

Report on the Radio Testing

For

EkkoSense Ltd

on

EkkoHub

Report no. TRA-050806-47-00A

31 March 2021

RF915 7.0



Report Number: TRA-050806-47-00A  
Issue: A

REPORT ON THE RADIO TESTING OF A  
EkkoSense Ltd  
EkkoHub  
WITH RESPECT TO SPECIFICATION  
FCC 47CFR 15.247

TEST DATE: 5th - 13th January 2021

Written by:

D Winstanley  
Radio Senior Test Engineer

Approved by:

J Charters  
Lab Manager

Date: 31 March 2021

Disclaimers:

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

## 1 Revision Record

<i>Issue Number</i>	<i>Issue Date</i>	<i>Revision History</i>
A	31 March 2021	Original

## 2 Summary

TEST REPORT NUMBER: TRA-050806-47-00A

WORKS ORDER NUMBER TRA-050806-01

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): EkkoHub

FCC IDENTIFIER: 2AP4G-FS-EH-03

EUT SERIAL NUMBER: D0-14-11-00-00-2D, D0-14-11-00-00-28

MANUFACTURER/AGENT: EkkoSense Ltd

ADDRESS: Sir Colin Campbell Building  
University of Nottingham Innovation Park  
Triumph Road  
Nottingham  
NG7 2TU  
United Kingdom

CLIENT CONTACT: David Corder  
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TEST DATE: 5th - 13th January 2021

TESTED BY: D Winstanley  
Element

## 2.1 Test Summary

<i>Test Method and Description</i>		<i>Requirement Clause 47CFR15</i>	<i>Applicable to this equipment</i>	<i>Result / Note</i>
Radiated spurious emissions (restricted bands of operation and cabinet radiation)		15.205	<input checked="" type="checkbox"/>	<i>Pass</i>
AC power line conducted emissions		15.207	<input checked="" type="checkbox"/>	<i>Pass</i>
Occupied bandwidth		15.247(a)(2)	<input checked="" type="checkbox"/>	<i>Pass</i>
Conducted carrier power	Peak	15.247(b)(3)	<input checked="" type="checkbox"/>	<i>Pass</i>
	Max.		<input type="checkbox"/>	
Conducted / radiated RF power out-of-band		15.247(d)	<input checked="" type="checkbox"/>	<i>Pass</i>
Power spectral density, conducted		15.247(e)	<input checked="" type="checkbox"/>	<i>Pass</i>
Calculation of duty correction		15.35(c)	<input type="checkbox"/>	<i>N/A</i>

### 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-050806-47-00A presents the results of the Radio testing on a EkkoSense Ltd, EkkoHub to specification 47CFR15 Radio Frequency Devices.

The testing was carried out for EkkoSense Ltd by Element, at the address detailed below.

<input type="checkbox"/>	Element Hull Unit E South Orbital Trading Park Hedon Road Hull HU9 1NJ UK	<input checked="" type="checkbox"/>	Element Skelmersdale Unit 1 Pendle Place Skemersdale West Lancashire WN8 9PN UK
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This report details the configuration of the equipment, the test methods used and any relevant modifications where appropriate.

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

Throughout this report EUT denotes equipment under test.

FCC Site Listing:

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

IC Registration Number(s):

Element Hull	3483A
Element North West	3930B

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

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



## **5 Test Specifications**

### **5.1 Normative References**

- FCC 47 CFR Ch. I – Part 15 – Radio Frequency Devices.
- ANSI C63.10-2013 – American National Standard of Procedures for Compliance Testing of Unlicensed Wireless Devices.
- ANSI C63.4-2014 – American National Standard for Methods of Measurement of Radio-Noise Emissions from Low-Voltage Electrical and Electronic Equipment in the Range of 9 kHz to 40 GHz.

### **5.2 Deviations from Test Standards**

There were no deviations from the test standard.

## 6 Glossary of Terms

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

## 7 Equipment Under Test

### 7.1 EUT Identification

- Name: EkkoHub
- Serial Number: D0-14-11-00-00-2D, D0-14-11-00-00-28
- Model Number: FS-EH-03
- 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.

#### Customer support Equipment

POE switch (GS108PE) with PSU (S10 & S12)  
Dell Precision M4400 laptop with PSU (S03 & S04)

### 7.3 EUT Mode of Operation

#### 7.3.1 Transmission

The mode of operation for Tx tests was as follows:-  
The EUT was set to permanently transmit a modulated carrier.

### 7.4 EUT Radio Parameters

#### 7.4.1 General

<b>Frequency of operation:</b>	923.0 MHz
<b>Modulation type(s):</b>	GFSK
<b>Occupied channel bandwidth(s):</b>	>500 kHz
<b>Channel spacing:</b>	Single Frequency only
<b>ITU emission designator(s):</b>	753KF1D
<b>Declared output power(s):</b>	5 dBm (Conducted)
<b>Nominal Supply Voltage:</b>	5 Vdc (from AC Mains Adaptor) or POE

### 7.4.2 Antennas

<b>Manufacturer</b>	Taoglas	Pulse Electronics / Larsen Antenna
<b>Model:</b>	FXUB66.07.0150C	W1063M
<b>Type:</b>	flexible wideband	902-928MHZ Swivel Type Dipole
<b>Frequency range:</b>	650 MHz - 6000MHz	902-928 MHz
<b>Impedance:</b>	50Ω	50Ω
<b>Gain:</b>	2.7 dBi (650 MHz – 900 MHz)	1.0 dBi
<b>Polarisation:</b>	Linear	Vertical
<b>Beam width:</b>	Omni-Directional	Omni-Directional
<b>Connector type:</b>	IPEX MHFI U.FL Compatible(Fully customizable)	SMA Male
<b>Length:</b>	120.4 x 50.4 x 0.2 mm	195±2mm
<b>Environmental limits:</b>	-40°C to 85°C	-20° C /+65° C
<b>Mounting:</b>	adhesive	Screw on

### 7.4.3 Product specific declarations

<b>Multiple antenna configuration(s), e.g. MIMO:</b>	Single
<b>Fixed pt-pt operations (yes/no):</b>	No
<b>Installation manual advice on pt-pt operational restrictions (yes/no):</b>	N/A
<b>Fixed pt-mpt operations (yes/no):</b>	No
<b>Simultaneous tx (yes/no):</b>	N/A

### 7.5 EUT Description

The EUT is a Hub used to receive radio messages from sensors.

## **8 Modifications**

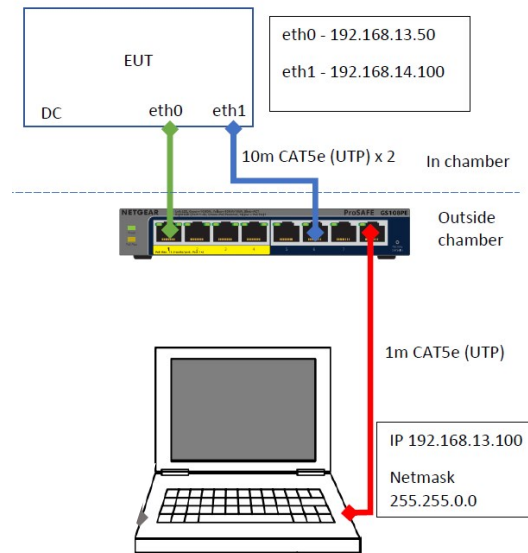
No modifications were performed during this assessment.

## 9 EUT Test Setup

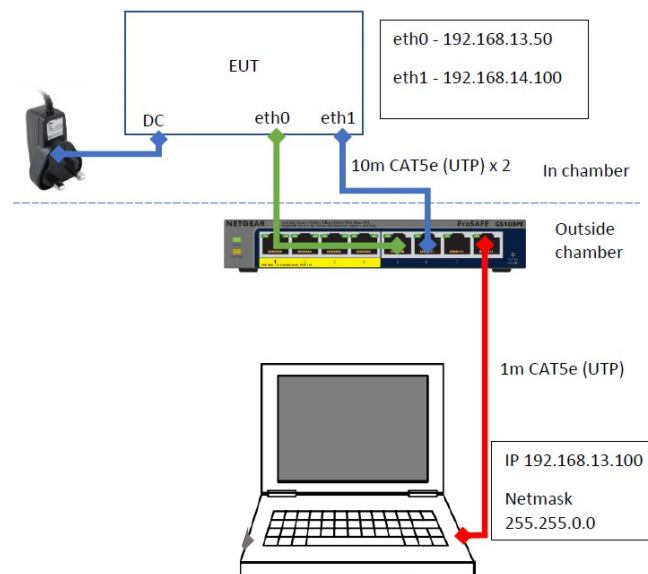
### 9.1 Block Diagram

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

EkkoHub Test configuration – POE Powered

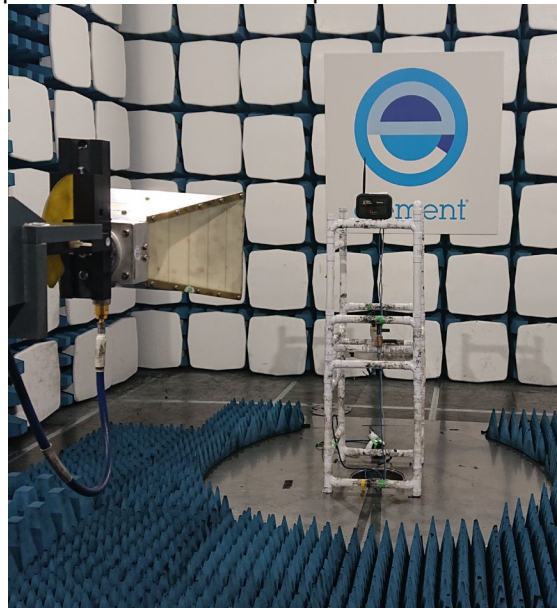


EkkoHub Test configuration – POE Powered



## 9.2 General Set-up Photograph

The following photograph shows basic EUT set-up:



Setup Overview



EUT With External Antenna



EUT With integral Antenna

## 9.3 Measurement software

Where applicable, the following software was used to perform measurements contained within this report.

Element Emissions R5 (See Note)  
 Element Transmitter Bench Test (See Note)  
 ETS Lindgren EMPower V1.0.4.2

Note:

The version of the Element software used is recorded in the results sheets contained within this report.

## 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. 5 V dc from the adaptor or powered via POE.

### 10.2 Varying Test Conditions

There are no specific frequency stability requirements for the type of device. The results contained in this report demonstrate that the occupied bandwidth is contained within the authorised band.

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

	<b>Category</b>	<b>Nominal</b>	<b>Variation</b>
<input type="checkbox"/>	Mains	110 V ac +/-2 %	85 % and 115 %
<input type="checkbox"/>	Battery	New battery	N/A
<input checked="" type="checkbox"/>	Other	5 Vdc	85 % and 115 %



## 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 (SK03)
Test Standard and Clause:	ANSI C63.10-2013, Clause 6.5 and 6.6
EUT Frequency Measured:	923.0 MHz
Deviations From Standard:	None
Measurement BW:	30 MHz to 1 GHz: 120 kHz; Above 1 GHz: 1 MHz
Measurement Detector:	Up to 1 GHz: quasi-peak; Above 1 GHz: RMS average and Peak

### Environmental Conditions (Normal Environment)

Temperature: 23°C	+15 °C to +35 °C (as declared)
Humidity: 40 % RH	20 % RH to 75 % RH (as declared)

### 11.3 Test Limit

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

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

<i>Frequency (MHz)</i>	<i>Field Strength (<math>\mu</math>V/m at 3 m)</i>
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 dB $\mu$ V/m at the regulatory distance, using:

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

$$\text{Factor} = CL + AF - PA$$

Where,

PR is the power recorded on the receiver / spectrum analyzer in dB $\mu$ V;

CL is the cable loss in dB;

AF is the test antenna factor in dB/m;

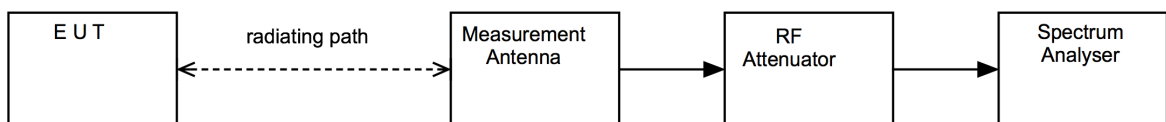
PA is the pre-amplifier gain in dB (where used);

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

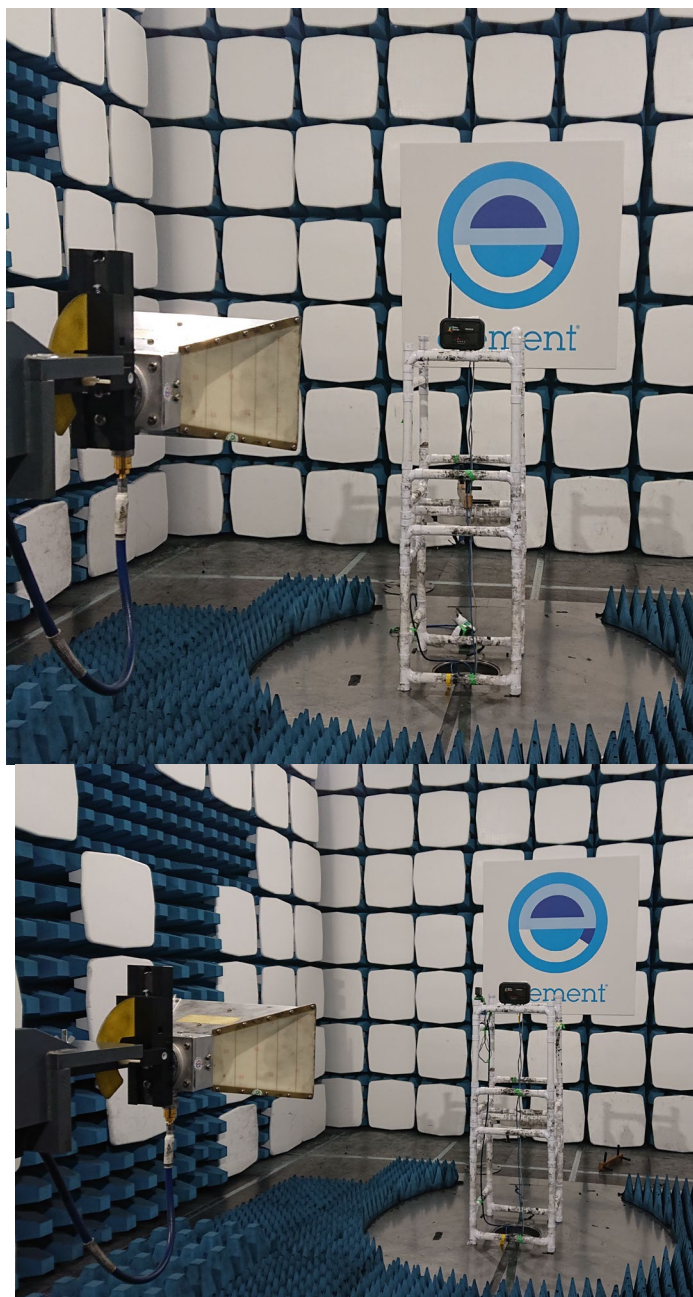
CF is the distance factor in dB (where measurement distance different to limit distance);

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

**Figure i Test Setup**



**11.5 Test Set-up Photograph**

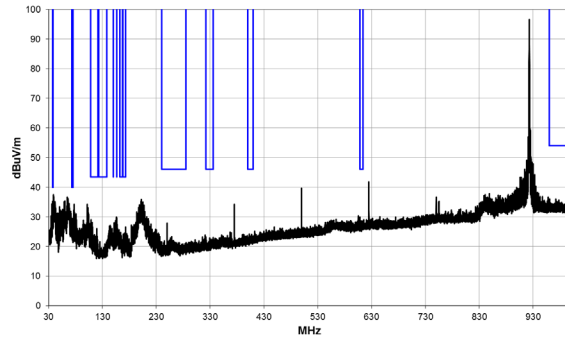


**11.6 Test Equipment**

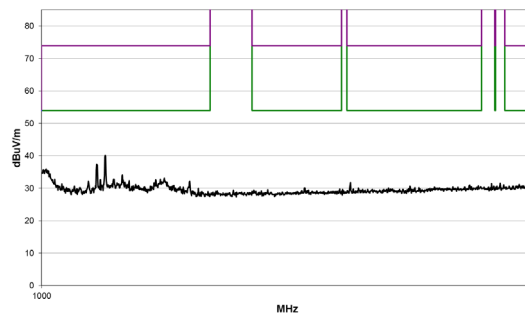
Equipment Type	Manufacturer	Equipment Description	Element No	Due For Calibration
CBL611/A	Chase	Bilog	U573	2021-09-19
FSU26	R&S	Spectrum Analyser	REF909	2021-07-09
8449B	Agilent	Pre Amp	L572	2021-10-19
3115	EMCO	1-18GHz Horn	L139	2021-07-16
6201-69	Watkins Johnson	PreAmp	U372	2021-02-26
VHF-1500+	MiniCircuits	High Pass Filter	U519	2021-01-22

### 11.7 Test Results

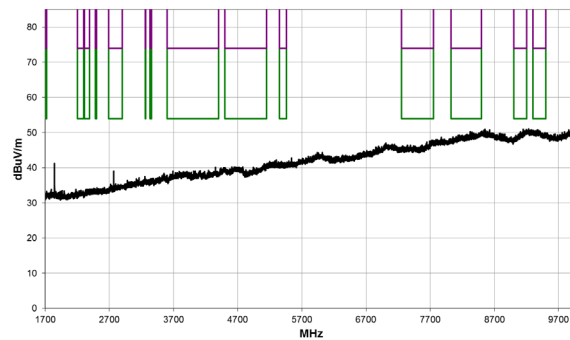
Internal Antenna – 5 Vdc from Mains Adaptor



30 MHz – 1 GHz



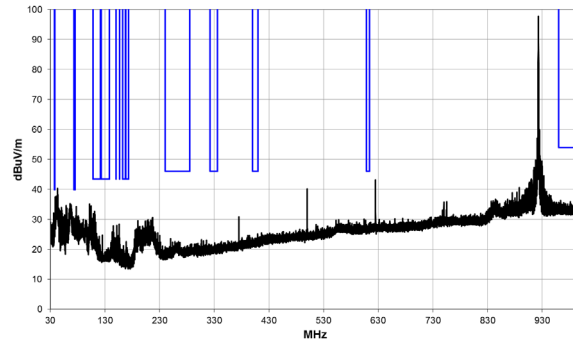
1 GHz – 1.7 GHz



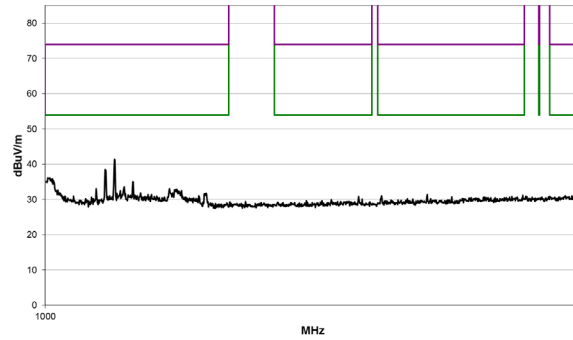
1.7 GHz – 10 GHz

Freq (MHz)	Amplitude (dBuV)	Factor (dB)	Antenna Height (meters)	Azimuth (degrees)	Test Distance (meters)	External Attenuation (dB)	Polarity/ Transducer Type	Detector	Distance Adjustment (dB)	Adjusted (dBuV/m)	Spec. Limit (dBuV/m)	Compared to Spec. (dB)
1091.000	49.9	-11.6	1.6	8.1	3.0	0.0	Horz	AV	0.0	38.3	54.0	-15.7
1091.292	57.2	-11.6	1.6	8.1	3.0	0.0	Horz	PK	0.0	45.6	74.0	-28.4
2768.392	34.5	-2.2	1.6	2.0	3.0	0.0	Horz	AV	0.0	32.3	54.0	-21.7
2769.767	47.9	-2.2	1.6	2.0	3.0	0.0	Horz	PK	0.0	45.7	74.0	-28.3

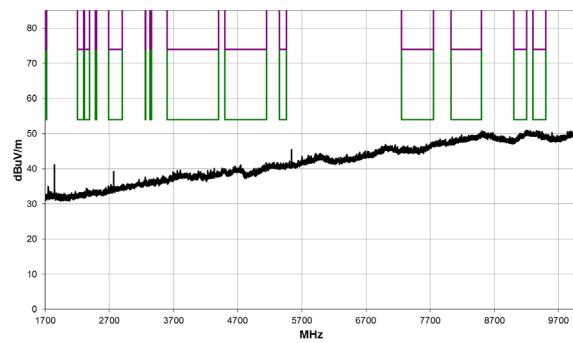
Internal Antenna – POE



30 MHz – 1 GHz



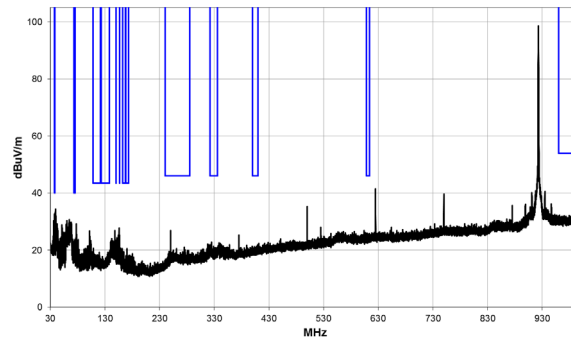
1 GHz – 1.7 GHz



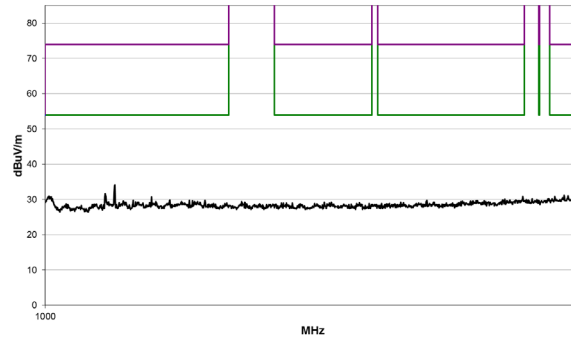
1.7 GHz – 10 GHz

Freq (MHz)	Amplitude (dBuV)	Factor (dB)	Antenna Height (meters)	Azimuth (degrees)	Test Distance (meters)	External Attenuation (dB)	Polarity/Transducer Type	Detector	Distance Adjustment (dB)	Adjusted (dBuV/m)	Spec. Limit (dBuV/m)	Compared to Spec. (dB)
73.067	40.2	-15.7	1.12	315.0	3.0	0.0	Vert	QP	0.0	24.5	40.0	-15.5
1091.008	50.6	-11.6	1.6	358.1	3.0	0.0	Horz	AV	0.0	39.0	54.0	-15.0
1090.733	58.2	-11.6	1.6	358.1	3.0	0.0	Horz	PK	0.0	46.6	74.0	-27.4
2768.408	36.6	-2.2	1.19	327.0	3.0	0.0	Vert	AV	0.0	34.4	54.0	-19.6
2769.550	48.4	-2.2	1.19	327.0	3.0	0.0	Vert	PK	0.0	46.2	74.0	-27.8

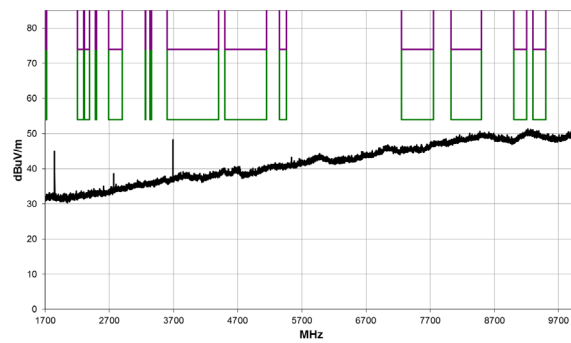
External Antenna – 5 Vdc from Mains Adaptor



30 MHz – 1 GHz



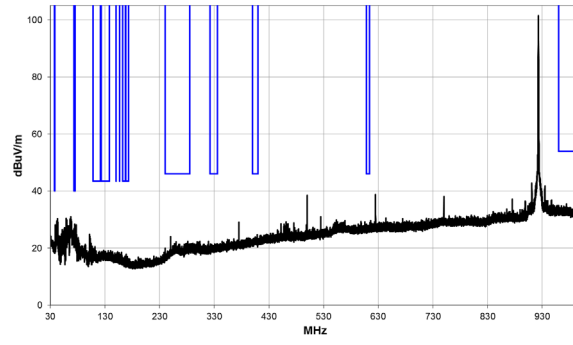
1 GHz – 1.7 GHz



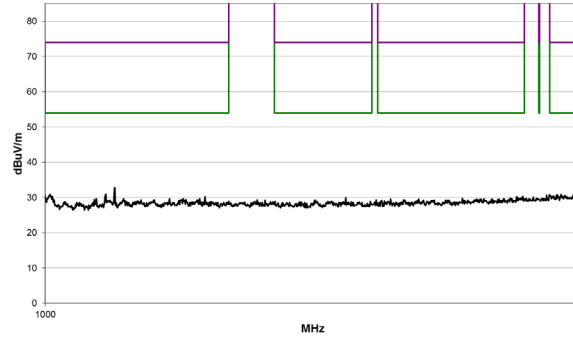
1.7 GHz – 10 GHz

Freq (MHz)	Amplitude (dBuV)	Factor (dB)	Antenna Height (meters)	Azimuth (degrees)	Test Distance (meters)	External Attenuation (dB)	Polarity/Transducer Type	Detector	Distance Adjustment (dB)	Adjusted (dBuV/m)	Spec. Limit (dBuV/m)	Compared to Spec. (dB)
3691.217	39.6	1.4	1.6	130.0	3.0	0.0	Horz	AV	0.0	41.0	54.0	-13.0
3692.917	50.5	1.4	1.6	130.0	3.0	0.0	Horz	PK	0.0	51.9	74.0	-22.1

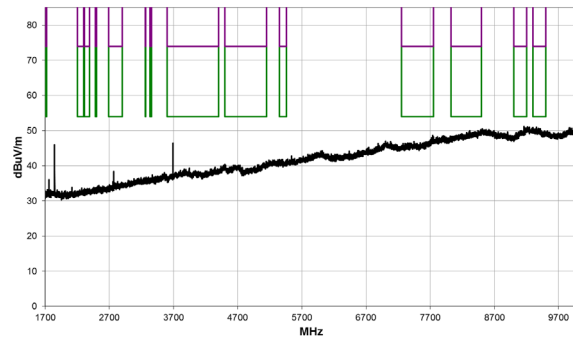
External Antenna – POE



30 MHz – 1 GHz



1 GHz – 1.7 GHz



1.7 GHz – 10 GHz

Freq (MHz)	Amplitude (dBuV)	Factor (dB)	Antenna Height (meters)	Azimuth (degrees)	Test Distance (meters)	External Attenuation (dB)	Polarity/ Transducer Type	Detector	Distance Adjustment (dB)	Adjusted (dBuV/m)	Spec. Limit (dBuV/m)	Compared to Spec. (dB)
3691.200	40.2	1.4	1.31	117.9	3.0	0.0	Horz	AV	0.0	41.6	54.0	-12.4
3691.050	51.0	1.4	1.31	117.9	3.0	0.0	Horz	PK	0.0	52.4	74.0	-21.6

## 12 AC power-line conducted emissions

### 12.1 Definition

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

### 12.2 Test Parameters

Test Location:	Element Skelmersdale
Test Chamber:	LF Laboratory (U404)
Test Standard and Clause:	ANSI C63.10-2013, Clause 6.2
EUT Channels / Frequencies Measured:	923.0 MHz
EUT Modulation:	GFSK
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: 21 % RH	20 % RH to 75 % RH (as declared)

### 12.3 Test Limit

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

**Table 3 – AC Power Line Conducted Emission Limits**

Frequency (MHz)	Conducted limit (dB $\mu$ V)	
	Quasi-Peak	Average**
0.15 to 0.5	66 to 56*	56 to 46*
0.5 to 5	56	46
5 to 30	60	50

\*The level decreases linearly with the logarithm of the frequency.

\*\*A linear average detector is required.



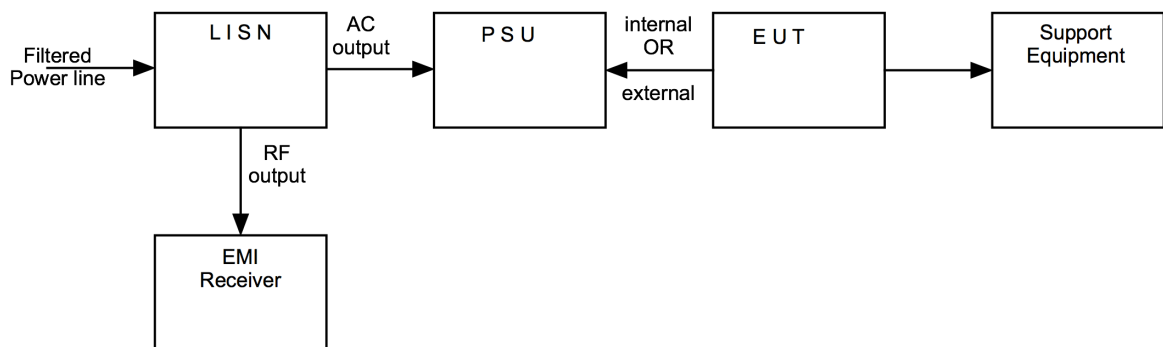
**12.4 Test Method**

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

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

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

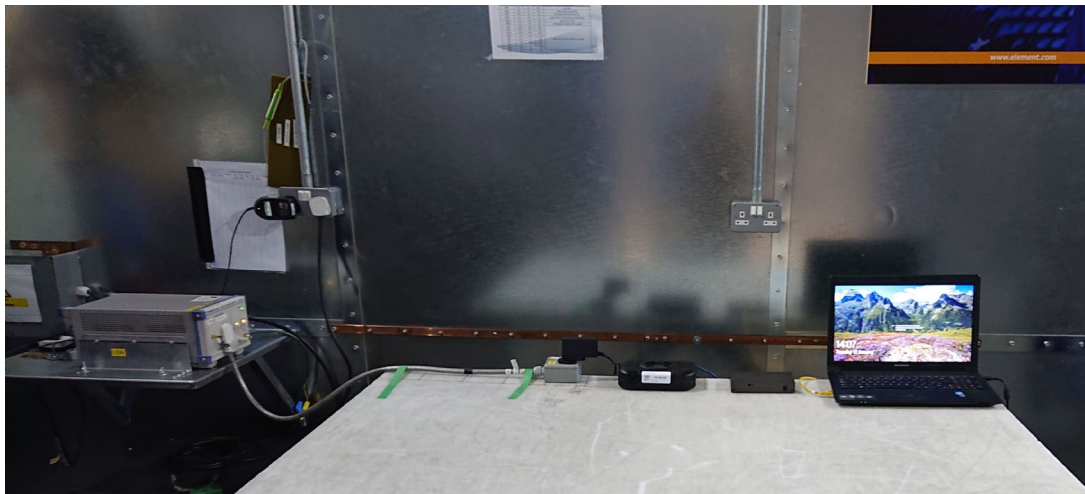
**Figure ii Test Setup**



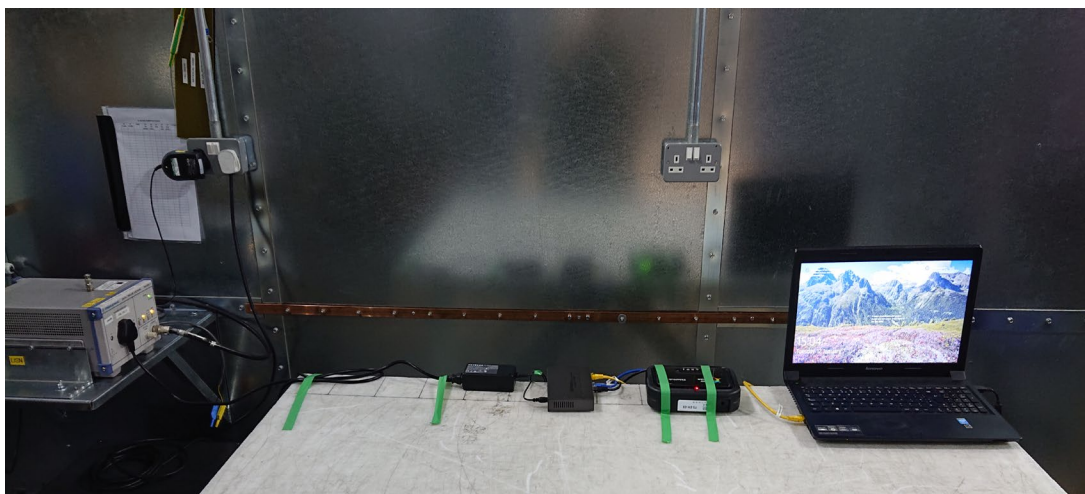
**12.5 Test Equipment**

Equipment Type	Manufacturer	Equipment Description	Element No	Due For Calibration
ESHS10	R&S	Measuring Receiver	RFG125	2016-04-17
ENV216	R&S	Lisn	U396	2021-09-07
ESH3-Z2	R&S	Pulse Limiter	U443	2022-02-12

### 12.6 Test Set-up Photograph



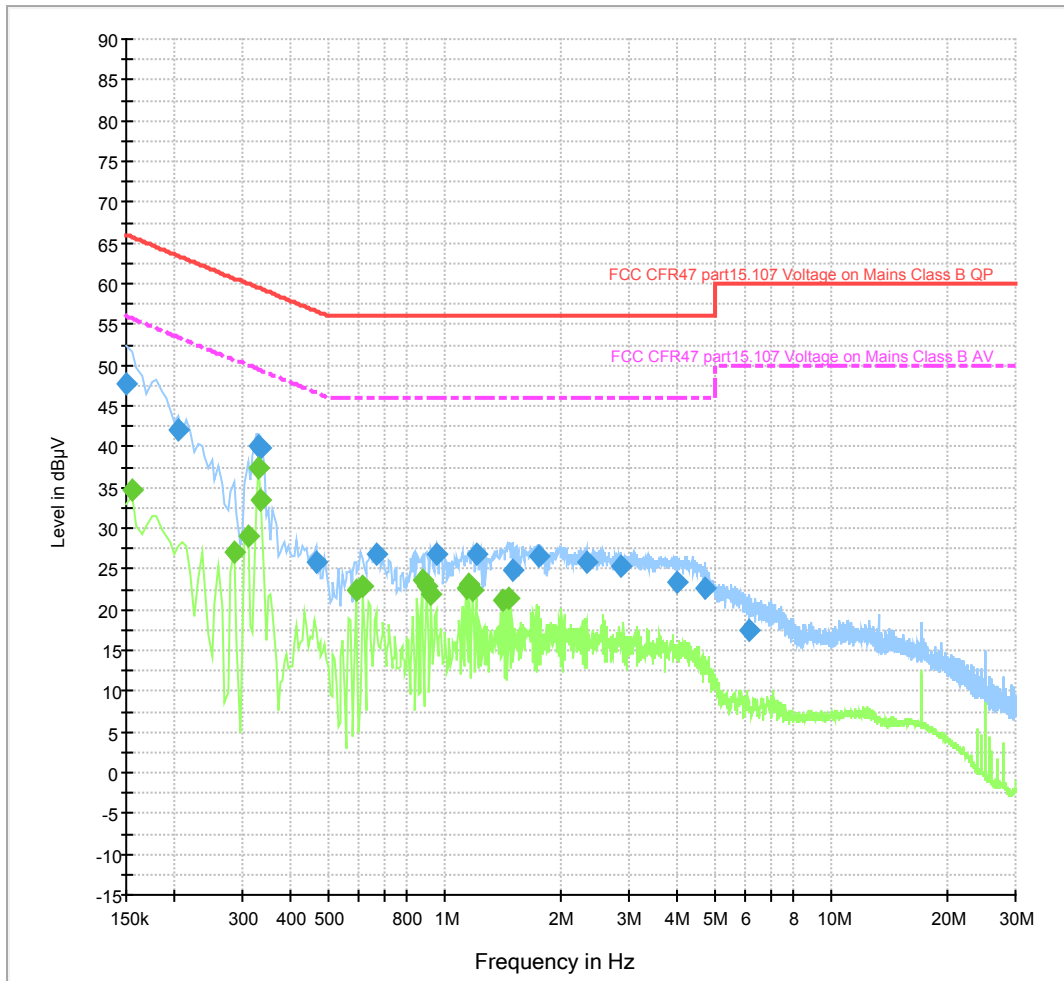
EUT powered By PSU



EUT powered By POE

### 12.7 Test Results - PSU

Conducted emissions on Mains 9kHz-30MHz ESHS10+UH396+UH443PL

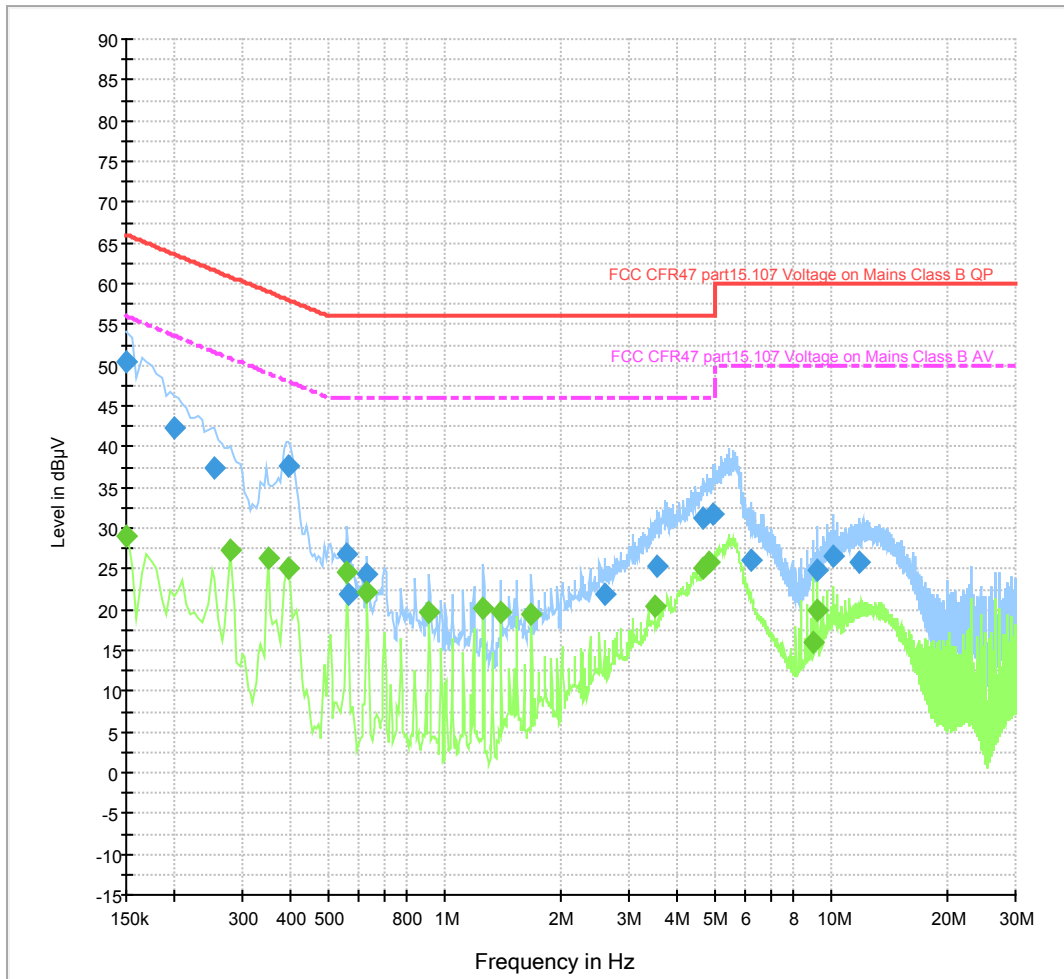


Quasi Peak Detector								
Frequency (MHz)	QuasiPeak (dBµV)	Meas. Time (ms)	Bandwidth (kHz)	Filter	Line	Corr. (dB)	Margin (dB)	Limit (dBµV)
0.150000	47.7	2000.0	10.000	On	L1	19.9	18.3	66.0
0.205000	42.1	2000.0	10.000	On	N	19.8	21.4	63.4
0.330000	40.0	2000.0	10.000	On	L1	19.6	19.4	59.5
0.335000	39.9	2000.0	10.000	On	N	19.6	19.4	59.3
0.465000	25.8	2000.0	10.000	On	N	19.6	30.8	56.6
0.670000	26.8	2000.0	10.000	On	N	19.5	29.2	56.0
0.950000	26.9	2000.0	10.000	On	N	19.5	29.1	56.0
1.210000	26.9	2000.0	10.000	On	N	19.5	29.1	56.0
1.500000	24.8	2000.0	10.000	On	N	19.5	31.2	56.0
1.750000	26.6	2000.0	10.000	On	N	19.5	29.4	56.0
2.320000	25.7	2000.0	10.000	On	N	19.5	30.3	56.0
2.865000	25.4	2000.0	10.000	On	N	19.5	30.6	56.0
3.985000	23.3	2000.0	10.000	On	L1	19.6	32.7	56.0
4.715000	22.6	2000.0	10.000	On	N	19.6	33.4	56.0
6.150000	17.4	2000.0	10.000	On	L1	19.6	42.6	60.0

Average Detector								
Frequency (MHz)	Average (dBµV)	Meas. Time (ms)	Bandwidth (kHz)	Filter	Line	Corr. (dB)	Margin (dB)	Limit (dBµV)
0.155000	34.6	2000.0	10.000	On	N	19.9	21.2	55.7
0.285000	27.1	2000.0	10.000	On	L1	19.7	23.6	50.7
0.310000	29.1	2000.0	10.000	On	L1	19.6	20.9	50.0
0.330000	37.3	2000.0	10.000	On	L1	19.6	12.1	49.5
0.335000	33.6	2000.0	10.000	On	L1	19.6	15.8	49.3
0.590000	22.4	2000.0	10.000	On	N	19.5	23.6	46.0
0.615000	22.8	2000.0	10.000	On	N	19.5	23.2	46.0
0.875000	23.6	2000.0	10.000	On	N	19.5	22.4	46.0
0.900000	22.9	2000.0	10.000	On	N	19.5	23.1	46.0
0.920000	21.8	2000.0	10.000	On	N	19.5	24.2	46.0
1.135000	22.6	2000.0	10.000	On	N	19.5	23.4	46.0
1.160000	23.0	2000.0	10.000	On	N	19.5	23.0	46.0
1.180000	22.5	2000.0	10.000	On	N	19.5	23.5	46.0
1.420000	21.1	2000.0	10.000	On	N	19.5	24.9	46.0
1.465000	21.5	2000.0	10.000	On	N	19.5	24.5	46.0

### 12.8 Test Results - POE

Conducted emissions on Mains 9kHz-30MHz ESHS10+UH396+UH443PL



Quasi Peak Detector								
Frequency (MHz)	QuasiPeak (dBμV)	Meas. Time (ms)	Bandwidth (kHz)	Filter	Line	Corr. (dB)	Margin (dB)	Limit (dBμV)
0.150000	50.4	2000.0	10.000	On	L1	19.9	15.6	66.0
0.200000	42.4	2000.0	10.000	On	L1	19.8	21.2	63.6
0.255000	37.3	2000.0	10.000	On	N	19.7	24.3	61.6
0.395000	37.7	2000.0	10.000	On	N	19.6	20.2	58.0
0.560000	26.9	2000.0	10.000	On	N	19.5	29.1	56.0
0.565000	21.9	2000.0	10.000	On	N	19.5	34.1	56.0
0.630000	24.3	2000.0	10.000	On	L1	19.5	31.7	56.0
2.590000	22.0	2000.0	10.000	On	N	19.5	34.0	56.0
3.550000	25.4	2000.0	10.000	On	L1	19.5	30.6	56.0
4.670000	31.2	2000.0	10.000	On	L1	19.6	24.8	56.0
4.945000	31.7	2000.0	10.000	On	L1	19.6	24.3	56.0
6.210000	26.1	2000.0	10.000	On	L1	19.6	33.9	60.0
9.240000	24.7	2000.0	10.000	On	L1	19.7	35.3	60.0
10.080000	26.5	2000.0	10.000	On	L1	19.7	33.5	60.0
11.865000	25.8	2000.0	10.000	On	L1	19.7	34.2	60.0

Average Detector								
Frequency (MHz)	Average (dBμV)	Meas. Time (ms)	Bandwidth (kHz)	Filter	Line	Corr. (dB)	Margin (dB)	Limit (dBμV)
0.150000	29.1	2000.0	10.000	On	L1	19.9	26.9	56.0
0.280000	27.3	2000.0	10.000	On	N	19.7	23.5	50.8
0.350000	26.2	2000.0	10.000	On	N	19.6	22.7	49.0
0.395000	25.1	2000.0	10.000	On	N	19.6	22.8	48.0
0.560000	24.6	2000.0	10.000	On	N	19.5	21.4	46.0
0.630000	22.2	2000.0	10.000	On	L1	19.5	23.8	46.0
0.910000	19.6	2000.0	10.000	On	N	19.5	26.4	46.0
1.260000	20.2	2000.0	10.000	On	N	19.5	25.8	46.0
1.400000	19.6	2000.0	10.000	On	L1	19.5	26.4	46.0
1.680000	19.5	2000.0	10.000	On	L1	19.5	26.5	46.0
3.500000	20.4	2000.0	10.000	On	L1	19.5	25.6	46.0
4.680000	25.2	2000.0	10.000	On	L1	19.6	20.8	46.0
4.850000	25.9	2000.0	10.000	On	L1	19.6	20.1	46.0
8.960000	15.9	2000.0	10.000	On	L1	19.7	34.1	50.0
9.240000	19.9	2000.0	10.000	On	L1	19.7	30.1	50.0

## 13 Occupied Bandwidth

### 13.1 Definition

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

### 13.2 Test Parameters

Test Location:	Element Skelmersdale
Test Chamber:	Radio Laboratory
Test Standard and Clause:	IC: ANSI C63.10-2013, Clause 6.9 FCC: ANSI C63.10-2013, Clause 11.8
EUT Channels / Frequencies Measured:	923.0 MHz
EUT Test Modulations:	GFSK
Deviations From Standard:	None
Measurement BW: (IC requirement: 1% to 5% OBW; FCC requirement: 100 kHz)	100 kHz / 30 kHz
Spectrum Analyzer Video BW:	300 kHz / 100 kHz
Measurement Span:	5 MHz
Measurement Detector:	Peak

### Environmental Conditions (Normal Environment)

Temperature: 24 °C	+15 °C to +35 °C (as declared)
Humidity: 38 % RH	20 % RH to 75 % RH (as declared)

### 13.3 Test Limit

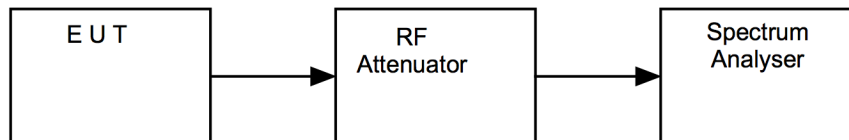
The minimum -6 dB bandwidth shall be at least 500 kHz.

### 13.4 Test Method

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

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

**Figure iii Test Setup**



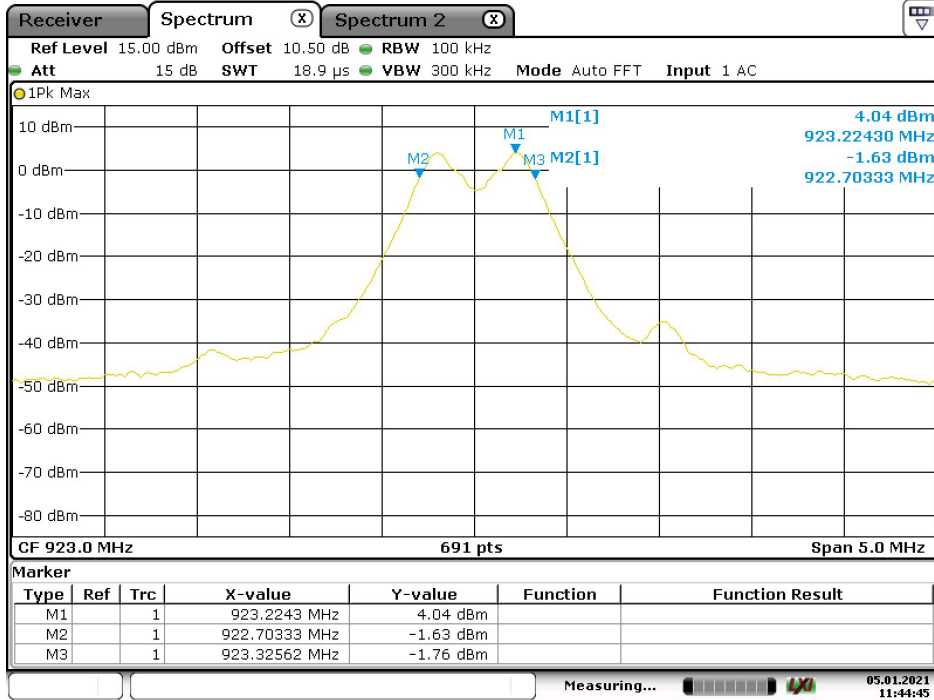
### 13.5 Test Equipment

Equipment Type	Manufacturer	Equipment Description	Element No	Due For Calibration
AA18-10H	Atlantec	10 dB Attenuator	U634	In Use
ESR7	R&S	EMI Receiver	U456	2021-12-17



13.6 Test Results

FCC 15.247. Modulation: GFSK 6 dB Bandwidth				
Channel Frequency (MHz)	$F_L$ (MHz)	$F_H$ (MHz)	6dB Bandwidth (kHz)	Result
923.0	922.70333	923.32562	622.29	PASS



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## 14 Maximum peak conducted output power

### 14.1 Definition

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

The maximum conducted output power is defined as the total transmit power delivered to all antennas and antenna elements averaged across all symbols in the signaling alphabet when the transmitter is operating at its maximum power control level.

### 14.2 Test Parameters

Test Location:	Element Skelmersdale
Test Chamber:	Radio Laboratory
Test Standard and Clause:	ANSI C63.10-2013, Clause 11.9.1
EUT Frequency Measured:	923.0 MHz
Deviations From Standard:	None
Measurement BW:	2 MHz
Spectrum Analyzer Video BW: (requirement at least 3x RBW)	10 MHz
Measurement Detector:	Peak
Voltage Extreme Environment Test Range:	Mains Power = 85 % and 115 % of Nominal (FCC only requirement); Battery Power = new battery.

### Environmental Conditions (Normal Environment)

Temperature: 24 °C	+15 °C to +35 °C (as declared)
Humidity: 38 % RH	20 % RH to 75 % RH (as declared)

### 14.3 Test Limit

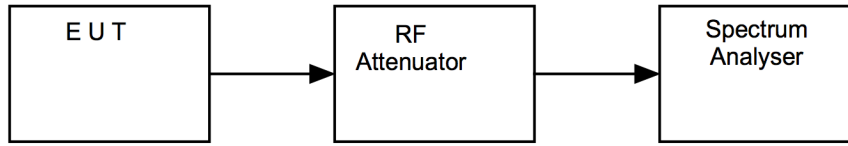
For systems employing digital modulation techniques operating in the bands 902 to 928 MHz, 2400 to 2483.5 MHz and 5725 to 5850 MHz, the maximum peak conducted output power shall not exceed 1 W.

### 14.4 Test Method

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

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

**Figure iv Test Setup**

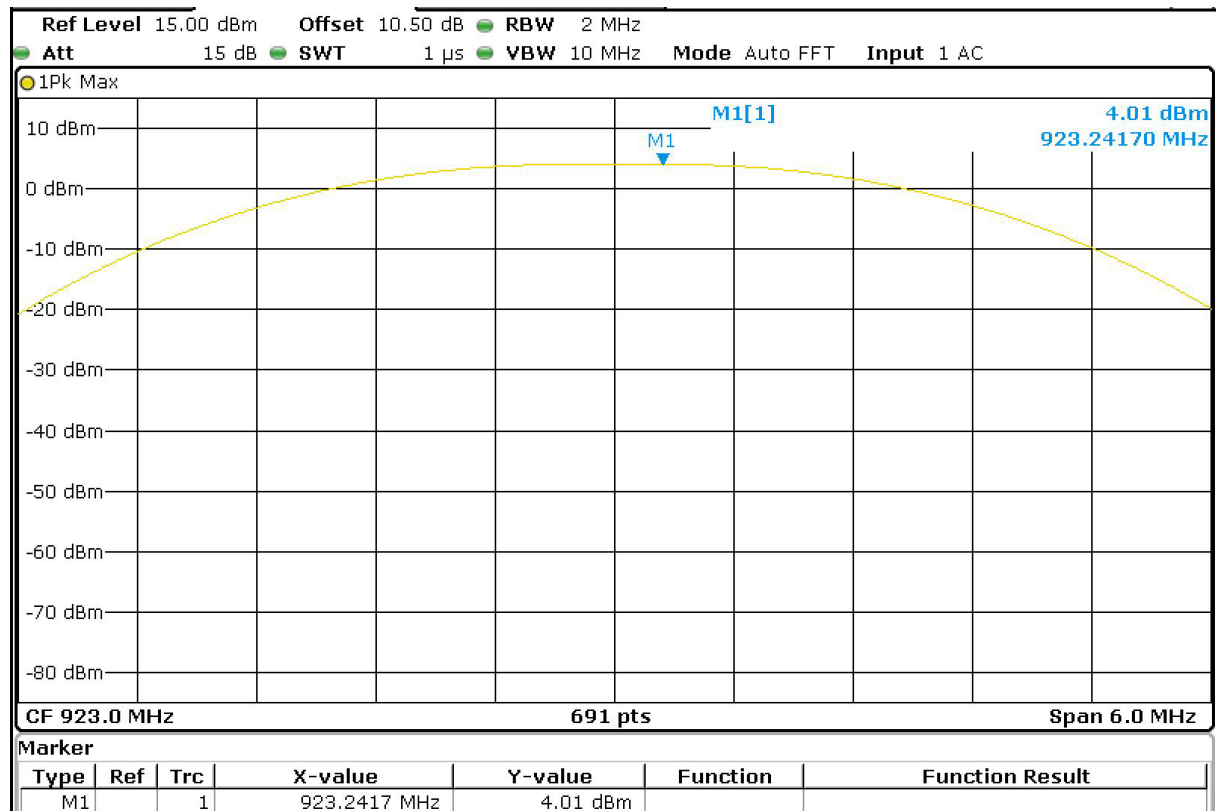


**14.5 Test Equipment**

Equipment Type	Manufacturer	Equipment Description	Element No	Due For Calibration
AA18-10H	Atlantec	10 dB Attenuator	U634	In Use
ESR7	R&S	EMI Receiver	U456	2021-12-17

**14.6 Test Results**

Channel Frequency (MHz)	Analyzer Level (dBm)	Cable loss (dB)	Power (mW)	Result
923	-6.49	10.50	2.52	PASS



## 15 Out-of-band and conducted spurious emissions

### 15.1 Definition

#### *Out-of-band emission.*

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

#### *Spurious emission.*

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

### 15.2 Test Parameters

Test Location:	Element Skelmersdale
Test Chamber:	Radio Laboratory
Test Standard and Clause:	ANSI C63.10-2013, Clause 11.11
EUT Frequency Measured:	923.0 MHz
Deviations From Standard:	None
Measurement BW:	100 kHz
Spectrum Analyzer Video BW: (requirement at least 3x RBW)	300 kHz
Measurement Detector:	Peak
Measurement Range:	9 kHz to 10 GHz

### Environmental Conditions (Normal Environment)

Temperature: 18 °C	+15 °C to +35 °C (as declared)
Humidity: 48 % RH	20 % RH to 75 % RH (as declared)

### 15.3 Test Limit

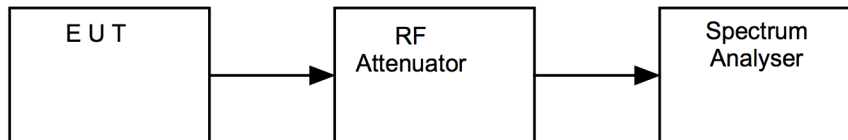
In any 100 kHz bandwidth outside the frequency band in which the spread spectrum or digitally modulated device is operating, the RF power that is produced shall be at least 20 dB below that in the 100 kHz bandwidth within the band that contains the highest level of the desired power, based on either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

### 15.4 Test Method

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

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

**Figure v Test Setup**



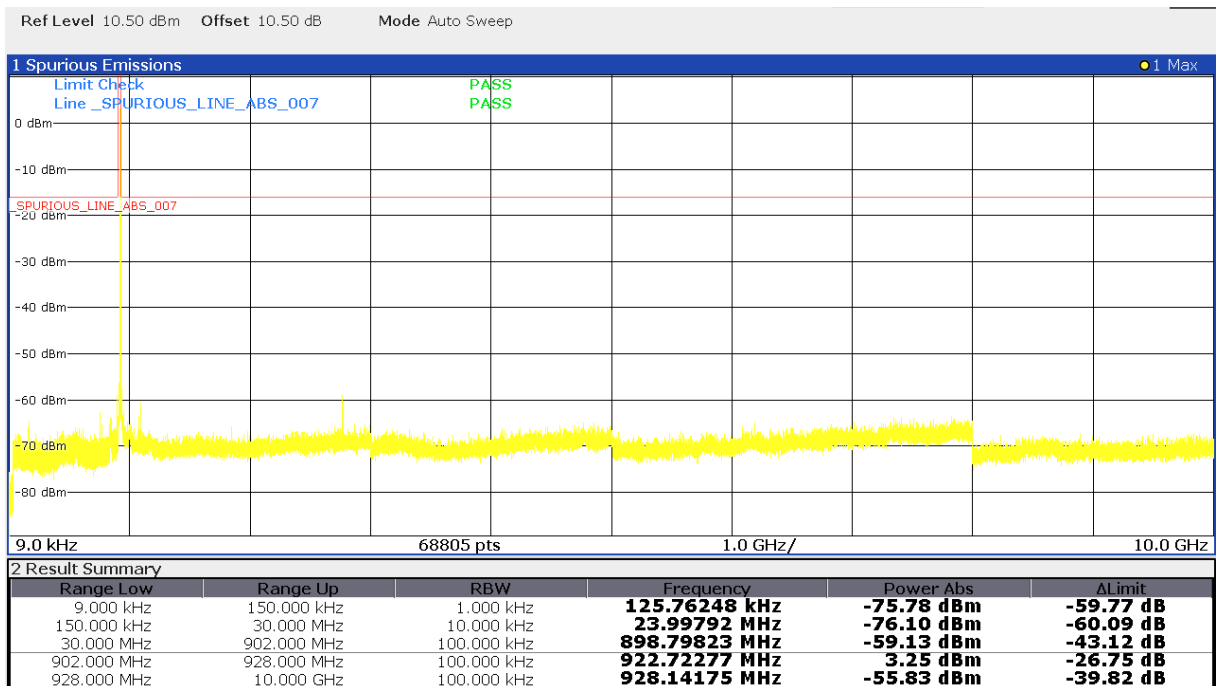
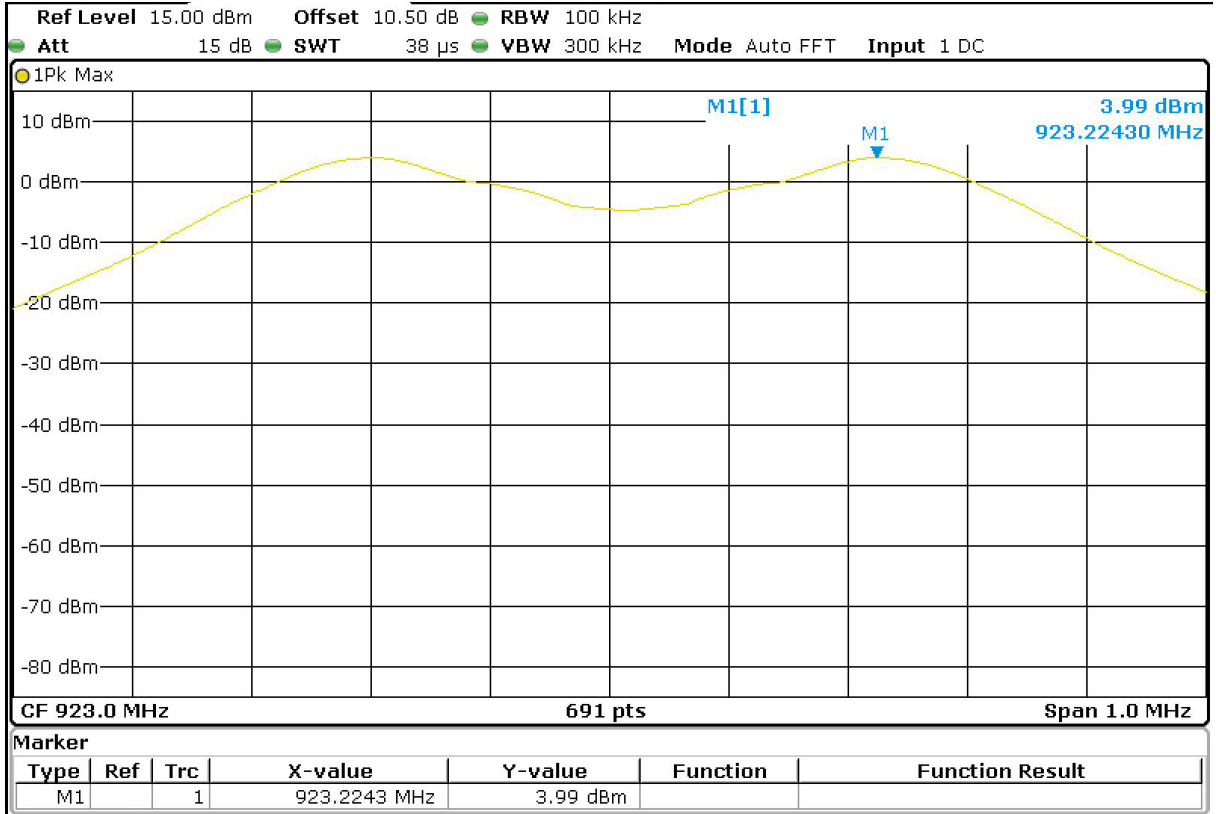
### 15.5 Test Equipment

Equipment Type	Manufacturer	Equipment Description	Element No	Due For Calibration
AA18-10H	Atlantec	10 dB Attenuator	U634	In Use
FSW26	Rohde & Schwarz	Spectrum Analyser	101805*	2021-07-23

\* Denotes Serial number of hired test equipment

15.6 Test Results

Channel Frequency (MHz)	Emission Frequency (MHz)	Analyzer Level (dBm)	Emission Level (dBm)	Limit (dBm)	Margin (dB)	Result
Low	923	3.99	3.99	N/A	N/A	PASS



## 16 Power spectral density

### 16.1 Definition

The power per unit bandwidth.

### 16.2 Test Parameters

Test Location:	Element Skelmersdale
Test Chamber:	Radio Laboratory
Test Standard and Clause:	ANSI C63.10-2013, Clause 11.10
EUT Frequency Measured:	923.0 MHz
Deviations From Standard:	None
Measurement BW:	100 kHz
Spectrum Analyzer Video BW: (requirement at least 3x RBW)	300 kHz
Measurement Span: (requirement 1.5 times Channel BW)	1 MHz
Measurement Detector:	Peak

### Environmental Conditions (Normal Environment)

Temperature: 24 °C	+15 °C to +35 °C (as declared)
Humidity: 38 % RH	20 % RH to 75 % RH (as declared)

### 16.3 Test Limit

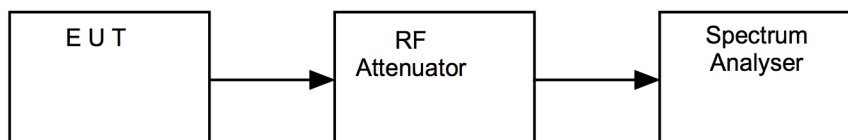
The transmitter power spectral density conducted from the transmitter to the antenna shall not be greater than 8 dBm in any 3 kHz band during any time interval of continuous transmission.

### 16.4 Test Method

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

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

**Figure vi Test Setup**



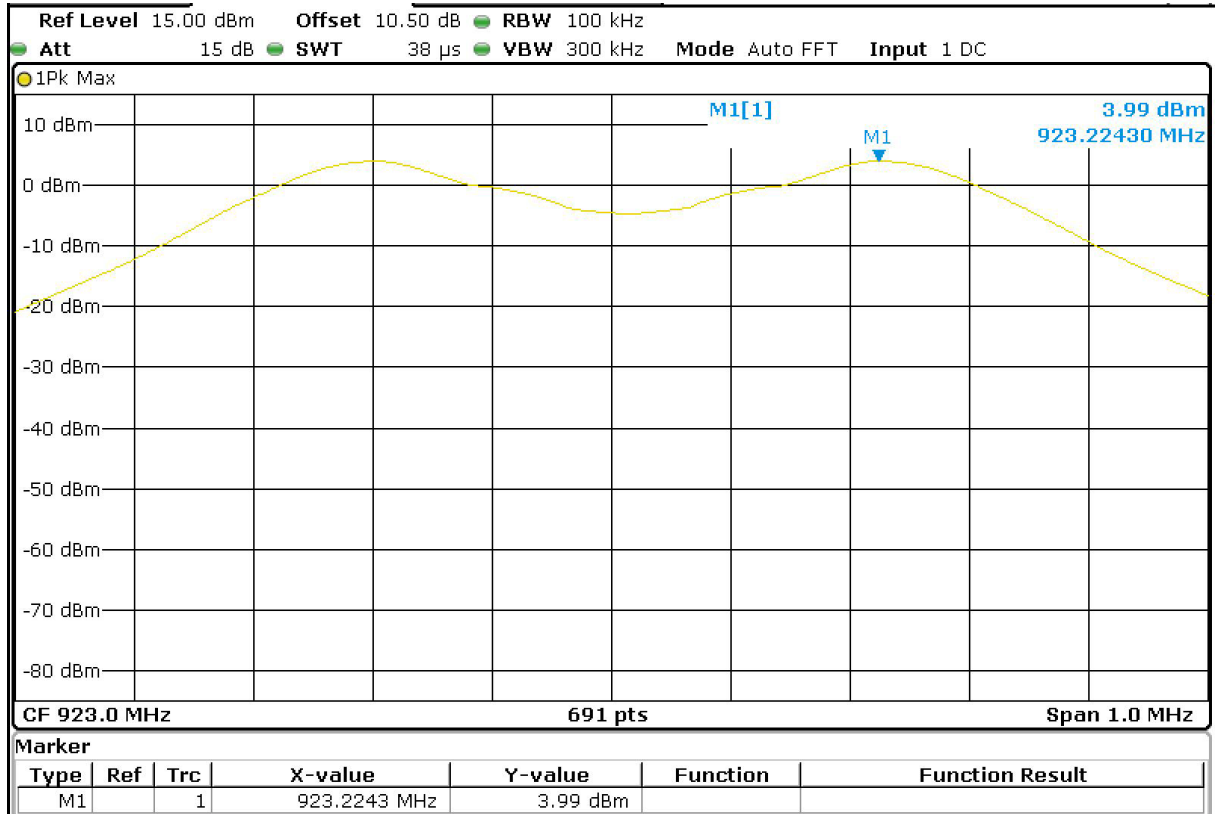
### 16.5 Test Equipment

Equipment Type	Manufacturer	Equipment Description	Element No	Due For Calibration
AA18-10H	Atlantec	10 dB Attenuator	U634	In Use
ESR7	R&S	EMI Receiver	U456	2021-12-17

### 16.6 Test Results

Channel Frequency (MHz)	Analyzer Level (dBm)	Cable loss (dB)	Power (dBm)	Result
923.0	-6.51	10.50	3.99	PASS

#





## 17 Measurement Uncertainty

### Calculated Measurement Uncertainties

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

#### [1] Radiated spurious emissions

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

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

#### [2] AC power line conducted emissions

Uncertainty in test result = **3.2 dB**

#### [3] Occupied bandwidth

Uncertainty in test result = **15.58 %**

#### [4] Conducted carrier power

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

#### [5] Conducted RF power out-of-band

Uncertainty in test result – up to 8.1 GHz = **3.31 dB**

Uncertainty in test result – 8.1 GHz to 15.3 GHz = **4.43 dB**

#### [6] Radiated RF power out-of-band

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

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

#### [7] Power spectral density

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

#### [8] ERP / EIRP

Uncertainty in test result (Laboratory) = **4.71 dB**

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

## 18 RF Exposure

### General SAR test reduction & exclusion guidance

#### Prediction of MPE limit at a given distance

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

Equation from IEEE C95.1

$$S = \frac{EIRP}{4\pi R^2} \text{ re - arranged } R = \sqrt{\frac{EIRP}{S4\pi}}$$

Where:

S = power density

R = distance to the centre of radiation of the antenna

EIRP = EUT Maximum power

Result

Frequency (MHz)	Maximum EIRP (mW)	Power density limit (mW/cm <sup>2</sup> )	Distance required to be less than the power density limit (cm)
923	5.0	0.6	0.8

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