Report on the Radio Testing

For

Extronics LTD

on

Plymouth project iTAG X30

Report no. TRA-048957-47-04B

22 July 2020

RF915 7.0

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Report Number: TRA-048957-47-04B
Issue: B

REPORT ON THE RADIO TESTING OF A
Extronics LTD
iTAG X30
WITH RESPECT TO SPECIFICATION
FCC 47CFR 15.247

TEST DATE: 2020-02-20

Written by: Steve Garwell cn=Steve Garwell, o=Element Material Technology, ou, email=steve.garwell@element.com, c=GB I am the author of this document 2020.07.24 09:16:24 +01'00'

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John Charters
Department Manager - Radio

Date: 22 July 2020

1 Revision Record

Issue Number	*Issue Date*	*Revision History*
A	2020-04-15	Original
B	22 July 2020	RF Exposure Updated

2 Summary

TEST REPORT NUMBER:	TRA-048957-47-04B
WORKS ORDER NUMBER:	TRA-048957-01
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):	47CFR 15.247
EQUIPMENT UNDER TEST (EUT):	iTAG X30
FCC IDENTIFIER:	2AIZEEXTRFID00003
EUT SERIAL NUMBER:	102
MANUFACTURER/AGENT:	Extronics LTD
ADDRESS:	1 Dalton Way Midpoint 18 Middlewich Cheshire CW10 0HU United Kingdom
CLIENT CONTACT:	Barry Ellis ☎ 01606 539636 ✉ ellis@extronics.com
ORDER NUMBER:	PO-0019901
TEST DATE:	20-2-2020
TESTED BY:	Daniel Moncayola Steve Garwell Michael Else Element

2.1 Test Summary

Test Method and Description		*Requirement Clause 47CFR15*	*Applicable to this equipment*	*Result / Note*
Radiated spurious emissions (restricted bands of operation and cabinet radiation)		15.205	☒	*PASS*
AC power line conducted emissions		15.207	☒	*PASS*
Occupied bandwidth		15.247(a)(2)	☒	*PASS*
Conducted carrier power	Peak	15.247(b)(3)	☒	*PASS*
	Max.		☐	
Conducted / radiated RF power out-of-band		15.247(d)	☒	*PASS*
Power spectral density, conducted		15.247(e)	☒	*PASS*
Calculation of duty correction		15.35(c)	☐	*Note 1*

Notes:

Note 1: Not applicable 100% duty cycle.

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).

3 Contents

4 Introduction

This report TRA-048957-47-04B presents the results of the Radio testing on a Extronics LTD, iTAG X30 to specification 47CFR15 Radio Frequency Devices Category I Equipment.

The testing was carried out for Extronics LTD by Element, at the address detailed below.

☐ Element Hull
Unit E
South Orbital Trading Park
Hedon Road
Hull
HU9 1NJ
UK

☒ Element Skelmersdale
Unit 1
Pendle Place
Skemersdale
West Lancashire
WN8 9PN
UK

This report details the configuration of the equipment, the test methods used and any relevant modifications where appropriate.

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

Throughout this report EUT denotes equipment under test.

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

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

§	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: iTAG X30
- Serial Number: 102
- Model Number: iTAG X30
- Software Revision: 1..22.4..7402.00
- Build Level / Revision Number: REV 2

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 Transmit tests was as follows:
The EUT was transmitting modulated carrier on the frequencies indicated.

7.4 EUT Radio Parameters

7.4.1 General

Frequencies of operation:	2402 MHz – 2480 MHz
Modulation type:	GFSK
Channel spacing:	2 MHz
Declared output power:	5 dBm
Nominal Supply Voltage:	3.7 Vdc

7.4.2 Antennas

Type:	PCB Trace antenna
Gain:	1.7 dBi

7.5 EUT Description

The Plymouth system is the next generation in Extronics Worker Safety solutions and is designed to accurately locate workers in all areas of Industrial/Processing sites whether in a Wi-Fi dense area or not. It will allow Wi-Fi tracking as well as GNSS cap

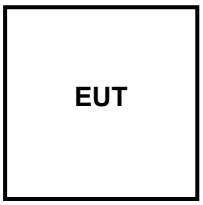
8 Modifications

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:

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 3.7 Vdc from a Lithium Ion battery.

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 Frequencies Measured:	2402 MHz / 2440 MHz / 2480 MHz
EUT Channel Bandwidths:	2 MHz
Deviations From Standard:	None
Measurement BW:	30 MHz to 1 GHz: 120 kHz Above 1 GHz: 1 MHz
Measurement Detector:	Up to 1 GHz: quasi-peak Above 1 GHz: RMS average and Peak

Environmental Conditions (Normal Environment)

Temperature: 21 °C	+15 ºC to +35 ºC (as declared)
Humidity: 38 % RH	20 % RH to 75 % RH (as declared)
Supply: 3.7 Vdc	3.7 Vdc (as declared)

11.3 Test Limit

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

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

Frequency (MHz)	***Field Strength (µV/m at 3 m)***
30 to 88	100
88 to 216	150
216 to 960	200
Above 960	500

11.4 Test Method

With the EUT setup as per section 9 of this report and connected as per Figure i, the emissions from the EUT were measured on a spectrum analyzer / EMI receiver.

Radiated electromagnetic emissions from the EUT are checked first by preview scans. Preview scans for all spectrum and modulation characteristics are checked, using a peak detector and where applicable worst-case determined for function, operation, orientation, etc. for both vertical and horizontal polarisations. Pre-scan plots are shown with a peak detector and 100 kHz RBW.

If the EUT connects to auxiliary equipment and is table or floor standing, the configurations prescribed in ANSI C63.10 are followed. Alternatively, a layout closest to normal use (as declared by the provider) is employed, (see EUT setup photographs for more detail).

Emissions between 30 MHz and 1 GHz are measured using calibrated broadband antennas. Emissions above 1 GHz are characterized using standard gain horn antennas. Pre-amplifiers and filters are used where required. Care is taken to ensure that test receiver resolution bandwidth, video bandwidth and detector type(s) meet the regulatory requirements.

For both horizontal and vertical polarizations, the EUT is then rotated through 360 degrees in azimuth until the highest emission is detected. At the previously determined azimuth the test antenna is raised and lowered from 1 to 4 m in height until a maximum emission level is detected, this maximum value is recorded.

Power values measured on the test receiver / analyzer are converted to field strength, FS, in dBµV/m at the regulatory distance, using:

$$FS = PR + CL + AF – PA + DC – CF$$

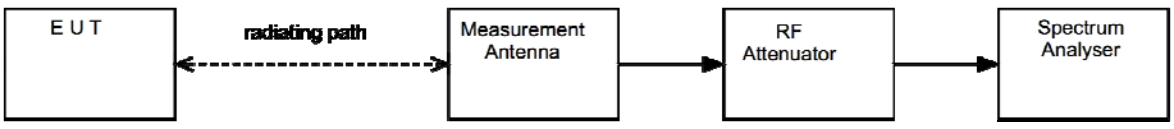
$$Factor – CL + AF - PA$$

Where,

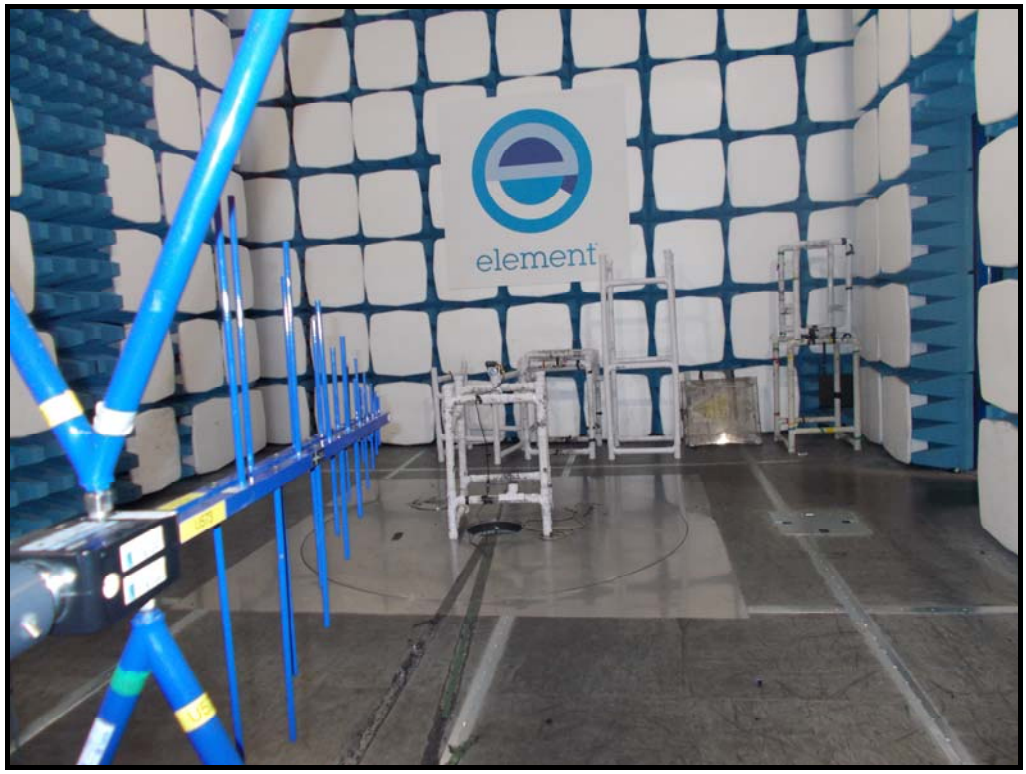
PR is the power recorded on the receiver / spectrum analyzer in dBµV;
CL is the cable loss in dB;
AF is the test antenna factor in dB/m;
PA is the pre-amplifier gain in dB (where used);
DC is the duty correction factor in dB (where used, e.g. harmonics of pulsed fundamental);
CF is the distance factor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



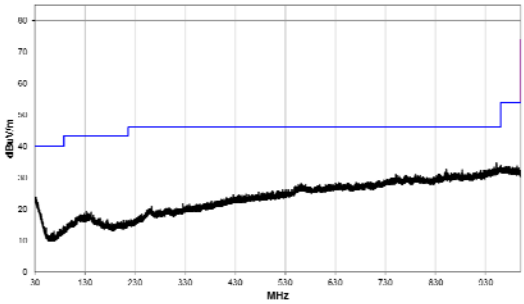
11.6 Test Equipment

Equipment Type	Manufacturer	Equipment Description	Element No	Due For Calibration
CBL611/A	Chase	Bilog	U573	2021-09-19
3115	EMCO	1-18GHz Horn	L139	2021-07-16
20240-20	Flann	Horn 18-26GHz (&U330)	L300	2020-04-24
8449B	Agilent	Pre Amp	L572	2020-10-15
PreAmp	Watkins Johnson	6201-69	U372	2021-02-26
AFH-07000	Atlantic Microwave	High Pass Filter	U558	2020-03-20
Spectrum Analyser	Keysight	N9030B	*MY57140717	2020-04-15

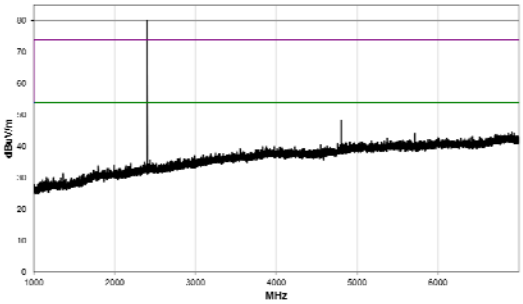
*Loan Spectrum Analyser

11.7 Test Results

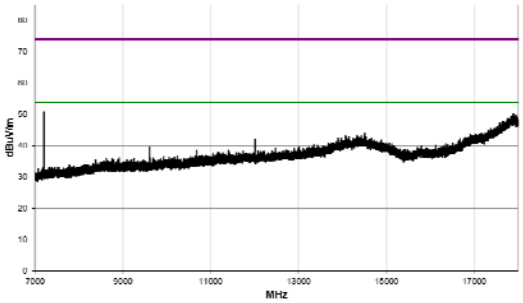
Bottom channel, 2402 MHz



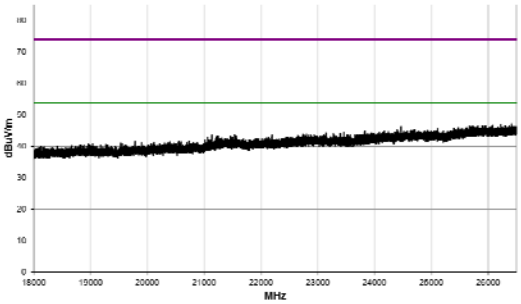
30 MHz – 1 GHz



1 GHz – 7 GHz



7 GHz – 18 GHz

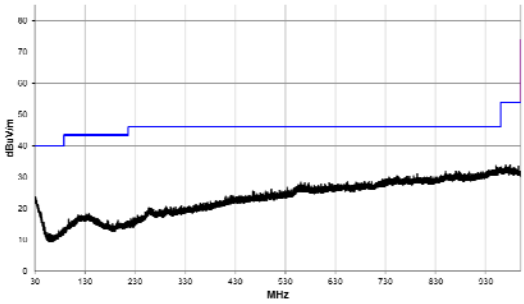


18 GHz – 26.5 GHz

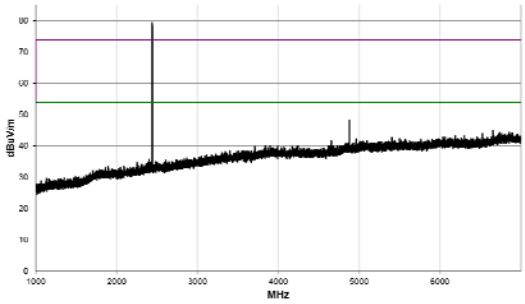
Freq (MHz)	Amplitude (dBuV)	Factor (dB)	Antenna Height (meters)	Azimuth (degrees)	Test Distance (meters)	External Attenuation (dB)	Polarity/ Transducer Type	Detector	Distance Adjustment (dB)	Adjusted (dBuV/m)	Spec. Limit (dBuV/m)	Compared to Spec. (dB)
4803.733	46.7	3.0	1.9	268.9	3.0	0.0	Horz	AV	0.0	49.7	54.0	-4.3
4803.700	41.3	3.0	1.41	139.0	3.0	0.0	Vert	AV	0.0	44.3	54.0	-9.7
4803.233	54.5	3.0	1.9	268.9	3.0	0.0	Horz	PK	0.0	57.5	74.0	-16.5
4803.008	51.0	2.9	1.41	139.0	3.0	0.0	Vert	PK	0.0	53.9	74.0	-20.1

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)
11998.590	31.5	12.2	1.5	76.9	1.0	0.0	Horz	AV	-9.5	34.2	54.0	-19.8
11998.600	31.5	12.2	1.5	240.9	1.0	0.0	Vert	AV	-9.5	34.2	54.0	-19.8
12003.490	44.9	12.2	1.5	76.9	1.0	0.0	Horz	PK	-9.5	47.6	74.0	-26.4
12001.780	44.7	12.2	1.5	240.9	1.0	0.0	Vert	PK	-9.5	47.4	74.0	-26.6

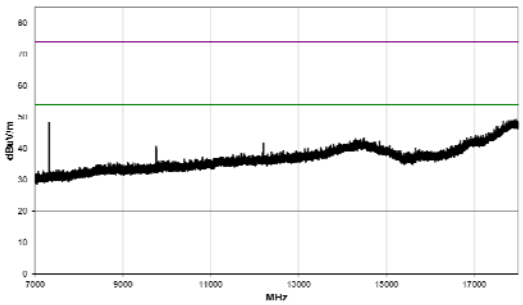
Middle channel, 2440 MHz



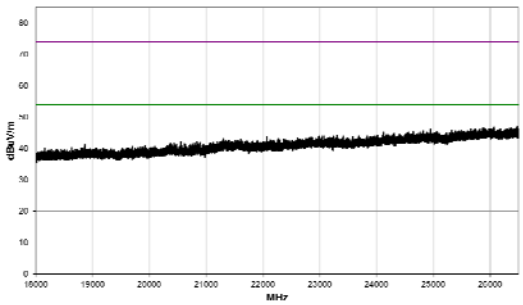
30 MHz – 1 GHz



1 GHz – 7 GHz



7 GHz – 18 GHz

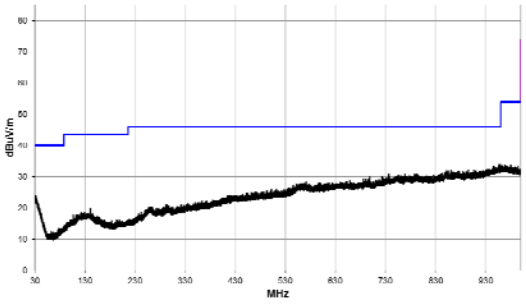


18 GHz – 26.5 GHz

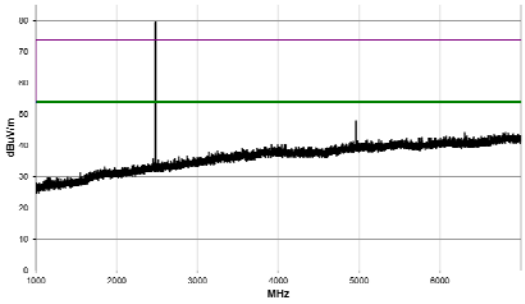
Freq (MHz)	Amplitude (dBuV)	Factor (dB)	Antenna Height (meters)	Azimuth (degrees)	Test Distance (meters)	External Attenuation (dB)	Polarity/ Transducer Type	Detector	Distance Adjustment (dB)	Adjusted (dBuV/m)	Spec. Limit (dBuV/m)	Compared to Spec. (dB)
4879.675	45.3	3.3	1.76	253.9	3.0	0.0	Horz	AV	0.0	48.6	54.0	-5.4
4879.808	40.3	3.3	1.66	126.0	3.0	0.0	Vert	AV	0.0	43.6	54.0	-10.4
4880.150	53.4	3.3	1.76	253.9	3.0	0.0	Horz	PK	0.0	56.7	74.0	-17.3
4879.983	50.2	3.3	1.66	126.0	3.0	0.0	Vert	PK	0.0	53.5	74.0	-20.5

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)
7318.950	48.4	8.0	1.61	316.0	1.0	0.0	Horz	AV	-9.5	46.9	54.0	-7.1
7320.183	46.5	8.0	1.5	123.1	1.0	0.0	Vert	AV	-9.5	45.0	54.0	-9.0
12198.160	37.4	12.2	1.5	132.0	1.0	0.0	Vert	AV	-9.5	40.1	54.0	-13.9
12198.120	34.1	12.2	1.5	349.0	1.0	0.0	Horz	AV	-9.5	36.8	54.0	-17.2
7318.692	55.8	8.0	1.61	316.0	1.0	0.0	Horz	PK	-9.5	54.3	74.0	-19.7
7320.142	54.2	8.0	1.5	123.1	1.0	0.0	Vert	PK	-9.5	52.7	74.0	-21.3
12200.740	48.1	12.2	1.5	132.0	1.0	0.0	Vert	PK	-9.5	50.8	74.0	-23.2
12201.040	46.9	12.2	1.5	349.0	1.0	0.0	Horz	PK	-9.5	49.6	74.0	-24.4

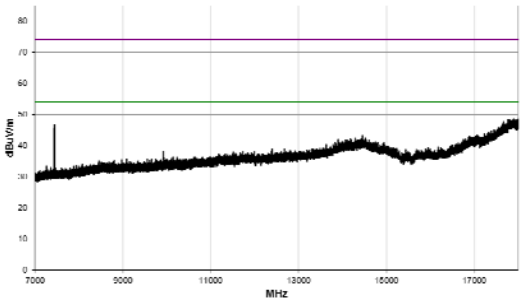
Top channel, 2480 MHz



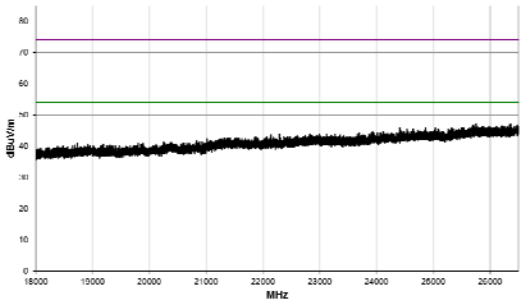
30 MHz – 1 GHz



1 GHz – 7 GHz



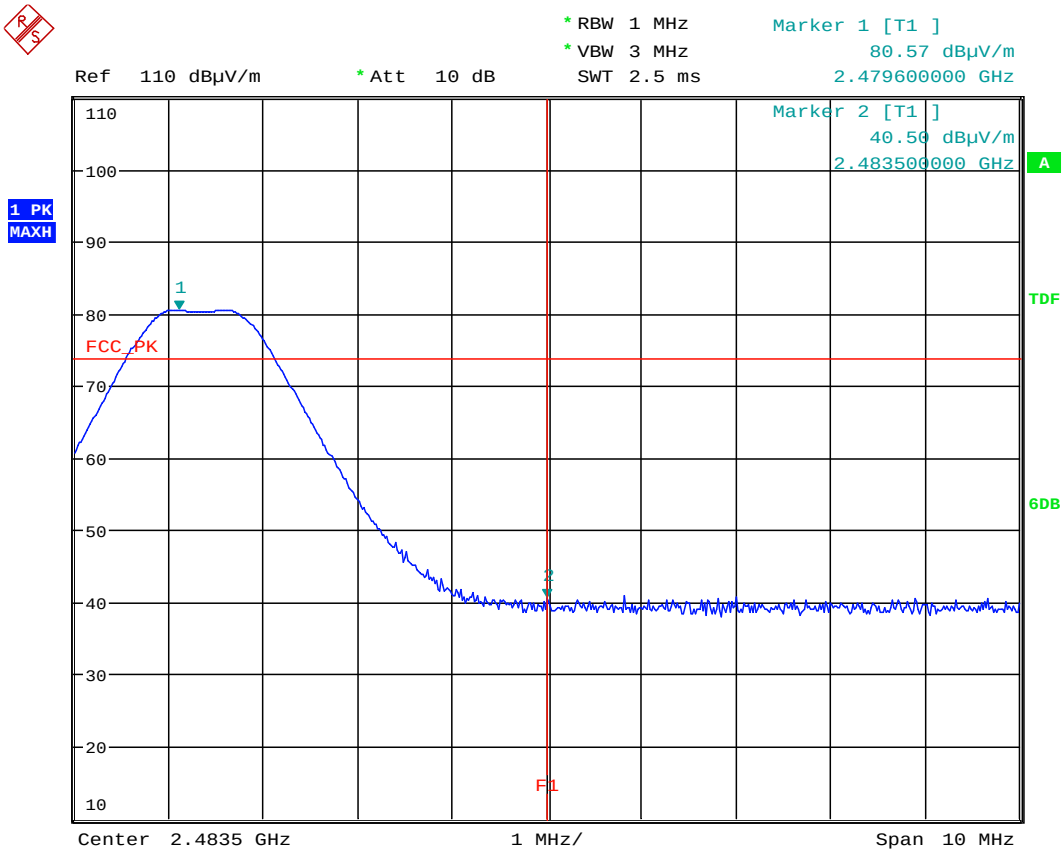
7 GHz – 18 GHz



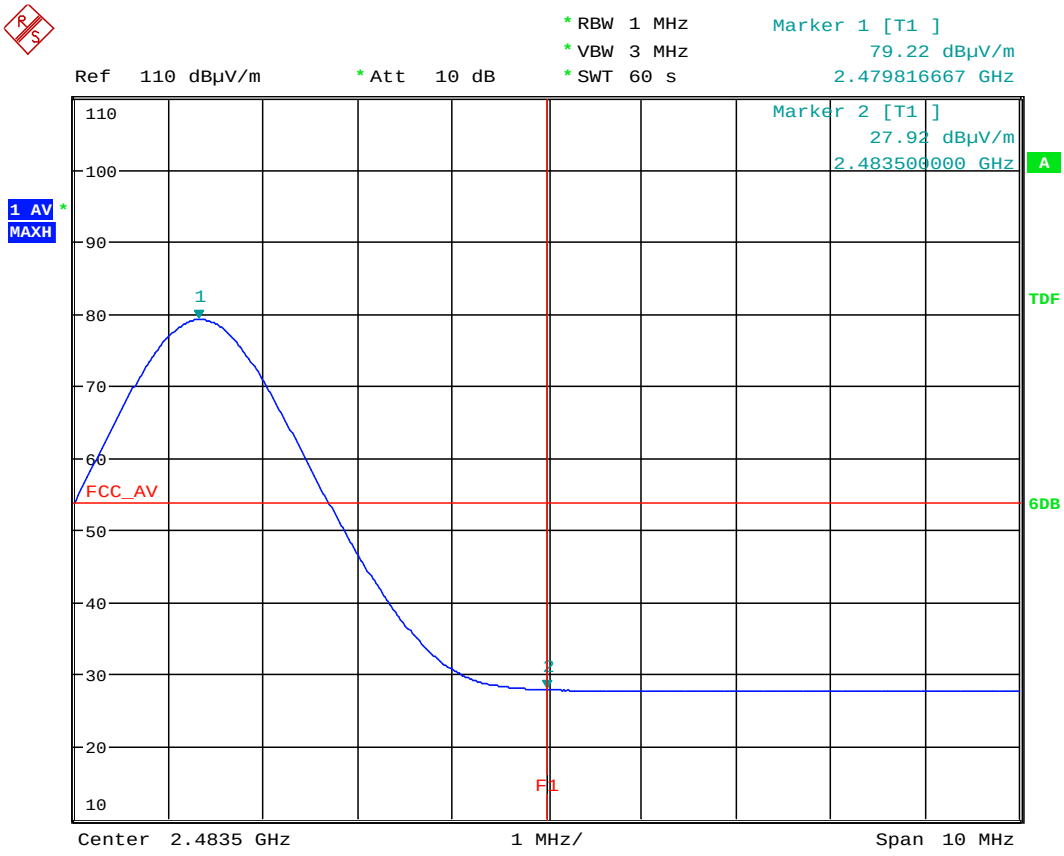
18 GHz – 26.5 GHz

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)
4959.742	44.4	3.5	1.65	262.0	3.0	0.0	Horz	AV	0.0	47.9	54.0	-6.1
4959.758	41.0	3.5	2.45	134.9	3.0	0.0	Vert	AV	0.0	44.5	54.0	-9.5
4959.175	53.2	3.5	1.65	262.0	3.0	0.0	Horz	PK	0.0	56.7	74.0	-17.3
4959.000	51.2	3.5	2.45	134.9	3.0	0.0	Vert	PK	0.0	54.7	74.0	-19.3

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)
7440.225	46.2	8.1	1.75	124.9	1.0	0.0	Vert	AV	-9.5	44.8	54.0	-9.2
7440.192	45.2	8.1	1.5	268.1	1.0	0.0	Horz	AV	-9.5	43.8	54.0	-10.2
7440.192	53.8	8.1	1.75	124.9	1.0	0.0	Vert	PK	-9.5	52.4	74.0	-21.6
7440.300	53.0	8.1	1.5	268.1	1.0	0.0	Horz	PK	-9.5	51.6	74.0	-22.4



Upper Band Edge1 MHz Bandwidth Peak



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Lower Band Edge 1 MHz Bandwidth Average

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:	Transient Lab
Test Standard and Clause:	ANSI C63.10-2013, Clause 6.2
EUT Frequencies Measured:	2440 MHz
EUT Channel Bandwidths:	1 MHz
EUT Modulation:	GFSK
Deviations From Standard:	None
Measurement Detectors:	Quasi-Peak and Average, RMS

Environmental Conditions (Normal Environment)

Temperature: 24 °C	+15 ºC to +35 ºC (as declared)
Humidity: 30 % RH	20 % RH to 75 % RH (as declared)
Supply: 3.7 V dc	3.7 V dc (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 (dBµV)***	
	Quasi-Peak	***Average*** [**]
0.15 to 0.5	66 to 56[*]	56 to 46[*]
0.5 to 5	56	46
5 to 30	60	50

*The level decreases linearly with the logarithm of the frequency.
**A linear average detector is required.

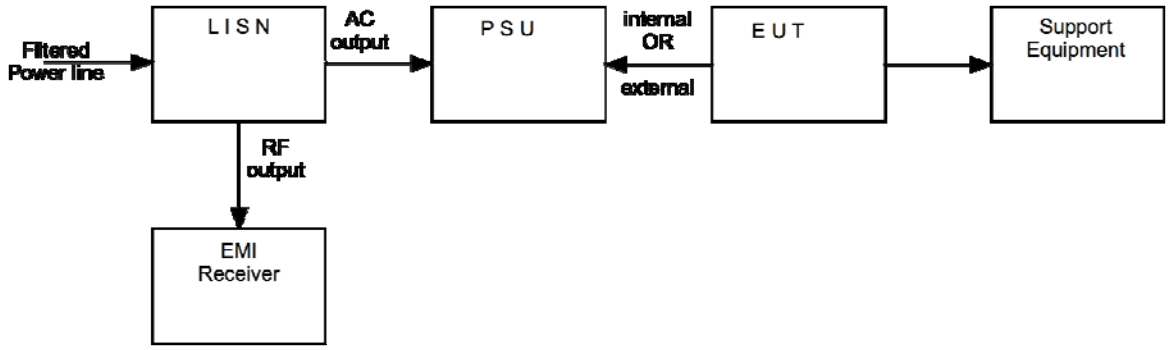
12.4 Test Method

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

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

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

Figure ii Test Setup

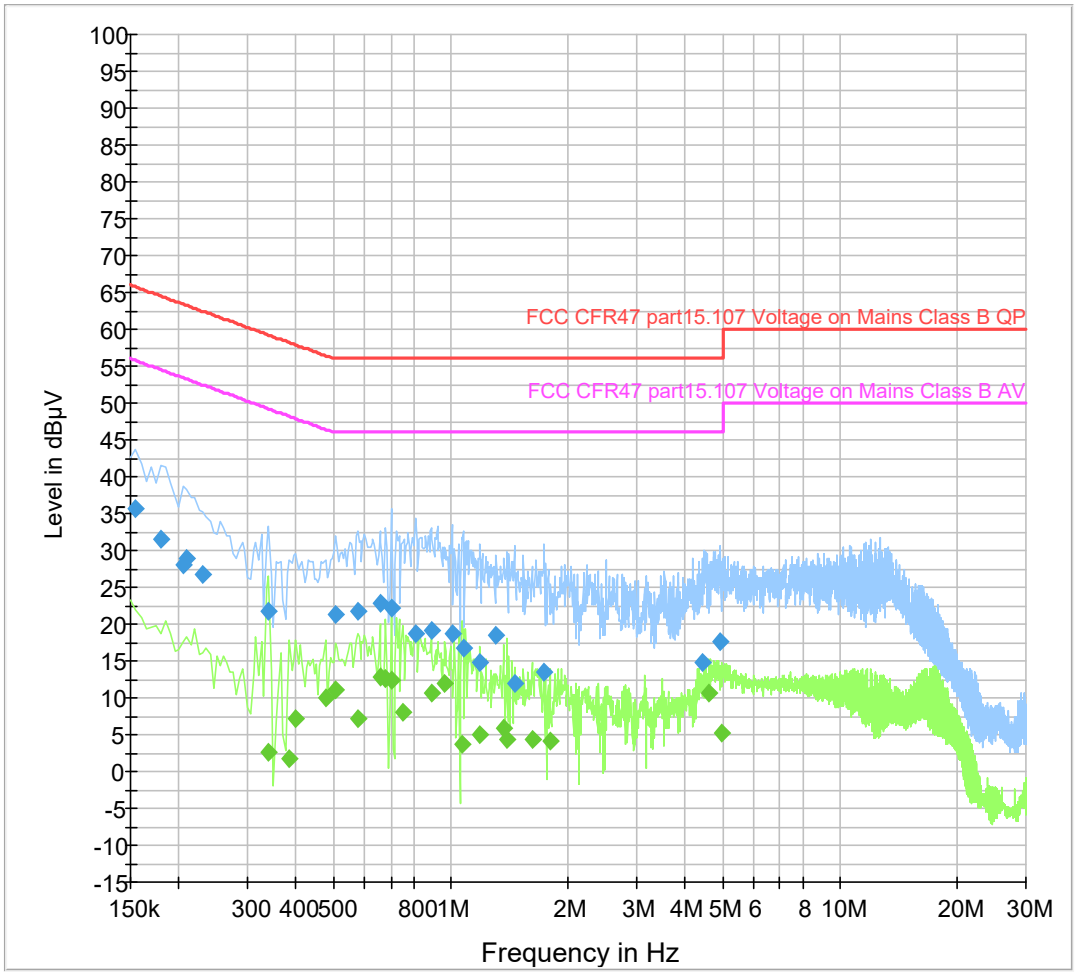


12.5 Test Set-up Photograph

12.6 Test Equipment

Equipment Type	Manufacturer	Equipment Description	Element No	Due For Calibration
ESHS10	R&S	Receiver	U003	2020-10-23
ESH3-Z5.831.5	R&S	Lisn	U195	2020-10-04
ESH3-Z2	R&S	Pulse Limiter	U559	2020-10-17

12.7 Test Results



AC power-line conducted emissions, Transmit mode									
Results measured using the average detector									
Frequency (MHz)	**Average (dBµV)**	**Meas. Time (ms)**	**Bandwidth (kHz)**	**PE**	**Line**	**Corr. (dB)**	**Margin (dB)**	**Limit (dBµV)**	**Comment**
0.340000	2.7	2000.0	10.000	GND	L1	10.0	46.5	49.2	PASS
0.385000	1.8	2000.0	10.000	GND	L1	10.0	46.4	48.2	PASS
0.400000	7.3	2000.0	10.000	GND	L1	10.0	40.6	47.9	PASS
0.475000	9.9	2000.0	10.000	GND	L1	10.0	36.5	46.4	PASS
0.505000	11.2	2000.0	10.000	GND	L1	10.0	34.8	46.0	PASS
0.575000	7.2	2000.0	10.000	GND	L1	10.0	38.8	46.0	PASS
0.655000	12.9	2000.0	10.000	GND	L1	10.0	33.1	46.0	PASS
0.680000	12.5	2000.0	10.000	GND	L1	10.0	33.5	46.0	PASS
0.700000	12.5	2000.0	10.000	GND	L1	10.0	33.5	46.0	PASS
0.750000	8.1	2000.0	10.000	GND	L1	10.0	37.9	46.0	PASS
0.890000	10.7	2000.0	10.000	GND	L1	10.0	35.3	46.0	PASS
0.965000	11.9	2000.0	10.000	GND	L1	10.0	34.1	46.0	PASS
1.065000	3.7	2000.0	10.000	GND	L1	10.0	42.3	46.0	PASS
1.185000	4.9	2000.0	10.000	GND	L1	10.0	41.1	46.0	PASS
1.365000	5.9	2000.0	10.000	GND	L1	10.1	40.1	46.0	PASS
1.390000	4.3	2000.0	10.000	GND	L1	10.1	41.7	46.0	PASS
1.615000	4.4	2000.0	10.000	GND	L1	10.1	41.6	46.0	PASS
1.800000	4.2	2000.0	10.000	GND	L1	10.1	41.8	46.0	PASS
4.590000	10.6	2000.0	10.000	GND	L1	10.3	35.4	46.0	PASS
4.975000	5.3	2000.0	10.000	GND	L1	10.3	40.7	46.0	PASS

Results measured using the quasi-peak detector									
Frequency (MHz)	**Average (dBµV)**	**Meas. Time (ms)**	**Bandwidth (kHz)**	**PE**	**Line**	**Corr. (dB)**	**Margin (dB)**	**Limit (dBµV)**	**Comment**
0.155000	35.6	2000.0	10.000	GND	L1	10.0	30.1	65.7	PASS
0.180000	31.5	2000.0	10.000	GND	L1	10.0	33.0	64.5	PASS
0.205000	28.1	2000.0	10.000	GND	L1	10.0	35.3	63.4	PASS
0.210000	28.8	2000.0	10.000	GND	L1	10.0	34.4	63.2	PASS
0.230000	26.8	2000.0	10.000	GND	L1	10.0	35.6	62.4	PASS
0.340000	21.8	2000.0	10.000	GND	L1	10.0	37.4	59.2	PASS
0.505000	21.2	2000.0	10.000	GND	L1	10.0	34.8	56.0	PASS
0.575000	21.6	2000.0	10.000	GND	L1	10.0	34.4	56.0	PASS
0.655000	22.9	2000.0	10.000	GND	L1	10.0	33.1	56.0	PASS
0.700000	22.3	2000.0	10.000	GND	L1	10.0	33.7	56.0	PASS
0.810000	18.7	2000.0	10.000	GND	L1	10.0	37.3	56.0	PASS
0.890000	19.1	2000.0	10.000	GND	L1	10.0	36.9	56.0	PASS
1.005000	18.7	2000.0	10.000	GND	L1	10.0	37.3	56.0	PASS
1.075000	16.7	2000.0	10.000	GND	L1	10.0	39.3	56.0	PASS
1.185000	14.8	2000.0	10.000	GND	L1	10.0	41.2	56.0	PASS
1.305000	18.4	2000.0	10.000	GND	L1	10.1	37.6	56.0	PASS
1.455000	11.9	2000.0	10.000	GND	L1	10.1	44.1	56.0	PASS
1.735000	13.5	2000.0	10.000	GND	L1	10.1	42.5	56.0	PASS
4.425000	14.8	2000.0	10.000	GND	L1	10.2	41.2	56.0	PASS
4.930000	17.6	2000.0	10.000	GND	L1	10.3	38.4	56.0	PASS

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 Lab
Test Standard and Clause:	FCC: ANSI C63.10-2013, Clause 11.8
EUT Frequencies Measured:	2402 MHz / 2440 MHz / 2480 MHz
EUT Channel Bandwidths:	1 MHz
EUT Test Modulations:	GFSK
Deviations From Standard:	None
Measurement BW: (IC requirement: 1% to 5% OBW; FCC requirement: 100 kHz)	30 kHz/100 kHz
Spectrum Analyzer Video BW: (requirement at least 3x RBW)	100 kHz/ 300 kHz
Measurement Span: (requirement 2 to 5 times OBW)	3 MHz
Measurement Detector:	Peak

Environmental Conditions (Normal Environment)

Temperature: 24 °C	+15 ºC to +35 ºC (as declared)
Humidity: 30 % RH	20 % RH to 75 % RH (as declared)
Supply: 3.7 V dc	3.7 V dc (as declared)

13.3 Test Limit

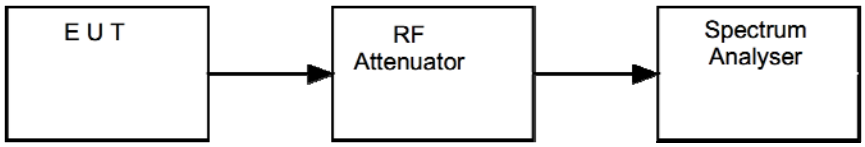
The minimum -6 dB bandwidth shall be at least 500 kHz.

13.4 Test Method

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

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

Figure iii Test Setup

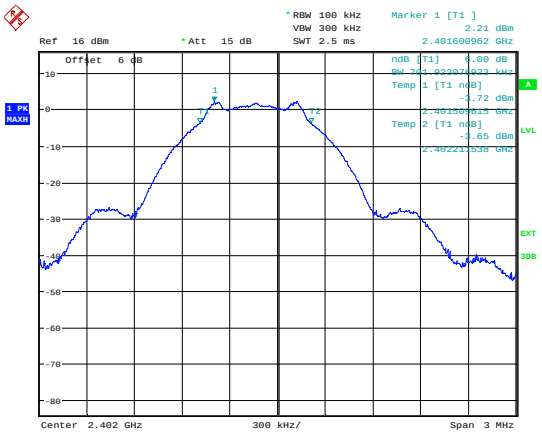


13.5 Test Equipment

Equipment Type	*Manufacturer*	*Equipment Description*	*Element No*	*Due For Calibration*
FSU46	R&S	Spectrum Analyser	REF910	2020-10-17

13.6 Test Results

FCC 15.247. Modulation: GFSK; Data rate: 1 Mbps; Power setting: 5				
Channel Frequency (MHz)	**F_L (MHz)**	**F_H (MHz)**	**6dB Bandwidth (kHz)**	**Result**
2402	2401.509615	2402.211538	701.923077	PASS
2442	2441.500000	2442.216346	716.346154	PASS
2480	2479.490385	2480.216346	725.961538	PASS



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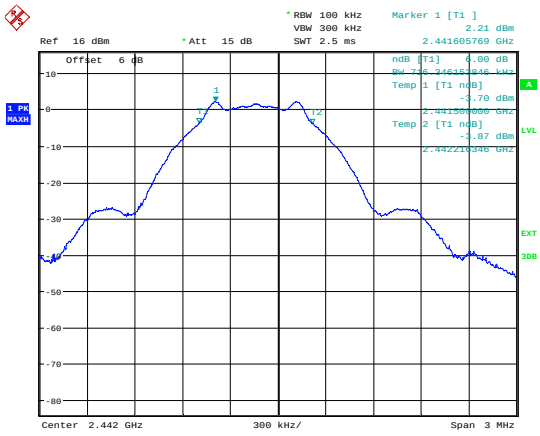

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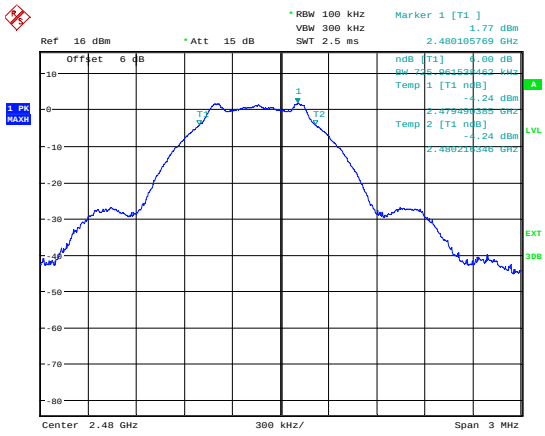

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14 Maximum peak conducted output power

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 Frequencies Measured:	2402 MHz / 2440 MHz / 2480 MHz
EUT Channel Bandwidths:	1 MHz
Deviations From Standard:	None
Measurement BW:	2 MHz
Spectrum Analyzer Video BW: (requirement at least 3x RBW)	5 MHz
Measurement Detector:	Peak
Voltage Extreme Environment Test Range:	Battery Power = new battery.

Environmental Conditions (Normal Environment)

Temperature: 24 °C	+15 ºC to +35 ºC (as declared)
Humidity: 30 % RH	20 % RH to 75 % RH (as declared)

14.3 Test Limit

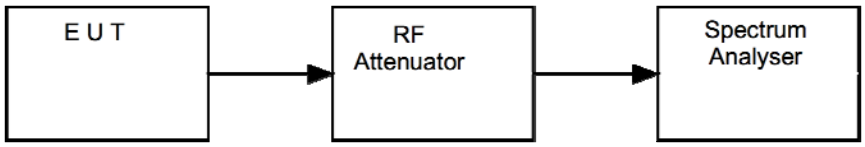
For systems employing digital modulation techniques operating in the bands 902 to 928 MHz, 2400 to 2483.5 MHz and 5725 to 5850 MHz, the maximum peak conducted output power shall not exceed 1 W.

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

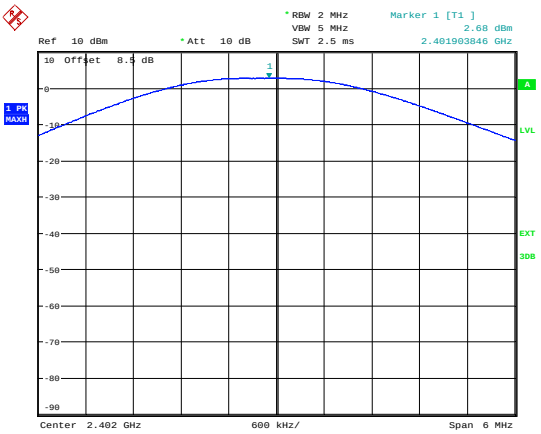


14.5 Test Equipment

Equipment Type	*Manufacturer*	*Equipment Description*	*Element No*	*Due For Calibration*
FSU46	R&S	Spectrum Analyser	REF910	2020-10-17

14.6 Test Results

Modulation: GFSK; Data rate: 1 Mbps; Power setting: 5				
Channel Frequency (MHz)	***Analyzer Level (dBm)***	***Cable loss (dB)***	***Power (mW)***	***Result***
2402	2.68	N/A	1.854	PASS
2442	2.86	N/A	1.932	PASS
2480	2.68	N/A	1.854	PASS



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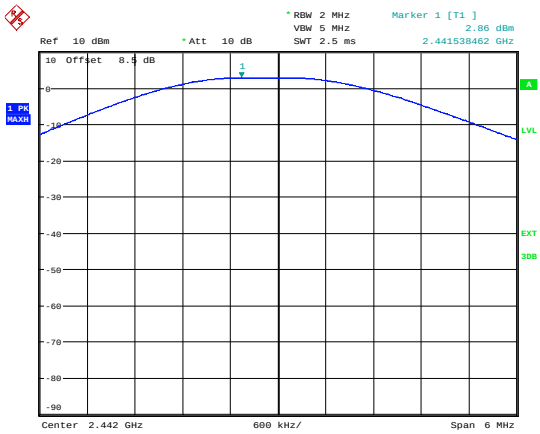
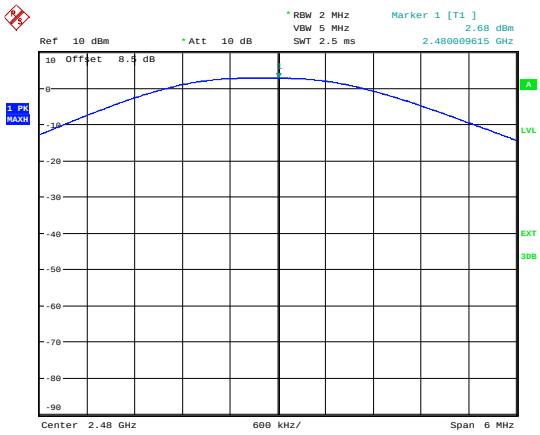


Middle



Top

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 Frequencies Measured:	2402 MHz / 2440 MHz / 2480 MHz
EUT Channel Bandwidths:	1 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:	30 MHz to 26.5 GHz

Environmental Conditions (Normal Environment)

Temperature: 24 °C	+15 ºC to +35 ºC (as declared)
Humidity: 30 % RH	20 % RH to 75 % RH (as declared)
Supply: 3.7 Vdc	3.7 Vdc (as declared)

15.3 Test Limit

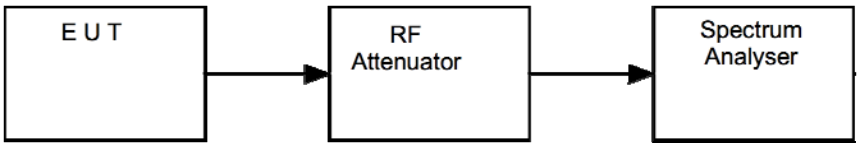
In any 100 kHz bandwidth outside the frequency band in which the spread spectrum or digitally modulated device is operating, the RF power that is produced shall be at least 20 dB below that in the 100 kHz bandwidth within the band that contains the highest level of the desired power, based on either 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 RSS-Gen is not required.

15.4 Test Method

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

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

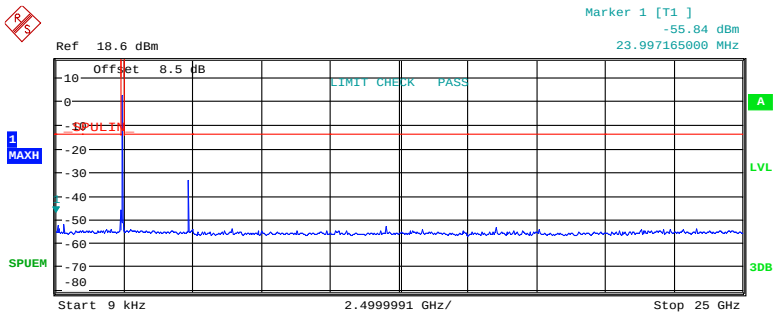
Figure v Test Setup



15.5 Test Equipment

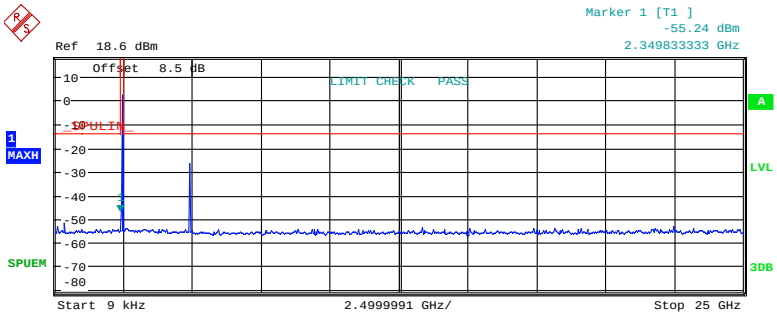
Equipment Type	*Manufacturer*	*Equipment Description*	*Element No*	*Due For Calibration*
FSU46	R&S	Spectrum Analyser	REF910	2020-10-17

15.6 Test Results



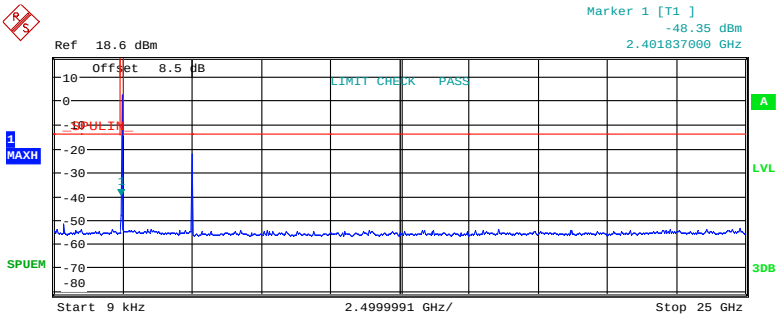
Start [Hz]	Stop [Hz]	RBW [Hz]	Freq [Hz]	PwrAbs [dBm]	Δ Limit [dB]
9.000 k	150.000 k	1.00 k	15.100962 k	-67.77	-53.73
150.000 k	30.000 M	10.00 k	23.997165 M	-55.84	-41.80
30.000 M	1.000 G	100.00 k	300.242000 M	-52.64	-38.60
1.000 G	2.400 G	100.00 k	2.399953 G	-48.34	-34.30
2.400 G	2.483 G	100.00 k	2.401587 G	2.35	-17.65
2.483 G	5.000 G	100.00 k	4.803461 G	-33.57	-19.53
5.000 G	10.000 G	100.00 k	6.409000 G	-54.46	-40.42
10.000 G	15.000 G	100.00 k	12.008000 G	-53.33	-39.29
15.000 G	20.000 G	100.00 k	16.026500 G	-53.89	-39.85
20.000 G	25.000 G	100.00 k	23.320000 G	-54.49	-40.45

Bottom



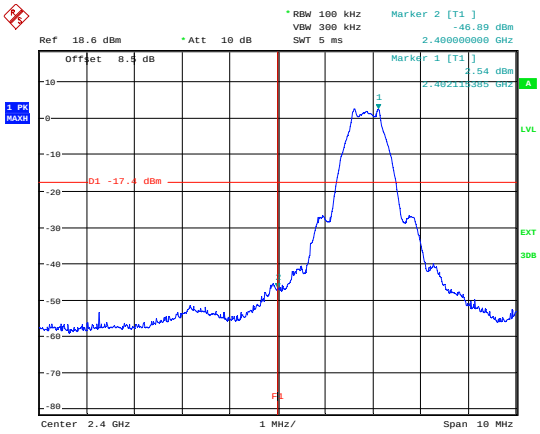
Start [Hz]	Stop [Hz]	RBW [Hz]	Freq [Hz]	PwrAbs [dBm]	Δ Limit [dB]
9.000 k	150.000 k	1.00 k	9.677885 k	-67.43	-53.39
150.000 k	30.000 M	10.00 k	24.000150 M	-56.22	-42.18
30.000 M	1.000 G	100.00 k	305.221333 M	-52.13	-38.09
1.000 G	2.400 G	100.00 k	1.625147 G	-54.87	-40.83
2.400 G	2.483 G	100.00 k	2.441583 G	2.58	-17.42
2.483 G	5.000 G	100.00 k	4.884241 G	-26.74	-12.70
5.000 G	10.000 G	100.00 k	9.345000 G	-54.72	-40.68
10.000 G	15.000 G	100.00 k	13.353000 G	-53.91	-39.87
15.000 G	20.000 G	100.00 k	17.403500 G	-54.29	-40.25
20.000 G	25.000 G	100.00 k	22.465500 G	-53.54	-39.50

Middle



Start [Hz]	Stop [Hz]	RBW [Hz]	Freq [Hz]	PwrAbs [dBm]	Δ Limit [dB]
9.000 k	150.000 k	1.00 k	9.677885 k	-67.63	-53.59
150.000 k	30.000 M	10.00 k	23.997165 M	-55.43	-41.39
30.000 M	1.000 G	100.00 k	309.974333 M	-52.11	-38.07
1.000 G	2.400 G	100.00 k	2.077907 G	-54.43	-40.39
2.400 G	2.483 G	100.00 k	2.480160 G	2.38	-17.62
2.483 G	5.000 G	100.00 k	4.959233 G	-22.47	-8.43
5.000 G	10.000 G	100.00 k	6.725000 G	-54.83	-40.79
10.000 G	15.000 G	100.00 k	13.288000 G	-54.83	-40.79
15.000 G	20.000 G	100.00 k	16.050500 G	-54.35	-40.31
20.000 G	25.000 G	100.00 k	24.809000 G	-54.16	-40.12

Top



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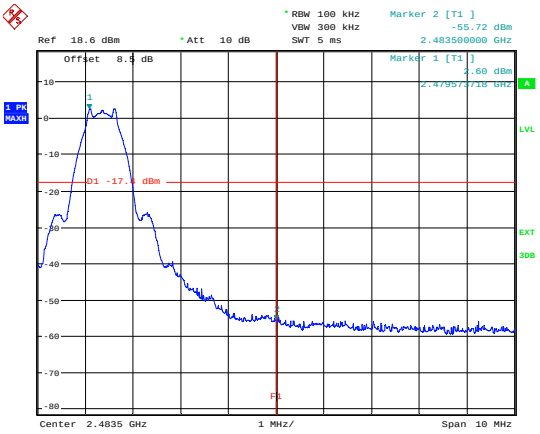
Lower Band edge



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Upper Band Edge

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 Frequencies Measured:	2402 MHz / 2440 MHz / 2480 MHz
EUT Channel Bandwidths:	1 MHz
Deviations From Standard:	None
Measurement BW:	30 kHz
Spectrum Analyzer Video BW: (requirement at least 3x RBW)	100 kHz
Measurement Span: (requirement 1.5 times Channel BW)	1.5 MHz
Measurement Detector:	Peak

Environmental Conditions (Normal Environment)

Temperature: 24 °C	+15 ºC to +35 ºC (as declared)
Humidity: 30 % RH	20 % RH to 75 % RH (as declared)
Supply: 3.7 Vdc	3.7 Vdc (as declared)

16.3 Test Limit

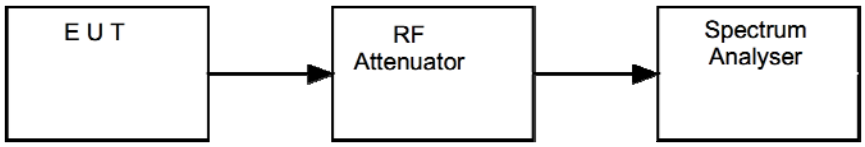
The transmitter power spectral density conducted from the transmitter to the antenna shall not be greater than 8 dBm in any 3 kHz band during any time interval of continuous transmission.

16.4 Test Method

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

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

Figure vi Test Setup

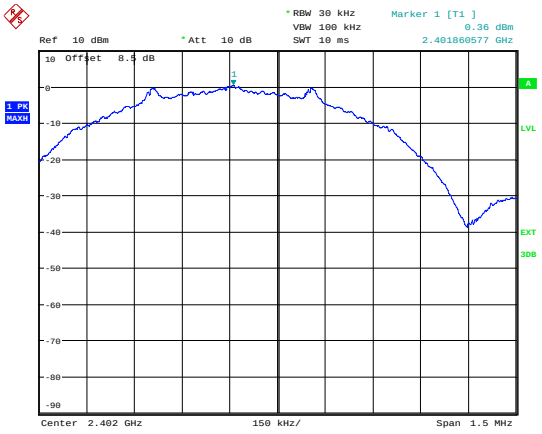


16.5 Test Equipment

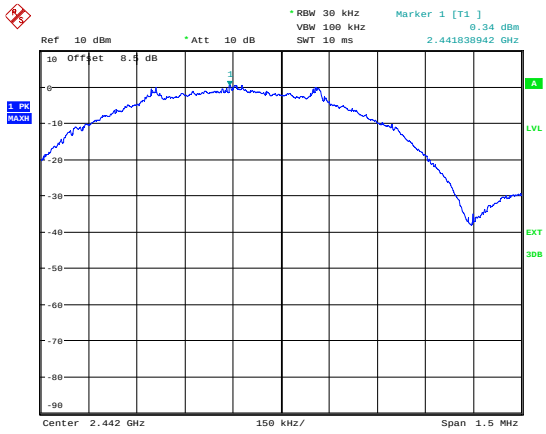
Equipment Type	*Manufacturer*	*Equipment Description*	*Element No*	*Due For Calibration*
FSU46	R&S	Spectrum Analyser	REF910	2020-10-17

16.6 Test Results

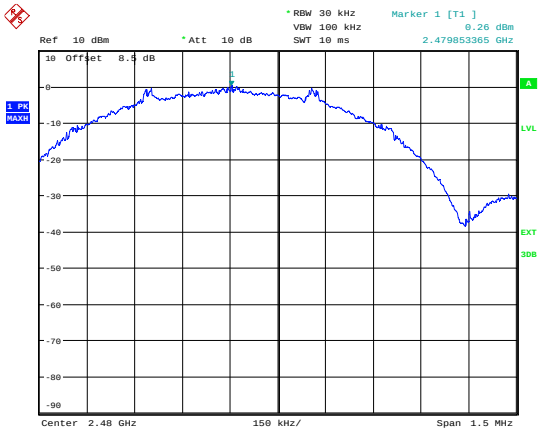
Modulation: GFSK; Data rate: 1 Mbps; Power setting: 5				
Channel Frequency (MHz)	**Analyzer Level (dBm)**	**Cable loss (dB)**	**Power (dBm)**	**Result**
2402	0.36	N/A	0.36	PASS
2442	0.34	N/A	0.34	PASS
2480	0.26	N/A	0.26	PASS



Bottom



Middle



Top

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 General SAR test reduction and exclusion guidance

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 <5mm, the SAR Test Exclusion Threshold for operation in the 2400 – 2483.5 MHz band will be determined as follows

SAR Exclusion Threshold (SARET)

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

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 = When the minimum *test separation distance* is < 5 mm, a distance of 5 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.

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

Operating Frequency 2.402 GHz

SARET = [(3.0 x 5) / √2.402]
SARET = [15 / 1.55]
SARET = 9.677mW

Operating Frequency 2.440 GHz

SARET = [(3.0 x 5) / √2.442]
SARET = [15 / 1.56]
SARET = 9.615mW

Operating Frequency 2.480 GHz

SARET = [(3.0 x 5) / √2.48]
SARET = [15 / 1.57]
SARET = 9.554mW

KDB 447498				
Evaluation Frequency	2404	2442	2480	MHz
SAR Exclusion Threshold	9.677	9.615	9.554	mW
Conduced Power	2.68	2.86	2.68	dBm
Antenna Gain	1.7	1.7	1.7	dBi
EIRP	2.74	2.86	2.74	mW
SAR Evaluation	***Exempt***			