Report on the Radio Testing

For

Technology Solutions (UK) Ltd

on

1166 Bluetooth and rugged UHF RFID reader

Report no. TRA-030913-47-00-A

11th July 2016

RF916 6.0

Report Number: TRA-030913-47-00-A
Issue: A

REPORT ON THE RADIO TESTING OF A
Technology Solutions (UK) Ltd
1166 Bluetooth and rugged UHF RFID reader
WITH RESPECT TO SPECIFICATION
FCC 47CFR 15.247 & IC RSS-247

TEST DATE: 27/04/2016

Written by: S Hodgkinson — S Hodgkinson, Radio Test Engineer

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Date: 2016.07.12 11:59:38 +01'00'

Date: 11th July 2016

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[2] THE RESULTS CONTAINED IN THIS DOCUMENT RELATE ONLY TO THE ITEM(S) TESTED

Element Materials Technology Warwick Ltd.
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Company Reg No. 02536659

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UKAS TESTING 0026

1 Revision Record

Issue Number	*Issue Date*	*Revision History*
A	11th July 2016	Original

2 Summary

TEST REPORT NUMBER:	TRA-030913-47-00-A
WORKS ORDER NUMBER	TRA-030913-00
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 Radio communication Act and 21(1) of the Radio communication Regulations.
TEST SPECIFICATION(S):	47CFR15.247 & RSS-247
EQUIPMENT UNDER TEST (EUT):	Bluetooth and rugged UHF RFID reader
FCC IDENTIFIER:	S6J1166
INDUSTRY CANADA:	8948A-1166
EUT SERIAL NUMBER:	1166-00108 & 1166-00103
MANUFACTURER/AGENT:	Technology Solutions (UK) Ltd
ADDRESS:	Suite A Loughborough Technology Centre Epinal Way Loughborough Leicestershire LE11 3GE United Kingdom
CLIENT CONTACT:	David Corder ☎ 01509234248 ✉ david.corder@tsl.uk.com
ORDER NUMBER:	0001603130
TEST DATE:	27/04/2016
TESTED BY:	S Hodgkinson 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	☐	
Carrier frequency separation	247, 5.1 (2)	15.247(a)(1)	☒	*Pass*
Number of hopping channels	247, 5.1 (3), (4) and (5)	15.247(a)(1) (i), (ii) and (iii)	☒	*Pass*
Average time of occupancy	247, 5.1 (3), (4) and (5)	15.247(a)(1) (i), (ii) and (iii)	☒	*Pass*
Maximum peak conducted output power	247, 5.4 (1), (2) and (3)	15.247 (a)(1), (b)(1) and (b)(2)	☒	*Pass*
20dB emission bandwidth	247, 5.1 (1)	15.247(a)(1) (i) and (ii)	☒	*Pass*
Out-of-band emissions	247, 5.5	15.247(d)	☒	*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-030913-47-00-A presents the results of the Radio testing on a Technology Solutions (UK) Ltd, Bluetooth and rugged UHF RFID reader 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 Technology Solutions (UK) 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: Bluetooth and rugged UHF RFID reader
- Serial Number: 1166-00108 & 1166-00103
- Model Number: 1166

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.

Not Applicable – No support/monitoring equipment required.

7.3 EUT Mode of Operation

7.3.1 Transmission

The mode of operation for Tx tests was as follows…
The transmitter was operated on the following channels bottom, middle, top, and whilst hopping

7.3.2 Reception

The mode of operation for Rx tests was as follows…
The receiver was operated on the following channels bottom, middle, top, and whilst hopping

7.4 EUT Radio Parameters

7.4.1 General

Frequency of operation:	902-928MHz
Modulation type(s):	FHSS
Occupied channel bandwidth(s):	74.919kHz
Channel spacing:	500kHz
ITU emission designator(s):	100KA1D
Declared output power(s):	30dBm
Nominal Supply Voltage:	11.25Vdc
Duty cycle:	50%

7.4.2 Antennas

Type:	AQUA920S_8012_TSL_N
Frequency range:	902-928MHz
Gain:	4.5dBi

7.4.3 Product specific declarations

Not applicable.

7.5 EUT Description

The EUT is a UHF RFID reader that also makes use of Bluetooth technology.

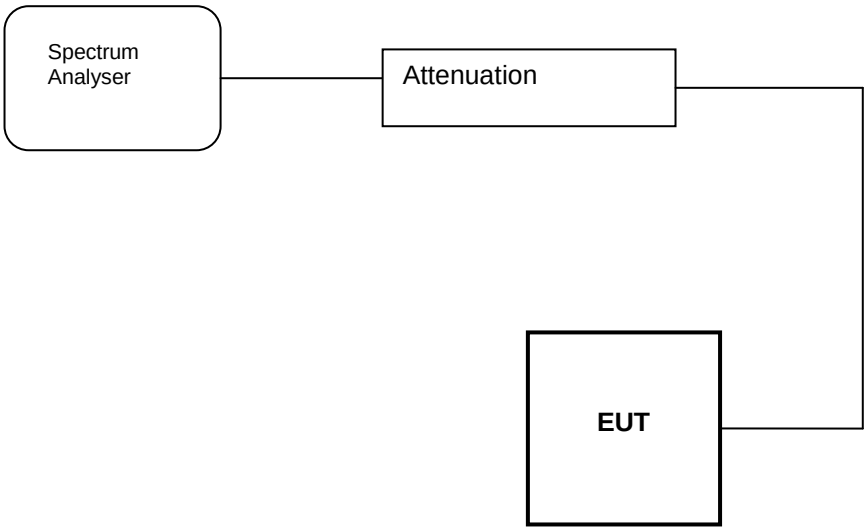
8 Modifications

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

10.1 Normal Conditions

The E U T was tested under the normal environmental conditions of the test laboratory, except where otherwise stated. The normal power source applied was approx. 11.25 V dc from Lithium ion 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 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

Test Location:	Element Skelmersdale
Test Chamber:	Radio chamber 3
Test Standard and Clause:	ANSI C63.10-2013, Clause 6.5 and 6.6
EUT Channels / Frequencies Measured:	Low / Mid / High
EUT Channel Bandwidths:	74.118kHz/74.519kHz/74.919kHz
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: 24 °C	+15 ºC to +35 ºC (as declared)
Humidity: 27 % RH	20 % RH to 75 % RH (as declared)
Supply: 11.25V dc	11.25Vdc ±10 % (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:

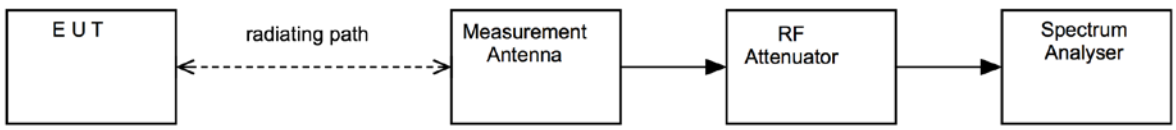
$$FS = PR + CL + AF - PA + DC - CF$$

Where,

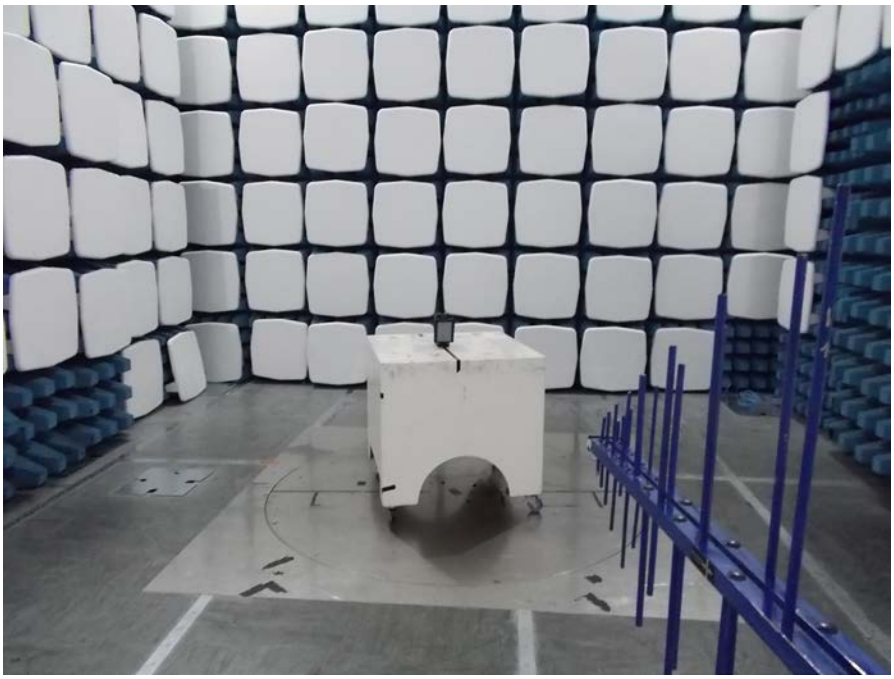
PR is the power recorded on the receiver / spectrum analyzer in dBµV;
CL is the cable loss in dB;
AF is the test antenna factor in dB/m;
PA is the pre-amplifier gain in dB (where used);
DC is the duty correction factor in dB (where used, e.g. harmonics of pulsed fundamental);
CF is the distance factor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

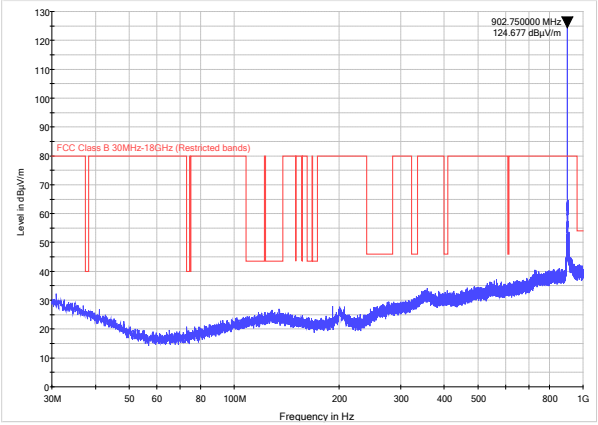


11.6 Test Equipment

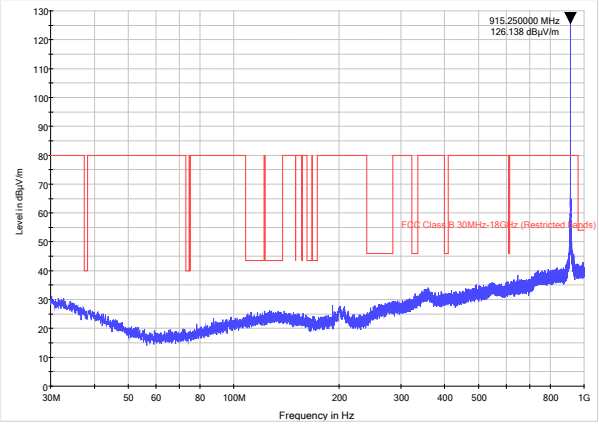
Equipment Type	Manufacturer	Equipment Description	Element No	Due For Calibration
CBL611/A	Chase	Bilog	U195	26/02/2017
ESVS10	R&S	Receiver	L317	11/03/2017
ATS	Rainford EMC	Radio Chamber	REF940	08/09/2017
3115	EMCO	1-18GHz Horn	L139	25/09/2017
FSU50	R&S	Spectrum Analyser	U544	16/03/2017
8449B	Agilent	Pre Amp	L572	16/02/2017
1500+	Mini Circuits	High Pass Filter	U519	25/02/2017

11.7 Test Results

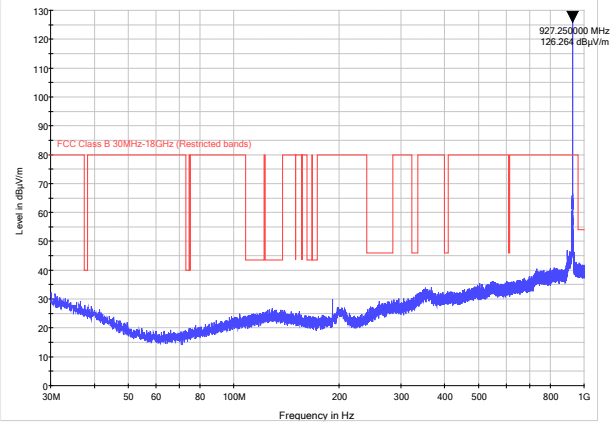
Tx 902.75MHz 30MHz-1GHz



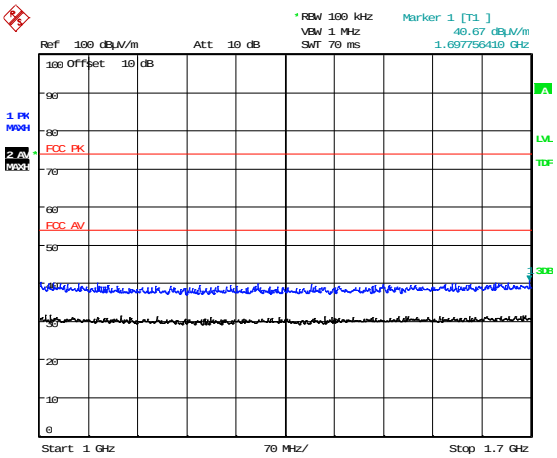
Tx 915.25MHz 30MHz-1GHz



Tx 927.25MHz 30MHz-1GHz



Tx 902.75MHz 1-1.7GHz



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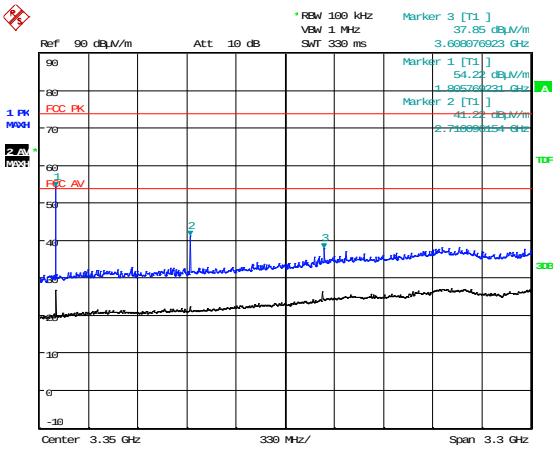
Tx 902.75MHz 1.7-5GHz



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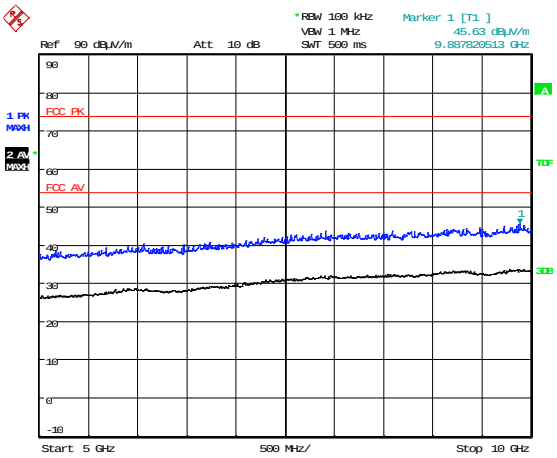
Tx 902.75MHz 5GHz-10GHz



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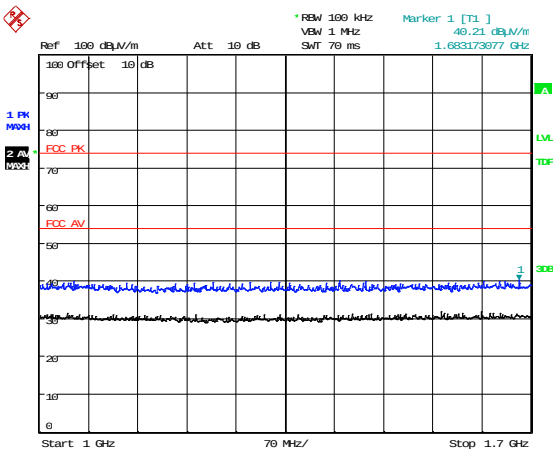
Tx 915.25MHz 1-1.7GHz



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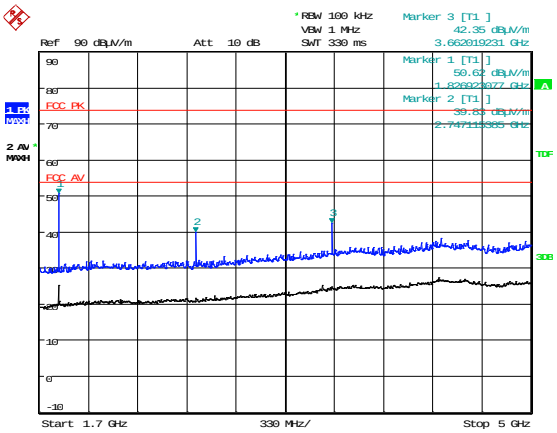
Tx 915.25MHz 1.7-5GHz



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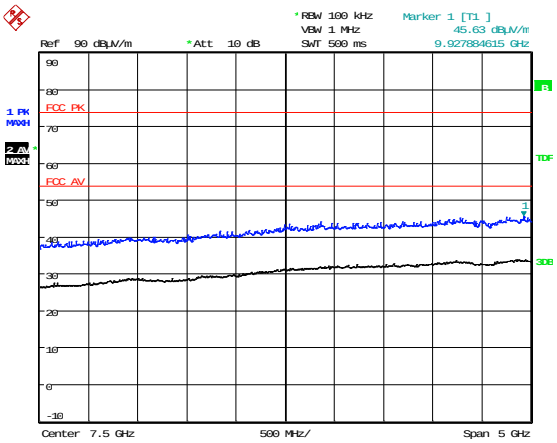
Tx 915.25MHz 5GHz-10GHz



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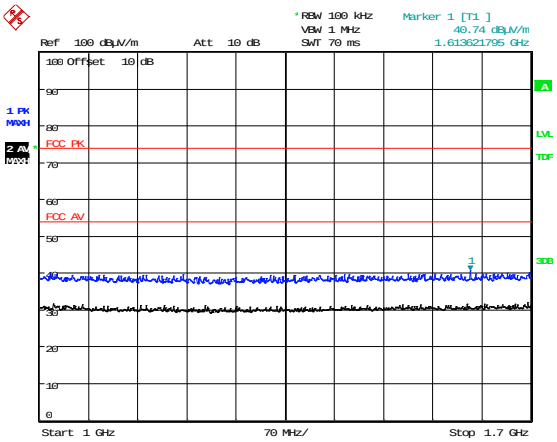
Tx 927.25MHz 1-1.7GHz



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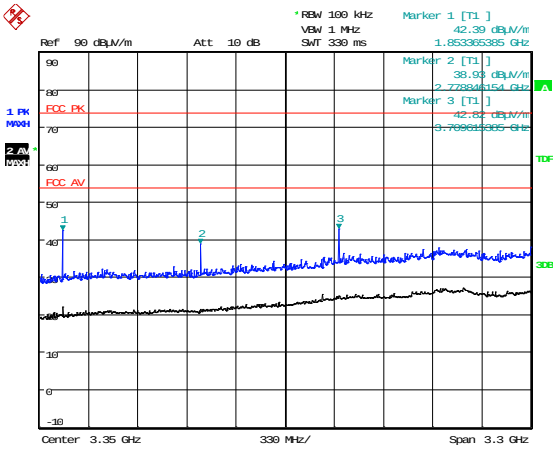
Tx 927.25MHz 1.7GHz-5GHz



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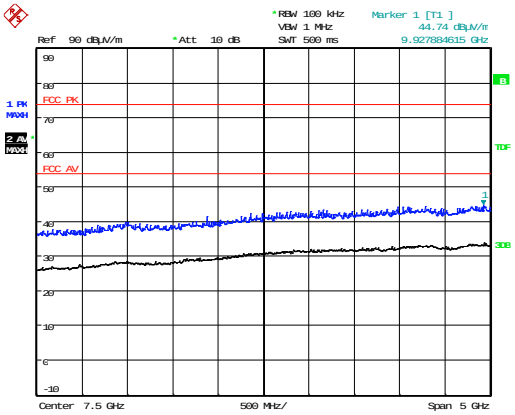
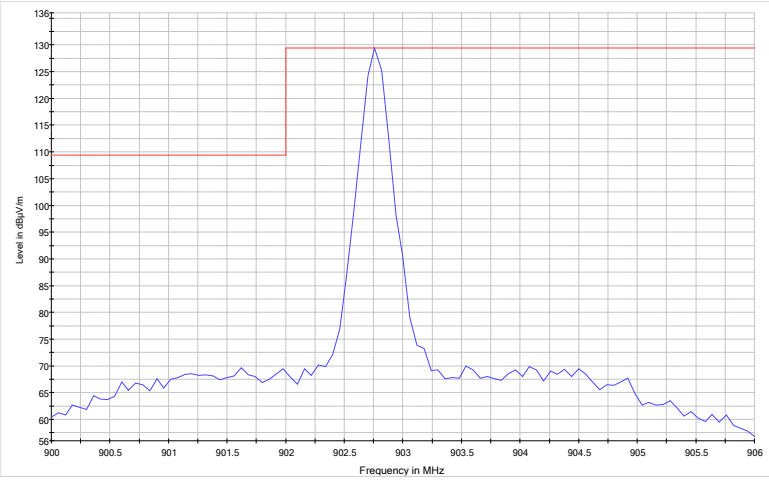
Tx 927.25MHz 5GHz-10GHz

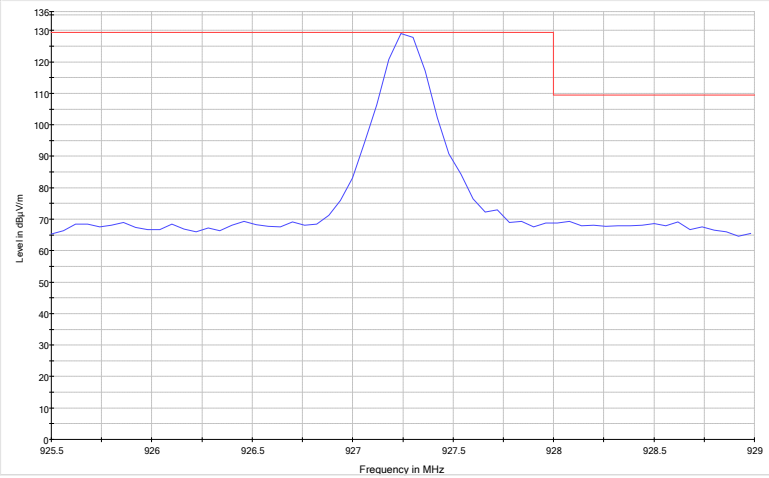


Date: 15.JUN.2016 10:54:39

Tx bottom bandedge



Tx Bandedge Top Channel



High Power; Channel: low 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)***
Pk	2708.18	59.10	3.60	28.90	36.06	0.00	0.00	55.54	598.41	5012
Av	2708.18	51.71	3.60	28.90	36.06	0.00	0.00	48.15	255.56	500
Pk	3610.96	50.79	4.30	31.60	35.74	0.00	0.00	50.95	352.78	5012
Av	3610.96	39.06	4.30	31.60	35.74	0.00	0.00	39.22	91.41	500

High Power; Channel: mid 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)***
Pk	2745.75	52.28	3.60	29.00	36.06	0.00	0.00	48.82	276.06	5012
Av	2745.75	41.04	3.60	29.00	36.06	0.00	0.00	37.58	75.68	500
Pk	3660.98	51.26	4.30	31.70	35.71	0.00	0.00	51.55	378.01	5012
Av	3660.98	41.48	4.30	31.70	35.71	0.00	0.00	41.77	122.60	500

High Power; Channel: high 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)***
Pk	2781.75	51.23	3.70	29.10	36.07	0.00	0.00	47.96	250.03	5012
Av	2781.75	39.19	3.70	29.10	36.07	0.00	0.00	35.92	62.52	500
Pk	3709.00	51.02	4.30	31.80	35.69	0.00	0.00	51.43	372.82	5012
Av	3709.00	40.81	4.30	31.80	35.69	0.00	0.00	41.22	115.08	500

12 Carrier frequency separation

12.1 Definition

The carrier frequency separation is the frequency separation between two adjacent hopping frequencies.

12.2 Test Parameters

Test Location:	Element Skelmersdale
Test Chamber:	Radio Lab
Test Standard and Clause:	ANSI C63.10-2013, Clause 7.8.2
EUT Channels / Frequencies Measured:	All; 2405 to 2480 MHz
EUT 20dB Bandwidth:	74.118kHz/74.519kHz/74.919kHz
EUT Test Modulations:	Internal pattern generation – hopping enabled
Deviations From Standard:	None
Measurement Detector:	Peak

Environmental Conditions (Normal Environment)

Temperature: 24 °C	+15 ºC to +35 ºC (as declared)
Humidity: 27 % RH	20 % RH to 75 % RH (as declared)
Supply: 11.25 V dc	11.25Vdc±10 % (as declared)

12.3 Test Limit

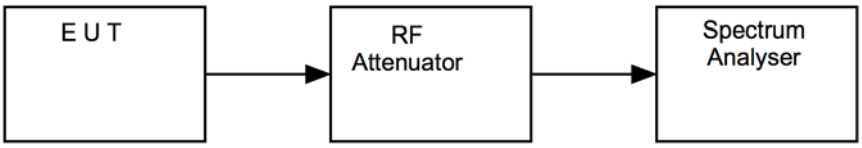
Frequency hopping systems shall have hopping channel carrier frequencies separated by a minimum of 25 kHz or the -20 dB bandwidth of the hopping channel, whichever is greater. Alternatively, frequency hopping systems operating in the band 2400 to 2483.5 MHz may have hopping channel carrier frequencies that are separated by 25 kHz or two-thirds of the -20 dB bandwidth of the hopping channel, whichever is greater, provided that the systems operate with an output power no greater than 0.125 W.

12.4 Test Method

With the EUT setup as per section 9 of this report and connected as per Figure iii, the emissions of 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 nominal bandwidth.

Figure iii Test Setup



12.5 Test Equipment

Equipment Type	Manufacturer	Equipment Description	Element No	Due For Calibration
Spectrum Analyser	R&S	FSU50	U544	16/03/2017
Attenuator	Bird	10dB	TRL112	Cal in use
Attenuator	Spinner	20dB	TRLUH225	Cal in use
Signal generator	R&S	SMBV100A	REF916	21/03/2017

12.6 Test Results

$F1_c$ (MHz)	***$F2_c$ (MHz)***	***Channel Separation, $F2_c - F1_c$ (kHz)***	***Result***
914.743990	915.2427881	498.798076	PASS

13 Number of hopping frequencies

13.1 Definition

The total number of hopping frequencies (the centre frequencies defined within the hopping sequence of a FHSS equipment) which are randomly sequenced in order to spread the transmission.

13.2 Test Parameters

Test Location:	Element Skelmersdale
Test Chamber:	Radio Lab
Test Standard and Clause:	ANSI C63.10-2013, Clause 7.8.3
EUT Channels / Frequencies Measured:	All; 2405 – 2480 MHz
EUT 20dB Bandwidth:	74.118kHz/74.519kHz/74.919kHz
EUT Test Modulations:	Internal pattern generation – hopping enabled
Deviations From Standard:	None
Measurement Detector:	Peak

Environmental Conditions (Normal Environment)

Temperature: 24 °C	+15 ºC to +35 ºC (as declared)
Humidity: 27 % RH	20 % RH to 75 % RH (as declared)
Supply: 11.25 V dc	11.25 V dc ±10 % (as declared)

13.3 Test Limit

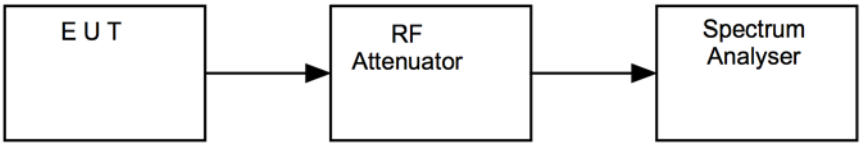
- For frequency hopping systems in the band 902 to 928 MHz: if the -20 dB bandwidth of the hopping channel is less than 250 kHz, the system shall use at least 50 hopping channels;
  If the -20 dB bandwidth of the hopping channel is 250 kHz or greater, the system shall use at least 25 hopping channels;
- Frequency hopping systems operating in the band 2400 to 2483.5 MHz shall use at least 15 hopping channels;
- Frequency hopping systems operating in the band 5725 to 5850 MHz shall use at least 75 hopping channels.

13.4 Test Method

With the EUT setup as per section 9 of this report and connected as per Figure iv, the emissions of 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 nominal bandwidth.

Figure iv Test Setup



13.5 Test Equipment

Equipment Type	Manufacturer	Equipment Description	Element No	Due For Calibration
Spectrum Analyser	R&S	FSU50	U544	16/03/2017
Attenuator	Bird	10dB	TRL112	Cal in use
Attenuator	Spinner	20dB	TRLUH225	Cal in use
Signal generator	R&S	SMBV100A	REF916	21/03/2017

13.6 Test Results

Lowest channel, F_{CL} (MHz)	***Highest channel, F_{CH} (MHz)***	***Number of channels observed***	***Result***
902.75MHz	927.25	50	PASS

14 Average channel occupancy

14.1 Definition

The channel occupancy is the total of the transmitter 'on' times, during an observation period, on a particular hopping frequency.

14.2 Test Parameters

Test Location:	Element Skelmersdale
Test Chamber:	Radio Lab
Test Standard and Clause:	ANSI C63.10-2013, Clause 7.8.4
EUT Channels / Frequencies Measured:	Mid
EUT 20dB bandwidth:	74.118kHz/74.519kHz/74.919kHz
EUT Number of hopping channels:	50
EUT Test Modulations:	Internal pattern generation – hopping enabled
Deviations From Standard:	None
Measurement Detector:	Peak

Environmental Conditions (Normal Environment)

Temperature: 24 °C	+15 ºC to +35 ºC (as declared)
Humidity: 27 % RH	20 % RH to 75 % RH (as declared)
Supply: 11.25 V ac	11.25 V dc ±10 % (as declared)

14.3 Test Limit

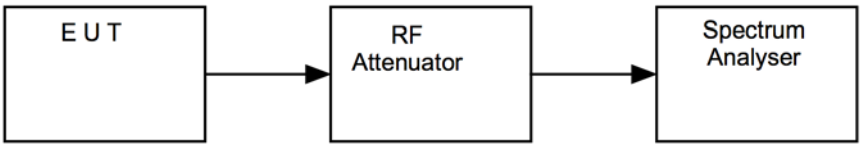
- For frequency hopping systems in the band 902 to 928 MHz: if the -20 dB bandwidth of the hopping channel is less than 250 kHz, the average time of occupancy on any channel shall not be greater than 0.4 seconds within a 20 second period;
  If the -20 dB bandwidth of the hopping channel is 250 kHz or greater, the average time of occupancy on any channel shall not be greater than 0.4 seconds within a 10 second period;
- Frequency hopping systems operating in the band 2400 to 2483.5 MHz: The average time of occupancy on any channel shall not be greater than 0.4 seconds within a period of 0.4 seconds, multiplied by the number of hopping channels employed;
- Frequency hopping systems operating in the band 5725 to 5850 MHz: The average time of occupancy on any frequency shall not be greater than 0.4 seconds within a 30 second period.

14.4 Test Method

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

The measurements were performed with EUT set at its maximum duty. A number of hops were observed to confirm consistency of the dwell time / observe the worst case. All modulation schemes, data rates and power settings were used to observe the worst-case configuration.

Figure v Test Setup



14.5 Test Equipment

Equipment Type	Manufacturer	Equipment Description	Element No	Due For Calibration
Spectrum Analyser	R&S	FSU50	U544	16/03/2017
Attenuator	Bird	10dB	TRL112	Cal in use
Attenuator	Spinner	20dB	TRLUH225	Cal in use
Signal generator	R&S	SMBV100A	REF916	21/03/2017

14.6 Test Results

Individual occupancy time (ms)	***Observation period (s)***	***Number of hops observed***	***Average time of occupancy (s)***	***Result***
188.833	21	2	0.377666	PASS

15 Maximum peak conducted output power

15.1 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.

15.2 Test Parameters

Test Location:	Element Skelmersdale
Test Chamber:	Radio Lab
Test Standard and Clause:	ANSI C63.10-2013, Clause 6.9
EUT Channels / Frequencies Measured:	Low / Mid / High – hopping stopped.
EUT Channel Bandwidths:	74.118kHz/74.519kHz/74.919kHz
EUT Test Modulations:	FHSS
Deviations From Standard:	None
Measurement BW:	100kHz
Voltage Extreme Environment Test Range:	Mains Power = 85 % and 115 % of Nominal (FCC only requirement); Battery Power = new battery.

Environmental Conditions (Normal Environment)

Temperature: 24 °C	+15 ºC to +35 ºC (as declared)
Humidity: 27 % RH	20 % RH to 75 % RH (as declared)

15.3 Test Limit

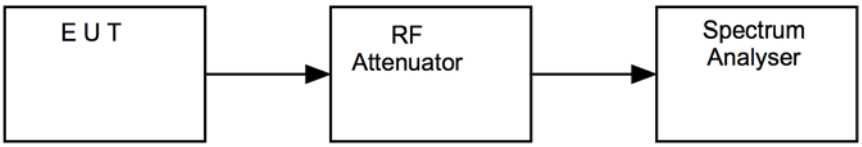
- For frequency hopping systems operating in the band 902 to 928 MHz, the maximum peak conducted output power shall not exceed 1 W, and the e.i.r.p. shall not exceed 4 W, if the hopset uses 50 or more hopping channels;
  the maximum peak conducted output power shall not exceed 0.25 W, and the e.i.r.p. shall not exceed 1 W, if the hopset uses less than 50 hopping channels.
- For frequency hopping systems operating in the band 2400 to 2483.5 MHz and employing at least 75 hopping channels, the maximum peak conducted output power shall not exceed 1 W;
  for all other frequency hopping systems in the band, the maximum peak conducted output power shall not exceed 0.125 W. The e.i.r.p. shall not exceed 4 W.
- For frequency hopping systems operating in the band 5725 to 5850 MHz, the maximum peak conducted output power shall not exceed 1 W. The e.i.r.p. shall not exceed 4 W.
- Point-to-point systems in the bands 2400-2483.5 MHz and 5725 to 5850 MHz are permitted to have an e.i.r.p. higher than 4 W provided that the higher e.i.r.p. is achieved by employing higher gain directional antennas and not higher transmitter output powers.

15.4 Test Method

With the EUT setup as per section 9 of this report and connected as per Figure vi, 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 vi Test Setup



15.5 Test Equipment

Equipment Type	Manufacturer	Equipment Description	Element No	Due For Calibration
Spectrum Analyser	R&S	FSU50	U544	16/03/2017
Attenuator	Bird	10dB	TRL112	Cal in use
Attenuator	Spinner	20dB	TRLUH225	Cal in use
Signal generator	R&S	SMBV100A	REF916	21/03/2017

15.6 Test Results

Modulation: FHSS; Power setting: Max						
Channel Frequency (MHz)	***Analyzer Level (dBm)***	***Cable loss (dB)***	***Maximum peak conducted output power (W)***	***Antenna gain (dBi)***	***E.I.R.P. (W)***	***Result***
902.75	-1.62	30.7	.809	4.0	2.03	PASS
915.25	-1.60	30.7	.812	4.0	2.04	PASS
927.25	-1.26	30.8	.899	4.0	2.26	PASS

16 Occupied Bandwidth

16.1 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.

16.2 Test Parameters

Test Location:	Element Skelmersdale
Test Chamber:	Radio Lab
Test Standard and Clause:	ANSI C63.10-2013, Clause 6.9
EUT Channels / Frequencies Measured:	Low / Mid / High – hopping stopped.
EUT Channel Bandwidths:	74.118kHz/74.519kHz/74.919kHz
EUT Test Modulations:	FHSS
Deviations From Standard:	None
Measurement BW: (requirement: 1 % to 5 % OBW)	1kHz
Spectrum Analyzer Video BW: (requirement at least 3x RBW)	3kHz
Measurement Span: (requirement 2 to 5 times OBW)	250kHz
Measurement Detector:	Peak

Environmental Conditions (Normal Environment)

Temperature: 24 °C	+15 ºC to +35 ºC (as declared)
Humidity: 27 % RH	20 % RH to 75 % RH (as declared)
Supply: 11.25 V dc	11.25V dc ±10 % (as declared)

16.3 Test Limit

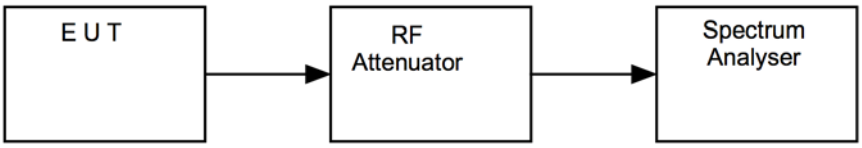
- For frequency hopping systems in the band 902 to 928 MHz: The maximum allowed -20 dB bandwidth of the hopping channel is 500 kHz.
- Frequency hopping systems operating in the band 5725 to 5850 MHz: The maximum -20 dB bandwidth of the hopping channel shall be 1 MHz

16.4 Test Method

With the EUT setup as per section 9 of this report and connected as per Figure vii, 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 vii Test Setup



16.5 Test Equipment

Equipment Type	Manufacturer	Equipment Description	Element No	Due For Calibration
Spectrum Analyser	R&S	FSU50	U544	16/03/2017
Attenuator	Bird	10dB	TRL112	Cal in use
Attenuator	Spinner	20dB	TRLUH225	Cal in use
Signal generator	R&S	SMBV100A	REF916	21/03/2017

16.6 Test Results

Modulation: FHSS; Power setting: Max				
Channel Frequency (MHz)	***F_L (MHz)***	***F_H (MHz)***	***20dB Bandwidth (kHz)***	***Result***
902.275	902.710336	902.784454	74.118	PASS
915.250	915.210336	915.284855	74.519	PASS
927.250	927.210336	927.285255	74.919	PASS

17 Out-of-band and conducted spurious emissions

17.1 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.

17.2 Test Parameters

Test Location:	Element Skelmersdale / Element Hull
Test Chamber:	Chamber 3
Test Standard and Clause:	ANSI C63.10-2013, Clause 7.8.8
EUT Channels / Frequencies Measured:	Low / Mid / High
Deviations From Standard:	None
Measurement BW:	100 kHz
Measurement Detector:	Peak
Measurement Range:	30 MHz to 26.5 GHz

Environmental Conditions (Normal Environment)

Temperature: 24 °C	+15 ºC to +35 ºC (as declared)
Humidity: 27 % RH	20 % RH to 75 % RH (as declared)
Supply: 11.25 V dc	11.25dc ±10 % (as declared)

17.3 Test Limits

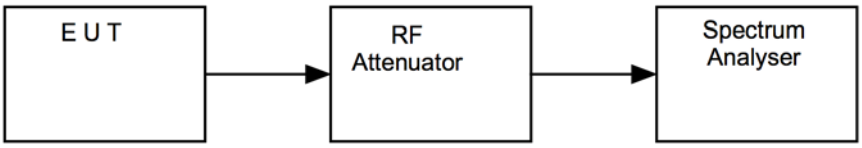
In any 100 kHz bandwidth outside the frequency band in which the spread spectrum or digitally modulated device is operating, the RF power that is produced shall be at least 20 dB below that in the 100 kHz bandwidth within the band that contains the highest level of the desired power, based on either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

17.4 Test Method

With the EUT setup as per section 9 of this report and connected as per Figure viii, 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 viii Test Setup



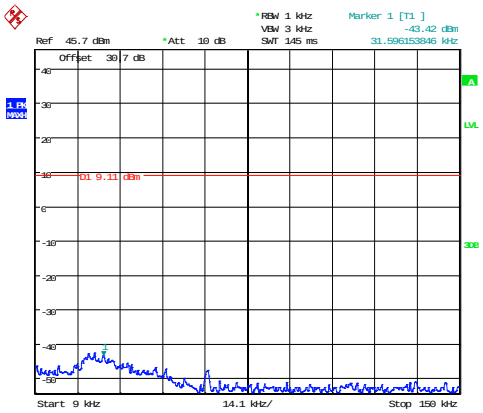
17.5 Test Equipment

Equipment Type	Manufacturer	Equipment Description	Element No	Due For Calibration
FSU50	R&S	Spectrum Analyser	U544	16/03/2017

Test Results

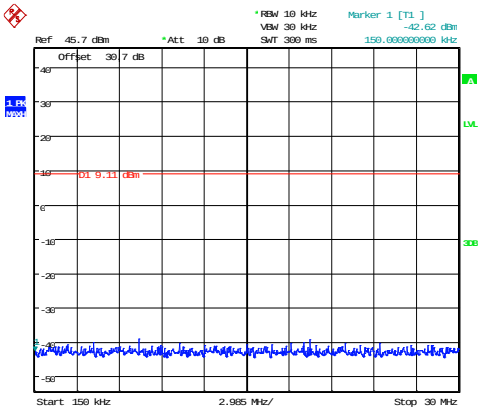
Channel Frequency (MHz)	Emission Frequency (MHz)	Analyzer Level (dBm)	Emission Level (dBm)	Limit (dBm)	Margin (dB)	Result
Low	No Significant emissions					PASS

Tx Bottom 9-150kHz



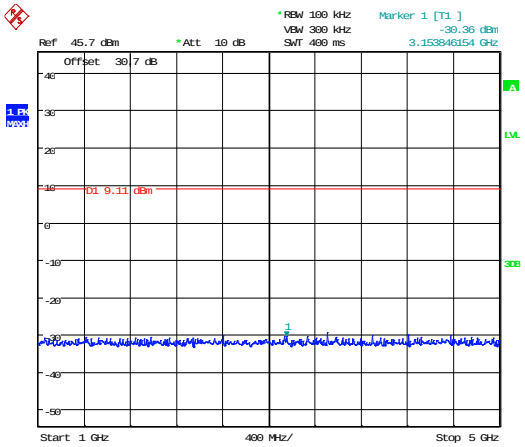
Date: 27.APR.2016 11:59:57

Tx Bottom 150kHz-30MHz



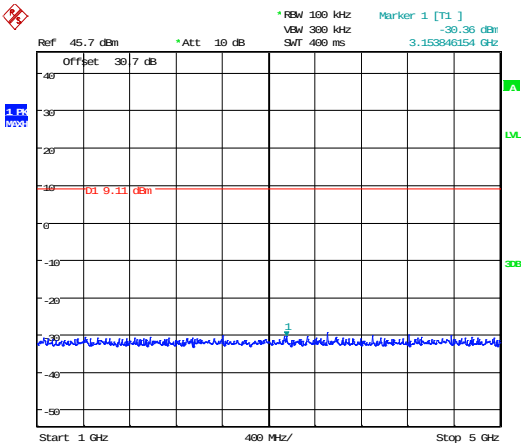
Date: 27.APR.2016 12:00:29

Tx bottom 30MHz – 1GHz



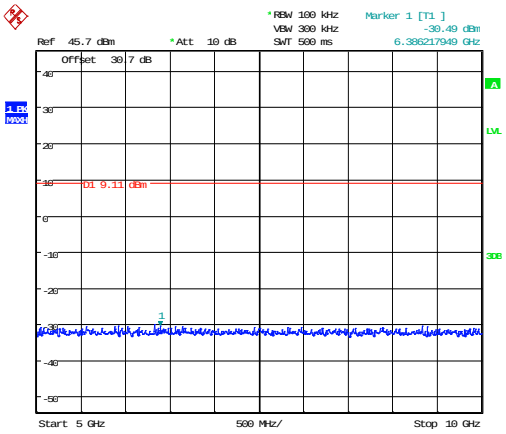
Date: 27.APR.2016 12:01:33

Tx bottom 1-5GHz



Date: 27.APR.2016 12:01:33

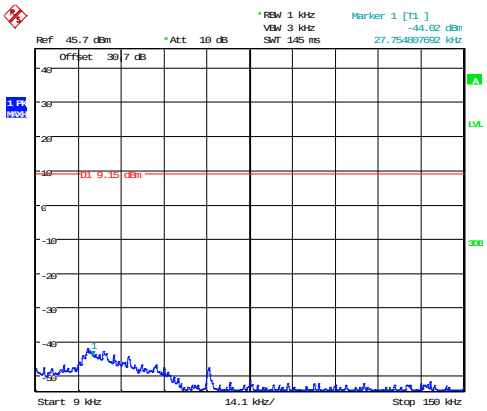
Tx bottom 5-10GHz



Date: 27.APR.2016 12:02:03

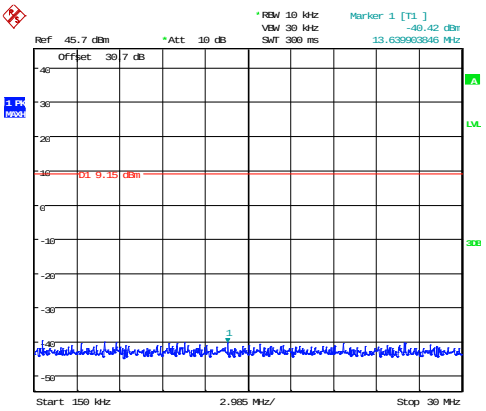
Channel Frequency (MHz)	***Emission Frequency (MHz)***	***Analyzer Level (dBm)***	***Emission Level (dBm)***	***Limit (dBm)***	***Margin (dB)***	***Result***
Mid	No Significant emissions					PASS

Tx Middle 9-150kHz Tx



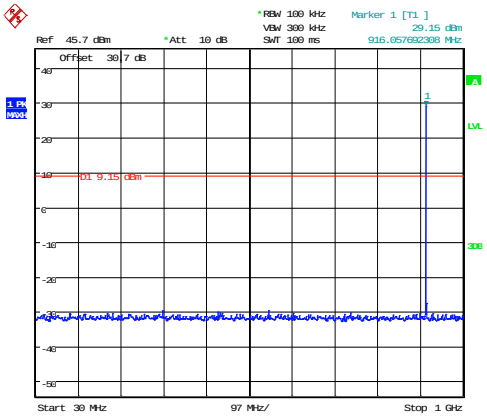
Date: 27.APR.2016 12:06:53

Middle 150kHz – 30MHz



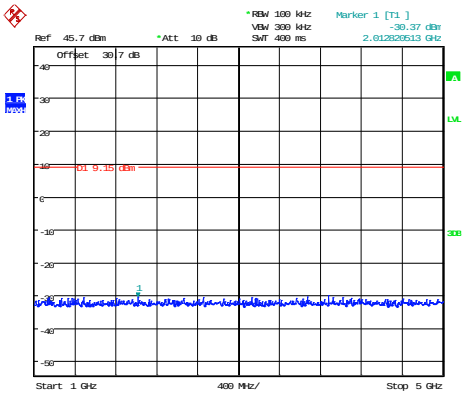
Date: 27.APR.2016 12:07:21

Tx Middle 30MHz – 1GHz



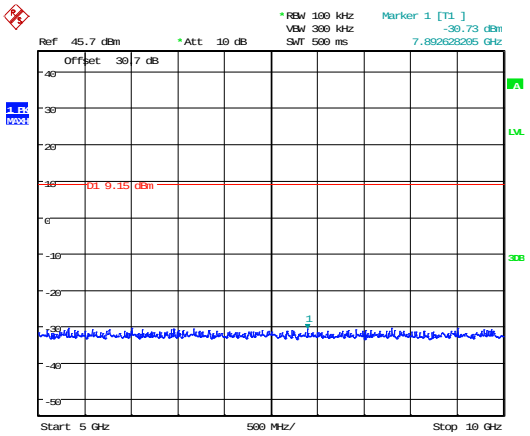
Date: 27.APR.2016 12:06:16

Tx Middle 1GHz – 5GHz



Date: 27.APR.2016 12:07:59

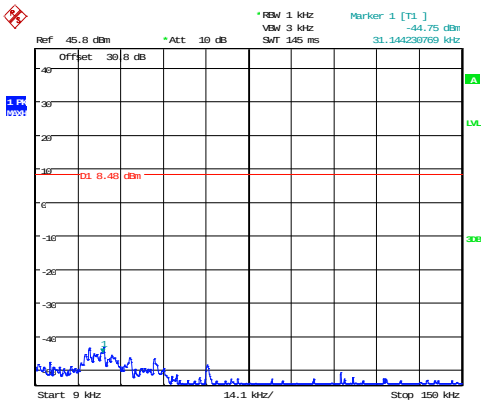
Tx Middle 5GHz – 10GHz



Date: 27.APR.2016 12:08:19

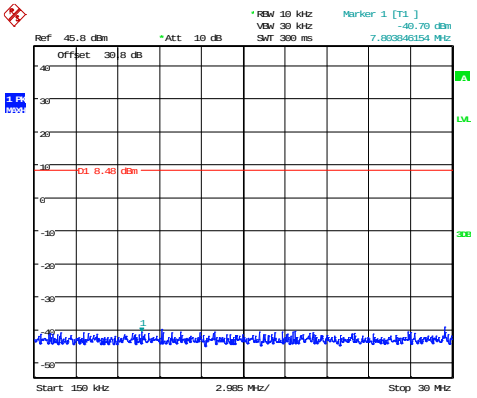
Channel Frequency (MHz)	***Emission Frequency (MHz)***	***Analyzer Level (dBm)***	***Emission Level (dBm)***	***Limit (dBm)***	***Margin (dB)***	***Result***
High	No Significant emissions					PASS

Tx Top 9-150kHz



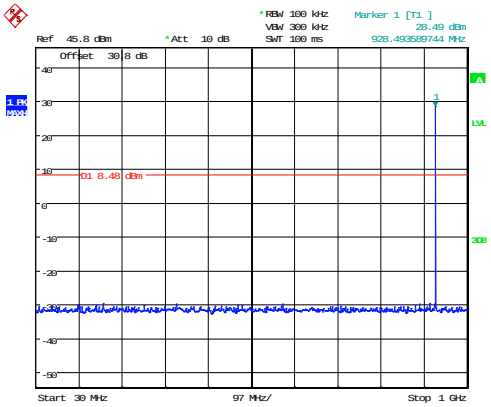
Date: 27.APR.2016 12:13:11

Tx Top 150kHz-30MHz



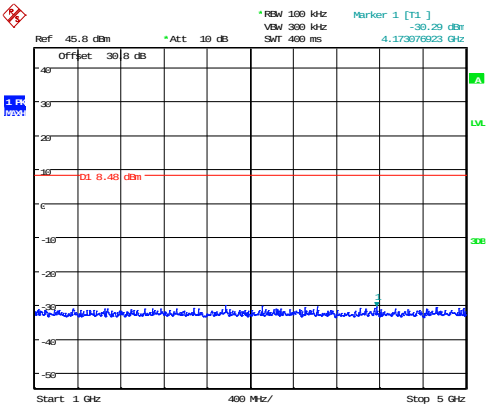
Date: 27.APR.2016 12:13:34

Tx Top 30MHz-1GHz



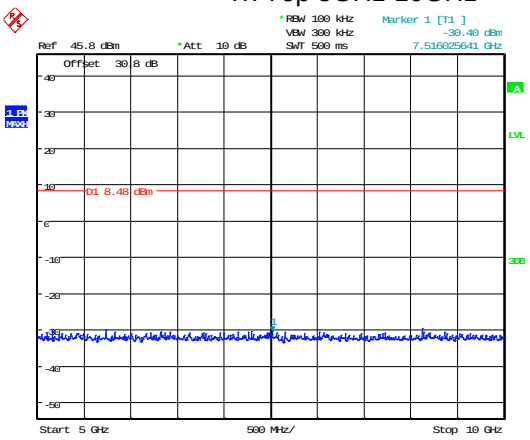
Date: 27.APR.2016 12:15:02

Tx Top 1GHz-5GHz



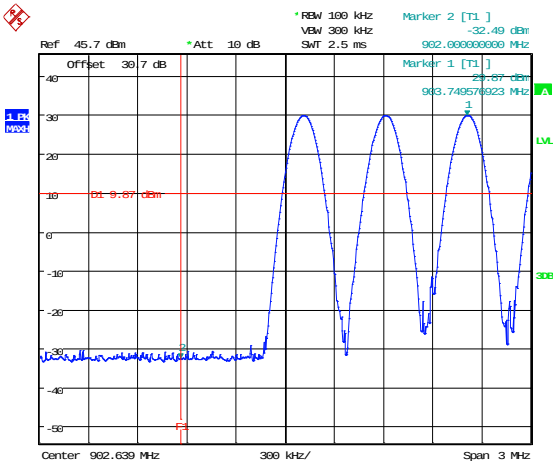
Date: 27.APR.2016 12:15:22

Tx Top 5GHz-10GHz



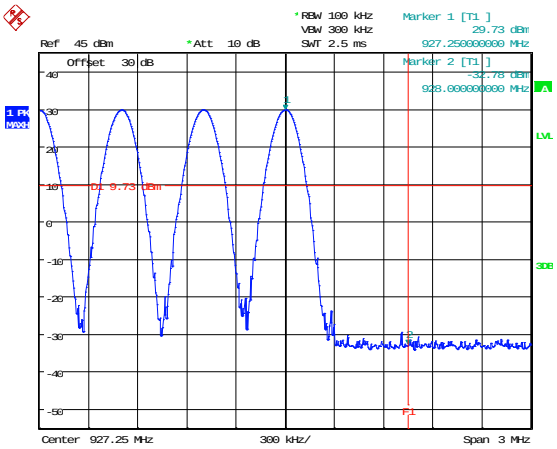
Date: 27.APR.2016 12:15:50

Tx bandedge Hopping



Date: 27.APR.2016 13:14:24

Tx bandedge Hopping



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18 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] Frequency separation

Uncertainty in test result (Spectrum Analyser) = **3.6 kHz**

[7] Accumulated channel occupancy time

Uncertainty in test result = **7.98 %**