

Report Number: TRA-065950-47-00B
Issue: B

Report on the Radio Testing of an
Elatec GmbH
TWN4 MultiTech Nano Plus M
With Respect to Specification
FCC 47CFR 15.209

Test Date: 2024-10-07 to 2024-10-15

Tested by: D Winstanley, S Garwell

Written by:



S Garwell
Radio Test Engineer

Approved by:



Digitally signed by
John Charters
Date: 2025.01.06
16:20:58 Z

J Charters
Lab manager

Date: 2025-01-06

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- [2] The results contained in this document relate only to the item(s) tested

RF959 7



1 Revision Record

<i>Issue</i>	<i>Issue Date</i>	<i>Revision History</i>
A	2024-11-01	Original
B	2025-01-06	Updates and corrections throughout document

2 Summary

Test Report Number: TRA-065950-47-00B

Works Order Number: TRA-065950-00

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: 47CFR15.209

Equipment Under Test (EUT): TWN4 MultiTech Nano Plus M

FCC Identifier: WP5TWN4F23

EUT Serial Number: Test Sample S1

Manufacturer: Elatec GmbH

Address: Zeppelinstr. 1
Puchheim
82178
Germany

Client Contact: Birgit Bachl
☎ +49 89 552 9961 0
✉ b.bachl@elatec.com

Authorised Agent: Element Materials Technology Straubing GmbH

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Straubing
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Contact: Katja Frankl
☎ +49 9421 56868-0
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Order Number: DE05100168PO

Test Date: 2024-10-07 to 2024-10-15

Tested By: D Winstanley, S Garwell
Element

2.1 Test Summary

<i>Test Method and Description</i>	<i>Requirement Clause 47CFR15</i>	<i>Applicable to This Equipment</i>	<i>Result / Note</i>
Radiated Spurious Emissions, Below 30 MHz	15.209	☒	Pass
Radiated Spurious Emissions, Above 30 MHz	15.209	☒	Pass
AC Power Line Conducted Emissions	15.207	☒	Pass
Occupied Bandwidth	-	☒	Pass
Field Strength of Fundamental	15.209	☒	Pass

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).

The decision rule for compliance is not inherent within this specification and compliance is based on the customer requesting a simple acceptance rule based on understanding and acceptance of Elements Measurement Uncertainty values.

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4 Introduction

This report TRA-065950-47-00B presents the results of the Radio testing on an Elatec GmbH, TWN4 MultiTech Nano Plus M to specification 47CFR15 Radio Frequency Devices.

The testing was carried out for Elatec GmbH by Element, at the address detailed below.

☒	Element Skelmersdale Unit 1 Pendle Place Skelmersdale West Lancashire WN8 9PN UK	☐	Element Surrey Hills Unit 15 B Henley Business Park Pirbright Road Normandy Guildford GU3 2DX 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 ISO/IEC 17025:2017 accredited 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 following US-UK MRA, Designation numbers.

Element Surrey Hills	UK2027
Element Skelmersdale	UK2020

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

There were no deviations from the test standard.

6 Glossary of Terms

S	denotes a section reference from the standard, not this document
AC	Alternating Current
ANSI	American National Standards Institute
BW	bandwidth
°C	Degrees 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: TWN4 MultiTech Nano Plus M
- Serial Number: Test Sample S1
- Model Number: (HVIN): EL20244
- Software Revision: B1.50/NCF4.07/PRS1.04/E
- Build Level / Revision Number: C

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.

- *Test Laptop*

7.3 EUT Mode of Operation

7.3.1 Transmission

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

The EUT was programmed via a test laptop using client supplied software (ApprovalCommander200). The EUT was tested reading / searching for an RFID tag as specified.

7.4 EUT Radio Parameters

7.4.1 General

Frequency of Operation:	125 kHz
Modulation Type:	ASK
Occupied Channel Bandwidth:	N/A
Channel Spacing:	N/A
Nominal Supply Voltage:	5 Vdc via USB

7.4.2 Antennas

Type:	Inductive Loop
Length / Diameter:	16,3mm (outer), 14,1mm (inner)
Number of Turns:	About 144 turns (150 max.)
Mounting:	PCB Mounted

7.5 EUT Description

The TWN4 MultiTech Nano Plus M is an integrated device for contactless read/write operations on a transponder, i.e. a transponder card.

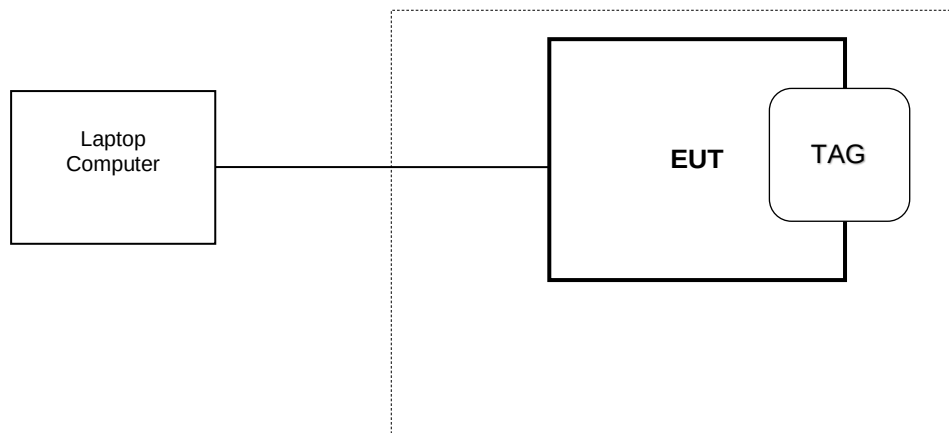
8 Modifications

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)

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 TWN4 MultiTech Nano Plus M was tested under the normal environmental conditions of the test laboratory, except where otherwise stated. The normal power source applied was 5 Vdc via USB.

11 Radiated emissions below 30 MHz

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:	REF910
Test Standard and Clause:	ANSI C63.10-2013, Clause 6.4
EUT Frequencies Measured:	125 kHz
Deviations From Standard:	None
Measurement Distance and Site	REF910 (SAR), 3m
EUT Height:	1m
Measurement Antenna and Height:	60cm shielded loop; 1m
Measurement BW:	9 kHz to 150 kHz: 200 Hz; 150 kHz to 30 MHz: 9 kHz
Measurement Detector:	9 – 90 kHz and 110 – 490 kHz: Average, RMS Other frequencies below 30 MHz: Quasi-peak.

Environmental Conditions (Normal Environment)

Temperature: 21 °C	+15 °C to +35 °C (as declared)
Humidity: 52 %RH	20%RH to 75%RH (as declared)
Supply: 5 Vdc	5 Vdc (as declared)

Test Limits

Radiated emissions shall comply with the field strength limits shown in the Table 6. Additionally, the level of any transmitter unwanted emission shall not exceed the level of the transmitter's fundamental emission.

Table 6 - General field strength limits at frequencies below 30 MHz

<i>Frequency, f (kHz)</i>	<i>Field Strength</i>	<i>Measurement Distance (m)</i>
9 – 490 ¹	6.37 / f (μA/m) 2,400 / f (μV/m)	300
490 – 1,750	63.7 / f (μA/m) 24,000 / f (μV/m)	30
1,705 – 30,000	0.08 (μA/m) 30 (μV/m)	30

Note 1: The emission limits for the ranges 9-90 kHz and 110-490 kHz are based on measurements employing a linear average detector.

11.3 Test Method

With the EUT setup as per section 9 of this report and connected as per Figure i, the EUT fundamental frequency was maximised by rotating the EUT through 360°, in three orthogonal planes, and adjusting the measurement antenna azimuth.

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 9 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 9 kHz and 30 MHz are measured using a calibrated 60cm active loop antenna. 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.

Power values measured on the test receiver / analyzer are converted to field strength, FS, in $\mu\text{V/m}$ at the regulatory distance, using:

$$FS = 10^{(PR - CF) / 20}$$

Where,

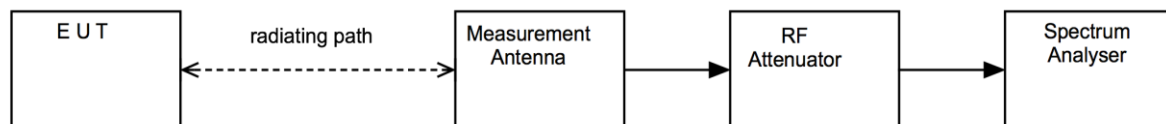
PR is the power recorded on the receiver / spectrum analyzer in dB μV and includes any cable loss, antenna factor and pre-amplifier gain;

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

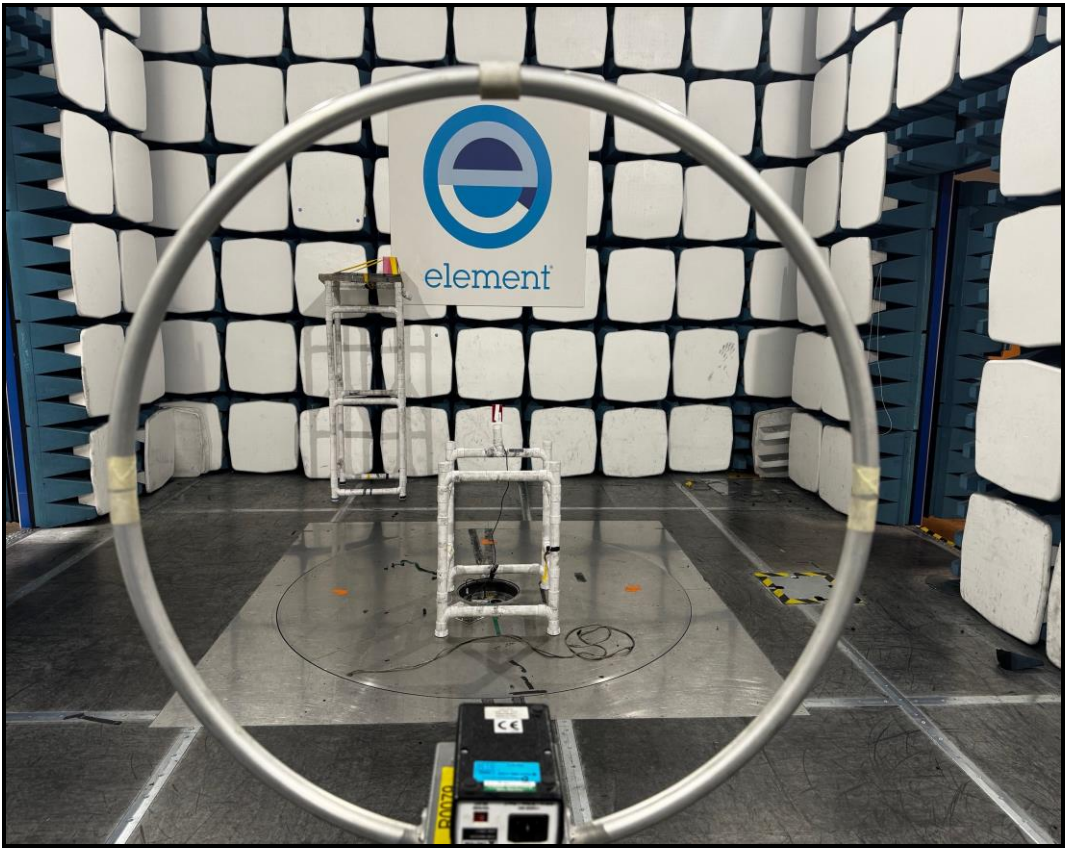
Per FCC 47CFR15.31(f)(2) / ISED RSS-Gen 6.5, an extrapolation factor of 40 dB per decade was used for measurements at distances closer than specified.

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

Figure i Test Setup



Test Setup Photograph



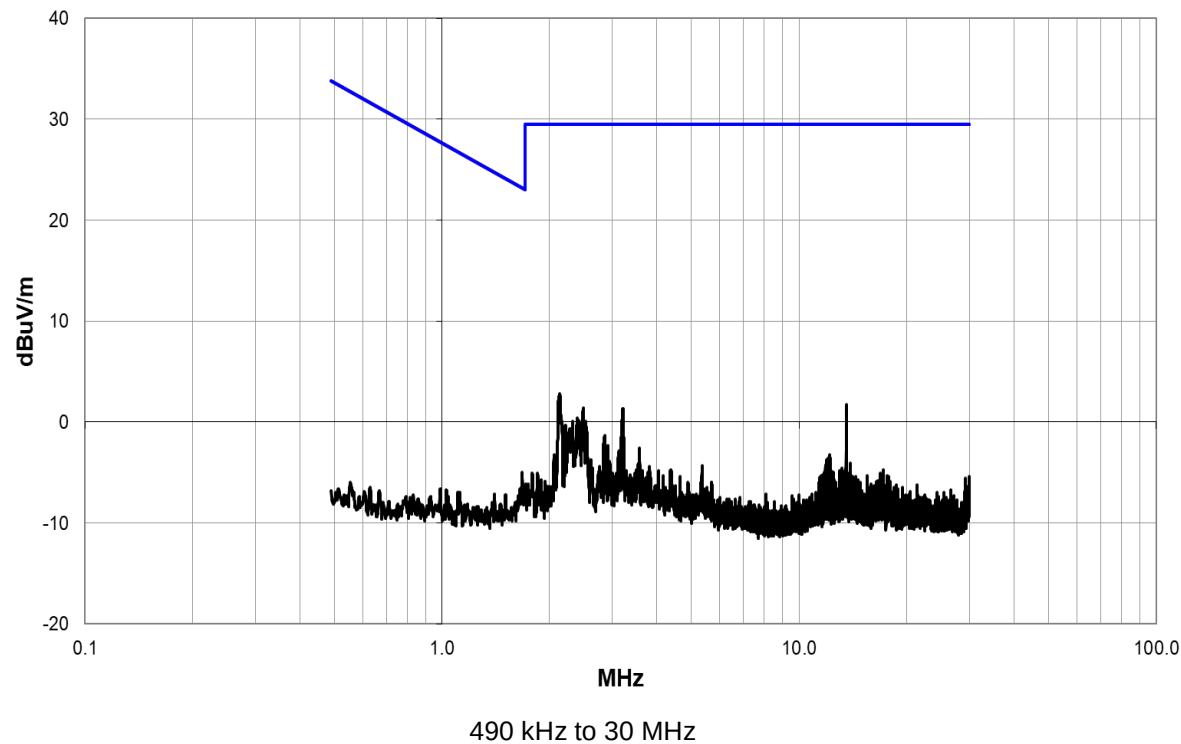
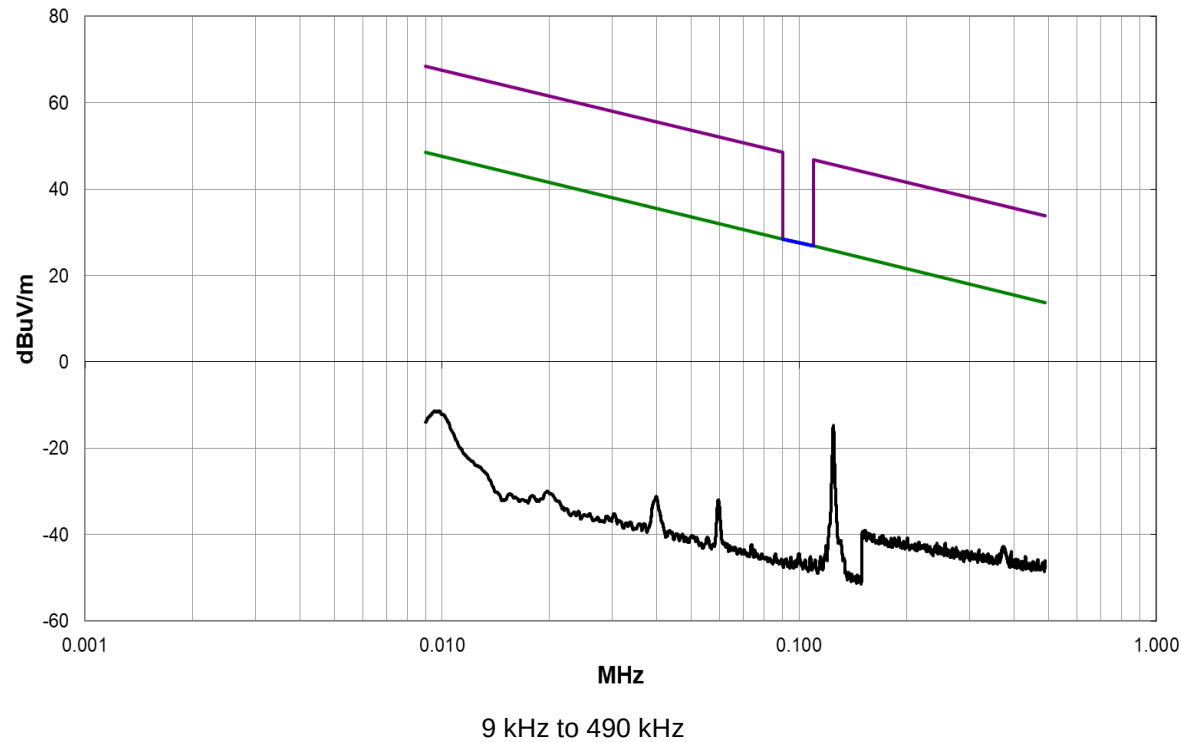
9 kHz to 30 MHz setup

11.4 Test Equipment

Equipment Type	Manufacturer	Equipment Description	Element No	Due For Calibration
EMI Receiver	R&S	ESR7	U456	2025-03-08
Active Loop Antenna	EMCO	6502	R0079	2024-11-10

11.5 Test Results

Frequency: 125 kHz; Modulation: ASK; Power Setting: Default – With TAG



Note: The emission at 125 kHz is the fundamental

Frequency: 125 kHz; Modulation: ASK; Power Setting: Default						
Emission Frequency (MHz)	Receiver Level (dBμV/m)	Measurement Distance (m)	Limit Distance (m)	Extrapolation Factor (dB)	Field Strength (μV/m)	Result
No significant emissions within 20 dB of the limit						Pass

12 Radiated emissions 30 MHz to 1 GHz

12.1 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.

12.2 Test Parameters

Test Location:	Element Skelmersdale
Test Chamber:	REF910
Test Standard and Clause:	ANSI C63.10-2013, Clause 6.5 and 6.6
EUT Frequencies Measured:	125 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: 22 °C	+15 °C to +35 °C (as declared)
Humidity: 52 %RH	20%RH to 75%RH (as declared)
Supply: 5 Vdc	5 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

<i>Frequency (MHz)</i>	<i>Field Strength (μV/m at 3m)</i>
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.

12.3 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:

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

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

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;

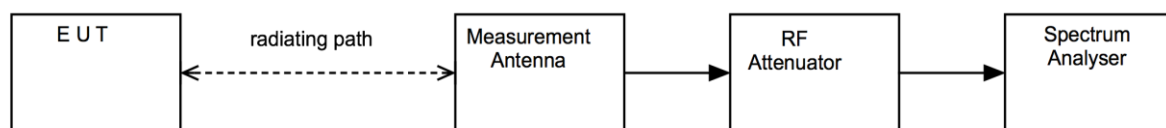
PA is the pre-amplifier gain in dB (where used);

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



Test Setup Photograph



30 MHz to 1 GHz setup

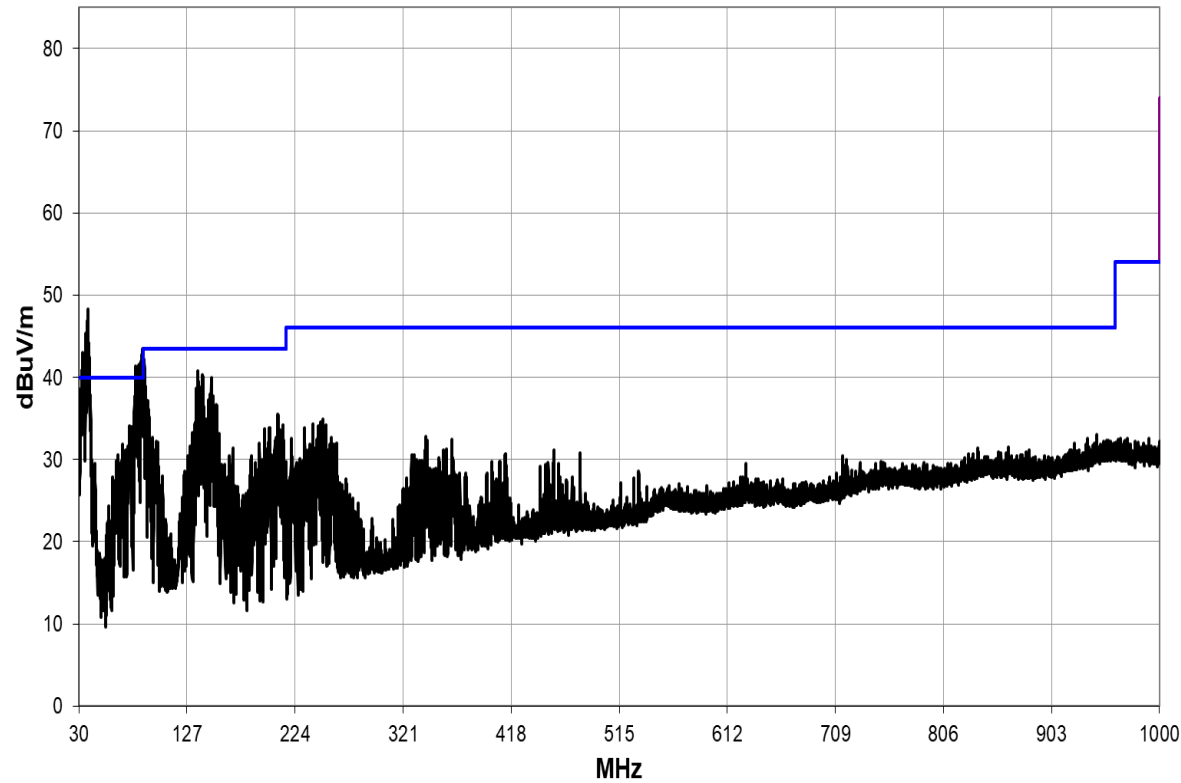
12.4 Test Equipment

Equipment Type	Manufacturer	Equipment Description	Element No	Due For Calibration
Spectrum Analyser	R&S	ESR 7	U727	2025-05-17
Bilog	Chase	CBL611/B	U573	2024-10-14
PreAmp	Watkins Johnson	6201-69	U372	2025-03-15
Radio Chamber - PP	Rainford EMC	ATS	REF940	2026-01-29
Radiated Test Software	Element	Emissions R5	REF9000	Cal Not Required

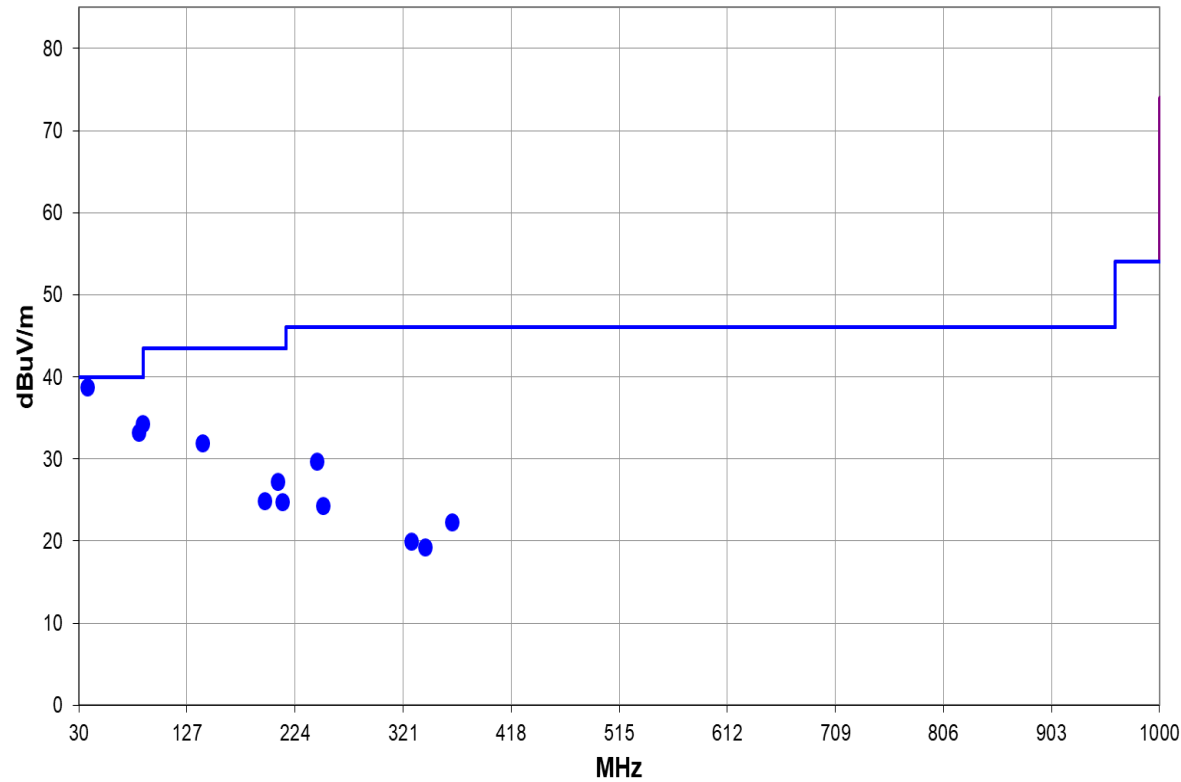
Note: Antenna U573 was in calibration at time of test.

12.5 Test Results

Frequency: 125 kHz; Modulation: ASK; Power Setting: Default – Searching for TAG



30 MHz to 1 GHz



30 MHz to 1 GHz – Final Measurements

30 MHz to 1 GHz – Measurement Results

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)
38.020	46.7	-8.0	1.5	194.9	3.0	0.0	Vert	QP	0.0	38.7	40.0	-1.3
87.482	47.9	-13.7	1.0	279.0	3.0	0.0	Vert	QP	0.0	34.2	40.0	-5.8
83.971	47.5	-14.3	1.5	14.1	3.0	0.0	Vert	QP	0.0	33.2	40.0	-6.8
141.038	41.5	-9.6	1.0	204.9	3.0	0.0	Vert	QP	0.0	31.9	43.5	-11.6
208.711	39.1	-11.9	1.0	214.0	3.0	0.0	Vert	QP	0.0	27.2	43.5	-16.3
244.108	38.8	-9.1	1.79	166.1	3.0	0.0	Vert	QP	0.0	29.7	46.0	-16.3
196.734	36.9	-12.0	2.58	185.1	3.0	0.0	Vert	QP	0.0	24.9	43.5	-18.6
213.031	36.7	-11.9	1.0	249.1	3.0	0.0	Vert	QP	0.0	24.8	43.5	-18.7

Note: the measurements above are for emissions common to all modes of operation.

13 Radiated emissions 1 GHz to 2 GHz

13.1 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.

13.2 Test Parameters

Test Location:	Element Skelmersdale
Test Chamber:	REF910
Test Standard and Clause:	ANSI C63.10-2013, Clause 6.5 and 6.6
EUT Frequencies Measured:	125 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: 21 °C	+15 °C to +35 °C (as declared)
Humidity: 52 % RH	20 % RH to 75 % RH (as declared)
Supply: 5 Vdc	5 Vdc (as declared)

13.3 Test Limit

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

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

<i>Frequency (MHz)</i>	<i>Field Strength (μV/m at 3 m)</i>	<i>Field Strength (dBμV/m at 3 m)</i>
30 to 88	100	40.0
88 to 216	150	43.5
216 to 960	200	46.0
Above 960	500	54.0

On frequencies below or equal to 1000 MHz, the limits shown are based on measuring equipment employing a CISPR quasi-peak detector function. On frequencies above 1000 MHz, the radiated emission limits are based on the use of measurement instrumentation employing an average detector function. The limit on peak radio frequency emissions is 20 dB above the maximum permitted average emission limit.

13.4 Test Method

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

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

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

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

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

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

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

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

Where,

PR is the power recorded on the receiver / spectrum analyzer in dB μ V;

CL is the cable loss in dB;

AF is the test antenna factor in dB/m;

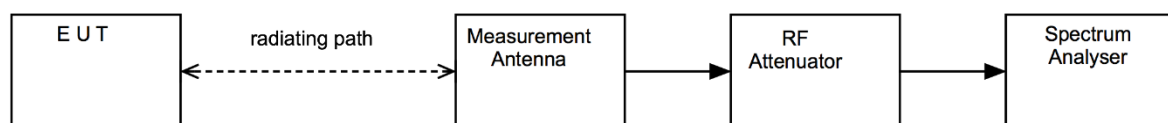
PA is the pre-amplifier gain in dB (where used);

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

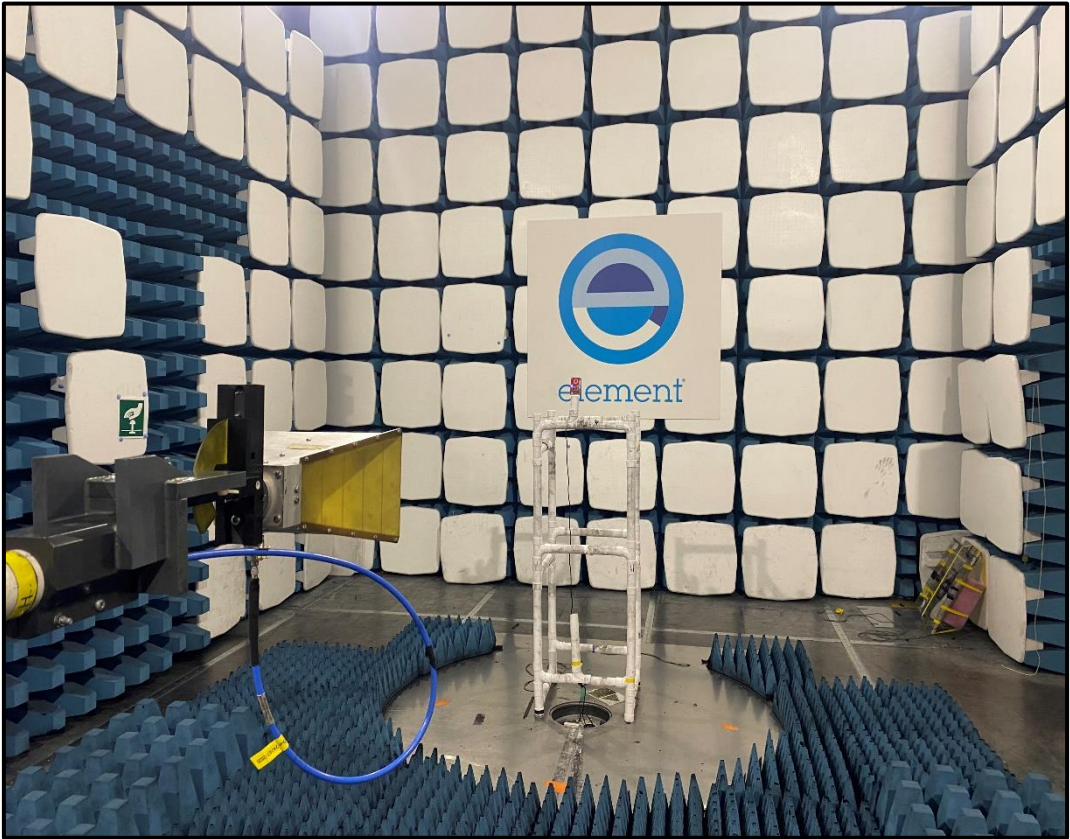
CF is the distance factor in dB (where measurement distance different to limit distance);

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

Figure i Test Setup



13.5 Test Set-up Photograph



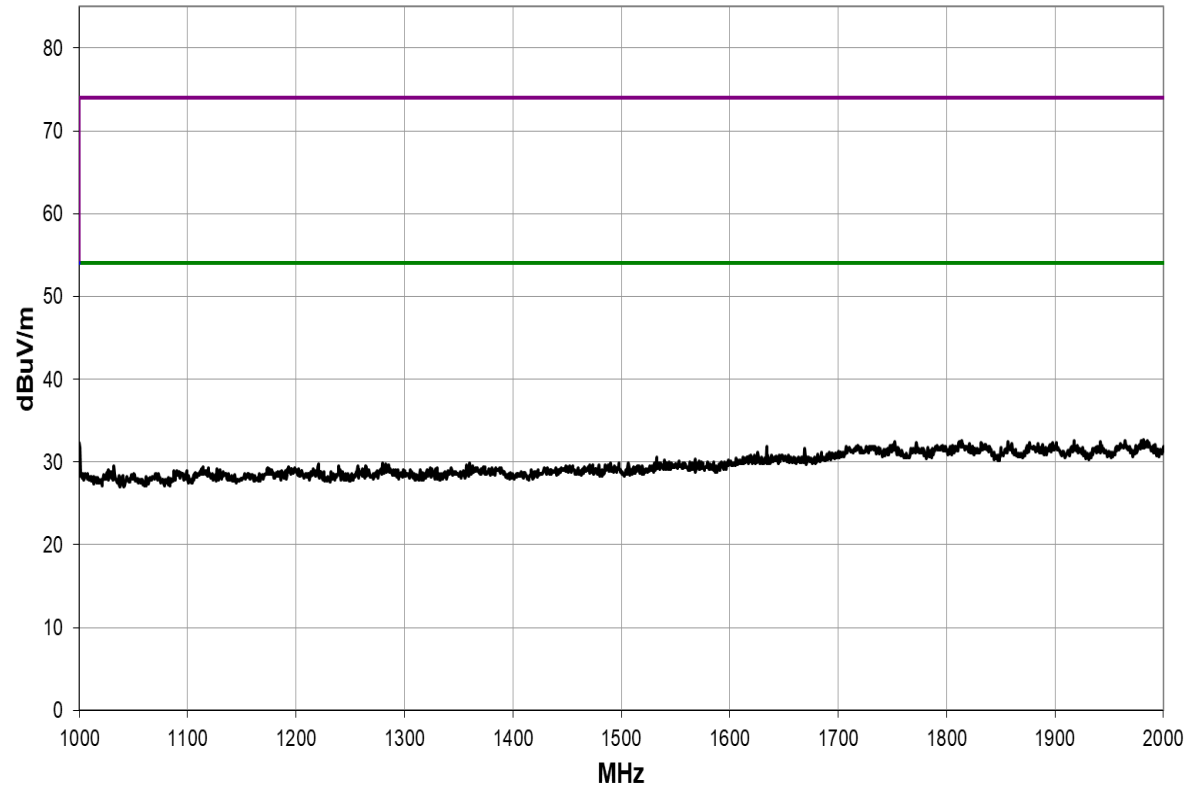
1 GHz to 2 GHz Setup

13.6 Test Equipment

Equipment Type	Manufacturer	Equipment Description	Element No	Due For Calibration
Spectrum Analyser	R&S	ESR 7	U727	2025-05-17
1-18GHz Horn	EMCO	3115	U223	2026-01-17
Pre Amp	Agilent	8449B	L572	2024-10-30
Radio Chamber - PP	Rainford EMC	ATS	REF940	2026-01-29
Radiated Test Software	Element	Emissions R5	REF9000	Cal Not Required

13.7 Test Results

Frequency: 125 kHz; Modulation: ASK; Power Setting: Default – Searching for TAG



1 GHz to 2 GHz

Frequency: 125 kHz; Modulation: ASK; Power Setting: Default										
Detector	Freq. (MHz)	Meas'd Emission (dBµV)	Cable Loss (dB)	Antenna Factor (dB/m)	Pre-amp Gain (dB)	Duty Cycle Corr'n (dB)	Distance Extrap'n Factor (dB)	Field Strength (dBµV/m)	Field Strength (µV/m)	Limit (µV/m)
No significant emissions within 20 dB of the limit										Pass

14 AC power-line conducted emissions

14.1 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.

14.2 Test Parameters

Test Location:	Element Skelmersdale
Test Chamber:	Transient Laboratory
Test Standard and Clause:	ANSI C63.10-2013, Clause 6.2
EUT Frequencies Measured:	125 kHz
EUT Modulation:	ASK
Deviations From Standard:	None
Measurement BW:	9 kHz
Measurement Detectors:	Quasi-Peak and Average, RMS

Environmental Conditions (Normal Environment)

Temperature: 21 °C	+15 °C to +35 °C (as declared)
Humidity: 48 %RH	20%RH to 75%RH (as declared)
Supply: 5 Vdc	5 Vdc (as declared)

Test Limits

For radio apparatus that are designed to be connected to the public utility (AC) power network, the radio frequency voltage that is conducted back onto the AC power line on any frequency or frequencies within the range 150 kHz to 30 MHz shall not exceed the limits in Table 4, as measured using a 50 μ H / 50 Ω line impedance stabilization network. This requirement applies for the radio frequency voltage measured between each power line and the ground terminal of each AC power-line mains cable of the EUT.

For an EUT that connects to the AC power lines indirectly, through another device, the requirement for compliance with the limits in Table 4 shall apply at the terminals of the AC power-line mains cable of a representative support device, while it provides power to the EUT. The device used to power the EUT shall be representative of typical applications.

The lower limit applies at the boundary between the frequency ranges.

Table 4 – AC power-line conducted emissions limits

Frequency (MHz)	Conducted limit (dB μ V)	
	Quasi-Peak	Average**
0.15 – 0.5	66 to 56 ¹	56 to 46 ¹
0.5 – 5.0	56	46
5.0 – 30.0	60	50

Note 1: The level decreases linearly with the logarithm of the frequency.

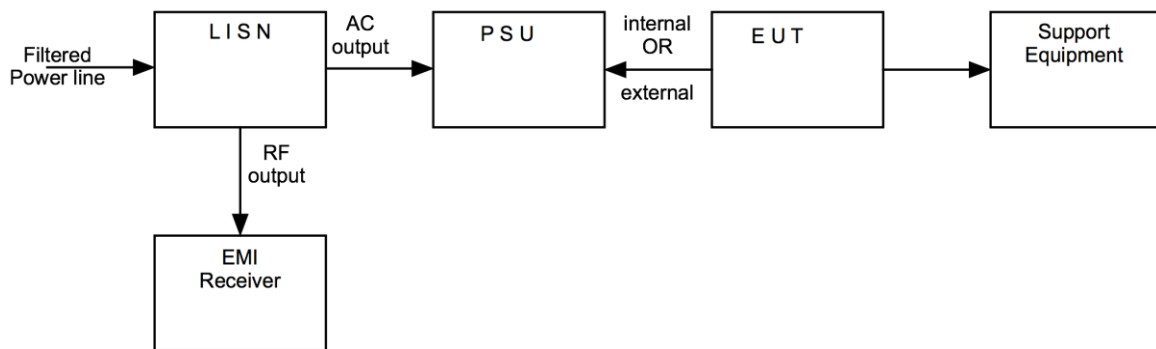
14.3 Test Method

With the EUT setup in a screened room, as per section 9 of this report and connected as per Figure iii, 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 iii Test Setup



Test Setup Photograph

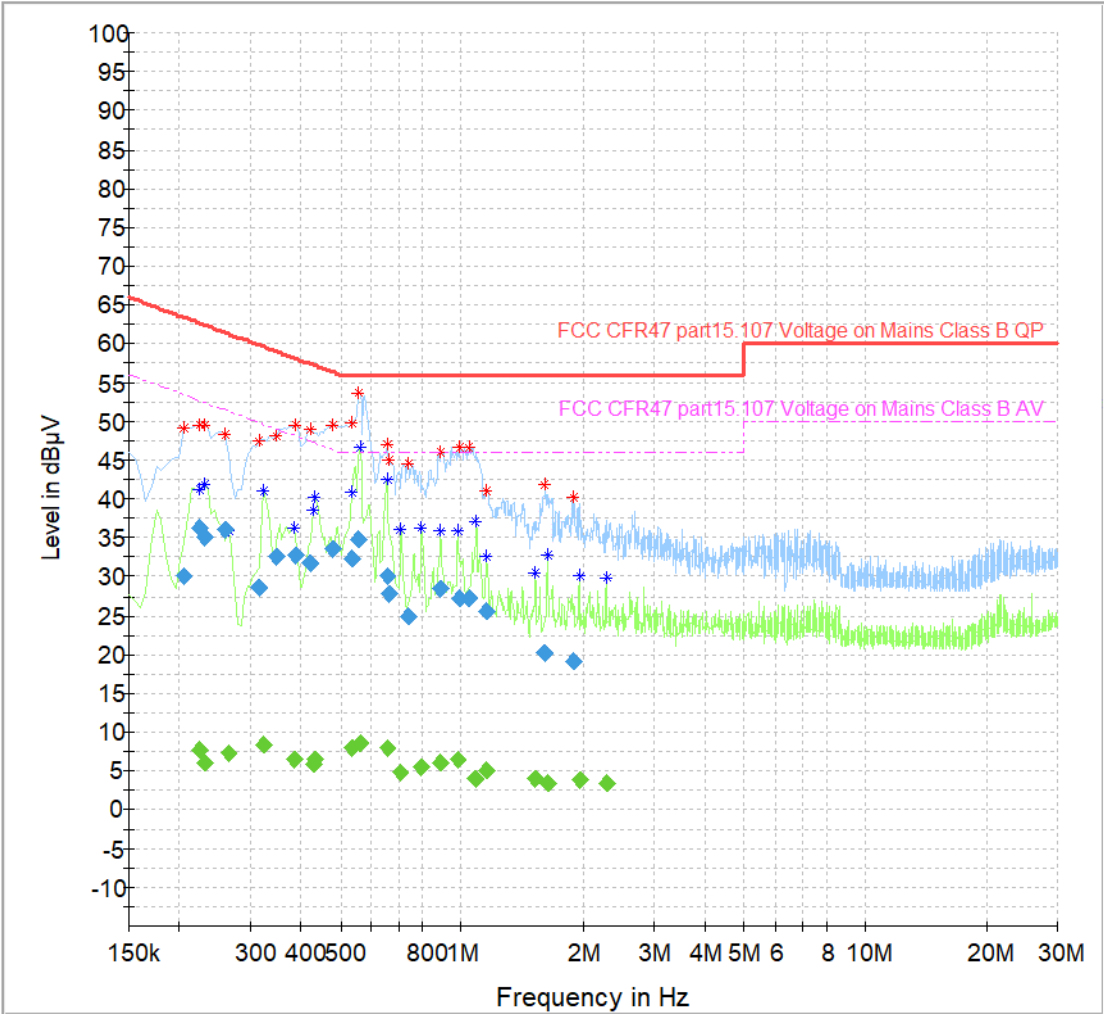


14.4 Test Equipment

<i>Equipment Type</i>	<i>Manufacturer</i>	<i>Equipment Description</i>	<i>Element No</i>	<i>Due For Calibration</i>
Spectrum Analyser	R&S	ESR 7	U727	2025-05-17
Lisn	R&S	ENV216	U396	2025-05-16
Pulse Limiter	R&S	ESH3-Z2	U443	2025-03-11

14.5 Test Results

Frequency: 125 kHz; Modulation: ASK; Power Setting: Default – Searching for TAG
Full Spectrum



Frequency: 125 kHz; Modulation: ASK; Power Setting: Default – Searching for TAG

Frequency (MHz)	QuasiPeak (dBμV)	CAverage (dBμV)	Limit (dBμV)	Margin (dB)	Meas. Time (ms)	Bandwidth (kHz)	Line	Filter	Corr. (dB)
0.204725	30.03	---	63.42	33.39	5000.0	9.000	N	OFF	19.6
0.224625	---	7.85	52.65	44.80	5000.0	9.000	L1	OFF	19.6
0.224625	36.24	---	62.65	26.41	5000.0	9.000	N	OFF	19.6
0.229600	---	6.19	52.46	46.28	5000.0	9.000	L1	OFF	19.6
0.229600	34.96	---	62.46	27.50	5000.0	9.000	N	OFF	19.6
0.259450	36.15	---	61.45	25.30	5000.0	9.000	N	OFF	19.6
0.264425	---	7.26	51.29	44.04	5000.0	9.000	N	OFF	19.6
0.314175	28.69	---	59.86	31.17	5000.0	9.000	N	OFF	19.6
0.324125	---	8.32	49.60	41.28	5000.0	9.000	N	OFF	19.6
0.349000	32.56	---	58.99	26.43	5000.0	9.000	N	OFF	19.6
0.383825	---	6.58	48.20	41.62	5000.0	9.000	N	OFF	19.6
0.388800	32.87	---	58.09	25.22	5000.0	9.000	N	OFF	19.6
0.423625	31.65	---	57.38	25.72	5000.0	9.000	N	OFF	19.6
0.428600	---	5.86	47.28	41.42	5000.0	9.000	N	OFF	19.6
0.433575	---	6.44	47.18	40.75	5000.0	9.000	N	OFF	19.6
0.478350	33.62	---	56.37	22.75	5000.0	9.000	N	OFF	19.6
0.533075	---	7.90	46.00	38.10	5000.0	9.000	N	OFF	19.6
0.533075	32.45	---	56.00	23.55	5000.0	9.000	N	OFF	19.6
0.552975	34.91	---	56.00	21.09	5000.0	9.000	N	OFF	19.6
0.557950	---	8.56	46.00	37.44	5000.0	9.000	N	OFF	19.7
0.652475	30.07	---	56.00	25.93	5000.0	9.000	N	OFF	19.7
0.652475	---	8.04	46.00	37.96	5000.0	9.000	N	OFF	19.7
0.662425	27.80	---	56.00	28.20	5000.0	9.000	L1	OFF	19.7
0.707200	---	4.91	46.00	41.09	5000.0	9.000	N	OFF	19.7
0.737050	24.83	---	56.00	31.17	5000.0	9.000	N	OFF	19.7
0.796750	---	5.53	46.00	40.47	5000.0	9.000	N	OFF	19.7
0.886300	28.47	---	56.00	27.53	5000.0	9.000	N	OFF	19.7
0.886300	---	6.14	46.00	39.86	5000.0	9.000	N	OFF	19.7
0.975850	---	6.48	46.00	39.52	5000.0	9.000	N	OFF	19.7
0.990775	27.26	---	56.00	28.74	5000.0	9.000	N	OFF	19.7
1.040525	27.12	---	56.00	28.88	5000.0	9.000	N	OFF	19.7
1.085300	---	3.96	46.00	42.04	5000.0	9.000	N	OFF	19.7
1.149975	25.46	---	56.00	30.54	5000.0	9.000	N	OFF	19.7
1.154950	---	4.99	46.00	41.01	5000.0	9.000	N	OFF	19.7
1.523100	---	4.06	46.00	41.94	5000.0	9.000	N	OFF	19.8
1.602700	20.16	---	56.00	35.84	5000.0	9.000	N	OFF	19.8
1.632550	---	3.42	46.00	42.58	5000.0	9.000	N	OFF	19.8
1.886275	19.14	---	56.00	36.86	5000.0	9.000	N	OFF	19.8
1.960900	---	3.90	46.00	42.10	5000.0	9.000	N	OFF	19.8
2.289250	---	3.47	46.00	42.53	5000.0	9.000	N	OFF	19.8

15 Occupied Bandwidth

15.1 Definition

Occupied bandwidth

The width of a frequency band such that, below the lower and above the upper frequency limits, the mean powers emitted are each equal to 0.5% of the emitted power. This is also known as the 99% *emission bandwidth*. For transmitters in which there are multiple carriers, contiguous or non-contiguous in frequency, the occupied bandwidth is to be the sum of the occupied bandwidths of the individual carriers.

20dB bandwidth

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.

15.2 Test Parameters

Test Location:	Element Skelmersdale
Test Chamber:	Radio Laboratory
Test Standard and Clause:	ANSI C63.10-2013, Clause 6.9
EUT Frequencies Measured:	125 kHz
EUT Test Modulations:	ASK
Deviations From Standard:	None
Measurement BW: (requirement: 1% to 5% OBW)	500 Hz
Spectrum Analyzer Video BW: (requirement at least 3x RBW)	2 kHz
Measurement Span: (requirement 2 to 5 times OBW)	30 kHz
Measurement Detector:	Peak

Environmental Conditions (Normal Environment)

Temperature: 23 °C	+15 °C to +35 °C (as declared)
Humidity: 48 %RH	20%RH to 75%RH (as declared)
Supply: 5 Vdc	5 Vdc (as declared)

Test Limits

ICED RSS-Gen:

The occupied bandwidth shall be reported for all equipment in addition to the specified bandwidth required in the applicable RSSs

FCC 47CFR15:

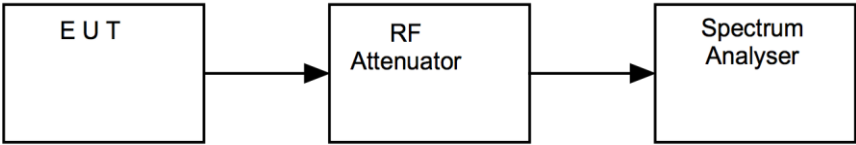
No requirement specified.

15.3 Test Method

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

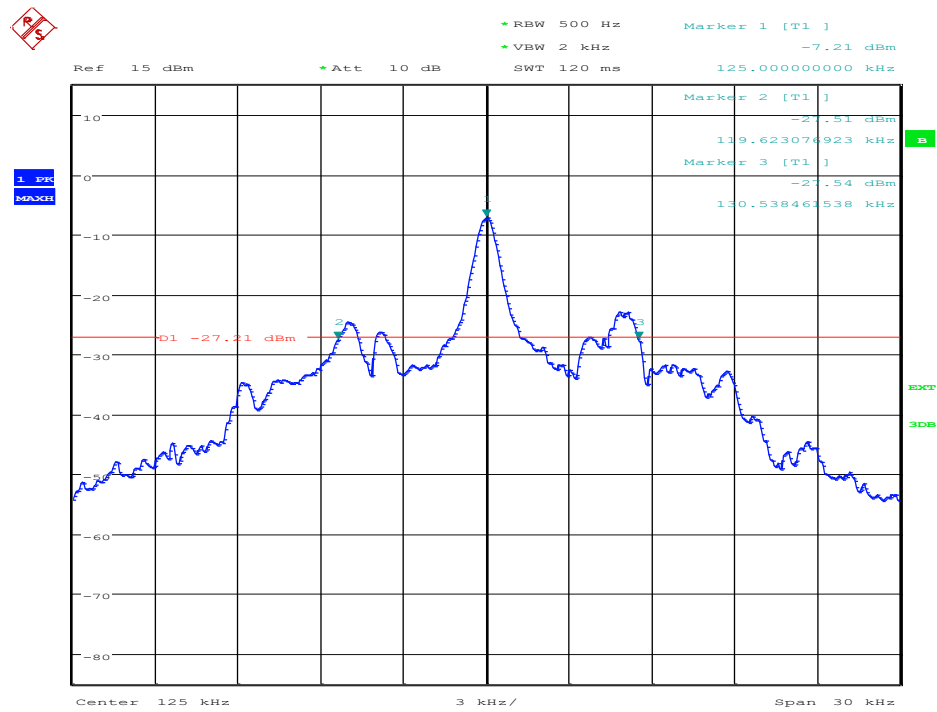


15.4 Test Equipment

<i>Equipment Description</i>	<i>Manufacturer</i>	<i>Equipment Type</i>	<i>Element No</i>	<i>Due For Calibration</i>
Spectrum Analyser	R&S	FSU46	REF910	2025-01-30

15.5 Test Results

15.209. Modulation: ASK; Power setting: Default – With TAG			
Channel Frequency (kHz)	F_L (kHz)	F_H (kHz)	20 dB Bandwidth (kHz)
125	119.623076923	130.538461538	10.91538462



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16 Transmitter output power (fundamental radiated emission)

16.1 Definition

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

16.2 Test Parameters

Test Location:	Element Skelmersdale
Test Chamber:	OATS
Test Antenna:	Active 60cm loop
Test Standard and Clause:	ANSI C63.10-2013, Clause 6.3 / 6.4
EUT Frequencies Measured:	125 kHz
Deviations From Standard:	None
Measurement BW:	200 Hz
Spectrum Analyzer Video BW: (requirement at least 3x RBW)	1 kHz
Measurement Detector:	Average
Voltage Extreme Environment Test Range:	Mains Power = 85% and 115% of Nominal (FCC only requirement);

Environmental Conditions (Normal Environment)

Temperature: 23 °C	+15 °C to +35 °C (as declared)
Humidity: 48 % RH	20 % RH to 75 % RH (as declared)

Test Limits

ISED RSS-210:

Transmitters whose wanted and unwanted emissions fall within the general field strength limits specified in RSS-Gen may operate in any of the frequency bands, other than the restricted bands listed in RSS-Gen and the TV bands, and shall be certified under RSS-210. Under no circumstance shall the level of any unwanted emissions exceed the level of the fundamental emissions

FCC 47CFR15.209(a):

Except as provided in § paragraph (g), fundamental emissions from intentional radiators operating under this section shall not be located in the frequency bands 54–72 MHz, 76– 88 MHz, 174–216 MHz or 470–806 MHz. However, operation within these frequency bands is permitted under other sections of this part, e.g., §§ 15.231 and 15.241.

Table of the general field strength limits per 15.209 / RSS-Gen

Frequency (MHz)	Field Strength ($\mu\text{V/m}$)	Measurement distance (m)
0.009-0.490	2400/f(kHz)	300
0.490-1.705	24000/f(kHz)	30
1.705-30	30	30
30-88	100	3
88-216	150	3
216-960	200	3
Above 960	500	3

16.3 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.

Power values measured on the test receiver / analyzer are converted to field strength, FS, in $\mu\text{V/m}$ at the regulatory distance, using:

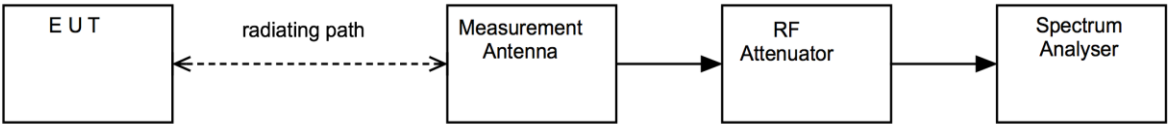
$$FS = 10 (PR - CF) / 20$$

Where,
PR is the power recorded on the receiver / spectrum analyzer in $\text{dB}\mu\text{V}$ and includes any cable loss, antenna factor and pre-amplifier gain;
CF is the distance extrapolation factor in dB (where measurement distance different to limit distance);

Per FCC 47CFR15.31(f)(2) / RSS-Gen 6.4, an extrapolation factor from 1 m to 3 m of 23.70 dB was determined from measurements at 1 and 3 metres.

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

Figure v Test Setup



16.4 Test Equipment

Equipment Type	Manufacturer	Equipment Description	Element No	Due For Calibration
EMI Receiver	R&S	ESR7	U456	2025-03-08
Active Loop Antenna	EMCO	6502	R0079	2024-11-10

Test Setup Photograph



16.5 Test Results

Frequency: 125 kHz; Modulation: ASK; Power Setting: Default – With TAG								
Channel Frequency (kHz)	Receiver Level (dB μ V/m)	Measurement Distance (m)	Limit Distance (m)	Extrapolation Factor (dB)	Field Strength (dB μ V/m)	Result (μ V/m)	Limit (μ V/m)	Result
125	64.50	3	300	80.00	-15.50	0.168	19.200	Pass

17 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) Sampling Power Meter to 8 GHz	MU4001	0.9 dB
Carrier Power and PSD - Spectrum Analysers	MU4004	1.7 dB
Adjacent Channel Power	MU4002	1.9 dB
Transmitter conducted spurious emissions (Including emissions due to intermodulation)	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
In-band (3450-3650 MHz) TRP using CATR_ASH_B2	MU4051	4.1 dB
Cellular Radiated Spurious Emissions in a SAC 30 MHz to 180 MHz	MU4052	6.3 dB
Cellular Radiated Spurious Emissions in a SAC 180 MHz to 18 GHz	MU4052	3.6 dB
Cellular Radiated Spurious Emissions in a FAR 30 MHz to 180 MHz	MU4052	5.4 dB
Cellular Radiated Spurious Emissions in a FAR 180 MHz to 18 GHz	MU4052	3.0 dB
Spurious Emissions Electric and Magnetic Field		
Radiated Spurious Emissions 30 MHz to 1 GHz (Including emissions due to intermodulation)	MU4037	4.8 dB
Radiated Spurious Emissions 1-18 GHz (Including emissions due to intermodulation)	MU4032	4.5 dB
E Field Emissions 18 GHz to 26 GHz	MU4024	3.2 dB
E Field Emissions 26 GHz to 40 GHz	MU4025	3.3 dB
E Field Emissions 40 GHz to 50 GHz	MU4026	3.5 dB
E Field Emissions 50 GHz to 75 GHz	MU4027	3.6 dB
E Field Emissions 75 GHz to 110 GHz	MU4028	3.6 dB
Radiated Magnetic Field Emissions	MU4031	2.3 dB

Test/Measurement	Budget Number	MU
Frequency Measurements		
Frequency Deviation	MU4022	3.7 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	678.984 µs
DFS Generator - Frequency Error	MU4007	91.650 Hz
DFS Threshold Conducted	MU4008	1.3 dB
DFS Threshold Radiated	MU4009	3.2 dB
Receiver Parameters		
EN 300 328 Receiver Blocking	MU4010	1.1 dB
EN 301 893 Receiver Blocking	MU4011	1.1 dB
EN 303 340 Adjacent Channel Selectivity	MU4012	1.1 dB
EN 303 340 Overloading	MU4013	1.1 dB
EN 303 340 Receiver Blocking	MU4014	1.1 dB
EN 303 340 Receiver Sensitivity	MU4015	0.9 dB
EN 303 372-1 Image Rejection	MU4016	1.4 dB
EN 303 372-1 Receiver Blocking	MU4017	1.1 dB
EN 303 372-2 Adjacent Channel Selectivity	MU4018	1.1 dB
EN 303 372-2 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