

Report on the Radio Testing
For
System Loco Ltd
On a
LocoTrack Rechargeable
Report no. TRA-054381-47-03B
17 June 2021

RF908 2.0

Report Number: TRA-054381-47-03B
Issue: B

REPORT ON THE RADIO TESTING OF A
System Loco Ltd
LocoTrack Rechargeable
WITH RESPECT TO SELECTED CLAUSES OF SPECIFICATIONS
ETSI EG 203 367 V1.1.1 (2016-06)
&
KDB 996369 D04 v02
(Intermodulation Investigation)

TEST DATE: 2021-May-24 to 2021-June-02

Tested by: M Else

Written by:  Digitally signed by Michael Else
DN: cn=Michael Else,
email=michael.else@element.com, c=GB
Date: 2021.06.17 10:34:59 +01'00'

Michael Else
Radio Test Engineer

Approved by:  Digitally signed by John Charters
DN: cn=John Charters, o=Element
Materials Technology Ltd.,
email=john.charters@element.com, c=GB
Reason: I am approving this document
Date: 2021.06.17 14:58:48 +01'00'

J Charters
Lab Manager

Date: 17 June 2021

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	10 June 2021	Original
B	17 June 2021	Certification amendments

Summary

TEST REPORT NUMBER:	TRA-054381-47-03B
WORKS ORDER NUMBER:	TRA-054381-16
TEST SPECIFICATION:	ETSI EG 203 367 V1.1.1 & KDB 996369 D04 v02
EQUIPMENT UNDER TEST (EUT):	LocoTrack Rechargeable
FCC IDENTIFIER:	2AYMO-LTR-H4-3
ISED IDENTIFIER:	27269-LTRH43
CONTAINS FCC IDENTIFIER:	XMR201910BG95M3
CONTAINS ISED IDENTIFIER:	10224A-2019BG95M3
CONTAINS FCC IDENTIFIER:	2AC7Z-ESPWROOM02D
CONTAINS ISED IDENTIFIER:	21098-ESPWROOM02D
MANUFACTURER/AGENT:	System Loco Ltd.
ADDRESS:	Parkfield Greaves Park Greaves Road Lancaster LA1 4TZ United Kingdom
CLIENT CONTACT:	Daniel Essafi ☎ 07951587074 ✉ d.essafi@systemloco.com
ORDER NUMBER:	PO-2020AA0085
TEST DATE:	2021-MAY-24 to 2021-JUNE-02
TESTED BY:	M.Else Element

1.1 Test Summary

<i>Test Method and Description</i>	<i>Applicable to this equipment</i>	<i>Result / Note</i>
Radiated Spurious Emissions (Intermodulation Investigation)	☒	Pass

Notes:

Only limited testing was performed to check the intermodulation emissions.

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).

2 Contents

1	Revision Record	3
1.1	Test Summary.....	5
2	Contents	6
3	Introduction.....	7
4	Test Specifications	8
4.1	Normative References	8
4.2	Deviations from Test Standards.....	8
5	Glossary of Terms	9
6	Equipment under Test.....	10
6.1	EUT Identification.....	10
6.2	Pre-approved module identification	10
6.3	System Equipment.....	10
6.4	EUT Mode of Operation	10
6.5	EUT Radio Parameters.....	11
6.6	EUT Description	12
7	Modifications	13
8	EUT Test Setup.....	14
8.1	Block Diagram.....	14
8.2	General Set-up Photograph	15
9	General Technical Parameters	16
9.1	Normal Conditions.....	16
10	Transmitter unwanted emissions in the spurious domain and intermodulation (EU)	17
10.1	Definition.....	17
10.2	Test Parameters	17
10.3	Test Method.....	18
10.4	Test Equipment	20
10.5	Test Results.....	21
11	Radiated emissions, Intermodulation products (FCC).....	27
11.1	Definitions.....	27
11.2	Test Parameters	27
11.3	Test Limit	27
11.4	Test Method.....	28
11.5	Test Equipment	29
11.6	Test Results.....	30
12	Measurement Uncertainty	38

3 Introduction

This report **Error! Reference source not found.** presents the results of the Radio testing on a System Loco Ltd LocoTrack Rechargeable (HFR4 Build) to selected clauses of specifications ETSI EG 203 367 V1.1.1 (2016-06) & KDB 996369 D04 Module Integration Guide v02 - Modular transmitter integration guide - Guidance for host product manufacturers.

The testing was carried out for System Loco Ltd, 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.

4 Test Specifications

4.1 Normative References

- ETSI EG 203 367 V1.1.1 (2016-06) - Guide to the application of harmonised standards covering articles 3.1b and 3.2 of the Directive 2014/53/EU (RED) to multi-radio and combined radio and non-radio equipment.
- ETSI EN 300 328 V2.2.2 (2019-07) - Wideband transmission systems; Data transmission equipment operating in the 2,4 GHz band; Harmonised Standard for access to radio spectrum.
- FCC 47 CFR Ch. I – Part 15 – Radio Frequency Devices.
- FCC 47 CFR Ch. I – Part 22 – Public Mobile Services.
- FCC 47 CFR Ch. I – Part 24 – Personal Communications Services.
- FCC 47 CFR Ch. I – Part 27 – Miscellaneous Wireless Communications Services.
- 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 996369 D04 Module Integration Guide v02 - Modular transmitter integration guide -Guidance for host product manufacturers.
- ETSI EN 301 908-1 V11.1.1 IMT cellular networks; Harmonised Standard covering the essential requirements of article 3.2 of Directive 2014/53/EU; Part 1: Introduction and common requirements.
- ETSI EN 301 511 V12.5.1 Global System for Mobile communications (GSM); Mobile Stations (MS) equipment; Harmonised Standard covering the essential requirements of article 3.2 of Directive 2014/53/EU.
- ETSI TS 151 010-1 V12.8.0 Digital cellular telecommunications system (Phase 2+); Mobile Station (MS) conformance specification; Part 1: Conformance specification (3GPP TS 51.010-1 version 12.8.0 Release 12).
-

4.2 Deviations from Test Standards

Only limited testing was performed to check the intermodulation emissions.

5 Glossary of Terms

S	denotes a section reference from the standard, not this document
AC	Alternating Current
ACK	Acknowledgement signal
AFH	Adaptive Frequency Hopping
BTC	Bluetooth Classic
BTLE	Bluetooth Low Energy
BW	bandwidth
C	Celsius
CCA	Clear Channel Assessment
COT	Channel Occupancy Time
CW	Continuous Wave
dB	decibel
dBm	dB relative to 1 milliwatt
DAA	Detect And Avoid
DC	Direct Current
EIRP	Equivalent Isotropically Radiated Power
EN	European Normative document
EUT	Equipment Under Test
FCC	Federal Communications Commission
FHSS	Frequency Hopping Spread Spectrum
Hz	hertz
IC	Industry Canada
ITU	International Telecommunication Union
LBT	Listen Before Talk
m	metre
max	maximum
min	minimum
N/A	Not Applicable
PCB	Printed Circuit Board
PDF	Portable Document Format
R&TTE	Radio and Telecommunications Terminal Equipment
RE	Radio Equipment
RF	Radio Frequency
RH	Relative Humidity
RMS	Root Mean Square
Rx	receiver
s	second
Tx	transmitter
UKAS	United Kingdom Accreditation Service
V	volt
W	watt
Ω	ohm

6 Equipment under Test

6.1 EUT Identification

- Name: : LocoTrack Rechargeable
- Model Number: HFR4 Build wired charger, HGR4 Build Wireless Charger
- Serial Number: 38041 (Sample 1, HFR4), 83038 (Sample 2, HGR4)
- Software Revision: N/A
- Build Level / Revision Number: 2.0

6.2 Pre-approved module identification

Wi-Fi Module Information

- Manufacturer: Espressif Systems (SHANGHAI) Company Limited
- Model: ESP-WROOM-02
- CONTAINS FCC ID: 2AC7Z-ESPWROOM02D
- CONTAINS ISSED ID: 21098-ESPWROOM02D

Cellular Module information

- Manufacturer: Quectel Wireless Solutions Company Limited
- Model: Quectel BG95M3
- CONTAINS FCC ID: XMR201910BG95M3
- CONTAINS ISSED ID: 10224A-2019BG95M3

6.3 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: CMW 500 Wideband Communications Tester – Serial Number: 112969
- 2: Power Supply, XP Power, Model no: VEL12Us050-UK-JA
- 3: Laptop
- 4: Wireless Charger, Model no: CHOETECH T511 (FCC ID:2ARDY-T511)

6.4 EUT Mode of Operation

The mode of operation for transmitter tests was as follows:

Radios were set to transmit permanently in various combinations, the spectrum was checked to determine if any intermodulation products were generated due to multiple radios operating simultaneously. The worst case emission plots are shown in this document.

EUT was operated with worst case modes of operation for each radio device.

6.5 EUT Radio Parameters

Modes of operation:	BTLE	Wi-Fi
Frequencies of operation:	2402 MHz to 2480 MHz	2412 MHz to 2462 MHz
Modulation type(s)	GFSK	DSSS / OFDM
Nominal Supply Voltage:	3.7 V DC Rechargeable Battery	3.7 V DC Rechargeable Battery

Mode of operation:	Cellular
Bands / Frequencies of operation:	GSM 850: 837 MHz GSM 900: 902.5 MHz GSM 1800: 1747.5 MHz GSM 1900: 1880 MHz LTE Band 1: 1950 MHz LTE Band 2: 1880 MHz LTE Band 3: 1747.5 MHz LTE Band 4: 1732.5 MHz LTE Band 5: 836.5 MHz LTE Band 12: 707.5 MHz LTE Band 20: 847 MHz LTE Band 28: 725.5 MHz

6.6 *EUT Description*

The EUT is a Rechargeable battery-powered tracking receiver for use in warehouses etc. to communicate with several BTLE-enabled tracking tags.

Two models, HFR4 with charging cable and HGR4 without charging cable.

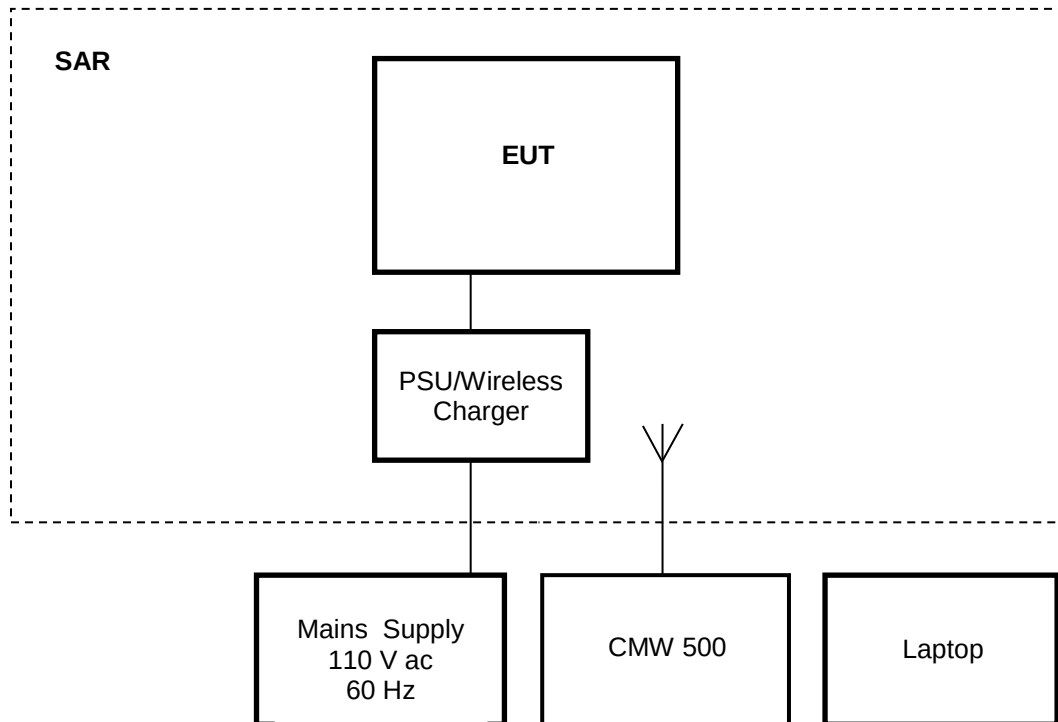
7 Modifications

No modifications were performed during this assessment.

8 EUT Test Setup

8.1 Block Diagram

The following diagram shows basic EUT interconnections.

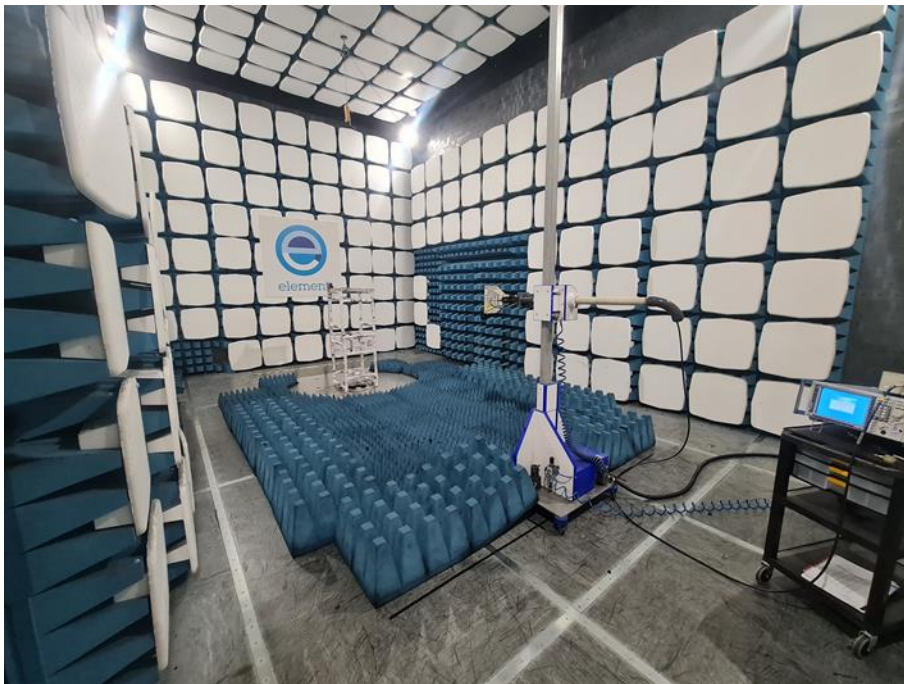


8.2 General Set-up Photograph

The following photographs shows basic EUT radiated set-up for EU testing:



The following photographs shows basic EUT radiated set-up for FCC testing:



9 General Technical Parameters

9.1 Normal Conditions

The EUT was tested under the normal environmental conditions of the test laboratory, except where otherwise stated. The normal power source applied was 3.7 Vdc from internal Rechargeable battery.

10 Transmitter unwanted emissions in the spurious domain and intermodulation (EU)

10.1 Definition

Spurious emissions

Transmitter unwanted emissions in the spurious domain are emissions outside the allocated band and outside the out-of-band domain when the equipment is in Transmit mode.

Inter-transmitter intermodulation

The phenomenon where one or more transmitters on a site inter-modulate, either within the transmitters themselves or within a non-linear component on site to produce intermodulation products.

10.2 Test Parameters

Test Location:	Element Skelmersdale
Test Chamber:	SK03 Radio Chamber SK01 Radio Chamber
Test Standards and Clauses:	ETSI EN 301 908-1 V1.1.1 clause 4.2.2 ETSI EN 301 511 V12.5.1 (217-03) Clause 4.2.1.6 ETSI EN 300 328 V2.2.2 (2019-07), Clause 5.4.9
Deviations from Standard:	None
Measurement BW:	Below 1 GHz: 100 kHz; Above 1 GHz: 1 MHz
Measurement Detector:	RMS

Environmental Conditions (Normal Environment)

Temperature: 21 °C	Standard Requirement: +15 °C to +35 °C
Humidity: 41 % RH	Standard Requirement: 20 % RH to 75 % RH
Supply: 3.7 V dc	3.7 V dc (as declared)

Test Limits

The applicable spurious emissions requirements and limits for multi-radio equipment are those specified in the relevant radio harmonised standards applicable to each radio product.

In the majority of cases the requirements and limits for spurious emissions set out in radio harmonised standards are identical.

If the applicable harmonised radio standards contain different limits and measuring conditions, then the multi-radio equipment should be assessed to the harmonised radio standard that specifies the least stringent limits for the common part of the frequency measurement ranges, in those cases where more than one transmitter operates at the same time. To assess the remaining parts of the frequency measurement ranges, the limits from the relevant harmonised radio standard should be used.

EN 301 908-1 Limit

The frequency boundary and reference bandwidths for the detailed transitions of the limits between the requirements for out-of-band emissions and spurious emissions are based on Recommendations ITU-R SM.329-12 §[1] and SM.1539-1§[i.6].

The requirements shown in table 4.2.2.2-1 are only applicable for frequencies in the spurious domain.

Table 4.2.2.2-1: Radiated spurious emissions requirements (UE)

Frequency (MHz)	Minimum requirement in idle mode erp / BW	Minimum requirement in traffic mode erp / BW
$30 \leq f < 1\,000$	-57 dBm / 100 kHz	-36 dBm / 100 kHz
$1\,000 \leq f < 12,750$	-47 dBm / 1 MHz	-30 dBm / 1 MHz

EN 301 511 Limit

Technology	GSM 400 GSM 700 T-GSM 810 GSM 850 GSM 900	DCS 1 800	PCS 1 900
Frequency			
30 MHz to 1 GHz	-36 dBm	-36 dBm	-36 dBm
1 GHz to 1 710 MHz	-30 dBm	-30 dBm	-30 dBm
1 710 MHz to 1 785 MHz	-30 dBm	-36 dBm	-30 dBm
1 785 MHz to 4 GHz	-30 dBm	-30 dBm	-30 dBm

EN 300 328 Limit

The transmitter unwanted emissions in the spurious domain shall not exceed the values given in table 12a.

In case of equipment with antenna connectors, these limits apply to emissions at the antenna port (conducted). For emissions radiated by the cabinet or emissions radiated by integral antenna equipment (without antenna connectors), these limits are e.r.p. for emissions up to 1 GHz and e.i.r.p. for emissions above 1 GHz.

Table 12a: Transmitter limits for spurious emissions

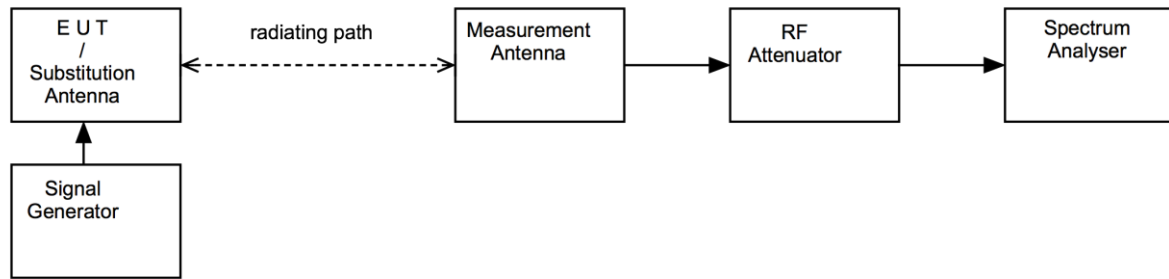
Frequency range	Maximum power	Bandwidth
30 MHz to 47 MHz	-36 dBm	100 kHz
47 MHz to 74 MHz	-54 dBm	100 kHz
74 MHz to 87,5 MHz	-36 dBm	100 kHz
87,5 MHz to 118 MHz	-54 dBm	100 kHz
118 MHz to 174 MHz	-36 dBm	100 kHz
174 MHz to 230 MHz	-54 dBm	100 kHz
230 MHz to 470 MHz	-36 dBm	100 kHz
470 MHz to 694 MHz	-54 dBm	100 kHz
694 MHz to 1 GHz	-36 dBm	100 kHz
1 GHz to 12,75 GHz	-30 dBm	1 MHz

10.3 Test Method

With the EUT connected as per Figure ix, the RF spectrum of the EUT was observed as the EUT was rotated through 360 degrees.

Following a peak pre-scan, all emissions identified as more than 10 dB below the limit were measured individually with RMS detector.

Figure ix Test Setup

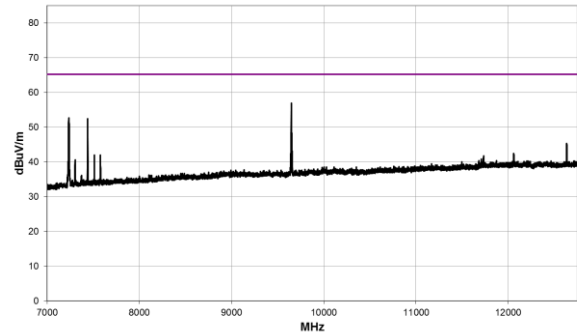
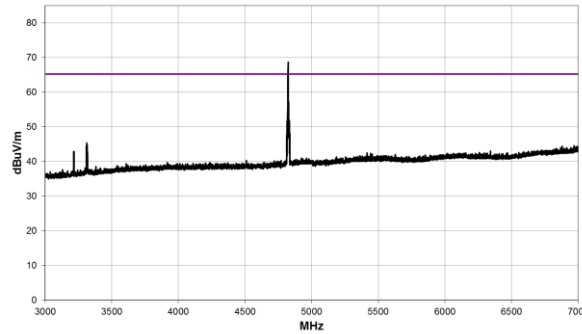
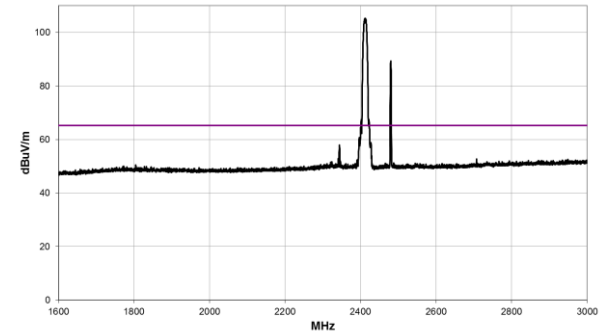
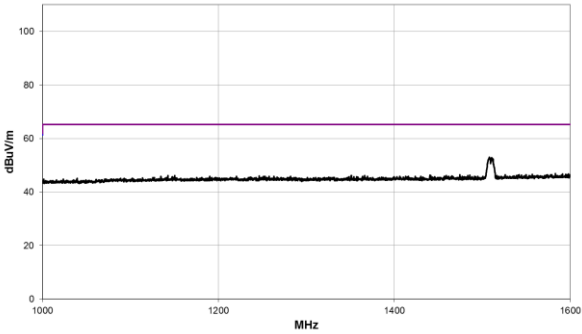
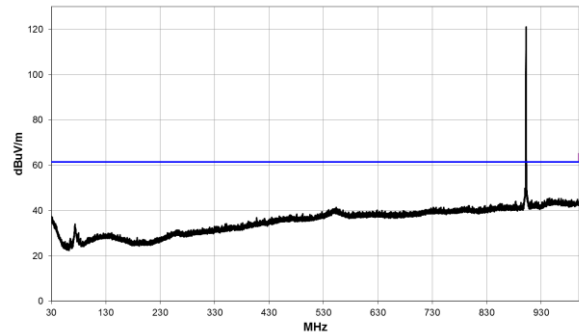


10.4 Test Equipment

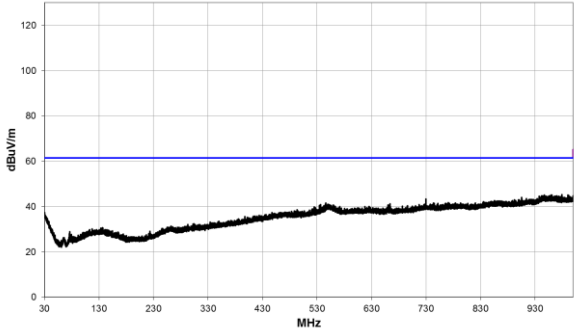
Equipment Description	Manufacturer	Equipment Type	Element No	Due For Calibration
Radio Chamber - PP	Rainford EMC	ATS	REF940	2021-12-09
Chamber 1	Rainford EMC	ATS	U387	2021-09-09
Signal Generator	R&S	SMB100A	U677	2022-01-26
1-18GHz Horn	EMCO	3115	L139	2021-07-16
PreAmp	Watkins Johnson	6201-69	U372	2022-03-01
Pre Amp	Agilent	8449B	L572	2021-10-19
Bilog	Chase	CBL611/A	U573	2023-01-28
High Pass Filter	MiniCircuits	VHF-1500+	U519	2022-01-30
High Pass Filter	BSC	SH4141	REF977	2022-01-30
Spectrum Analyser	R&S	FSW 43	U728	2022-04-20

10.5 Test Results

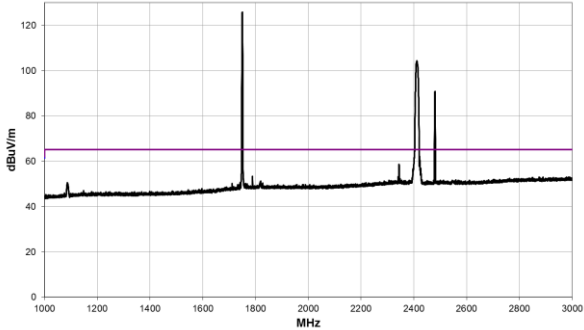
Radio 1: Bluetooth LE; Frequency: 2480 MHz; Power Setting: 0 dBm; Data Rate: 1 Mbps Radio 2: 2.4 GHz WiFi; Frequency: 2412 MHz; Power Setting: Fixed; Data Rate:11b 1M; Radio 3: GSM 900; ARFCN: 62; Frequency: 902.4 MHz; Power Setting: High;					
Emission	Frequency (MHz)	Level (dBm)	Limit (dBm)	Margin (dB)	Result
1	2344.067	56.7	65.2	-8.5	PASS



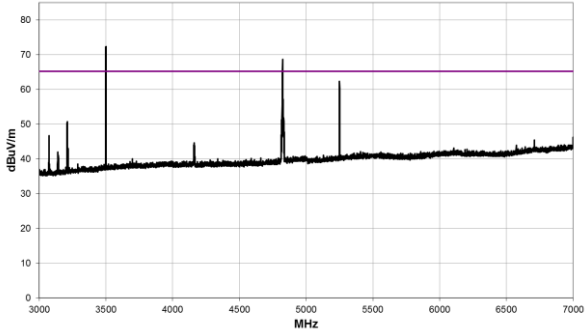
Radio 1: Bluetooth LE; Frequency: 2480 MHz; Power Setting: 0 dBm; Data Rate: 1 Mbps Radio 2: 2.4 GHz WiFi; Frequency: 2412 MHz; Power Setting: Fixed; Data Rate: 11b 1M; Radio 3: GSM 1800; ARFCN: 711; Frequency: 1750 MHz; Power Setting: High;					
Emission	Frequency (MHz)	Level (dBm)	Limit (dBm)	Margin (dB)	Result
1	2344.092	56.9	65.2	-8.3	PASS



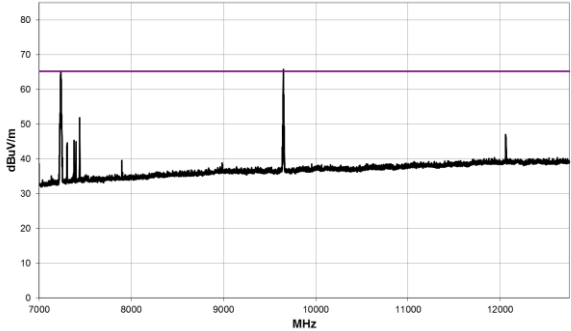
30 MHz to 1 GHz



1 GHz to 3 GHz

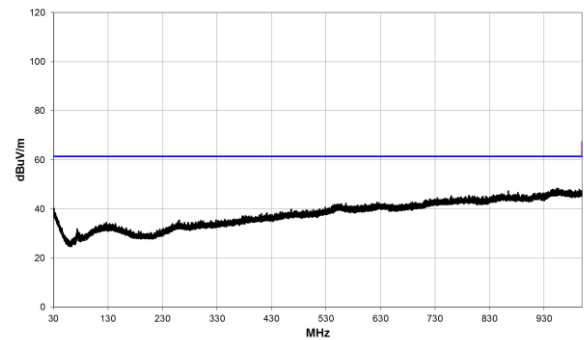


3 GHz to 7 GHz

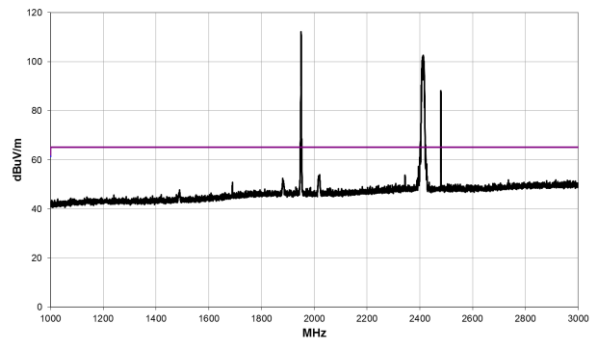


7 GHz to 12.75 GHz

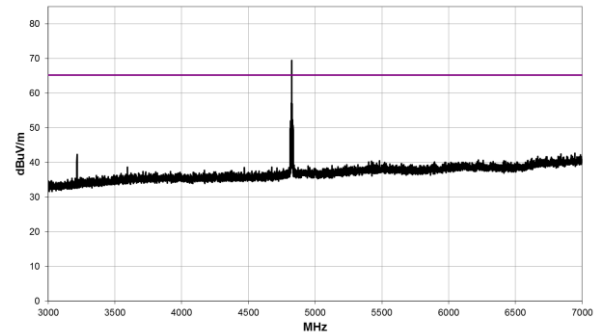
Radio 1: Bluetooth LE; Frequency: 2480 MHz; Power Setting: 0 dBm; Data Rate: 1 Mbps Radio 2: 2.4 GHz WiFi; Frequency: 2412 MHz; Power Setting: Fixed; Data Rate: 11b 1M; Radio 3: LTE Band 1; EARFCN: 18300; Frequency: 1950 MHz; Power Setting: High;					
Emission	Frequency (MHz)	Level (dBm)	Limit (dBm)	Margin (dB)	Result
1	2021.082	56.7	65.2	-8.5	PASS



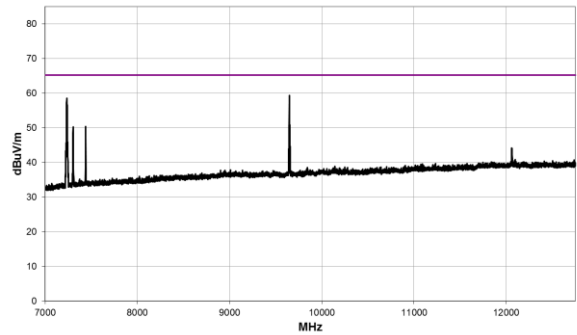
30 MHz to 1 GHz



1 GHz to 3 GHz

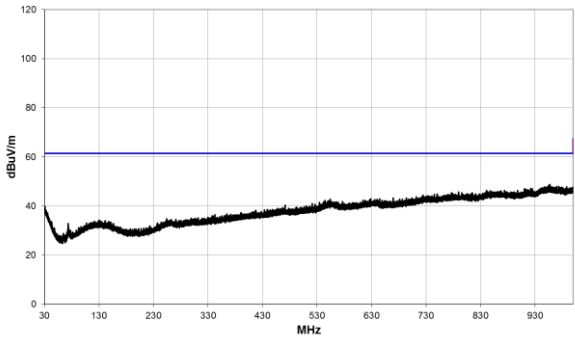


3 GHz to 7 GHz

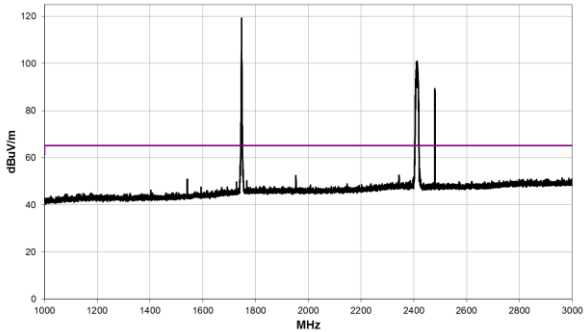


7 GHz to 12.75 GHz

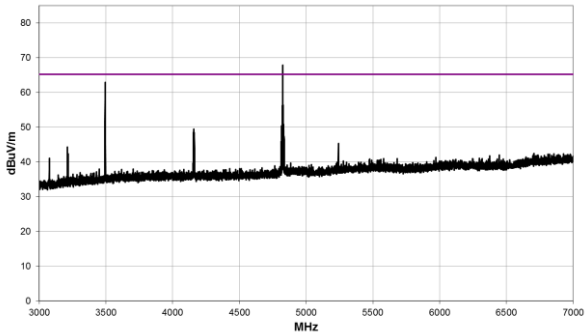
Radio 1: Bluetooth LE; Frequency: 2480 MHz; Power Setting: 0 dBm; Data Rate: 1 Mbps Radio 2: 2.4 GHz WiFi; Frequency: 2412 MHz; Power Setting: Fixed; Data Rate: 11b 1M; Radio 3: LTE Band 3; EARFCN: 19575; Frequency: 1747.5 MHz; Power Setting: High;					
Emission	Frequency (MHz)	Level (dBm)	Limit (dBm)	Margin (dB)	Result
No Intermodulation emissions were detected within 10 dB of the limit.					



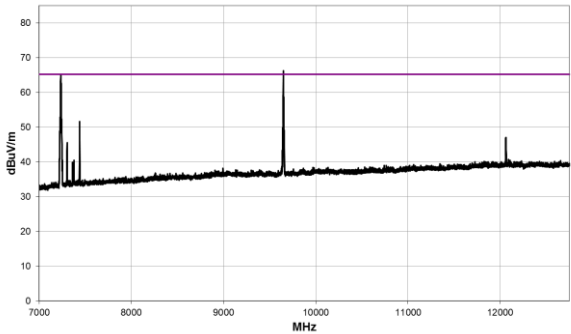
30 MHz to 1 GHz



1GHz to 3 GHz

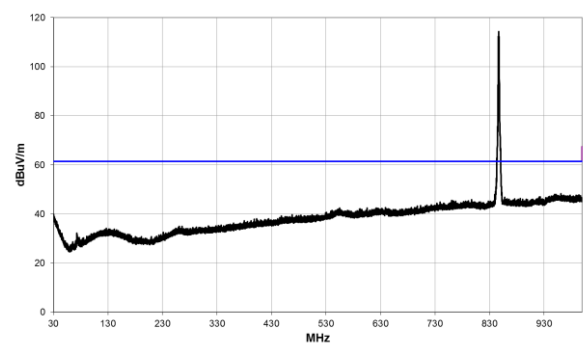


3 GHz to 7 GHz

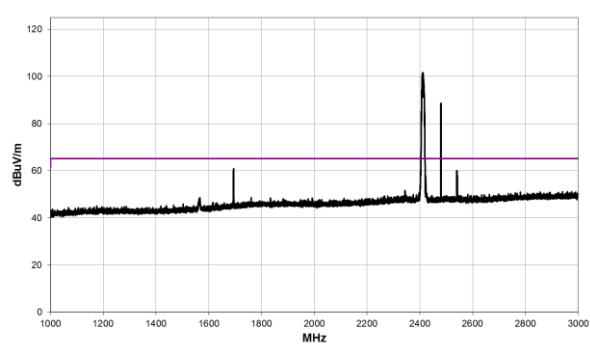


7 GHz to 12.75 GHz

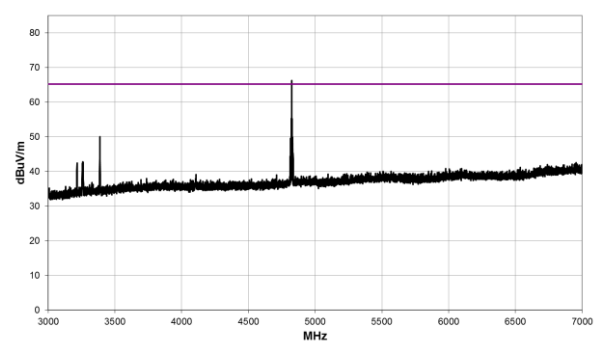
Radio 1: Bluetooth LE; Frequency: 2480 MHz; Power Setting: 0 dBm; Data Rate: 1 Mbps Radio 2: 2.4 GHz WiFi; Frequency: 2412 MHz; Power Setting: Fixed; Data Rate: 11b 1M; Radio 3: LTE Band 20; EARFCN: 24300; Frequency: 847 MHz; Power Setting: High;					
Emission	Frequency (MHz)	Level (dBm)	Limit (dBm)	Margin (dB)	Result
1	2540.967	61.6	65.2	-3.6	PASS



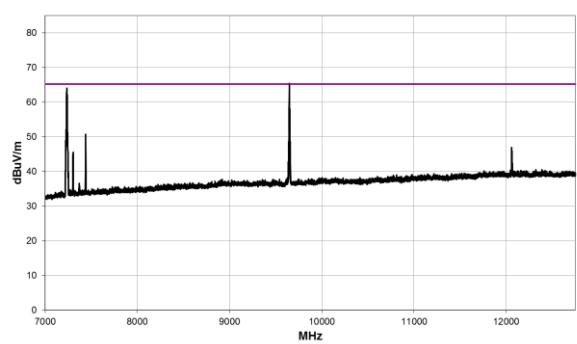
30 MHz to 1 GHz



1 GHz to 3 GHz

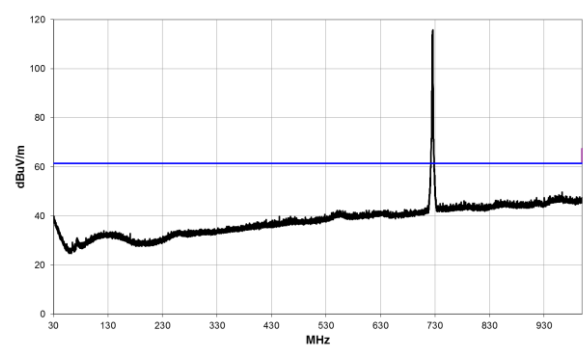


3 GHz to 7 GHz

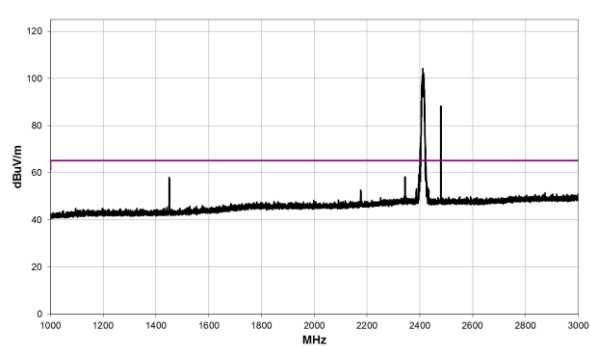


7 GHz to 12.75 GHz

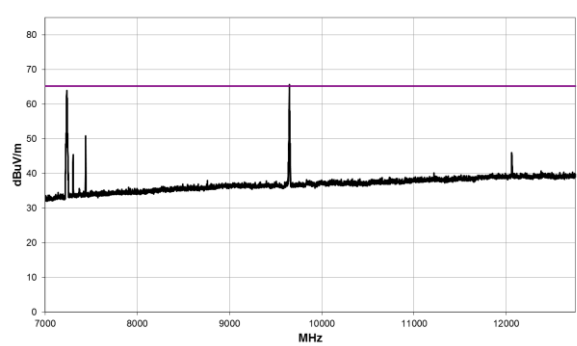
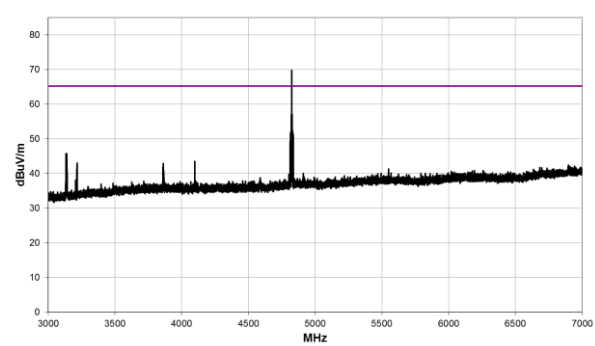
Radio 1: Bluetooth LE; Frequency: 2480 MHz; Power Setting: 0 dBm; Data Rate: 1 Mbps Radio 2: 2.4 GHz WiFi; Frequency: 2412 MHz; Power Setting: Fixed; Data Rate: 11b 1M; Radio 3: LTE Band 28; EARFCN: 27435; Frequency: 725.5 MHz; Power Setting: High;					
Emission	Frequency (MHz)	Level (dBm)	Limit (dBm)	Margin (dB)	Result
1	2343.983	55.9	65.2	-9.3	PASS



30 MHz to 1 GHz



1 GHz to 3 GHz



11 Radiated emissions, Intermodulation products (FCC)

11.1 Definitions

Spurious emissions

Emissions on a frequency or frequencies, which are outside the necessary bandwidth and the level of which may be reduced without affecting the corresponding transmission of information. Spurious emissions include harmonic emissions, parasitic emissions, intermodulation products and frequency conversion products, but exclude out-of-band emissions.

Restricted bands

A frequency band in which intentional radiators are permitted to radiate only spurious emissions but not fundamental signals.

11.2 Test Parameters

Test Location:	Element Skelmersdale
Test Chamber:	SK01 Radio Chamber Sk03 Radio Chamber
Test Standard and Clause:	ANSI C63.10-2013, Clause 6.5 and 6.6
Deviations from Standard:	None
Measurement BW:	30 MHz to 1 GHz: 120 kHz; Above 1 GHz: 1 MHz
Measurement Detector:	Up to 1 GHz: quasi-peak; Above 1 GHz: RMS average and Peak

Environmental Conditions (Normal Environment)

Temperature: 22 °C	Standard Requirement: +15 °C to +35 °C
Humidity: 28 % RH	Standard Requirement: 20 % RH to 75 % RH

11.3 Test Limit

Part 15

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

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

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

Part 22, Part 24 & Part 27

At least $43 + 10 \log P$ dB

$$(10 \log P_{\text{watts}}) - (43 + 10 \log (P_{\text{watts}} * 1000)) = \text{LIMIT} = -13 \text{ dBm}$$

11.4 Test Method

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

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

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

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

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

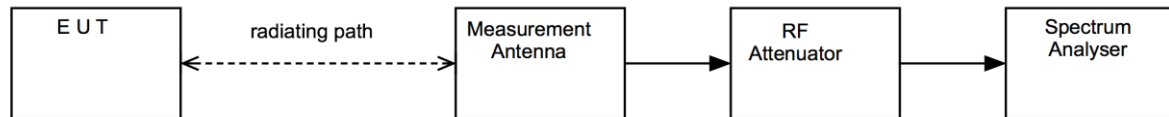
Power values measured on the test receiver / analyzer are converted to field strength, FS, in dBμV/m at the regulatory distance, using:

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

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 different to limit distance);

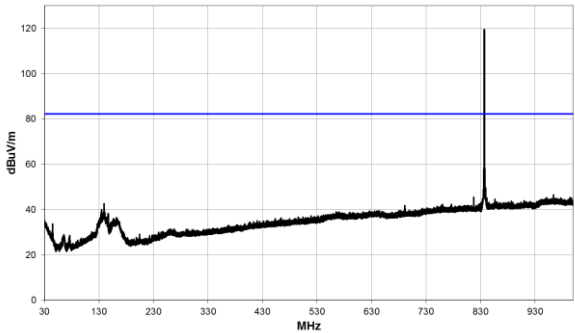
This field strength value is then compared with the regulatory limit.

Figure i Test Setup**11.5 Test Equipment**

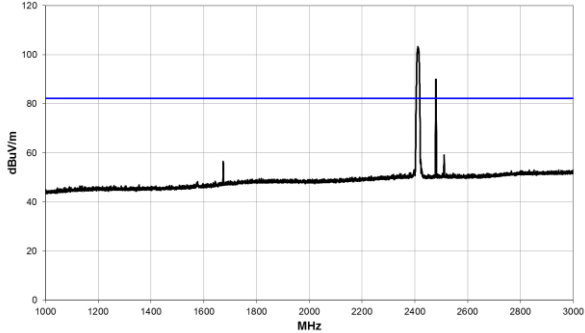
Equipment Description	Manufacturer	Equipment Type	Element No	Due For Calibration
Radio Chamber - PP	Rainford EMC	ATS	REF940	2021-12-09
Chamber 1	Rainford EMC	ATS	U387	2021-09-09
Signal Generator	R&S	SMB100A	U677	2022-01-26
1-18GHz Horn	EMCO	3115	L139	2021-07-16
PreAmp	Watkins Johnson	6201-69	U372	2022-03-01
Pre Amp	Agilent	8449B	L572	2021-10-19
Bilog	Chase	CBL611/A	U573	2023-01-28
High Pass Filter	MiniCircuits	VHF-1500+	U519	2022-01-30
High Pass Filter	BSC	SH4141	REF977	2022-01-30
Spectrum Analyser	R&S	FSW 43	U728	2022-04-20
Horn 18-26GHz (&U330)	Flann	20240-20	L300	2022-04-23

11.6 Test Results

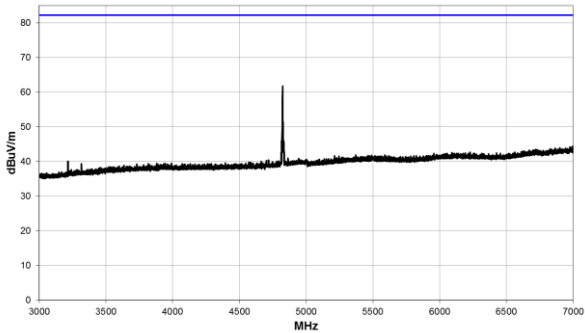
Mains 110 V, 60 Hz; Radio 1: Bluetooth LE; Frequency: 2480 MHz; Power Setting: 0 dBm; Data Rate: 1 Mbps Radio 2: 2.4 GHz WiFi; Frequency: 2412 MHz; Power Setting: Fixed; Data Rate: 11b 1M; Radio 3: GSM 850; ARFCN: 162; Frequency: 837 MHz; Power Setting: High;					
Emission	Frequency (MHz)	Level (dBm)	Limit (dBm)	Margin (dB)	Result
No Intermodulation emissions were detected within 10 dB of the limit.					



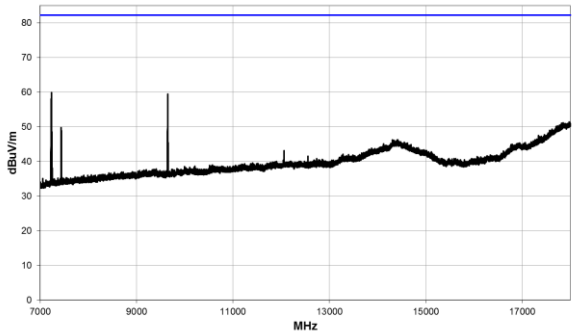
30 MHz to 1 GHz



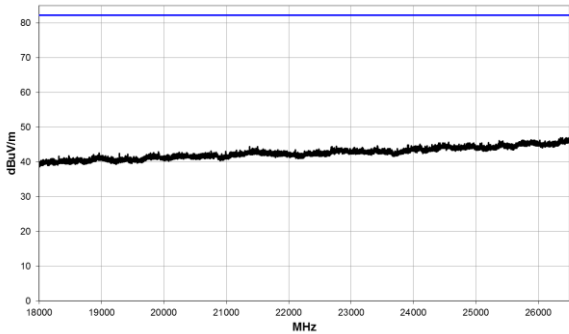
1 GHz to 3 GHz



3 GHz to 7 GHz

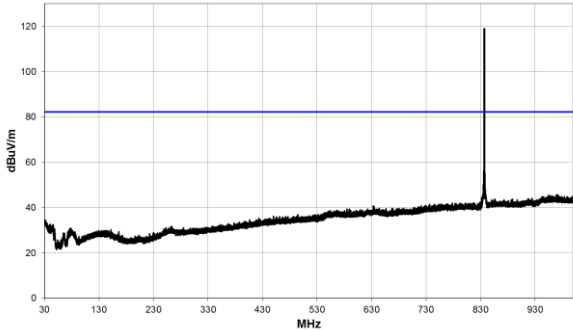


7 GHz to 18 GHz

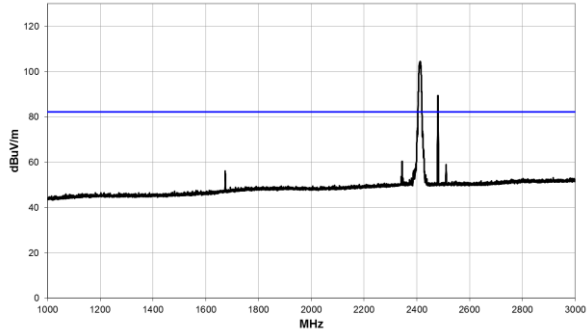


18 GHz to 26.5 GHz

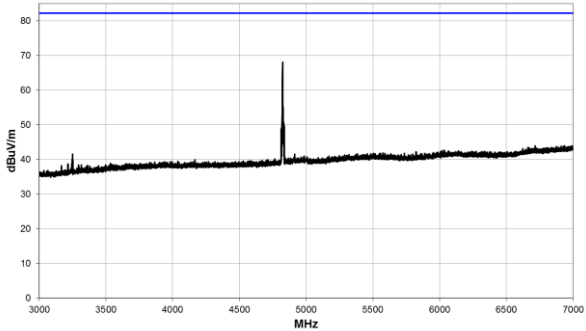
Wireless Charger;					
Radio 1: Bluetooth LE; Frequency: 2480 MHz; Power Setting: 0 dBm; Data Rate: 1 Mbps					
Radio 2: 2.4 GHz WiFi; Frequency: 2412 MHz; Power Setting: Fixed; Data Rate: 11b 1M;					
Radio 3: GSM 850; ARFCN: 162; Frequency: 837 MHz; Power Setting: High;					
Emission	Frequency (MHz)	Level (dBm)	Limit (dBm)	Margin (dB)	Result
No Intermodulation emissions were detected within 10 dB of the limit.					



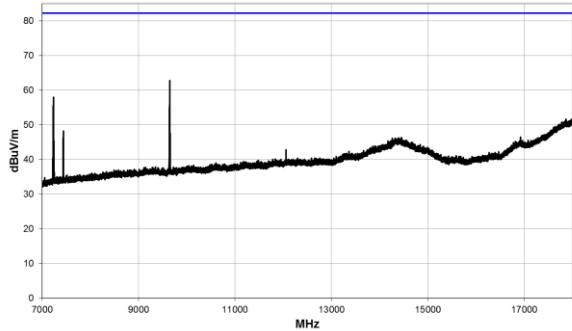
30 MHz to 1 GHz



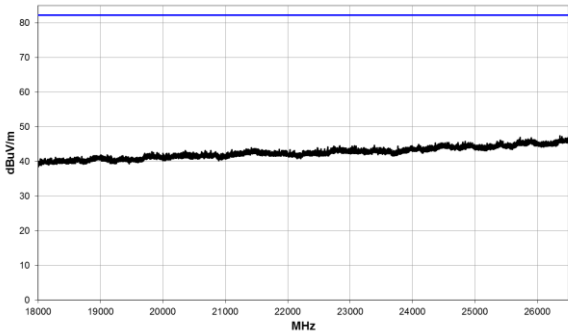
1 GHz to 3 GHz



3 GHz to 7 GHz

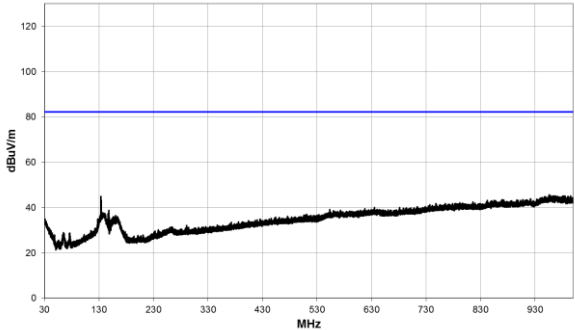


7 GHz to 18 GHz

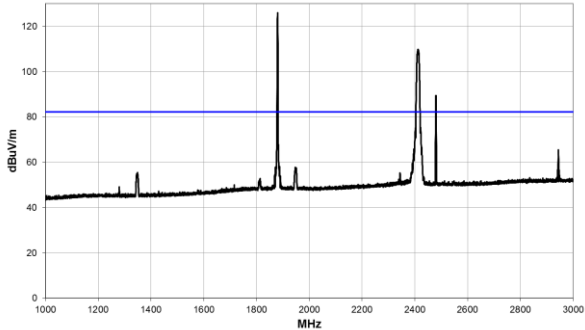


18 GHz to 26.5 GHz

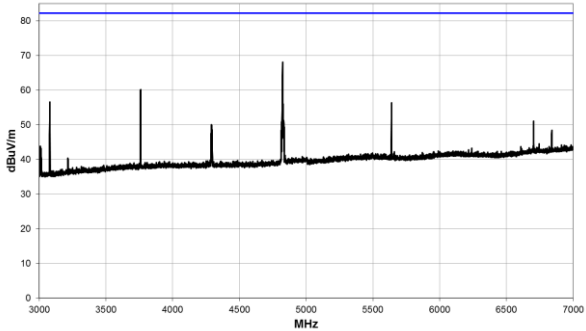
Mains 110 V, 60 Hz; Radio 1: Bluetooth LE; Frequency: 2480 MHz; Power Setting: 0 dBm; Data Rate: 1 Mbps Radio 2: 2.4 GHz WiFi; Frequency: 2412 MHz; Power Setting: Fixed; Data Rate: 11b 1M; Radio 3: GSM 1900; ARFCN: 1960; Frequency: 1880 MHz; Power Setting: High;					
Emission	Frequency (MHz)	Level (dBm)	Limit (dBm)	Margin (dB)	Result
No Intermodulation emissions were detected within 10 dB of the limit.					



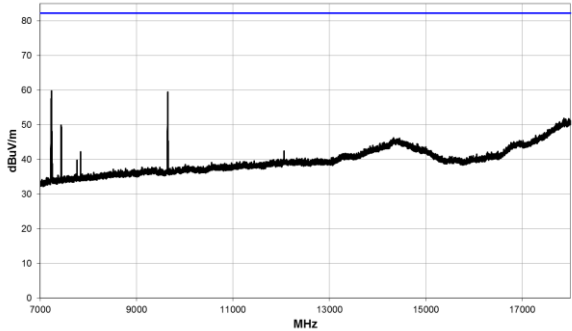
30 MHz to 1 GHz



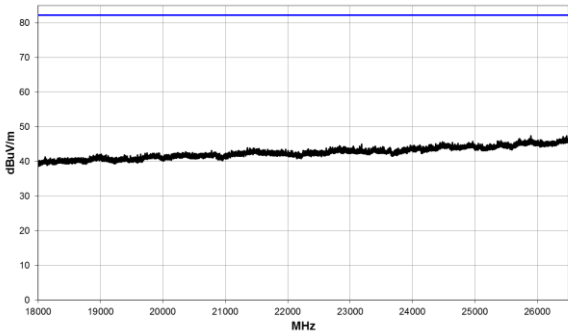
1GHz to 3 GHz



3 GHz to 7 GHz

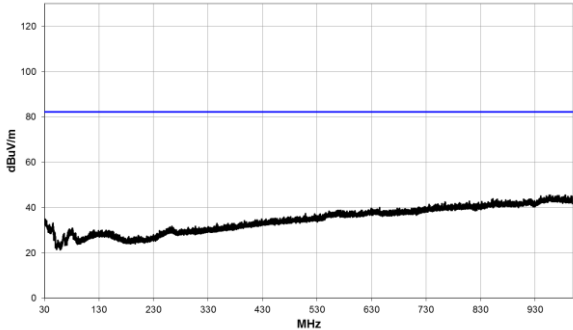


7 GHz to 18 GHz

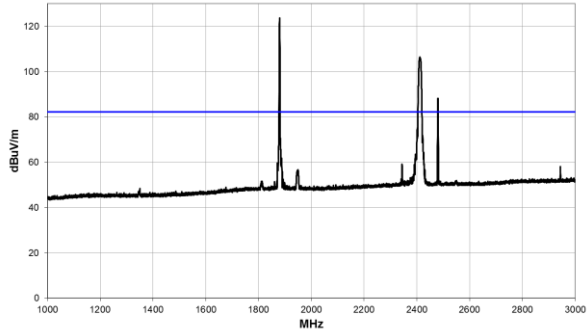


18 GHz to 26.5 GHz

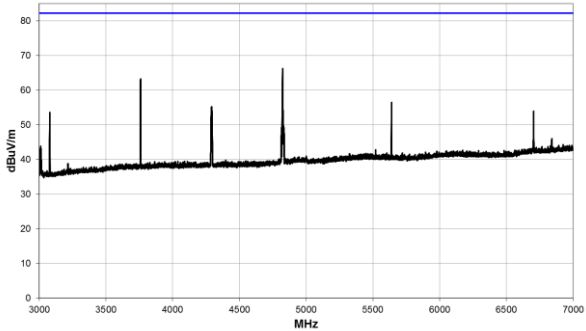
Wireless Charger;					
Radio 1: Bluetooth LE; Frequency: 2480 MHz; Power Setting: 0 dBm; Data Rate: 1 Mbps					
Radio 2: 2.4 GHz WiFi; Frequency: 2412 MHz; Power Setting: Fixed; Data Rate: 11b 1M;					
Radio 3: GSM 1900; ARFCN: 1960; Frequency: 1880 MHz; Power Setting: High;					
Emission	Frequency (MHz)	Level (dBm)	Limit (dBm)	Margin (dB)	Result
No Intermodulation emissions were detected within 10 dB of the limit.					



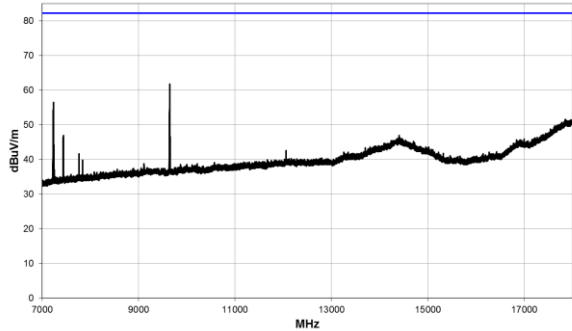
30 MHz to 1 GHz



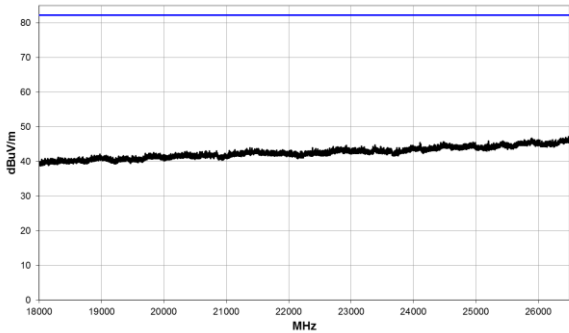
1GHz to 3 GHz



3 GHz to 7 GHz

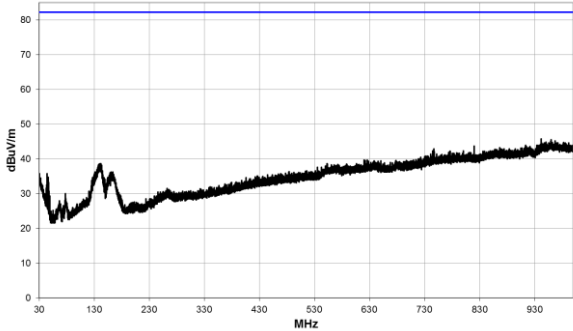


7 GHz to 18 GHz

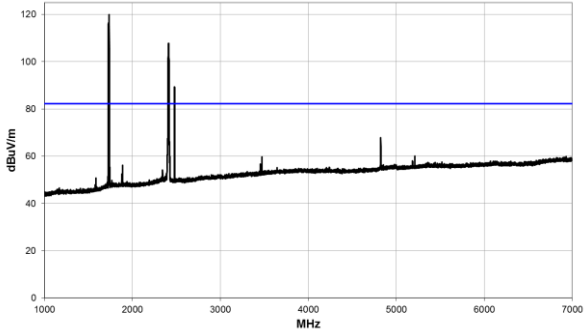


18 GHz to 26.5 GHz

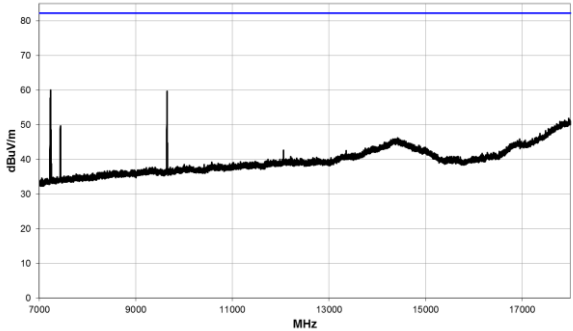
Mains 110 V, 60 Hz; Radio 1: Bluetooth LE; Frequency: 2480 MHz; Power Setting: 0 dBm; Data Rate: 1 Mbps Radio 2: 2.4 GHz WiFi; Frequency: 2412 MHz; Power Setting: Fixed; Data Rate: 11b 1M; Radio 3: LTE Band 4; ARFCN: 20175; Frequency: 1732.5 MHz; Power Setting: High;					
<i>Emission</i>	<i>Frequency (MHz)</i>	<i>Level (dBm)</i>	<i>Limit (dBm)</i>	<i>Margin (dB)</i>	<i>Result</i>
No Intermodulation emissions were detected within 10 dB of the limit.					



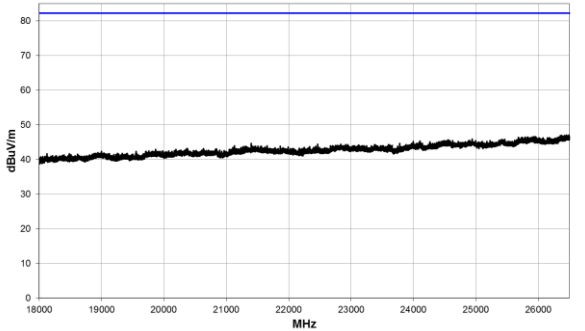
30 MHz to 1 GHz



1 GHz to 7 GHz

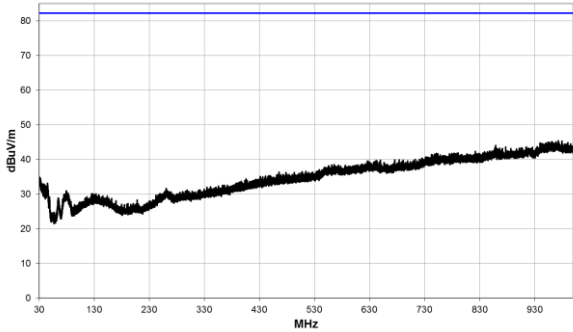


7 GHz to 18 GHz

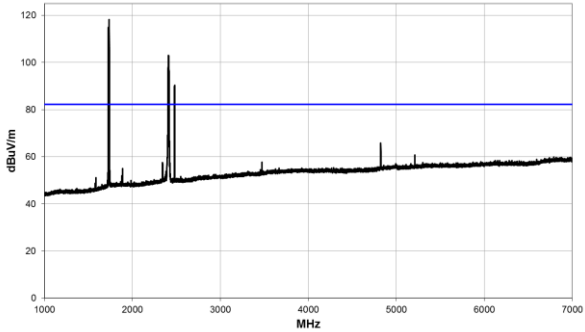


18 GHz to 26.5 GHz

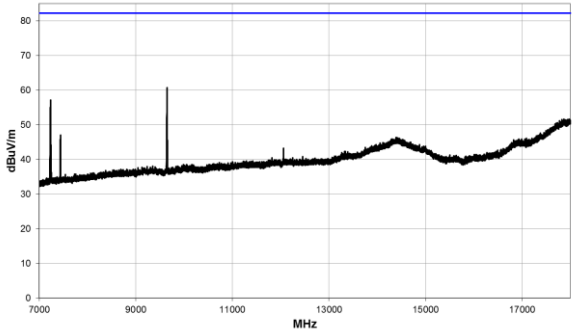
Wireless Charger;					
Radio 1: Bluetooth LE; Frequency: 2480 MHz; Power Setting: 0 dBm; Data Rate: 1 Mbps					
Radio 2: 2.4 GHz WiFi; Frequency: 2412 MHz; Power Setting: Fixed; Data Rate: 11b 1M;					
Radio 3: LTE Band 4; ARFCN: 20175; Frequency: 1732.5 MHz; Power Setting: High;					
Emission	Frequency (MHz)	Level (dBm)	Limit (dBm)	Margin (dB)	Result
No Intermodulation emissions were detected within 10 dB of the limit.					



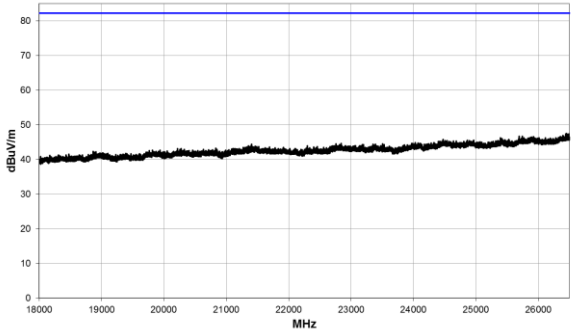
30 MHz to 1 GHz



1 GHz to 7 GHz

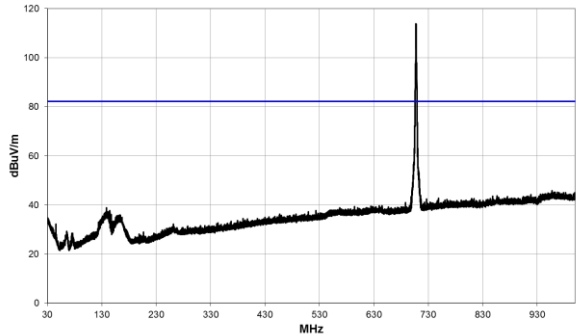


7 GHz to 18 GHz

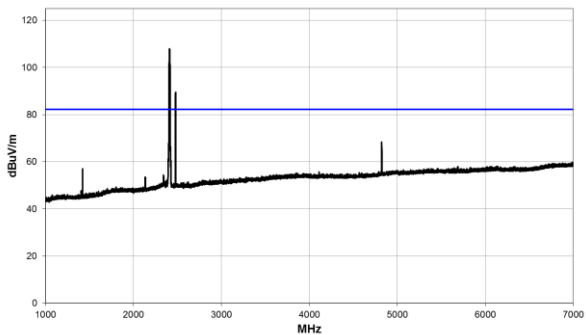


18 GHz to 26.5 GHz

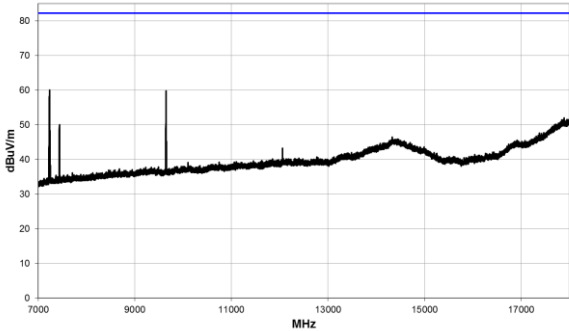
Mains 110V, 60 Hz; Radio 1: Bluetooth LE; Frequency: 2480 MHz; Power Setting: 0 dBm; Data Rate: 1 Mbps Radio 2: 2.4 GHz WiFi; Frequency: 2412 MHz; Power Setting: Fixed; Data Rate: 11b 1M; Radio 3: LTE Band 12; ARFCN: 23095; Frequency: 707.5 MHz; Power Setting: High;					
Emission	Frequency (MHz)	Level (dBm)	Limit (dBm)	Margin (dB)	Result
No Intermodulation emissions were detected within 10 dB of the limit.					



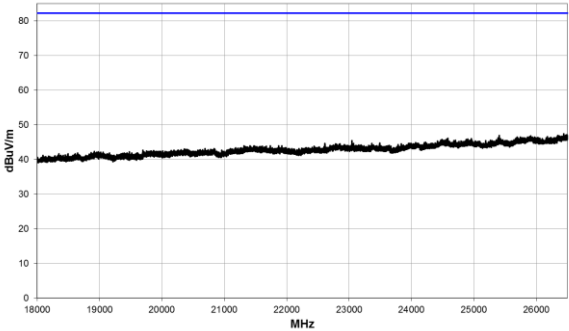
30 MHz to 1 GHz



1 GHz to 7 GHz

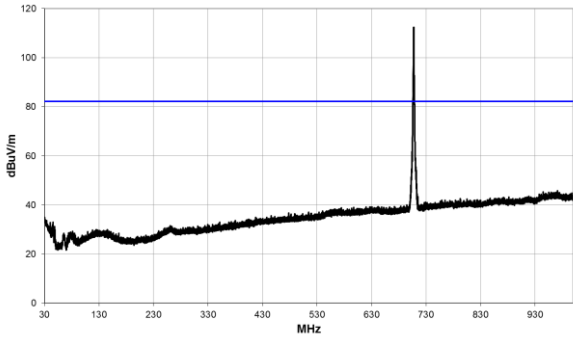


7 GHz to 18 GHz

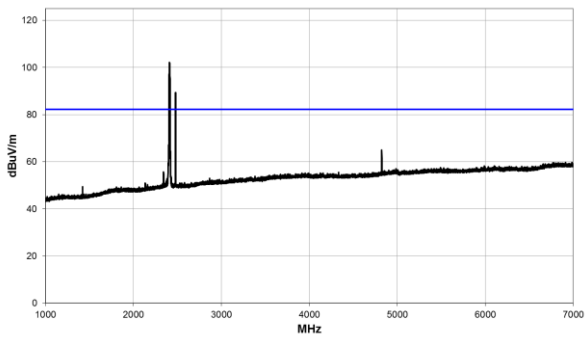


18 GHz to 26.5 GHz

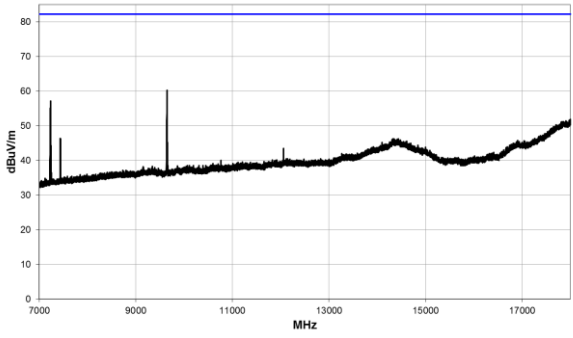
Wireless Charger;					
Radio 1: Bluetooth LE; Frequency: 2480 MHz; Power Setting: 0 dBm; Data Rate: 1 Mbps					
Radio 2: 2.4 GHz WiFi; Frequency: 2412 MHz; Power Setting: Fixed; Data Rate: 11b 1M;					
Radio 3: LTE Band 12; ARFCN: 23095; Frequency: 707.5 MHz; Power Setting: High;					
Emission	Frequency (MHz)	Level (dBm)	Limit (dBm)	Margin (dB)	Result
No Intermodulation emissions were detected within 10 dB of the limit.					



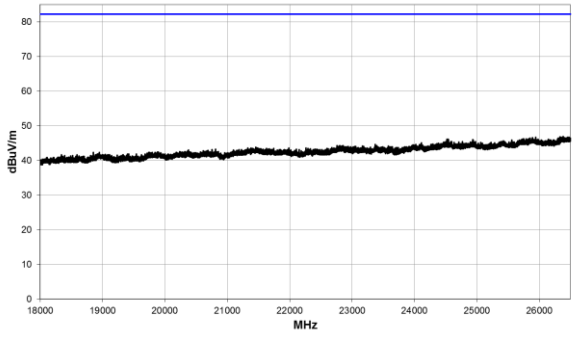
30 MHz to 1 GHz



1 GHz to 7 GHz



7 GHz to 18 GHz



18 GHz to 26.5 GHz

12 Measurement Uncertainty

Required Measurement Uncertainties

The following maximum measurement uncertainty requirements are defined in the standard:

Parameter	Uncertainty
Occupied channel bandwidth	±5 %
RF output power, conducted	±1,5 dB
Power Spectral Density, conducted	±3 dB
Unwanted Emissions, conducted	±3 dB
All emissions, radiated	±6 dB
Temperature	±3 °C
Supply voltages	±3 %
Time	±5 %

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.

Reference No.	Parameter	Description	Value	Unit
1	Adjacent Channel Power	Uncertainty in test result	1.86	dB
2	Carrier Power	Uncertainty in test result (Power Meter)	0.070	dB
		Uncertainty in test result (Spectrum Analyser)	3.11	
3	Effective Radiated Power	Uncertainty in test result	4.71	dB
4	Radiated Spurious Emissions	Uncertainty in test result 30 MHz to 1 GHz	4.75	dB
		1 GHz to 18 GHz	4.46	
5	Maximum Frequency Error	Uncertainty in test result (CMTA)	113.441	Hz

Reference No.	Parameter	Description	Value	Unit
6	Radiated Emissions, Field Strength OATS 9 kHz – 110 GHz Electric Field	Uncertainty in test result (9 kHz – 30 MHz)	2.3	dB
		Uncertainty in test result (30 MHz – 1 GHz)	4.75	
		Uncertainty in test result (1 GHz – 18 GHz)	4.46	
		Uncertainty in test result (18 GHz – 26 GHz)	3.2	
		Uncertainty in test result (26 GHz – 40 GHz)	3.3	
		Uncertainty in test result (40 GHz – 50 GHz)	3.5	
		Uncertainty in test result (50 GHz – 75 GHz)	3.6	
		Uncertainty in test result (75 GHz – 110 GHz)	3.6	
7	Frequency Deviation	Uncertainty in test result	3.7	%
8	Magnetic Field Emissions	Uncertainty in test result	2.3	dB
9	Conducted Spurious	Uncertainty in test result Up to 26 GHz	0.921	dB
10	Channel Bandwidth	Uncertainty in test result	15.71	%
11	Spectrum Mask Measurements	Uncertainty in test result (frequency)	2.59	%
		Uncertainty in test result (amplitude)	1.32	dB
12	Adjacent Sub Band Selectivity	Uncertainty in test result	1.24	dB
13	Receiver Blocking – Listen Mode, Radiated	Uncertainty in test result	3.23	dB
14	Receiver Blocking – Talk Mode, Radiated	Uncertainty in test result	3.36	dB
15	Receiver Blocking – Talk Mode, Conducted	Uncertainty in test result	1.24	dB
16	Receiver Threshold	Uncertainty in test result	3.42	dB
17	Transmission Time Measurement	Uncertainty in test result	4.40	%