

Report on the Radio Testing
For
Lacuna Space
on
LS300
Report no. TRA-058206-47-01C
2022-12-09

RF915 8.0



Report Number: TRA-058206-47-01C
Issue: A

REPORT ON THE RADIO TESTING OF A
Lacuna Space
LS300
WITH RESPECT TO SPECIFICATION
FCC 47CFR 25

TEST DATE: 03 Oct 2022 - 20 Oct 2022

Tested by:  Sing Lung Siu

Written by:  Sing Lung Siu
Radio Test Engineer

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Department Manager - Radio
Date: 2023-04-13

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	2022-10-20	Original
B	2022-12-09	Contact details changed
C	2023-04-13	Changed wordings and re-plotted part of the graph in Section 13 to clarify the result.

2 Summary

TEST REPORT NUMBER:	TRA-058206-47-01C
WORKS ORDER NUMBER:	TRA-058206-02
PURPOSE OF TEST:	Certification
TEST SPECIFICATION:	47CFR25.202, 25.204, 25.216
EQUIPMENT UNDER TEST (EUT):	LS300
FCC IDENTIFIER:	2A8AP-LS300
EUT SERIAL NUMBER:	0003, 0009
MANUFACTURER/AGENT:	Lacuna Space
ADDRESS:	R104 Rutherford Appleton Laboratory Harwell Campus Didcot OX11 0QX United Kingdom
CLIENT CONTACT:	Rob Spurret  +447827828624  regulatory@lacuna.space
ORDER NUMBER:	LN-PO-042-22
TEST DATE:	03 Oct 2022 - 20 Oct 2022
TESTED BY:	Sing Lung Siu Element

2.1 Test Summary

<i>Test Method and Description</i>	<i>Requirement Clause 47CFR25</i>	<i>Applicable to this equipment</i>	<i>Result / Note</i>
Frequency tolerance	Clause 25.202(d)	☒	<i>Pass</i>
Emission Mask	Clause 25.202(f)	☒	<i>Pass</i>
Emission Limitation – Spurious Emission	Clause 25.202(f)	☒	<i>Pass</i>
Power Limits (radiated e.i.r.p.)	Clause 25.204 (a)	☒	<i>Pass</i>
Limits on emissions from mobile earth stations for protection of aeronautical radionavigation-satellite service	Clause 25.216 (e)	☒	<i>Pass</i>

General Notes:

The results contained in this report relate only to the items tested, in the condition at time of test, and were obtained in the period between the date of initial receipt of samples and the date of issue of the report.

The apparatus was set up and exercised using the configurations, modes of operation and arrangements defined in this report only. Any modifications made are identified in Section 8 of this report.

Particular operating modes, apparatus monitoring methods and performance criteria required by the standards tested to have been performed except where identified in Section 5.2 of this test report (Deviations from Test Standards).

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4 Introduction

This report TRA-058206-47-01C presents the results of the Radio testing on a Lacuna Space, LS300 to specification 47CFR25 Satellite Communications

The testing was carried out for Lacuna Space 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 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:

The test laboratory is accredited for the above sites under the US-UK MRA,

Designation number(s):

Element Hull UK2007

Element Skelmersdale UK2020

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* – Part 2 Frequency Allocations and Radio Treaty Matters; General Rules and Regulations
- *FCC 47 CFR* – Part 25 – Satellite Communication.
- *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: LS300
- Serial Number: 0003
0009
- Model Number: LS300-868-A
- Software Revision: LSM Ver 0.10.0
- Build Level / Revision Number: Version 2.1

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

The EUT was put into test mode which transmitted in a designated channel and power setting. It was exercised by sending commands to the EUT via the serial port using Teraterm.

7.4 EUT Radio Parameters

7.4.1 General

Frequency of operation:	1980MHz – 2010MHz
Modulation type(s):	LR-FHSS
Authorised channel bandwidth(s):	150 kHz
Nominal Supply Voltage:	4.5Vdc

7.4.2 Antennas

Type:	Integrated RHCP patch antennas
Frequency range:	2000MHz – 2010 MHz (uplink)
Axial Ratio:	< 6dB
Reflection Coefficient:	<-10dB
Gain:	2.65dBic
Mounting:	Fixed – Non replaceable

7.5 EUT Description

The EUT is a battery powered sensor and relay for direct communication with the Lacuna satellite network

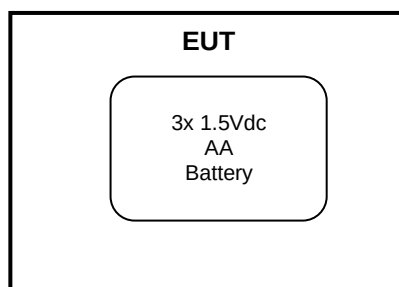
8 Modifications

No modifications were performed during this assessment.

9 EUT Test Setup

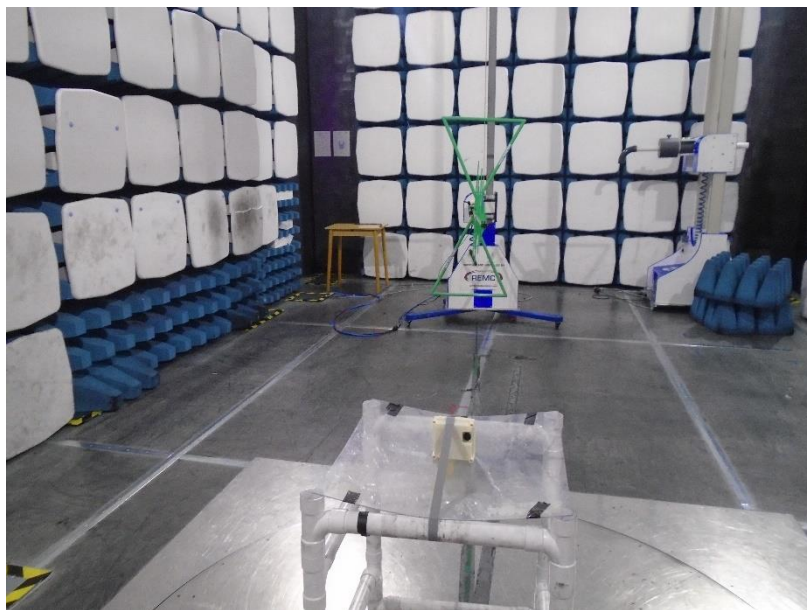
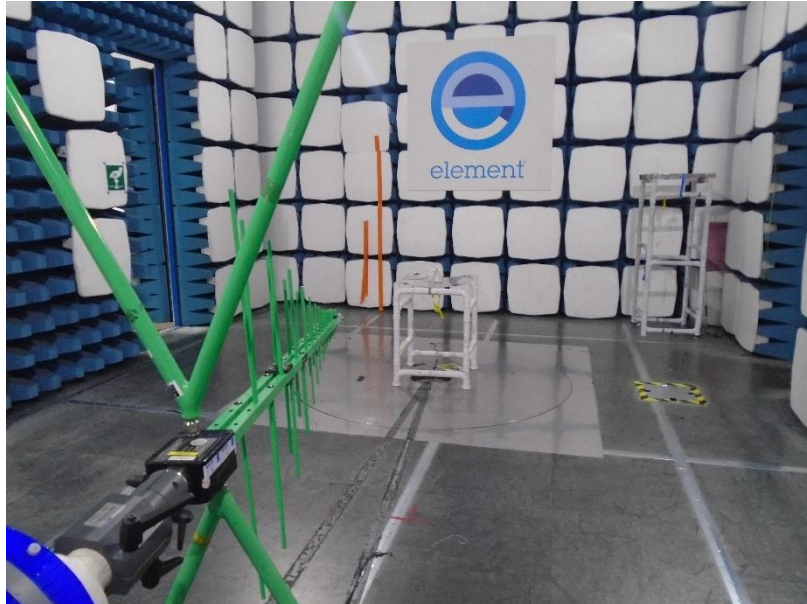
9.1 Block Diagram

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
ETS Lindgren EMPower V1.0.4.2

10 General Technical Parameters

10.1 Normal Conditions

The EUT was tested under the normal environmental conditions of the test laboratory, except where otherwise stated. The normal power source applied was 4.5 Vdc from alkaline batteries

10.2 Varying Test Conditions

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

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

	<i>Category</i>	<i>Nominal</i>	<i>Variation</i>
☐	Mains	110 Vac +/-2 %	85 % and 115 %
☒	Battery	New battery	3.3Vdc – 5Vdc
☒	Temperature	Ambient Temperature	-20 to 50°C

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:	Chamber 1
EUT Frequencies Measured:	2000.2 MHz, 2005.0 MHz, 2009.8MHz
Test Standard and Clause:	FCC Part 25.202(f) & 25.216(e)
Deviations from Standard:	None
Measurement BW:	4 kHz
Measurement Detector:	Average

Environmental Conditions (Normal Environment)

Temperature: 19.1 °C	+15 °C to +35 °C (as declared)
Humidity: 50 % RH	20 % RH to 75 % RH (as declared)
Supply: 4.5Vdc	New AA Battery

11.3 Test Limit

On any frequency removed from the assigned frequency by the following percentage of the authorised bandwidth

±50%	-	100%	-25 dBc
±100%	-	250 %	-35 dBc
> ±250%			At least 43 + 10 log PdB

$$(10\log P_{\text{watts}}) - (43 + 10\log (P_{\text{watts}} * 1000)) = \text{LIMIT} = -13 \text{ dBm}$$

The e.i.r.p density of emissions from mobile earth stations with assigned uplink frequencies between 1990 MHz and 2025 MHz shall not exceed -70 dBW/MHz, averaged over any 2 millisecond active transmission interval, in frequencies between 1559 MHz and 1610 MHz. The e.i.r.p. of discrete emissions of less than 700 Hz bandwidth from such stations between 1559 MHz and 1605 MHz shall not exceed -80 dBW, averaged over any 2 millisecond active transmission interval. The e.i.r.p. of discrete emissions of less than 700 Hz bandwidth from such stations between 1605 MHz and 1610 MHz manufactured more than six months after Federal Register publication of the rule changes adopted in FCC 03-283 shall not exceed -80 dBW, averaged over any 2 millisecond active transmission interval.

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:

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

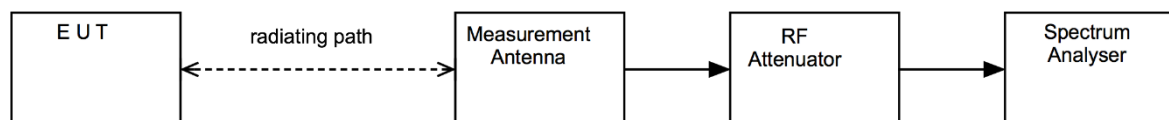
$$\text{Factor} = CL + AF - PA$$

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

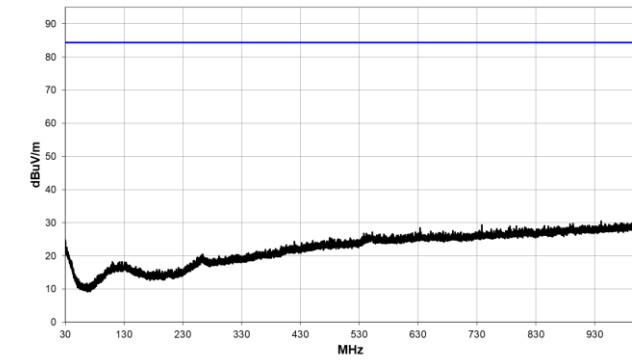


11.5 Test Equipment

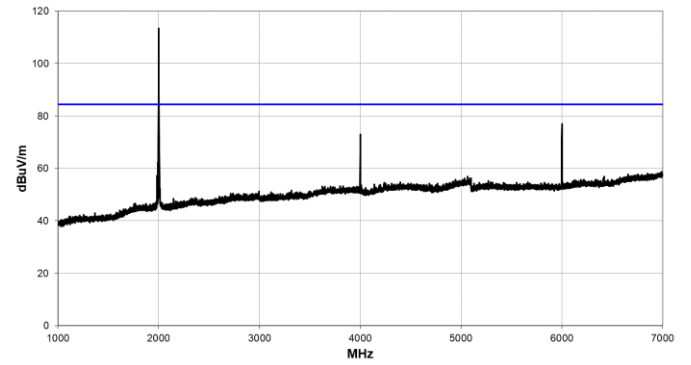
Equipment Type	Manufacturer	Equipment Description	Element No	Due For Calibration
8449B	Agilent	PreAmp	L572	2023-10-24
FSW 43	R&S	Spectrum Analyser	U728	2023-04-26
3115	EMCO	1-18GHz Horn	U223	2023-12-13
CBL6112B	Chase	Bilog	U093	2023-09-15
6201-69	Watkins Johnson	PreAmp	U372	2023-03-01
20240-20	Flann	Horn 18-26GHz (&U330)	L300	2024-06-30
Radiated Test Software	Element	Emissions R5	REF9000	Cal not required
Radio Chamber - PP	Rainford EMC	ATS	REF940	2023-11-06

11.6 Test Results

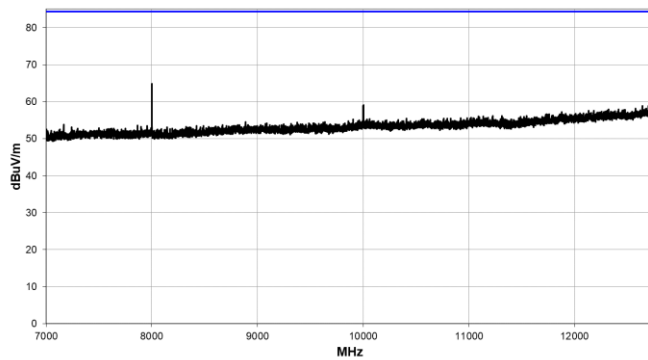
Bottom Channel:



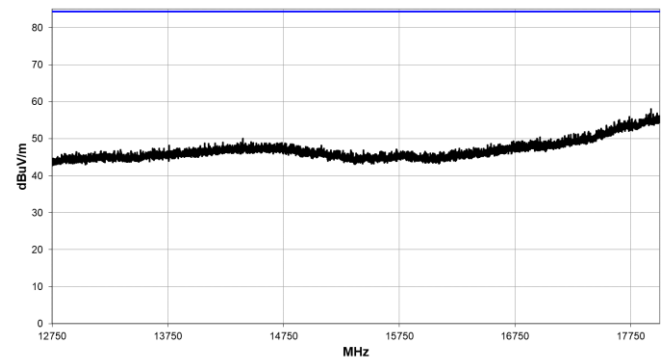
30MHz – 1 GHz



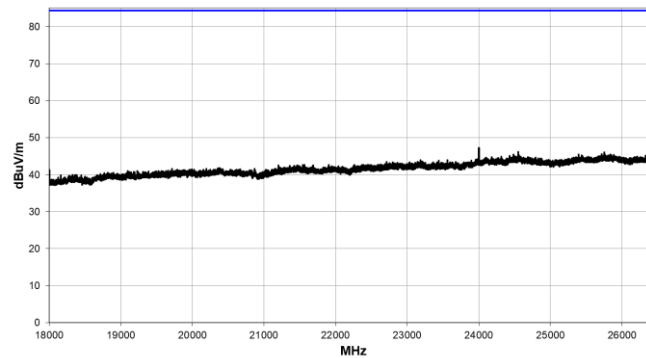
1 GHz – 7 GHz



7GHz – 12.75 GHz

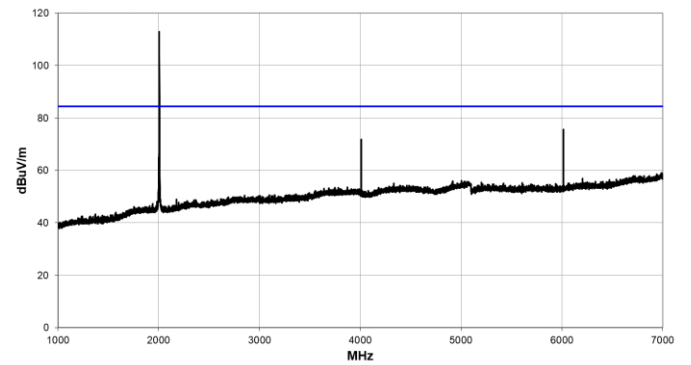
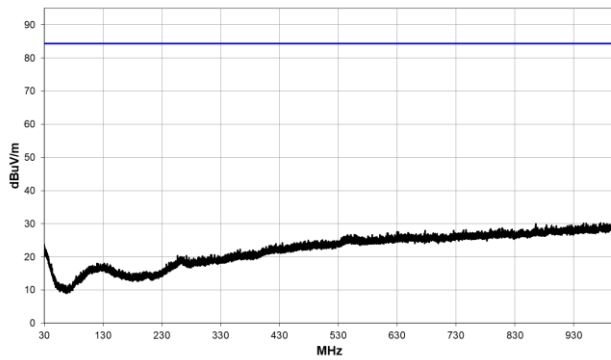
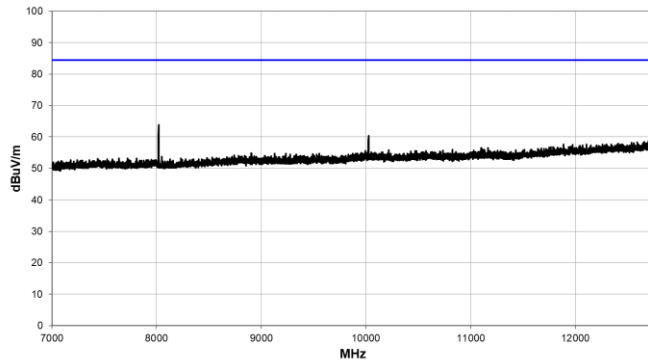
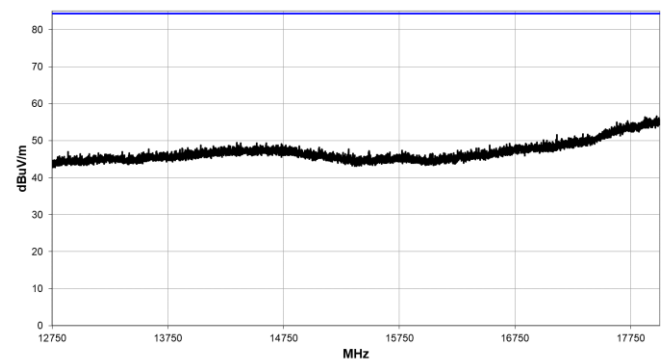
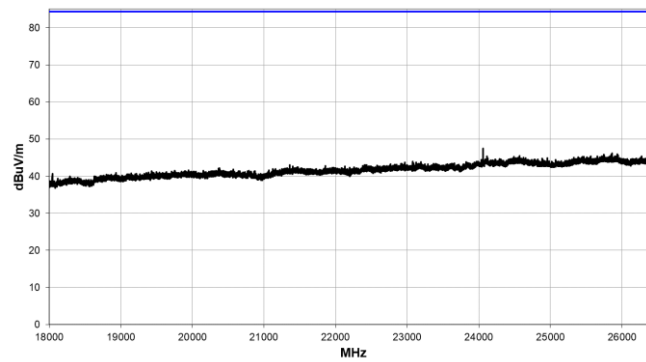


12.75 GHz – 18GHz

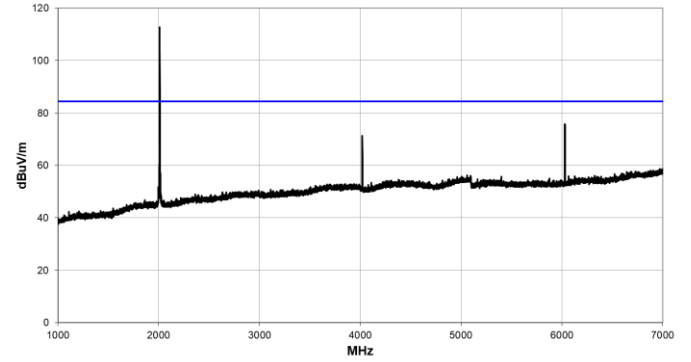
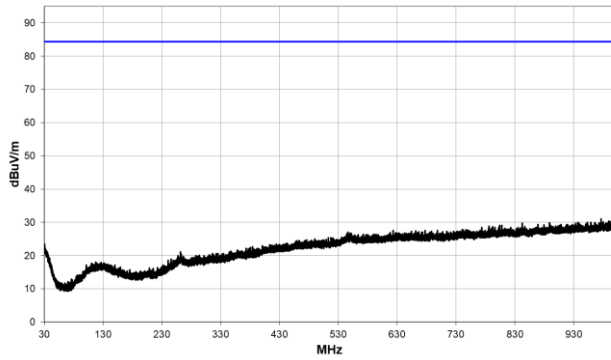
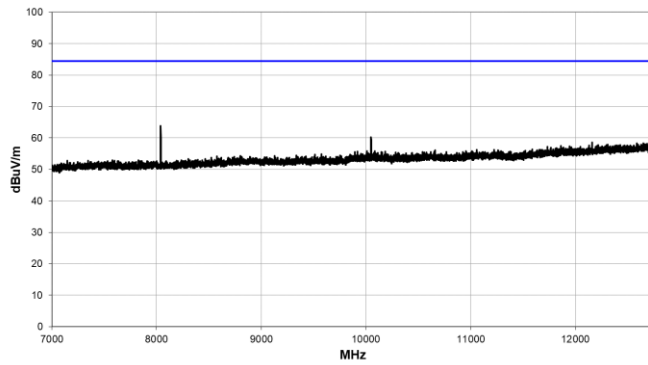
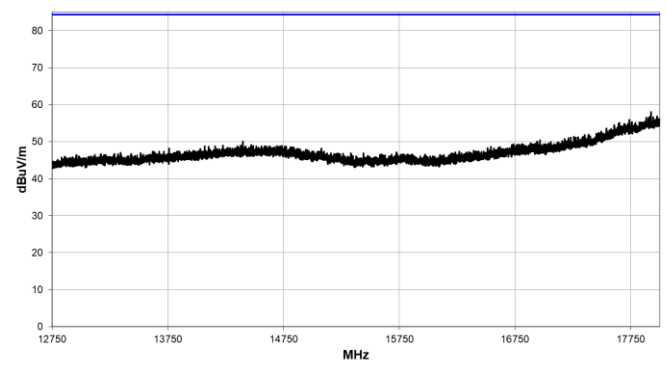
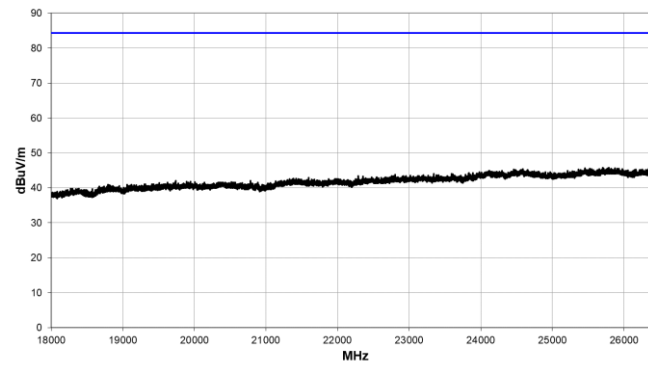


18 GHz – 26.5 GHz

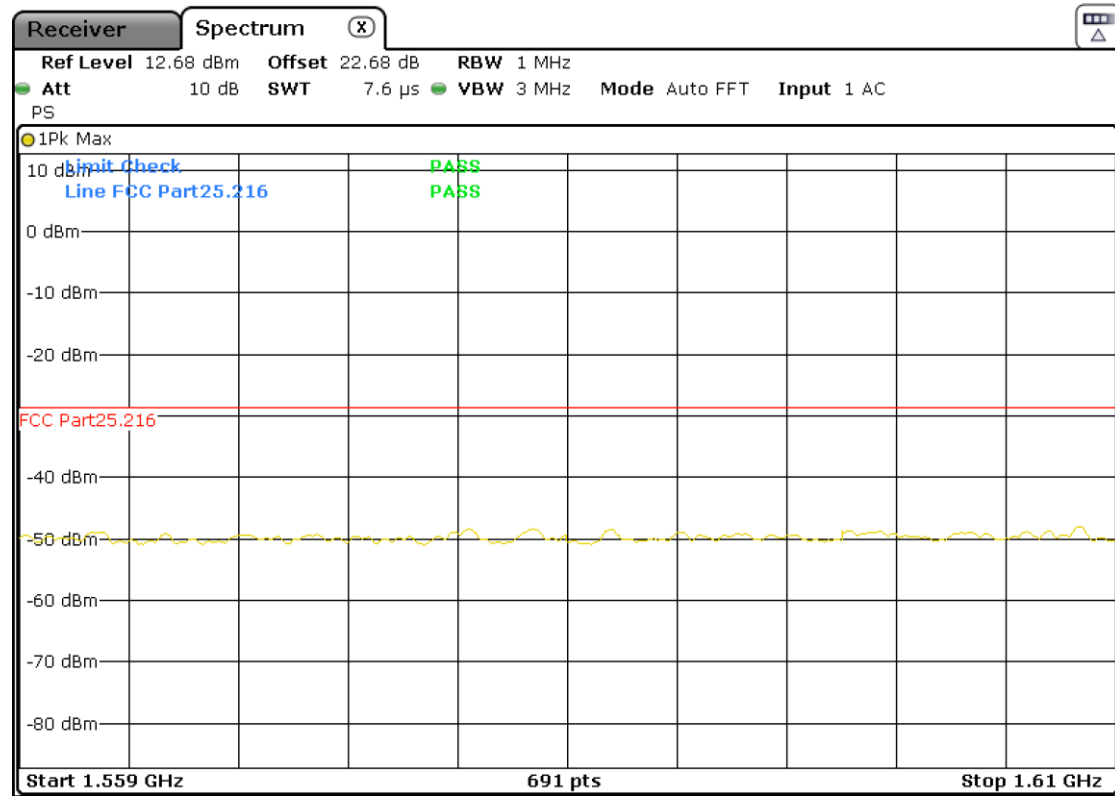
Frequency: 2000.2 MHz; Power Setting: 23;				
Detector	Freq. (MHz)	Level (dBm)	Limit (dBm)	Margin (dB)
PK	4000.292	-19.83	-13	-6.83
PK	4000.350	-22.63	-13	-9.63
PK	6000.442	-17.93	-13	-4.93
PK	6000.800	-25.53	-13	-12.53
PK	8000.634	-26.43	-13	-13.43
PK	8000.750	-31.93	-13	-18.93

Middle Channel:**30MHz – 1 GHz****1 GHz – 7 GHz****7GHz – 12.75 GHz****12.75 GHz – 18GHz****18 GHz – 26.5 GHz**

<i>Frequency: 2005 MHz; Power Setting: 23;</i>				
<i>Detector</i>	<i>Freq. (MHz)</i>	<i>Level (dBm)</i>	<i>Limit (dBm)</i>	<i>Margin (dB)</i>
PK	4009.950	-20.83	-13	-7.83
PK	4010.125	-23.53	-13	-10.53
PK	6014.884	-18.03	-13	-5.03
PK	6015.158	-19.03	-13	-6.03

Top Channel:**30MHz – 1 GHz****1 GHz – 7 GHz****7GHz – 12.75 GHz****12.75 GHz – 18GHz****18 GHz – 26.5 GHz**

<i>Frequency:2009.8MHz; Power Setting: 23;</i>				
<i>Detector</i>	<i>Freq. (MHz)</i>	<i>Level (dBm)</i>	<i>Limit (dBm)</i>	<i>Margin (dB)</i>
PK	4019.484	-19.93	-13	-6.93
PK	4019.425	-23.73	-13	-10.73
PK	6029.250	-23.73	-13	-10.73
PK	6029.400	-18.03	-13	-5.03

25.216(e) Emission between 1559MHz to 1610 MHz

Note: This graph represents the emission of 3 of the channels.

Note: No emission within 20dB, no further measurement is made.

12 Frequency Tolerance

12.1 Definition

The frequency tolerance is defined as the frequency range allowed to deviate in a range of temperature or voltage supply.

12.2 Test Parameters

Test Location:	Element Skelmersdale
Test Chamber:	Radio Laboratory
Test Standard and Clause:	FCC Part15.202(d)
EUT Channels / Frequencies Measured:	Bot / Mid / Top
Deviations From Standard:	None

Environmental Test Conditions

Temperature:	-20 °C to +50 °C
Supply:	3.3 Vdc to 5 Vdc

12.3 Test Limit

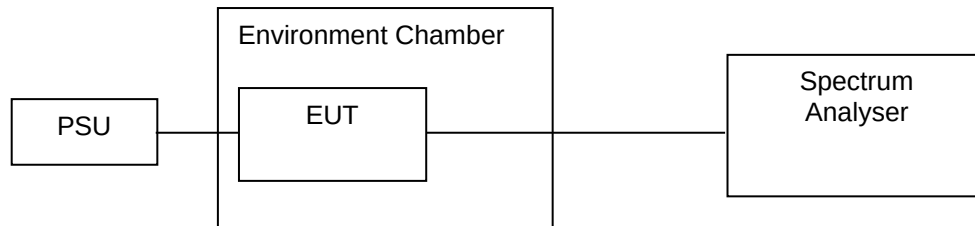
The carrier frequency shall be maintained within 0.001 percent of the reference frequency.

12.4 Test Method

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

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

Figure iii Test Setup



12.5 Test Equipment

Equipment Type	Manufacturer	Equipment Description	Element No	Due For Calibration
ESR26	R&S	EMI Receiver	U489	2023-03-04
2000T	Digitron	Temperature Indicator	U720	2023-05-09
VT 4002	Votsch	Temperature Chamber	U521	-
IPSB303A	RS Pro	Power Supply	U742	-
52 Series II	Fluke	Temperature Indicator	L426	2023-07-18

12.6 Test Results

Bottom Channel 2000.2MHz

Variation of Temperature:

Centre Frequency (MHz)	Temperature (°C)	Frequency (MHz)	Difference (Hz)	Deviation (%)	Limit (%)	Comments
2000.2	Ambient (20°C)	2000.200112	-	-	-	Reference
2000.2	-20	2000.199942	0.00017	0.00001	0.001	Pass
2000.2	-10	2000.199884	0.00023	0.00001	0.001	Pass
2000.2	0	2000.199855	0.00026	0.00001	0.001	Pass
2000.2	10	2000.200075	0.00004	0.00000	0.001	Pass
2000.2	20	2000.200112	0.00000	0.00000	0.001	Pass
2000.2	30	2000.200088	0.00002	0.00000	0.001	Pass
2000.2	40	2000.200127	0.00002	0.00000	0.001	Pass
2000.2	50	2000.200368	0.00026	0.00001	0.001	Pass

Variation of Voltage:

Centre Frequency (MHz)	Voltage (Vdc)	Frequency (MHz)	Difference (Hz)	Deviation (%)	Limit (%)	Comments
2000.2	4.5	2000.200112	-	-	-	Reference
2000.2	3.3	2000.199904	0.0002	0.0000104	0.001	Pass
2000.2	5	2000.199965	0.0001	0.0000073	0.001	Pass

Middle Channel 2005MHz

Variation of Temperature

Centre Frequency (MHz)	Temperature (°C)	Frequency (MHz)	Difference (Hz)	Deviation (%)	Limit (%)	Comments
2005	Ambient (20°C)	2005.000112	-	-	-	Reference
2005	-20	2005.001302	0.00119	0.00006	0.001	Pass
2005	-10	2004.999884	0.00023	0.00001	0.001	Pass
2005	0	2004.999913	0.00020	0.00001	0.001	Pass
2005	10	2005.000081	0.00003	0.00000	0.001	Pass
2005	20	2005.000112	0.00000	0.00000	0.001	Pass
2005	30	2005.000720	0.00061	0.00003	0.001	Pass
2005	40	2005.000257	0.00014	0.00001	0.001	Pass
2005	50	2005.000353	0.00024	0.00001	0.001	Pass

Variation of Voltage

Centre Frequency (MHz)	Voltage (Vdc)	Frequency (MHz)	Difference (Hz)	Deviation (%)	Limit (%)	Comments
2005	4.5	2005.000112	-	-	-	Reference
2005	3.3	2004.999916	0.0002	0.0000098	0.001	Pass
2005	5	2004.999962	0.0000	0.0000075	0.001	Pass

Top Channel 2009.8MHz**Variation of Temperature:**

Centre Frequency (MHz)	Temperature (°C)	Frequency (MHz)	Difference (Hz)	Deviation (%)	Limit (%)	Comments
2009.8	Ambient (20°C)	2009.800112	-	-	-	Reference
2009.8	-20	2009.799942	0.00017	0.000008	0.001	Pass
2009.8	-10	2009.799884	0.00023	0.000011	0.001	Pass
2009.8	0	2009.799913	0.00020	0.000010	0.001	Pass
2009.8	10	2009.800049	0.00006	0.000003	0.001	Pass
2009.8	20	2009.800112	0.00000	0.000000	0.001	Pass
2009.8	30	2009.800064	0.00005	0.000002	0.001	Pass
2009.8	40	2009.800255	0.00014	0.000007	0.001	Pass
2009.8	50	2009.800321	0.00021	0.000010	0.001	Pass

Variation of Voltage:

Centre Frequency (MHz)	Voltage (Vdc)	Frequency (MHz)	Difference (Hz)	Deviation (%)	Limit (%)	Comments
2009.8	4.5	2009.800112	-	-	-	Reference
2009.8	3.3	2009.799939	0.00017	-0.000009	0.001	Pass
2009.8	5	2009.799959	0.00002	-0.000008	0.001	Pass

13 Emission Limitation

13.1 Test Parameters

Test Location:	Element Skelmersdale
Test Chamber:	Radio Laboratory
Test Standard and Clause:	FCC Part 25.202(f)
EUT Channels / Frequencies Measured:	Bot / Mid / Top
EUT Channel Bandwidths:	150 kHz
Deviations From Standard:	None
Measurement BW:	4 kHz
Measurement Detector:	Average

Environmental Conditions (Normal Environment)

Temperature: 23 °C	+15 °C to +35 °C (as declared)
Humidity: 46 % RH	20 % RH to 75 % RH (as declared)

13.2 Test Limit

The mean power of emissions shall be attenuated below the mean output power of the transmitter in accordance with the schedule set forth in the following paragraph.

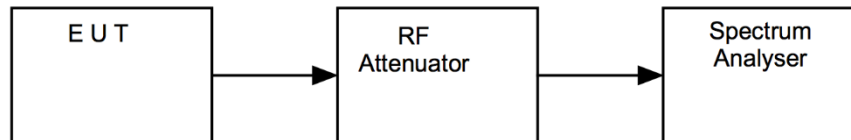
- (1) In any 4 kHz band, the center frequency of which is removed from the assigned frequency by more than 50 percent up to and including 100 percent of the authorized bandwidth: 25 dB;
- (2) In any 4 kHz band, the center frequency of which is removed from the assigned frequency by more than 100 percent up to and including 250 percent of the authorized bandwidth: 35 dB;
- (3) In any 4 kHz band, the center frequency of which is removed from the assigned frequency by more than 250 percent of the authorized bandwidth: An amount equal to 43 dB plus 10 times the logarithm (to the base 10) of the transmitter power in watts;
- (4) In any event, when an emission outside of the authorized bandwidth causes harmful interference, the Commission may, at its discretion, require greater attenuation than specified in paragraphs (1), (2) and (3) of this section.

13.3 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

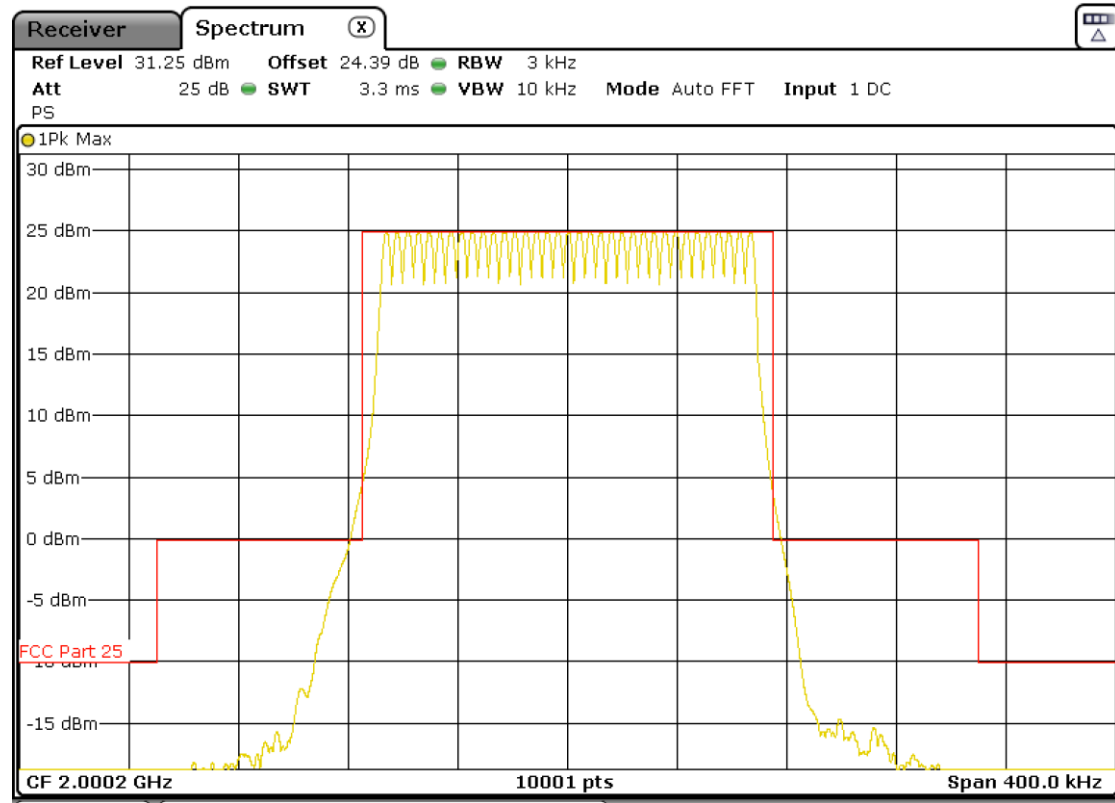


13.4 Test Equipment

Equipment Type	Manufacturer	Equipment Description	Element No	Due For Calibration
ESR26	R&S	EMI Receiver	U489	2023-03-04

13.5 Test Results

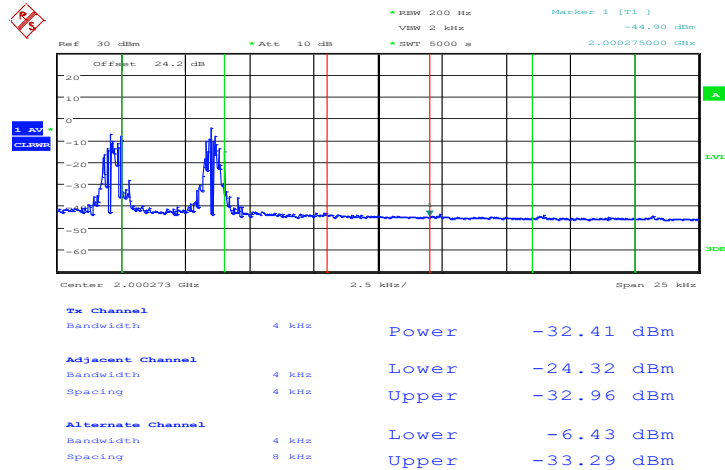
Bottom Channel 2000.2 MHz



Analyser Offset = Antenna Gain + Cable and Attenuation Loss+ Bandwidth Adaption

Note: A further measurement is made at the edge of the bandwidth and the result is shown on the next page. The upper edge is 2000.275MHz and the lower edge is 2000.125MHz.

Upper limit

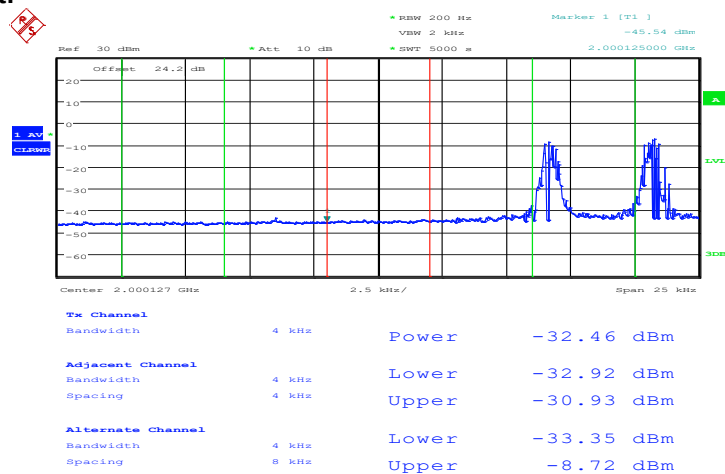


Frequency (MHz)	Power* (dBm)	Peak Power (dBm)	Limit (dBc)	Power Difference (dB)	Result
2000.275 – 2000.279 (Upper Adjacent Channel)	-32.96	23.48#	25	56.44	Pass
2000.279 – 2000.283 (Upper Alternate Channel)	-33.29	23.48#	25	56.77	Pass

*Power in 4kHz from the upper band edge (TX channel BW on above plot)

#The Peak Power value reference to section 14

Lower limit:

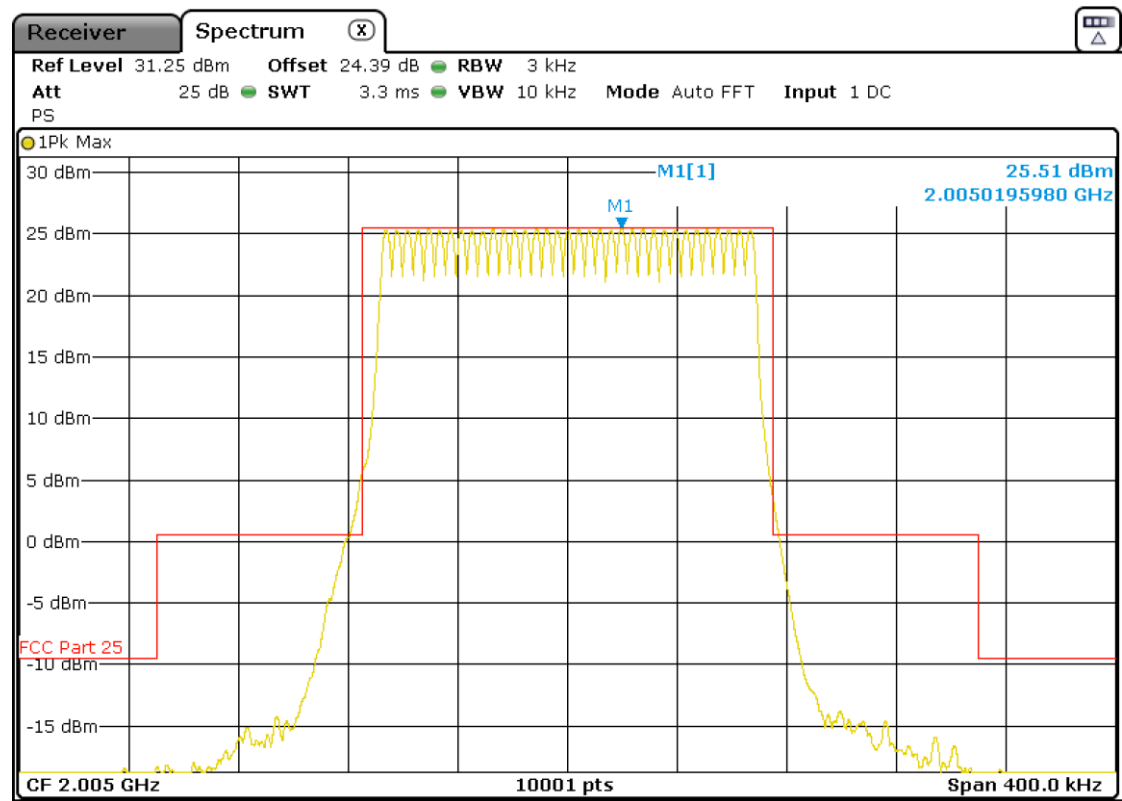


Frequency (MHz)	Power* (dBm)	Peak Power (dBm)	Limit (dBc)	Power Difference (dB)	Result
2000.121 - 2000.125 (Lower Adjacent Channel)	-32.92	23.48#	25	56.4	Pass
2000.117 - 2000.121 (Lower Alternate Channel)	-33.35	23.48#	25	56.83	Pass

*Power in 4kHz from the lower band edge (TX channel BW on above plot)

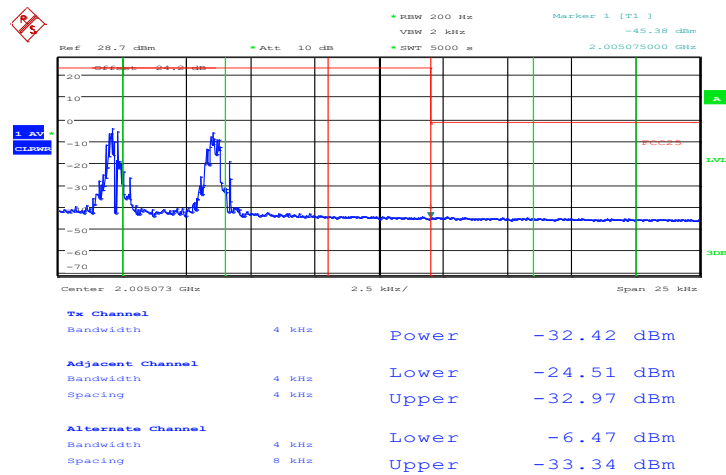
#The Peak Power value reference to section 14

Middle Channel 2005 MHz



Analyser Offset = Antenna Gain + Cable and Attenuation Loss + Bandwidth Adaption

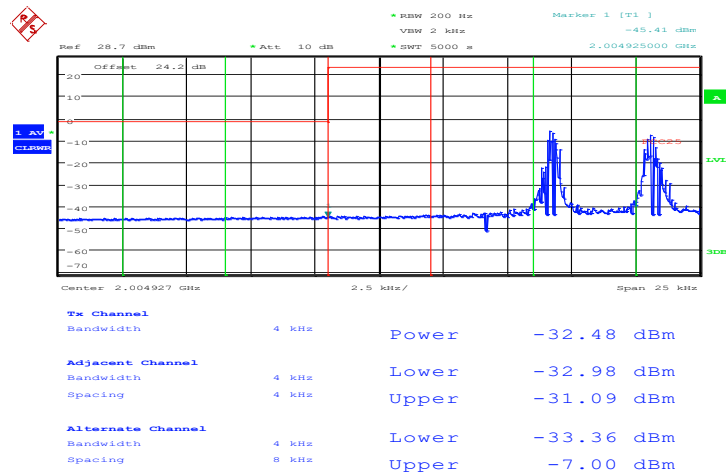
Note: A further measurement is made at the edge of the bandwidth and the result is shown on the next page. The upper edge is 2005.075MHz and the lower edge is 2004.925MHz.

Upper limit:

Frequency (MHz)	Power* (dBm)	Peak Power (dBm)	Limit (dBc)	Power Difference (dB)	Result
2005.075 – 2000.079 (Upper Adjacent Channel)	-32.97	23.58#	25	56.55	Pass
2000.079 – 2000.083 (Upper Alternate Channel)	-33.34	23.58#	25	56.92	Pass

***Power in 4kHz from the upper band edge (TX channel BW on above plot)**

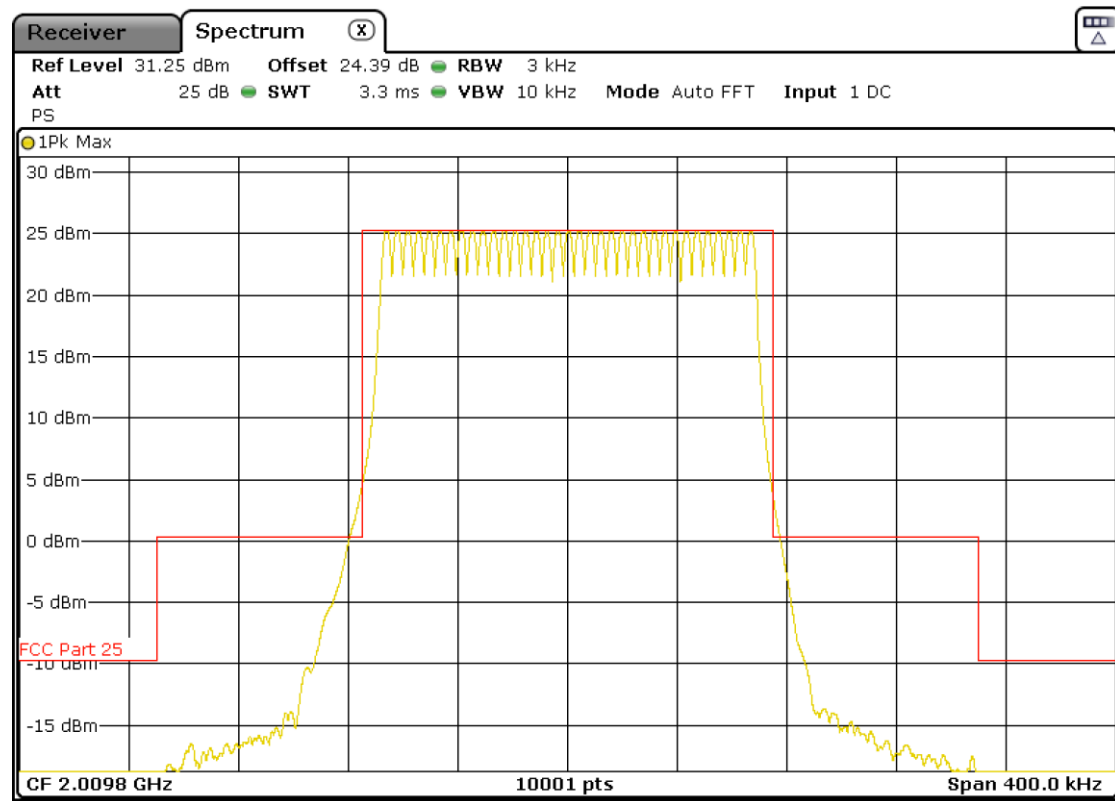
#The Peak Power value reference to section 14

Lower limit

Frequency (MHz)	Power* (dBm)	Peak Power (dBm)	Limit (dBc)	Power Difference (dB)	Result
2004.921 - 2004.925 (Lower Adjacent Channel)	-32.98	23.58#	25	56.56	Pass
2004.917 - 2004.921 (Lower Alternate Channel)	-33.36	23.58#	25	56.94	Pass

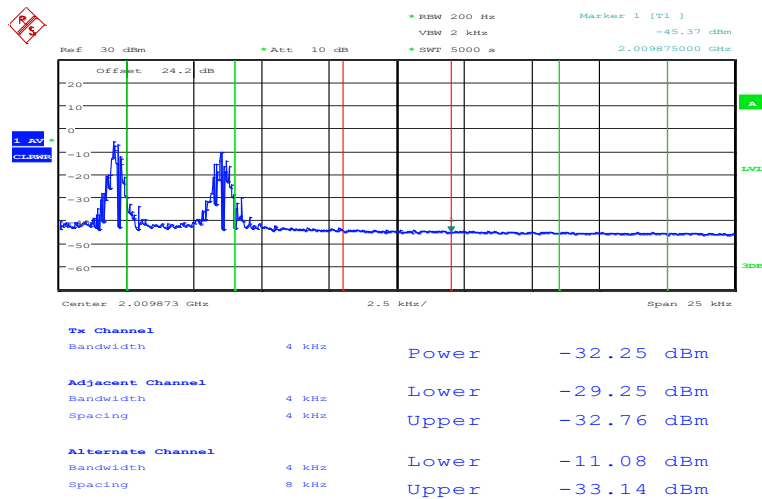
***Power in 4kHz from the lower band edge (TX channel BW on above plot)**

#The Peak Power value reference to section 14

Top Channel 2009.8MHz:

Analyser Offset = Antenna Gain + Cable and Attenuation Loss+ Bandwidth Adaption

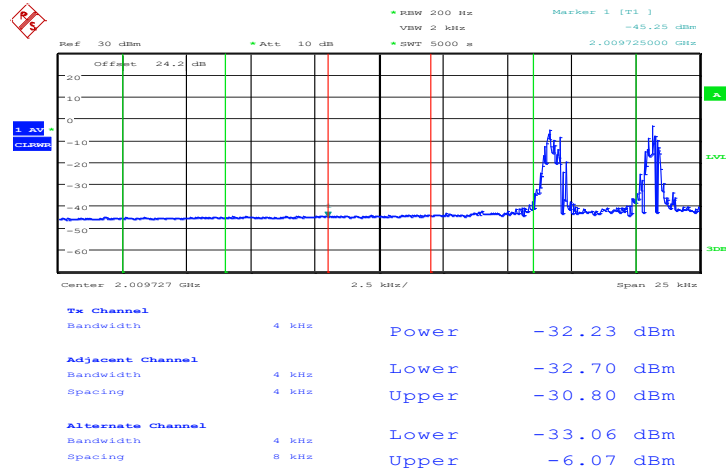
Note: A further measurement is made at the edge of the bandwidth and the result is shown on the next page. The upper edge is 2009.875Mhz and the lower edge is 2009.725MHz.

Upper Limit:

Frequency (MHz)	Power* (dBm)	Peak Power (dBm)	Limit (dBc)	Power Difference (dB)	Result
2009.875 – 2009.579 (Upper Adjacent Channel)	-32.76	23.49#	25	56.25	Pass
2009.579 – 2009.583 (Upper Alternate Channel)	-33.14	23.49#	25	56.63	Pass

*Power in 4kHz from the upper band edge (TX channel BW on above plot)

#The Peak Power value reference to section 14

Lower Limit:

Frequency (MHz)	Power* (dBm)	Peak Power (dBm)	Limit (dBc)	Power Difference (dB)	Result
2009.721 - 2009.725 (Lower Adjacent Channel)	-32.7	23.49	25	56.19	Pass
2009.717 - 2009.721 (Lower Alternate Channel)	-33.06	23.49	25	56.55	Pass

*Power in 4kHz from the lower band edge (TX channel BW on above plot)

#The Peak Power value reference to section 14

14 Power Limit

14.1 Test Parameters

Test Location:	Element Skelmersdale
Test Chamber:	Radio Room
Test Standard and Clause:	FCC Part 25.204(a)
EUT Channels / Frequencies Measured:	Bot / Mid / Top
EUT Channel Bandwidths:	150 kHz
Deviations From Standard:	None

Environmental Conditions (Normal Environment)

Temperature: 23 °C	+15 °C to +35 °C (as declared)
Humidity: 46 % RH	20 % RH to 75 % RH (as declared)
Supply: 4.5 V/dc	230 V ac ± 10 % (as declared)

14.2 Test Limit

In bands shared coequally with terrestrial radio communication services, the equivalent isotropically radiated power transmitted in any direction towards the horizon by an earth station, other than an ESV, operating in frequency bands between 1 and 15 GHz, shall not exceed the following limits:

- + 40 dBW in any 4 kHz band for $\theta \leq 0^\circ$
- + 40 + 3θ dBW in any 4 kHz band for $0^\circ < \theta \leq 5^\circ$

where θ is the angle of elevation of the horizon viewed from the center of radiation of the antenna of the earth station and measured in degrees as positive above the horizontal plane and negative below it.

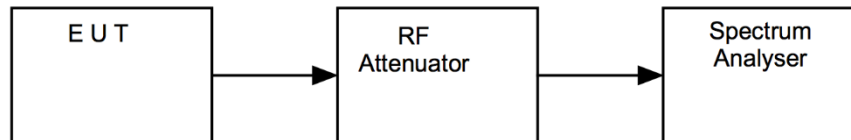
For angles of elevation of the horizon greater than 5° there shall be no restriction as to the equivalent isotropically radiated power transmitted by an earth station towards the horizon.

14.3 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



14.4 Test Equipment

Equipment Type	Manufacturer	Equipment Description	Element No	Due For Calibration
ESR26	R&S	EMI Receiver	U489	2023-03-04

14.5 Test Results

Frequency (MHz)	Level at Power Meter (dBm)	Attenuator and cable loss (dB)	Antenna Gain (dBi)	Peak Carrier Power EIRP (dBm)	Peak Carrier Power EIRP (dBW)	Limit (dBW)
2000.2	-0.57	21.37	2.68	23.48	-6.52	+40
2005.0	-0.49	21.37	2.68	23.56	-6.44	+40
2009.8	-0.54	21.35	2.68	23.49	-6.51	+40

15 Measurement Uncertainty

Radio Testing – General Uncertainty Schedule

All statements of uncertainty are expanded standard uncertainty using a coverage factor of 1.96 to give a 95 % confidence where no required test level exists.

Test/Measurement	Budget Number	MU
Conducted RF Power, Power Spectral Density, Adjacent Channel Power and Spurious emissions		
Absolute RF power (via antenna connector) Dare RPR3006W Power Head	MU4001	0.9 dB
Carrier Power and PSD - Spectrum Analysers	MU4004	0.9 dB
Adjacent Channel Power	MU4002	1.9 dB
Transmitter conducted spurious emissions	MU4041	0.9 dB
Conducted power and spurious emissions 40 GHz to 50 GHz	MU4042	2.4 dB
Conducted power and spurious emissions 50 GHz to 75 GHz	MU4043	2.5 dB
Conducted power and spurious emissions 75 GHz to 110 GHz	MU4044	2.4 dB
Radiated RF Power and Spurious emissions ERP and EIRP		
Effective Radiated Power Reverb Chamber	MU4020	3.7 dB
Effective Radiated Power	MU4021	4.7 dB
TRP Emissions 30 MHz to 1 GHz using CBL6111 or CBL6112 Bilog Antenna	MU4046	5.3 dB
TRP Emissions 1 GHz to 18 GHz using HL050 Log Periodic Antenna	MU4047	5.1 dB
TRP Emissions 18 GHz to 26.5 GHz using Standard Gain Horn	MU4048	2.7 dB
TRP Emissions 26.5 GHz to 40 GHz using Standard Gain Horn	MU4049	2.7 dB
Spurious Emissions Electric and Magnetic Field		
Radiated Spurious Emissions 30 MHz to 1 GHz	MU4037	4.7 dB
Radiated Spurious Emissions 1-18 GHz	MU4032	4.5 dB
E Field Emissions 18GHz to 26 GHz	MU4024	3.2 dB
E Field Emissions 26GHz to 40 GHz	MU4025	3.3 dB
E Field Emissions 40GHz to 50 GHz	MU4026	3.5 dB
E Field Emissions 50GHz to 75 GHz	MU4027	3.6 dB
E Field Emissions 75GHz to 110 GHz	MU4028	3.6 dB
Radiated Magnetic Field Emissions	MU4031	2.3 dB
Frequency Measurements		
Frequency Deviation	MU4022	0.316 kHz
Frequency error using CMTA test set	MU4023	113.441 Hz
Frequency error using GPS locked frequency source	MU4045	0.0413 ppm
Bandwidth/Spectral Mask Measurements		
Channel Bandwidth	MU4005	3.87 %
Transmitter Mask Amplitude	MU4039	1.3 dB
Transmitter Mask Frequency	MU4040	2.59 %
Time Domain Measurements		
Transmission Time	MU4038	4.40 %
Dynamic Frequency Selection (DFS) Parameters)		
DFS Analyser - Measurement Time	MU4006	679 μ s
DFS Generator - Frequency Error	MU4007	92 Hz
DFS Threshold Conducted	MU4008	1.3 dB
DFS Threshold Radiated	MU4009	3.2 dB

Test/Measurement	Budget Number	MU
Receiver Parameters		
EN300328 Receiver Blocking	MU4010	1.1 dB
EN301893 Receiver Blocking	MU4011	1.1 dB
EN303340 Adjacent Channel Selectivity	MU4012	1.1 dB
EN303340 Overloading	MU4013	1.1 dB
EN303340 Receiver Blocking	MU4014	1.1 dB
EN303340 Receiver Sensitivity	MU4015	0.9 dB
EN303372-1 Image Rejection	MU4016	1.4 dB
EN303372-1 Receiver Blocking	MU4017	1.1 dB
EN303372-2 Adjacent Channel Selectivity	MU4018	1.1 dB
EN303372-2 Dynamic Range	MU4019	0.9 dB
Receiver Blocking Talk Mode Conducted	MU4033	1.2 dB
Receiver Blocking Talk Mode- radiated	MU4034	3.4 dB
Rx Blocking, listen mode, blocking level	MU4035	3.2 dB
Rx Blocking, listen mode, radiated Threshold Measurement	MU4036	3.4 dB
Adjacent Sub Band Selectivity	MU4003	4.2 dB

16 Appendix A - MPE Calculation

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

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

Where:

S = power density

R = distance to the centre of radiation of the antenna

EIRP = EUT Maximum power

Result

Channel Frequency (MHz)	EIRP (mW)	Power density limit (S) (mW/cm²)	Distance (R) cm required to be less than the power density limit
2000.2	222.8	1.0	4.2
2005	227.0	1.0	4.3
2009.8	2223.4	1.0	4.2

17 Appendix B - General SAR test reduction & 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.

The SAR Test Exclusion Threshold for frequencies in the range 100 MHz to 6 GHz, and for test separation distance of ≤ 50 mm, is determined as follows.

$$\text{SAR Exclusion Threshold (SARET)} = (\text{NT} \times \text{TSD}_A) / \sqrt{f_{\text{GHz}}}$$

Where,

NT = Numeric Threshold (3.0 for 1-g SAR and 7.5 for 10-g SAR)

TSD_A = Minimum Test separation distance or 50 mm (whichever is lower)

f_{GHz} = Transmit frequency in GHz

<i>Channel Frequency (MHz)</i>	<i>Maximum Conducted Power (mW)</i>	<i>SAR Exclusion Threshold at 50 mm (mW)</i>	<i>SAR Evaluation</i>
2000.2	120.2	106.1	Required
2005	122.5	105.9	Required
2009.8	120.5	105.8	Required

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