Report on the Radio Testing

For

A M Bromley Limited

on

Tire Monitor System

Report no. TRA-054442-47-00A

2022-08-26

Element Materials Technology Warwick Ltd.
Registered in England and Wales. Registered Office: 5 Fleet Place, London, EC4M 7RD
Company Reg No. 02536659

Report Number: TRA-054442-47-00A
Issue: A

REPORT ON THE RADIO TESTING OF A
A M Bromley Limited
Tire Monitor System
WITH RESPECT TO SPECIFICATION
FCC 47CFR 15.231

TEST DATE: 2022-06-27

Tested by: Steven Garwell
Radio Test Engineer

Approved by: John Charters
Department Manager - Radio

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Date: 2022.08.26 08:53:49 +01'00'

Date: 2022-08-26

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1 Revision Record

Issue Number	*Issue Date*	*Revision History*
A	2022-08-26	Original

2 Summary

TEST REPORT NUMBER:	TRA-054442-47-00A
WORKS ORDER NUMBER	TRA-054442-01
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:	47CFR15.231
EQUIPMENT UNDER TEST (EUT):	Tire Monitor System
FCC IDENTIFIER:	TMITMS23
EUT SERIAL NUMBER:	SO2799 (unmodulated) / SO2800 (modulated)
MANUFACTURER/AGENT:	A M Bromley Limited
ADDRESS:	West Road House 26A West Road Buxton SK17 6HF United Kingdom
CLIENT CONTACT:	Mandy Bromley ☎ 0129877166 ✉ mandy.bromley@ambromley.co.uk
ORDER NUMBER:	P14026
TEST DATE:	2022-06-27
TESTED BY:	Steven Garwell Element

2.1 Test Summary

Test Method and Description	*Requirement Clause*	*Applicable to this equipment*	*Result / Note*
	47CFR15		
Radiated spurious emissions, below 30 MHz	15.209	☐	*Note 1*
Radiated spurious emissions	15.231(b) / 15.231(e)	☒	*PASS*
AC power line conducted emissions	15.207	☐	*Note 1*
Occupied bandwidth	15.231(c)	☐	*Note 1*
Field strength of fundamental	15.231(b) / 15.231(e)	☒	*PASS*
Frequency stability	15.231(d)	☐	*Note 1*
Periodic operation	15.231(a) / 15.231(e)	☐	*Note 1*

Notes:

Note 1: Existing product with FCC ID TMITMS23. Client has modified the enclosure only and intends to carry out a Permissive Change filing. Client has specifically requested a Class II Change be carried out. Limited testing was performed to the following as requested by the client.

1: Transmitter Radiated spurious emissions
2: Field strength of fundamental

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-054442-47-00A presents the results of the Radio testing on an A M Bromley Limited, Tire Monitor System to specification 47CFR15 Radio Frequency Devices.

The testing was carried out for A M Bromley Limited 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

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.

FCC Site Listing:
The test laboratory is accredited for the above sites under the US-EU MRA, Designation numbers UK0007 & UK0020.

ISED Registration Number(s):
Element Skelmersdale 3930B

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

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

Existing product with FCC ID TMITMS23. Client has modified the enclosure only and intends to carry out a Permissive Change filing. Client has specifically requested a Class II Change be carried out. Limited testing was performed to the following as requested by the client.

1: Transmitter Radiated spurious emissions
2: Field strength of fundamental

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
CISPR	Comité International Spécial des Perturbations Radioélectriques
CW	Continuous Wave
dB	decibel
dBm	dB relative to 1 milliwatt
DC	Direct Current
EIRP	Equivalent Isotropically Radiated Power
ERP	Effective Radiated Power
EUT	Equipment Under Test
FCC	Federal Communications Commission
Hz	hertz
IC	Industry Canada (now ISED)
ISED	Innovation, Science and Economic Development Canada
ITU	International Telecommunication Union
m	metre
max	maximum
min	minimum
MRA	Mutual Recognition Agreement
N/A	Not Applicable
PCB	Printed Circuit Board
PDF	Portable Document Format
QP	Quasi-Peak
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: Tire Monitor System
- Serial Number(s): SO2799 / SO2799 (unmodulated) / SO2800 (modulated)
- Model Number: TMS23
- Software Revision: S2799 : V10 build: 'Constant carrier variant' and S2800: V10 build: 'Rapid transmit'
- Build Level / Revision Number: pre-production

7.2 System Equipment

Equipment listed below forms part of the overall test setup and is required for equipment functionality and/or monitoring during testing. The compliance levels achieved in this report relate only to the EUT and not items given in the following list.

Not Applicable – No support/monitoring equipment required.

7.3 EUT Mode of Operation

7.3.1 Transmission

The mode of operation for Transmitter tests was as follows:-

The EUT was transmitting a modulated carrier on the frequencies as indicated.

7.4 EUT Radio Parameters

7.4.1 General

Frequency of operation:	433.92 MHz
Modulation type:	FM
Occupied channel bandwidth:	180 kHz
ITU emission designator:	118kF1D
Declared output power:	-30 dBm
Nominal Supply Voltage:	3.6 Vdc from a Lithium Thionyl Chloride 1/10 C (coin cell)
Duty cycle:	2 x 62 ms bursts every 5 minutes = 0.02%
Antenna Type:	Antenna is integral in the TMS sensor

7.5 EUT Description

The EUT is a Tire Pressure Monitor.

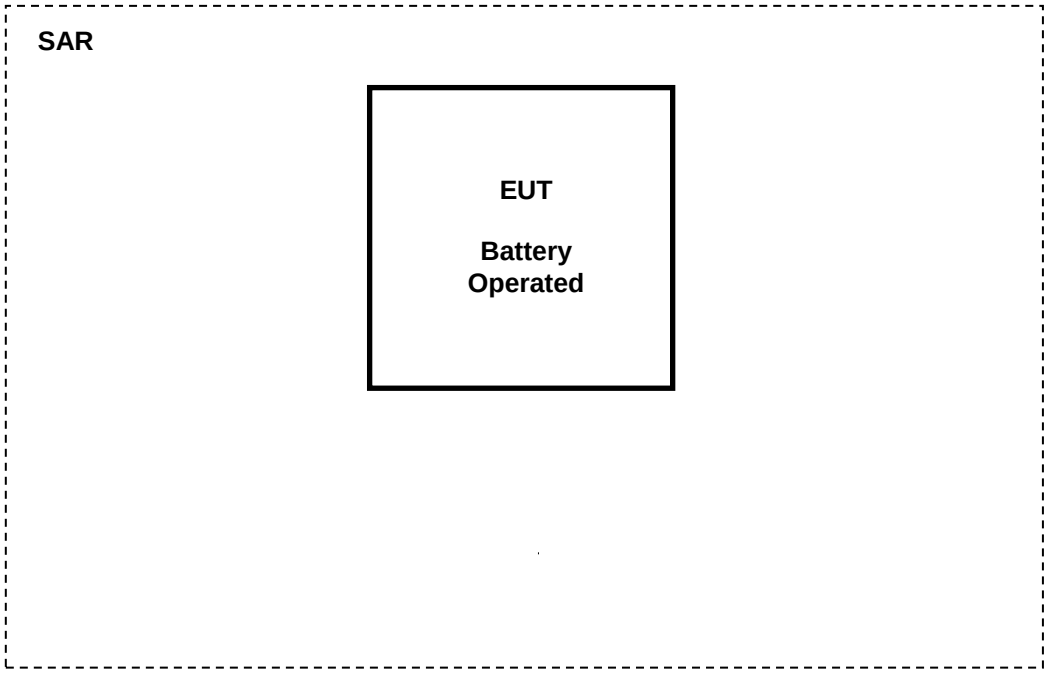
8 Modifications

No modifications were performed during this assessment.

9 EUT Test Setup

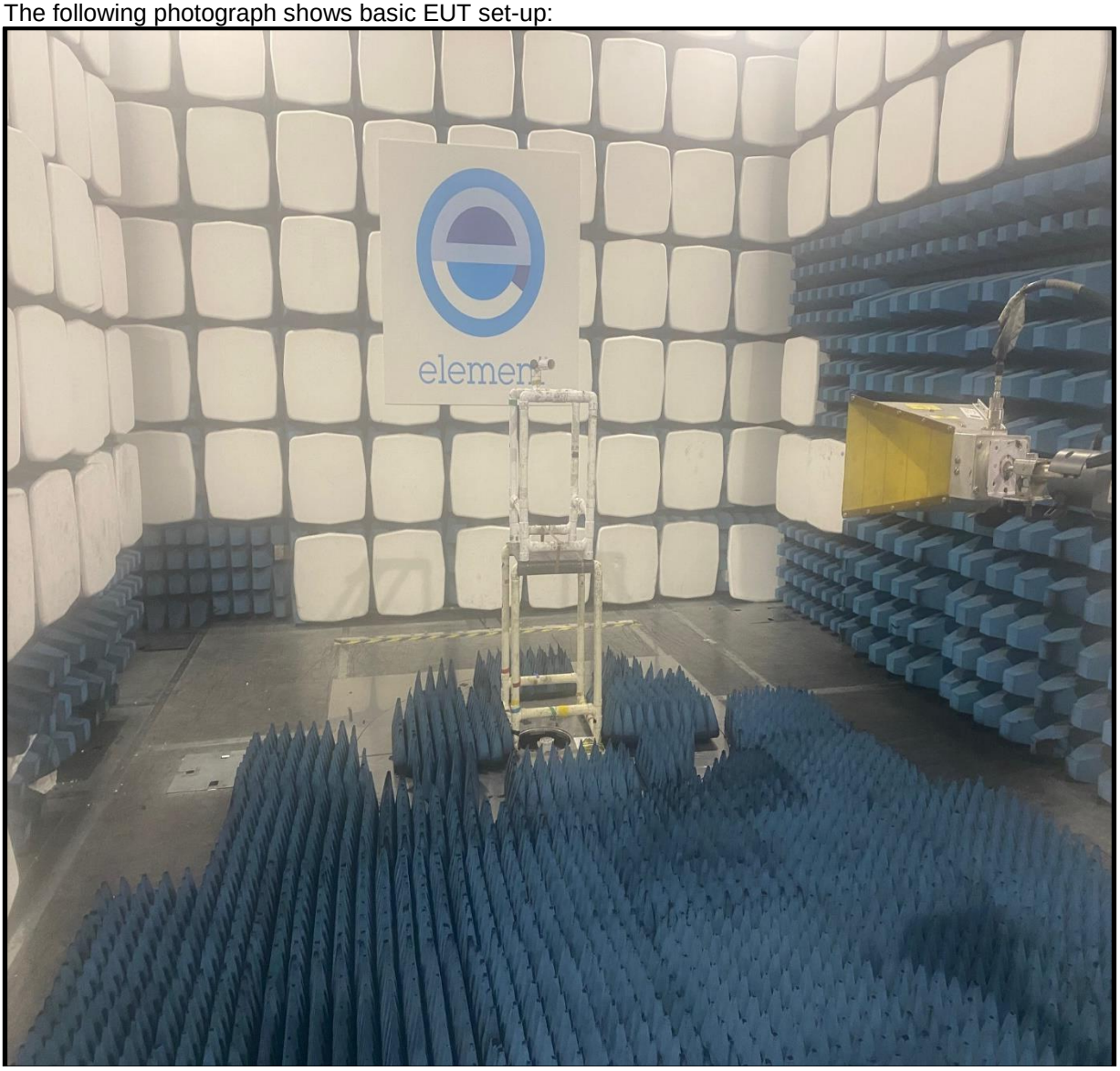
9.1 Block Diagram

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 2022.04.20.0 (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.

The following pictures are of the EUT:

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 3.6 Vdc from a Lithium Thionyl Chloride 1/10 C (coin cell).

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11 Radiated emissions

11.1 Definitions

Out-of-band emissions
Emissions on a frequency or frequencies immediately outside the necessary bandwidth which result from the modulation process, but exclude spurious emissions.

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:	SK01
Test Standard and Clause:	ANSI C63.10-2013, Clause 6.5 and 6.6
EUT Frequencies Measured:	433.92 MHz
EUT Channel Bandwidths:	180 kHz
Deviations From Standard:	None
Measurement BW:	30 MHz to 1 GHz: 120 kHz Above 1 GHz: 1 MHz
Measurement Detector:	Up to 1 GHz: quasi-peak Above 1 GHz: RMS average and Peak

Environmental Conditions (Normal Environment)

Temperature: 20 °C	+15 ºC to +35 ºC (as declared)
Humidity: 51 %RH	20%RH to 75%RH (as declared)
Supply: 3.6 Vdc	3.6 Vdc (as declared)

Test Limits
Emissions shall comply with the field strength limits shown in the Table 5. Additionally, the level of any transmitter emission shall not exceed the level of the transmitter's fundamental emission.

Table 5 - General field strength limits at frequencies above 30 MHz

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

n.b. per FCC 47CFR15.35(b) / ISED RSS-Gen 8.1, where an average measurement is specified, the peak limit is 20dB above the average limit.

11.3 Test Method

With the EUT setup as per section 9 of this report and connected as per Figure ii, 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 100kHz 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:

$$FS = PR + CL + AF – PA + DC – CF$$

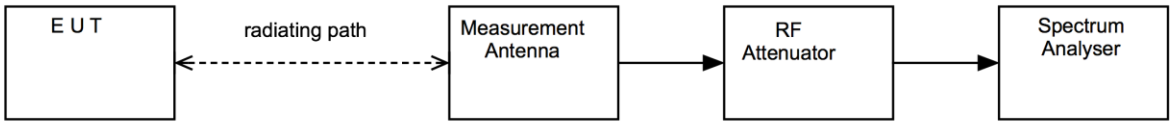
$$Factor = CL + AF – PA$$

Where,

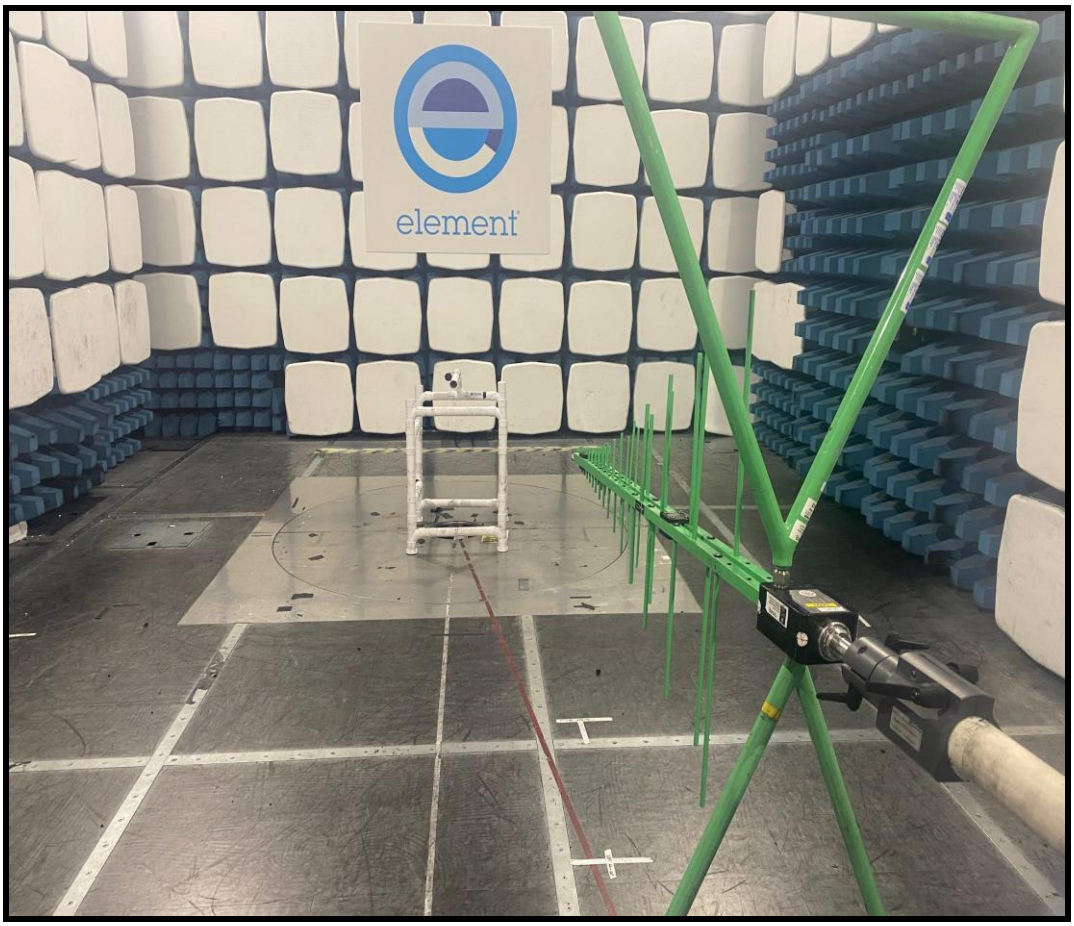
PR is the power recorded on the receiver / spectrum analyzer in dBµV;
CL is the cable loss in dB;
AF is the test antenna factor in dB/m;
PA is the pre-amplifier gain in dB (where used);
DC is the duty correction factor in dB (where used, e.g. harmonics of pulsed fundamental);
CF is the distance factor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

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

Figure i Test Setup



Test Setup Photograph(s)

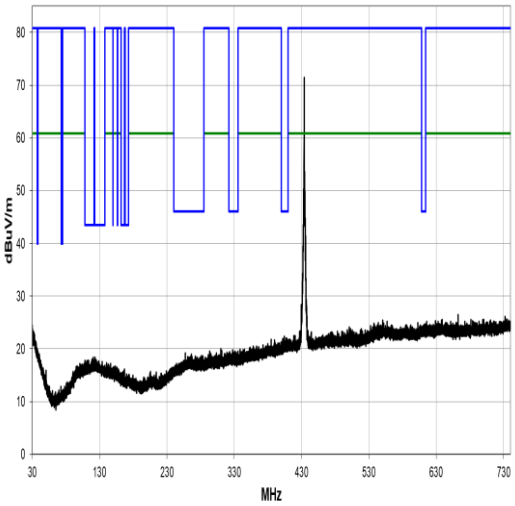


11.4 Test Equipment

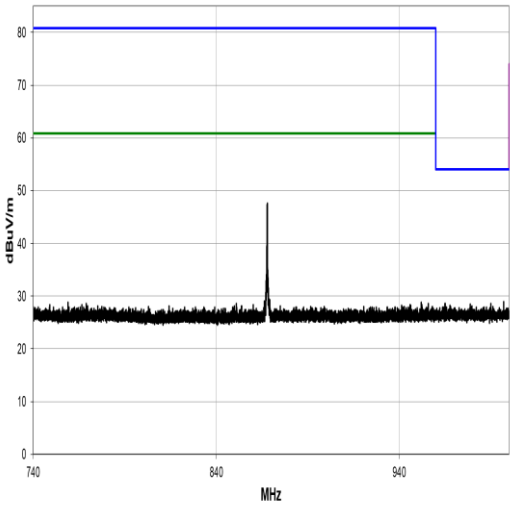
Equipment Description	*Manufacturer*	*Equipment Type*	*Element No*	*Due for Calibration*
Spectrum Analyser	R&S	ESR 7	U727	2023-04-27
Bilog	Chase	CBL6112B	U093	2023-10-15
1-18GHz Horn	EMCO	3115	U223	2023-12-13
Pre Amp	Watkins Johnson	6201-69	U372	2023-03-01
Pre Amp	Agilent	8449B	U457	2023-01-22
High Pass Filter	Mini Circuits	VHF-740+	U603	2023-02-03
High Pass Filter	MiniCircuits	VHF-1500+	U519	2023-02-03
Chamber 1	Rainford EMC	ATS	U387	2023-10-24

11.5 Test Results

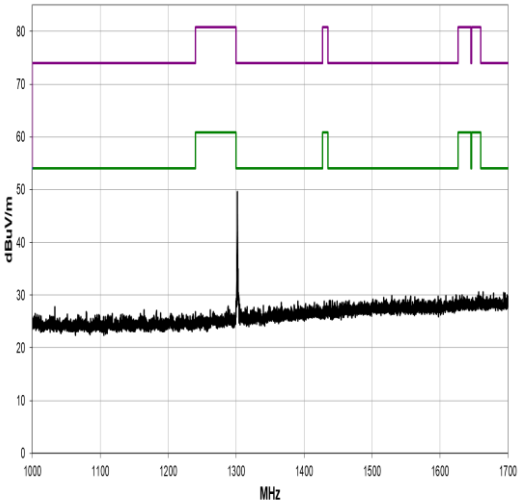
Frequency: 433.92 MHz



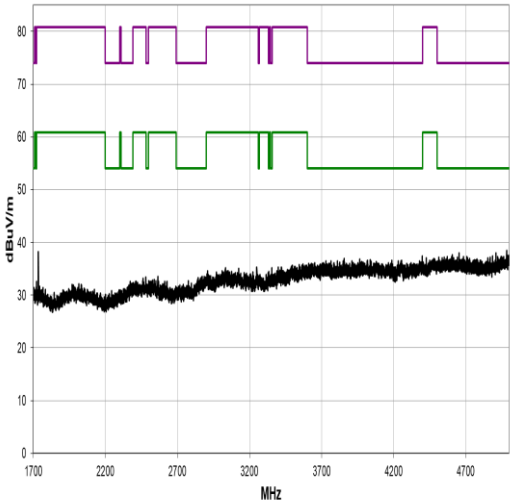
30 MHz to 740 MHz



740 MHz to 1 GHz



1 GHz to 1.7 GHz



1.7 GHz to 5 GHz

Freq (MHz)	Amplitude (dBuV)	Factor (dB/m)	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)
867.928	46.6	0.9	1.36	261.2	3.0	0.0	Vert	QP	0.0	47.5	60.8	-13.3
867.835	44.5	0.9	1.0	288.2	3.0	0.0	Horz	QP	0.0	45.4	60.8	-15.4

Freq (MHz)	Amplitude (dBuV)	Factor (dB/m)	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)
1302.058	57.0	-8.8	1.67	255.9	3.0	0.0	Horz	AV	0.0	48.2	54.0	-5.8
1302.116	47.6	-8.8	2.01	300.2	3.0	0.0	Vert	AV	0.0	38.8	54.0	-15.2
1301.817	61.1	-8.8	1.67	255.9	3.0	0.0	Horz	PK	0.0	52.3	74.0	-21.7
1301.758	54.1	-8.8	2.01	300.2	3.0	0.0	Vert	PK	0.0	45.3	74.0	-28.7

12 Transmitter output power (fundamental radiated emission)

12.1 Definition

The RF power dissipated in the standard output termination when operating under the rated duty cycle selected by the applicant for approval.

12.2 Test Parameters

Test Location:	Element Skelmersdale
Test Chamber:	SK01
Test Standard and Clause:	ANSI C63.10-2013, Clause 6.5 / 6.6
EUT Channels / Frequencies Measured:	433.92 MHz
EUT Channel Bandwidths:	180 kHz
Deviations From Standard:	None
Measurement BW:	200 kHz
Spectrum Analyzer Video BW: (requirement at least 3x RBW)	1 MHz
Measurement Detector:	Up to 1GHz: Quasi-peak Above 1GHz: Average RMS and Peak

Environmental Conditions (Normal Environment)

Temperature: 20 °C	+15 ºC to +35 ºC (as declared)
Humidity: 51 %RH	20%RH to 75%RH (as declared)

Test Limits

ISED RSS-210 A1.2 & FCC 47CFR15.231(b)
The field strength of emissions from momentarily operated intentional radiators shall not exceed the limits outlined in Table A1, based on the average value of the measured emissions. The requirements of the Pulsed Operation section of RSS-Gen / 47CFR15.35 apply for averaging pulsed emissions and limiting peak emissions.
Alternatively, compliance with the limits in Table A1 may be demonstrated using an International Special Committee on Radio Interference (CISPR) quasi-peak detector.

Table A1 – Permissible Field Strength Limits for Momentarily Operated Devices

Fundamental frequency (MHz)	***Field strength (µV/m at 3m)***	***Region***
40.66 – 40.70	2,250	USA only
70 – 130	1,250	USA and Canada
130 – 174	1,250 to 3,750*	USA and Canada
174 – 260	3,750	USA and Canada
260 – 470	3,750 to 12,500*	USA and Canada
Above 470	12,500	USA and Canada

* Linear interpolation with frequency, f, in MHz:
For 130-174 MHz: Field Strength (µV/m) = (56.82 x f)-6136
For 260-470 MHz: Field Strength (µV/m) = (41.67 x f)-7083

ISED RSS-210 A1.4 & FCC 47CFR15.231(e)
Devices may not meet the requirements in §Section A.1.1 / paragraph (a) of §15.231 and may be employed for any type of operation, provided the device complies with the requirements of §Section A.1.3 / paragarphs (b) through (d) of §15.231 and/except the field strength corresponds with the limits specified in Table A2.

Table A2 – Reduced Field Strength Limits for Momentarily Operated Devices

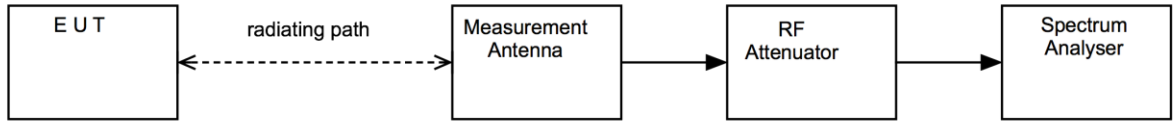
Fundamental frequency (MHz)	*Field strength (µV/m at 3m)*	*Region*
40.66 – 40.70	1,000	USA only
70 – 130	500	USA and Canada
130 – 174	500 to 1,500*	USA and Canada
174 – 260	1,500	USA and Canada
260 – 470	1,500 to 5,000*	USA and Canada
Above 470	5,000	USA and Canada

* Linear interpolation with frequency, f, in MHz:
For 130-174 MHz: Field Strength (µV/m) = (22.73 x f)-2454.55
For 260-470 MHz: Field Strength (µV/m) = (16.67 x f)-2833.33

12.3 Test Method

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



12.4 Test Equipment

Equipment Description	*Manufacturer*	*Equipment Type*	*Element No*	*Due for Calibration*
Spectrum Analyser	R&S	ESR 7	U727	2023-04-27
Bilog	Chase	CBL6112B	U093	2023-10-15
Pre Amp	Watkins Johnson	6201-69	U372	2023-03-01
Chamber 1	Rainford EMC	ATS	U387	2023-10-24

12.5 Test Results

The following formula may be used to convert field strength (FS) in volts/metre to transmitter output power (TP) in watts:

$$TP = (FS \times D)^2 / (30 \times G)$$

where D is the distance in metres between the two antennas and G is the antenna numerical gain referenced to isotropic gain.

Frequency: 433.92 MHz; Power setting: Default						
Channel Frequency (MHz)	*Field Strength (dBµV/m)*	*Distance (m)*	*Antenna Gain (dBi)*	*Max Power (mW)*	*Field Strength (µV/m)*	*Result*
433.92	71.6	3	N/A *	0.0026	3801.894	PASS

- Radiated Measurement

13 Measurement Uncertainty

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 connecter) 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 µs**
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**