Report on the Radio Testing

For

Ramtech Electronics Ltd

on

WES Control Board Mk2

Report no. TRA-041602-45-00B

4 January 2019

Report Number: TRA-041602-45-00B
Issue: B

REPORT ON THE RADIO TESTING OF A
Ramtech Electronics Ltd
WES Control Board Mk2
WITH RESPECT TO SPECIFICATION
FCC 47CFR 15.247

TEST DATE: 2018-11-12 to 2018-11-14

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Date: 4 January 2019

1 Revision Record

Issue Number	*Issue Date*	*Revision History*
A	19 November 2018	Original
B	4 January 2019	Applicant address, model number and FCC ID updated

2 Summary

TEST REPORT NUMBER:	TRA-041602-45-00B
WORKS ORDER NUMBER:	TRA-041602-01
PURPOSE OF TEST:	Testing of radio frequency equipment per the relevant authorization procedure of chapter 47 of CFR (code of federal regulations) Part 2, subpart J.
TEST SPECIFICATION:	47CFR15.247
EQUIPMENT UNDER TEST (EUT):	WES Control Board Mk2
FCC IDENTIFIER:	2AHNOW2CTRLMK2
EUT SERIAL NUMBERS:	DEG49918 & DEB70522
MANUFACTURER/AGENT:	Ramtech Electronics Ltd
ADDRESS:	6 Castlebridge Office Village Castle Marina Road Nottingham NG7 1TN United Kingdom
CLIENT CONTACT:	Dan Lewington ✉ Dan.Lewington@ramtech1.onmicrosoft.com
ORDER NUMBER:	P/052646
TEST DATE:	2018-11-12 to 2018-11-14
TESTED BY:	A Tosif & I Broadwell Element

2.1 Test Summary

Test Method and Description		*Requirement Clause 47CFR15*	*Applicable to this equipment*	*Result / Note*
Radiated spurious emissions (restricted bands of operation and cabinet radiation)		15.205	☒	*Pass*
AC power line conducted emissions		15.207	☐	*Note 1*
Occupied bandwidth		15.247(a)(2)	☒	*Pass*
Conducted carrier power	Peak	15.247(b)(3)	☐	*Pass*
	Max.		☒	
Out of band emissions		15.247(d)	☒	*Pass*
Power spectral density		15.247(e)	☒	*Pass*

Specific Note:

1. As per client, the EUT will only ever be battery powered and will never be connected (either directly or indirectly) to the mains electricity.

General 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-041602-45-00B presents the results of the Radio testing on a Ramtech Electronics Ltd, WES Control Board Mk2 to specification 47CFR15 Radio Frequency Devices.

The testing was carried out for Ramtech Electronics Ltd by Element, at the address 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.

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.

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: WES Control Board Mk2
- Serial Numbers: DEG49918 & DEB70522
- Model Number: W2CTRLMK2
- Software Revision: v3.4
- Build Level / Revision Number: Rev 2C

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.

Host equipment

7.3 EUT Mode of Operation

The EUT was transmitting permanent modulated carrier on the frequency indicated.

7.4 EUT Radio Parameters

Frequency of operation:	916.5 MHz
Declared output power:	14 dBm
Nominal Supply Voltage:	6 Vdc
Antenna Type:	1/4 Wave Whip Antenna
Antenna Gain:	1.6 dBi

7.5 EUT Description

The EUT is a 916.5 MHz radio module.

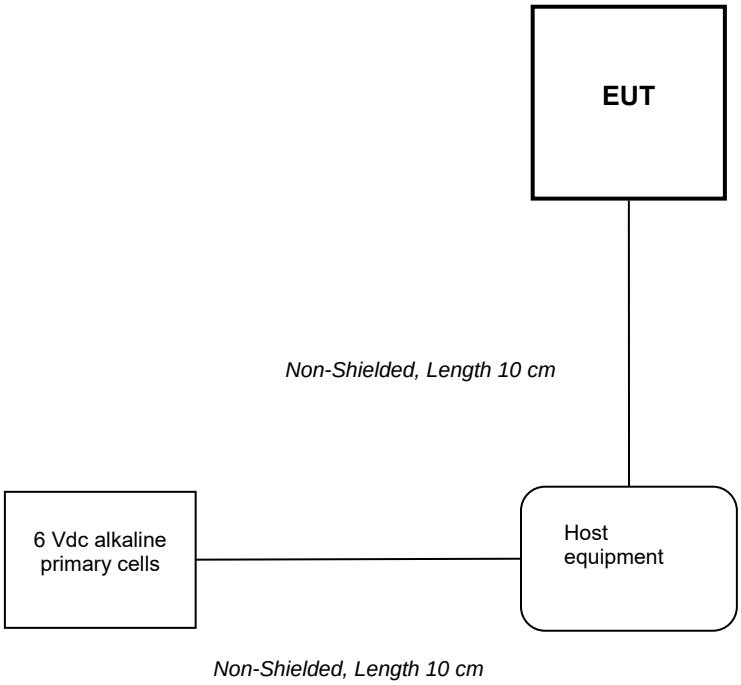
8 Modifications

No modifications were performed during this assessment.

9 EUT Test Setup

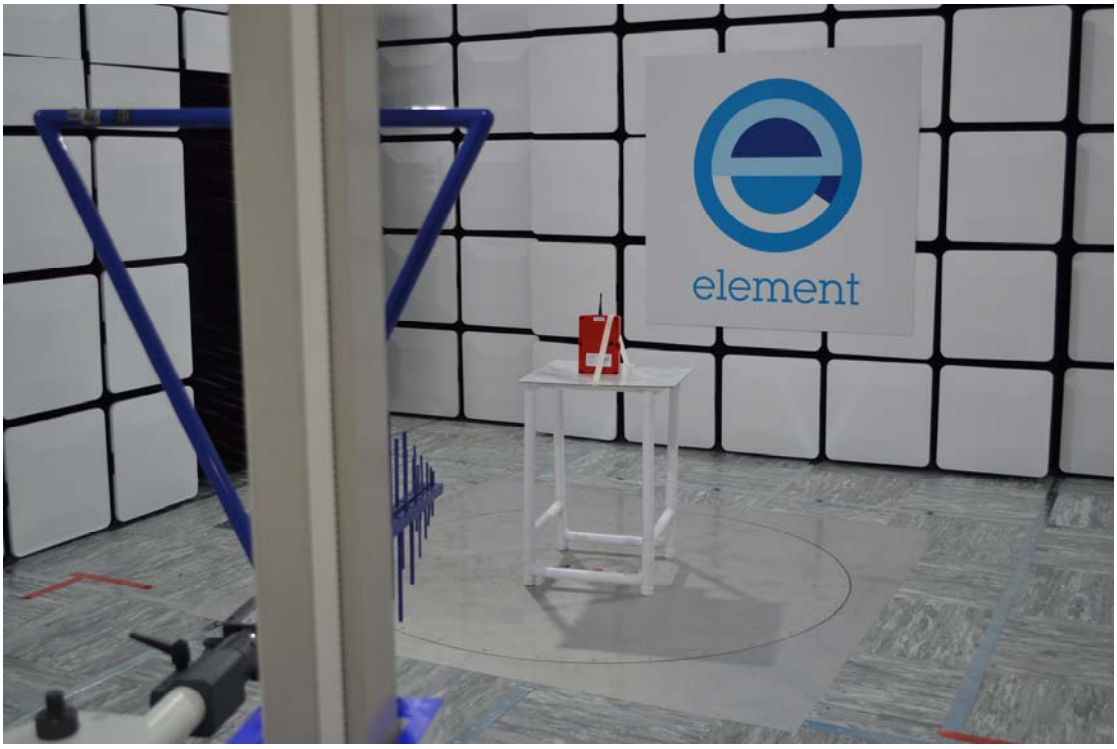
9.1 Block Diagram

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



9.2 General Set-up Photographs

The following photographs shows basic EUT set-up for radiated testing:



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 6 Vdc from alkaline batteries.

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.

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

Test Location:	Element Hull
Test Chamber:	Wireless Lab 2
Test Standard and Clause:	ANSI C63.10-2013, Clause 6.5 and 6.6
EUT Frequency Measured:	916.5 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: 22 °C	+15 ºC to +35 ºC (as declared)
Humidity: 41 % RH	20 % RH to 75 % RH (as declared)
Supply: 6 Vdc	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:

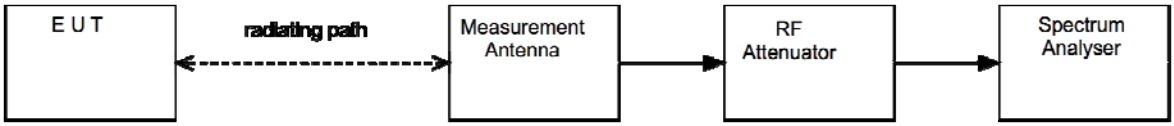
$$FS = PR + CL + AF – PA + DC – CF$$

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



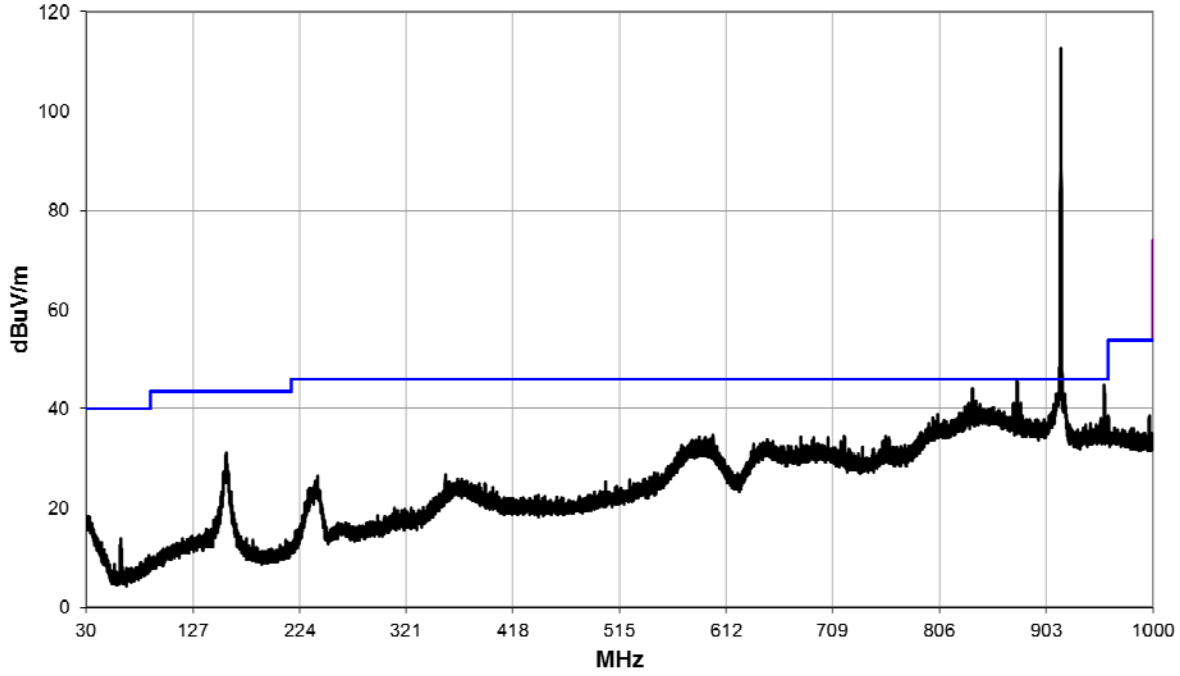
11.5 Test Equipment

Equipment Description	*Manufacturer*	*Equipment Type*	*Element No*	*Due For Calibration*
Ferrite Lined Chamber	Rainford	ATS	REF886	2020-07-29
EMI Test Receiver	R&S	ESW26	REF2235	2019-07-23
Pre-Amp (9 kHz – 1 GHz)	Sonoma	310	RFG673	2019-03-09
Bilog Antenna	Chase	CBL6111B	REF2218	2019-11-06
Horn Antenna	A Info Inc	LB-10180-NF	REF2241	2020-07-13
VHF-1300+	Mini-Circuits	High Pass Filter	REF2227	2019-02-27
VHF-1500+	Mini-Circuits	High Pass Filter	REF228	2019-02-27
VHF-3100+	Mini-Circuits	High Pass Filter	REF688	2019-02-27
AFH-07000	Atlantic Microwave	High Pass Filter	REF2240	2019-08-01

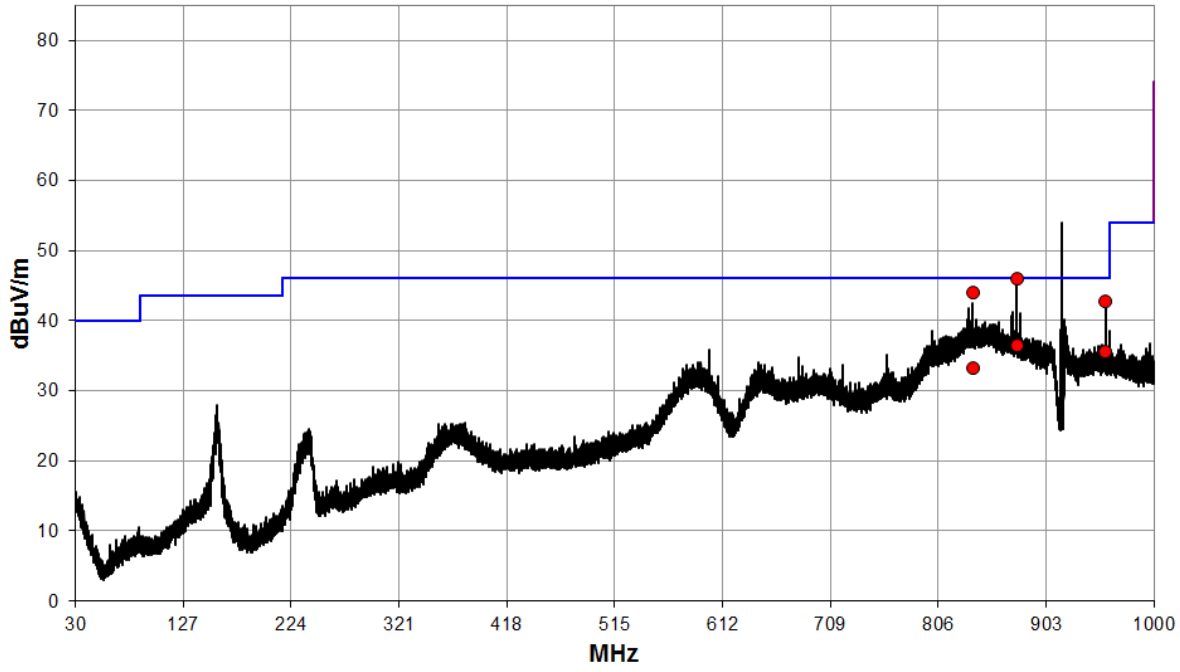
11.6 Test Results

Frequency: 916.5 MHz									
Detector	*Freq. (MHz)*	*Meas'd Emission (dBµV)*	*Cable Loss (dB)*	*Antenna Factor (dB/m)*	*Pre-amp Gain (dB)*	*Distance Extrap'n Factor (dB)*	*Field Strength (dBµV/m)*	*Field Strength (µV/m)*	*Limit (µV/m)*
QP	836.68	43.40	4.30	28.50	32.20	0.00	44.00	158.49	200
QP	876.36	44.60	4.30	29.00	32.00	0.00	45.90	197.24	200
QP	956.36	38.70	4.50	30.80	31.30	0.00	42.70	136.46	200
PK	1833.00	15.80	3.20	26.30	0.00	0.00	45.30	184.08	5000
AV	1833.00	8.500	3.20	26.30	0.00	0.00	38.00	79.43	500
PK	2749.95	16.60	3.90	28.90	0.00	0.00	49.40	295.12	5000
AV	2749.52	6.80	3.90	28.90	0.00	0.00	39.60	95.50	500
PK	3666.47	14.30	4.60	31.00	0.00	0.00	49.90	312.61	5000
AV	3666.52	2.20	4.60	31.00	0.00	0.00	37.80	77.62	500
PK	4581.48	17.00	5.10	32.90	0.00	-9.50	45.50	188.36	5000
AV	4581.70	4.50	5.10	32.90	0.00	-9.50	33.00	44.67	500
PK	5497.99	13.70	5.70	34.80	0.00	-9.50	44.70	171.79	5000
AV	5498.07	1.50	5.70	34.80	0.00	-9.50	32.50	42.17	500
PK	6414.39	13.90	6.20	36.40	0.00	-9.50	47.00	223.87	5000
AV	6414.18	1.30	6.20	36.40	0.00	-9.50	34.40	52.48	500
PK	7330.75	11.70	6.70	38.40	0.00	-9.50	47.30	231.74	5000
AV	7330.65	-1.30	6.70	38.40	0.00	-9.50	34.30	51.88	500

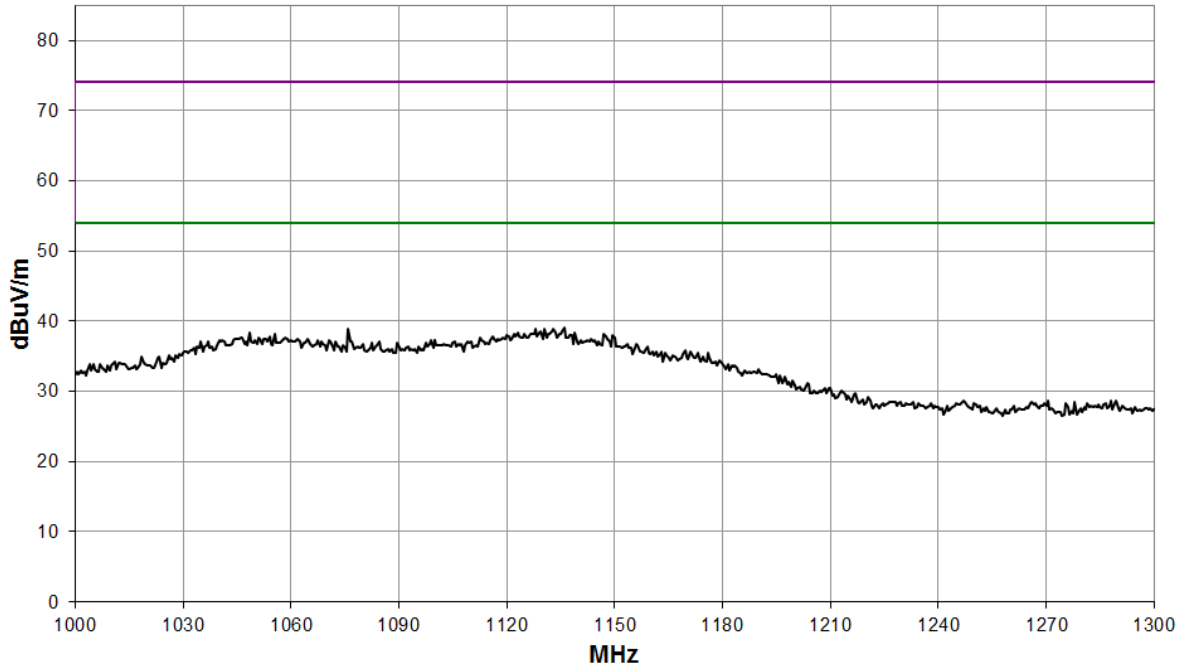
Plot 30 MHz - 1 GHz without filter



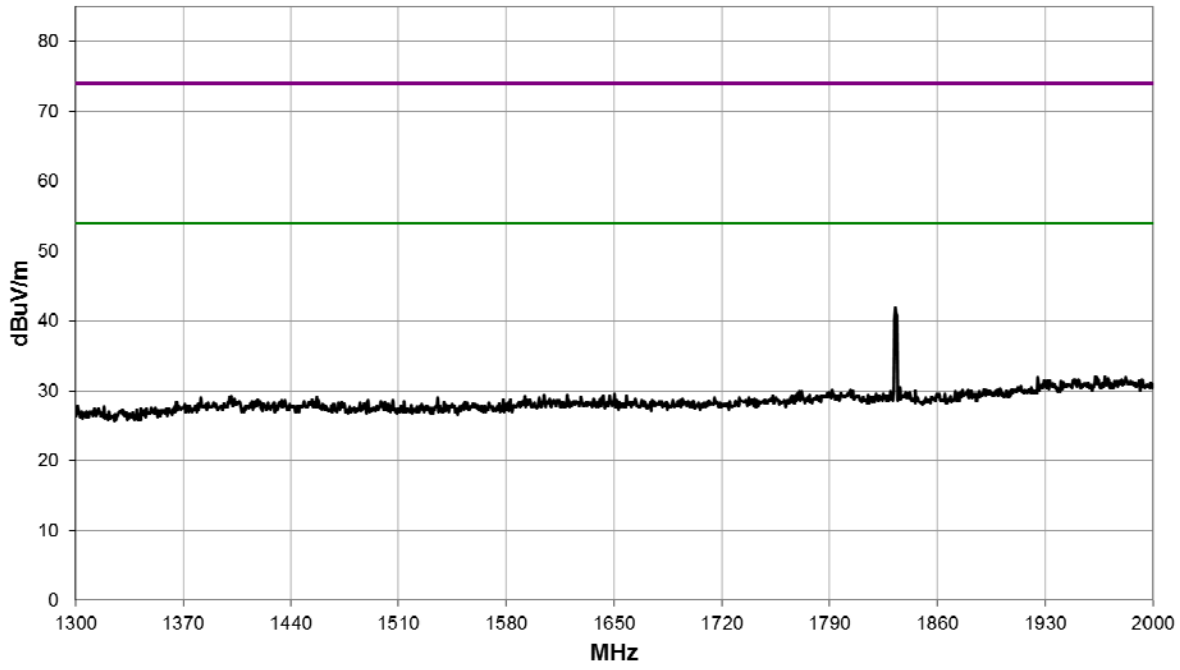
Plot 30 MHz - 1 GHz with narrow band notch filter tuned to the fundamental



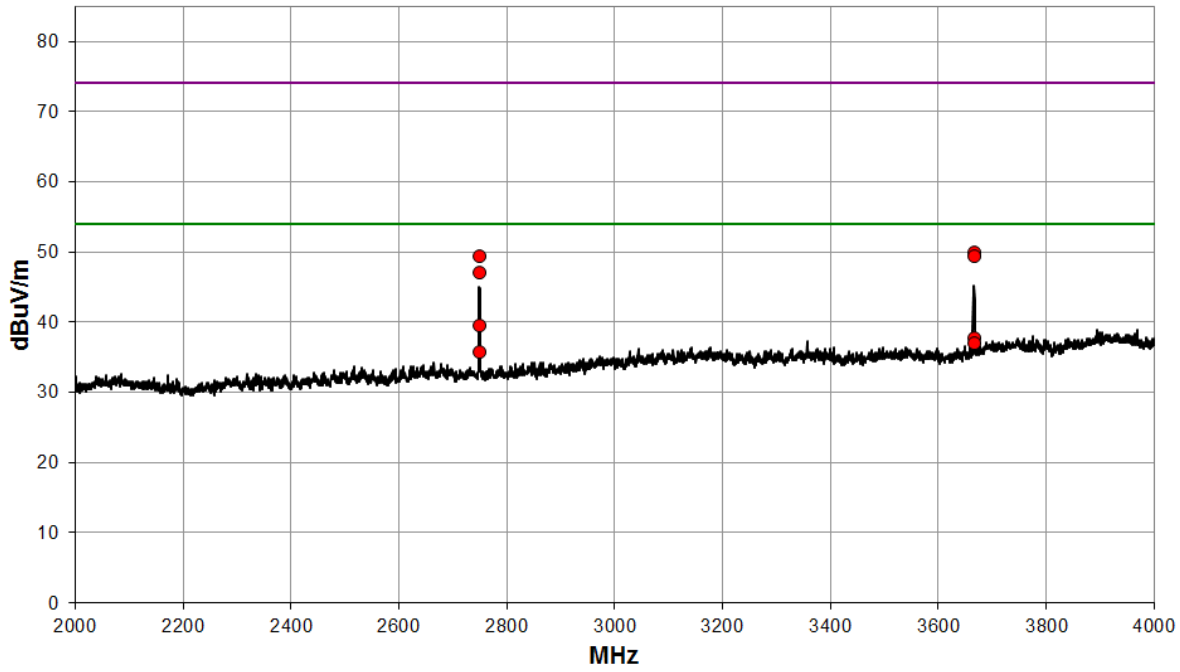
Plot 1 GHz - 1.3 GHz without filter



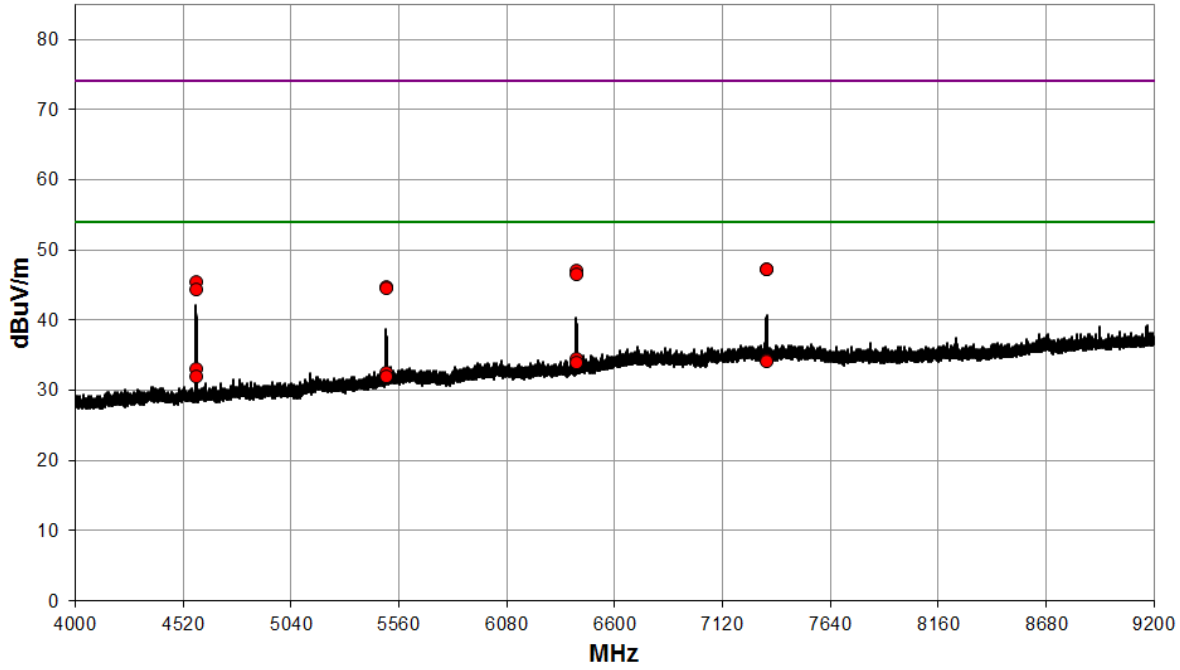
Plot 1.3 GHz – 2 GHz with 1.3 GHz high pass filter



Plot 2 GHz – 4 GHz with 1.5 GHz high pass filter



Plot 4 GHz - 9.2 GHz with 3.1 GHz high pass filter



12 Occupied Bandwidth

12.1 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.

12.2 Test Parameters

Test Location:	Element Hull
Test Chamber:	Wireless Lab 1
Test Standard and Clause:	ANSI C63.10-2013, Clause 11.8
EUT Frequency Measured:	916.5 MHz
Deviations From Standard:	None
Measurement Detector:	Peak

Environmental Conditions (Normal Environment)

Temperature: 24 °C	+15 ºC to +35 ºC (as declared)
Humidity: 34 % RH	20 % RH to 75 % RH (as declared)

12.3 Test Limit

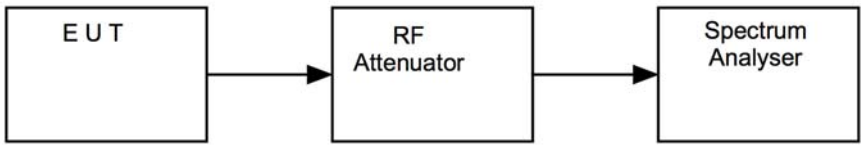
The minimum -6 dB bandwidth shall be at least 500 kHz.

12.4 Test Method

With the EUT 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

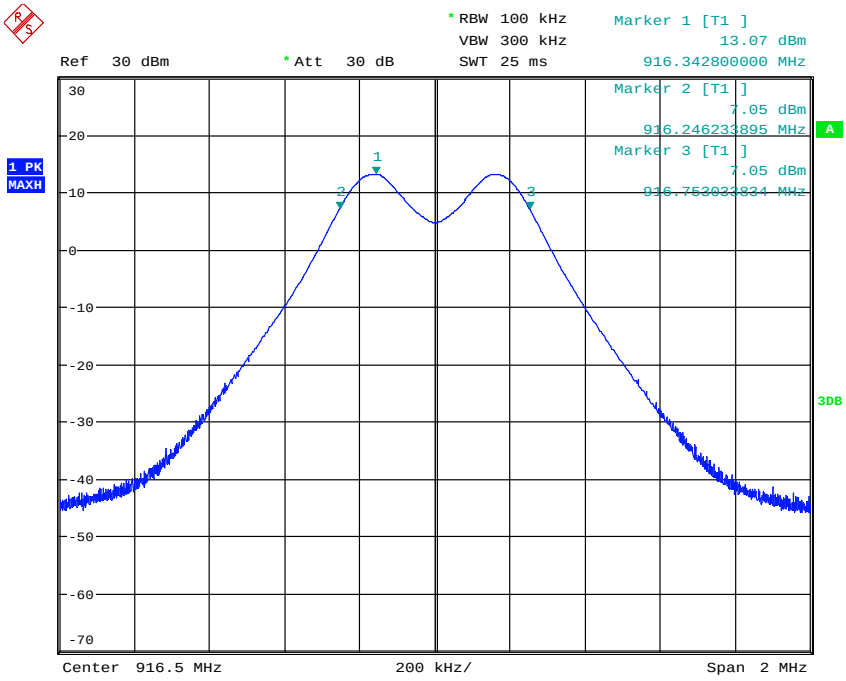


12.5 Test Equipment

Equipment Description	*Manufacturer*	*Equipment Type*	*Element No*	*Due For Calibration*
Spectrum Analyser	R&S	FSU26	REF909	2019-06-15

12.6 Test Results

6 dB Bandwidth				
Channel Frequency (MHz)	**F_L (MHz)**	**F_H (MHz)**	**6dB Bandwidth (kHz)**	**Result**
916.5	916.246234	916.753034	506.800	PASS



13 Maximum conducted output power

13.1 Definition

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.

13.2 Test Parameters

Test Location:	Element Hull
Test Chamber:	Wireless Lab 1
Test Standard and Clause:	ANSI C63.10-2013, Clause 11.9
EUT Frequency Measured:	916.5 MHz
Deviations From Standard:	None

Environmental Conditions (Normal Environment)

Temperature: 24 °C	+15 ºC to +35 ºC (as declared)
Humidity: 40 % RH	20 % RH to 75 % RH (as declared)

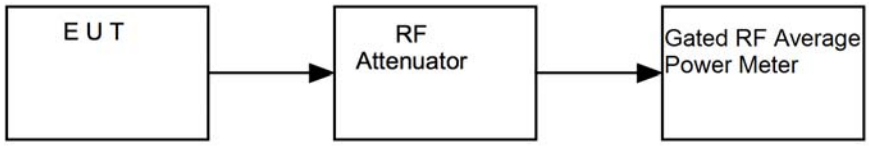
13.3 Test Limit

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.

13.4 Test Method

With the EUT connected as per Figure iv, the maximum conducted average output power was measured.

Figure iv Test Setup



13.5 Test Equipment

Equipment Description	*Manufacturer*	*Equipment Type*	*Element No*	*Due For Calibration*
Power Meter	Dare	RPR3006W	REF2112	2019-04-04

13.6 Test Results

Channel Frequency (MHz)	*Maximum conducted (average) output power*		*Antenna gain (dBi)*	*E.I.R.P.*		*Result*
	(dBm)	*(W)*		*(dBm)*	*(W)*	
916.5	13.00	0.0200	1.60	14.60	0.0288	PASS

14 Out-of-band and conducted spurious emissions

14.1 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.

14.2 Test Parameters

Test Location:	Element Hull
Test Chamber:	Wireless Lab 1
Test Standard and Clause:	ANSI C63.10-2013, Clause 11.11
EUT Frequency Measured:	916.5 MHz
Deviations From Standard:	None
Measurement Bandwidth:	100 kHz
Video Bandwidth:	300 kHz
Measurement Detector:	Peak
Measurement Range:	9 kHz to 9.2 GHz

Environmental Conditions (Normal Environment)

Temperature: 24 °C	+15 ºC to +35 ºC (as declared)
Humidity: 34 % RH	20 % RH to 75 % RH (as declared)

14.3 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.

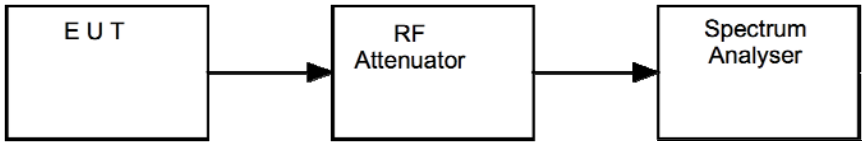
Attenuation below the general field strength limits specified in FCC 47CFR15.209 (a) is not required.

14.4 Test Method

With the EUT 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.

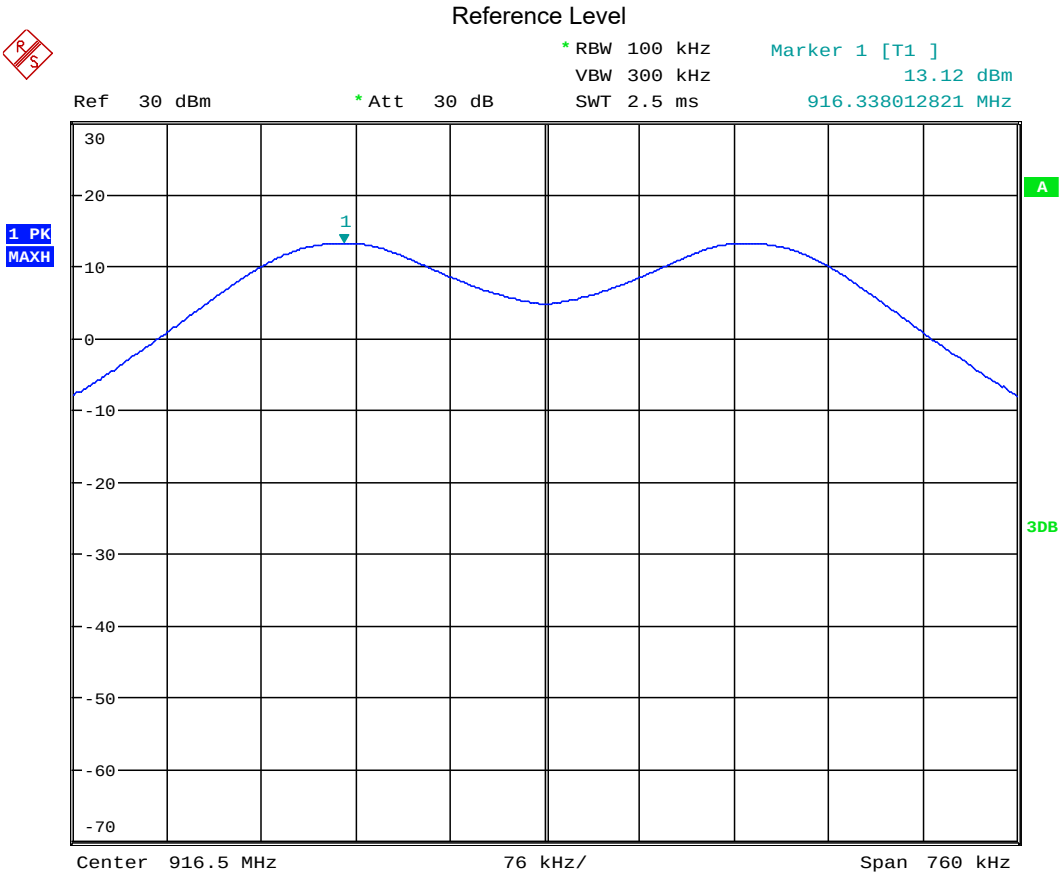
Figure v Test Setup



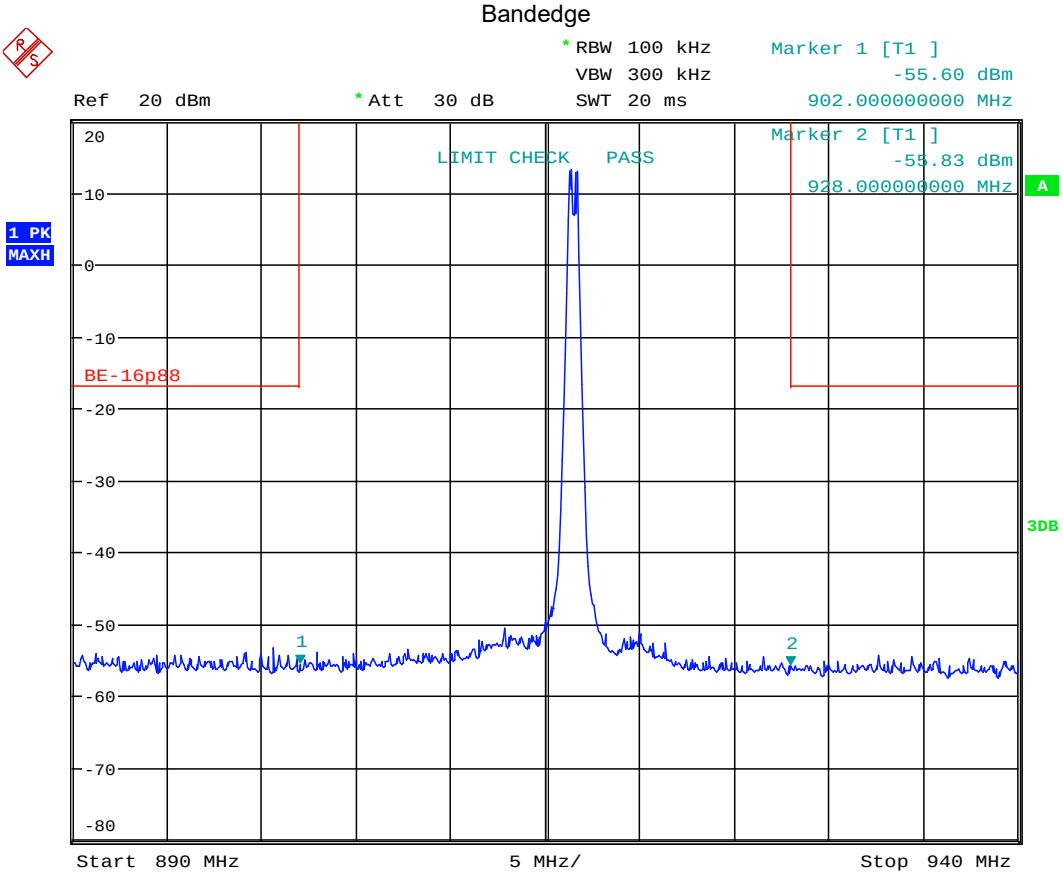
14.5 Test Equipment

Equipment Description	*Manufacturer*	*Equipment Type*	*Element No*	*Due For Calibration*
Spectrum Analyser	R&S	FSU26	REF909	2019-06-15

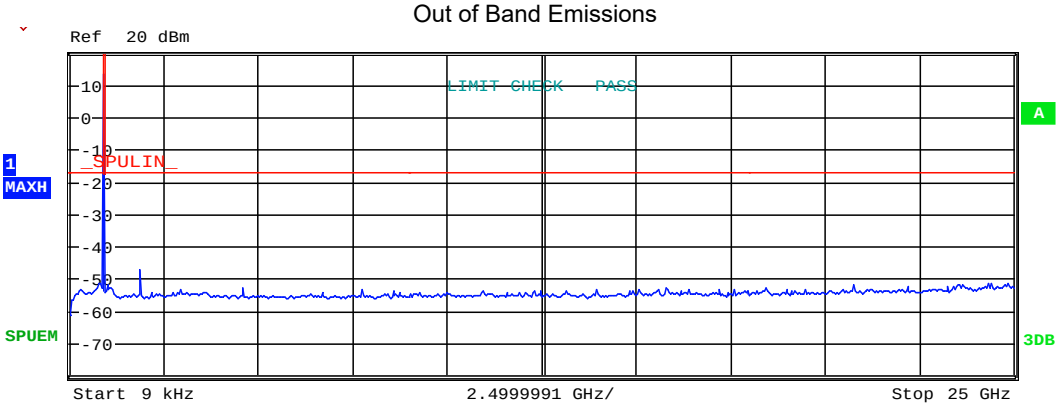
14.6 Test Results



Bandedge



Out of Band Emissions



Start [Hz]	Stop [Hz]	RBW [Hz]	Freq [Hz]	PwrAbs [dBm]	Δ Limit [dB]
9.000 k	30.000 k	1.00 k	19.230769 k	-69.33	-52.45
30.000 k	30.000 M	10.00 k	38.991000 k	-61.38	-44.50
30.000 M	902.000 M	100.00 k	876.712000 M	-51.22	-34.34
902.000 M	928.000 M	3.00 M	916.214200 M	13.13	-16.87
928.000 M	9.000 G	100.00 k	1.832064 G	-47.23	-30.35
9.000 G	18.000 G	100.00 k	15.795000 G	-53.12	-36.24
18.000 G	25.000 G	100.00 k	24.335000 G	-51.42	-34.54

15 Power spectral density

15.1 Definition

The power per unit bandwidth.

15.2 Test Parameters

Test Location:	Element Hull
Test Chamber:	Wireless Lab 1
Test Standard and Clause:	ANSI C63.10-2013, Clause 11.10
EUT Frequency Measured:	916.5 MHz
Deviations From Standard:	None
Measurement Detector:	RMS

Environmental Conditions (Normal Environment)

Temperature: 24 °C	+15 ºC to +35 ºC (as declared)
Humidity: 34 % RH	20 % RH to 75 % RH (as declared)

15.3 Test Limit

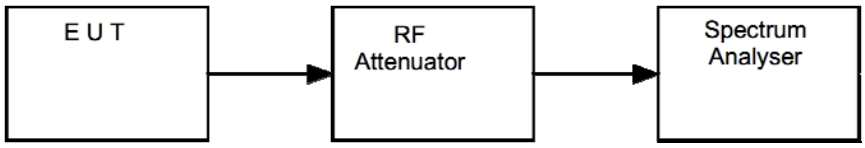
The transmitter power spectral density conducted from the transmitter to the antenna shall not be greater than 8 dBm in any 3 kHz band during any time interval of continuous transmission.

15.4 Test Method

With the EUT 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

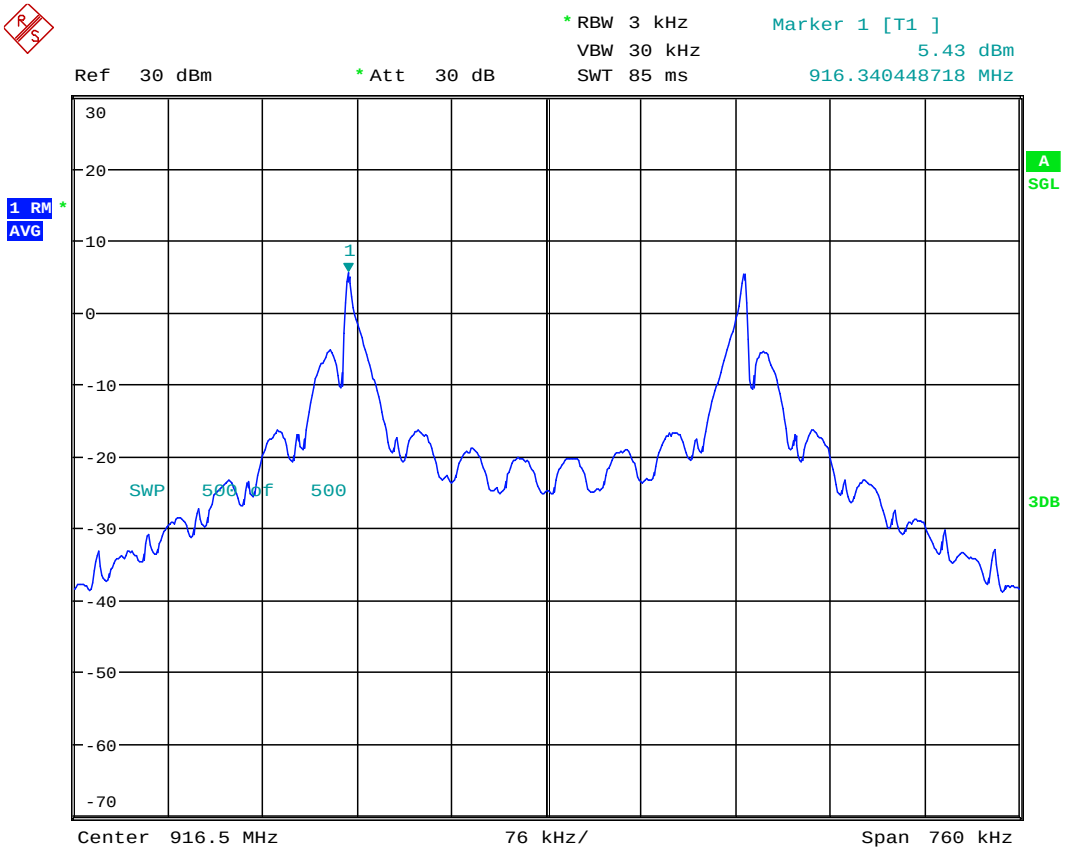


15.5 Test Equipment

Equipment Description	*Manufacturer*	*Equipment Type*	*Element No*	*Due For Calibration*
Spectrum Analyser	R&S	FSU26	REF909	2019-06-15

15.6 Test Results

Channel Frequency (MHz)	*Analyzer Level (dBm)*	*Cable loss (dB)*	*Power (dBm)*	*Result*
916.5	5.43	0.0	5.43	PASS



16 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) = **4.75 dB**
Uncertainty in test result (1 GHz to 18 GHz) = **4.46 dB**

[2] AC power line conducted emissions

Uncertainty in test result = **3.2 dB**

[3] Occupied bandwidth

Uncertainty in test result = **15.58 %**

[4] Conducted carrier power

Uncertainty in test result (Power Meter) = **0.93 dB**

[5] Conducted 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**

[6] Radiated RF power out-of-band

Uncertainty in test result (30 MHz to 1 GHz) = **4.75 dB**
Uncertainty in test result (1 GHz to 18 GHz) = **4.46 dB**

[7] Power spectral density

Uncertainty in test result (Spectrum Analyser) = **3.11 dB**

[8] ERP / EIRP

Uncertainty in test result (Laboratory) = **4.71 dB**
Uncertainty in test result (Pershore OATS) = **4.26 dB**