

Report on the Radio Testing
For
Accesso Technology Group PLC
on
BLE Base Station
Report no. TRA-033907-09-45-00A
5th April 2017

RF915 4.0



Report Number: TRA-033907-09-45-00A
Issue: A

REPORT ON THE RADIO TESTING OF A
Accesso Technology Group PLC
BLE Base Station
WITH RESPECT TO SPECIFICATION
FCC 47CFR 15.247

TEST DATE: 04th - 05th April 2017

Written by: A Tosif

A Tosif
Radio Test Engineer

Approved by:

J Charters
Department Manager- Radio

Date: 5th April 2017

Disclaimers:

- [1] THIS DOCUMENT MAY BE REPRODUCED ONLY IN ITS ENTIRETY AND WITHOUT CHANGE
[2] THE RESULTS CONTAINED IN THIS DOCUMENT RELATE ONLY TO THE ITEM(S) TESTED

RF915 4.0

1 Revision Record

<i>Issue Number</i>	<i>Issue Date</i>	<i>Revision History</i>
A	5th April 2017	Original

2 Summary

TEST REPORT NUMBER:	TRA-033907-09-45-00A
WORKS ORDER NUMBER:	TRA-033907-09
PURPOSE OF TEST:	Certification
TEST SPECIFICATION(S):	47CFR15.247
EQUIPMENT UNDER TEST (EUT):	BLE Base Station
FCC IDENTIFIER:	2AKCM-P2400-485
EUT SERIAL NUMBER:	not applicable
MANUFACTURER/AGENT:	Accesso Technology Group PLC
ADDRESS:	Unit 2 The Pavilions Ruscombe Park Twyford Berkshire RG10 9NN United Kingdom
CLIENT CONTACT:	Tony Underwood ☎ TPS01189 347446 ✉ tony.underwood@accesso.com
ORDER NUMBER:	1465
TEST DATE:	04th - 05th April 2017
TESTED BY:	A Wong / A Tosif Element

2.1 Test Summary

Test Method and Description		Requirement Clause	Applicable to this equipment	Result / Note
		47CFR15		
Radiated spurious emissions (restricted bands of operation and cabinet radiation)		15.205	<input checked="" type="checkbox"/>	Pass
AC power line conducted emissions		15.207	<input checked="" type="checkbox"/>	Pass
Occupied bandwidth		15.247(a)(2)	<input checked="" type="checkbox"/>	Pass
Conducted carrier power	Peak	15.247(b)(3)	<input checked="" type="checkbox"/>	Pass
	Max.		<input type="checkbox"/>	
Conducted / radiated RF power out-of-band		15.247(d)	<input checked="" type="checkbox"/>	Pass
Power spectral density, conducted		15.247(e)	<input checked="" type="checkbox"/>	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).

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4 Introduction

This report TRA-033907-09-45-00A presents the results of the Radio testing on a Accesso Technology Group PLC, BLE Base Station 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 Accesso Technology Group PLC by Element, at the address(es) detailed below.

<input checked="" type="checkbox"/>	Element Hull Unit E South Orbital Trading Park Hedon Road Hull HU9 1NJ UK	<input type="checkbox"/>	Element Skelmersdale Unit 1 Pendle Place Skelmersdale West Lancashire WN8 9PN UK
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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: BLE Base Station
- Serial Number: not applicable
- Model Number: P2400-485-ACC
- Software Revision: V1.00-test
- Build Level / Revision Number: Not Applicable

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.

Laptop

Feeder unit

7.3 EUT Mode of Operation

EUT was transmitting permanent modulated carrier on channels 2402 MHz, 2426 MHz and 2480 MHz.

7.4 EUT Radio Parameters

7.4.1 General

Frequency of operation:	2402 – 2480 MHz
Modulation type(s):	GFSK
Occupied channel bandwidth(s):	2 MHz
Channel spacing:	2 MHz
Declared output power(s):	+4 dBm
Nominal Supply Voltage:	24 Vdc

7.4.2 Antennas

Type:	TL-ANT2409A Directional Antenna
Frequency range:	2402 – 2480 MHz
Impedance:	50 Ω
SWR:	1.92:1 Max
Gain:	9 dBi
Polarisation:	Linear, Vertical
Beam width:	Horizontal 60°. Vertical 76°.
Connector type:	RP-SMA Male
Length:	100 cm
Weight:	500 g
Environmental limits:	Operating temperature: -10 °C ~ 60 °C; Operating Humidity; 10 % ~ 90 % non-condensing
Mounting:	Pole mount or wall mount

7.5 EUT Description

The EUT is a radio base station unit comprising of three Bluetooth Low Energy modules and a GPS receiver. The unit is powered by 24 V dc from a pre-approved switch mode power supply. This report only covers the intentional operation of BLE Radio.

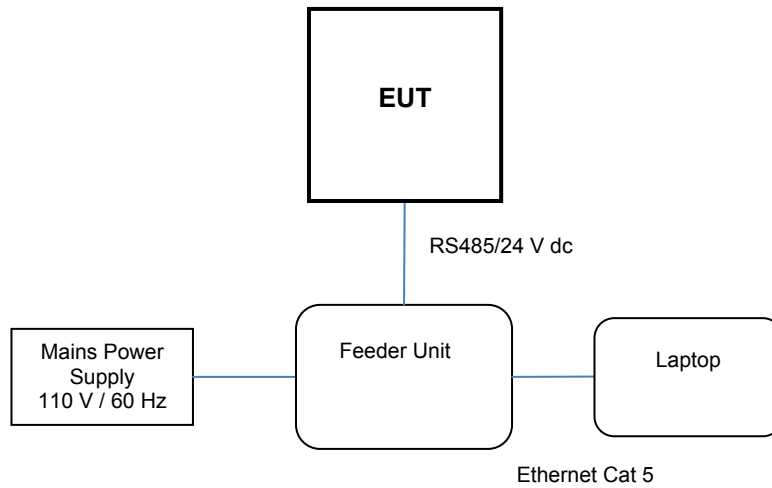
8 Modifications

No modifications were performed during this assessment.

9 EUT Test Setup

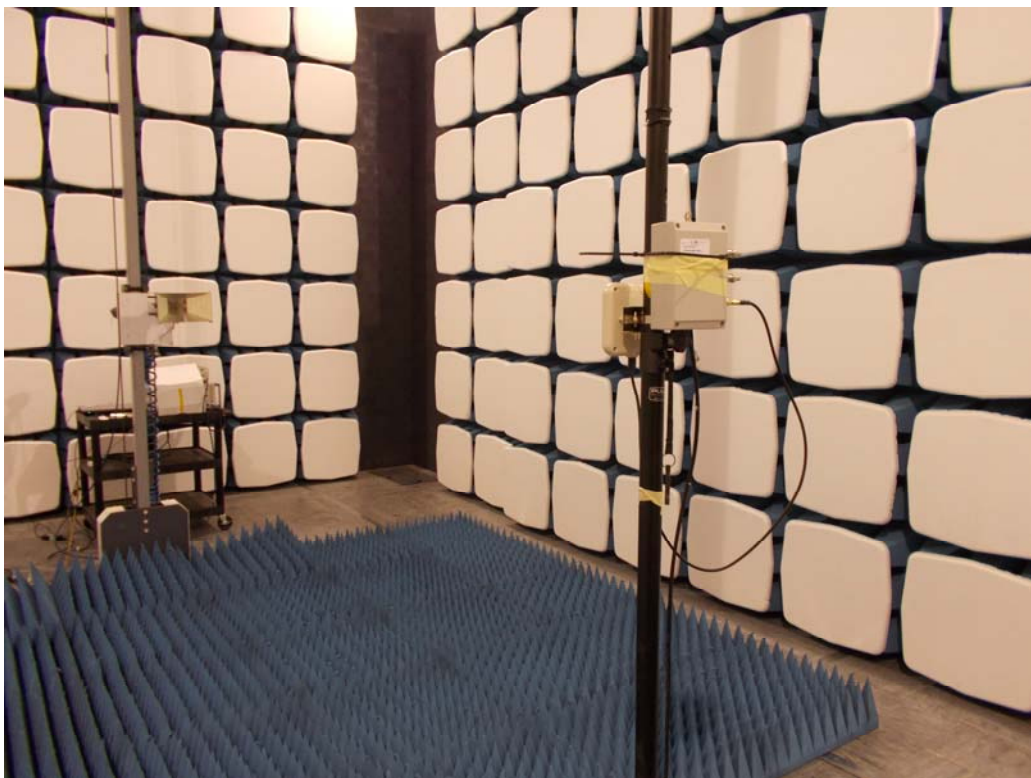
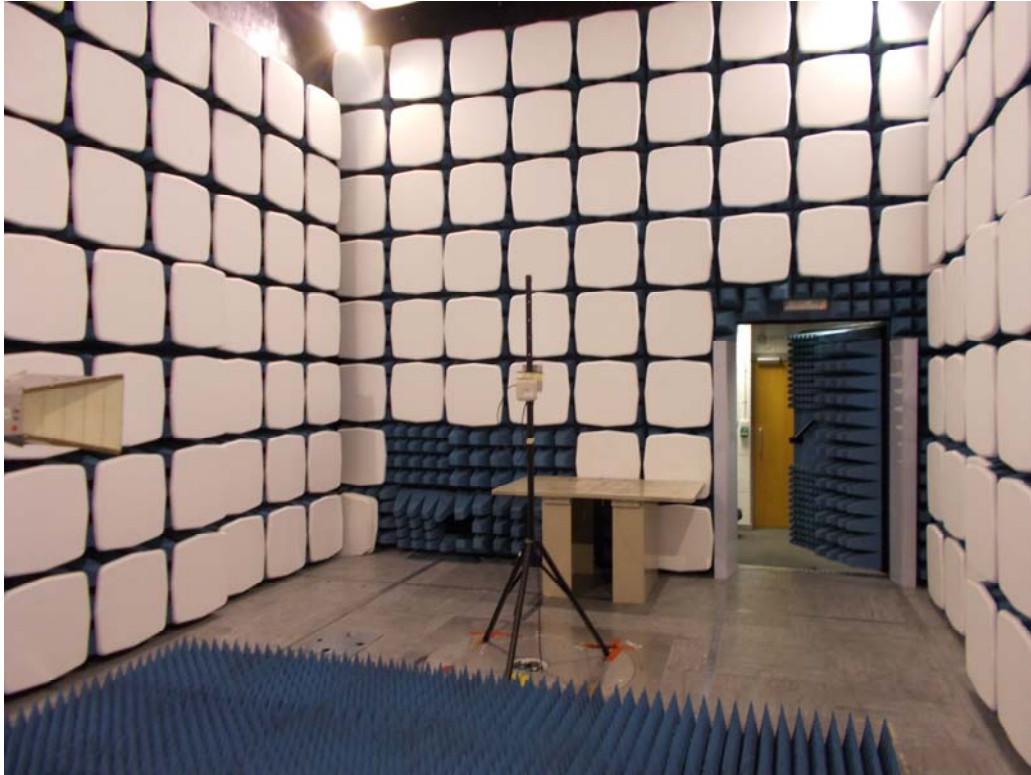
9.1 Block Diagram

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:



10 General Technical Parameters

The EUT was tested under the normal environmental conditions of the test laboratory, except where otherwise stated. The normal power source applied was approx. 24 V dc.

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

Test Location:	Element Hull
Test Chamber:	Wireless Laboratory 2 (Lab16)
Test Standard and Clause:	ANSI C63.10-2013, Clause 6.5 and 6.6
EUT Frequencies Measured:	2402 / 2426 / 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: 20 °C	+15 °C to +35 °C (as declared)
Humidity: 32 % RH	20 % RH to 75 % RH (as declared)
Supply: 24 V dc	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 ($\mu\text{V/m}$ 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;

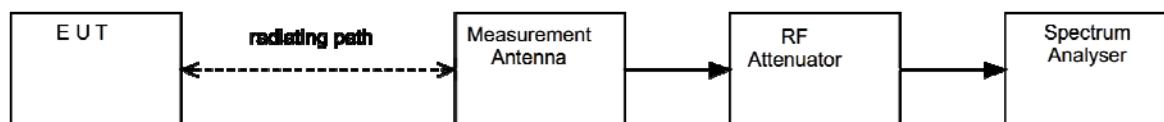
PA is the pre-amplifier gain in dB (where used);

DC is the duty correction factor in dB (where used, e.g. harmonics of pulsed fundamental);

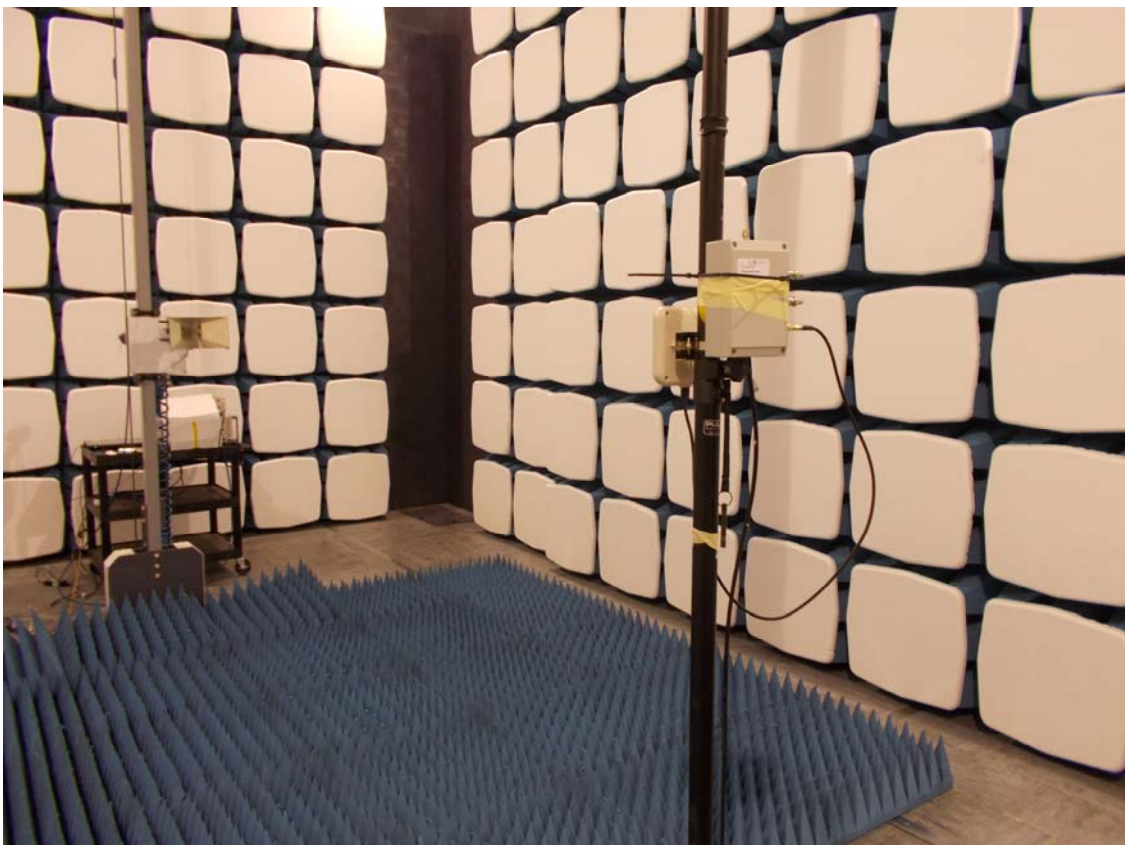
CF is the distance factor in dB (where measurement distance different to limit distance);

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

Figure i Test Setup



11.5 Test Set-up Photograph



11.6 Test Equipment

<i>Equipment Description</i>	<i>Manufacturer</i>	<i>Equipment Type</i>	<i>Element No</i>	<i>Due For Calibration</i>
Biconical Antenna	EMCO	3109	RFG095	17/05/2019
Log Periodic Antenna	EMCO	3146	RFG191	17/05/2019
Horn Antenna	EMCO	3115	RFG129	09/02/2018
18-26.5 GHz	Q-par	Horn Antenna	RFG630	24/11/2017
Spectrum Analyser	R&S	FSU46	REF910	05/07/2017
N-Type RF coaxial cable	Unknown	Cable	REF884	04/12/2017
Pre-Amp (9kHz – 1GHz)	Sonoma	310	REF927	30/06/2018
Short SMA RF Cable	AtlanTec	Cable	REF2165	09/12/2017
Cable	Teledyne	5m 2.92mm	REF919	05/10/2017
Pre-Amp (1 – 26.5GHz)	Agilent	8449B	REF913	02/02/2018

11.7 Test Results

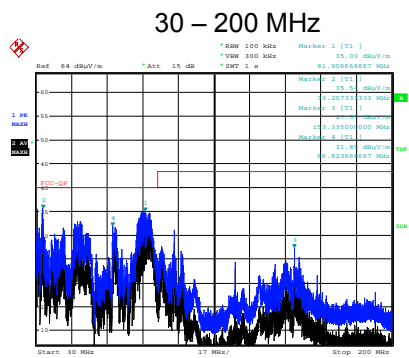
Channel Frequency: 2402 MHz				
Detector	Frequency (MHz)	Field Strength (dBμV/m)	Field Strength (μV/m)	Limit (μV/m)
No emissions were detected within 20 dB of the limit				

Channel Frequency: 2426 MHz				
Detector	Frequency (MHz)	Field Strength (dBμV/m)	Field Strength (μV/m)	Limit (μV/m)
No emissions were detected within 20 dB of the limit				

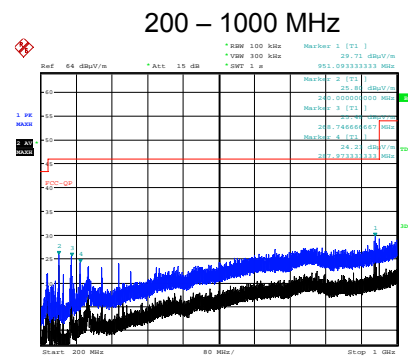
Channel Frequency: 2480 MHz				
Detector	Frequency (MHz)	Field Strength (dBμV/m)	Field Strength (μV/m)	Limit (μV/m)
No emissions were detected within 20 dB of the limit				

Emissions unrelated to the channel frequency				
Detector	Frequency (MHz)	Field Strength (dBμV/m)	Field Strength (μV/m)	Limit (μV/m)
Quasi Peak	30.641	30.0	31.6	100
Quasi Peak	32.139	33.6	40.5	100
Quasi Peak	36.158	30.2	32.4	100
Quasi Peak	42.939	31.4	37.2	100
Quasi Peak	48.002	26.9	22.1	100
Quasi Peak	51.084	31.7	38.5	100
Quasi Peak	56.789	30.1	32.0	100
Quasi Peak	60.190	34.1	50.7	100
Quasi Peak	60.240	31.8	38.9	100
Quasi Peak	78.090	31.6	38.0	100
Quasi Peak	78.122	31.4	37.2	100
Quasi Peak	81.327	31.9	39.4	100
Quasi Peak	95.990	35.2	57.5	150
Quasi Peak	96.958	30.0	31.6	150
Quasi Peak	98.385	27.4	23.4	150
Quasi Peak	98.965	30.4	33.1	150
Quasi Peak	125.012	26.9	22.1	150
Quasi Peak	139.186	24.1	16.0	200
Quasi Peak	316.782	25.1	18.0	200
Quasi Peak	483.082	16.8	6.9	200

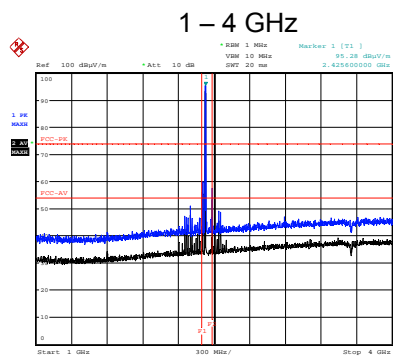
Bluetooth LE Channel Frequency 2462 MHz



Date: 3.APR.2017 16:55:18

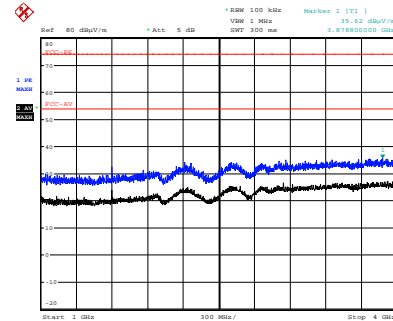


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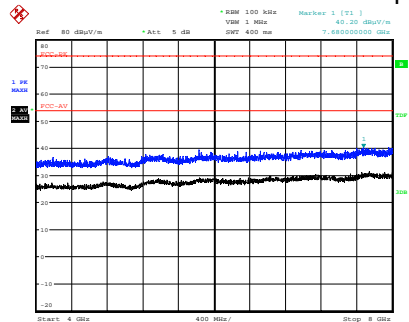
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1 – 4 GHz with 2.4 GHz Band-stop Filter



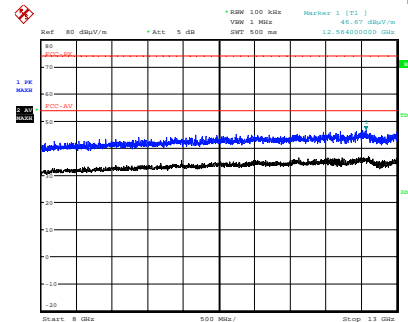
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4 – 8 GHz with 2.4 GHz Band-stop Filter

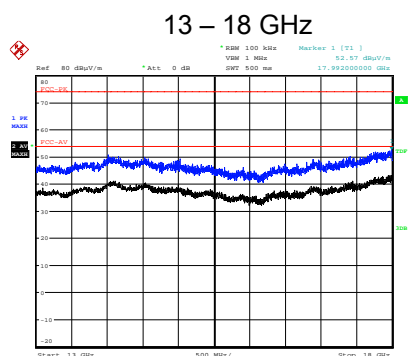


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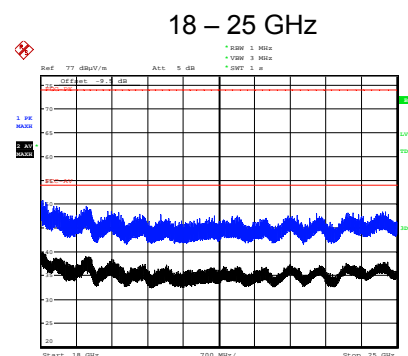
8 – 13 GHz with 2.4 GHz Band-stop Filter



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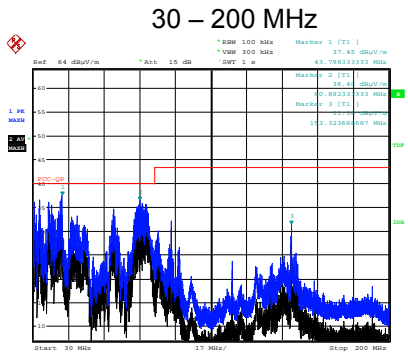


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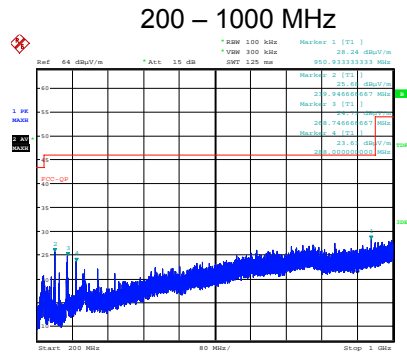


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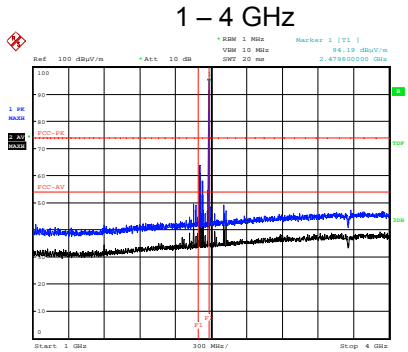
Bluetooth LE Channel Frequency 2480 MHz



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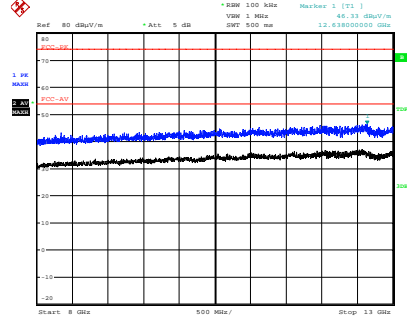


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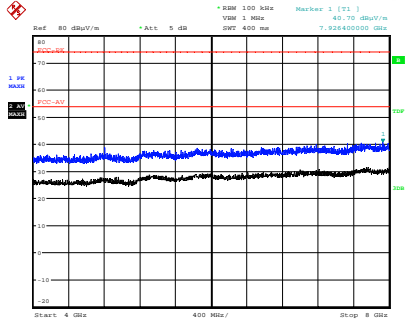
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1 – 4 GHz with 2.4 GHz Band-stop Filter



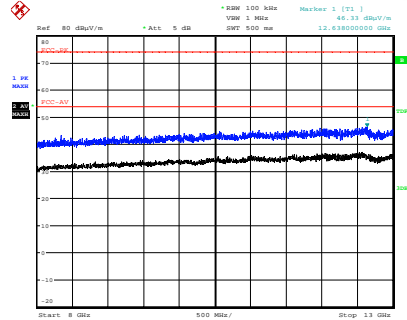
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4 – 8 GHz with 2.4 GHz Band-stop Filter

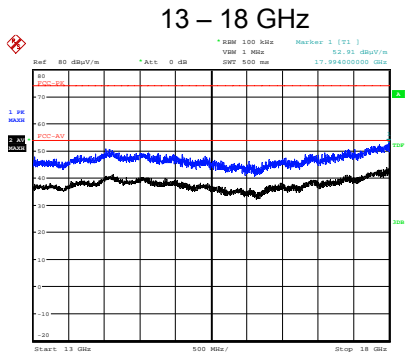


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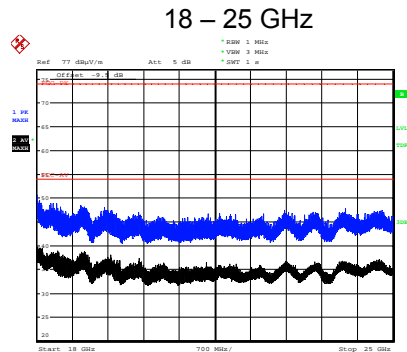
8 – 13 GHz with 2.4 GHz Band-stop Filter



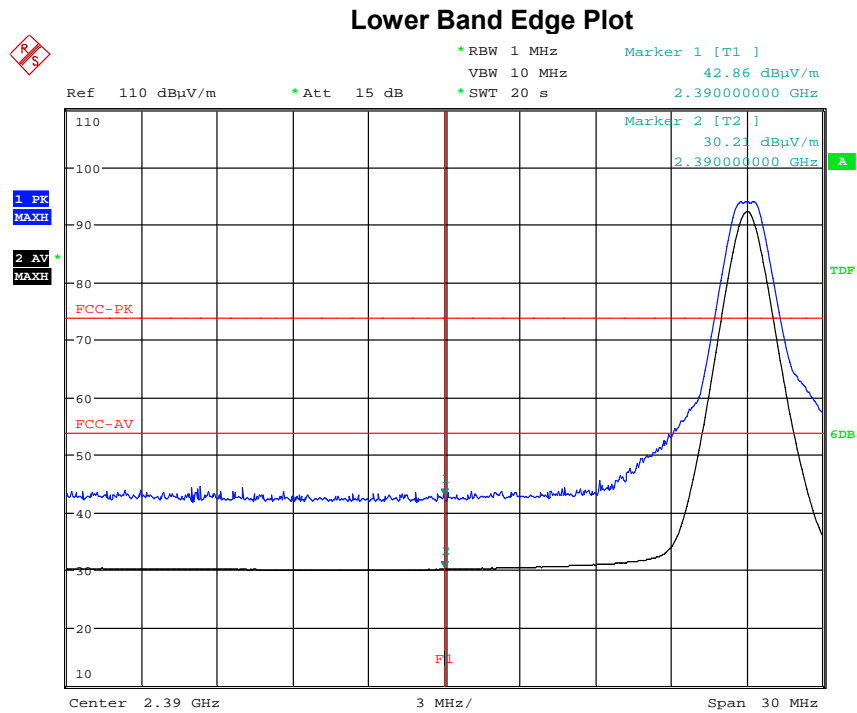
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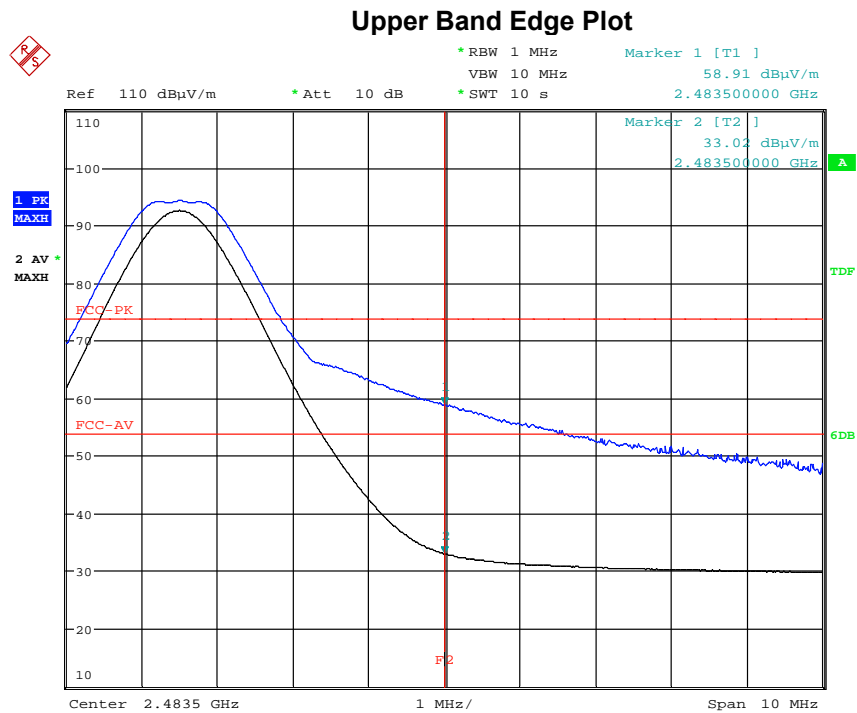
Date: 3.APR.2017 13:56:18



Date: 3.APR.2017 15:43:22



Date: 3.APR.2017 12:18:40



Date: 3.APR.2017 10:38:15

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 1
Test Standard and Clause:	ANSI C63.10-2013, Clause 6.2
EUT Channels / Frequencies Measured:	2402 / 2426 / 2480 MHz
EUT Channel Bandwidths:	2 MHz
EUT Modulation:	GFSK
Deviations From Standard:	None
Measurement Detectors:	Quasi-Peak and Average, RMS

Environmental Conditions (Normal Environment)

Temperature: 21 °C	+15 °C to +35 °C (as declared)
Humidity: 37 % 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 (dB μ V)	
	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.

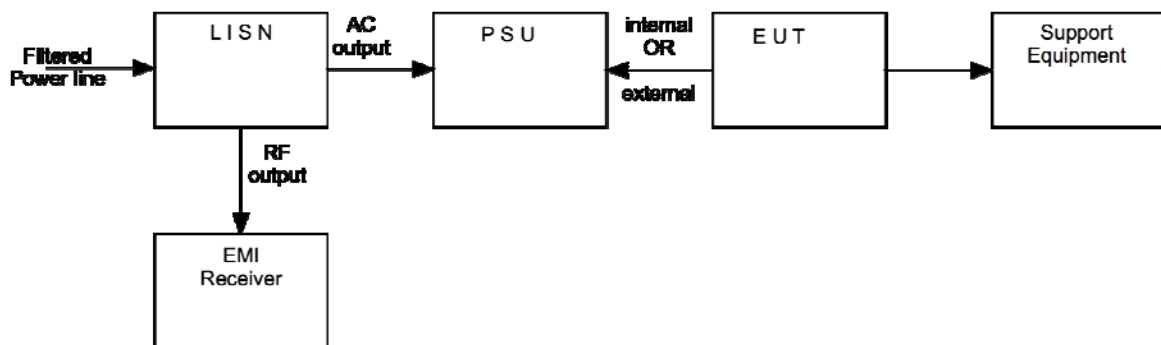
12.4 Test Method

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



12.6 Test Equipment

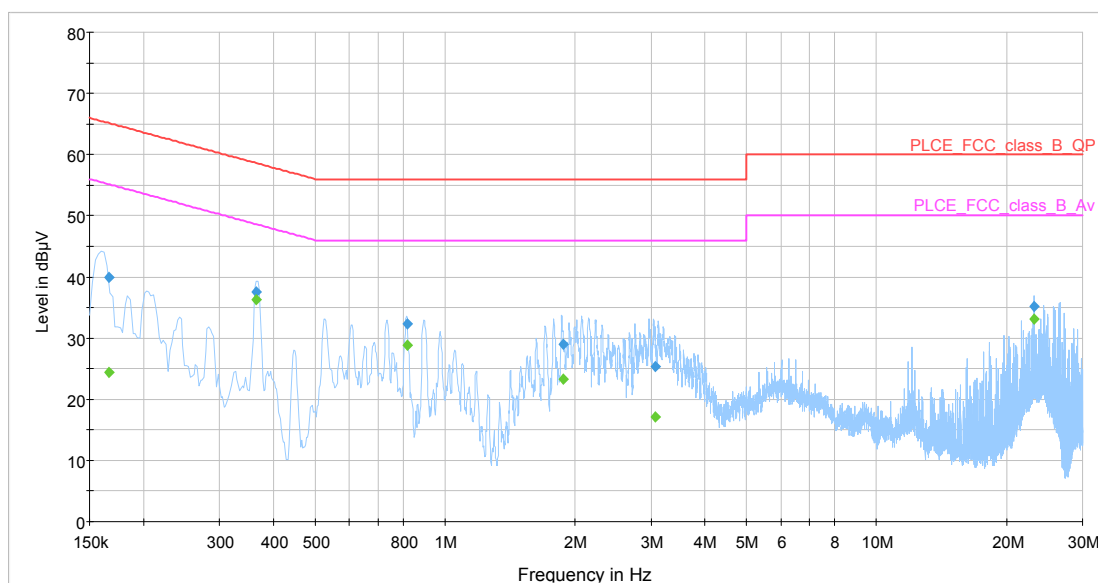
Equipment Type	Manufacturer	Equipment Description	Element No	Due For Calibration
ESH3-Z2	R&S	Pulse Limiter	RFG680	14/06/17
ESH3-Z5	R&S	LISN	RFG189	02/08/17
ESCI7	R&S	Measuring Receiver	RFG715	06/10/17

12.7

12.8 Test Results

Frequency (MHz)	QuasiPeak (dBμV)	Meas. Time (ms)	Bandwidth (kHz)	Line	Corr. (dB)	Margin (dB)	Limit (dBμV)
0.166000	40.0	15000.0	9.000	N	0.2	25.2	65.2
0.365750	37.6	15000.0	9.000	N	0.2	21.0	58.6
0.815950	32.3	15000.0	9.000	N	0.4	23.7	56.0
1.877975	28.9	15000.0	9.000	L1	0.4	27.1	56.0
3.067950	25.4	15000.0	9.000	N	0.4	30.6	56.0
23.129000	35.2	15000.0	9.000	L1	1.5	24.8	60.0

Frequency (MHz)	Average (dBμV)	Meas. Time (ms)	Bandwidth (kHz)	Line	Corr. (dB)	Margin (dB)	Limit (dBμV)
0.166000	24.4	15000.0	9.000	N	0.2	30.8	55.2
0.365750	36.3	15000.0	9.000	N	0.2	12.3	48.6
0.815950	28.8	15000.0	9.000	N	0.4	17.2	46.0
1.877975	23.3	15000.0	9.000	L1	0.4	22.7	46.0
3.067950	17.2	15000.0	9.000	N	0.4	28.8	46.0
23.129000	33.1	15000.0	9.000	L1	1.5	16.9	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:	Wireless Lab 1
Test Standard and Clause:	IC: ANSI C63.10-2013, Clause 6.9 FCC: ANSI C63.10-2013, Clause 11.8
EUT Channels / Frequencies Measured:	2402 MHz / 2426 MHz / 2480 MHz
EUT Channel Bandwidths:	2 MHz
EUT Test Modulations:	GFSK
Deviations From Standard:	None
Measurement BW:	100 kHz
Spectrum Analyzer Video BW:	300 kHz
Measurement Span:	3 MHz
Measurement Detector:	Peak

Environmental Conditions (Normal Environment)

Temperature: 21 °C	+15 °C to +35 °C (as declared)
Humidity: 36 % RH	20 % RH to 75 % RH (as declared)
Supply: 24 V dc	As declared

13.3 Test Limit

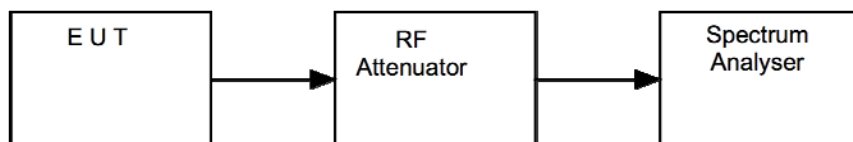
The minimum -6 dB bandwidth shall be at least 500 kHz.

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

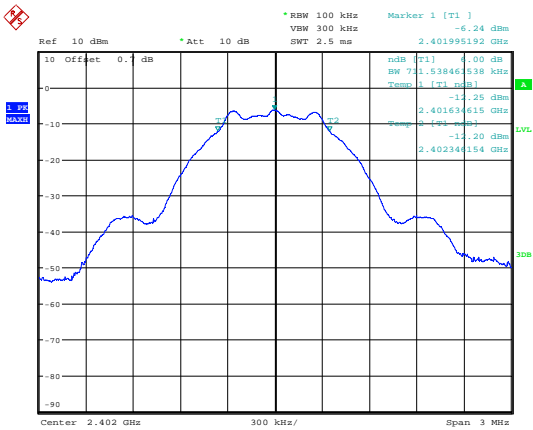


13.5 Test Equipment

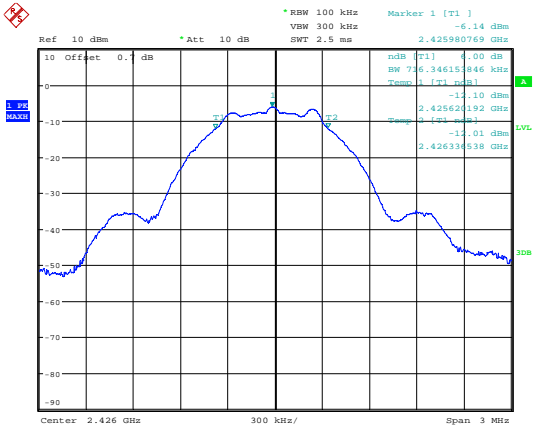
Equipment Type	Manufacturer	Equipment Description	Element No	Due For Calibration
FSU46	R&S	Spectrum Analyser	REF910	05/07/17

13.6 Test Results

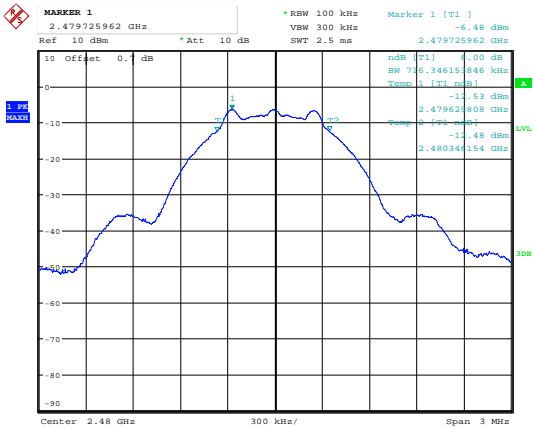
Channel Frequency (MHz)	F_L (MHz)	F_H (MHz)	6dB Bandwidth (kHz)	Result
2402	2401.634615	2402.346154	711.539	PASS
2426	2425.620192	2426.336538	716.346	PASS
2480	2479.629808	2480.346154	716.346	PASS



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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:	Wireless Lab 1
Test Standard and Clause:	ANSI C63.10-2013, Clause 11.9.1
EUT Channels / Frequencies Measured:	2402 MHz / 2426 MHz / 2480 MHz
EUT Channel Bandwidths:	2 MHz
Deviations From Standard:	None
Measurement BW:	3 MHz
Spectrum Analyzer Video BW:	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: 21 °C	+15 °C to +35 °C (as declared)
Humidity: 36 % RH	20 % RH to 75 % RH (as declared)
Supply: 24 V dc	As declared

14.3 Test Limit

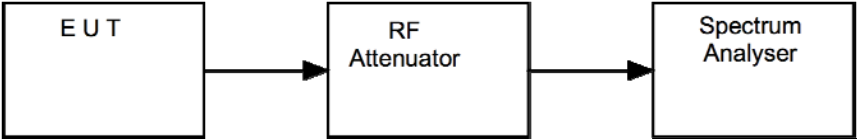
For systems employing digital modulation techniques operating in the bands 902 to 928 MHz, 2400 to 2483.5 MHz and 5725 to 5850 MHz, the maximum peak conducted output power shall not exceed 1 W.

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

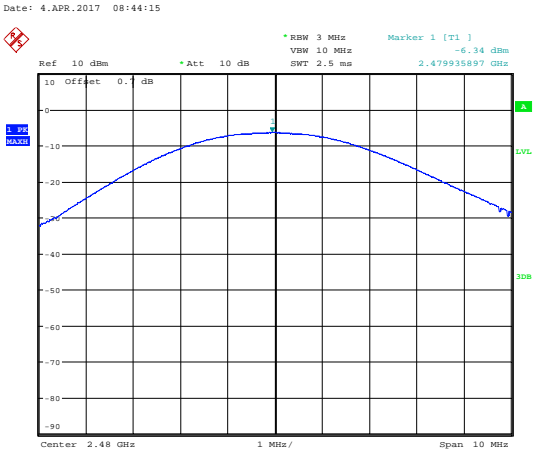
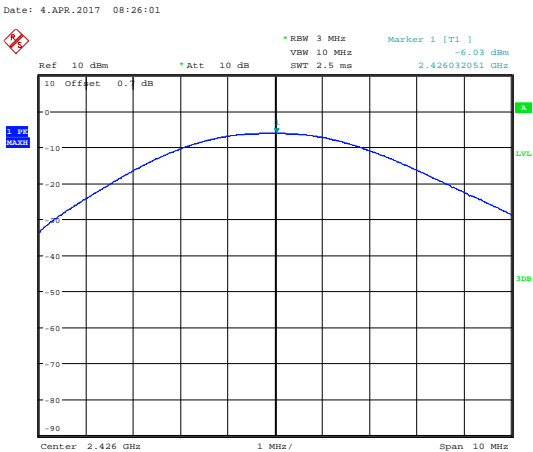
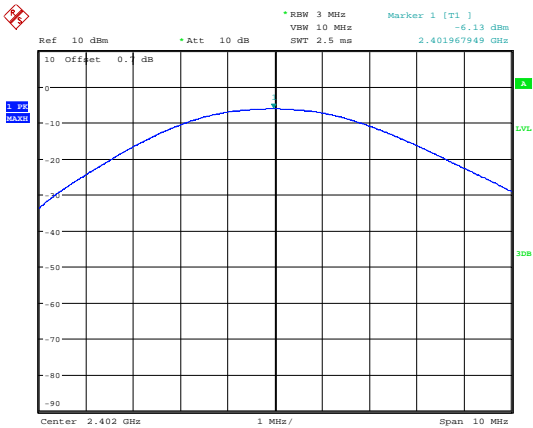


14.5 Test Equipment

Equipment Type	Manufacturer	Equipment Description	Element No	Due For Calibration
FSU46	R&S	Spectrum Analyser	REF910	05/07/17

14.6 Test Results

Channel Frequency (MHz)	Maximum peak conducted output power (dBm)	Maximum peak conducted output power (W)	Antenna gain (dBi)	E.I.R.P. (W)	Result
2402	-6.13	0.00024	9.00	0.00194	PASS
2426	-6.03	0.00025	9.00	0.00198	PASS
2480	-6.34	0.00023	9.00	0.00185	PASS



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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:	Wireless Lab 1
Test Standard and Clause:	ANSI C63.10-2013, Clause 11.11
EUT Channels / Frequencies Measured:	2402 MHz / 2426 MHz / 2480 MHz
EUT Channel Bandwidths:	2 MHz
Deviations From Standard:	None
Measurement BW:	100 kHz
Spectrum Analyzer Video BW:	300 kHz
Measurement Detector:	Peak
Measurement Range:	30 MHz to 25 GHz

Environmental Conditions (Normal Environment)

Temperature: 21 °C	+15 °C to +35 °C (as declared)
Humidity: 36 % RH	20 % RH to 75 % RH (as declared)
Supply: 24 V dc	As declared

15.3 Test Limit

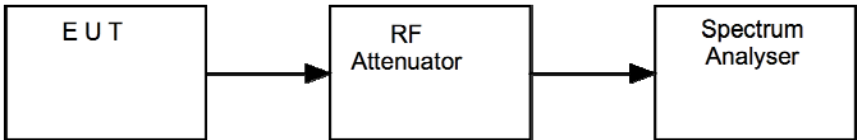
In any 100 kHz bandwidth outside the frequency band in which the spread spectrum or digitally modulated device is operating, the RF power that is produced shall be at least 20 dB below that in the 100 kHz bandwidth within the band that contains the highest level of the desired power, based on either 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

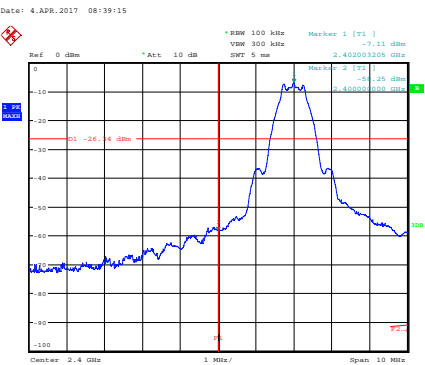
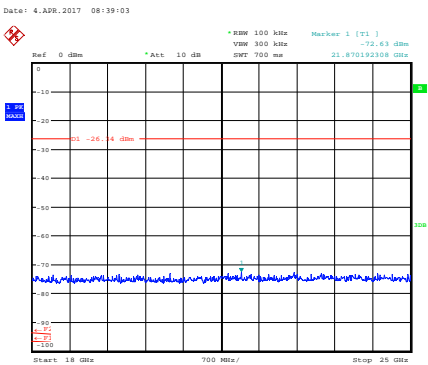
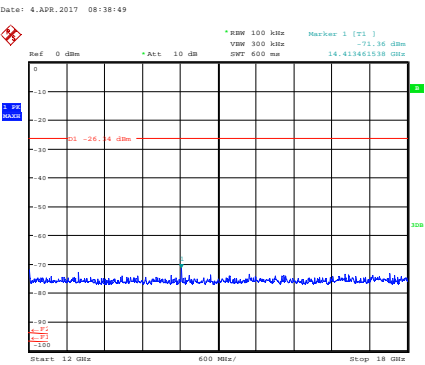
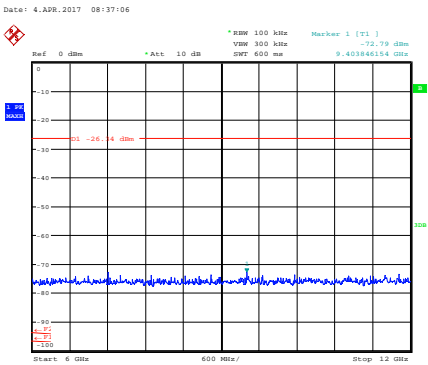
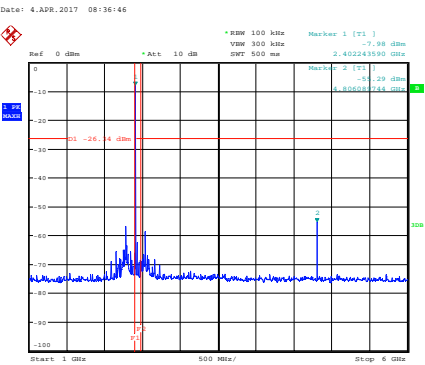
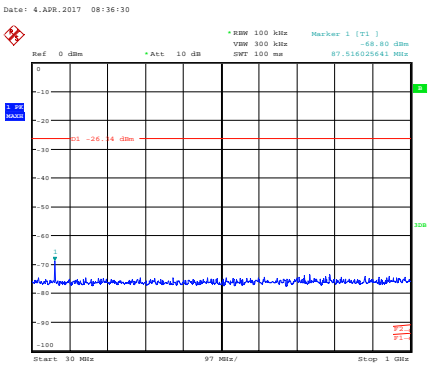
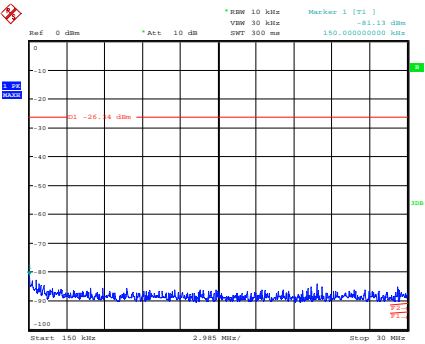
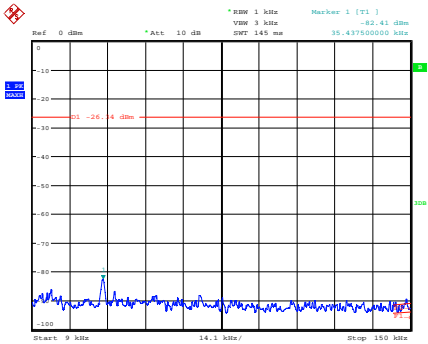


15.5 Test Equipment

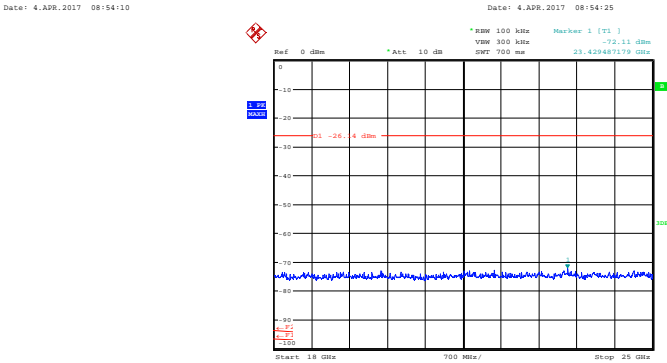
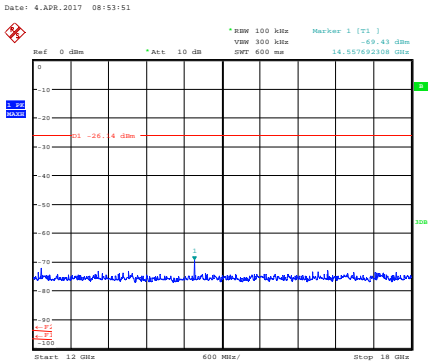
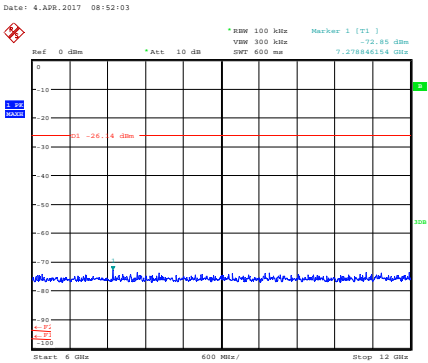
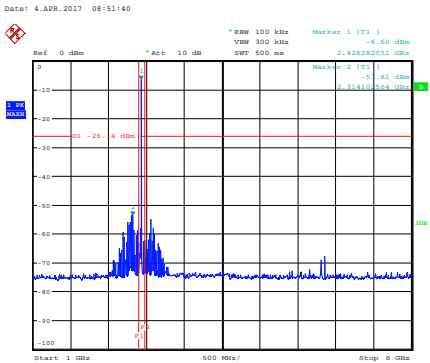
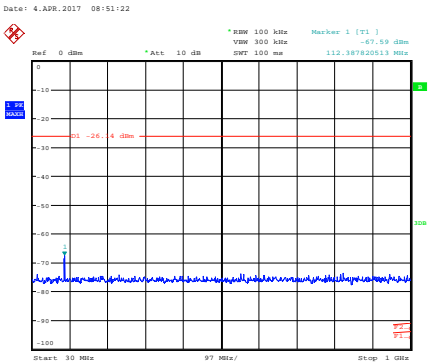
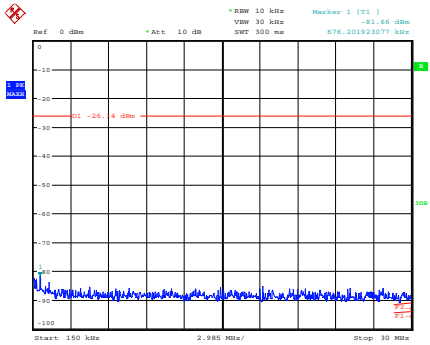
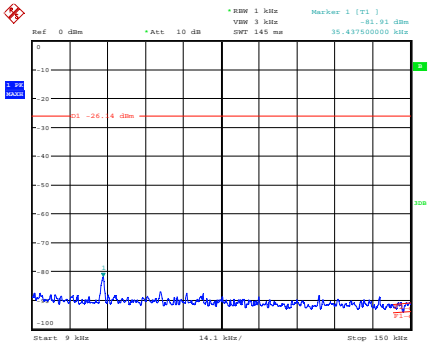
Equipment Type	Manufacturer	Equipment Description	Element No	Due For Calibration
FSU46	R&S	Spectrum Analyser	REF910	05/07/17

15.6 Test Results

Channel Frequency (MHz)	Emission Frequency (MHz)	Analyzer Level (dBm)	Emission Level (dBm)	Limit (dBm)	Margin (dB)	Result
2402	No emissions were detected within 10 dB of the limit					PASS

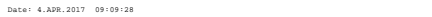
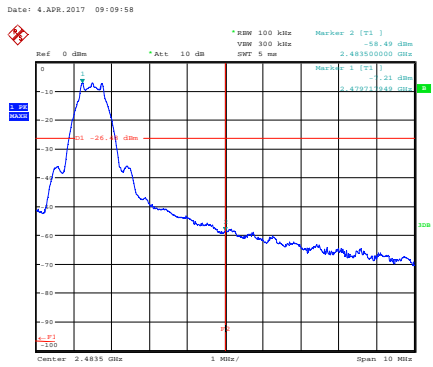
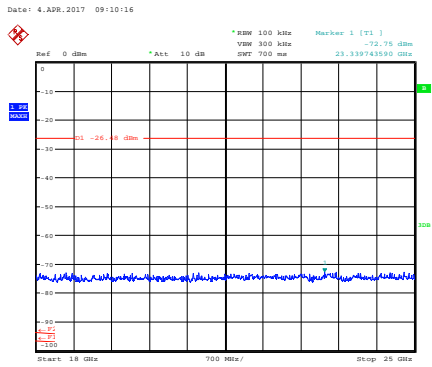
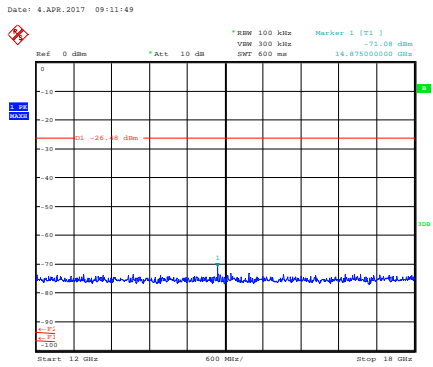
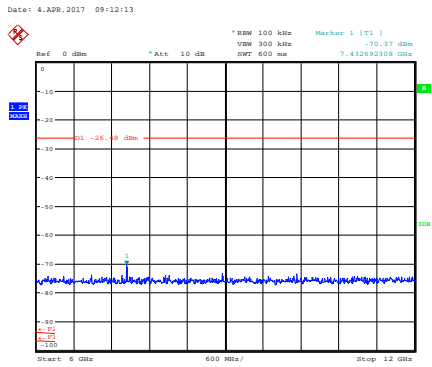
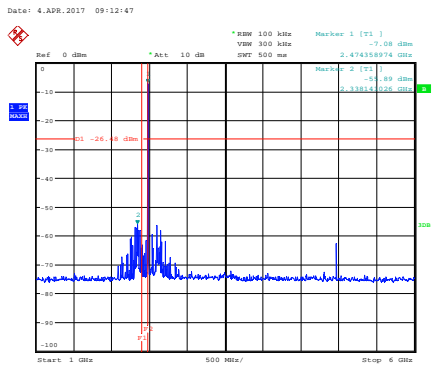
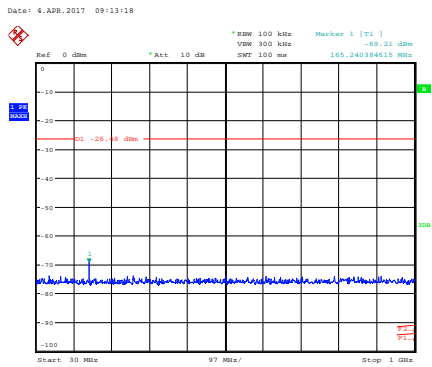
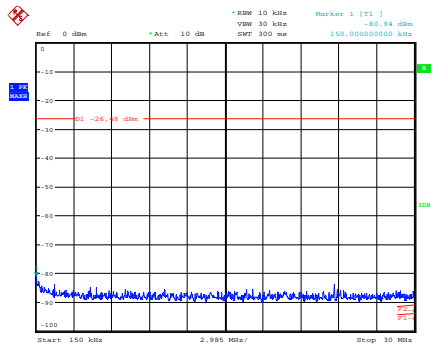
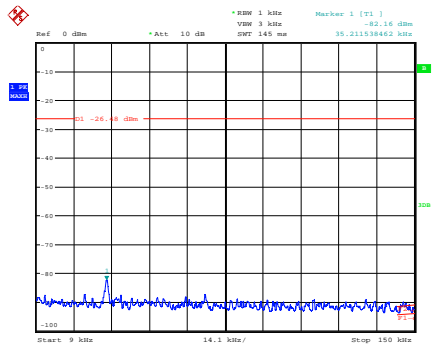


Channel Frequency (MHz)	Emission Frequency (MHz)	Analyzer Level (dBm)	Emission Level (dBm)	Limit (dBm)	Margin (dB)	Result
2426	No emissions were detected within 10 dB of the limit					PASS



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Channel Frequency (MHz)	Emission Frequency (MHz)	Analyzer Level (dBm)	Emission Level (dBm)	Limit (dBm)	Margin (dB)	Result
2480	No emissions were detected within 10 dB of the limit					PASS



16 Power spectral density

16.1 Definition

The power per unit bandwidth.

16.2 Test Parameters

Test Location:	Element Hull
Test Chamber:	Wireless Lab 1
Test Standard and Clause:	ANSI C63.10-2013, Clause 11.10
EUT Channels / Frequencies Measured:	2402 MHz / 2426 MHz / 2480 MHz
EUT Channel Bandwidths:	2 MHz
Deviations From Standard:	None
Measurement BW:	100 kHz
Spectrum Analyzer Video BW:	300 kHz
Measurement Span:	1 MHz
Measurement Detector:	Peak

Environmental Conditions (Normal Environment)

Temperature: 21 °C	+15 °C to +35 °C (as declared)
Humidity: 36 % RH	20 % RH to 75 % RH (as declared)
Supply: 24 V dc	As declared

16.3 Test Limit

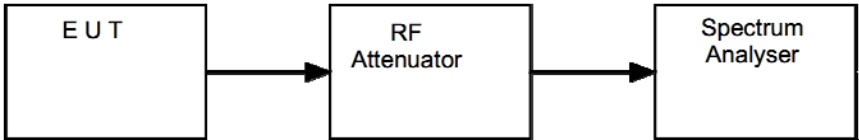
The transmitter power spectral density conducted from the transmitter to the antenna shall not be greater than 8 dBm in any 3 kHz band during any time interval of continuous transmission.

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

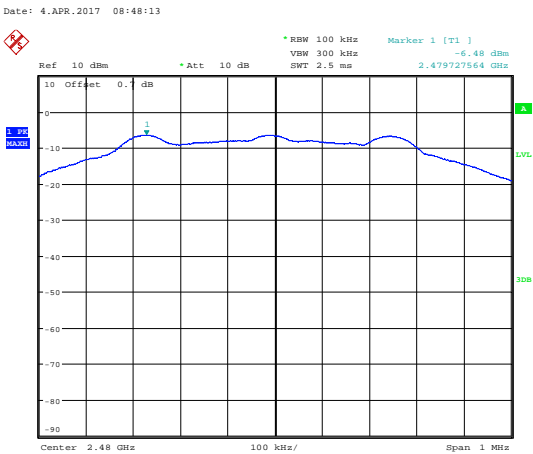
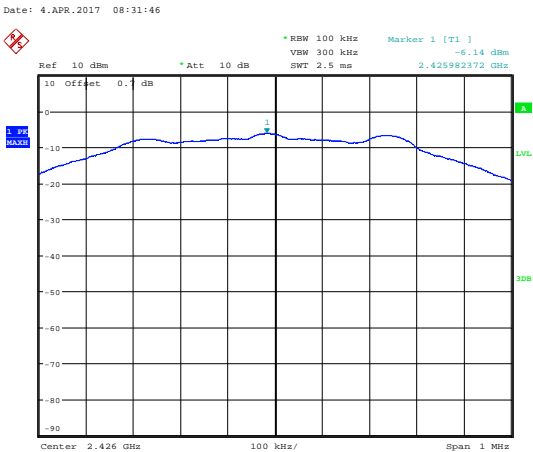
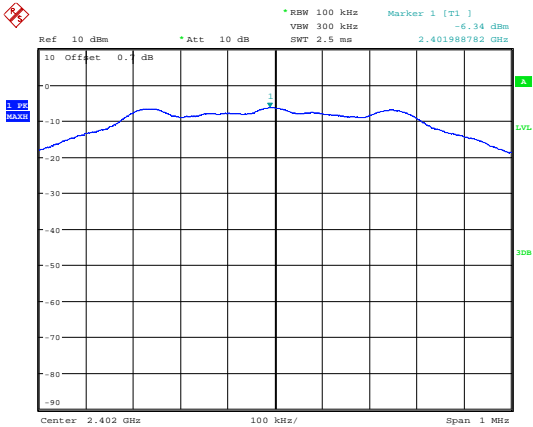


16.5 Test Equipment

Equipment Type	Manufacturer	Equipment Description	Element No	Due For Calibration
FSU46	R&S	Spectrum Analyser	REF910	05/07/17

16.6 Test Results

Channel Frequency (MHz)	Power Spectral Density (dBm)	Result
2402	-6.34	PASS
2426	-6.14	PASS
2480	-6.48	PASS



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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 and 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

$$\text{SAR Exclusion Threshold (SARET)} \\ \text{SAR Exclusion Threshold} = \text{Step 1} + \text{Step 2}$$

Step 1

$$NT = [(MP/TSD^A) * \sqrt{f_{GHz}}]$$

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)
 TSD^A = 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.

$$= [(NT \times TSD^A) / \sqrt{f_{GHz}}]$$

For Distances Greater than 50 mm Step 2 applies

Step 2

$$(TSD^B - 50\text{mm}) * 10\}$$

Where:

$$TSD^B = \text{Min Test separation Distance (mm)} = 50$$

Note: Step 2 is not required here as the TSD^A is 5mm.

Operating Frequency 2.402 GHz

$$\begin{aligned} \text{SARET} &= [(3.0 \times 5) / \sqrt{2.402}] \\ \text{SARET} &= 9.68\text{mW} \end{aligned}$$

Operating Frequency 2.426 GHz

$$\begin{aligned} \text{SARET} &= [(3.0 \times 5) / \sqrt{2.426}] \\ \text{SARET} &= 9.63\text{mW} \end{aligned}$$

Operating Frequency 2.480 GHz

$$\begin{aligned} \text{SARET} &= [(3.0 \times 5) / \sqrt{2.480}] \\ \text{SARET} &= 9.53\text{mW} \end{aligned}$$

Channel Frequency (MHz)	EIRP (mW)	SAR Exclusion Threshold (mW)	SAR Evaluation
2402	1.94	9.68	Not Required
2426	1.98	9.63	Not Required
2480	1.85	9.53	Not Required

MPE Calculation

Prediction of MPE limit at a given distance

For purposes of these requirements mobile devices are defined by the FCC as transmitters designed to be used in other than fixed locations and to generally be used in such a way that a separation distance of at least 20 centimeters is normally maintained between radiating structures and the body of the user or nearby persons. These devices are normally evaluated for exposure potential with relation to the MPE limits. As the 20cm separation specified under FCC rules may not be achievable under normal operation of the EUT, an RF exposure calculation is needed to show the minimum distance required to be less than the power density limit, as required under FCC rules.

Equation from IEEE C95.1

$$S = \frac{EIRP}{4 \pi R^2} \text{ re - arranged } R = \sqrt{\frac{EIRP}{S 4 \pi}}$$

Where:

S = power density

R = distance to the centre of radiation of the antenna

EIRP = EUT Maximum power

Result

Prediction Frequency (MHz)	Maximum EIRP (mW)	Power density limit (S) (mW/cm ²)	Distance (R) cm required to be less than the power density limit
2426	1.98	1.00	0.40