

Report on the Radio Testing

For

Magocard Ltd

on

Pronto 100

Report no. TRA-064783-47-12A

5th September 2024

RF914 9.0



Report Number: TRA-064783-47-12A
Issue: A

REPORT ON THE RADIO TESTING OF A
Magicard Ltd
Pronto 100
WITH RESPECT TO SPECIFICATION
FCC 47CFR 15.225

TEST DATE: 26th July to 29th July 2024

Tested by:

S Hodgkinson
Radio Test Engineer

Approved by:

J Charters
Laboratory Manager

Date: 5th September 2024

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

RF914 9.0



1 Revision Record

<i>Issue Number</i>	<i>Issue Date</i>	<i>Revision History</i>
A	5th September 2024	Original

2 Summary

TEST REPORT NUMBER:	TRA-064783-47-12A
WORKS ORDER NUMBER:	TRA-064783-00
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(S):	47CFR15.225
EQUIPMENT UNDER TEST (EUT):	Pronto 100
FCC IDENTIFIER:	XDW3100-0900
EUT SERIAL NUMBER:	75848701
MANUFACTURER/AGENT:	Magicard Ltd
ADDRESS:	Hampshire Road Weymouth Dorset DT4 9XD United Kingdom
CLIENT CONTACT:	William Macer ☎ 07775491564 ✉ will.macer@bradycorp.com
ORDER NUMBER:	13660
TEST DATE:	26th July to 29th July 2024
TESTED BY:	S Hodgkinson Element

2.1 Test Summary

Test Method and Description	Requirement Clause	Applicable to this equipment	Result / Note
	47CFR15		
Radiated spurious emissions, below 30 MHz	15.225(d)	☒	Pass
Radiated spurious emissions	15.209	☒	Pass
AC power line conducted emissions	15.207	☒	Pass
Occupied bandwidth	15.215(c)	☒	Pass
Field strength of fundamental	15.225(a), (b) and (c)	☒	Pass
Frequency stability	15.225(e)	☒	Pass

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).

General notes

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-064783-47-12A presents the results of the Radio testing on a Magicard Ltd, Pronto 100 to specification 47CFR15 Radio Frequency Devices.

The testing was carried out for Magicard Ltd 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 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 following US-UK MRA, Designation numbers.

Element Skelmersdale	UK2020
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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.
- KDB 174176 D01 Line Conducted FAQ v01r01 - AC Power-Line Conducted Emissions Frequently Asked Questions

5.2 Deviations from Test Standards

Occupied Bandwidth:

Note: The resolution bandwidth requirement of meeting the 1% to 5% of the resulting 20 dB bandwidth for AM RFID type radio devices cannot be resolved.

As the resolution bandwidth is reduced, the 20 dB bandwidth will also reduce.

This scenario will continue, and the resulting bandwidth measurement will just continue to reduce to nothing. Therefore, a wider resolution bandwidth was used, which was greater than the 5% requirement.

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 (nowISED)
ISED	Innovation, Science and Economic Development 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: Pronto 100
- Serial Number: 75848701
- Model Number: Pronto 100
- Software Revision: 0.15
- Build Level / Revision Number: Production Build

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.

Equipment Description	Manufacturer	Serial / Asset No(s)
Network Switch	TpLink	TL-R470T
Support Laptop	HP Pro Book	5CD01315SG

7.3 EUT Mode of Operation

7.3.1 Transmission

The EUT was transmitting with a tag in the field.

7.4 EUT Radio Parameters

7.4.1 General

Frequency of Operation:	13.56 MHz
Modulation Type:	ASK
Channel Bandwidth:	N/A Wideband
Channel Spacing:	N/A Wideband
Antenna Type and Gain:	Inductive Loop
Nominal Supply Voltage:	24 Vdc Via supplied 120 Vac power supply

7.5 EUT Description

The EUT is an ID Card Printer that makes use of a 13.56 MHz Inductive loop system.

8 Modifications

The following modifications were incorporated in the equipment during testing, in the order detailed below giving reference to the associated test.

Any modifications carried out during the Transmitter testing are listed below:

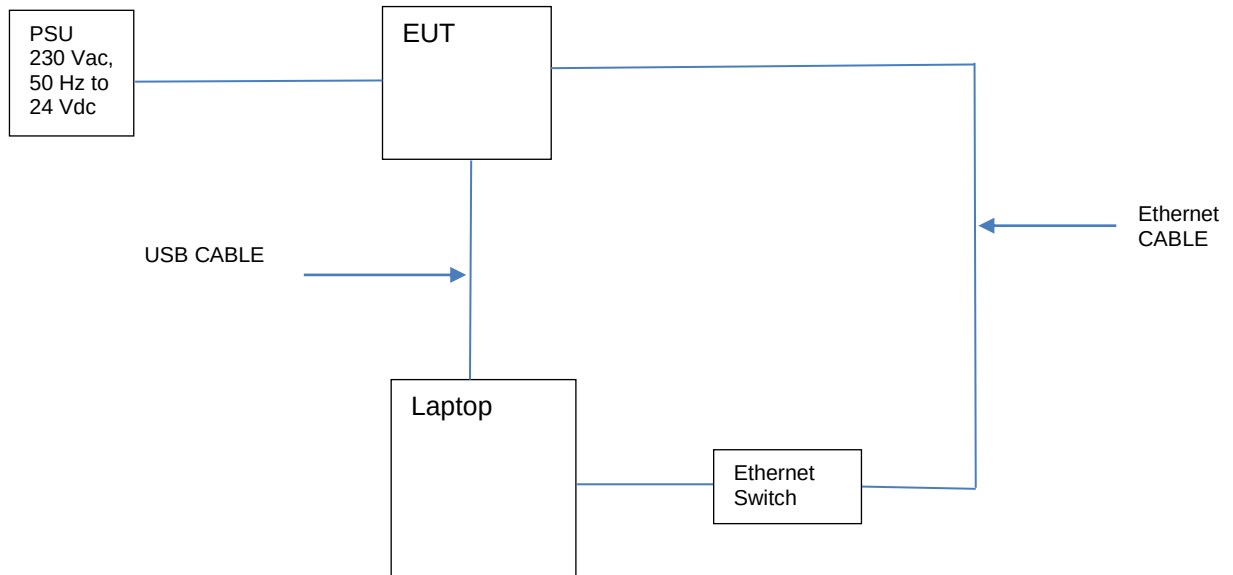
No.	Modification	Reason for Modification
1	Antenna capacitor changed from 33pf to 100pf	40.68 MHz radiated spurious emission
2	The firmware updated from version 0 .12 to version 0.15	Used to reduce the 27.12 MHz harmonic

Note: All the test results shown in this test report, relate to the capacitor modification shown above, and the firmware update from version 0 .12 to version 0.15.

9 EUT Test Setup

9.1 Block Diagram

The following diagram shows basic EUT interconnections with cable type:



General Set-up Photograph

The following photograph shows basic EUT set-up:



9.2 Measurement software

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

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

Note:

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

10 General Technical Parameters

10.1 Normal Conditions

The E U T was tested under the normal environmental conditions of the test laboratory, except where otherwise stated. The normal power source applied was approx. 24 V dc from the 120 Vac power supply.

10.2 Varying Test Conditions

Variation of temperature is required to ensure stability of the declared fundamental frequency. During frequency error testing the following variations were made:

	Category	Variation
☒	Standard	-20 to +50 C in 10 degree steps
☐	Extended	

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

	Category	Nominal	Variation
☒	Mains	110 V ac +/-2 %	85 % and 115 %
☐	Battery	New battery	N/A

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:	Chamber 3
Test Standard and Clause:	ANSI C63.10-2013, Clause 6.4
Frequencies Measured:	13.56 MHz
Deviations From Standard:	None
Measurement Distance and Site:	3 m, SAC
EUT Height:	1 m
Measurement Antenna and Height:	60 cm shielded loop; 1 m
Measurement BW:	9 kHz to 150 kHz: 200 Hz; 150 kHz to 30 MHz: 9 kHz
Measurement Detector:	9 kHz to 90 kHz and 110 kHz to 490 kHz: Average, RMS Other frequencies below 30 MHz: Quasi-peak.

Environmental Conditions (Normal Environment)

Temperature: 21.5 °C	+15 °C to +35 °C (as declared)
Humidity: 61 % RH	20 % RH to 75 % RH (as declared)
Supply: 120 Vac	

11.3 Test Limit

Emissions from license-exempt transmitters shall comply with the field strength limits shown in the table below. Additionally, the level of any transmitter emission shall not exceed the level of the transmitter's fundamental emission.

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

<i>Frequency, f (kHz)</i>	<i>Field Strength</i>	<i>Measurement Distance (m)</i>
9 to 490	2,400 / 377.f (μA/m) 2,400 / f (μV/m)	300
490 to 1,750	24,000 / 377.f (μA/m) 24,000 / f (μV/m)	30
1,750 to 30,000	30 (μV/m)	30

n.b. Devices operated pursuant to §15.225 are exempt from complying with the restricted band requirements for the 13.36–13.41 MHz band only.

11.4 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 μV/m at the regulatory distance, using:

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

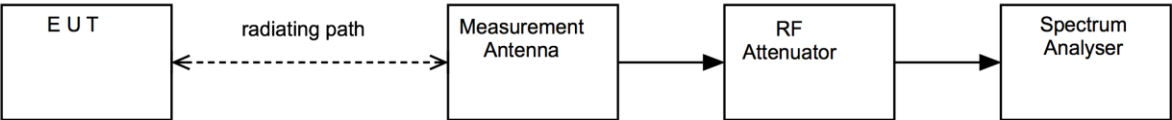
Where,

PR is the power recorded on the receiver / spectrum analyzer in dBμV 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);

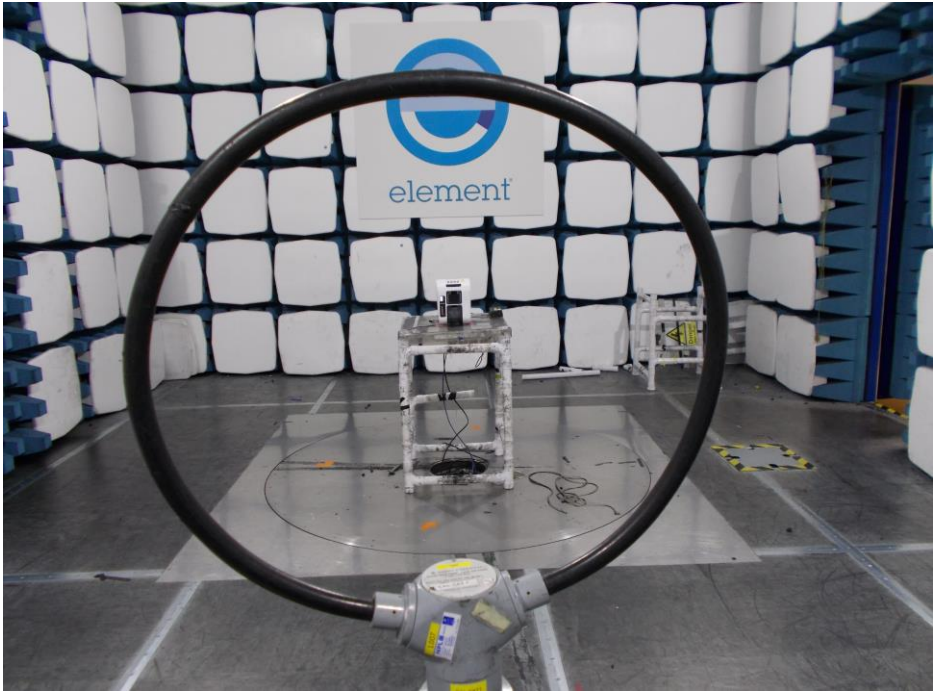
Per FCC 47CFR15.31(f)(2), an extrapolation factor of 40 dB per decade was used for measurements at distances closer than specified.

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

Figure i Test Setup



11.5 Test Set-up Photograph

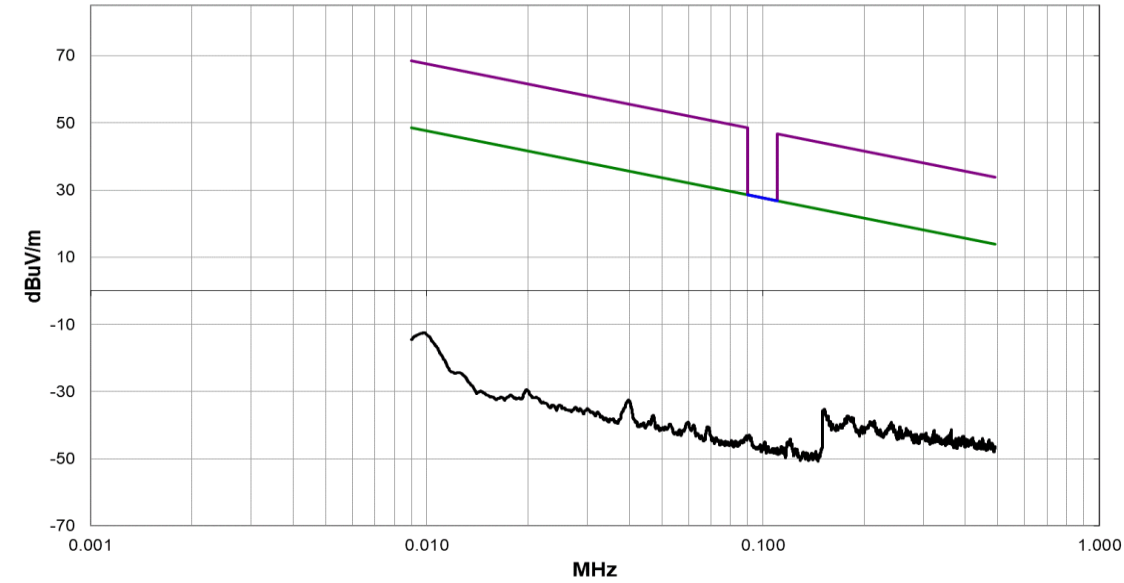


11.6 Test Equipment

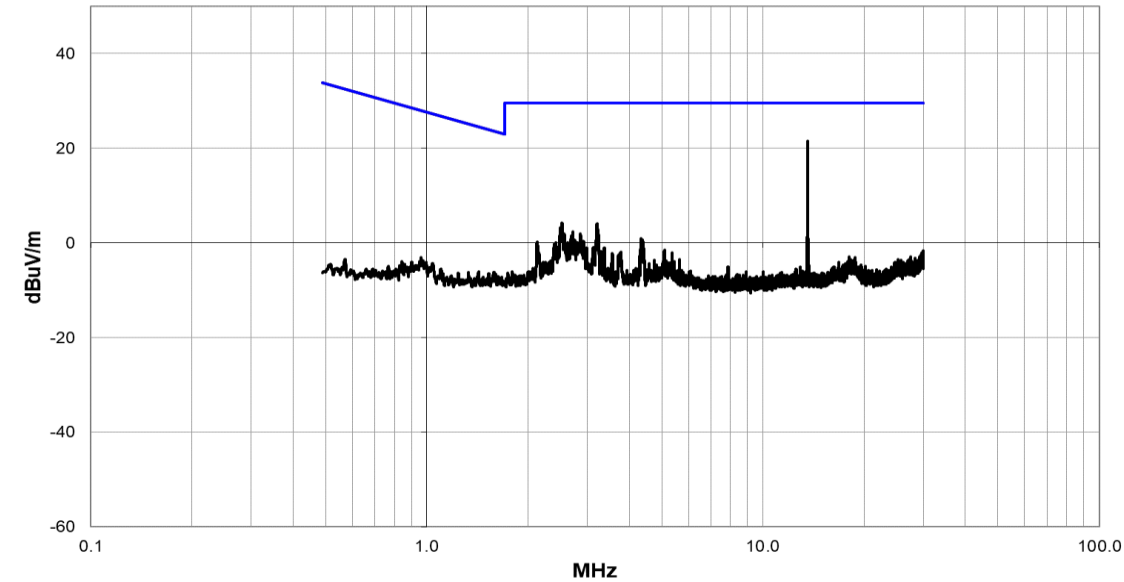
Equipment Type	Manufacturer	Equipment Description	Element No	Due For Calibration
hfh2	R&S	Loop Antenna	L007	2024-10-11
ESR7	R&S	EMI Receiver	U456	2025-03-08

11.7 Test Results

9 kHz-490 kHz



490 kHz-30 MHz



Modulation: ASK; 13.56 MHz						
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 dBm of the limit						PASS

12 Radiated emissions

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:	Chamber 3
Test Standard and Clause:	ANSI C63.10-2013, Clause 6.5
Frequencies Measured:	13.56 MHz
Deviations From Standard:	None
Measurement BW:	30 MHz to 1000 MHz: 120 kHz / 1 GHz to 6.5 GHz: 1 MHz
Measurement Detector:	Quasi-peak

Environmental Conditions (Normal Environment)

Temperature: 21.5 °C	+15 °C to +35 °C (as declared)
Humidity: 61.0 % RH	20 % RH to 75 % RH (as declared)
Supply: 120 V ac	

12.3 Test Limit

Emissions from license-exempt transmitters shall comply with the field strength limits shown in the table below. Additionally, the level of any transmitter emission shall not exceed the level of the transmitter's fundamental emission.

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

Frequency (MHz)	Field Strength ($\mu\text{V/m}$ at 3 m)
30 to 88	100
88 to 216	150
216 to 960	200
Above 960	500

12.4 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 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;

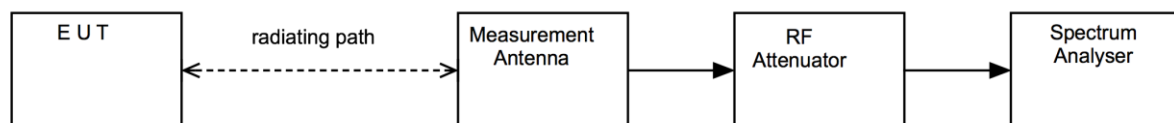
PA is the pre-amplifier gain in dB (where used);

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

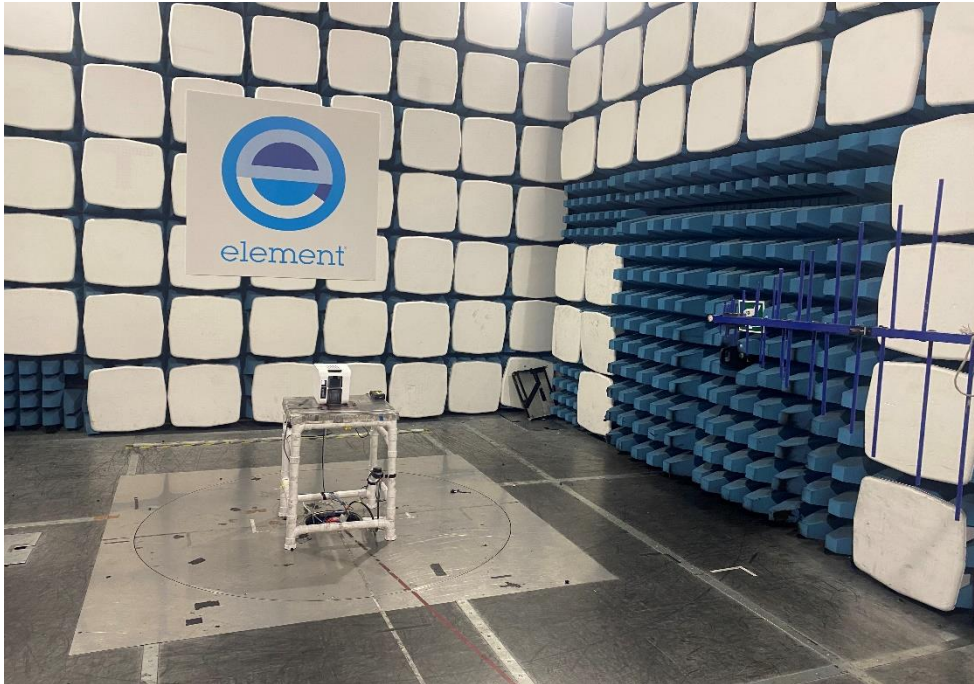
CF is the distance factor in dB (where measurement distance is different to limit distance);

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

Figure ii Test Setup



Test Set up Photographs

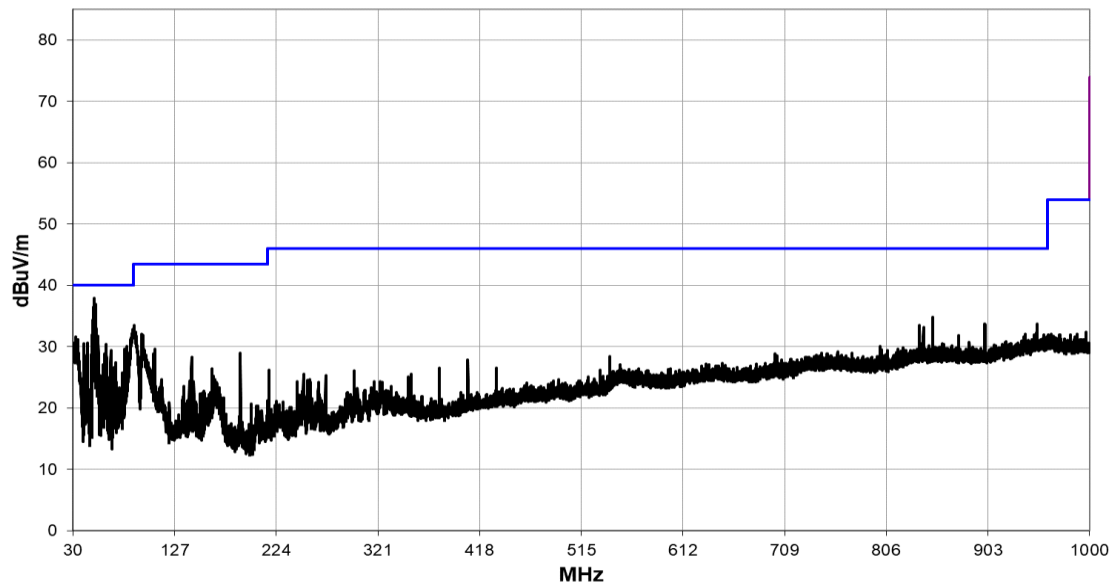


12.5 Test Equipment

Equipment Type	Manufacturer	Equipment Description	Element No	Due For Calibration
3115	EMCO	1-18GHz Horn	U223	2026-01-17
ESR7	R&S	EMI Receiver	U456	2025-03-08
CBL611/B	Chase	Bilog	U573	2024-10-14
8449B	Agilent	Pre Amp	L572	2024-10-30

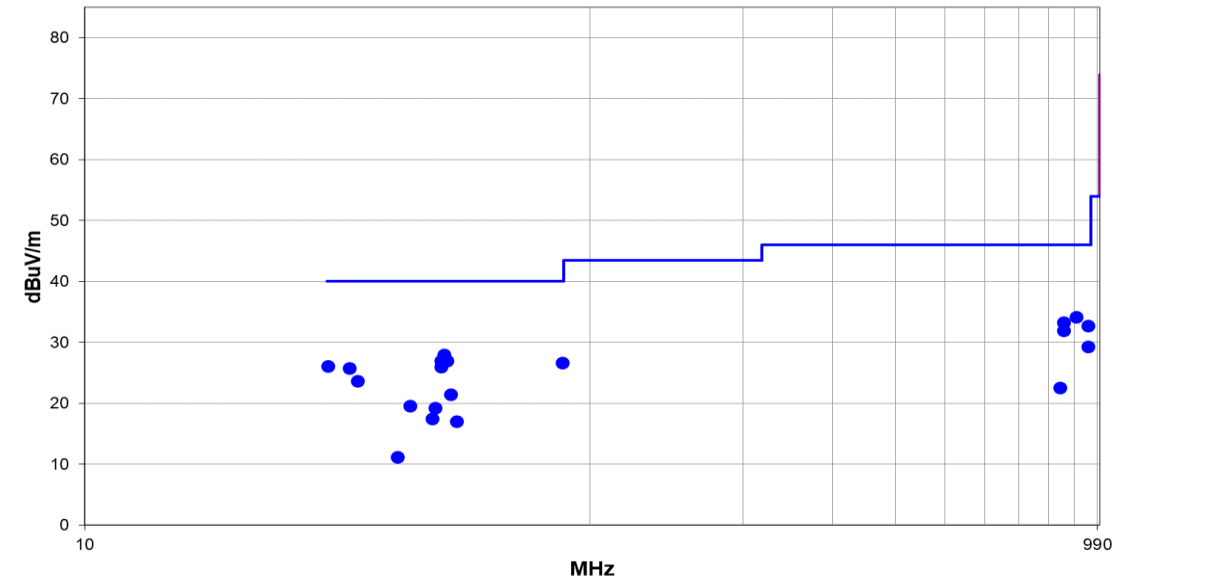
12.6 Test Results

30 MHz -1 GHz



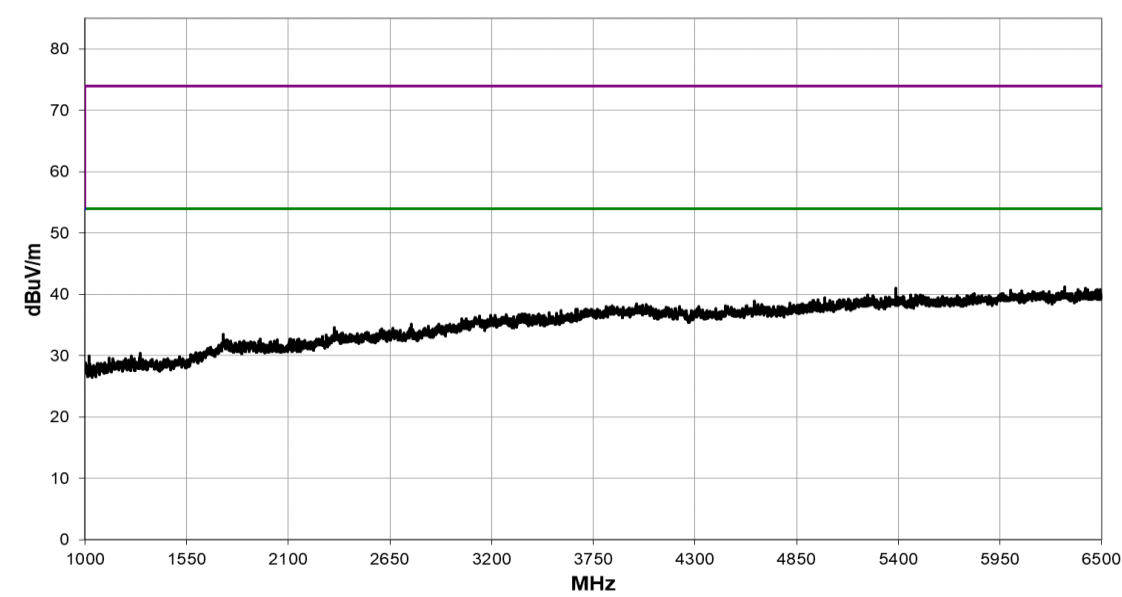
Freq (MHz)	Amplitude (dBuV)	Factor (dB/m)	Antenna Height (meters)	Azimuth (degrees)	Test Distance (meters)	External Attenuation (dB)	Polarity/ Transducer Type	Detector	Distance Adjustment (dB)	Adjusted (dBuV/m)	Spec. Limit (dBuV/m)	Compared to Spec. (dB)
900.103	29.6	4.5	1.0	86.0	3.0	0.0	Horz	QP	0.0	34.1	46.0	-11.9
51.092	42.8	-14.9	1.5	267.0	3.0	0.0	Vert	QP	0.0	27.9	40.0	-12.1
850.099	28.8	4.4	1.0	201.0	3.0	0.0	Horz	QP	0.0	33.2	46.0	-12.8
50.460	41.7	-14.7	2.0	285.1	3.0	0.0	Vert	QP	0.0	27.0	40.0	-13.0
51.832	42.0	-15.1	1.0	224.0	3.0	0.0	Vert	QP	0.0	26.9	40.0	-13.1
950.107	26.2	6.5	1.69	161.0	3.0	0.0	Vert	QP	0.0	32.7	46.0	-13.3
87.487	40.3	-13.7	1.0	350.0	3.0	0.0	Vert	QP	0.0	26.6	40.0	-13.4
30.172	30.0	-3.9	1.0	194.0	3.0	0.0	Vert	QP	0.0	26.1	40.0	-13.9
50.471	40.5	-14.6	1.0	105.0	3.0	0.0	Vert	QP	0.0	25.9	40.0	-14.1
850.100	27.5	4.4	1.0	154.0	3.0	0.0	Vert	QP	0.0	31.9	46.0	-14.1
33.251	31.1	-5.4	1.0	27.0	3.0	0.0	Vert	QP	0.0	25.7	40.0	-14.3
34.464	29.6	-6.0	1.15	319.0	3.0	0.0	Vert	QP	0.0	23.6	40.0	-16.4
950.109	22.8	6.5	1.5	115.9	3.0	0.0	Horz	QP	0.0	29.3	46.0	-16.7
52.608	36.8	-15.4	1.0	141.0	3.0	0.0	Vert	QP	0.0	21.4	40.0	-18.6
43.824	30.7	-11.2	1.0	191.0	3.0	0.0	Vert	QP	0.0	19.5	40.0	-20.5
49.063	33.2	-14.0	1.0	289.1	3.0	0.0	Vert	QP	0.0	19.2	40.0	-20.8
48.477	31.1	-13.7	1.0	292.1	3.0	0.0	Vert	QP	0.0	17.4	40.0	-22.6
54.196	32.9	-15.9	1.5	152.0	3.0	0.0	Vert	QP	0.0	17.0	40.0	-23.0
837.273	18.1	4.4	1.2	102.0	3.0	0.0	Horz	QP	0.0	22.5	46.0	-23.5
41.365	21.0	-9.8	1.0	147.0	3.0	0.0	Vert	QP	0.0	11.2	40.0	-28.8

30 MHz -1 GHz Maximum



(MHz)	(dBuV)	(dB/m)	(meters)	(degrees)	(meters)	(dB)			(dB)	(dBuV/m)	(dBuV/m)	(dB)
900.103	29.6	4.5	1.0	86.0	3.0	0.0	Horz	QP	0.0	34.1	46.0	-11.9
51.092	42.8	-14.9	1.5	267.0	3.0	0.0	Vert	QP	0.0	27.9	40.0	-12.1
850.099	28.8	4.4	1.0	201.0	3.0	0.0	Horz	QP	0.0	33.2	46.0	-12.8
50.460	41.7	-14.7	2.0	285.1	3.0	0.0	Vert	QP	0.0	27.0	40.0	-13.0
51.832	42.0	-15.1	1.0	224.0	3.0	0.0	Vert	QP	0.0	26.9	40.0	-13.1
950.107	26.2	6.5	1.69	161.0	3.0	0.0	Vert	QP	0.0	32.7	46.0	-13.3
87.487	40.3	-13.7	1.0	350.0	3.0	0.0	Vert	QP	0.0	26.6	40.0	-13.4
30.172	30.0	-3.9	1.0	194.0	3.0	0.0	Vert	QP	0.0	26.1	40.0	-13.9
50.471	40.5	-14.6	1.0	105.0	3.0	0.0	Vert	QP	0.0	25.9	40.0	-14.1
850.100	27.5	4.4	1.0	154.0	3.0	0.0	Vert	QP	0.0	31.9	46.0	-14.1
33.251	31.1	-5.4	1.0	27.0	3.0	0.0	Vert	QP	0.0	25.7	40.0	-14.3
34.464	29.6	-6.0	1.15	319.0	3.0	0.0	Vert	QP	0.0	23.6	40.0	-16.4
950.109	22.8	6.5	1.5	115.9	3.0	0.0	Horz	QP	0.0	29.3	46.0	-16.7
52.608	36.8	-15.4	1.0	141.0	3.0	0.0	Vert	QP	0.0	21.4	40.0	-18.6
43.824	30.7	-11.2	1.0	191.0	3.0	0.0	Vert	QP	0.0	19.5	40.0	-20.5

1 GHz - 6.5 GHz



Note: The equipment under test makes use of a 650 MHz clock frequency, hence the spurious emission frequency searched from 1 GHz to 6.5 GHz.

13 AC power-line conducted emissions

13.1 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.

13.2 Test Parameters

Test Location:	Element Skelmersdale
Test Chamber:	Transient Lab 2
Test Standard and Clause:	ANSI C63.10-2013, Clause 6.2
Frequencies Measured:	13.56 MHz
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: 50 % RH	20 % RH to 75 % RH (as declared)
Supply: 120 Vac	

13.3 Test Limit

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

Table 3 – AC Power Line Conducted Emission Limits

Frequency (MHz)	Conducted limit (dBµV)	
	Quasi-Peak	Average**
0.15 to 0.5	66 to 56*	56 to 46*
0.5 to 5	56	46
5 to 30	60	50

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

**A linear average detector is required.

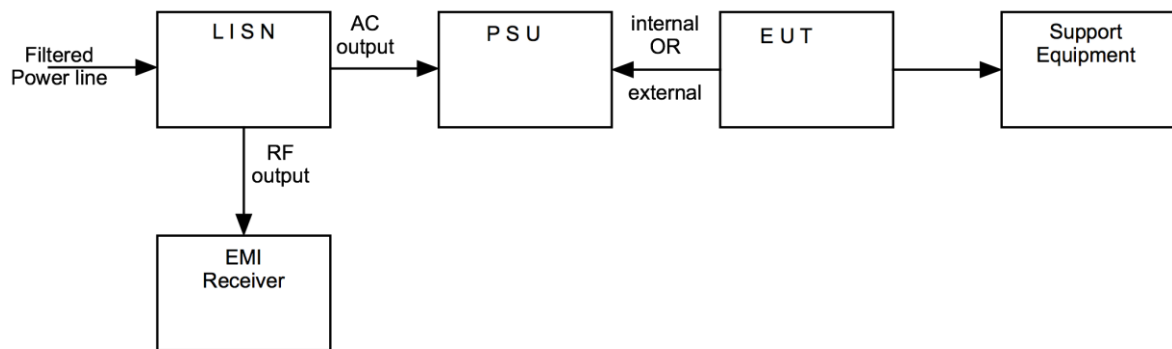
13.4 Test Method

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



13.5 Test Set-up Photograph

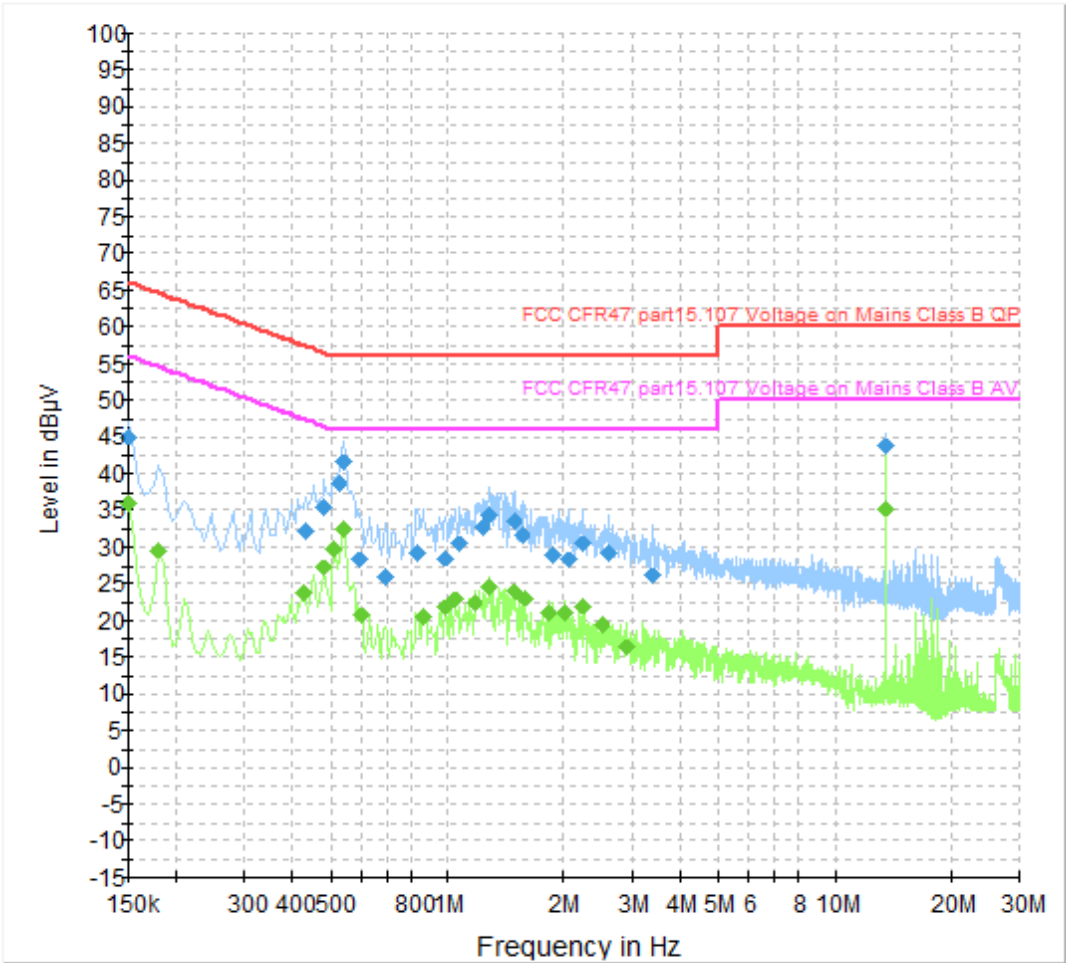


13.6 Test Equipment

Equipment Type	Manufacturer	Equipment Description	Element No	Due For Calibration
ENV216	R&S	Lisn	U396	2025-05-16
ESR26	R&S	EMI Receiver	U489	2024-10-11
PCR 4000L	Kikusui	AC power supply	U580	Use REF976
34405a	Agilent	Multimeter	REF976	2025-01-26

13.7 Test Results

CE Transient Lab 150kHz - 30MHz (Auto Test) RX



Test Results Quasi Peak detector

Frequency (MHz)	QuasiPeak (dBμV)	Meas. Time (ms)	Bandwidth (kHz)	Filter	Line	Corr. (dB)	Margin (dB)	Limit (dBμV)	Comment
0.150000	45.0	2000.0	9.000	Off	L1	19.6	21.0	66.0	
0.430000	32.1	2000.0	9.000	Off	N	19.6	25.1	57.3	
0.480000	35.4	2000.0	9.000	Off	N	19.6	20.9	56.3	
0.525000	38.7	2000.0	9.000	Off	L1	19.6	17.3	56.0	
0.540000	41.5	2000.0	9.000	Off	L1	19.6	14.5	56.0	
0.595000	28.3	2000.0	9.000	Off	N	19.7	27.7	56.0	
0.690000	25.8	2000.0	9.000	Off	N	19.7	30.2	56.0	
0.835000	29.2	2000.0	9.000	Off	N	19.7	26.8	56.0	
0.985000	28.5	2000.0	9.000	Off	N	19.7	27.5	56.0	
1.080000	30.3	2000.0	9.000	Off	L1	19.7	25.7	56.0	
1.225000	32.7	2000.0	9.000	Off	N	19.7	23.3	56.0	
1.280000	34.3	2000.0	9.000	Off	L1	19.7	21.7	56.0	
1.480000	33.4	2000.0	9.000	Off	N	19.8	22.6	56.0	
1.555000	31.5	2000.0	9.000	Off	L1	19.7	24.5	56.0	
1.865000	29.0	2000.0	9.000	Off	L1	19.7	27.0	56.0	
2.045000	28.3	2000.0	9.000	Off	N	19.8	27.7	56.0	
2.230000	30.4	2000.0	9.000	Off	N	19.8	25.6	56.0	
2.595000	29.2	2000.0	9.000	Off	N	19.8	26.8	56.0	
3.385000	26.0	2000.0	9.000	Off	N	19.8	30.0	56.0	
13.560000	43.6	2000.0	9.000	Off	N	20.5	16.4	60.0	

Test Results Average detector

Frequency (MHz)	Average (dBμV)	Meas. Time (ms)	Bandwidth (kHz)	Filter	Line	Corr. (dB)	Margin (dB)	Limit (dBμV)	Comment
0.150000	35.9	2000.0	9.000	Off	L1	19.6	20.1	56.0	
0.180000	29.5	2000.0	9.000	Off	N	19.6	25.0	54.5	
0.425000	23.6	2000.0	9.000	Off	N	19.6	23.7	47.3	
0.480000	27.1	2000.0	9.000	Off	L1	19.6	19.2	46.3	
0.510000	29.8	2000.0	9.000	Off	L1	19.6	16.2	46.0	
0.540000	32.4	2000.0	9.000	Off	L1	19.6	13.6	46.0	
0.600000	20.6	2000.0	9.000	Off	N	19.7	25.4	46.0	
0.870000	20.5	2000.0	9.000	Off	L1	19.7	25.5	46.0	
0.990000	21.8	2000.0	9.000	Off	N	19.7	24.2	46.0	
1.045000	22.7	2000.0	9.000	Off	N	19.7	23.3	46.0	
1.175000	22.4	2000.0	9.000	Off	L1	19.7	23.6	46.0	
1.280000	24.6	2000.0	9.000	Off	N	19.7	21.4	46.0	
1.480000	24.0	2000.0	9.000	Off	N	19.8	22.0	46.0	
1.585000	23.0	2000.0	9.000	Off	N	19.8	23.0	46.0	
1.840000	21.1	2000.0	9.000	Off	L1	19.7	24.9	46.0	
2.020000	21.0	2000.0	9.000	Off	L1	19.8	25.0	46.0	
2.230000	22.0	2000.0	9.000	Off	N	19.8	24.0	46.0	
2.505000	19.3	2000.0	9.000	Off	L1	19.8	26.7	46.0	
2.905000	16.2	2000.0	9.000	Off	N	19.8	29.8	46.0	
13.560000	35.3	2000.0	9.000	Off	N	20.5	14.7	50.0	

14 Occupied Bandwidth

14.1 Definition

20 dB 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.

14.2 Test Parameters

Test Location:	Element Skelmersdale
Test Chamber:	Radio Laboratory
Test Standard and Clause:	ANSI C63.10-2013, Clause 6.9
Frequencies Measured:	13.56 MHz
EUT Test Modulations:	ASK
Deviations From Standard:	None
Measurement BW: (requirement: 1% to 5% OBW)	1 kHz
Spectrum Analyzer Video BW: (requirement at least 3x RBW)	3 kHz
Measurement Span: (requirement 2 to 5 times OBW)	20 kHz
Measurement Detector:	Peak

Environmental Conditions (Normal Environment)

Temperature: 20 °C	+15 °C to +35 °C (as declared)
Humidity: 51 % RH	20 % RH to 75 % RH (as declared)
Supply: 120 V ac	

14.3 Test Limit

Federal Communications Commission:

Intentional radiators operating under the alternative provisions to the general emission limits, as contained in §§ 15.217 through 15.257 and in subpart E of this part, must be designed to ensure that the 20 dB bandwidth of the emission, or whatever bandwidth may otherwise be specified in the specific rule section under which the equipment operates, is contained within the frequency band designated in the rule section under which the equipment is operated.

14.4 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

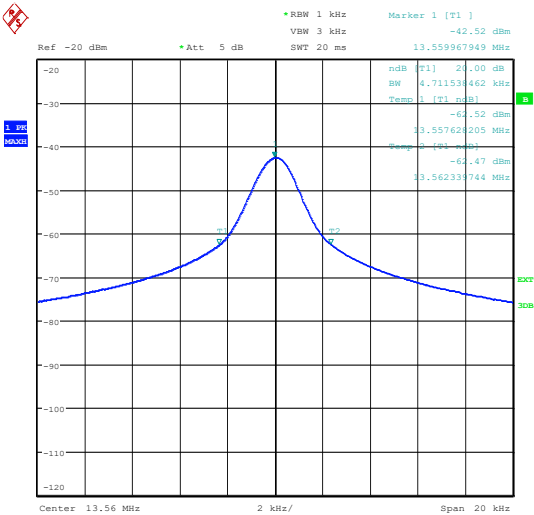


14.5 Test Equipment

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

14.6 Test Results

15.225. Modulation: ASK: 13.56 MHz			
Channel Frequency (MHz)	F_L (MHz)	F_H (MHz)	20 dB Bandwidth (kHz)
13.56	13.557628	13.562338	4.71



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Note: See section 5.2

15 Transmitter output power (fundamental radiated emission)

15.1 Definition

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

15.2 Test Parameters

Test Location:	Element Skelmersdale
Test Chamber:	10 m OATS
Test Antenna:	Active 60cm loop
Test Standard and Clause:	ANSI C63.10-2013, Clause 6.3 / 6.4
Frequencies Measured:	13.56 MHz
Deviations From Standard:	None
Measurement BW:	9 kHz
Measurement Detector:	Quasi-peak
Voltage Extreme Environment Test Range:	Mains Power = 85% and 115% of Nominal (FCC only requirement); Battery Power = new battery.

Environmental Conditions (Normal Environment)

Temperature: 21 °C	+15 °C to +35 °C (as declared)
Humidity: 51 % RH	20 % RH to 75 % RH (as declared)

15.3 Test Limit

The field strength measured at 30 m shall not exceed the limits in the following table:

Field Strength Limits for License-Exempt Transmitters for Any Application

<i>Frequency range (MHz)</i>	<i>Field strength (µV/m at 30m)</i>	<i>Field strength (dBµV/m at 30m)</i>
13.110 – 13.410	106	40.5
13.410 – 13.553	334	50.5
13.553 – 13.567	15,848	84.0
13.567 – 13.710	334	50.5
13.710 – 14.010	106	40.5

15.4 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);

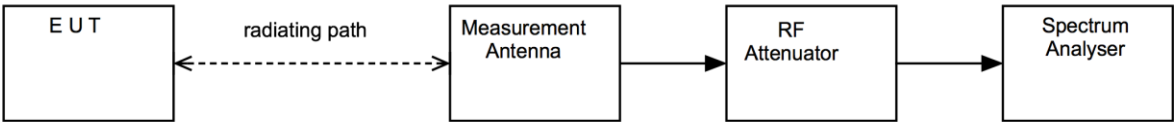
Per FCC 47CFR15.31(f)(2) / RSS-Gen 6.4, an extrapolation factor of 40 dB per decade was used for measurements at distances closer than specified.

$40 \text{ Log (wanted distance/measured distance) = extrapolation factor}$

$40 \text{ Log (30/10) = 19.08}$

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

Figure v Test Setup

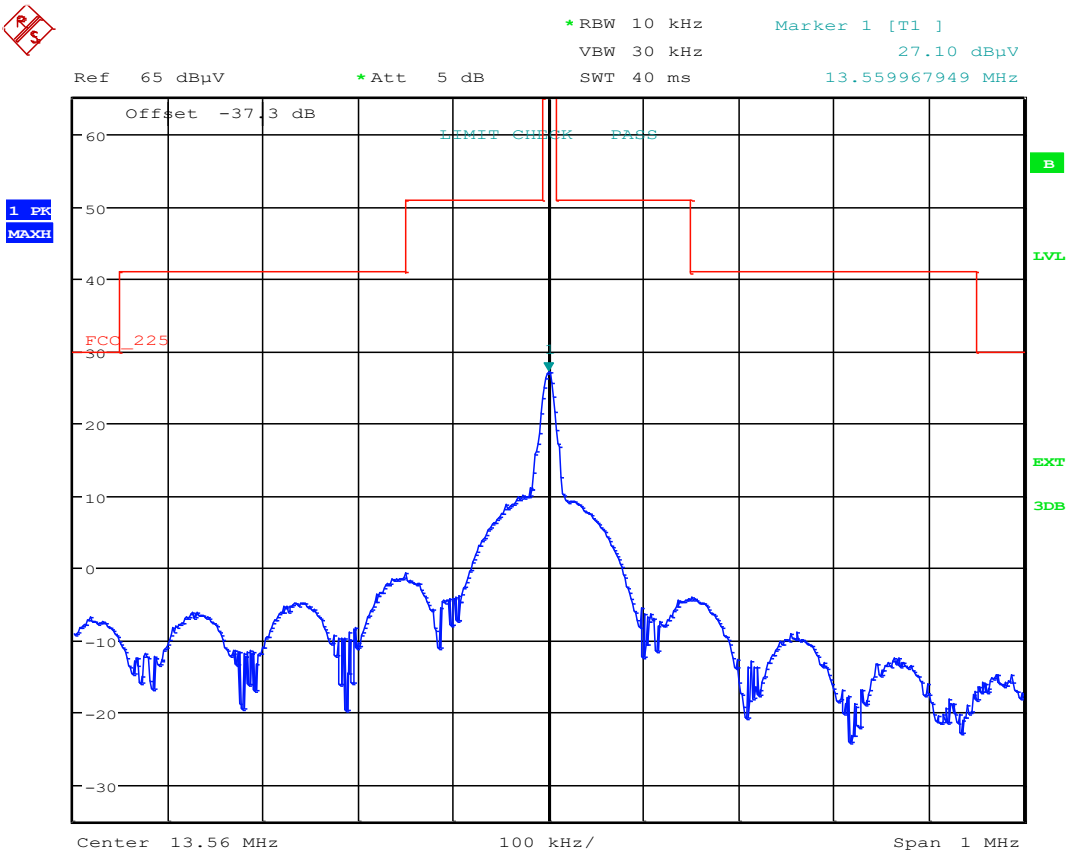


15.5 Test Equipment

Equipment Type	Manufacturer	Equipment Description	Element No	Due For Calibration
hfh2	R&S	Loop Antenna	L007	2024-10-11
ESR7	R&S	EMI Receiver	U456	2025-03-08

15.6 Test Results

Modulation: ASK; 13.56 MHz							
Channel Frequency (MHz)	Receiver Level (dBµV/m)	Measurement Distance (m)	Limit Distance (m)	Extrapolation Factor (dB)	Field Strength (dBµV/m)	Field Strength (µV/m)	Result
13.56	46.20	10.0	30	19.08	27.12	22.7	PASS



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16 Frequency stability

16.1 Definition

Frequency stability is a measure of frequency drift due to temperature and supply voltage variations, with reference to the frequency measured at an appropriate reference temperature and the rated supply voltage.

16.2 Test Parameters

Test Location:	Element Skelmersdale
Test Chamber:	Radio Laboratory
Test Standard and Clause:	ANSI C63.10-2013, Clause 6.8
Frequencies Measured:	13.56 MHz
Deviations From Standard:	None
Temperature Extreme Environment Test Range:	-20 to +50 C
Voltage Extreme Environment Test Range:	Mains Power = ±15% of Nominal;

Environmental Conditions (Normal Environment)

Temperature: 20 °C	Standard Requirement: +20 °C
Humidity: 78 %RH	20 % RH to 75 % RH (as declared)

16.3 Test Limit

Carrier frequency stability shall be maintained to ±0.01% (±100 ppm).

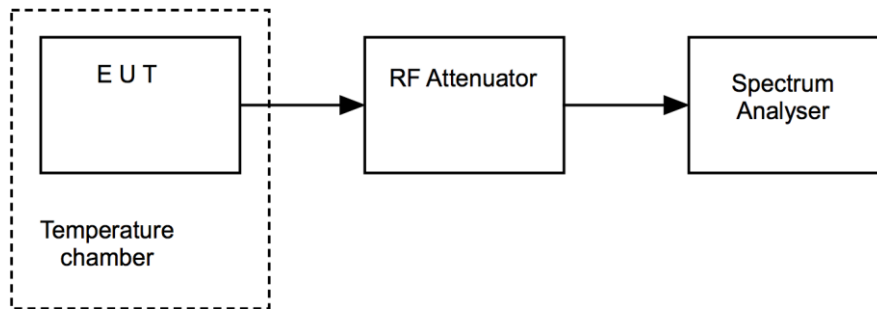
16.4 Test Method

With the EUT setup as per section 9 of this report and connected as per Figure v, the frequency was measured under varying conditions of temperature and supply voltage.

The measurements were performed with EUT transmitting with a tag in place.

Measurements were made once temperature stability was achieved at each temperature.

Figure v Test Setup



16.5 Test Equipment

Equipment Type	Manufacturer	Equipment Description	Element No	Due For Calibration
FSU46	R&S	Spectrum Analyser	REF910	2025-01-30
ETS	ETS-S1000CHS	Temperature Chamber	U522	Use L426 Or U720
2000T	Digitron	Temperature Indicator	U720	2025-06-10
PCR 4000L	KiKusui	Power Supply	U580	Use REF976
34405a	Agilent	Multimeter	REF976	2025-01-26

16.6 Test Results

EUT Frequency: 13.56 MHz					
Test Environment		Measured Frequency (MHz)	Frequency error (kHz)	Frequency error (%)	Result
-20 C	V _{nominal}	13.559967949	0.032051	0.00024	PASS
-10 C	V _{nominal}	13.560032051	0.032051	0.00024	PASS
0 C	V _{nominal}	13.560032051	0.032051	0.00024	PASS
+10 C	V _{nominal}	13.560032051	0.032051	0.00024	PASS
+20 C	V _{minimum}	13.560000000	0	0	PASS
	V _{nominal}	13.560000000	N/A	N/A	N/A
	V _{maximum}	13.560000000	0	0	PASS
+30 C	V _{nominal}	13.560000000	0	0	PASS
+40 C	V _{nominal}	13.559967949	0.032051	0.00024	PASS
+50 C	V _{nominal}	13.559935897	0.064103	0.00047	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	4.7 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

Test/Measurement	Budget Number	MU
Rohde & Schwarz TS8997		
Carrier frequency	MU4050	5.2 ppm
RF Output Power	MU4050	1.0 dB
Peak Power	MU4050	0.8 dB
Power Spectral Density	MU4050	1.0 dB
Occupied Channel Bandwidth	MU4050	2.08 %
Transmitter unwanted emissions in-band	MU4050	0.9 dB
Transmitter unwanted emissions in the spurious domain 30 MHz to 1 GHz	MU4050	0.6 dB
Transmitter unwanted emissions in the spurious domain 1 GHz to 12.75 GHz	MU4050	1.8 dB
Receiver Spurious emission 30 MHz to 1 GHz	MU4050	0.6 dB
Receiver Spurious emission 1 GHz to 12.75 GHz	MU4050	1.8 dB
Duty Cycle	MU4050	0.02 %
Tx Sequence	MU4050	0.02 %
Tx Gap	MU4050	0.02 %
Medium Utilisation	MU4050	0.1 %
Accumulated Transmit Time	MU4050	0.01 %
Minimum Frequency Occupation Time	MU4050	0.01 %
Hopping Frequency Separation	MU4050	0.6 %
Receiver blocking (for bit streams)	MU4050	3.0 dB
Channel Access Mechanism / Adaptivity / DFS / Contention Based Protocol	MU4050	1.8 dB

18 Appendix A

18.1 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

<i>Channel Frequency (MHz)</i>	<i>EIRP (mW)</i>	<i>Power density limit (S) (mW/cm²)</i>	<i>Distance (R) cm required to be less than the power density limit</i>
13.56	0.00002	1.0	0.00120