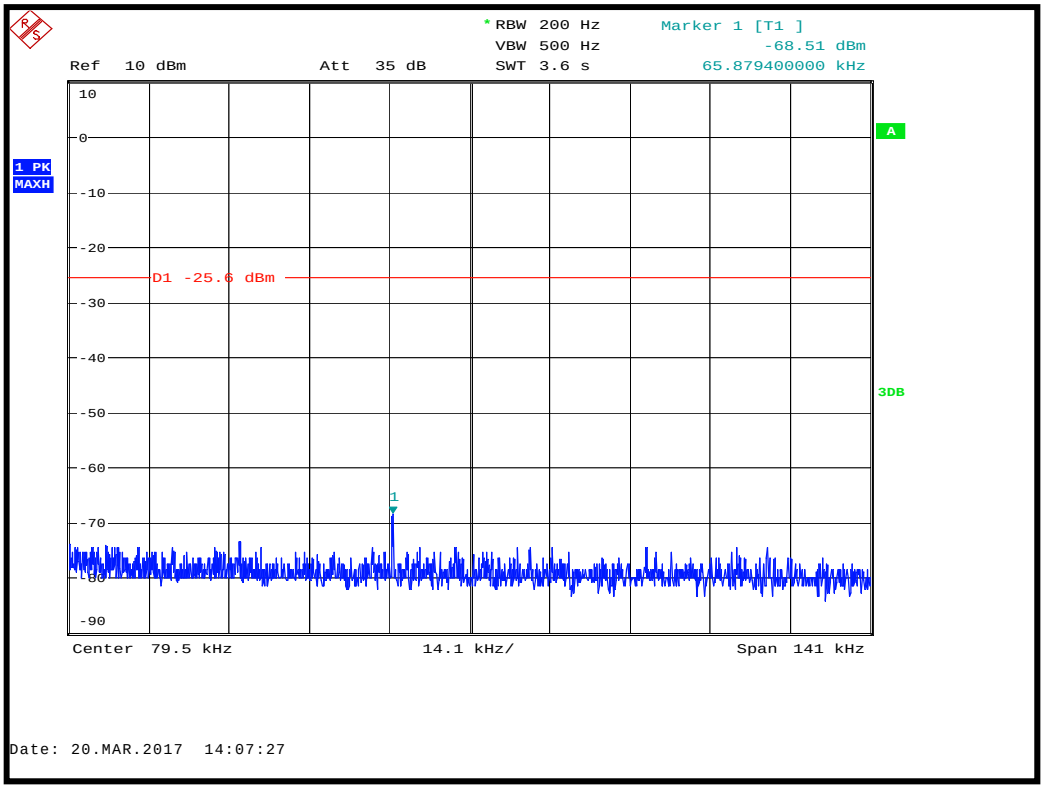

RBW 100 kHz
VBW 300 kHz
SWT 100 ms
Marker 1 [T1]
-51.98 dBm
780.780000000 MHz
Ref 10 dBm
Att 35 dB
1 PK
MAXH
A
3DB
D1 -24.9 dBm
Start 30 MHz
97 MHz/
Stop 1 GHz
Date: 20.MAR.2017 13:48:12

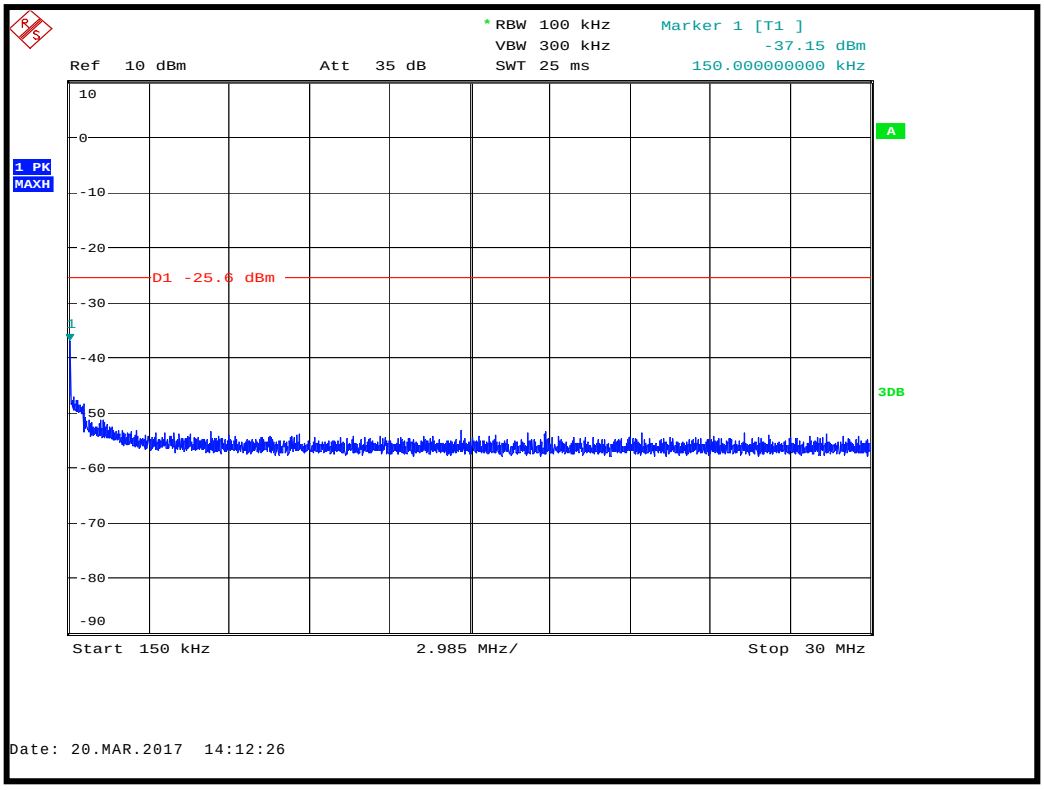

RBW 100 kHz
VBW 300 kHz
SWT 900 ms
Marker 1 [T1]
-5.19 dBm
2.440000000 GHz
Marker 2 [T1]
-50.05 dBm
9.793000000 GHz
Ref 10 dBm
Att 35 dB
1 PK
MAXH
A
3DB
D1 -24.9 dBm
Center 5.5 GHz
900 MHz/
Span 9 GHz
Date: 20.MAR.2017 13:54:55

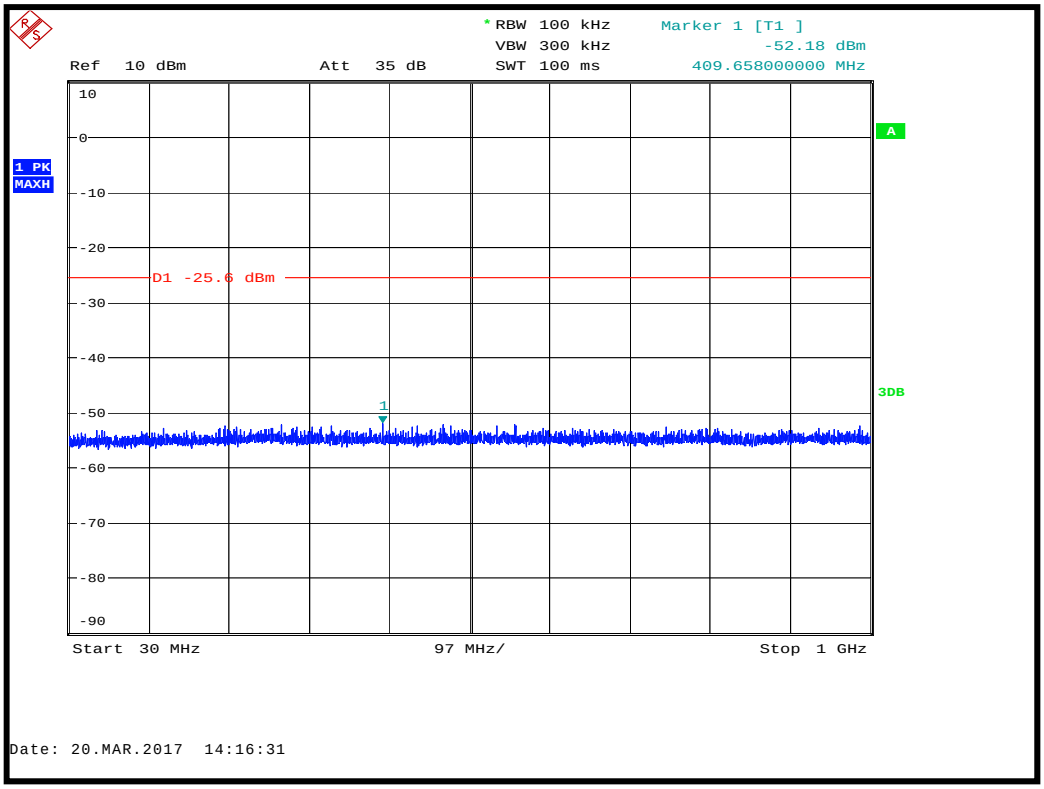

RBW 100 kHz
VBW 300 kHz
SWT 1.5 s
Marker 1 [T1]
-46.81 dBm
24.289000000 GHz
Ref 10 dBm
Att 35 dB
1 PK
MAXH
A
D1 -24.9 dBm
3DB
Start 10 GHz
1.5 GHz/
Stop 25 GHz
Date: 20.MAR.2017 13:58:56

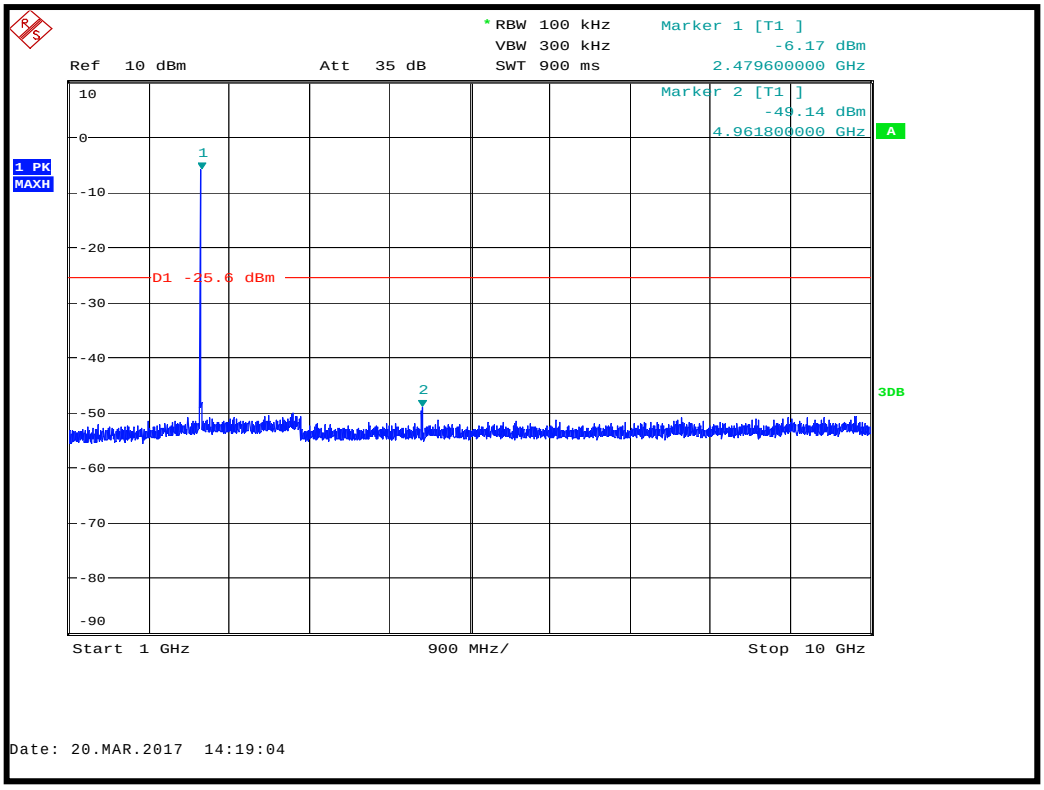
Channel: 2480 MHz; Modulation: Zigbee; Power setting: Full						
Channel Frequency (MHz)	**Emission Frequency (MHz)**	**Analyzer Level (dBm)**	**Emission Level (dBm)**	**Limit (dBm)**	**Margin (dB)**	**Result**
2480	2480	-5.64	-5.64	N/A	N/A	PASS
2480	0.066	-68.51	-68.51	-25.6	-42.91	PASS
2480	0.150	-37.15	-37.15	-25.6	-11.55	PASS
2480	409.658	-52.18	-52.18	-25.6	-26.58	PASS
2480	4961.800	-49.14	-49.14	-25.6	-23.54	PASS
2480	24811.000	-45.77	-45.77	-25.6	-20.17	PASS

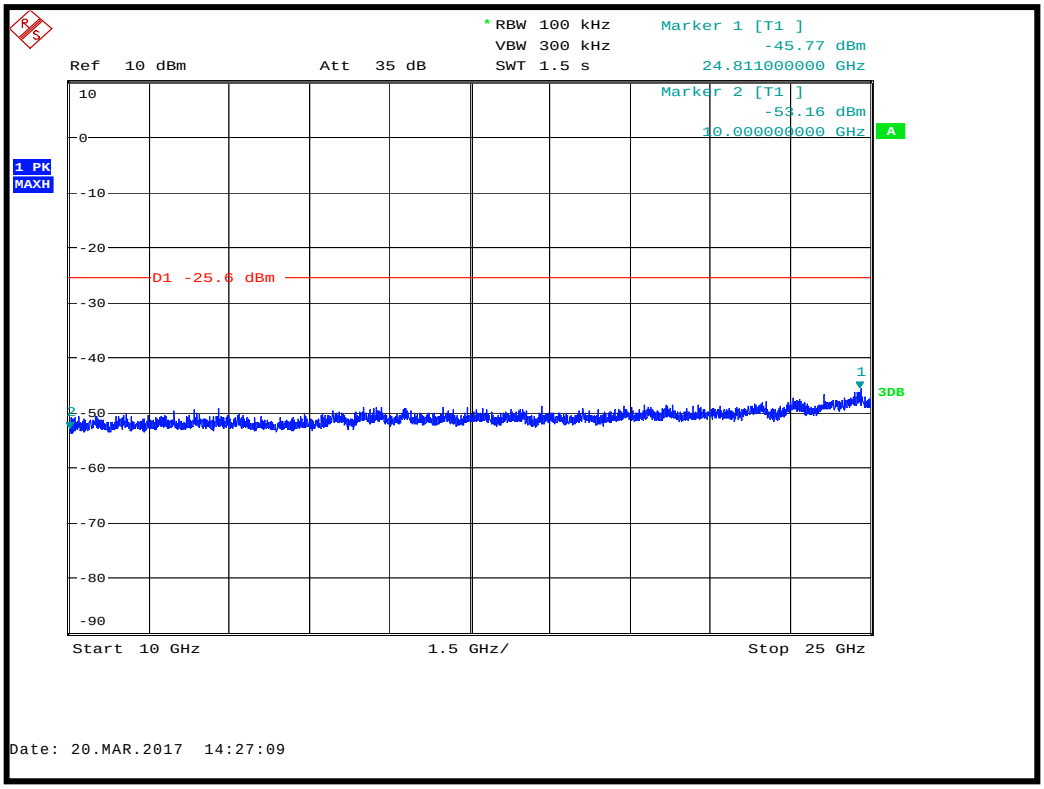



RBW 200 Hz
VBW 500 Hz
SWT 3.6 s
Marker 1 [T1]
-68.51 dBm
65.879400000 kHz
Ref 10 dBm
Att 35 dB
1 PK
MAXH
A
3DB
D1 -25.6 dBm
Center 79.5 kHz
14.1 kHz/
Span 141 kHz
Date: 20.MAR.2017 14:07:27


RBW 100 kHz
VBW 300 kHz
SWT 25 ms
Marker 1 [T1]
-37.15 dBm
150.000000000 kHz
Ref 10 dBm
Att 35 dB
1 PK
MAXH
A
3DB
D1 -25.6 dBm
Start 150 kHz
2.985 MHz/
Stop 30 MHz
Date: 20.MAR.2017 14:12:26


RBW 100 kHz
VBW 300 kHz
SWT 100 ms
Marker 1 [T1]
-52.18 dBm
409.658000000 MHz
Ref 10 dBm
Att 35 dB
1 PK
MAXH
A
3DB
D1 -25.6 dBm
Start 30 MHz
97 MHz/
Stop 1 GHz
Date: 20.MAR.2017 14:16:31


RBW 100 kHz
VBW 300 kHz
SWT 900 ms
Marker 1 [T1]
-6.17 dBm
2.479600000 GHz
Marker 2 [T1]
-49.14 dBm
4.961800000 GHz
Ref 10 dBm
Att 35 dB
1 PK
MAXH
A
3DB
D1 -25.6 dBm
Start 1 GHz
900 MHz/
Stop 10 GHz
Date: 20.MAR.2017 14:19:04


RBW 100 kHz
VBW 300 kHz
SWT 1.5 s
Marker 1 [T1]
-45.77 dBm
24.811000000 GHz
Marker 2 [T1]
-53.16 dBm
10.000000000 GHz
Ref 10 dBm
Att 35 dB
1 PK
MAXH
A
D1 -25.6 dBm
3DB
Start 10 GHz
1.5 GHz/
Stop 25 GHz
Date: 20.MAR.2017 14:27:09

16 Power spectral density

16.1 Definition

The power per unit bandwidth.

16.2 Test Parameters

Test Location:	Element Hull
Test Chamber:	Lab4
Test Standard and Clause:	ANSI C63.10-2013, Clause 11.10
EUT Channels / Frequencies Measured:	Low / Mid / High
EUT Channel Bandwidths:	2 MHz
Deviations From Standard:	None
Measurement BW:	3 kHz
Spectrum Analyzer Video BW: (requirement at least 3x RBW)	10 kHz
Measurement Span: (requirement 1.5 times Channel BW)	3 MHz
Measurement Detector:	Peak

Environmental Conditions (Normal Environment)

Temperature: 20 °C	+15 ºC to +35 ºC (as declared)
Humidity: 41 % RH	20 % RH to 75 % RH (as declared)

16.3 Test Limit

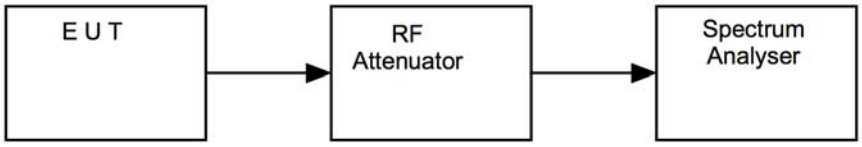
The transmitter power spectral density conducted from the transmitter to the antenna shall not be greater than 8 dBm in any 3 kHz band during any time interval of continuous transmission.

16.4 Test Method

With the EUT setup as per section 9 of this report and connected as per Figure vi, the peak emission of the EUT was measured on a spectrum analyser, with path losses taken into account.

The measurements were performed with EUT set at its maximum duty. All modulation schemes, data rates and power settings were used to observe the worst case configuration in each bandwidth.

Figure vi Test Setup

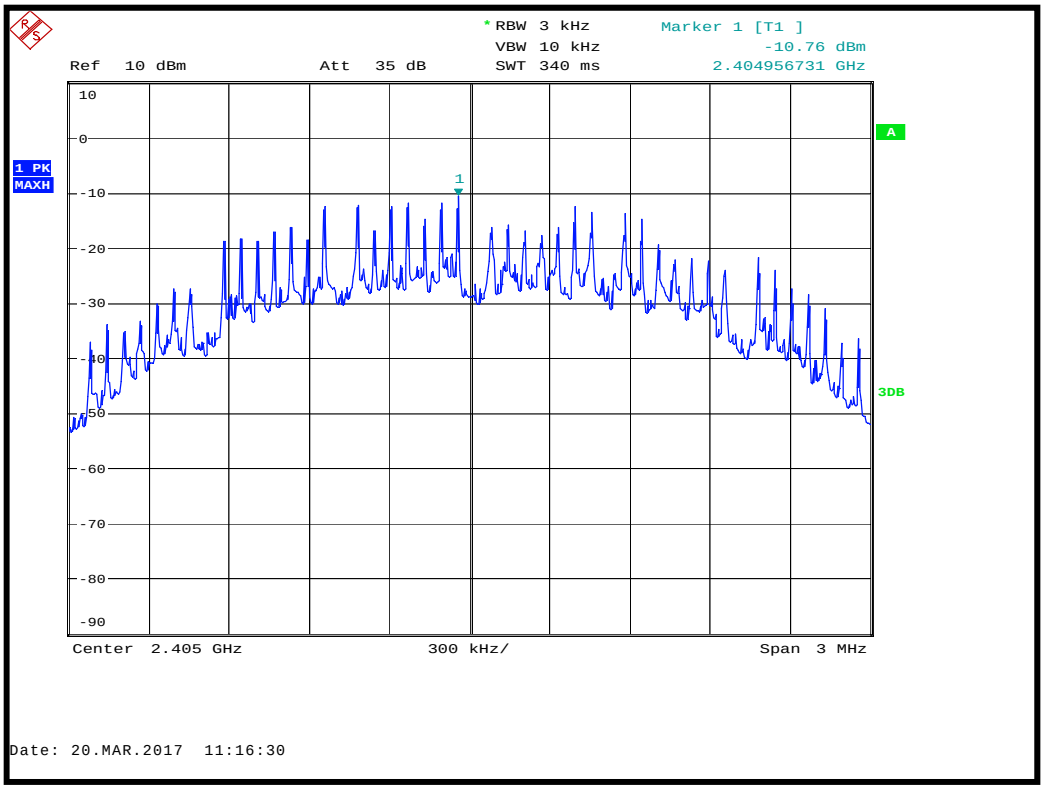


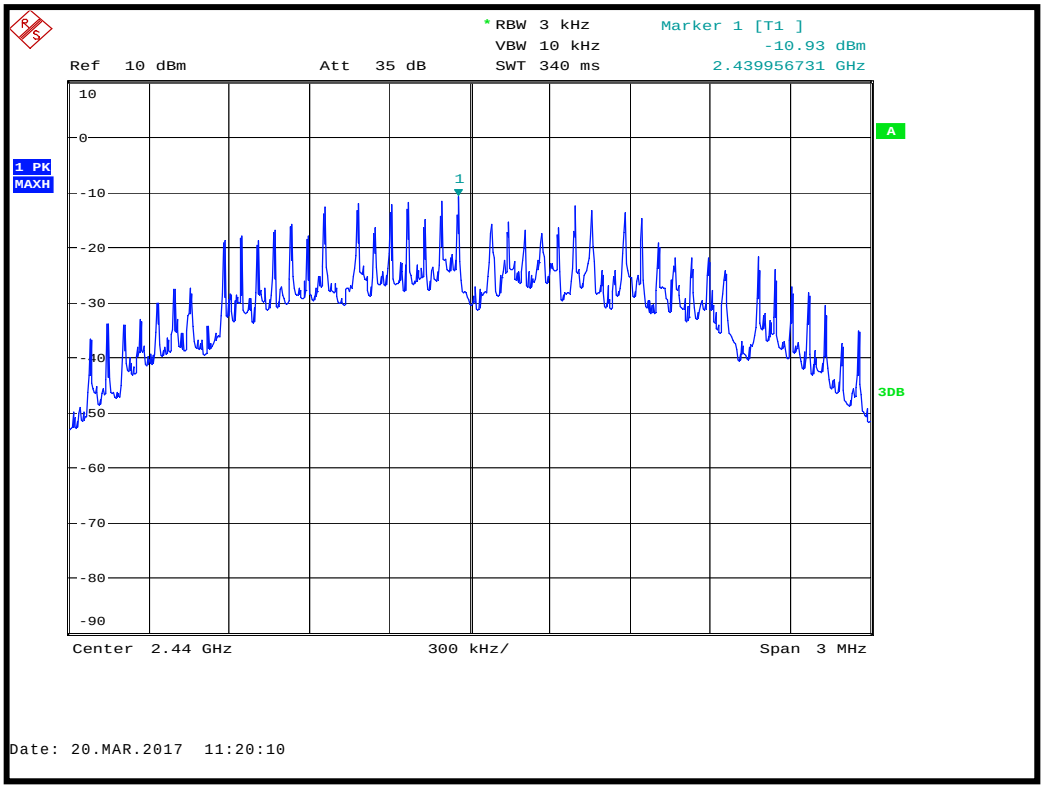
16.5 Test Equipment

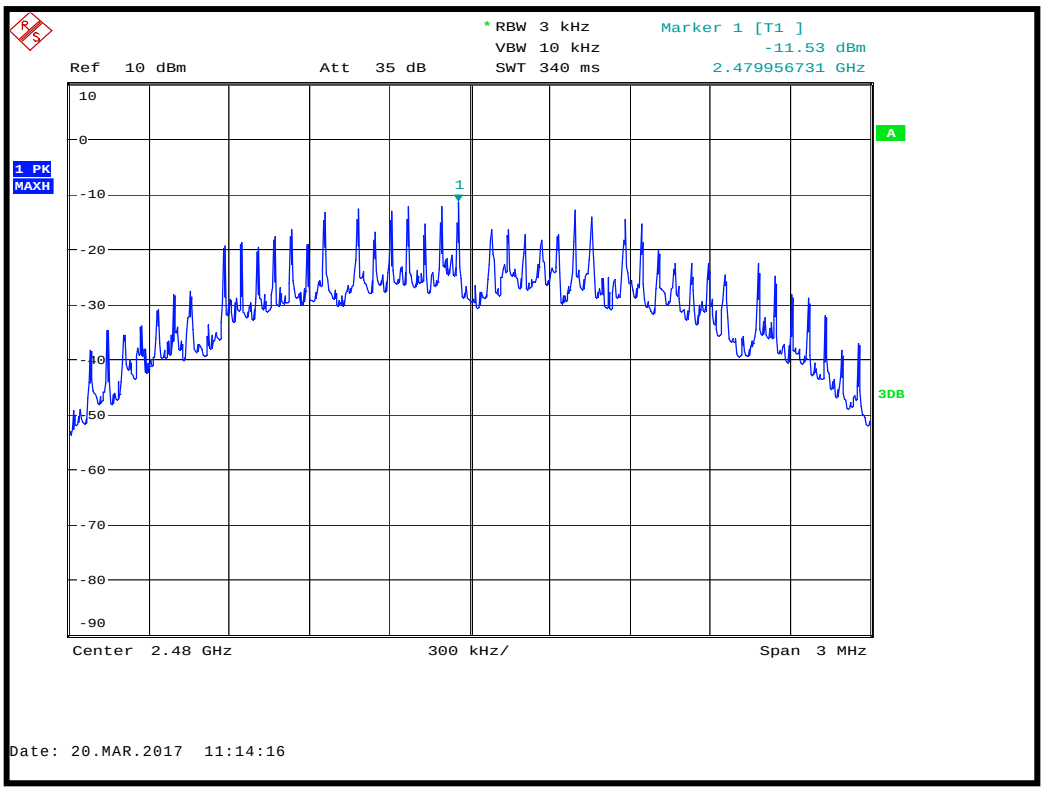
Equipment Type	Manufacturer	Equipment Description	Element No	Due For Calibration
FSU26	R&S	Spectrum Analyser	REF909	02/05/2017

16.6 Test Results

Modulation: Zigbee; Power setting: Full				
Channel Frequency (MHz)	**Analyzer Level (dBm)**	**Cable loss (dB)**	**Power (dBm)**	**Result**
2405	-10.76	0	-10.76	PASS
2440	-10.93	0	-10.93	PASS
2480	-11.53	0	-11.53	PASS




RBW 3 kHz
VBW 10 kHz
SWT 340 ms
Marker 1 [T1]
-10.93 dBm
2.439956731 GHz
Ref 10 dBm
Att 35 dB
1 PK
MAXH
A
3DB
10
0
-10
-20
-30
-40
-50
-60
-70
-80
-90
Center 2.44 GHz
300 kHz/
Span 3 MHz
Date: 20.MAR.2017 11:20:10


RBW 3 kHz
VBW 10 kHz
SWT 340 ms
Marker 1 [T1]
-11.53 dBm
2.479956731 GHz
Ref 10 dBm
Att 35 dB
1 PK
MAXH
A
3DB
10
0
-10
-20
-30
-40
-50
-60
-70
-80
-90
Center 2.48 GHz
300 kHz/
Span 3 MHz
Date: 20.MAR.2017 11:14:16

17 Measurement Uncertainty

Calculated Measurement Uncertainties

All statements of uncertainty are expanded standard uncertainty using a coverage factor of 1.96 to give a 95 % confidence:

[1] Radiated spurious emissions

Uncertainty in test result (30 MHz to 1 GHz) = **4.6 dB**
Uncertainty in test result (1 GHz to 18 GHz) = **4.7 dB**

[2] AC power line conducted emissions

Uncertainty in test result = **3.4 dB**

[3] Occupied bandwidth

Uncertainty in test result = **15.5 %**

[4] Conducted carrier power

Uncertainty in test result (Power Meter) = **1.08 dB**

[5] Conducted / radiated RF power out-of-band

Uncertainty in test result – up to 8.1 GHz = **3.31 dB**
Uncertainty in test result – 8.1 GHz to 15.3 GHz = **4.43 dB**
Uncertainty in test result (30 MHz to 1 GHz) = **4.6 dB**
Uncertainty in test result (1 GHz to 18 GHz) = **4.7 dB**

[6] Power spectral density

Uncertainty in test result (Spectrum Analyser) = **2.48 dB**

18 General SAR test reduction & exclusion guidance / MPE Calculation

KDB 447498

Section 4.3 General SAR test reduction and exclusion guidance

For Standalone SAR exclusion consideration, when SAR Exclusion Threshold requirement in KDB 447498 is satisfied, standalone SAR evaluation for general population exposure conditions by measurement or numerical simulation is not required.

The SAR Test Exclusion Threshold for operation in the 2400 – 2483.5 MHz band will be determined as follows

SAR Exclusion Threshold (SARET)

SAR Exclusion Threshold = Step 1 + Step 2

Step 1

NT = [(MP/TSDA) * √ fGHz]

NT = Numeric Threshold (3.0 for 1-g SAR and 7.5 for 10-g SAR)
MP = Max Power of channel (mW) (inc tune up)
TSDA = Min Test separation Distance or 50mm (whichever is lower) = 5mm (in this case)

We can transpose this formula to allow us to find the maximum power of a channel allowed and compare this to the measured maximum power.

= [(NT x TSDA) / √ fGHz]

For Distances Greater than 50 mm Step 2 applies

Step 2

(TSDB – 50mm) * 10}

Where:
TSDB = Min Test separation Distance (mm) = 50

Note: Step 2 is not required here as the TSDA is 5mm.

Operating Frequency 2.405 GHz

SARET = [(3.0 x 5) / √2.402]
SARET = 9.68 mW

Operating Frequency 2.440 GHz

SARET = [(3.0 x 5) / √2.440]
SARET = 9.60 mW

Operating Frequency 2.480 GHz

SARET = [(3.0 x 5) / √2.480]
SARET = 9.53 mW

Channel Frequency (MHz)	*Maximum Conducted Power (mW)*	SAR Exclusion Threshold (mW)	SAR Evaluation
2405	0.793	9.68	Not Required
2440	0.798	9.60	Not Required
2480	0.678	9.53	Not Required

Therefore standalone SAR evaluation for general population exposure conditions by measurement or numerical simulation is not required.

19 RF Exposure Technical Brief

RSS-102 issue 5
2.5.1 Exemption Limits for Routine Evaluation – SAR Evaluation

SAR evaluation is required if the separation distance between the user and/or bystander and the antenna and/or radiating element of the device is less than or equal to 20 cm, except when the device operates at or below the applicable output power level (adjusted for tune-up tolerance) for the specified separation distance.

Channel Frequency (MHz)	EIRP (mW)	SAR Exclusion Threshold at distance of ≤ 5 mm (mW)	SAR Evaluation
2405	1.26	4.26	Not Required
2440	1.26	4.05	Not Required
2480	1.07	3.94	Not Required

Note: EIRP is calculated by adding maximum conducted power and antenna gain of 2 dBi