

Report on the Radio Testing
For
IMC Group Limited
on
Notion Pro Echo Repeater
Report no. TRA-030757-45-00B
3rd January 2017

RF916 6.0



Report Number: TRA-030757-45-00B
Issue: B

REPORT ON THE RADIO TESTING OF A
IMC Group Limited
Notion Pro Echo Repeater
WITH RESPECT TO SPECIFICATION
FCC 47CFR 15.247

TEST DATE: 09/08/2016 to 12/08/2016

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Department Manager - Radio

Date: 3rd January 2017

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- [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

RF916 6.0

1 Revision Record

<i>Issue Number</i>	<i>Issue Date</i>	<i>Revision History</i>
A	3rd January 2017	Original

2 Summary

TEST REPORT NUMBER:	TRA-030757-45-00B
WORKS ORDER NUMBER	TRA-030757-01
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..
TEST SPECIFICATION(S):	47CFR15.247
EQUIPMENT UNDER TEST (EUT):	Notion Pro Echo Repeater
FCC IDENTIFIER:	N2OIN-RP002F2
EUT SERIAL NUMBER:	Unit 7
MANUFACTURER/AGENT:	IMC Group Limited
ADDRESS:	Suite 6 24 Swan Street Kingsclear Newbury United Kingdom
CLIENT CONTACT:	Neil Lundy ☎ 01635 291349 ✉ n.lundy@the-imcgroup.com
ORDER NUMBER:	PO160845
TEST DATE:	09/08/2016 to 12/08/2016
TESTED BY:	A Longley 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
Carrier frequency separation	15.247(a)(1)	<input checked="" type="checkbox"/>	Pass
Number of hopping channels	15.247(a)(1) (i), (ii) and (iii)	<input checked="" type="checkbox"/>	Pass
Average time of occupancy	15.247(a)(1) (i), (ii) and (iii)	<input checked="" type="checkbox"/>	Pass
Maximum peak conducted output power	15.247 (a)(1), (b)(1) and (b)(2)	<input checked="" type="checkbox"/>	Pass
20dB emission bandwidth	15.247(a)(1) (i) and (ii)	<input checked="" type="checkbox"/>	Pass
Out-of-band emissions	15.247(d)	<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-030757-45-00B presents the results of the Radio testing on an IMC Group Limited, Notion Pro Echo Repeater 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 IMC Group Limited 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.

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: Notion Pro Echo Repeater
- Serial Number: Unit 7
- Model Number: IN-RP002F
- Software Revision: Not Applicable
- 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.

Not Applicable – No support/monitoring equipment required.

7.3 EUT Mode of Operation

7.3.1 Transmission

The mode of operation for transmitter tests was as follows...

The EUT was set to continuously transmit on the Bottom, Middle or Top channels or to operate continuously in hopping mode as required for the individual tests. The EUT was controlled using the NotionRadioApproval.exe program supplied by the client. A copy of this program is retained in the job folder on the Element network.

7.3.2 Reception

The mode of operation for receiver tests was as follows...

The EUT was set to a permanent receive mode using the NotionRadioApproval.exe program supplied by the client. A copy of this program is retained in the job folder on the Element network.

7.4 EUT Radio Parameters

7.4.1 General

Frequency of operation:	902.1 MHz to 927.3 MHz
Modulation type(s):	FM
Occupied channel bandwidth(s):	20 kHz (20 dB) / 38 kHz (99%)
Channel spacing:	200 kHz
ITU emission designator(s):	38K0F1D
Declared output power(s):	28 dBm (max)
Warning against use of alternative antennas in user manual (yes/no):	Yes
Nominal Supply Voltage:	12 Vdc
Frequency stability:	±1 kHz
Location of notice for license exempt use:	Label / user manual / both.
Duty cycle:	19 ms in 100 ms period (19%)

7.4.2 Antennas

Type:	ANT-RP915SMA-Y
Frequency range:	902-928 MHz
Impedance:	50 Ω
SWR:	≤1.2
Gain:	2 dB
Polarisation:	Vertical (linear)
Beam width:	N/A
Connector type:	Reverse SMA
Length:	75 mm
Weight:	5 g
Environmental limits:	-40 to 60°C

7.4.3 Product specific declarations

Multiple antenna configuration(s), e.g. MIMO:	No (separate antennas used for Tx and Rx)
Fixed pt-pt operations (yes/no):	No
Installation manual advice on pt-pt operational restrictions (yes/no):	N/A
Fixed pt-mpt operations (yes/no):	Yes
Simultaneous tx (yes/no):	No

7.5 EUT Description

The EUT is an add-on for the Notion Pro system to provide extended radio range. It is intended to forward data between Notion Pro transmitter units and Network Receiver units.

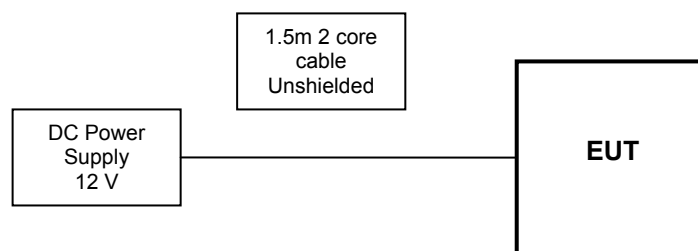
8 Modifications

No modifications were performed during this assessment.

9 EUT Test Setup

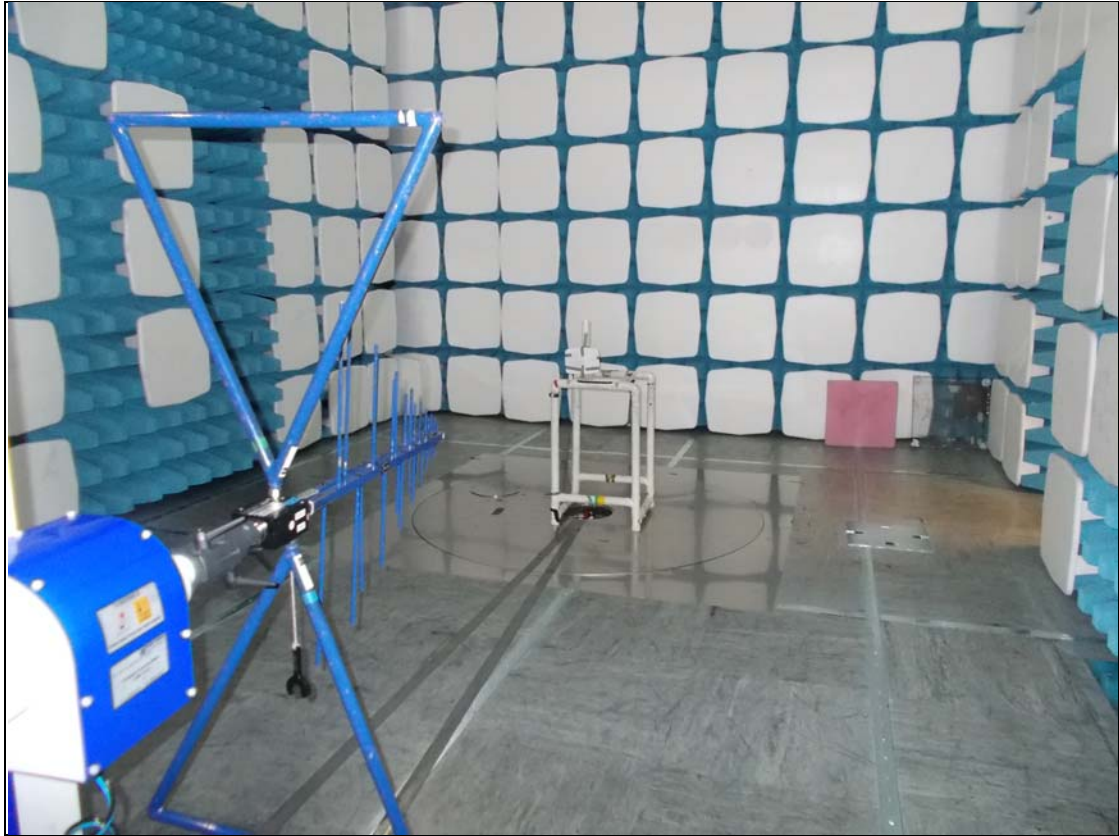
9.1 Block Diagram

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. 12 V dc from Bench Supply.

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
<input type="checkbox"/>	Mains	110 V ac +/-2 %	85 % and 115 %
<input checked="" type="checkbox"/>	DC power	12 V dc +/-2 %	85 % and 115 %
<input type="checkbox"/>	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:	Lab 16
Test Standard and Clause:	ANSI C63.10-2013, Clause 6.5 and 6.6
EUT Channels / Frequencies Measured:	Low / Mid / High
EUT Channel Bandwidths:	200 kHz
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: 41 % RH	20 % RH to 75 % RH (as declared)
Supply: 12 V dc	

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:

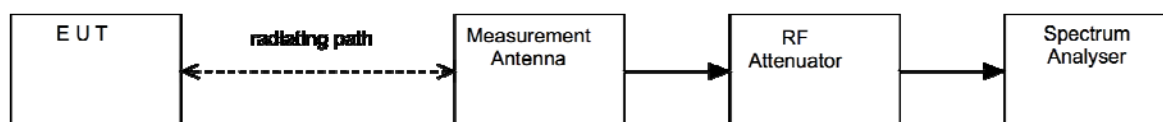
$$FS = PR + CL + AF - PA + DC - CF$$

Where,

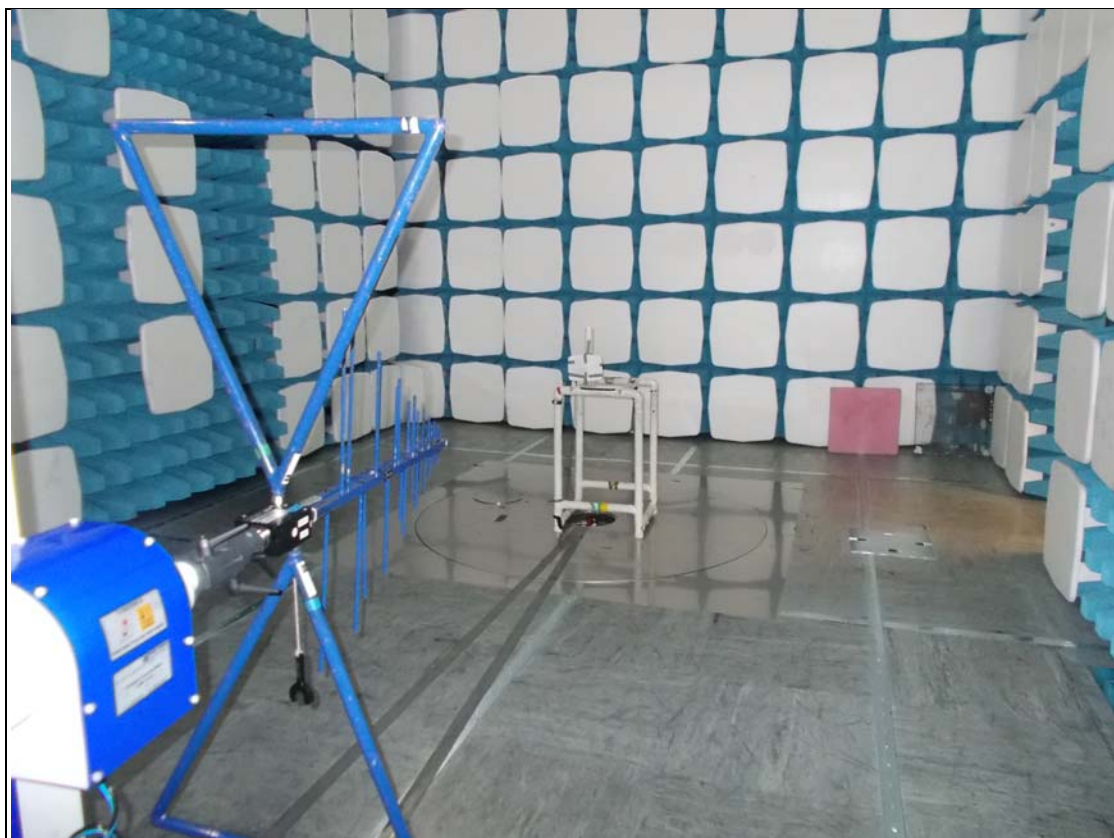
PR is the power recorded on the receiver / spectrum analyzer in dBμV;
 CL is the cable loss in dB;
 AF is the test antenna factor in dB/m;
 PA is the pre-amplifier gain in dB (where used);
 DC is the duty correction factor in dB (where used, e.g. harmonics of pulsed fundamental);
 CF is the distance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



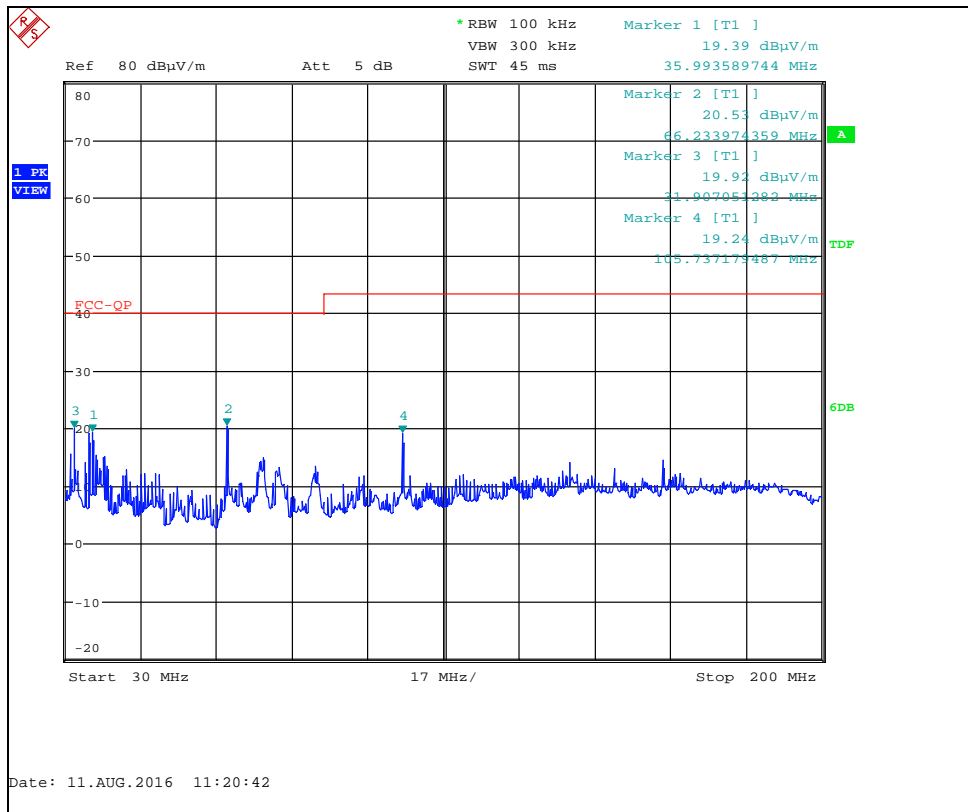
11.5 Test Set-up Photograph



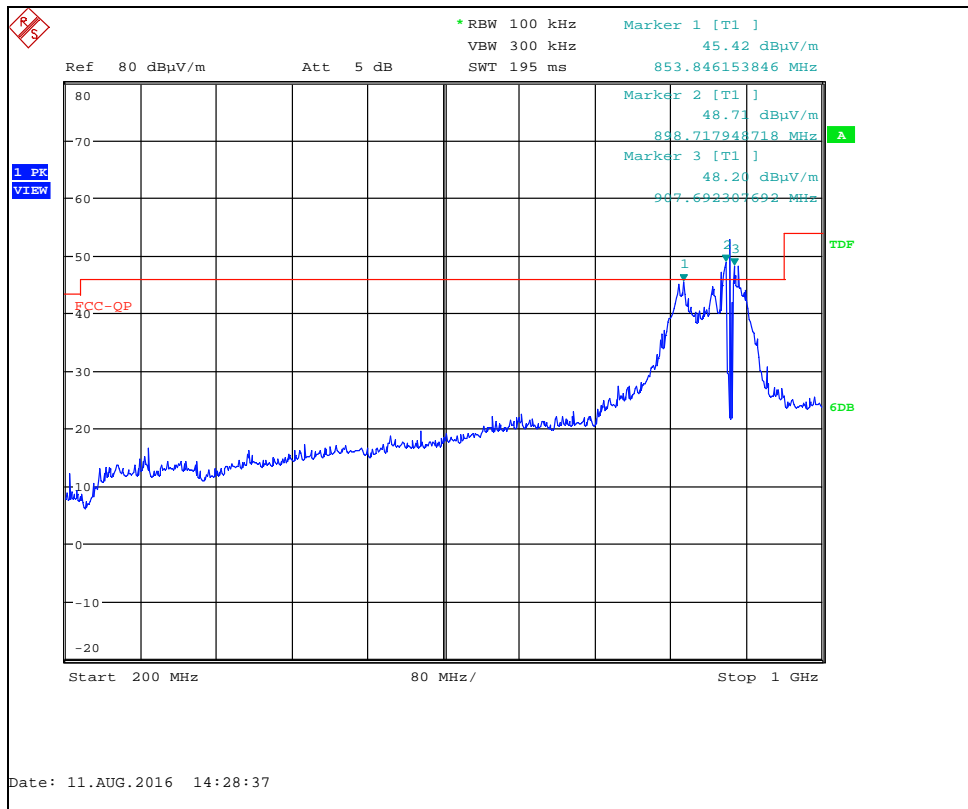
11.6 Test Equipment

Equipment Type	Manufacturer	Equipment Description	Element No	Due For Calibration
3109	EMCO	Biconical Antenna	RFG095	17/05/2019
3146	EMCO	Log Periodic Antenna	RFG191	17/05/2019
3115	EMCO	Horn Antenna	RFG129	09/02/2018
FSU46	R&S	Spectrum Analyser	REF910	05/07/2017
310	Sonoma	Pre-Amp (9kHz – 1GHz)	REF927	30/06/2018
8449B	Agilent	Pre-Amp (1 – 26.5GHz)	REF913	02/02/2018

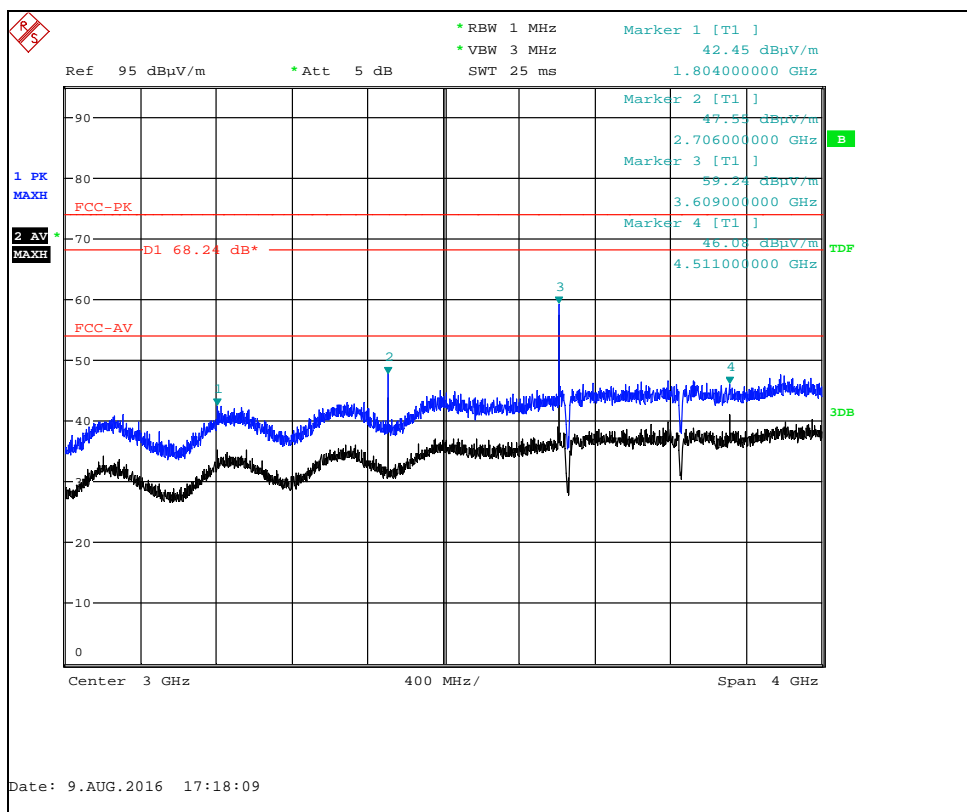
11.7 Test Results



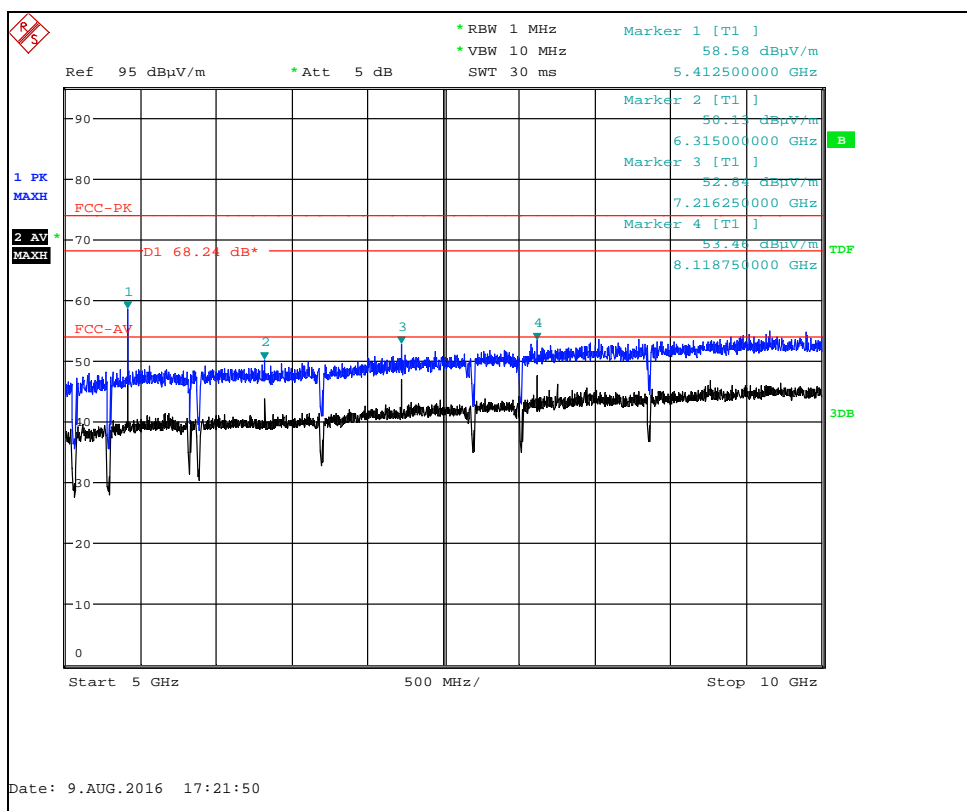
Bottom Channel : 30 MHz to 200 MHz



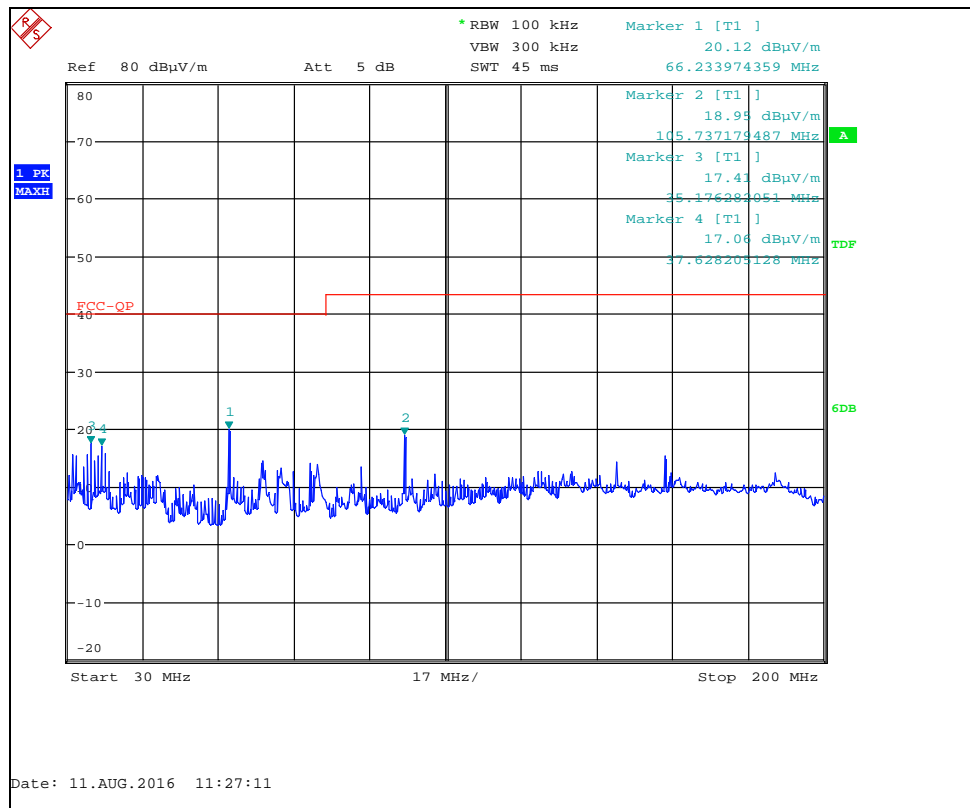
Bottom Channel : 200 MHz to 1 GHz



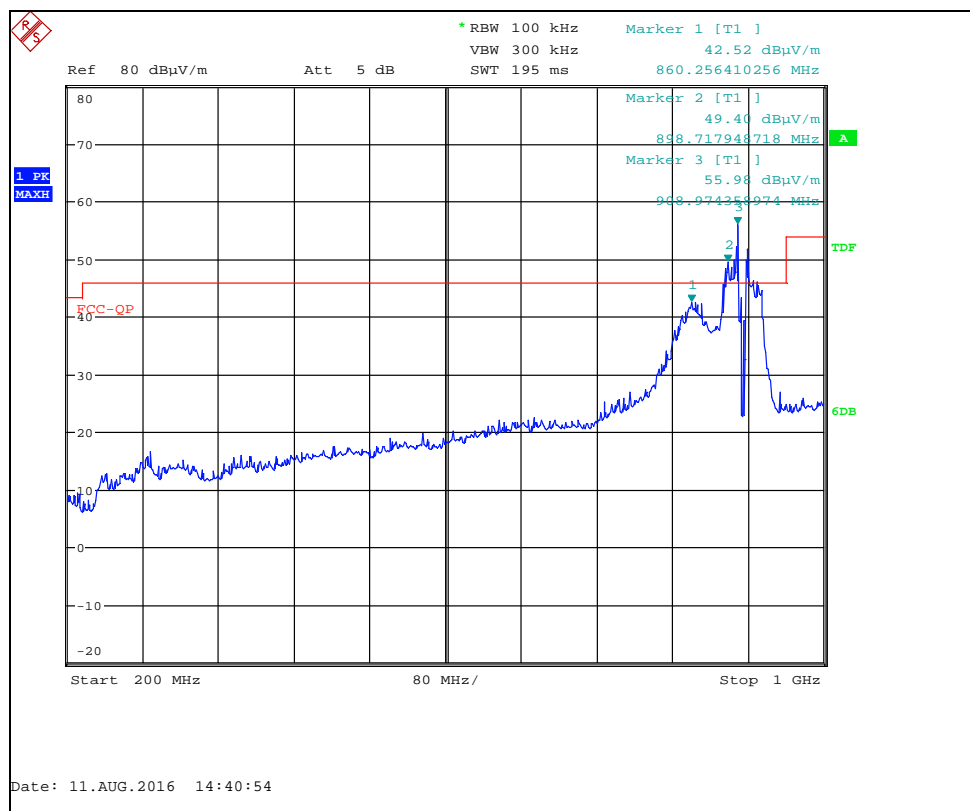
Bottom Channel : 1 GHz to 5 GHz



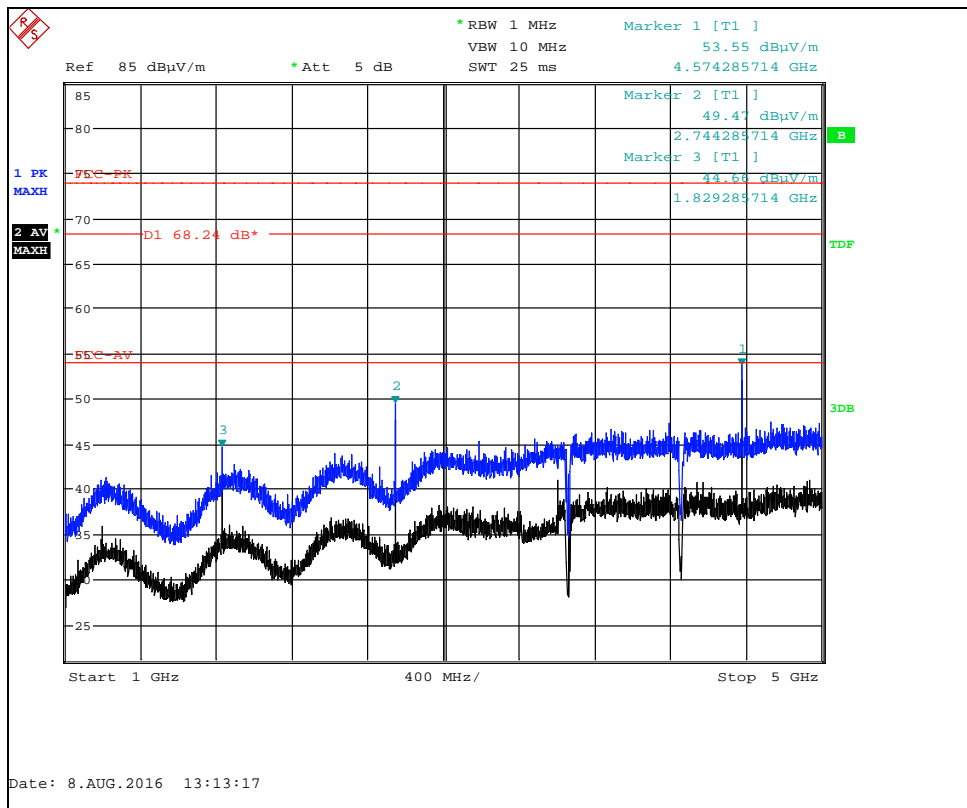
Bottom Channel : 5 GHz to 10 GHz



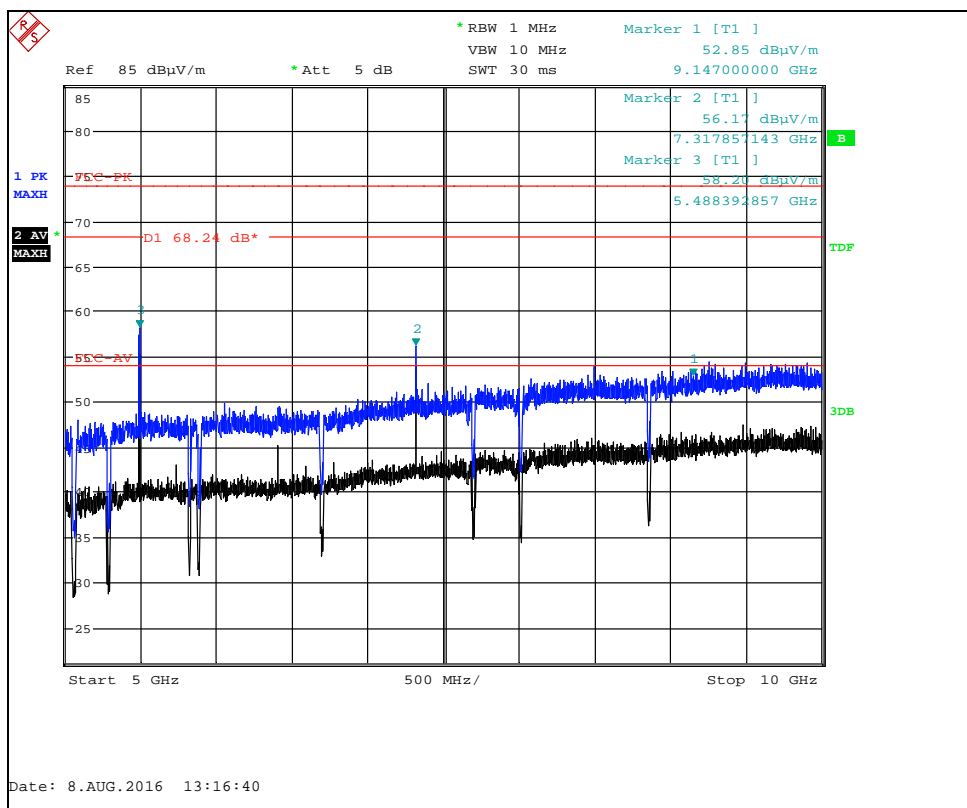
Middle Channel : 30 MHz to 200 MHz



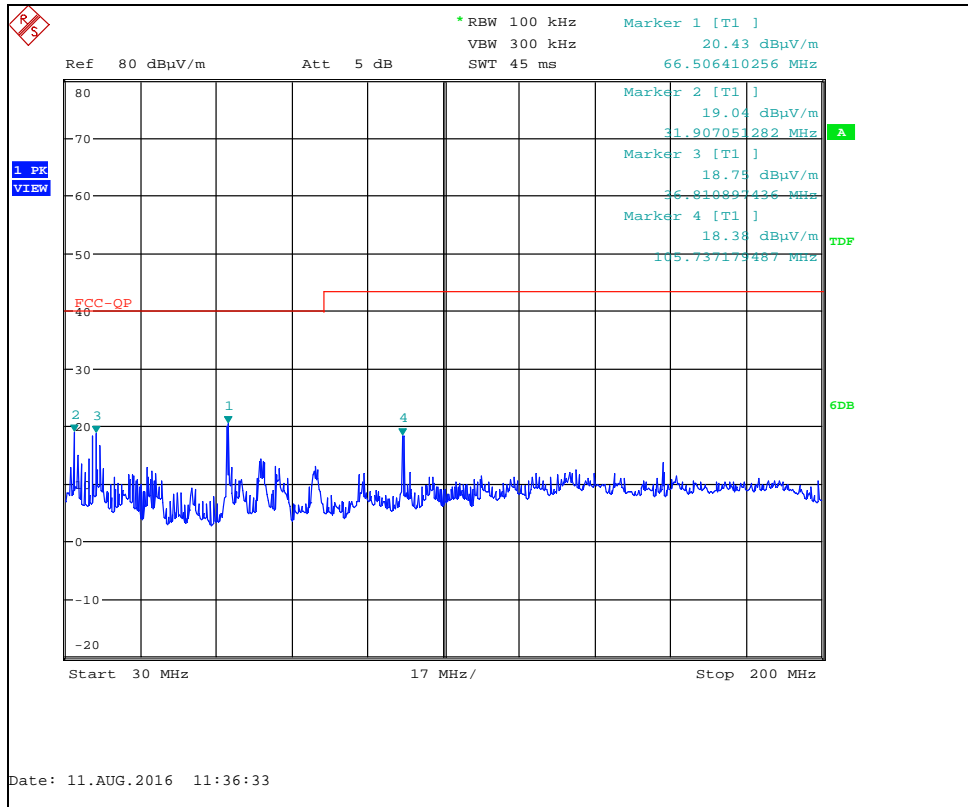
Middle Channel : 200 MHz to 1 GHz



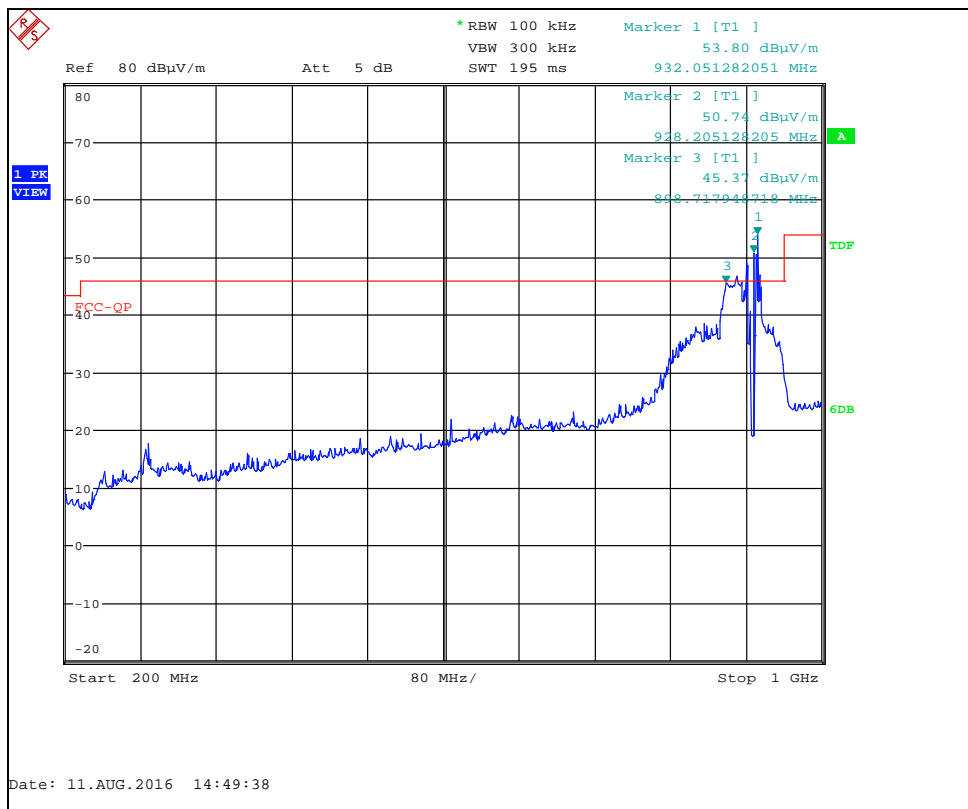
Middle Channel : 1 GHz to 5 GHz



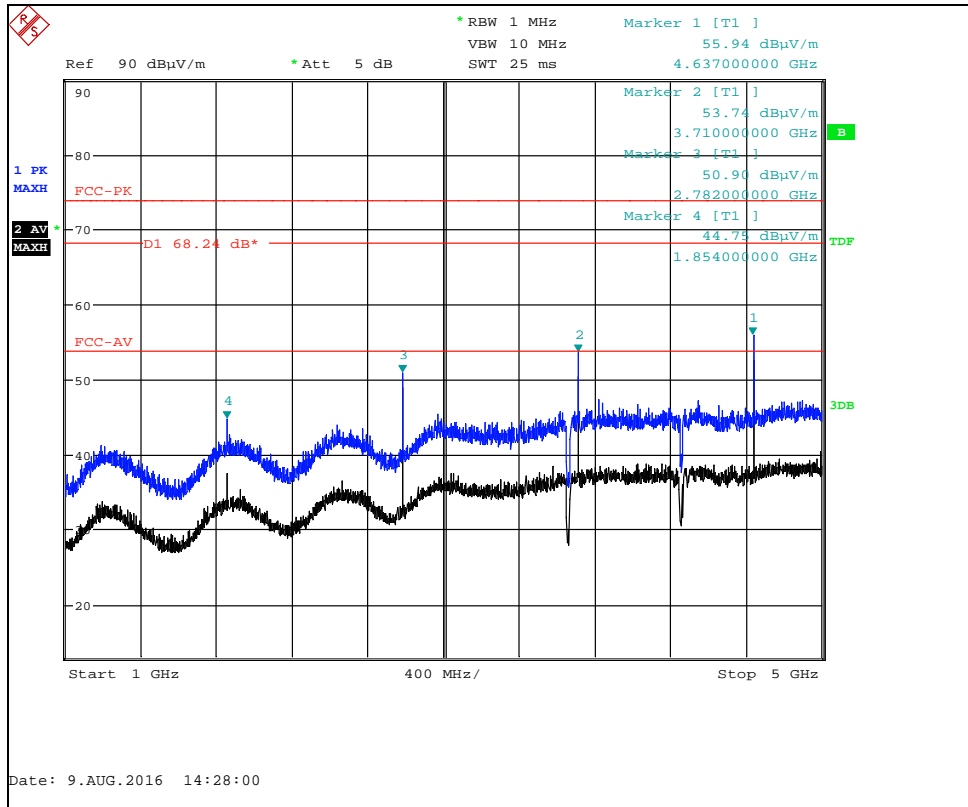
Middle Channel : 5 GHz to 10 GHz



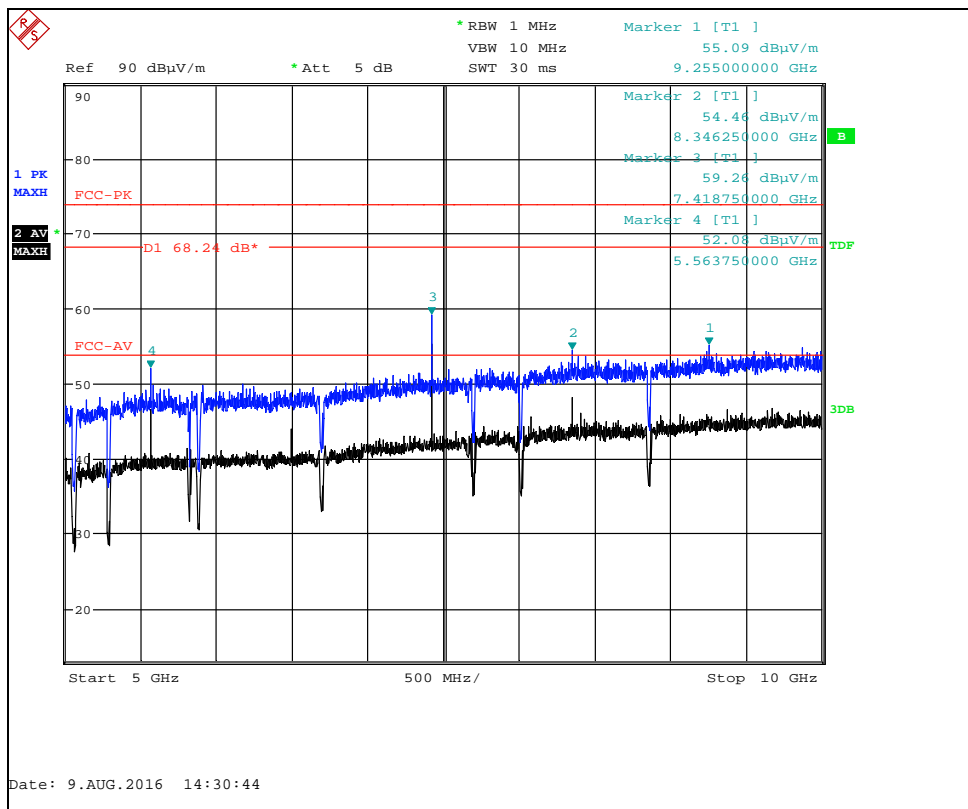
Top Channel : 30 MHz to 200 MHz



Top Channel : 200 MHz to 1 GHz



Top Channel : 1 GHz to 5 GHz



Top Channel : 5 GHz to 10 GHz

<i>High Power; Channel: 902.1 MHz</i>										
<i>Detector</i>	<i>Freq. (MHz)</i>	<i>Meas'd Emission (dBμV)</i>	<i>Cable Loss (dB)</i>	<i>Antenna Factor (dB/m)</i>	<i>Pre-amp Gain (dB)</i>	<i>Duty Cycle Corr'n (dB)</i>	<i>Distance Extrap'n Factor (dB)</i>	<i>Field Strength (dBμV/m)</i>	<i>Field Strength (μV/m)</i>	<i>Limit (μV/m)</i>
Pk	2706.298	62.63	4.2	29.1	34.63	-14.4	0	46.90	221.31	5000
Av	2706.298	61.46	4.2	29.1	34.63	-14.4	0	45.73	193.42	500
Pk	3608.399	65.79	4.9	31.6	34.57	-14.4	0	53.32	463.45	5000
Av	3608.399	64.62	4.9	31.6	34.57	-14.4	0	52.15	405.04	500
Pk	4510.500	49.13	5.4	32.5	34.65	-14.4	0	37.98	79.25	5000
Av	4510.500	40.37	5.4	32.5	34.65	-14.4	0	29.22	28.91	500
Pk	5412.599	51.44	5.9	34.4	34.47	-14.4	0	42.87	139.16	5000
Av	5412.599	46.40	5.9	34.4	34.47	-14.4	0	37.83	77.89	500
Pk	8118.898	48.59	7.3	36.9	35.01	-14.4	0	43.38	147.57	5000
Av	8118.898	39.62	7.3	36.9	35.01	-14.4	0	34.41	52.54	500

<i>High Power; Channel: 914.7 MHz</i>										
<i>Detector</i>	<i>Freq. (MHz)</i>	<i>Meas'd Emission (dBμV)</i>	<i>Cable Loss (dB)</i>	<i>Antenna Factor (dB/m)</i>	<i>Pre-amp Gain (dB)</i>	<i>Duty Cycle Corr'n (dB)</i>	<i>Distance Extrap'n Factor (dB)</i>	<i>Field Strength (dBμV/m)</i>	<i>Field Strength (μV/m)</i>	<i>Limit (μV/m)</i>
Pk	2744.095	60.99	4.2	29.1	34.64	-14.4	0	45.25	183.02	5000
Av	2744.095	59.11	4.2	29.1	34.64	-14.4	0	43.37	147.40	500
Pk	4573.494	57.53	5.4	32.6	34.64	-14.4	0	46.49	211.11	5000
Av	4573.494	54.01	5.4	32.6	34.64	-14.4	0	42.97	140.77	500
Pk	7317.581	54.77	6.8	37.0	34.81	-14.4	0	49.36	293.76	5000
Av	7317.581	49.94	6.8	37.0	34.81	-14.4	0	44.53	168.46	500

<i>High Power; Channel: 927.3 MHz</i>										
<i>Detector</i>	<i>Freq. (MHz)</i>	<i>Meas'd Emission (dBμV)</i>	<i>Cable Loss (dB)</i>	<i>Antenna Factor (dB/m)</i>	<i>Pre-amp Gain (dB)</i>	<i>Duty Cycle Corr'n (dB)</i>	<i>Distance Extrap'n Factor (dB)</i>	<i>Field Strength (dBμV/m)</i>	<i>Field Strength (μV/m)</i>	<i>Limit (μV/m)</i>
Pk	2781.900	49.18	4.2	29.1	34.65	-14.4	0	33.43	46.94	5000
Av	2781.900	44.46	4.2	29.1	34.65	-14.4	0	28.71	27.26	500
Pk	3709.175	56.05	5.0	32.1	34.56	-14.4	0	44.19	161.99	5000
Av	3709.175	51.92	5.0	32.1	34.56	-14.4	0	40.06	100.69	500
Pk	4636.500	56.87	5.6	32.6	34.63	-14.4	0	46.04	200.45	5000
Av	4636.500	53.13	5.6	32.6	34.63	-14.4	0	42.30	130.32	500
Pk	7418.380	56.50	7.0	37.1	34.84	-14.4	0	51.36	369.83	5000
Av	7418.380	52.39	7.0	37.1	34.84	-14.4	0	47.25	230.41	500
Pk	8345.700	51.52	7.4	37.4	35.02	-14.4	0	46.90	221.31	5000
Av	8345.700	41.50	7.4	37.4	35.02	-14.4	0	36.88	69.82	500

12 Radiated emissions – unintentional radiation / receiver emissions

12.1 Definitions

Receiver spurious emissions

The radio frequency signals generated within the receiver, which may cause interference to other equipment. This includes the period during which the equipment is scanning or switching channels.

Unintentional radiator

A device that generates RF energy which is not intended to be radiated for reception by a radio receiver.

12.2 Test Parameters

Test Location:	Element Hull
Test Chamber:	Lab 16
Test Standard and Clause:	ANSI C63.4-2014, Clause 8
EUT Channels / Frequencies Measured:	Low / Mid / High
EUT Channel Bandwidths:	200 kHz
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: Peak

Environmental Conditions (Normal Environment)

Temperature: 21 °C	+15 °C to +35 °C (as declared)
Humidity: 40 % RH	20 % RH to 75 % RH (as declared)
Supply: 12 V dc	

12.3 Test Limit

Note:

Only radio communication receivers operating in stand-alone mode within the band 30 to 960 MHz, as well as scanner receivers, are subject to requirements, as described above. All other receivers are exempted from any certification, testing, labelling and reporting requirements.

However, all receivers in all frequency bands shall comply with the limits set forth in FCC 47CFR15B even in cases where testing, reporting and/or certification are not required.

Receiver Radiated Limits

<i>Frequency (MHz)</i>	<i>Field Strength ($\mu\text{V/m}$ at 3 m)</i>
30 to 88	100
88 to 216	150
216 to 960	200
Above 960	500

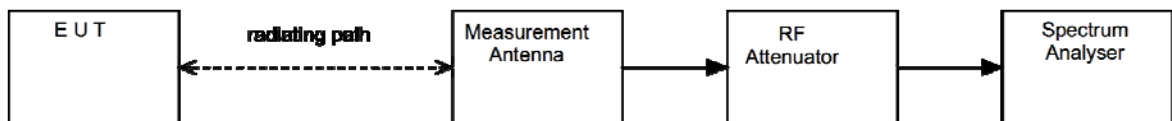
12.4 Test Method

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 analyzer / EMI receiver. The EUT was rotated in three orthogonal planes and the measurement antenna height scanned (below 1 GHz, from 1 to 4 m; above 1 GHz as necessary) in order to maximise emissions.

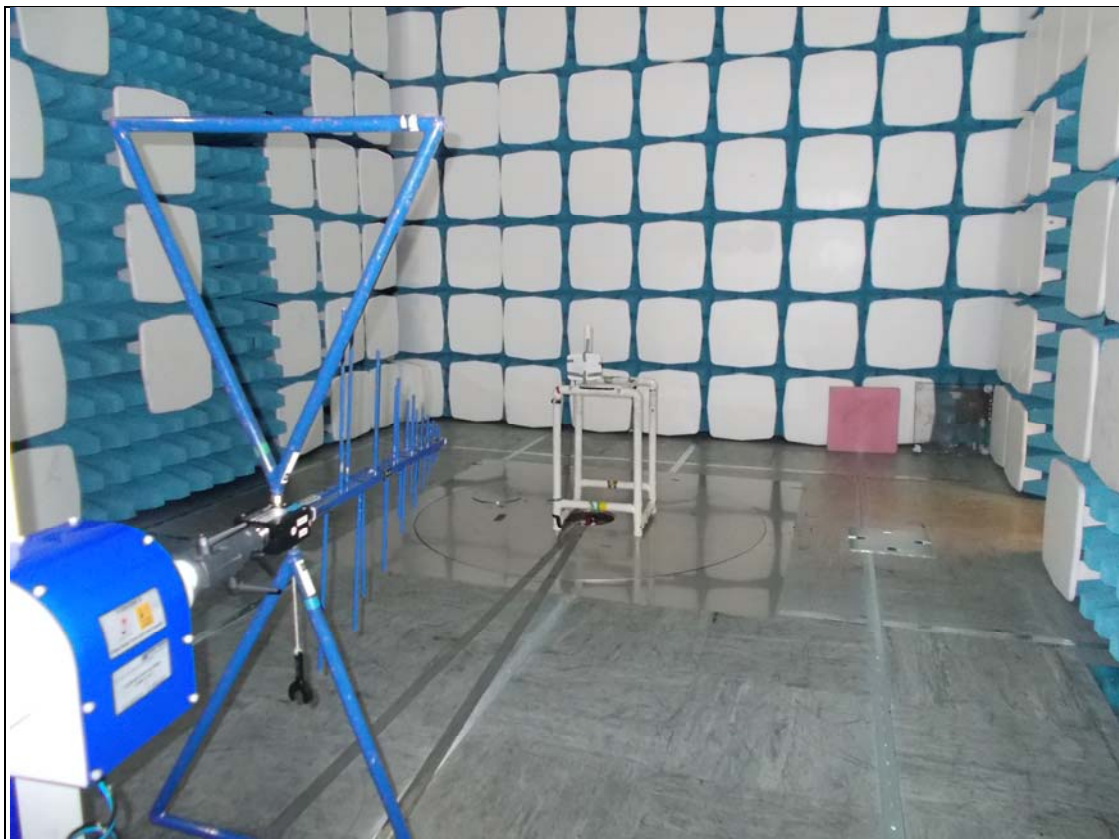
The measurements were performed with EUT set at its maximum duty. All modulation schemes, data rates and power settings were used to observe the worst-case configuration at each frequency.

Pre-scan plots are shown with a peak detector and 100 kHz RBW.

Figure viii Test Setup



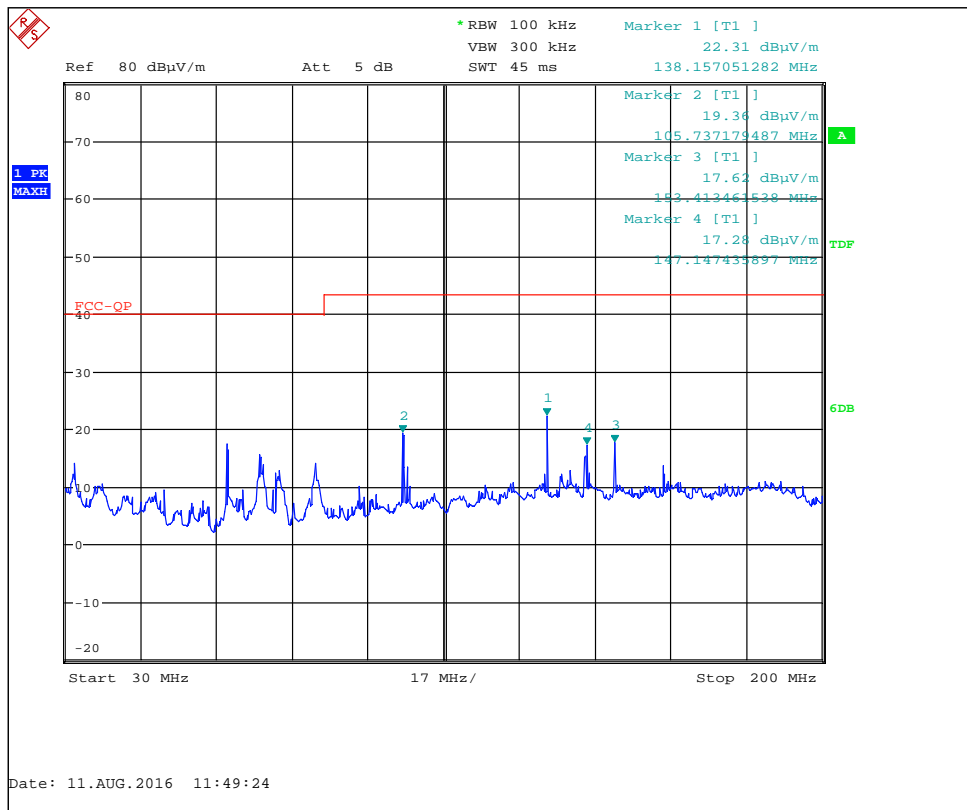
12.5 Test Set-up Photograph



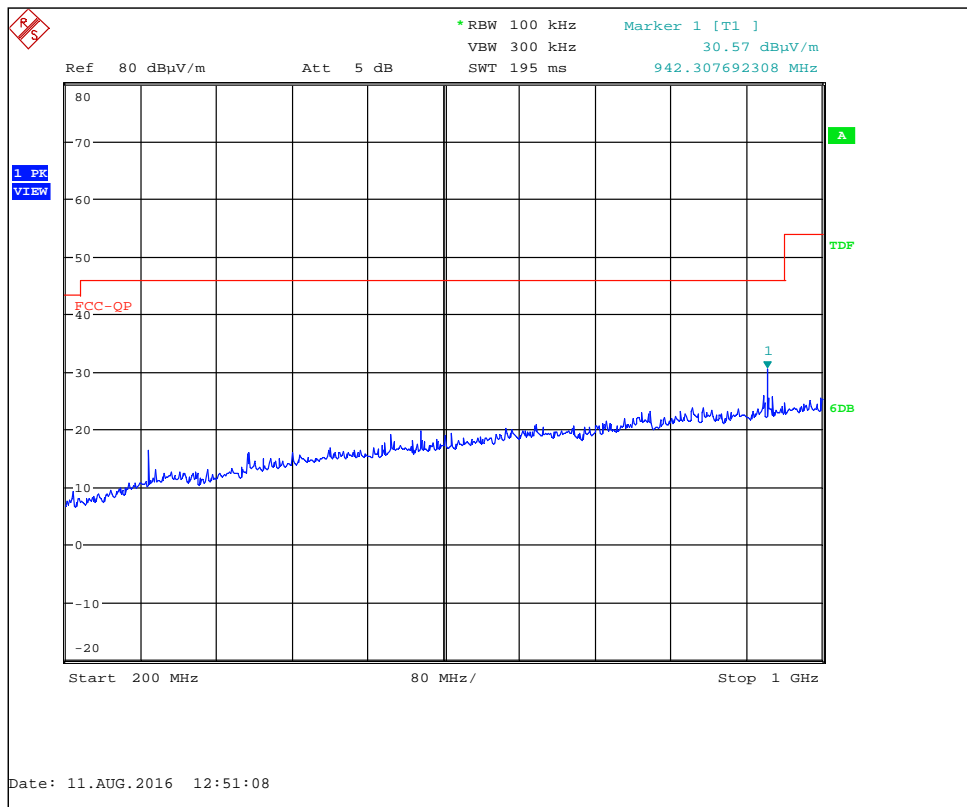
12.6 Test Equipment

Equipment Type	Manufacturer	Equipment Description	Element No	Due For Calibration
3109	EMCO	Biconical Antenna	RFG095	17/05/2019
3146	EMCO	Log Periodic Antenna	RFG191	17/05/2019
3115	EMCO	Horn Antenna	RFG129	09/02/2018
FSU46	R&S	Spectrum Analyser	REF910	05/07/2017
310	Sonoma	Pre-Amp (9kHz – 1GHz)	REF927	30/06/2018
8449B	Agilent	Pre-Amp (1 – 26.5GHz)	REF913	02/02/2018

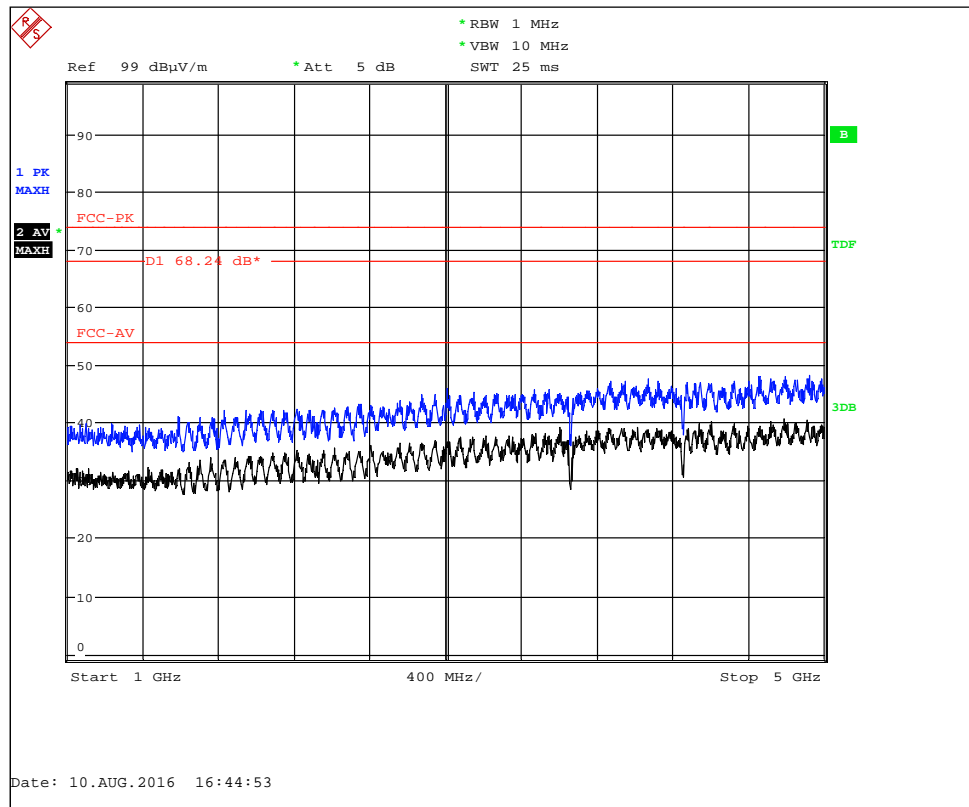
12.7 Test Results



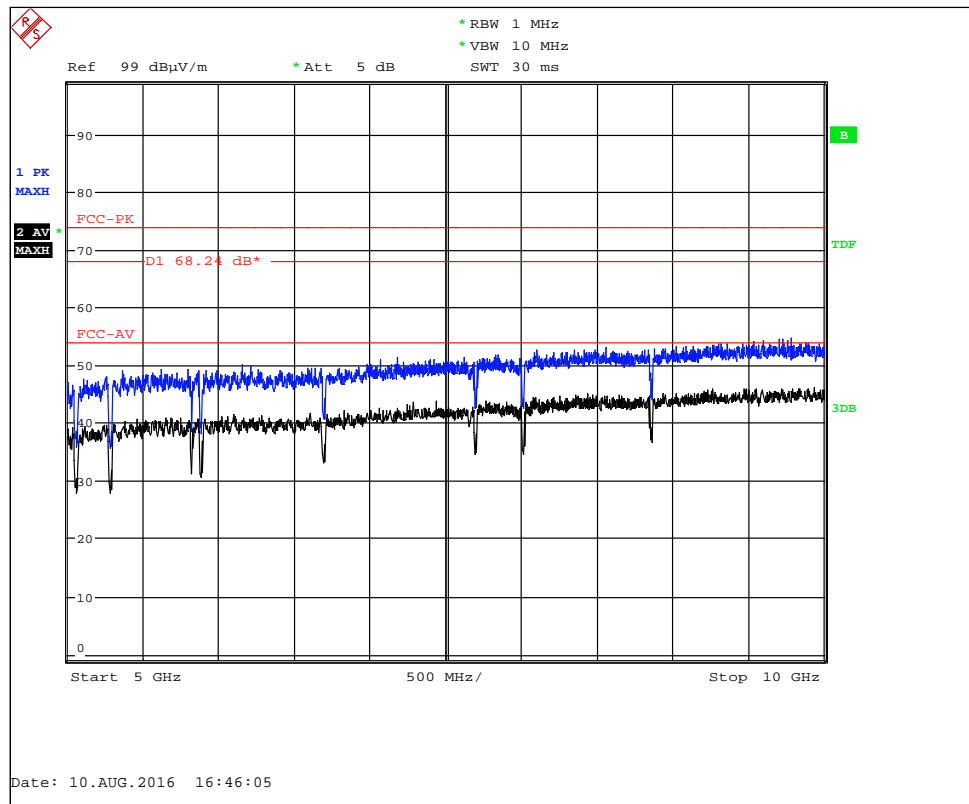
30 MHz to 200 MHz



200 MHz to 1 GHz



1 GHz to 5 GHz



5 GHz to 10 GHz

High Power; Receive mode									
Detector	Freq. (MHz)	Measured Emission (dBµV/m)	Cable Loss (dB)	Antenna Factor (dB/m)	Pre-amp Gain (dB)	Field Strength (dBµV/m)	Extrap'n Factor (dB)	Field Strength (µV/m)	Limit (µV/m)
No significant emissions were detected within 10 dB of the limit line									

13 AC power-line conducted emissions

13.1 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.

13.2 Test Parameters

Test Location:	Element Hull
Test Chamber:	Lab 5
Test Standard and Clause:	ANSI C63.10-2013, Clause 6.2
EUT Channels / Frequencies Measured:	Mid
EUT Channel Bandwidths:	20 kHz
EUT Modulation:	Modulation on, continuous operation
Deviations From Standard:	None
Measurement BW:	10 kHz
Measurement Detectors:	Quasi-Peak and Average, RMS

Environmental Conditions (Normal Environment)

Temperature: 20 °C	+15 °C to +35 °C (as declared)
Humidity: 47 % RH	20 % RH to 75 % RH (as declared)
Supply: 12 V dc	

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

<i>Frequency (MHz)</i>	<i>Conducted limit (dBμV)</i>	
	<i>Quasi-Peak</i>	<i>Average**</i>
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.

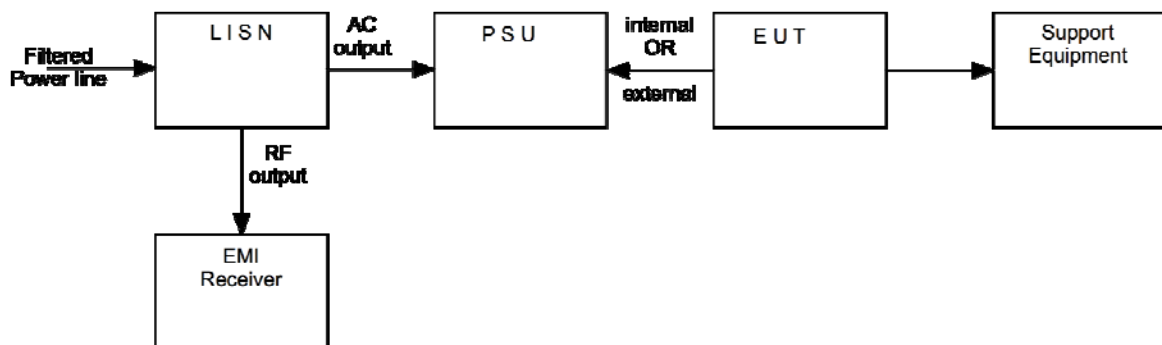
13.3 Test Method

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



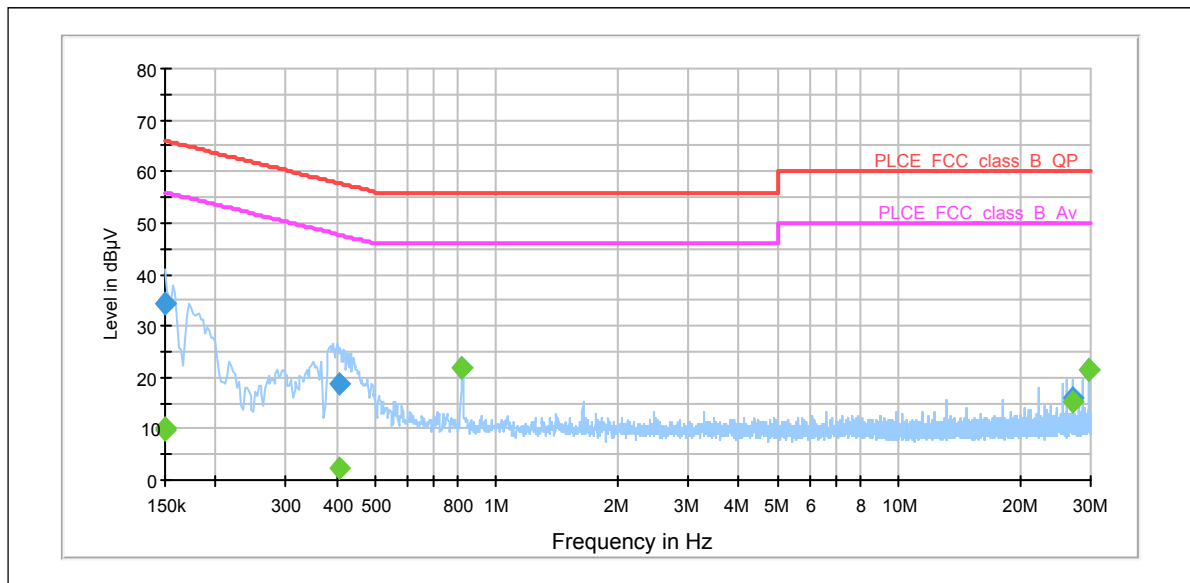
13.4 Test Set-up Photograph



13.5 Test Equipment

Equipment Type	Manufacturer	Equipment Description	Element No	Due For Calibration
ESH3-Z5	R&S	LISN	RFG189	02/08/2017
ESH3-Z2	R&S	Pulse Limiter	RFG680	14/06/2017
ESCI7	R&S	Measuring Receiver	RFG715	06/10/2017
8559	iR group	Frequency Converter	RFG109	Not calibrated

13.6 Test Results



Frequency (MHz)	QuasiPeak (dBµV)	Meas. Time (ms)	Bandwidth (kHz)	PE	Line	Corr. (dB)	Margin (dB)	Limit (dBµV)
0.150000	34.2	15000.0	0.200	GND	N	10.2	31.8	66.0
0.150000	34.2	15000.0	0.200	GND	N	10.2	31.8	66.0
0.408425	18.9	15000.0	9.000	GND	L1	10.4	38.8	57.7
0.820800	21.7	15000.0	9.000	GND	N	10.4	34.3	56.0
27.092500	16.1	15000.0	9.000	GND	L1	12.0	43.9	60.0
29.553500	21.6	15000.0	9.000	GND	L1	12.0	38.4	60.0

Frequency (MHz)	Average (dBµV)	Meas. Time (ms)	Bandwidth (kHz)	PE	Line	Corr. (dB)	Margin (dB)	Limit (dBµV)
0.150000	9.7	15000.0	9.000	GND	N	10.2	46.3	56.0
0.150000	10.0	15000.0	9.000	GND	N	10.2	46.0	56.0
0.408425	2.2	15000.0	9.000	GND	L1	10.4	45.5	47.7
0.820800	21.7	15000.0	9.000	GND	N	10.4	24.3	46.0
27.092500	15.0	15000.0	9.000	GND	L1	12.0	35.0	50.0
29.553500	21.3	15000.0	9.000	GND	L1	12.0	28.7	50.0

14 Carrier frequency separation

14.1 Definition

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

14.2 Test Parameters

Test Location:	Element Hull
Test Chamber:	Lab 4
Test Standard and Clause:	ANSI C63.10-2013, Clause 7.8.2
EUT Channels / Frequencies Measured:	All; 902 to 928 MHz
EUT 20dB Bandwidth:	21.2 kHz
EUT Test Modulations:	Internal pattern generation – hopping enabled
Deviations From Standard:	None
Measurement BW:	30 kHz
Measurement Detector:	Peak

Environmental Conditions (Normal Environment)

Temperature: 21 °C	+15 °C to +35 °C (as declared)
Humidity: 40 % RH	20 % RH to 75 % RH (as declared)
Supply: 12 V ac/dc	

14.3 Test Limit

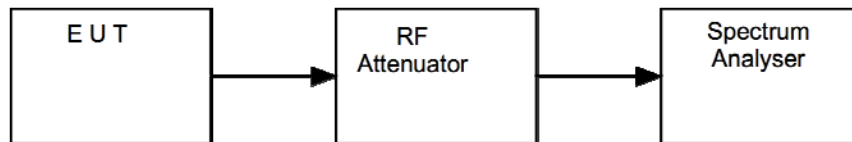
Frequency hopping systems shall have hopping channel carrier frequencies separated by a minimum of 25 kHz or the -20 dB bandwidth of the hopping channel, whichever is greater. Alternatively, frequency hopping systems operating in the band 2400 to 2483.5 MHz may have hopping channel carrier frequencies 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.

14.4 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

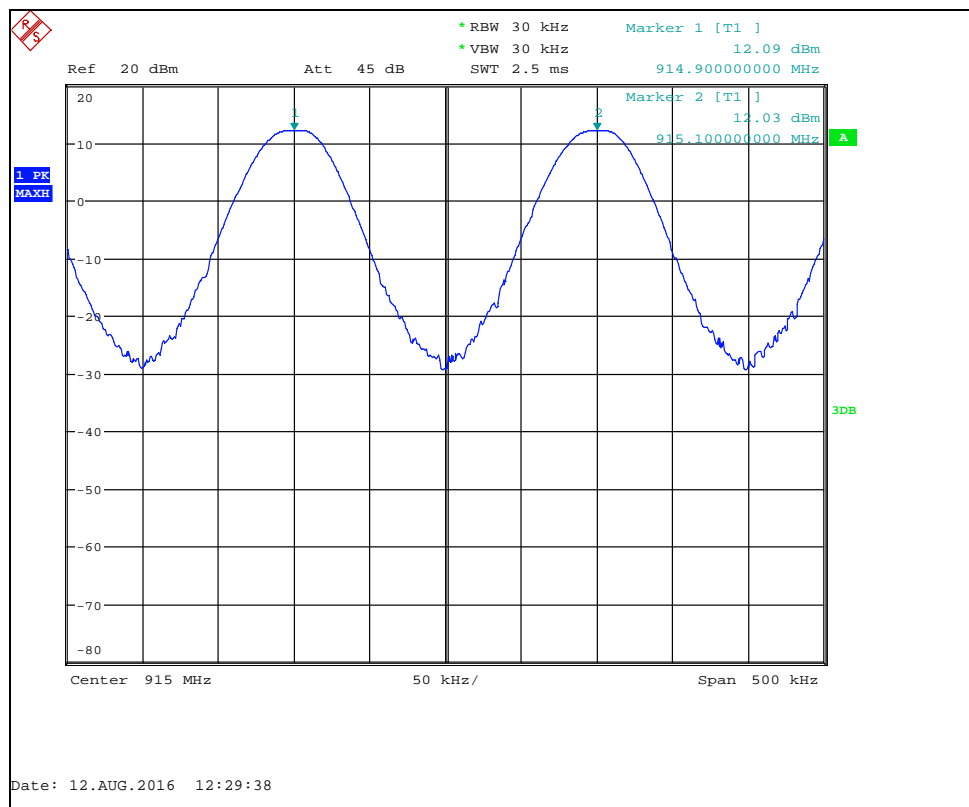


14.5 Test Equipment

Equipment Type	Manufacturer	Equipment Description	Element No	Due For Calibration
FSU26	R&S	Spectrum Analyser	REF909	26/04/2017

14.6 Test Results

Modulation: Hopping; Power setting: Full				
Data Rate	$F1_c$ (MHz)	$F2_c$ (MHz)	Channel Separation, $F2_c - F1_c$ (kHz)	Result
On	914.900	915.100	200	PASS



15 Number of hopping frequencies

15.1 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.

15.2 Test Parameters

Test Location:	Element Hull
Test Chamber:	Lab 4
Test Standard and Clause:	ANSI C63.10-2013, Clause 7.8.3
EUT Channels / Frequencies Measured:	All; 902 – 928 MHz
EUT 20dB Bandwidth:	21.2 kHz
EUT Test Modulations:	Internal pattern generation – hopping enabled
Deviations From Standard:	None
Measurement BW:	30 kHz
Measurement Detector:	Peak

Environmental Conditions (Normal Environment)

Temperature: 21 °C	+15 °C to +35 °C (as declared)
Humidity: 40 % RH	20 % RH to 75 % RH (as declared)
Supply: 12 V dc	

15.3 Test Limit

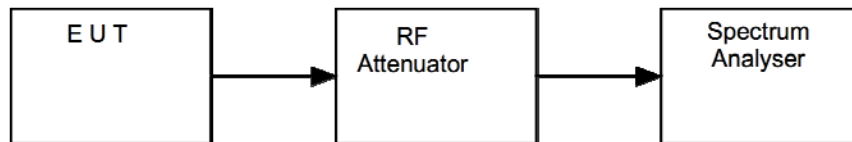
- For frequency hopping systems in the band 902 to 928 MHz: if the -20 dB bandwidth of the hopping channel is less than 250 kHz, the system shall use at least 50 hopping channels;
If the -20 dB bandwidth of the hopping channel is 250 kHz or greater, the system shall use at least 25 hopping channels;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

15.4 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

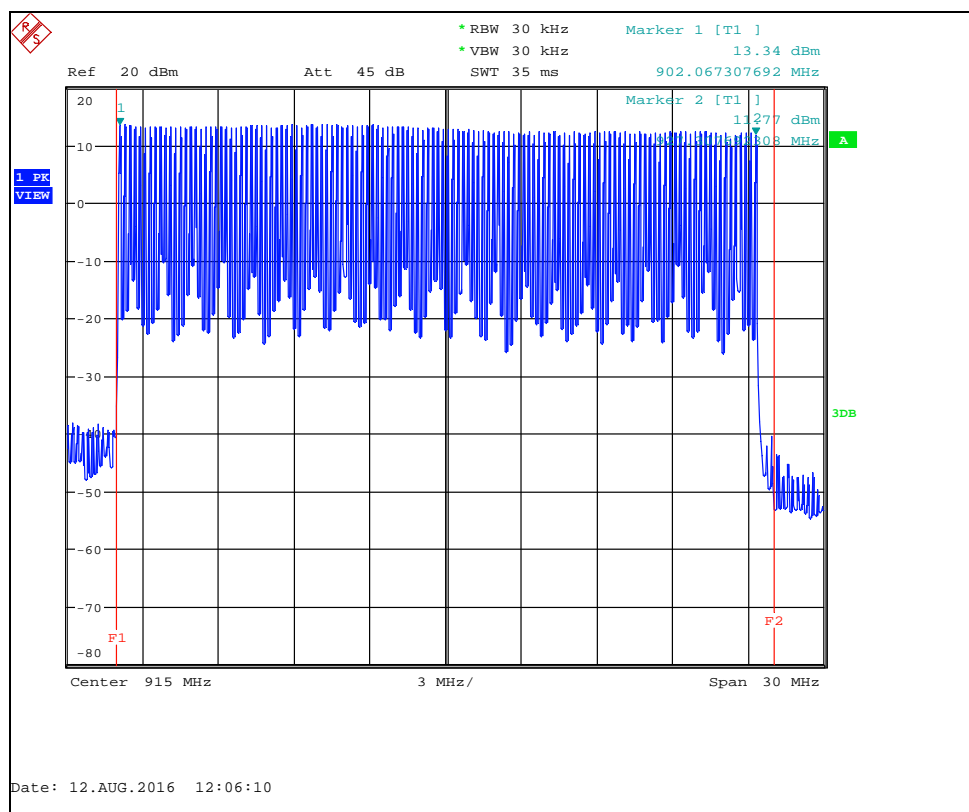


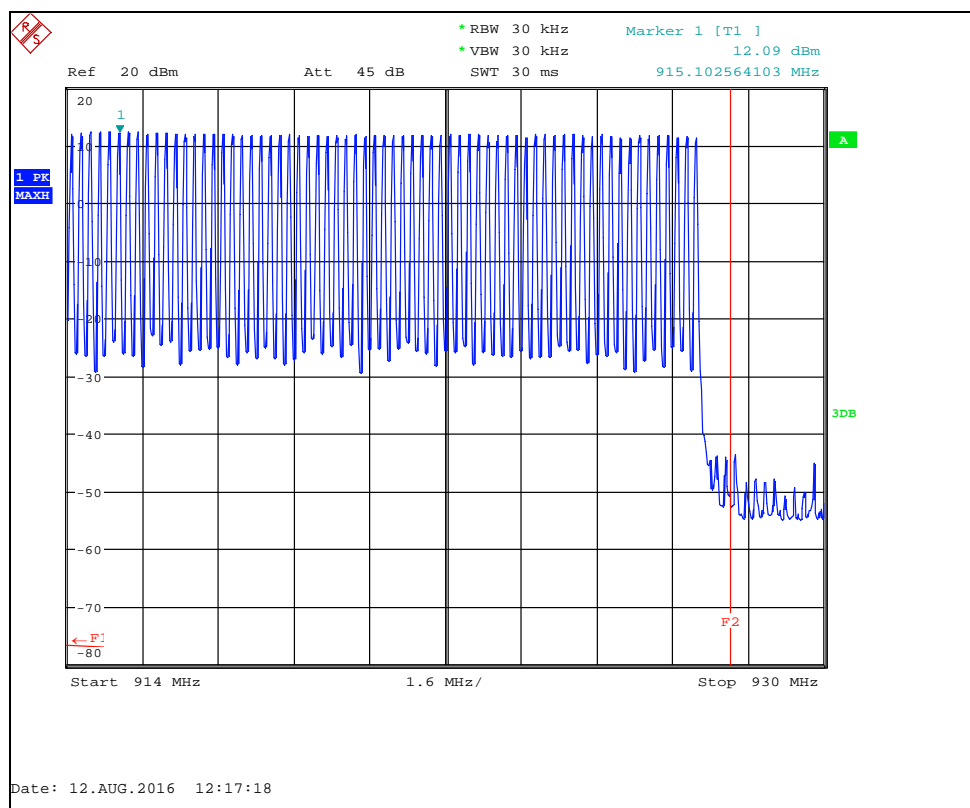
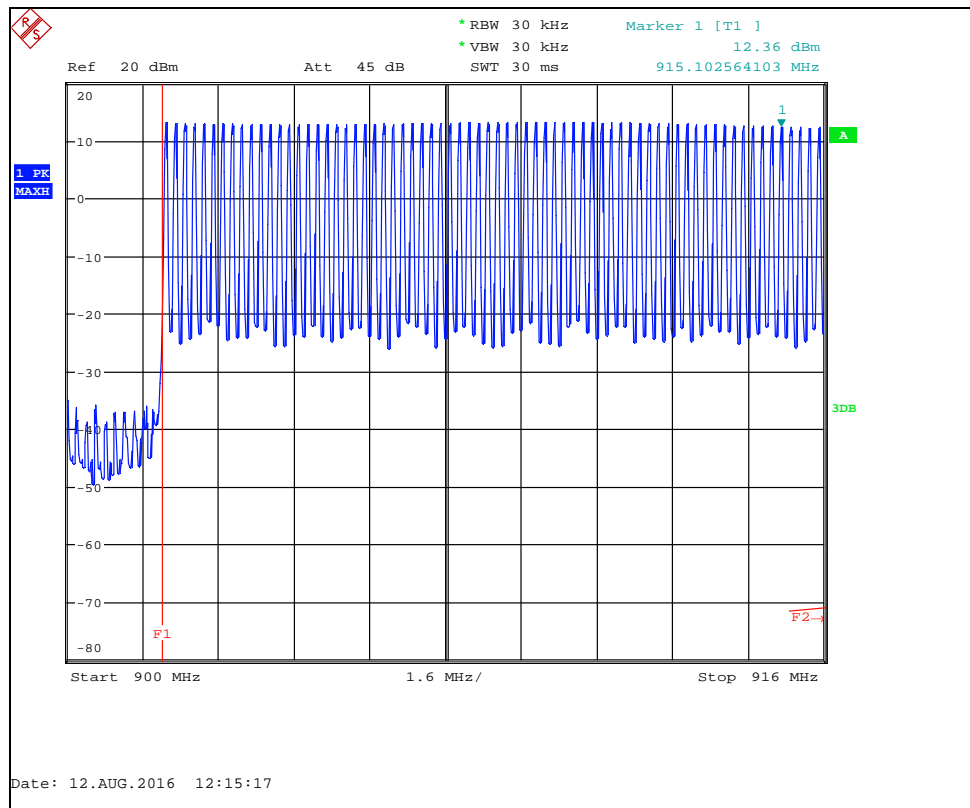
15.5 Test Equipment

Equipment Type	Manufacturer	Equipment Description	Element No	Due For Calibration
FSU26	R&S	Spectrum Analyser	REF909	26/04/2017

15.6 Test Results

Modulation: Hopping; Power setting: Full.				
Data Rate	Lowest channel, F_{CL} (MHz)	Highest channel, F_{CH} (MHz)	Number of channels observed	Result
On	902.067307692	927.307692308	127	PASS





16 Average channel occupancy

16.1 Definition

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

16.2 Test Parameters

Test Location:	Element Hull
Test Chamber:	Lab 4
Test Standard and Clause:	ANSI C63.10-2013, Clause 7.8.4
EUT Channels / Frequencies Measured:	Mid
EUT 20dB bandwidth:	21.2 kHz
EUT Number of hopping channels:	127
EUT Test Modulations:	Internal pattern generation – hopping enabled
Deviations From Standard:	None
Measurement BW:	30 kHz
Measurement Detector:	Peak

Environmental Conditions (Normal Environment)

Temperature: 21 °C	+15 °C to +35 °C (as declared)
Humidity: 40 % RH	20 % RH to 75 % RH (as declared)
Supply: 12 V dc	

16.3 Test Limit

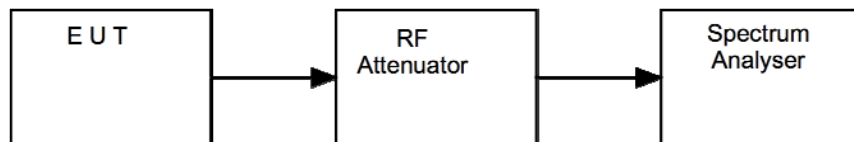
- For frequency hopping systems in the band 902 to 928 MHz: if the -20 dB bandwidth of the hopping channel is less than 250 kHz, the average time of occupancy on any channel shall not be greater than 0.4 seconds within a 20 second period; If the -20 dB bandwidth of the hopping channel is 250 kHz or greater, 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.

16.4 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

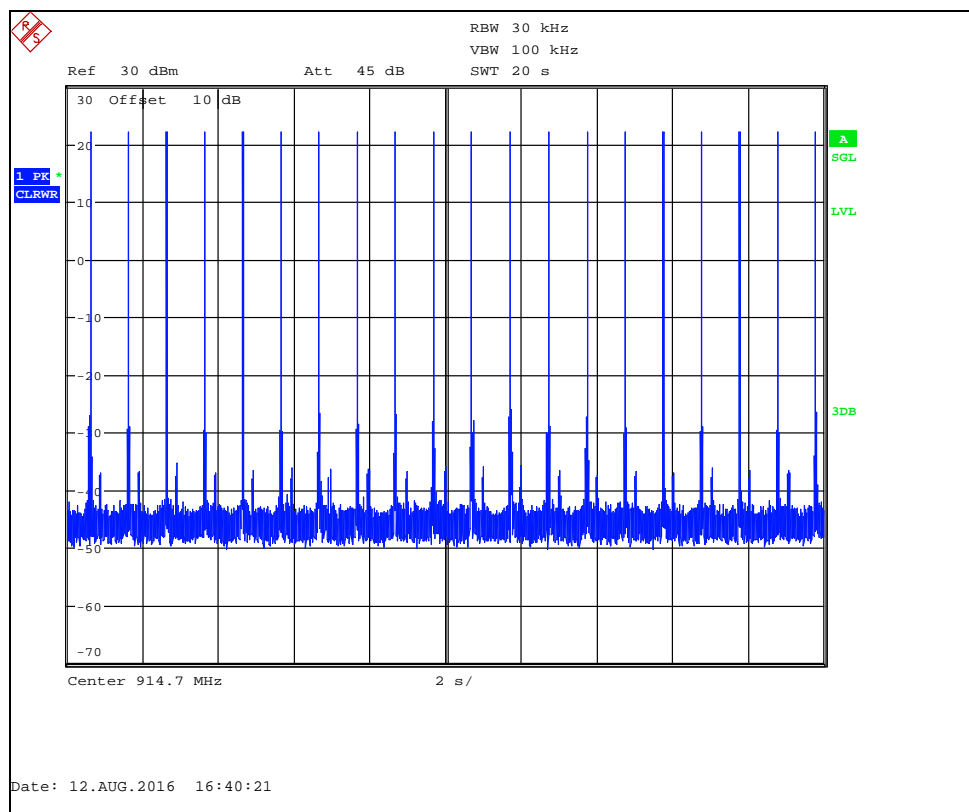


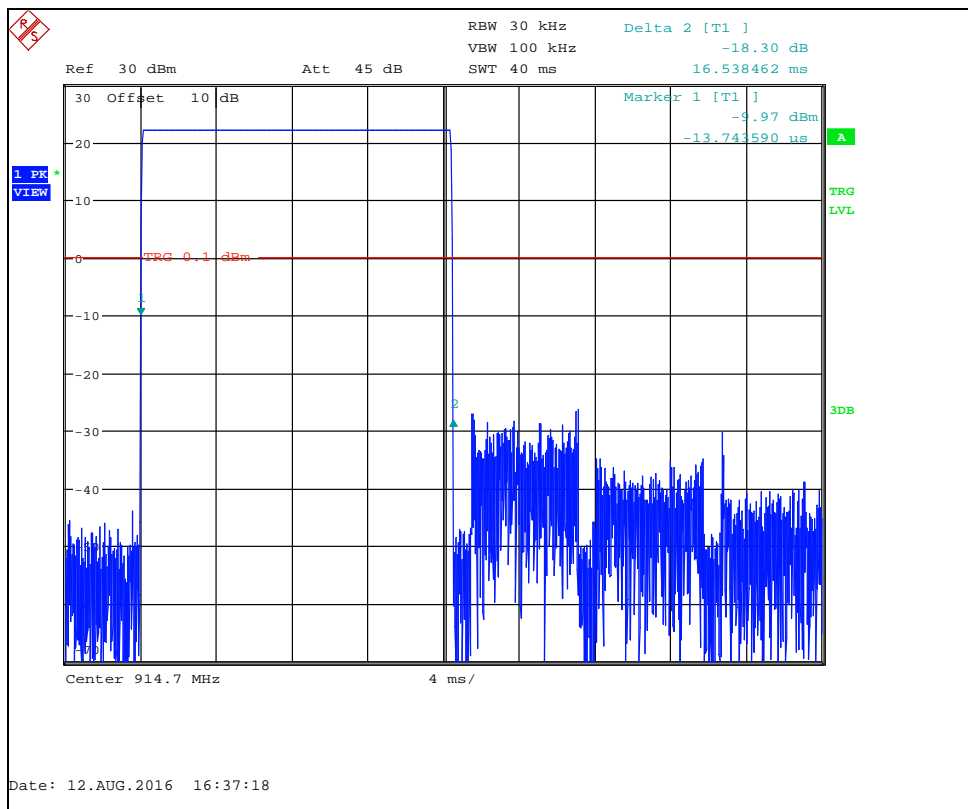
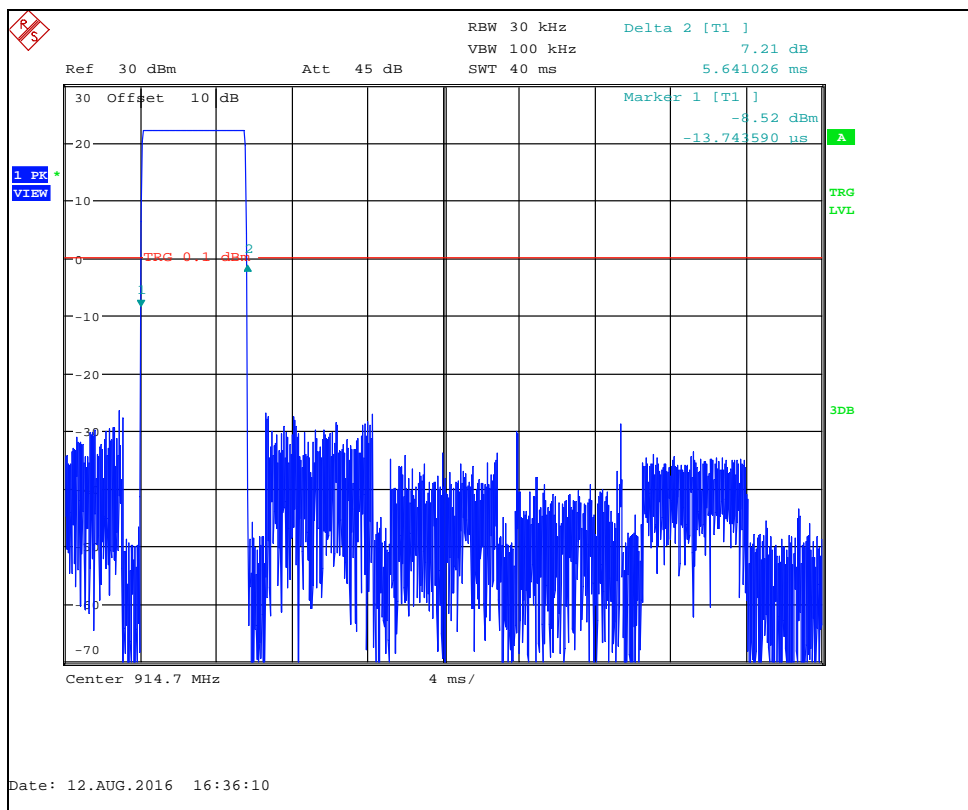
16.5 Test Equipment

Equipment Type	Manufacturer	Equipment Description	Element No	Due For Calibration
FSU26	R&S	Spectrum Analyser	REF909	26/04/2017

16.6 Test Results

Pulse	Individual occupancy time (ms)	Observation period (s)	Number of hops observed	Average time of occupancy (s)	Combined average time of occupancy (s)	Result
Short	5.641026	20	16	0.090256416	0.156410264	PASS
Long	16.538462	20	4	0.066153848		





17 Maximum peak conducted output power

17.1 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.

17.2 Test Parameters

Test Location:	Element Hull
Test Chamber:	Lab 4
Test Standard and Clause:	ANSI C63.10-2013, Clause 7.8.5
EUT Channels / Frequencies Measured:	Low / Mid / High – hopping disabled.
EUT Channel Bandwidths:	21.2 kHz
Deviations From Standard:	None
Measurement BW:	50 kHz
Spectrum Analyzer Video BW:	3 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: 40 % RH	20 % RH to 75 % RH (as declared)

17.3 Test Limit

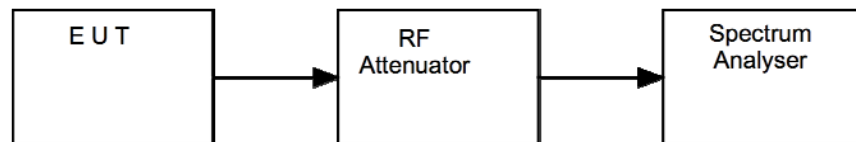
- For frequency hopping systems operating in the band 902 to 928 MHz, the maximum peak conducted output power shall not exceed 1 W, and the e.i.r.p. shall not exceed 4 W, if the hopset uses 50 or more hopping channels; the maximum peak conducted output power shall not exceed 0.25 W, and the e.i.r.p. 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.

17.4 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

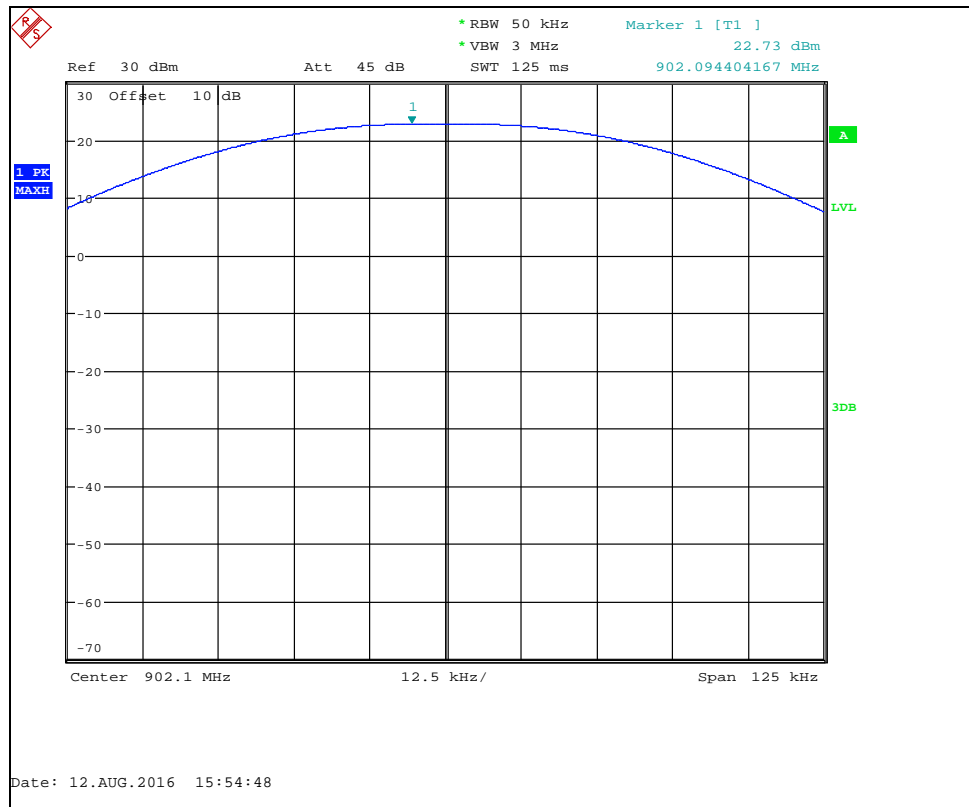


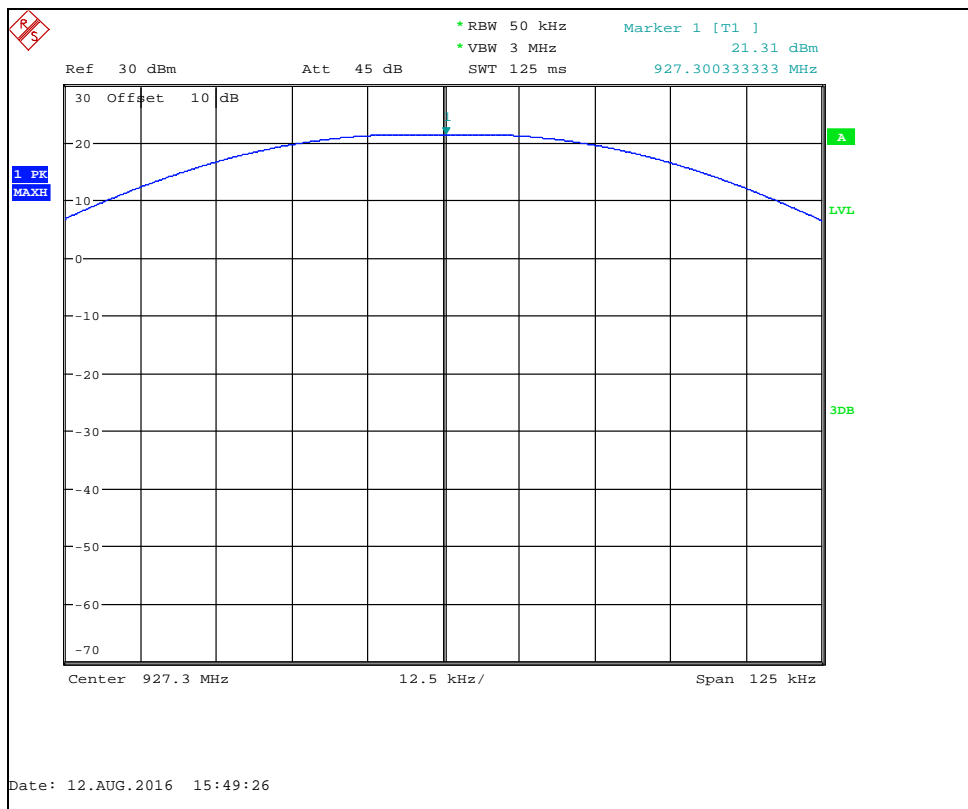
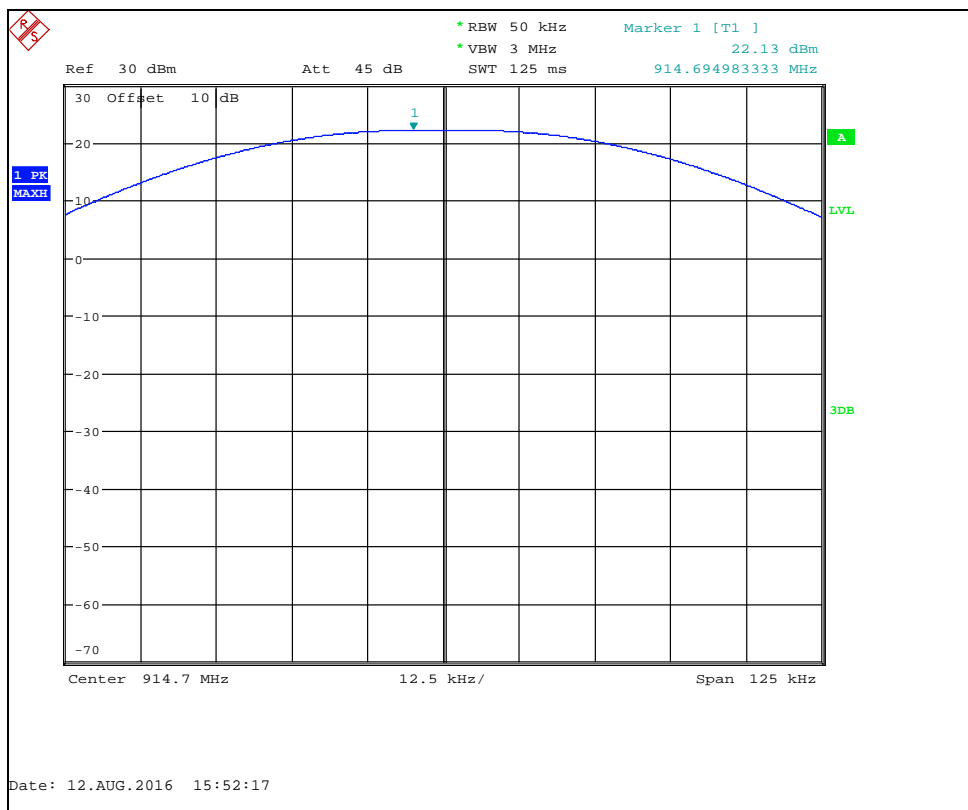
17.5 Test Equipment

Equipment Type	Manufacturer	Equipment Description	Element No	Due For Calibration
FSU26	R&S	Spectrum Analyser	REF909	26/04/2017

17.6 Test Results

Channel Frequency (MHz)	Analyzer Level (dBm)	Cable loss (dB)	Maximum peak conducted output power (W)	Antenna gain (dBi)	E.I.R.P. (W)	Result
902.1	22.73	0	0.187	2	0.297	PASS
914.7	22.13	0	0.163	2	0.259	PASS
927.3	21.31	0	0.135	2	0.214	PASS





18 Occupied Bandwidth

18.1 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.

18.2 Test Parameters

Test Location:	Element Hull
Test Chamber:	Lab 4
Test Standard and Clause:	ANSI C63.10-2013, Clause 6.9
EUT Channels / Frequencies Measured:	Low / Mid / High – hopping stopped.
EUT Channel Bandwidths:	200 kHz
EUT Test Modulations:	Normal modulation
Deviations From Standard:	None
Measurement BW: (requirement: 1 % to 5 % OBW)	1 kHz
Spectrum Analyzer Video BW: (requirement at least 3x RBW)	3 kHz
Measurement Span: (requirement 2 to 5 times OBW)	125kHz
Measurement Detector:	Peak

Environmental Conditions (Normal Environment)

Temperature: 21 °C	+15 °C to +35 °C (as declared)
Humidity: 40 % RH	20 % RH to 75 % RH (as declared)
Supply: 12 V dc	

18.3 Test Limit

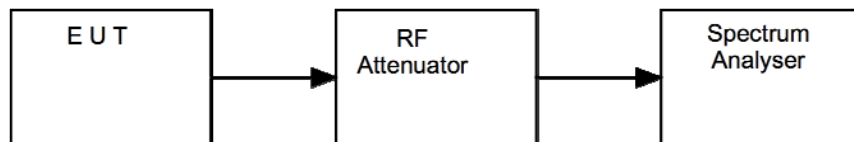
- For frequency hopping systems in the band 902 to 928 MHz: The maximum allowed -20 dB bandwidth of the hopping channel is 500 kHz.
- Frequency hopping systems operating in the band 5725 to 5850 MHz: The maximum -20 dB bandwidth of the hopping channel shall be 1 MHz

18.4 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

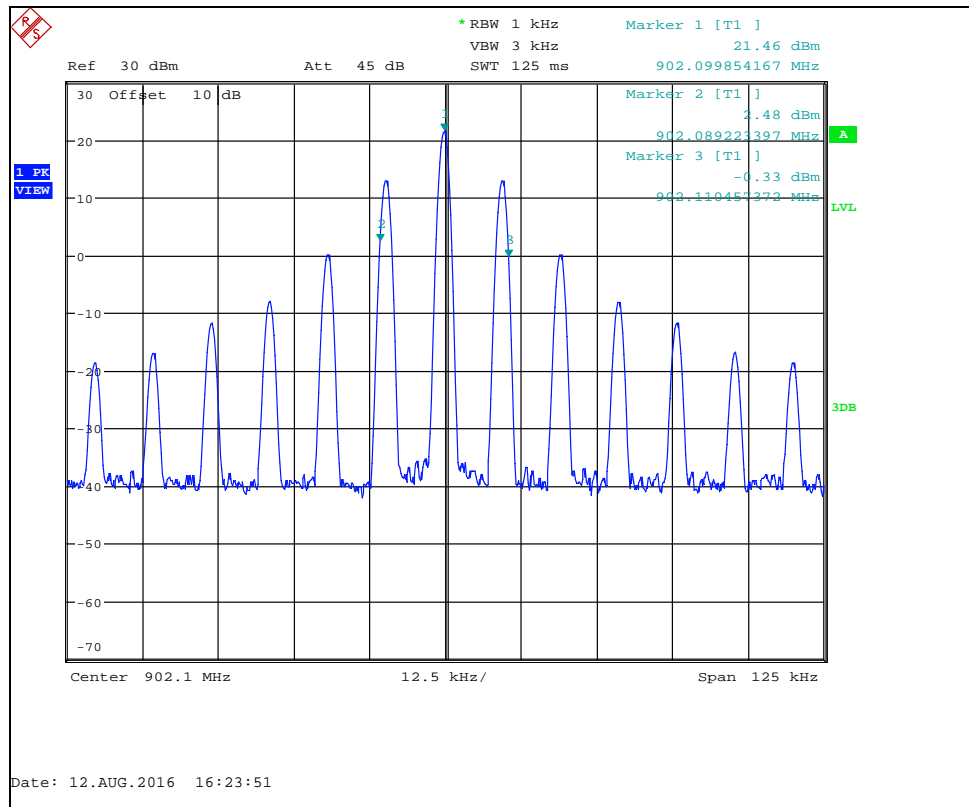


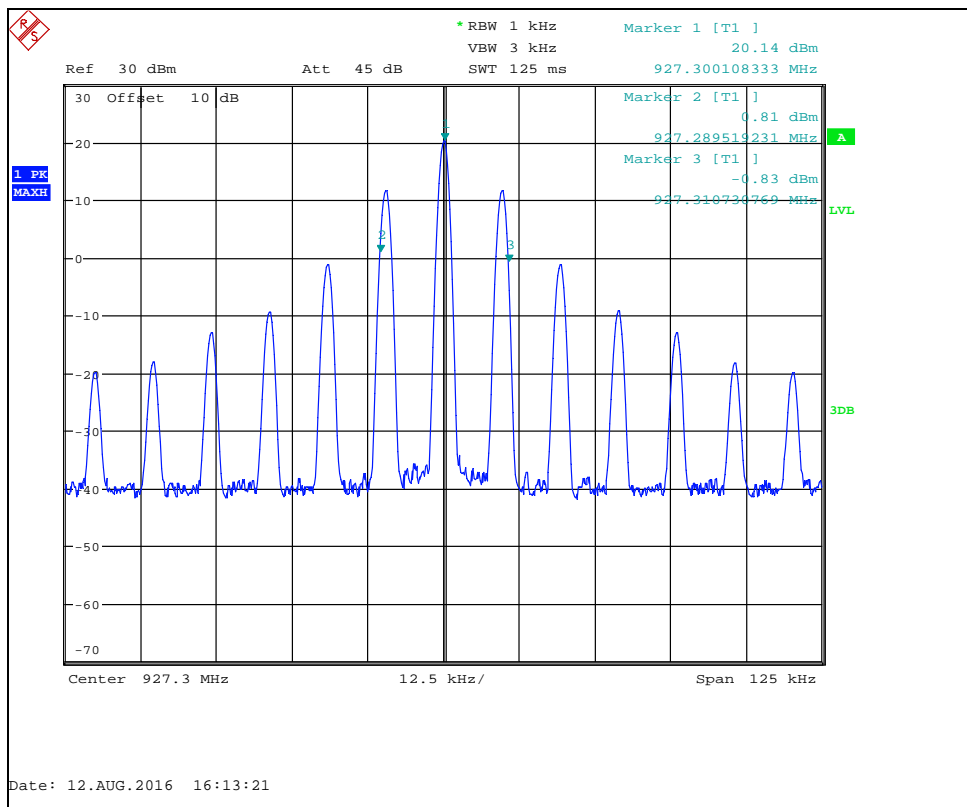
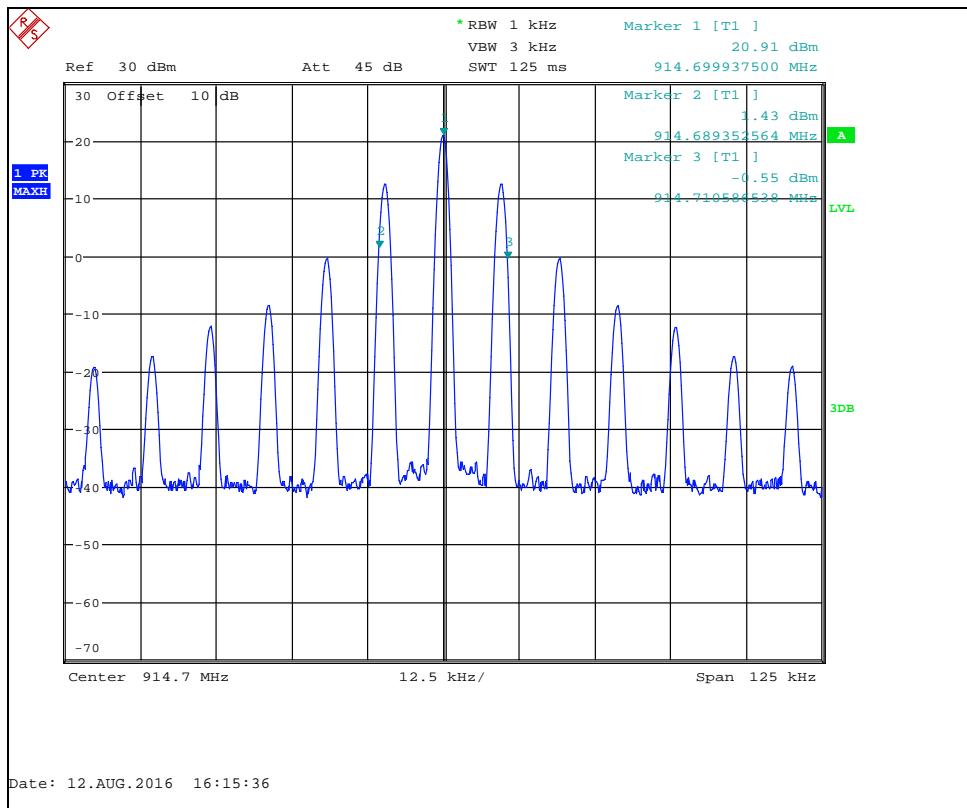
18.5 Test Equipment

Equipment Type	Manufacturer	Equipment Description	Element No	Due For Calibration
FSU26	R&S	Spectrum Analyser	REF909	26/04/2017

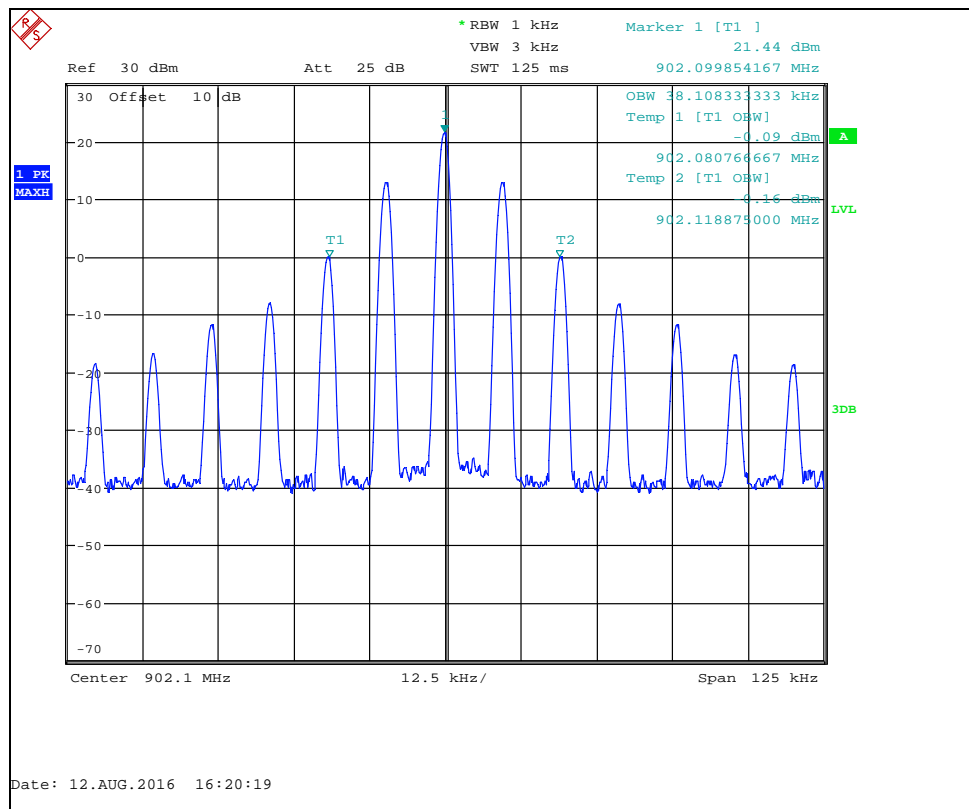
18.6 Test Results

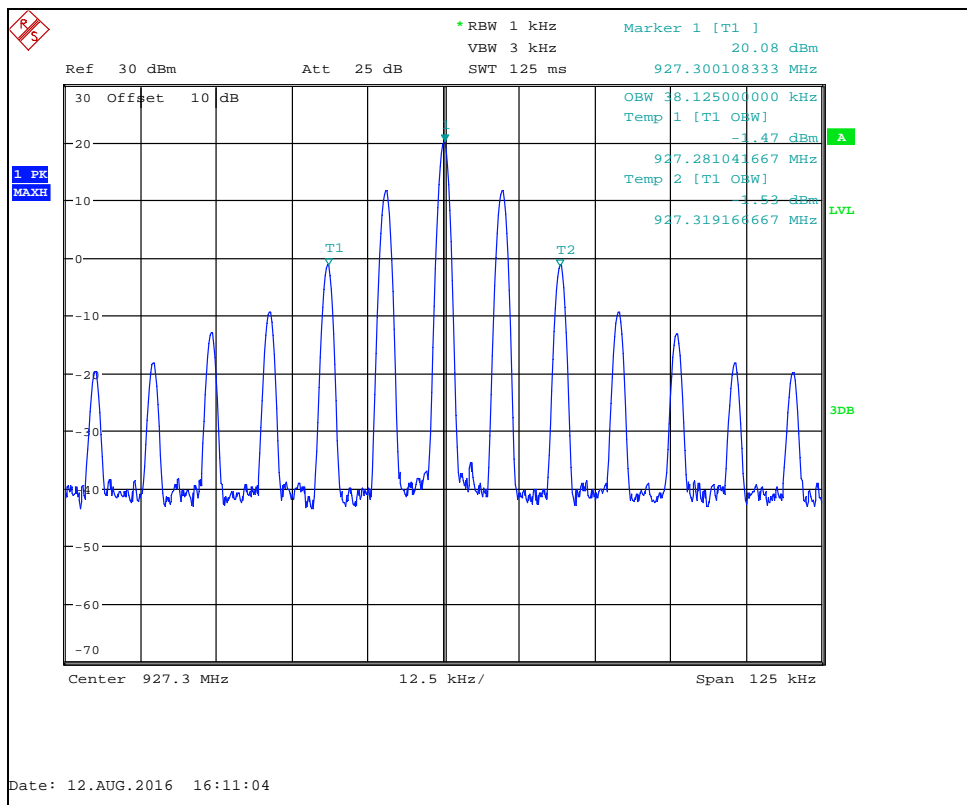
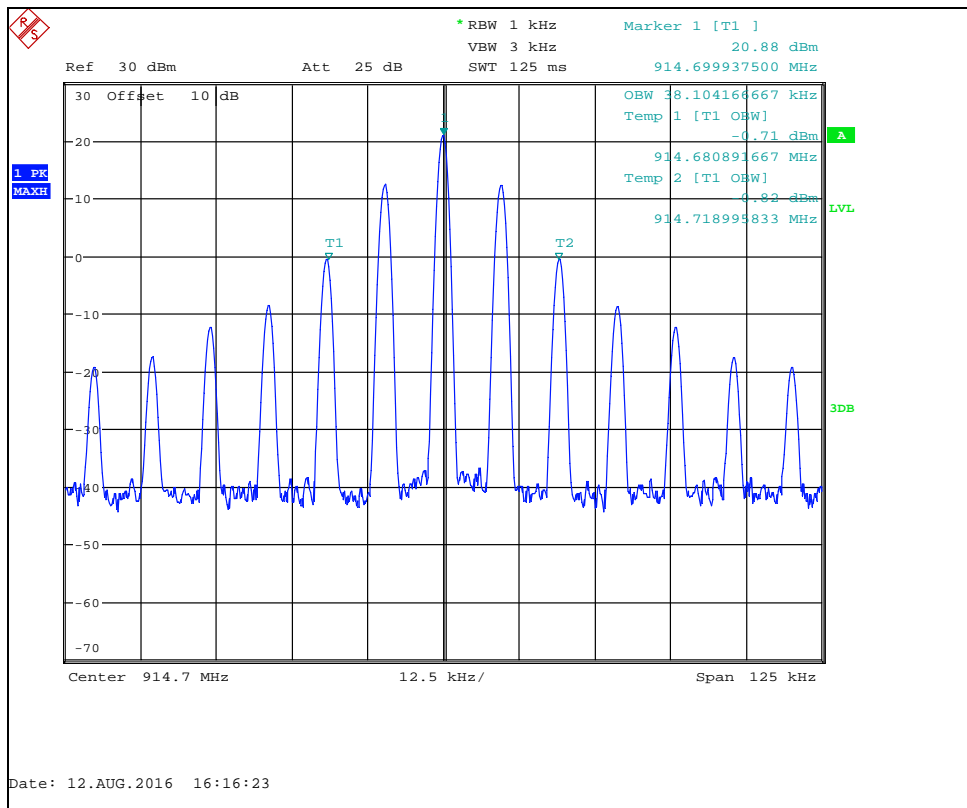
Modulation: Single hop; Power setting: Full				
Channel Frequency (MHz)	F_L (MHz)	F_H (MHz)	20dB Bandwidth (kHz)	Result
902.1	902.08922339	902.110457372	21.23	PASS
914.7	914.689352564	914.710586538	21.23	PASS
927.3	927.289519231	927.310730769	21.21	PASS





Modulation: Single hop; Power setting: Full				
Channel Frequency (MHz)	F_L (MHz)	F_H (MHz)	99% Bandwidth (kHz)	Result
902.1	902.080766667	902.118875000	38.108333333	PASS
914.7	914.680891667	914.718995833	38.104166667	PASS
927.3	927.281041667	927.319166667	38.125000000	PASS





19 Out-of-band and conducted spurious emissions

19.1 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.

19.2 Test Parameters

Test Location:	Element Hull
Test Chamber:	Lab 4
Test Standard and Clause:	ANSI C63.10-2013, Clause 7.8.8
EUT Channels / Frequencies Measured:	Low / Mid / High
EUT Channel Bandwidths:	200 kHz
Deviations From Standard:	None
Measurement BW:	100 kHz
Spectrum Analyzer Video BW: (requirement at least 3x RBW)	300 kHz
Measurement Detector:	Peak
Measurement Range:	9 kHz to 10 GHz

Environmental Conditions (Normal Environment)

Temperature: 21 °C	+15 °C to +35 °C (as declared)
Humidity: 40 % RH	20 % RH to 75 % RH (as declared)
Supply: 12 V dc	

19.3 Test Limits

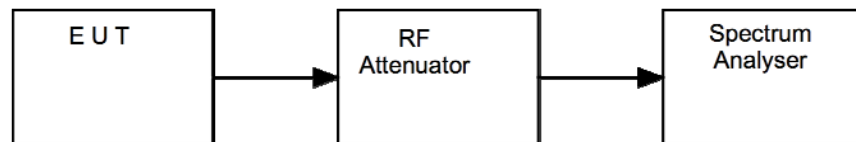
In any 100 kHz bandwidth outside the frequency band in which the spread spectrum or digitally modulated device is operating, the RF power that is produced shall be at least 20 dB below that in the 100 kHz bandwidth within the band that contains the highest level of the desired power, based on either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

19.4 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

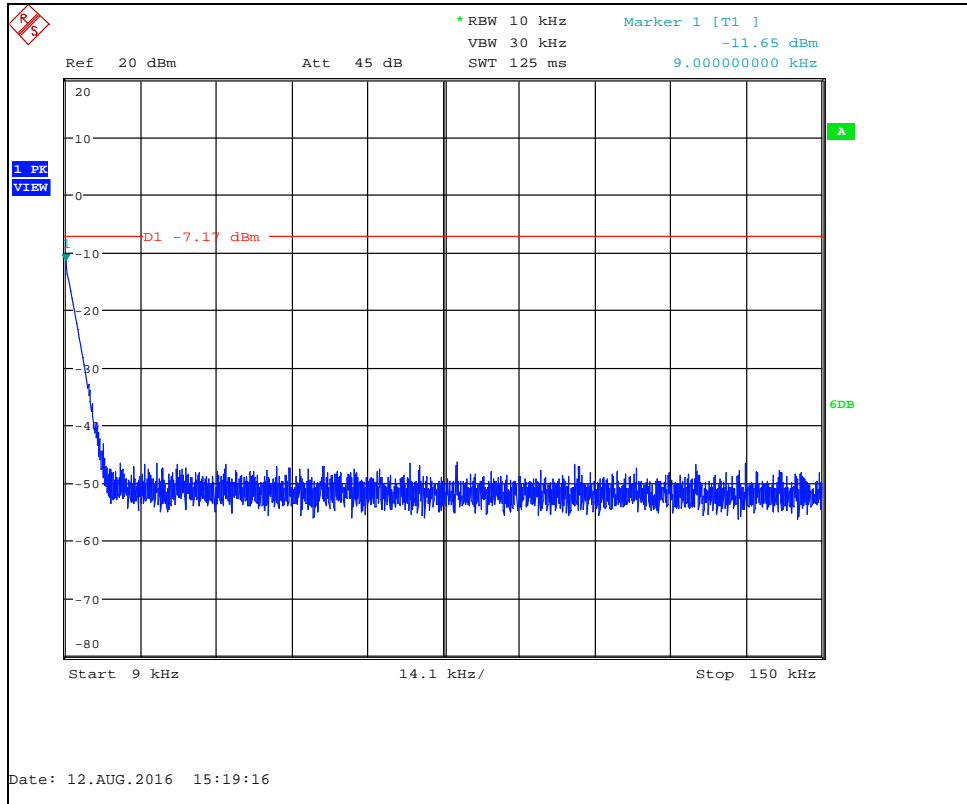


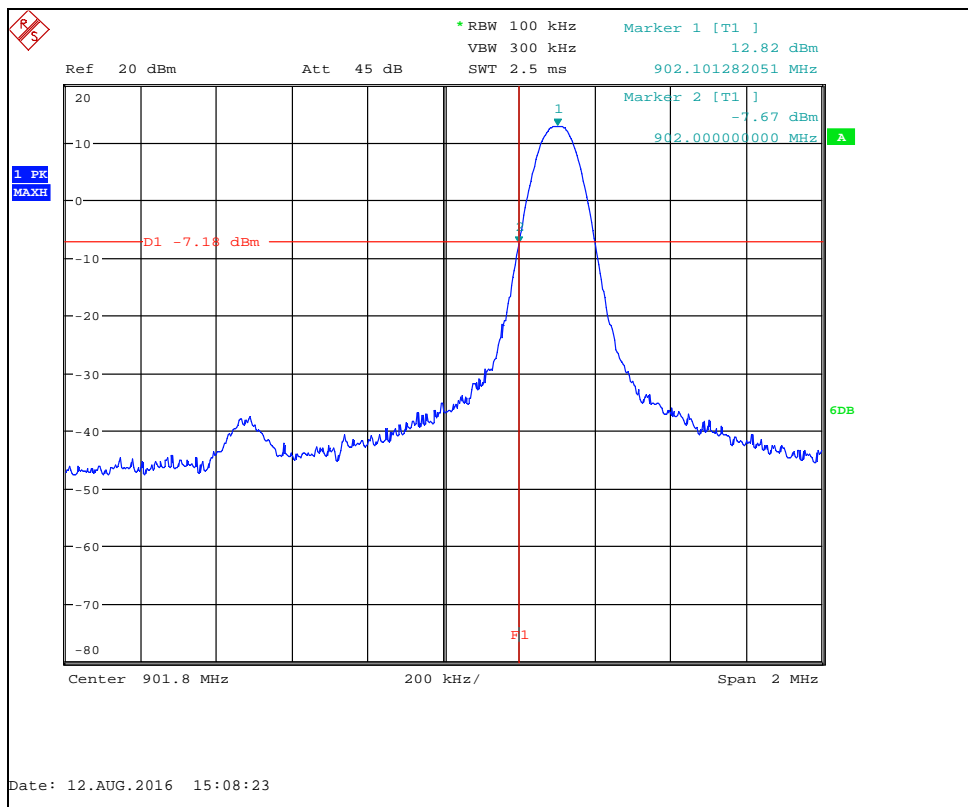
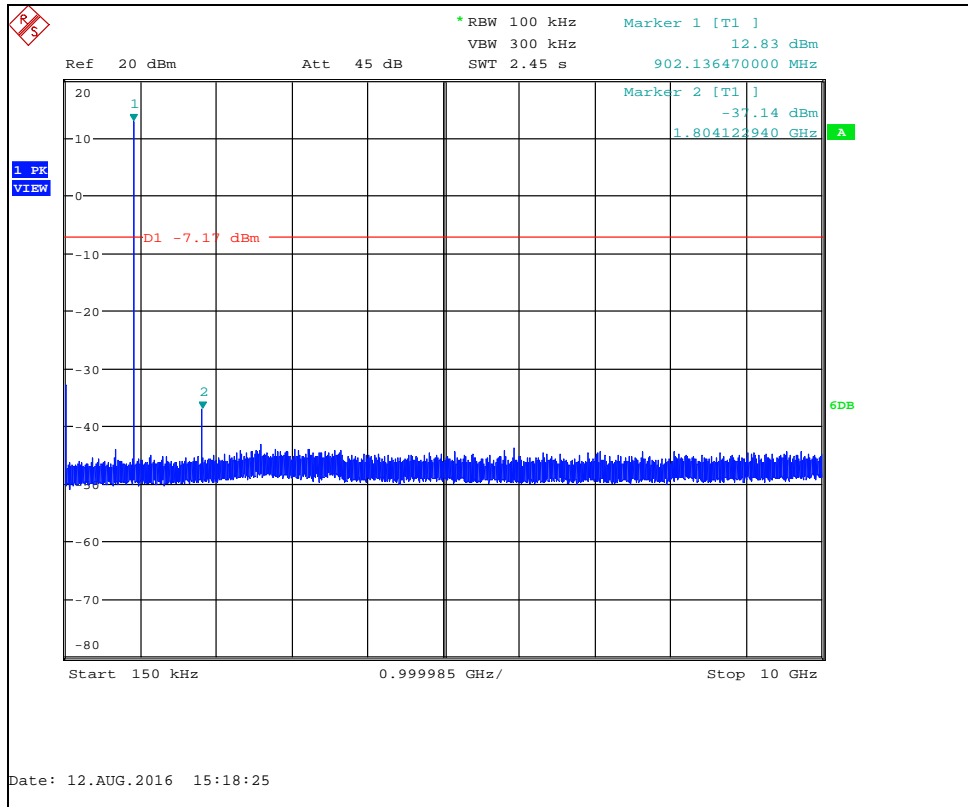
19.5 Test Equipment

Equipment Type	Manufacturer	Equipment Description	Element No	Due For Calibration
FSU26	R&S	Spectrum Analyser	REF909	26/04/2017

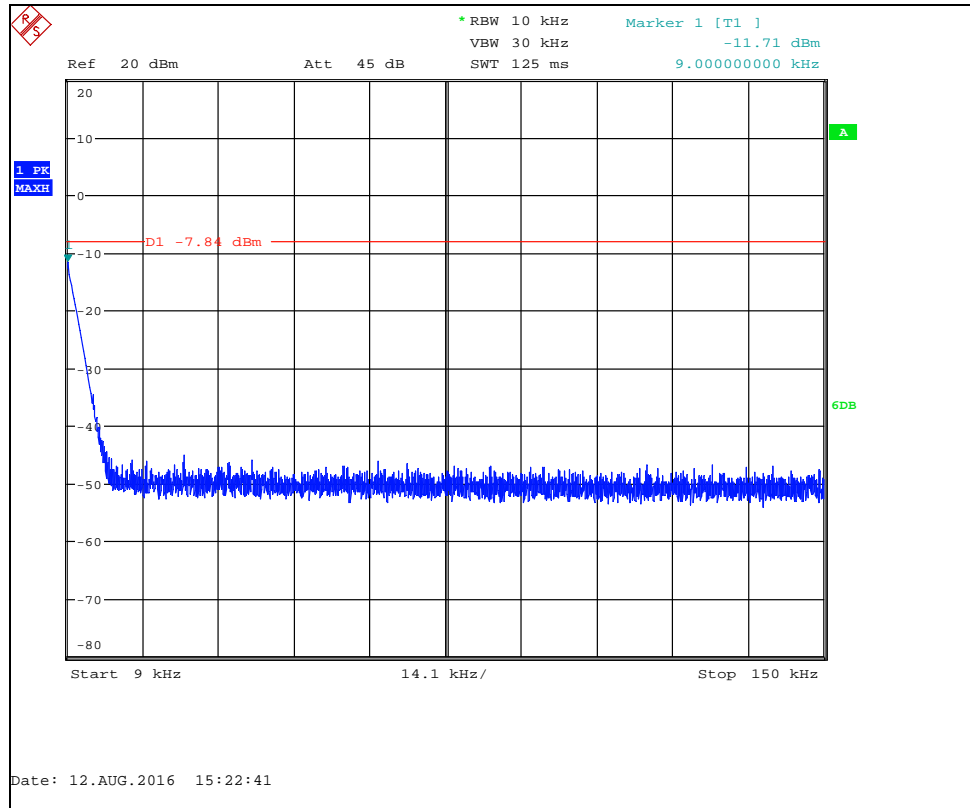
19.6 Test Results

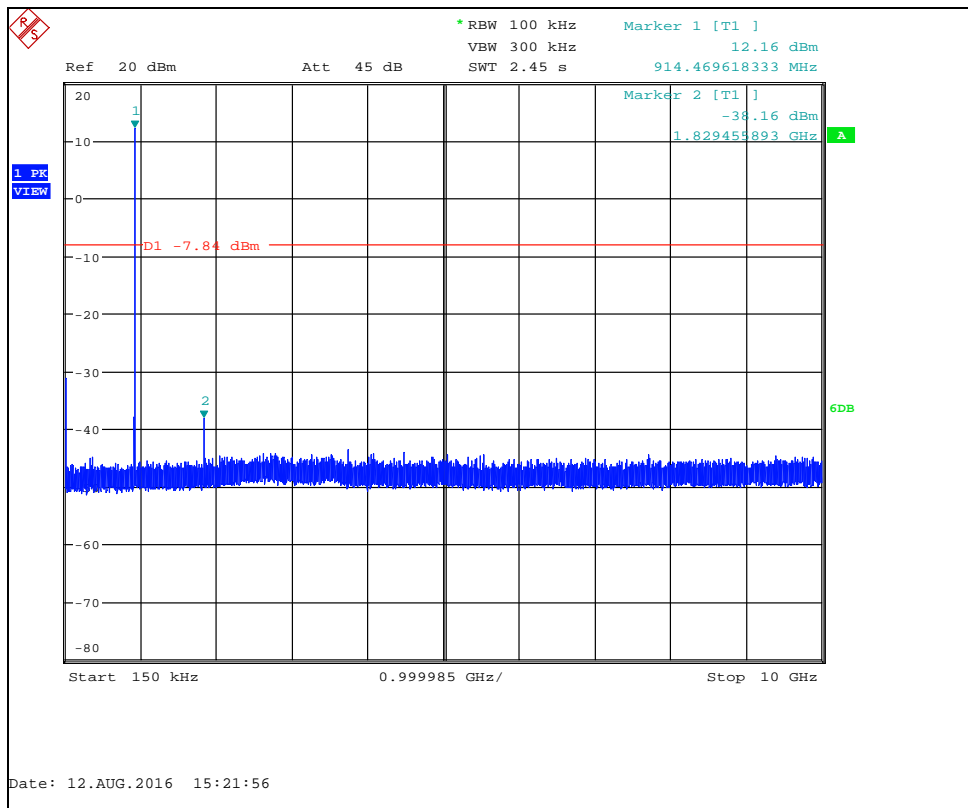
Modulation: Single hop; Power setting: Full						
Channel Frequency (MHz)	Emission Frequency (MHz)	Analyzer Level (dBm)	Emission Level (dBm)	Limit (dBm)	Margin (dB)	Result
Low	902.136	12.8	12.8	N/A	N/A	PASS
	902.000	-7.7	-7.7	-7.2	-0.5	PASS
	1804.123	-37.1	-37.1	-7.2	-29.9	PASS



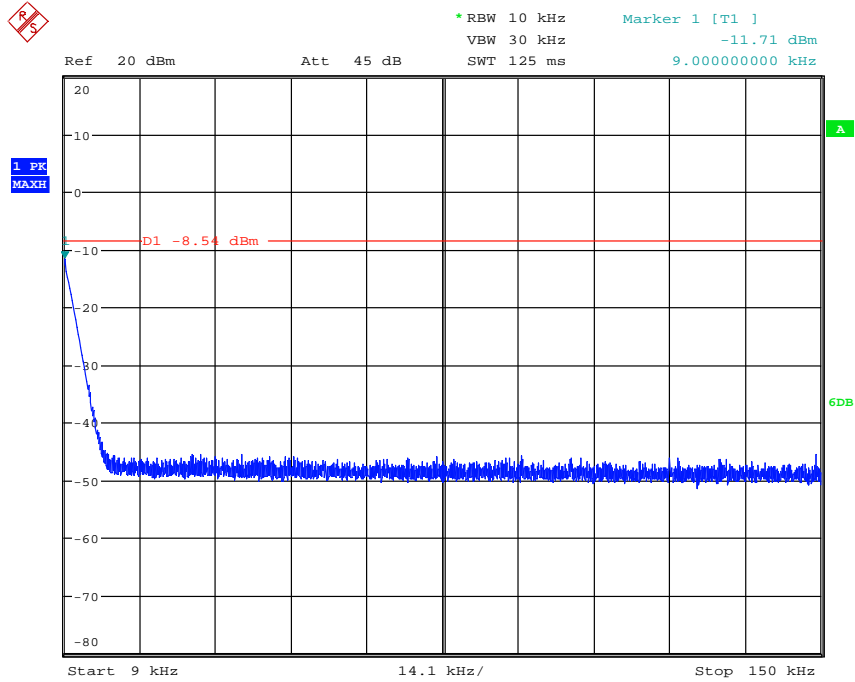


Modulation: Single hop; Power setting: Full						
Channel Frequency (MHz)	Emission Frequency (MHz)	Analyzer Level (dBm)	Emission Level (dBm)	Limit (dBm)	Margin (dB)	Result
Mid	914.470	12.2	12.2	N/A	N/A	PASS
	1829.456	-38.2	-38.2	-7.8	-30.4	PASS

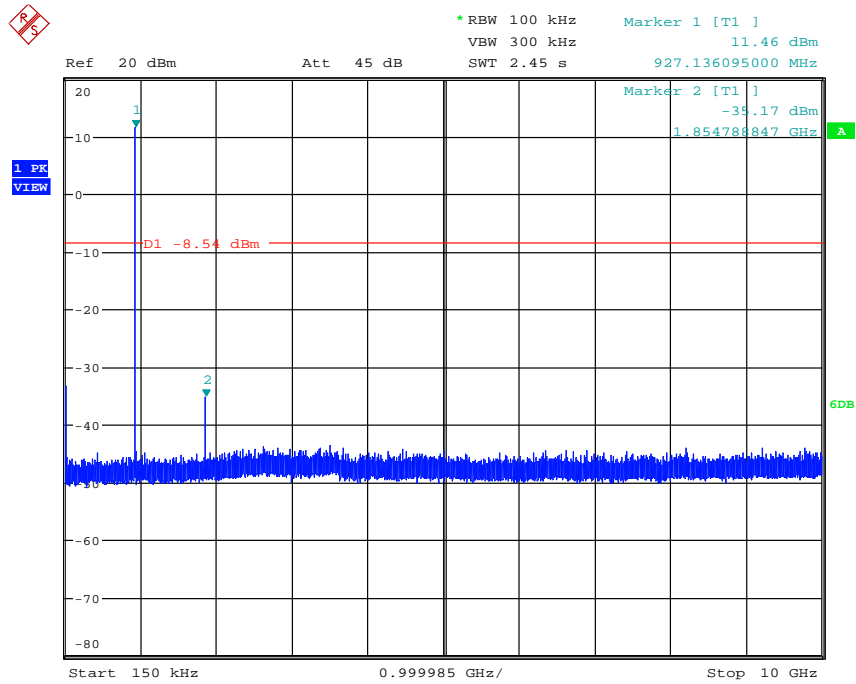




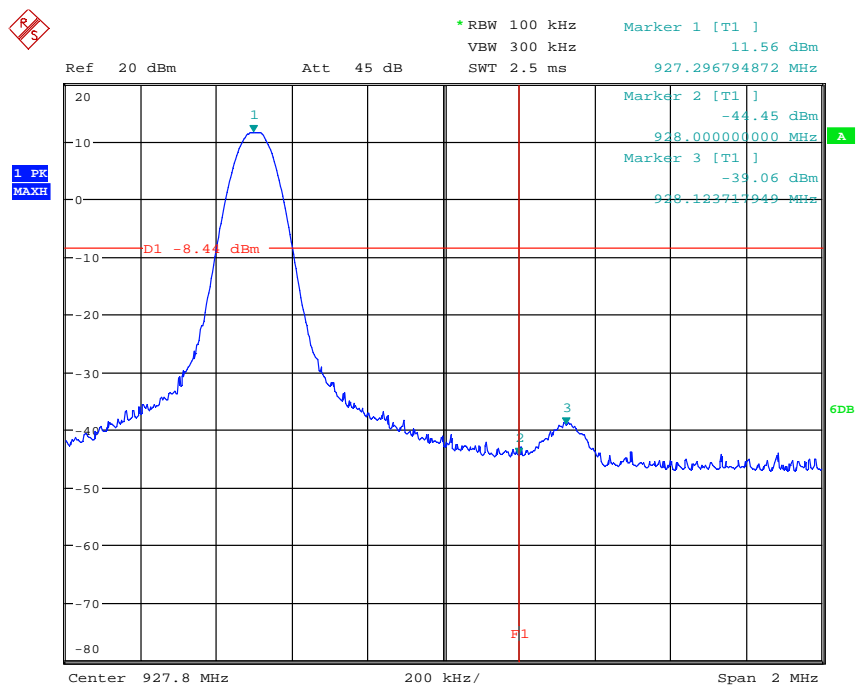
Modulation: Single hop; Power setting: Full						
Channel Frequency (MHz)	Emission Frequency (MHz)	Analyzer Level (dBm)	Emission Level (dBm)	Limit (dBm)	Margin (dB)	Result
High	927.136	11.5	11.5	N/A	N/A	PASS
	928.124	-39.1	-39.1	-8.4	-30.7	PASS
	1854.789	-35.2	-35.2	-8.4	-26.8	PASS



Date: 12.AUG.2016 15:32:08



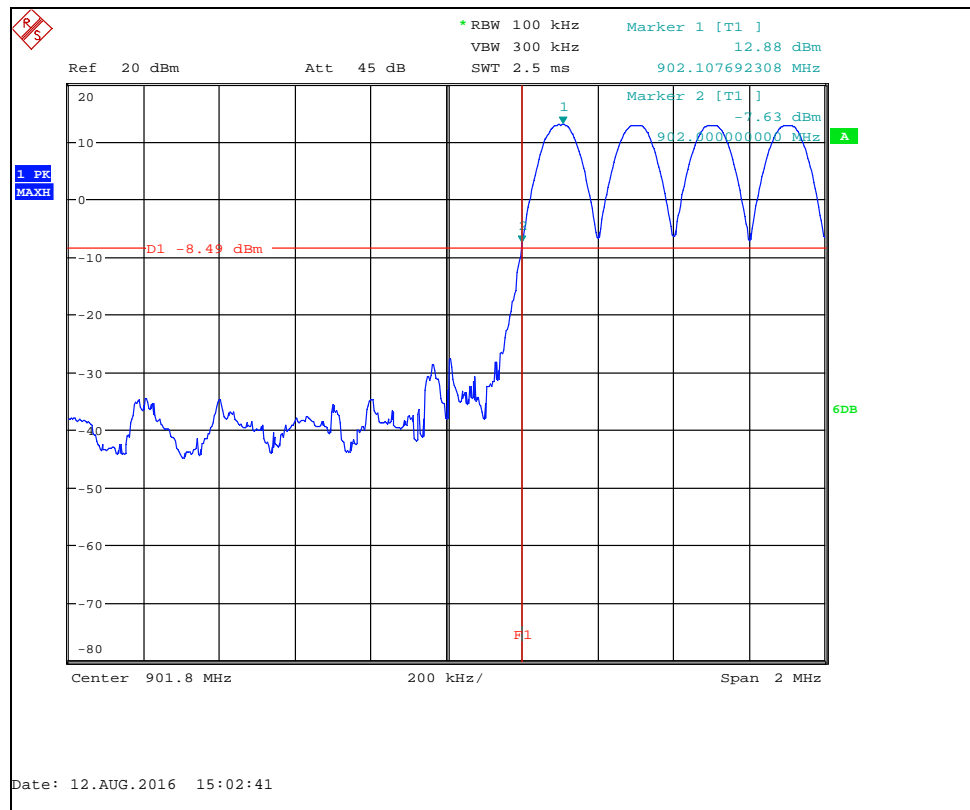
Date: 12.AUG.2016 15:26:19

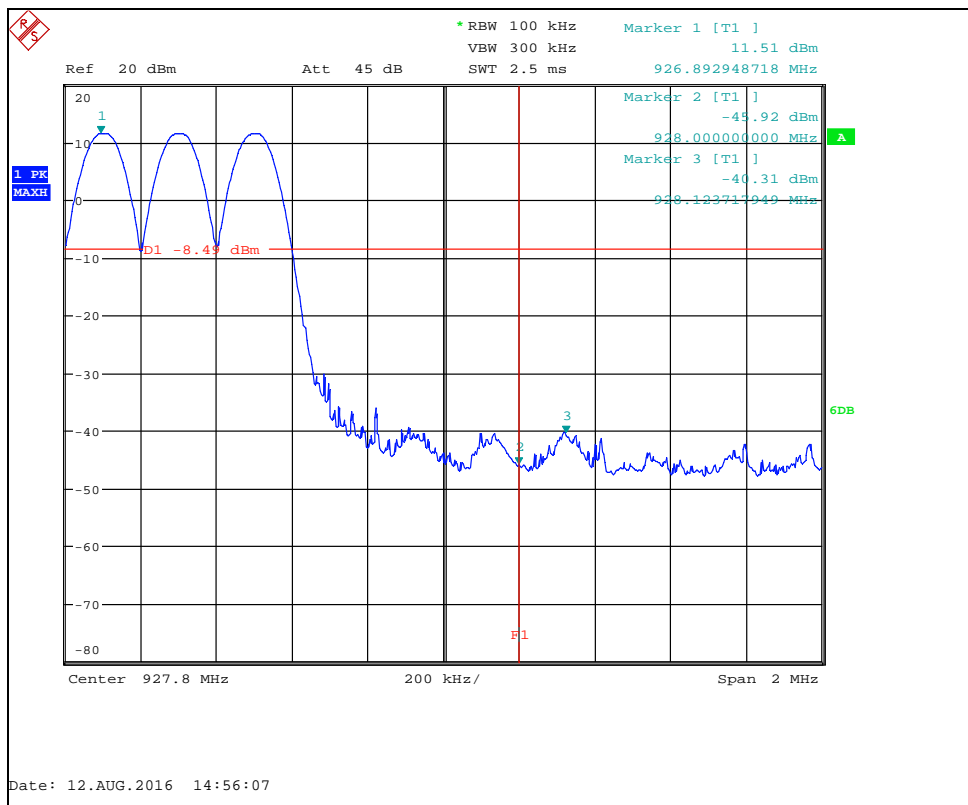
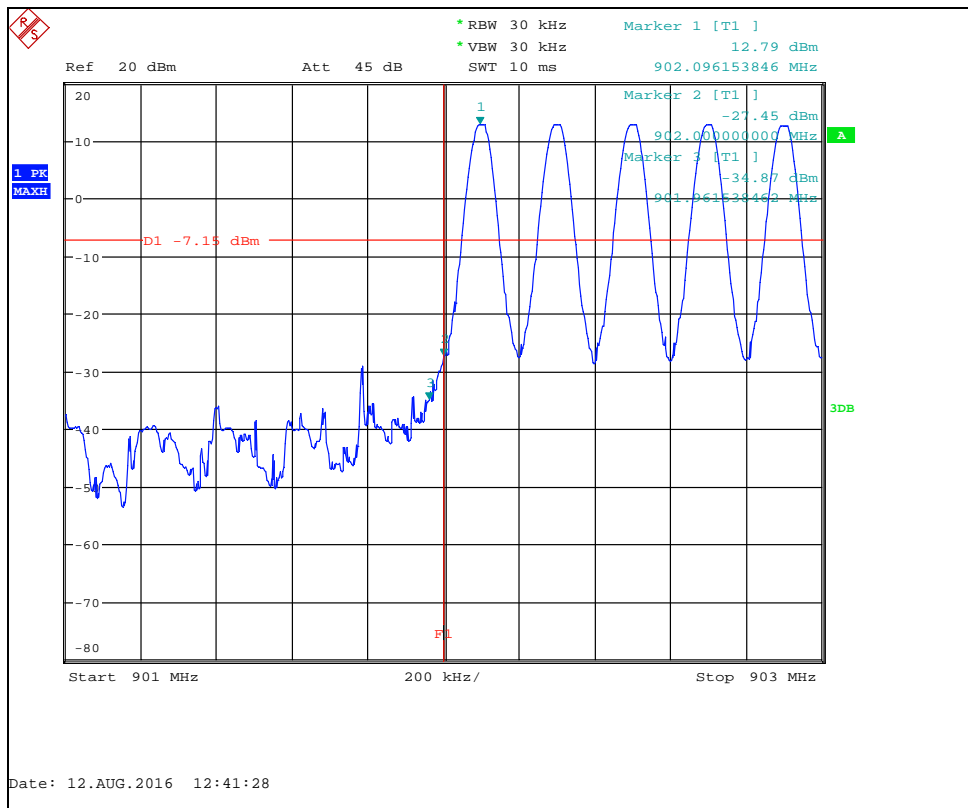


Date: 12.AUG.2016 14:54:12

Band Edge Compliance; Modulation: Hopping; Power setting: Full							
Channel Frequency (MHz)	Peak Level in 100 kHz (dBm)	Peak Level in 30 kHz (dBm)	Emission Frequency (MHz)	Delta Marker	Limit (dBm)	Margin (dB)	Result
902.1	12.88	12.79	902.0	40.24	-20	-20.24	PASS

As Peak Level in 100kHz and 30kHz are the same the delta level will apply directly to the limit





20 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 %**

21 RF Exposure

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.

In the frequency range below 100 MHz to 6 GHz and test separation distance of 50 mm, the SAR Test Exclusion Threshold for operation at 902.1 MHz, 914.7 MHz and 927.3 MHz will be determined as follows

SAR Exclusion Threshold (SARET)

SAR Exclusion Threshold = Step 1 + 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 50 mm (whichever is lower) = 50 mm

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 = Min Test separation Distance = 50 mm

Operating Frequency 902.1 MHz

$$\begin{aligned} \text{MP} &= [(7.5 \times 50) / \sqrt{0.9021}] + \{ (50 - 50) * [902.1/150] \} \\ \text{MP} &= [375 / 0.9498] + \{ 0 * 6.01 \} \\ \text{MP} &= 394.8 \text{ mW} \end{aligned}$$

The calculated output power 297 mW (Peak) is less than the SAR Exclusion Threshold of 394.8 mW.

Operating Frequency 914.7 MHz

$$\begin{aligned} \text{MP} &= [(7.5 \times 50) / \sqrt{0.9147}] + \{ (50 - 50) * [914.7/150] \} \\ \text{MP} &= [375 / 0.9564] + \{ 0 * 6.10 \} \\ \text{MP} &= 392.1 \text{ mW} \end{aligned}$$

The calculated output power 259 mW (Peak) is less than the SAR Exclusion Threshold of 392.1 mW.

Operating Frequency 927.3 MHz

$$\begin{aligned} \text{MP} &= [(7.5 \times 50) / \sqrt{0.9273}] + \{ (50 - 50) * [927.3/150] \} \\ \text{MP} &= [375 / 0.9630] + \{ 0 * 6.18 \} \\ \text{MP} &= 389.4 \text{ mW} \end{aligned}$$

The calculated output power 214 mW (Peak) is less than the SAR Exclusion Threshold of 389.4 mW.

Therefore standalone SAR evaluation for general population exposure conditions by measurement or numerical simulation is not required. Section 4.3 General SAR test reduction and exclusion guidance