Report on the Radio Testing

For

G4S Technology Ltd T/AS AMAG Technology

on

S884-OSDP Reader

Report no. TRA-048435-47-00A

28 November 2019

Report Number: TRA-048435-47-00A
Issue: A

REPORT ON THE RADIO TESTING OF A
G4S Technology Ltd T/AS AMAG Technology
S884-OSDP Reader
WITH RESPECT TO SPECIFICATION
FCC 47CFR 15.225

TEST DATE: 2019-11-18 to 2019-11-22

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D Moncayola
Radio Test Engineer

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J Charters
Lab Manager

Date: 28 November 2019

1 Revision Record

Issue Number	*Issue Date*	*Revision History*
A	28 November 2019	Original

2 Summary

TEST REPORT NUMBER:	TRA-048435-47-00A
WORKS ORDER NUMBER:	TRA-048435-01
PURPOSE OF TEST:	USA: Testing of radio frequency equipment per the relevant authorization procedure of chapter 47 of CFR (code of federal regulations) Part 2, subpart J.
TEST SPECIFICATION(S):	47CFR15.225
EQUIPMENT UNDER TEST (EUT):	S884-OSDP Reader
FCC IDENTIFIER:	OE5S884O
EUT SERIAL NUMBER:	1942001212
MANUFACTURER/AGENT:	G4S Technology Ltd T/AS AMAG Technology
ADDRESS:	Challenge House International Drive Tewkesbury Gloucestershire GL20 8UQ United Kingdom
CLIENT CONTACT:	Ian Williams ☎ 01684 850977 ✉ ian.williams@amag.com
ORDER NUMBER:	PUR140801
TEST DATE:	2019-11-18 to 2019-11-22
TESTED BY:	D Moncayola Element

2.1 Test Summary

Test Method and Description	*Requirement Clause 47CFR15*	*Applicable to this equipment*	*Result / Note*
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).

3 Contents

4 Introduction

This report TRA-048435-47-00A presents the results of the Radio testing on a G4S Technology Ltd T/AS AMAG Technology, S884-OSDP Reader to specification 47CFR15 Radio Frequency Devices.

The testing was carried out for G4S Technology Ltd T/AS AMAG Technology by Element, at the address detailed below.

☐ Element Hull
Unit E
South Orbital Trading Park
Hedon Road
Hull
HU9 1NJ
UK

☒ Element Skelmersdale
Unit 1
Pendle Place
Skelmersdale
West Lancashire
WN8 9PN
UK

This report details the configuration of the equipment, the test methods used and any relevant modifications where appropriate.

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

FCC Site Listing:
Element is accredited for the above sites under the US-EU MRA, Designation number UK0009.

ISED Registration Number(s):

Element Skelmersdale	3930B
Element Hull	3483A

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 (now ISED)
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: S884-OSDP Reader
- Serial Number: 1942001212
- Model Number: S884-OSDP
- Software Revision: Not Stated
- 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.

Not Applicable – No support/monitoring equipment required.

7.3 EUT Mode of Operation

7.3.1 Transmission

The mode of operation for transmitter tests was as follows…

The EUT was in normal operation mode constantly reading a card to produce a constant modulated signal.

7.4 EUT Radio Parameters

7.4.1 General

Frequency of operation:	13.56 MHz
Modulation type(s):	ASK
Occupied channel bandwidth(s):	Wideband
Channel spacing:	Not applicable
Declared output power(s):	Not stated
Nominal Supply Voltage:	12 Vdc

7.5 EUT Description

The EUT is a contactless smart card reader with a graphic LCD and keypad.

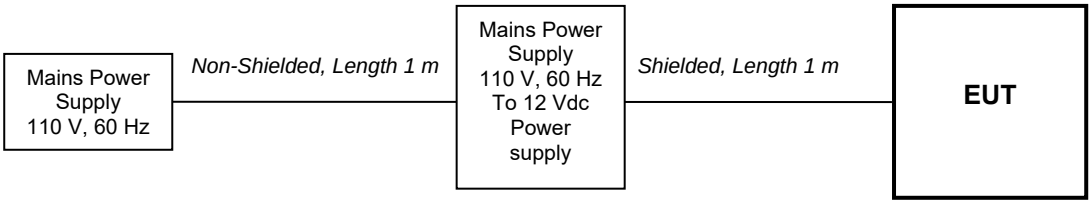
8 Modifications

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 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. 12 V dc from a power supply and where required connected to 110 V ac, 60 Hz mains 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 °C 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:	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: 20 °C	+15 ºC to +35 ºC (as declared)
Humidity: 32 % RH	20 % RH to 75 % RH (as declared)
Supply: 12 V dc	12 V dc (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

Frequency, f (kHz)	*Field Strength*	*Measurement Distance (m)*
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 360º, 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:

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

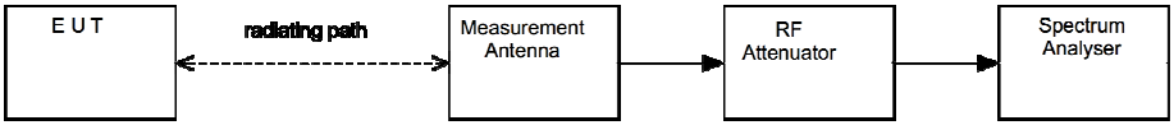
Where,

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

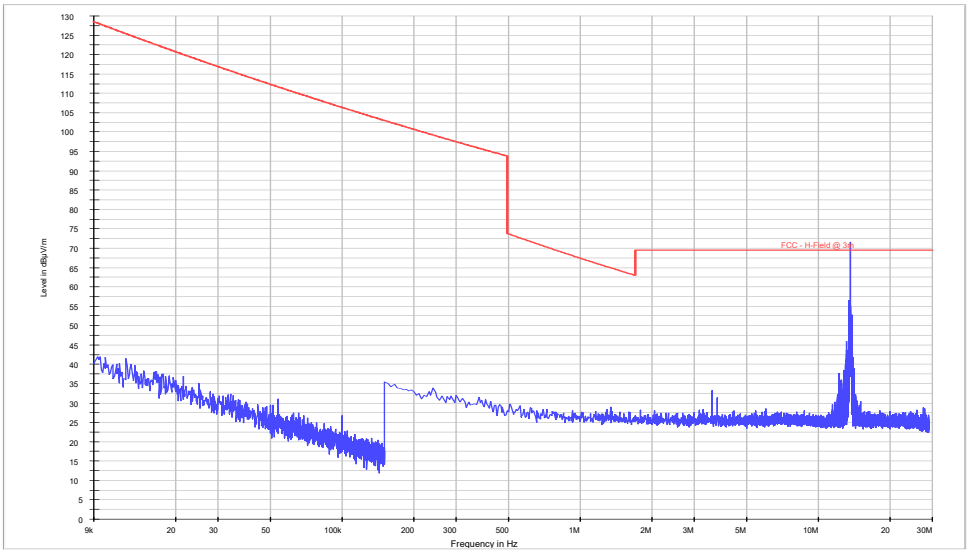


11.5 Test Set-up Photograph

11.6 Test Equipment

Equipment Type	Manufacturer	Equipment Description	Element No	Due For Calibration
hfh2	R&S	Loop Antenna	L007	2020-05-15
ESHS10	R&S	Receiver	U003	2020-10-23

11.7 Test Results



9 kHz to 30 MHz

High Power; Channel: high MHz										
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 to the limit										

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:	Radio Chamber
Test Standard and Clause:	ANSI C63.10-2013, Clause 6.5
Operating Frequency:	13.56 MHz
Deviations From Standard:	None
Measurement BW:	30 MHz to 1000 MHz: 120 kHz
Measurement Detector:	Quasi-peak

Environmental Conditions (Normal Environment)

Temperature: 24 °C	+15 ºC to +35 ºC (as declared)
Humidity: 32 % RH	20 % RH to 75 % RH (as declared)
Supply: 12 V dc	12 V dc (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 (µV/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:

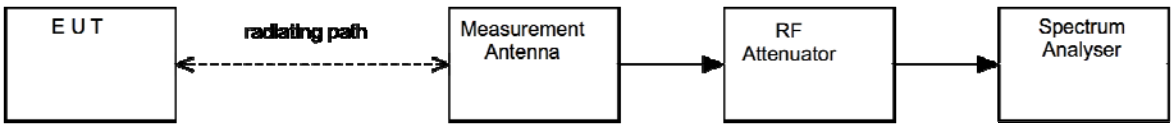
$$FS = PR + CL + AF – PA + DC – CF$$

Where,

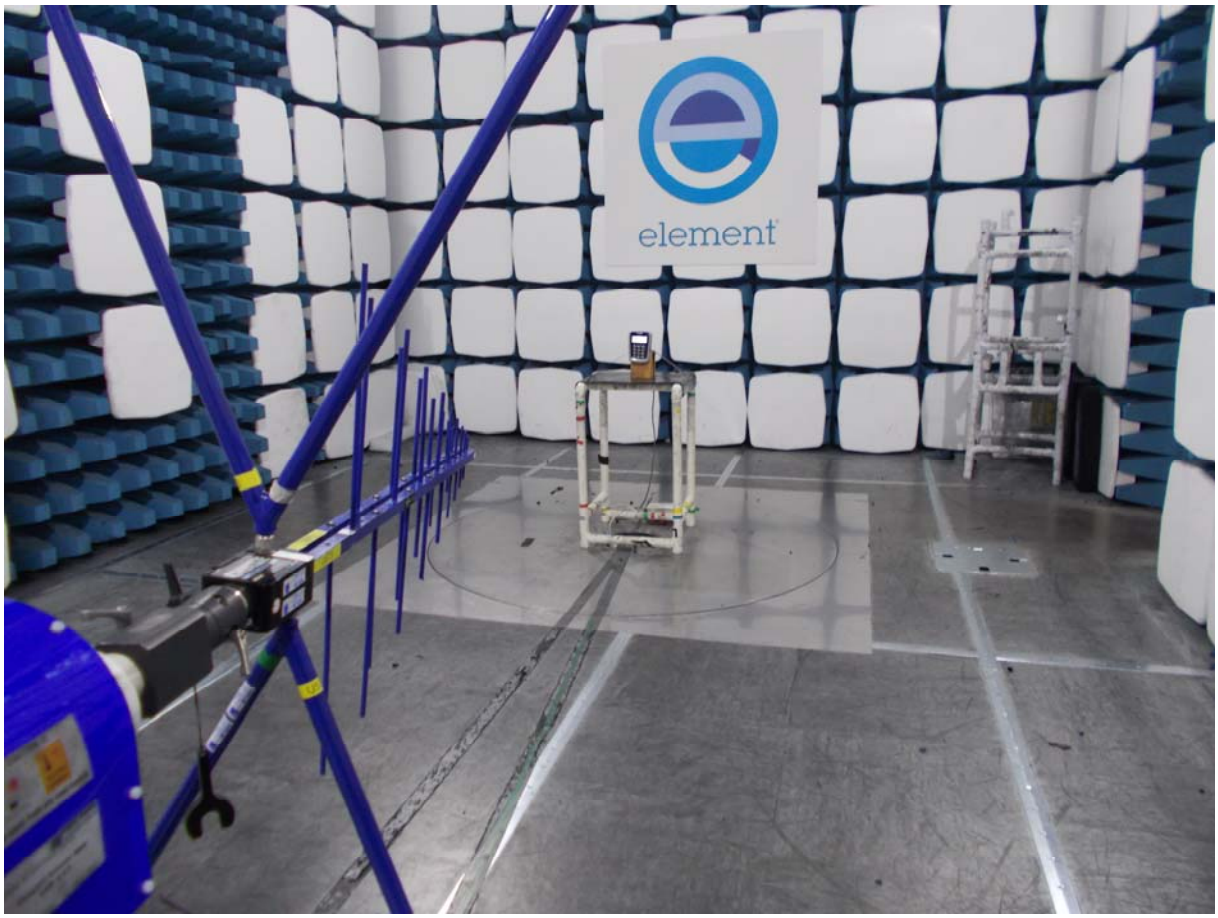
PR is the power recorded on the receiver / spectrum analyzer in dBµV;
CL is the cable loss in dB;
AF is the test antenna factor in dB/m;
PA is the pre-amplifier gain in dB (where used);
DC is the duty correction factor in dB (where used, e.g. harmonics of pulsed fundamental);
CF is the distance factor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



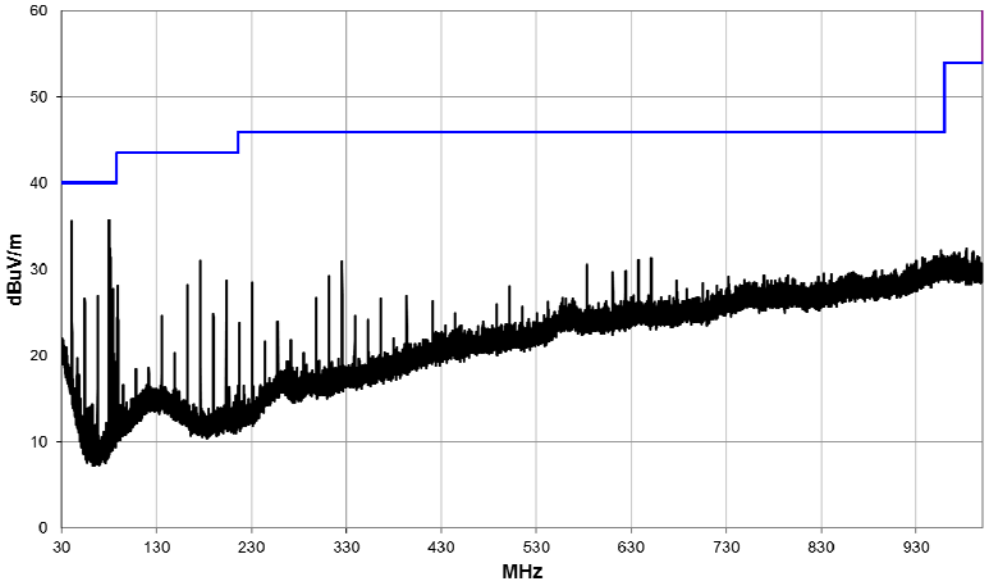
12.5 Test Set-up Photograph



12.6 Test Equipment

Equipment Type	Manufacturer	Equipment Description	Element No	Due For Calibration
CBL611/A	Chase	Bilog	U573	2021-09-19
6201-69	Watkins Johnson	PreAmp	U372	2020-02-25
FSU46	R&S	Spectrum Analyser	REF910	2020-10-17
ESVS10	R&S	Receiver	L317	2020-04-24

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)
40.712	41.7	-9.3	1.05	272.1	3.0	0.0	Vert	QP	0.0	32.4	40.0	-7.6
40.714	41.7	-9.3	1.0	246.0	3.0	0.0	Vert	QP	0.0	32.4	40.0	-7.6
40.714	35.7	-9.3	1.0	270.1	3.0	0.0	Vert	QP	0.0	26.4	40.0	-13.6
40.714	34.9	-9.3	2.98	327.9	3.0	0.0	Horz	QP	0.0	25.6	40.0	-14.4
176.342	41.1	-12.3	1.03	60.1	3.0	0.0	Vert	QP	0.0	28.8	43.5	-14.7
203.468	40.1	-11.7	1.15	234.1	3.0	0.0	Horz	QP	0.0	28.4	43.5	-15.1
67.838	40.3	-16.1	1.5	88.0	3.0	0.0	Vert	QP	0.0	24.2	40.0	-15.8
651.041	28.5	1.4	1.5	200.1	3.0	0.0	Vert	QP	0.0	29.9	46.0	-16.1
325.531	36.5	-6.6	1.0	96.9	3.0	0.0	Horz	QP	0.0	29.9	46.0	-16.1
637.477	28.3	1.4	1.5	153.0	3.0	0.0	Vert	QP	0.0	29.7	46.0	-16.3
162.778	38.6	-11.4	1.0	221.0	3.0	0.0	Vert	QP	0.0	27.2	43.5	-16.3
54.277	39.6	-16.0	1.21	141.0	3.0	0.0	Vert	QP	0.0	23.6	40.0	-16.4

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
Test Standard and Clause:	ANSI C63.10-2013, Clause 6.2
Frequency Measured:	13.56 MHz
EUT Modulation:	ASK
Deviations From Standard:	None
Measurement BW:	10 kHz
Measurement Detectors:	Quasi-Peak and Average, RMS

Environmental Conditions (Normal Environment)

Temperature: 24 °C	+15 ºC to +35 ºC (as declared)
Humidity: 32 % RH	20 % RH to 75 % RH (as declared)
Supply: 110 V ac	110 V ac (as declared)

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.

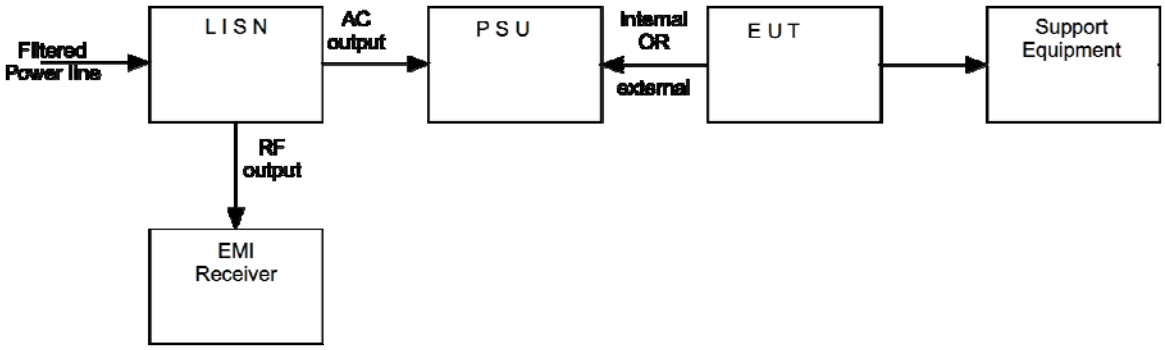
13.4 Test Method

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

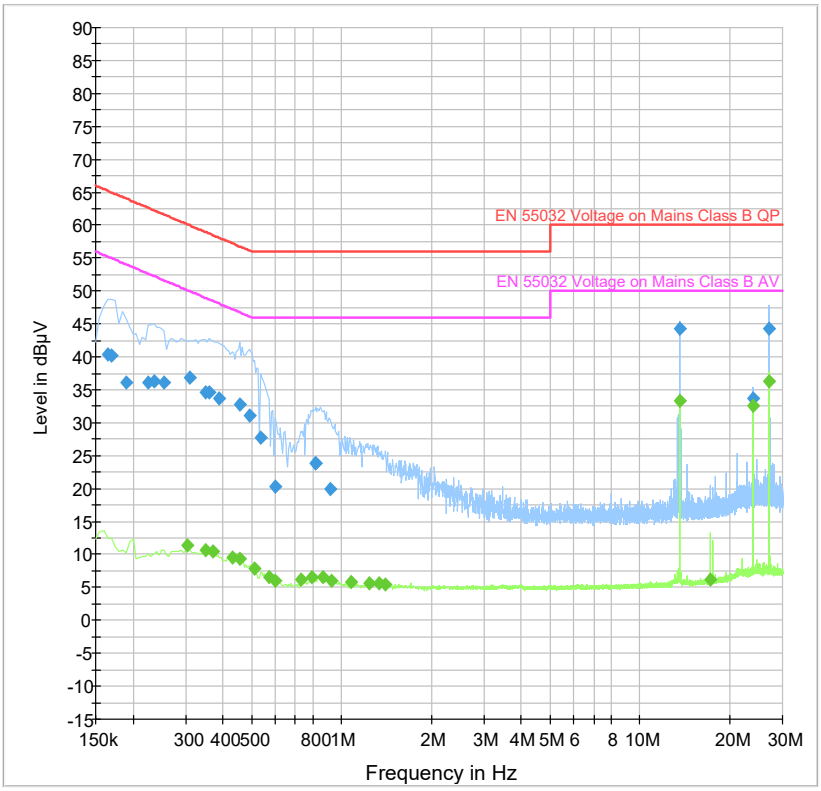


13.5 Test Set-up Photograph

13.6 Test Equipment

Equipment Type	Manufacturer	Equipment Description	Element No	Due For Calibration
ENV216	R&S	Lisn	U396	2020-08-16
ESHS10	R&S	Receiver	U003	2020-10-23

13.7 Test Results



Final Result 1

Frequency (MHz)	QuasiPeak (dBµV)	Meas. Time (ms)	Bandwidth (kHz)	Filter	Line	Corr. (dB)	Margin (dB)	Limit (dBµV)	Comment
0.165000	40.4	2000.0	10.000	On	L1	19.5	24.8	65.2	Pass
0.170000	40.1	2000.0	10.000	On	L1	19.5	24.8	65.0	Pass
0.190000	36.1	2000.0	10.000	On	L1	19.5	27.9	64.0	Pass
0.225000	36.1	2000.0	10.000	On	N	19.5	26.6	62.6	Pass
0.235000	36.2	2000.0	10.000	On	N	19.5	26.1	62.3	Pass
0.255000	36.2	2000.0	10.000	On	N	19.5	25.4	61.6	Pass
0.310000	36.8	2000.0	10.000	On	L1	19.5	23.2	60.0	Pass
0.350000	34.7	2000.0	10.000	On	N	19.5	24.3	59.0	Pass
0.360000	34.5	2000.0	10.000	On	N	19.5	24.2	58.7	Pass
0.390000	33.8	2000.0	10.000	On	N	19.5	24.3	58.1	Pass
0.455000	32.7	2000.0	10.000	On	N	19.5	24.1	56.8	Pass
0.490000	31.0	2000.0	10.000	On	N	19.5	25.1	56.2	Pass
0.535000	27.8	2000.0	10.000	On	N	19.5	28.2	56.0	Pass
0.600000	20.3	2000.0	10.000	On	N	19.5	35.7	56.0	Pass
0.815000	23.8	2000.0	10.000	On	L1	19.5	32.2	56.0	Pass
0.820000	23.7	2000.0	10.000	On	L1	19.5	32.3	56.0	Pass
0.920000	20.0	2000.0	10.000	On	L1	19.5	36.0	56.0	Pass
13.560000	44.3	2000.0	10.000	On	L1	19.8	15.7	60.0	Pass
24.000000	33.7	2000.0	10.000	On	L1	20.0	26.3	60.0	Pass
27.125000	44.2	2000.0	10.000	On	N	20.1	15.8	60.0	Pass

Final Result 2

Frequency (MHz)	Average (dBµV)	Meas. Time (ms)	Bandwidth (kHz)	Filter	Line	Corr. (dB)	Margin (dB)	Limit (dBµV)	Comment
0.305000	11.4	2000.0	10.000	On	L1	19.5	38.7	50.1	Pass
0.350000	10.7	2000.0	10.000	On	L1	19.5	38.3	49.0	Pass
0.370000	10.4	2000.0	10.000	On	L1	19.5	38.1	48.5	Pass
0.430000	9.6	2000.0	10.000	On	N	19.5	37.7	47.3	Pass
0.455000	9.4	2000.0	10.000	On	N	19.5	37.4	46.8	Pass
0.510000	7.8	2000.0	10.000	On	N	19.5	38.2	46.0	Pass
0.570000	6.6	2000.0	10.000	On	N	19.5	39.4	46.0	Pass
0.600000	6.1	2000.0	10.000	On	N	19.5	39.9	46.0	Pass
0.730000	6.1	2000.0	10.000	On	N	19.5	39.9	46.0	Pass
0.795000	6.6	2000.0	10.000	On	N	19.5	39.4	46.0	Pass
0.870000	6.6	2000.0	10.000	On	N	19.5	39.4	46.0	Pass
0.925000	6.1	2000.0	10.000	On	L1	19.5	39.9	46.0	Pass
1.075000	5.8	2000.0	10.000	On	N	19.5	40.2	46.0	Pass
1.245000	5.7	2000.0	10.000	On	N	19.5	40.3	46.0	Pass
1.335000	5.6	2000.0	10.000	On	N	19.5	40.4	46.0	Pass
1.395000	5.5	2000.0	10.000	On	N	19.5	40.5	46.0	Pass
13.565000	33.3	2000.0	10.000	On	N	19.9	16.7	50.0	Pass
17.175000	6.2	2000.0	10.000	On	L1	19.9	43.8	50.0	Pass
24.000000	32.6	2000.0	10.000	On	N	20.1	17.4	50.0	Pass
27.125000	36.3	2000.0	10.000	On	L1	20.0	13.7	50.0	Pass

14 Occupied Bandwidth

14.1 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.

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 Lab
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: (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)	10 kHz
Measurement Detector:	Peak

Environmental Conditions (Normal Environment)

Temperature: 20 °C	+15 ºC to +35 ºC (as declared)
Humidity: 32 % RH	20 % RH to 75 % RH (as declared)
Supply: 12 V dc	12 V dc (as declared)

14.3 Test Limit

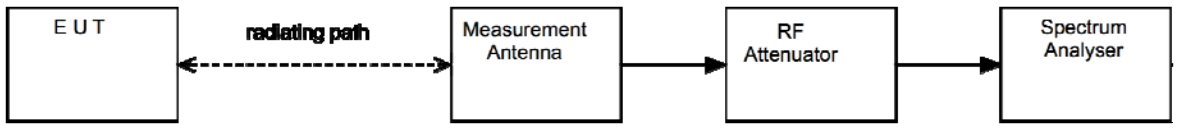
Federal Communications Commission:
Intentional radiators operating under the alternative provisions to the general emission limits, as contained in §§ 15.217 through 15.257 and in subpart E of this part, must be designed to ensure that the 20 dB bandwidth of the emission, or whatever bandwidth may otherwise 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

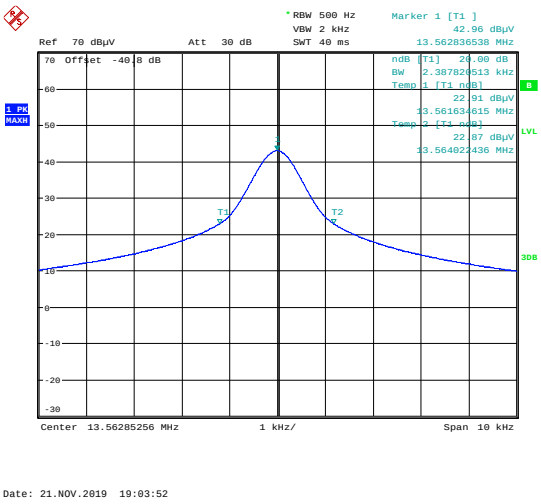


14.5 Test Equipment

Equipment Type	Manufacturer	Equipment Description	Element No	Due For Calibration
FSU46	R&S	Spectrum Analyser	REF910	2020-10-17

14.6 Test Results

15.225. Modulation: ASK; High Power setting			
Channel Frequency (MHz)	**F_L (MHz)**	**F_H (MHz)**	**20 dB Bandwidth (kHz)**
13.56	13.561634615	13.564022436	2.387820513



Occupied Bandwidth Upper / Lower Limits				
Min. F_L (MHz)	**F_{drift} (kHz)**	**F_L - F_{drift} (MHz)**	**Limit (MHz)**	**Result**
13.561634615	-0.028	13.533634615	13.110	PASS
Max. F_H (MHz)	**F_{drift} (kHz)**	**F_H + F_{drift} (MHz)**	**Limit (MHz)**	**Result**
13.564022436	0.0695	13.633522436	14.010	PASS

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:	OATS
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
Measurement Detector:	Quasi-peak
Voltage Extreme Environment Test Range:	Mains Power = 85% and 115% of Nominal

Environmental Conditions (Normal Environment)

Temperature: 20 °C	+15 ºC to +35 ºC (as declared)
Humidity: 32 % 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

Frequency range (MHz)	*Field strength (µV/m at 30m)*	*Field strength (dBµV/m at 30m)*
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 µV/m at the regulatory distance, using:

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

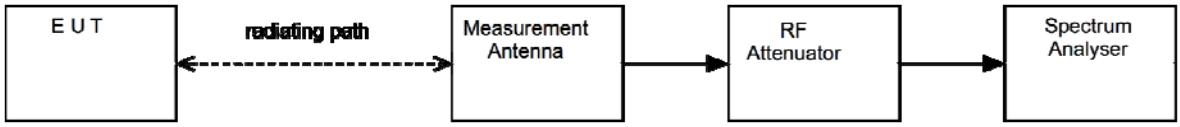
Where,

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 19.08 dB per decade was determined from measurements at 3 and 10 metres.

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

Figure v Test Setup



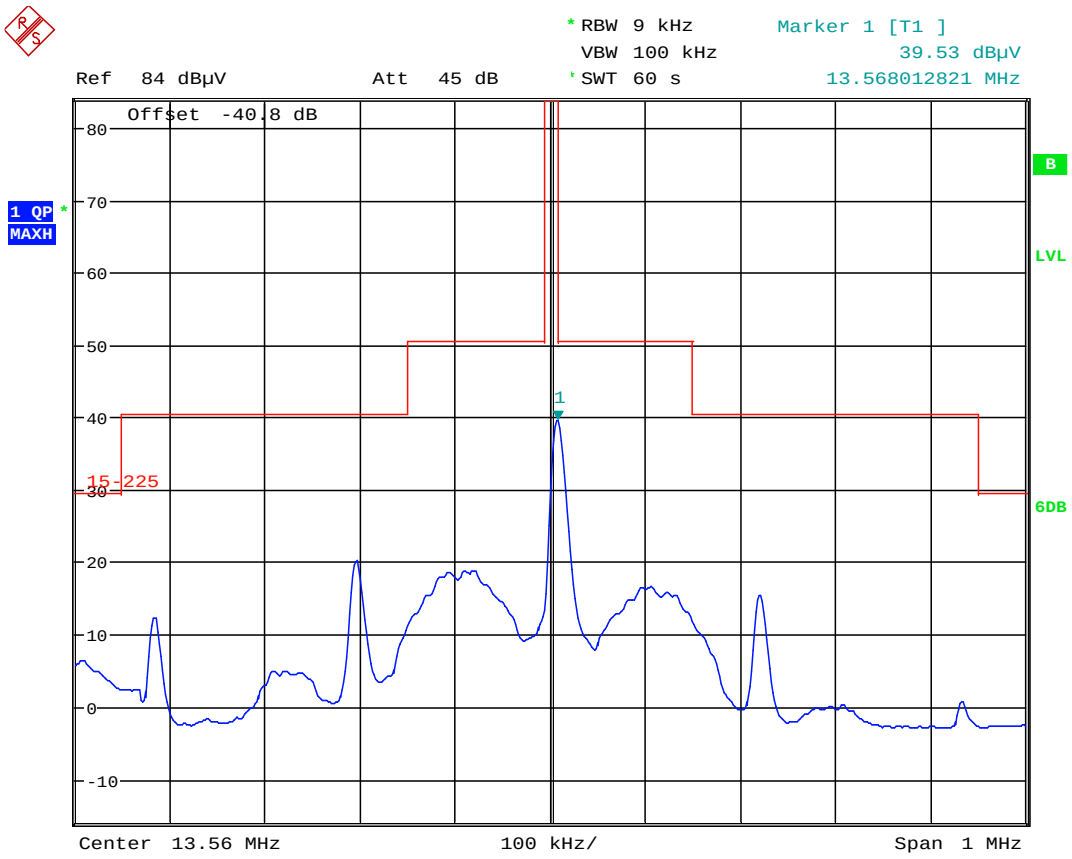
15.5 Test Equipment

Equipment Type	Manufacturer	Equipment Description	Element No	Due For Calibration
FSU46	R&S	Spectrum Analyser	REF910	2020-10-17
ESHS10	R&S	Receiver	U003	2020-10-23
hfh2	R&S	Loop Antenna	L007	2020-05-15

15.6 Test Results

High Power Setting; Frequency: 13.56 MHz						
Channel Frequency (MHz)	***Receiver Level (dBµV/m)***	***Measurement Distance (m)***	***Limit Distance (m)***	***Extrapolation Factor (dB)***	***Field Strength (µV/m)***	***Result***
13.56	77.55	3	30	38.08	94.028	PASS
13.56	58.55	10	30	19.08	94.028	PASS

3 meter to 10 meter correction 19 dB as measured
10 meter to 30 meter correction 19.08 dB as per 15.31(f)(2)
3 meter to 30 meter correction 38.08 dB (19dB + 19.08dB)



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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 Lab
Test Standard and Clause:	ANSI C63.10-2013, Clause 6.8
Frequencies Measured:	13.56 MHz
Modulation:	Off
Deviations From Standard:	None
Temperature Extreme Environment Test Range:	-20 °C to +50 °C
Voltage Extreme Environment Test Range:	±15% of Nominal;

Environmental Conditions (Normal Environment)

Temperature: 20 °C	Standard Requirement: +20 ºC
Humidity: 30 %RH	20 % RH to 75 % RH (as declared)

16.3 Test Limit

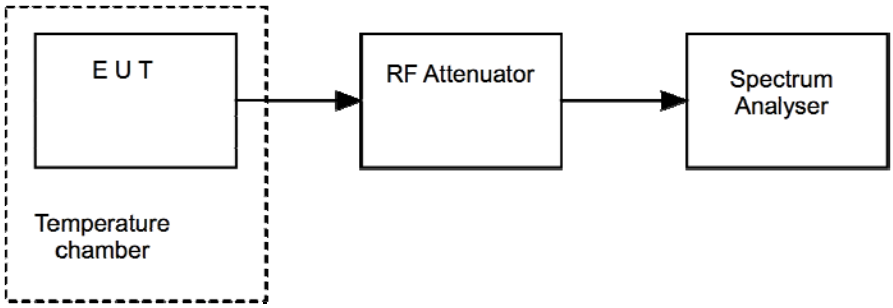
Carrier frequency stability shall be maintained to ±0.01% (±100 ppm).

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 set in a CW mode of operation.
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
IPS-303DD	ISO-Tech	Power Supply	U515	Use TRLS044
FSU46	R&S	Spectrum Analyser	REF910	2020-10-17
VT 4002	Votsch	Temperature Chamber	U521	Use L426
52 Series II	Fluke	Temperature Indicator	L426	2020-06-28
75 Series II	Fluke	Multimeter	TRLS044	2020-08-05

16.6 Test Results

EUT Frequency: 13.56 MHz					
Test Environment		***Measured Frequency (MHz)***	***Frequency error (kHz)***	***Frequency error (%)***	***Result***
-20 °C	$V_{nominal}$	13.562821	-0.0115	-0.00008	PASS
-10 °C	$V_{nominal}$	13.562869	0.0366	0.00027	PASS
0 °C	$V_{nominal}$	13.562902	0.0695	0.00051	PASS
+10 °C	$V_{nominal}$	13.562902	0.0695	0.00051	PASS
+20 °C	$V_{minimum}$	13.562832	0.0000	0.0000	PASS
	$V_{nominal}$	13.562832	N/A	N/A	N/A
	$V_{maximum}$	13.562818	-0.0140	-0.00010	PASS
+30 °C	$V_{nominal}$	13.562818	-0.0140	-0.00010	PASS
+40 °C	$V_{nominal}$	13.562840	0.0080	0.00006	PASS
+50 °C	$V_{nominal}$	13.562804	-0.0280	-0.00021	PASS

17 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**

18 RF Exposure

General SAR test reduction and exclusion guidance

KDB 447498 & RSS-102

Section 4.3 General SAR test reduction and exclusion guidance

For Standalone SAR exclusion consideration, when the considering SAR exclusion Threshold requirement in KDB 447498 is satisfied standalone SAR evaluation for general population exposure conditions by measurement or numerical simulation is not required.

In the frequency range below 100 MHz and test separation distance ≤ 50mm, the SAR Test Exclusion Threshold will be determined as follows

SAR Exclusion Threshold (SARET)

SAR Exclusion Threshold = ([Step 1 + Step2] * Step 3a) * Step 3b

Step 1

$$NT = [(MP/TSD^{A}) * \sqrt{} f_{GHz}]$$

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

MP = Max Power of channel (mW) (inc tune up)

TSD^{A} = Min Test separation Distance or 50mm (whichever is lower) = 50

f_{GHz} = Transmit frequency (or 100MHz if lower)

We can transpose this formula to allow us to find the maximum power of a channel allowed and compare this to the measured maximum power.

$$MP = [(NT \times TSD^{A}) / \sqrt{} f_{GHz}]$$

For Distances Greater than 50 mm Step 2 applies

Step 2

$$(TSD^B - 50mm) * f_{(MHz)}/150$$

Where:

f_{MHz} = Transmit frequency

TSD^B = Min Test separation Distance (mm) = 50

Step 3

3a) The power threshold at the corresponding test separation distance at 100 MHz in step 2) is multiplied by $[1 + \log(100/f_{(MHz)})]$ for *test separation distances* > 50 mm and < 200 mm

3b) The power threshold determined by the equation in steps 1 and 2 for 50 mm and 100 MHz is multiplied by ½ for *test separation distances* ≤ 50 mm

SARET = $(\{ [(NT \times TSD^A) / \sqrt{f_{GHz}}] + (TSD^B - 50) * [100/150] \} * (1 + Log [100 / F_{MHz}])) * {}^1/_2$

SARET = $(\{ [(3.0 \times 50) / \sqrt{0.1}] + (50 - 50) * [100/150] \} * (1 + Log [100 / F_{MHz)}]) * {}^1/_2$

SARET = $(474 * (1 + Log [100 / 13.56)) * {}^1/_2$

SARET = 442.65 mW

The calculated output power is 0.0024 mW (eirp) is less than the SAR Exclusion Threshold of 468mW, at 5mm test separation distance, for general population and uncontrolled exposure.

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