

Report on the Radio Testing

For

Pektron Group Limited

On

BTLE NFC Node

Report no.

TRA-051982-47-06B

2021-05-18

RF914 6.0



Report Number: TRA-051982-47-06B
Issue: B

REPORT ON THE RADIO TESTING OF A
Pektron Group Limited
BTLE NFC Node
WITH RESPECT TO SPECIFICATION
FCC 47CFR 15.225

TEST DATE: 2021-03-12 to 2021-03-16

Written by:



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Radio Test Engineer

Approved by:

Date: 2021-05-18

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Disclaimers:

- [1] THIS DOCUMENT MAY BE REPRODUCED ONLY IN ITS ENTIRETY AND WITHOUT CHANGE
- [2] THE RESULTS CONTAINED IN THIS DOCUMENT RELATE ONLY TO THE ITEM(S) TESTED

1 Revision Record

<i>Issue Number</i>	<i>Issue Date</i>	<i>Revision History</i>
A	2021-04-19	Original
B	2021-05-18	General updates

2 Summary

TEST REPORT NUMBER:	TRA-051982-47-06B
WORKS ORDER NUMBER:	TRA-051982-02
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:	47CFR15.225
EQUIPMENT UNDER TEST (EUT):	BTLE NFC Node
FCC IDENTIFIER:	AQO011
EUT SERIAL NUMBER(S):	AB10001253 (Radiated) AB10001263 (Conducted)
MANUFACTURER/AGENT:	Pektron Group Limited
ADDRESS:	Alfreton Road Derby Derbyshire DE21 4AP United Kingdom
CLIENT CONTACT:	Richard Jones ☎ 01332832424 ext 382 ✉ rjones@pektron.co.uk
ORDER NUMBER:	PROJ-00000632
TEST DATE:	2021-03-12 to 2021-03-16
TESTED BY:	Steven Garwell, Michael Else Element

2.1 Test Summary

<i>Test Method and Description</i>	<i>47CFR15</i>	<i>Applicable to this equipment</i>	<i>Result / Note</i>
Radiated spurious emissions, below 30 MHz	15.225(d)	<input checked="" type="checkbox"/>	Pass
Radiated spurious emissions	15.209	<input checked="" type="checkbox"/>	Pass
AC power line conducted emissions	15.207	<input type="checkbox"/>	Note 1
Occupied bandwidth	15.215(c)	<input checked="" type="checkbox"/>	Pass
Field strength of fundamental	15.225(a), (b) and (c)	<input checked="" type="checkbox"/>	Pass
Frequency Error	15.225(e)	<input checked="" type="checkbox"/>	Pass

Notes:

Note 1: The EUT is battery powered only.

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

1	Revision Record	3
2	Summary	4
2.1	Test Summary	5
3	Contents	6
4	Introduction	7
5	Test Specifications	8
5.1	Normative References	8
5.2	Deviations from Test Standards	8
6	Glossary of Terms	9
7	Equipment Under Test.....	10
7.1	EUT Identification	10
7.2	System Equipment.....	10
7.3	EUT Mode of Operation.....	10
7.3.1	Transmission	10
7.4	EUT Radio Parameters.....	10
7.4.1	General.....	10
7.5	EUT Description.....	10
8	Modifications.....	11
9	EUT Test Setup	11
9.1	Block Diagram	11
9.2	General Set-up Photograph	12
9.3	Measurement software	12
10	General Technical Parameters	13
10.1	Normal Conditions	13
10.2	Varying Test Conditions.....	13
11	Radiated emissions below 30 MHz	14
11.1	Definitions.....	14
11.2	Test Parameters	14
11.3	Test Limit	15
11.4	Test Method.....	15
11.5	Test setup photograph.....	16
11.6	Test Equipment.....	16
11.7	Test Results.....	17
12	Radiated emissions	18
12.1	Definitions.....	18
12.2	Test Parameters	18
12.3	Test Limit	18
12.4	Test Method.....	19
12.5	Test Set-up Photograph.....	20
12.6	Test Equipment.....	20
12.7	Test Results.....	21
13	Occupied Bandwidth.....	22
13.1	Definition.....	22
13.2	Test Parameters	22
13.3	Test Limit	22
13.4	Test Method.....	23
13.5	Test Equipment.....	23
13.6	Test Results.....	23
14	Transmitter output power (fundamental radiated emission)	24
14.1	Definition.....	24
14.2	Test Parameters	24
14.3	Test Limit	24
14.4	Test Method.....	25
14.5	Test Equipment.....	25
14.6	Test Results.....	26
15	Frequency stability.....	27
15.1	Definition.....	27
15.2	Test Parameters	27
15.3	Test Limit	27
15.4	Test Method.....	28
15.5	Test Equipment.....	28
15.6	Test Results.....	29
16	Measurement Uncertainty.....	30
17	MPE Calculation	31

4 Introduction

This report TRA-051982-47-06B presents the results of the Radio testing on a Pektron Group Limited, BTLE NFC Node to specification 47CFR15 Radio Frequency Devices.

The testing was carried out for Pektron Group Limited by Element, at the address detailed below.

<input type="checkbox"/>	Element Hull Unit E South Orbital Trading Park Hedon Road Hull HU9 1NJ UK	<input checked="" type="checkbox"/>	Element Skelmersdale Unit 1 Pendle Place Skelmersdale West Lancashire WN8 9PN UK
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This report details the configuration of the equipment, the test methods used and any relevant modifications where appropriate.

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

FCC Site Listing:

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

Designation number(s):

Element Hull	UK2007
Element Skelmersdale	UK2020

IC Registration Number(s):

Element Hull	3483A
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

There were no deviations from the test standard.

6 Glossary of Terms

§	denotes a section reference from the standard, not this document
AC	Alternating Current
ANSI	American National Standards Institute
BW	bandwidth
C	Celsius
CFR	Code of Federal Regulations
CW	Continuous Wave
dB	decibel
dBm	dB relative to 1 milliwatt
DC	Direct Current
DSSS	Direct Sequence Spread Spectrum
EIRP	Equivalent Isotropically Radiated Power
ERP	Effective Radiated Power
EUT	Equipment Under Test
FCC	Federal Communications Commission
FHSS	Frequency Hopping Spread Spectrum
Hz	hertz
IC	Industry Canada (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: BTLE NFC Node
- Serial Numbers: AB10001253 (Radiated) AB10001263 (Conducted)
- Model Number: A-0819G02
- Software Revision: Software Revision: Bootloader: P0819B1.0.4 / Application: P0819A2.1.2
- Build Level / Revision Number: 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.

1. Laptop Computer

7.3 EUT Mode of Operation

7.3.1 Transmission

The mode of operation for transmitter tests was as follows:

The unit was tested in normal operation mode forcing the unit to read a card continuously.

7.4 EUT Radio Parameters

7.4.1 General

Frequency of operation:	13.56 MHz
Modulation type(s):	ASK
Declared output power(s):	Not stated
Warning against use of alternative antennas in user manual (yes/no):	No
Nominal Supply Voltage:	12 Vdc

7.5 EUT Description

The EUT is an ACM connected to node with LF antenna.ACM connected to node with LF antenna.

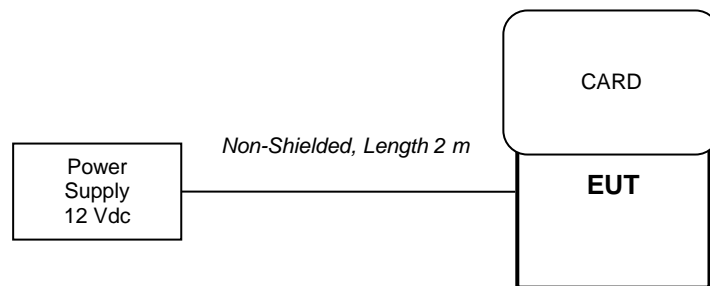
8 Modifications

No modifications were performed during this assessment.

9 EUT Test Setup

9.1 Block Diagram

The following diagram shows basic EUT interconnections with cable type and cable lengths identified



9.2 General Set-up Photograph

The following photograph shows basic EUT set-up:



9.3 Measurement software

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

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

Note:

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

10 General Technical Parameters

10.1 Normal Conditions

The EUT was tested under the normal environmental conditions of the test laboratory, except where otherwise stated. The normal power source applied 12 Vdc from a 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
<input checked="" type="checkbox"/>	Standard	-20 to +50 C in 10 degree steps
<input type="checkbox"/>	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
<input checked="" type="checkbox"/>	Power supply	12 Vdc	85 % and 115 %
<input type="checkbox"/>	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:	SK03 radio chamber
Test Standard and Clause:	ANSI C63.10-2013, Clause 6.4
Frequency Measured:	13.56 MHz
Deviations From Standard:	None
Measurement Distance and Site	3 m
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: 22 °C	+15 °C to +35 °C (as declared)
Humidity: 42 % RH	20 % RH to 75 % RH (as declared)
Supply: 12 Vdc	12 Vdc (as declared)

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 / RSS-210 B.6 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:

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

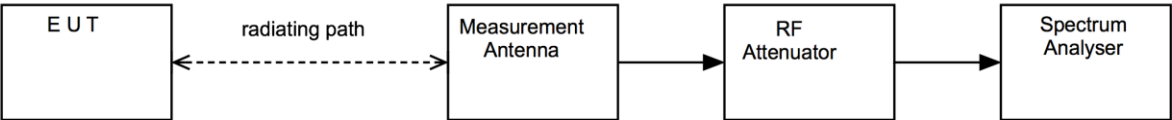
Where,

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) / RSS-Gen 6.4, an extrapolation factor of 40 dB per decade was used for extrapolation from 3 m to 30 m and from 3 m to 300 m.

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

Figure i Test Setup



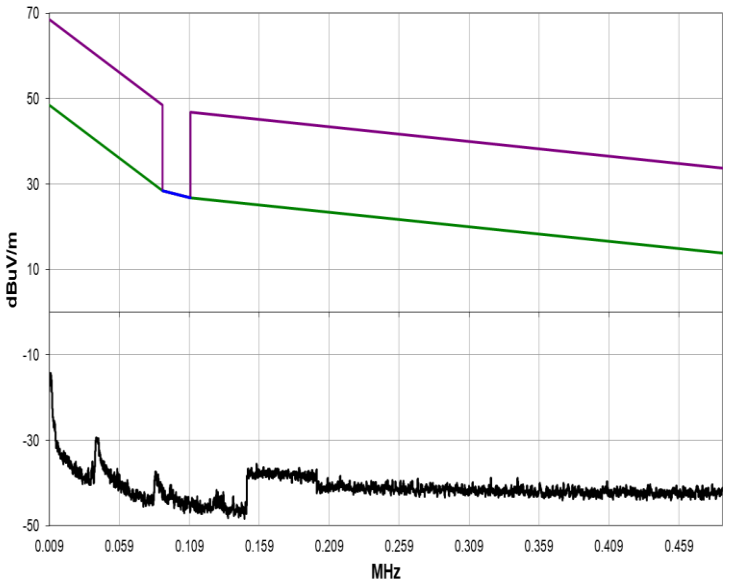
11.5 Test setup photograph



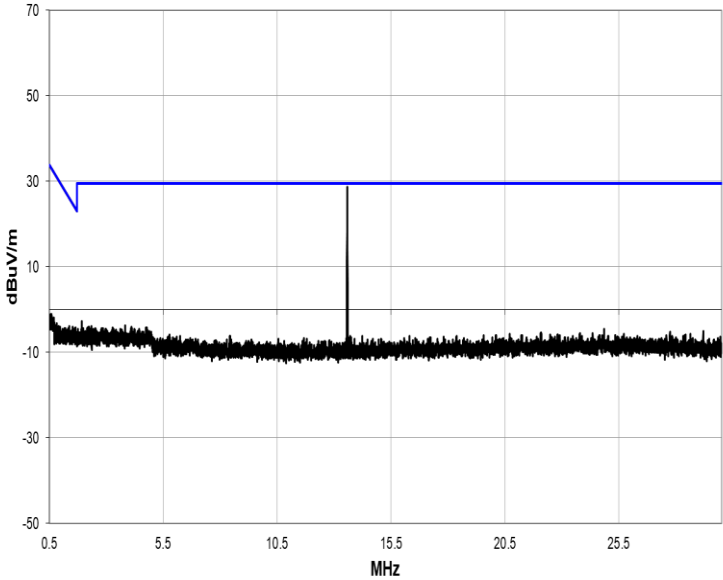
11.6 Test Equipment

Equipment Type	Manufacturer	Equipment Description	Element No	Due For Calibration
Spectrum Analyser	R&S	FSU46	REF910	2021-11-18
Loop Antenna	R&S	hfh2	L007	2021-07-09
ATS	Rainford EMC	Radio Chamber - PP	REF940	2021-12-09

11.7 Test Results



9 kHz to 490 kHz



490 kHz to 30 MHz

Modulation: ASK; Frequency: 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 dB to 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:	SK03 radio chamber
Test Standard and Clause:	ANSI C63.10-2013, Clause 6.5
Frequency Measured:	13.56 MHz
Deviations From Standard:	None
Measurement BW:	30 MHz to 300 MHz: 120 kHz
Measurement Detector:	Quasi-peak

Environmental Conditions (Normal Environment)

Temperature: 22 °C	+15 °C to +35 °C (as declared)
Humidity: 40 % RH	20 % RH to 75 % RH (as declared)
Supply: 12 Vdc	12 Vdc (as declared)

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 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;

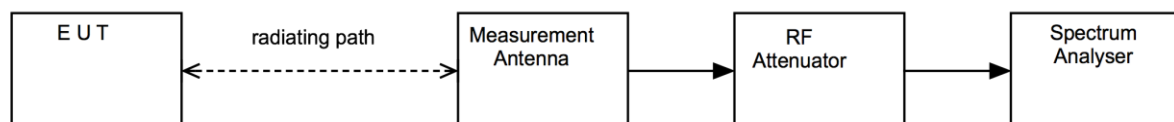
PA is the pre-amplifier gain in dB (where used);

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 is different to limit distance);

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

Figure ii Test Setup



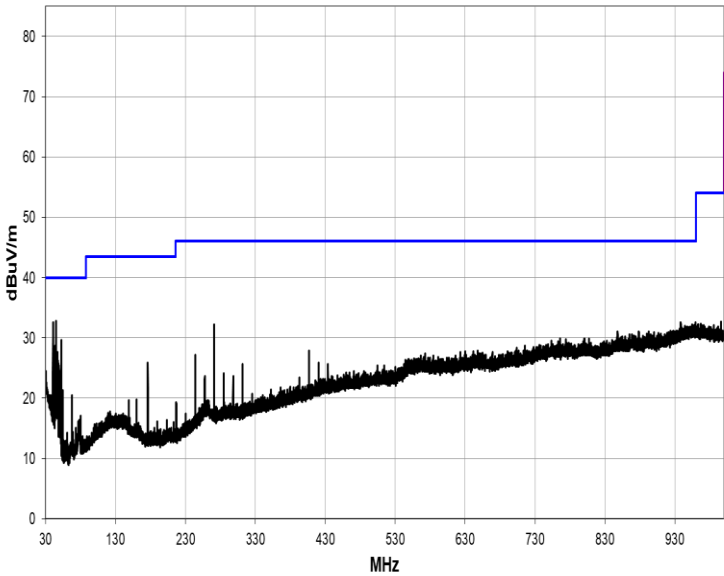
12.5 Test Set-up Photograph



12.6 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	FSU46	REF910	2021-11-18
Bilog	Chase	CBL611/A	U573	2023-01-28
PreAmp	Watkins Johnson	6201-69	U372	2022-03-01
Radio Chamber - PP	Rainford EMC	ATS	REF940	2021-12-09

12.7 Test Results



30 MHz to 1 GHz

Freq (MHz)	Amplitude (dBuV)	Factor (dB)	Antenna Height (meters)	Azimuth (degrees)	Test Distance (meters)	External Attenuation (dB)	Polarity/ Transducer Type	Detector	Distance Adjustment (dB)	Adjusted (dBuV/m)	Spec. Limit (dBuV/m)	Compared to Spec. (dB)
45.978	43.2	-12.4	1.02	231.9	3.0	0.0	Vert	QP	0.0	30.8	40.0	-9.2
271.203	37.8	-7.9	1.0	104.0	3.0	0.0	Horz	QP	0.0	29.9	46.0	-16.1
176.273	37.4	-12.1	1.0	56.0	3.0	0.0	Vert	QP	0.0	25.3	43.5	-18.2
176.278	36.6	-12.1	1.22	87.1	3.0	0.0	Horz	QP	0.0	24.5	43.5	-19.0
406.824	30.2	-3.9	2.23	120.0	3.0	0.0	Horz	QP	0.0	26.3	46.0	-19.7
244.083	35.4	-9.1	1.0	86.0	3.0	0.0	Horz	QP	0.0	26.3	46.0	-19.7

13 Occupied Bandwidth

13.1 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.

13.2 Test Parameters

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

Environmental Conditions (Normal Environment)

Temperature: 22 °C	+15 °C to +35 °C (as declared)
Humidity: 40 % RH	20 % RH to 75 % RH (as declared)
Supply: 12 Vdc	12 Vdc (as declared)

13.3 Test Limit

Federal Communications Commission:

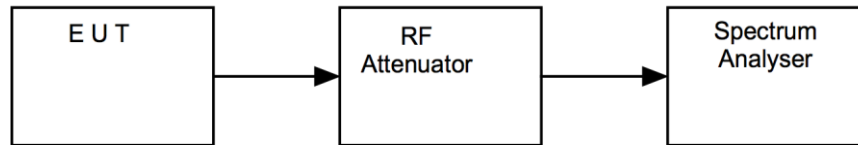
Intentional radiators operating under the alternative provisions to the general emission limits, as contained in §§ 15.217 through 15.257 and in subpart E of this part, must be designed to ensure that the 20 dB bandwidth of the emission, or whatever bandwidth may otherwise be specified in the specific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

13.4 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

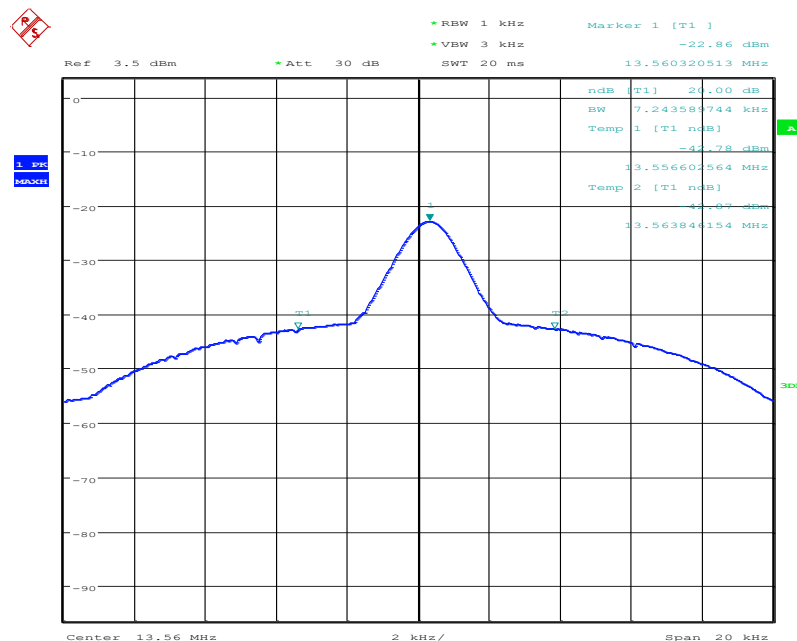


13.5 Test Equipment

Equipment Type	Manufacturer	Equipment Description	Element No	Due For Calibration
Spectrum Analyser	R&S	FSU46	REF910	2021-11-18
Attenuator	AtlanTecRF Microwave	10dB SMA Attenuator	U633	Cal In use

13.6 Test Results

15.225. Modulation: ASK; Frequency: 13.56 MHz			
Channel Frequency (MHz)	F_L (MHz)	F_H (MHz)	20 dB Bandwidth (kHz)
13.56	13.55660256	13.56384615	7.243589744



Date: 16.MAR.2021 09:17:38

14 Transmitter output power (fundamental radiated emission)

14.1 Definition

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

14.2 Test Parameters

Test Location:	Element Skelmersdale
Test Chamber:	Radio Laboratory
Test Antenna:	Active 60cm loop
Test Standard and Clause:	ANSI C63.10-2013, Clause 6.3 / 6.4
Frequency Measured:	13.56 MHz
Deviations From Standard:	None
Measurement BW:	9 kHz
Spectrum Analyzer Video BW: (requirement at least 3x RBW)	30 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: 24 °C	+15 °C to +35 °C (as declared)
Humidity: 40 % RH	20 % RH to 75 % RH (as declared)

14.3 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

14.4 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;

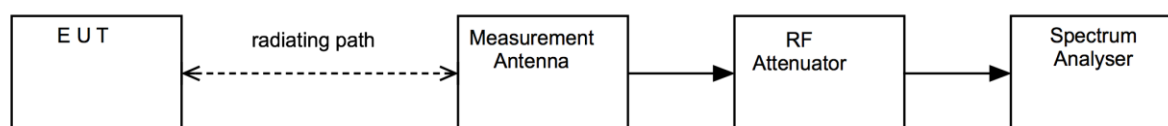
CF is the distance extrapolation factor in dB (where measurement distance different to limit distance);

Per FCC 47CFR15.31(f)(2) / RSS-Gen 6.4, an extrapolation factor of 40 dB per decade was used for extrapolation from 10 m to 30 m.

Per FCC 47CFR15.31(f)(2) / RSS-Gen 6.4, an extrapolation factor for 3 m to 10 m of 41.33 dB was determined from measurements at 3 and 10 metres.

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

Figure v Test Setup

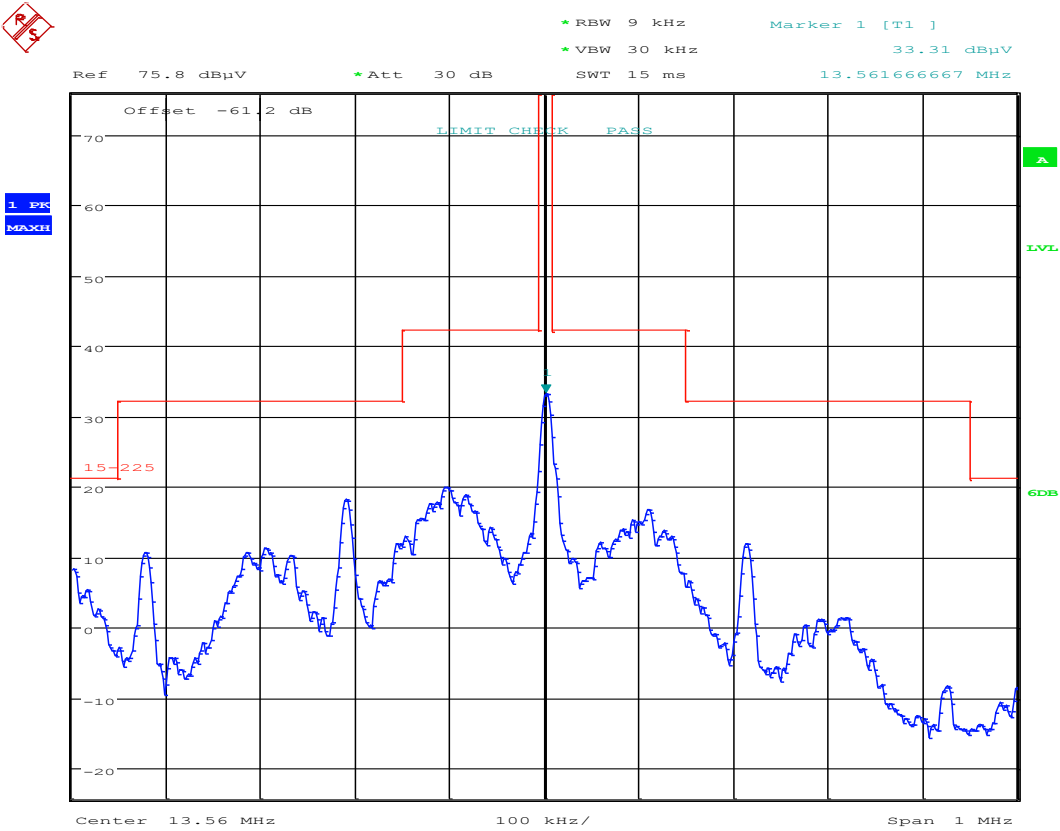


14.5 Test Equipment

<i>Equipment</i>		<i>Equipment</i>	<i>Element</i>	<i>Due For</i>
<i>Type</i>	<i>Manufacturer</i>	<i>Description</i>	<i>No</i>	<i>Calibration</i>
Spectrum Analyser	R&S	FSU46	REF910	2021-11-18
Receiver	R&S	ESHS10	U003	2021-12-11
Loop Antenna	R&S	hfh2	L007	2021-07-09

14.6 Test Results

Modulation: ASK; Frequency: 13.56 MHz						
Channel Frequency (MHz)	Receiver Level (dBµV/m)	Measurement Distance (m)	Limit Distance (m)	Extrapolation Factor (dB)	Field Strength (dBµV/m)	Result
13.56	93.71	3	30	60.41	33.30	Pass
13.56	52.38	10	30	19.08	33.30	Pass



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15 Frequency stability

15.1 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.

15.2 Test Parameters

Test Location:	Element Skelmersdale
Test Chamber:	Radio Laboratory
Test Standard and Clause:	ANSI C63.10-2013, Clause 6.8
Frequency Measured:	13.56 MHz
Modulation:	Off
Deviations From Standard:	None
Temperature Extreme Environment Test Range:	-20 to +50 C
Voltage Extreme Environment Test Range:	12 Vdc power supply = $\pm 15\%$ of Nominal;

Environmental Conditions (Normal Environment)

Temperature: 20 °C	Standard Requirement: +20 °C
Humidity: 40 %RH	20 % RH to 75 % RH (as declared)

15.3 Test Limit

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

Limit = $\pm 0.01\%$ = 1.3562 kHz

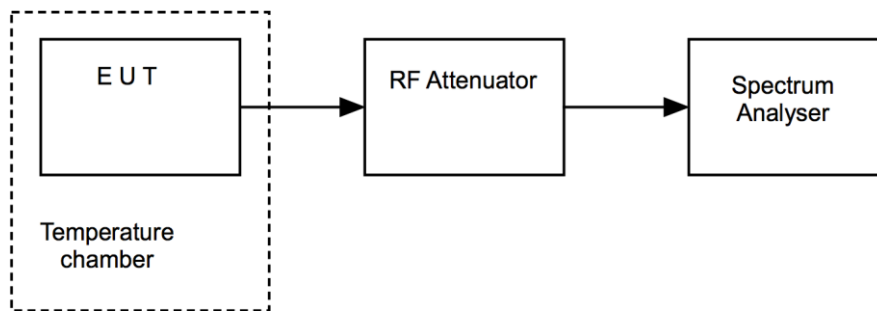
15.4 Test Method

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 set in a CW mode of operation.

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

Figure v Test Setup



15.5 Test Equipment

<i>Equipment Type</i>	<i>Manufacturer</i>	<i>Equipment Description</i>	<i>Element No</i>	<i>Due For Calibration</i>
IPS-303DD	ISO-Tech	Power Supply	U515	Use REF976
Spectrum Analyser	R&S	FSU46	REF910	2021-11-18
Temperature Indicator	Fluke	52 Series II	L426	2021-07-02
Multimeter	Agilent	34405a	REF976	2021-11-26
VT 4002	Votsch	Temperature Chamber	U521	Use L426

15.6 Test Results

<i>EUT Frequency: 13.56 MHz</i>				
<i>Test Environment</i>		<i>Measured Frequency (MHz)</i>	<i>Frequency error (kHz)</i>	<i>Result</i>
-20 °C	V _{nominal}	13.560256	-0.1122	Pass
-10 °C	V _{nominal}	13.560256	-0.1122	Pass
0 °C	V _{nominal}	13.560288	-0.0801	Pass
+10 °C	V _{nominal}	13.560353	-0.0160	Pass
+20 °C	V _{minimum}	13.560369	0.0000	Pass
	V _{nominal}	13.560369	0.0000	N/A
	V _{maximum}	13.560369	0.0000	Pass
+30 °C	V _{nominal}	13.560561	0.1923	Pass
+40 °C	V _{nominal}	13.560737	0.3686	Pass
+50 °C	V _{nominal}	13.560881	0.5128	Pass

Limit = $\pm 0.01\%$ = 1.3562 kHz

16 Measurement Uncertainty

Calculated Measurement Uncertainties

All statements of uncertainty are expanded standard uncertainty using a coverage factor of 1.96 to give a 95 % confidence:

[1] Radiated emissions below 30 MHz

Uncertainty in test result (9 kHz to 30 MHz) = **2.3 dB**

[2] Spurious emissions

Uncertainty in test result (30 MHz to 1 GHz) = **4.6 dB**

Uncertainty in test result (1 GHz to 18 GHz) = **4.7 dB**

[3] AC power line conducted emissions

Uncertainty in test result = **3.4 dB**

[4] Occupied bandwidth

Uncertainty in test result = **15.5 %**

[5] Maximum frequency error

Uncertainty in test result (Power Meter) = **0.113 ppm**

Uncertainty in test result (Spectrum Analyser) = **0.265 ppm**

17 MPE Calculation

Prediction of MPE limit at a given distance

For purposes of these requirements mobile devices are defined by the FCC as transmitters designed to be used in other than fixed locations and to generally be used in such a way that a separation distance of at least 20 centimeters is normally maintained between radiating structures and the body of the user or nearby persons. These devices are normally evaluated for exposure potential with relation to the MPE limits. As the 20 cm separation specified under FCC rules may not be achievable under normal operation of the EUT, an RF exposure calculation is needed to show the minimum distance required to be less than the power density limit, as required under FCC rules.

Equation from IEEE C95.1

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

Where:

S = power density

R = distance to the centre of radiation of the antenna

EIRP = EUT Maximum power

Result

Channel Frequency (MHz)	EIRP (mW)	Power density limit (S) (mW/cm²)	Distance (R) cm required to be less than the power density limit
13.56	0.7	0.979	0.24

See intermodulation report TRA-051982-47-08A for simultaneous operation assessment.