

Report on the Intermodulation Testing

For

GKD Technik Ltd

on

Base Station

Report no. TRA-051350

30th July to 3rd August 2021

RF915 4.0



Report Number: TRA-051350-47-02A
Issue: A

REPORT ON THE INTERMODULATION TESTING OF A
GKD Technik Ltd
Base Station
WITH RESPECT TO SPECIFICATIONS
47CFR15
INTERMODULATION EMISSIONS INVESTIGATION

TEST DATE: 30th July to 3rd August 2021

Written by:

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Date: 8 October 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

RF915 4.0

1 Revision Record

<i>Issue Number</i>	<i>Issue Date</i>	<i>Revision History</i>
A	8 October 2021	Original

2 Summary

TEST REPORT NUMBER:	TRA-051350-47-02A
WORKS ORDER NUMBER:	TRA-051350-04
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):	Intermodulation emissions investigation using 47CFR15
EQUIPMENT UNDER TEST (EUT):	Base Station
FCC ID:	2A2IY-P2100005
EUT SERIAL NUMBER:	W11352
MANUFACTURER/AGENT:	GKD Technik Ltd
ADDRESS:	17 Cobham Road Ferndowne Industrial Estate Wimborne Dorset BH21 7PE United Kingdom
CLIENT CONTACT:	Rowan Beale ☎ 01202 861961 ✉ Rowan.Beale@42technology.com
ORDER NUMBER:	0000601887
TEST DATE:	30th July to 3rd August 2021
TESTED BY:	Michael Else Element

2.1 Test Summary

<i>Test Method and Description</i>	<i>Requirement Clause</i>	<i>Applicable to this equipment</i>	<i>Result / Note</i>
	<i>47CFR</i>		
Multi-radio Simultaneous Transmission Spurious Emissions	Part 15	<input checked="" type="checkbox"/>	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).

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4 Introduction

This report TRA-051350-47-02A presents the results of the Radio testing on a GKD Technik Ltd, Base Station

The Base Station contains a LF 125 kHz radio, and 916 MHz radio and a 2.4 GHz Wi-Fi radio that are able to operate simultaneously, in the following combinations only.

- 1) 125 kHz and 2.4 GHz Wi-Fi
- 2) 916 MHz and 2.4 GHz Wi-Fi
- 3) 125 kHz and 916 MHz cannot operate simultaneously.

The testing was carried out for GKD Technik Ltd 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.

Throughout this report EUT denotes equipment under test.

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

The test site requirements of ANSI C63.4-2014 are met up to 1GHz.

The test site SVSWR requirements of CISPR 16-1-4:2010 are met over the frequency range 1 GHz to 18 GHz.

5 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
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

6 Equipment Under Test

6.1 EUT Identification

- Name: Base Station
- Serial Number: W11352
- Model Numbers: P2100005
- Software Revision: GKD-1103-SW-001 v5.4.0 / GKD-1103-SW-003 v5.1.0 / GKD-1103-SW-002 v4.00 / GKD-1103-SW-002 v4.0.0
- Hardware Version: v2.1

6.2 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 whilst the equipment was under test

6.3 EUT Mode of Operation

6.3.1 Transmission

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.

6.4 EUT Description

This test report only covers various combinations of multiple radio's operating at the same time.

125 kHz and 2.4 GHz Wi-Fi
916 MHz and 2.4 GHz Wi-Fi
125 kHz and 916 MHz cannot operate simultaneously.

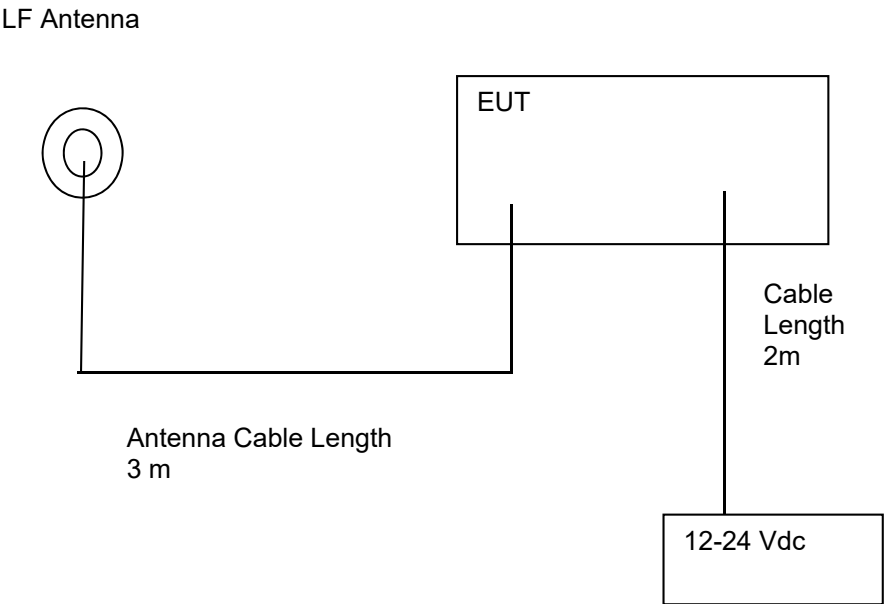
7 Modifications

No modifications were performed during this assessment.

8 EUT Test Setup

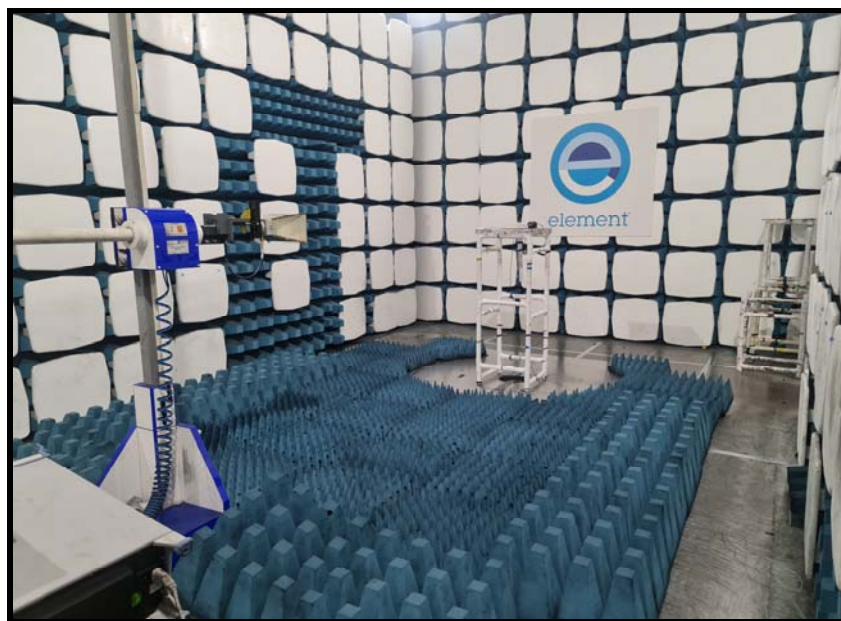
8.1 Block Diagram

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



8.2 General Set-up Photograph

The following photographs shows basic EUT set-up:



8.3 *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.

9 General Technical Parameters

9.1 Normal Conditions

The Base Station was tested under the normal environmental conditions of the test laboratory, except where otherwise stated. The normal power source applied was 12 Vdc from an external power supply.

<i>Modes of operation:</i>	WI-Fi	UHF	LF
<i>Frequencies of operation:</i>	2437 MHz	916 MHz	125 kHz
<i>Antenna type(s):</i>	PCB track	W3118A	OU000288
<i>Modulation type(s)</i>	OFDM	GFSK	On-off keying
<i>Nominal Supply Voltage:</i>	12-24 Vdc	12-24 Vdc	12-24 Vdc

10 Multi-radio Simultaneous Transmission Spurious Emissions below 30 MHz

10.1 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.

10.2 Test Parameters

Test Location:	Element Skelmersdale
Test Chamber:	SK03 radio chamber
Test Standard and Clause:	ANSI C63.10-2013, Clause 6.4
Frequencies Measured:	2437 MHz, (Wi-Fi) 125 kHz (LF)
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 °C to +35 °C (as declared)
Humidity: 50 % RH	20 % RH to 75 % RH (as declared)
Supply: 12 Vdc	12 Vdc (as declared)

10.3 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.

10.4 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:

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

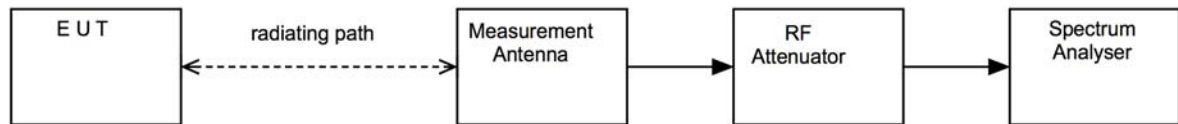
Where,

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 300 m and from 10 m to 300 m.

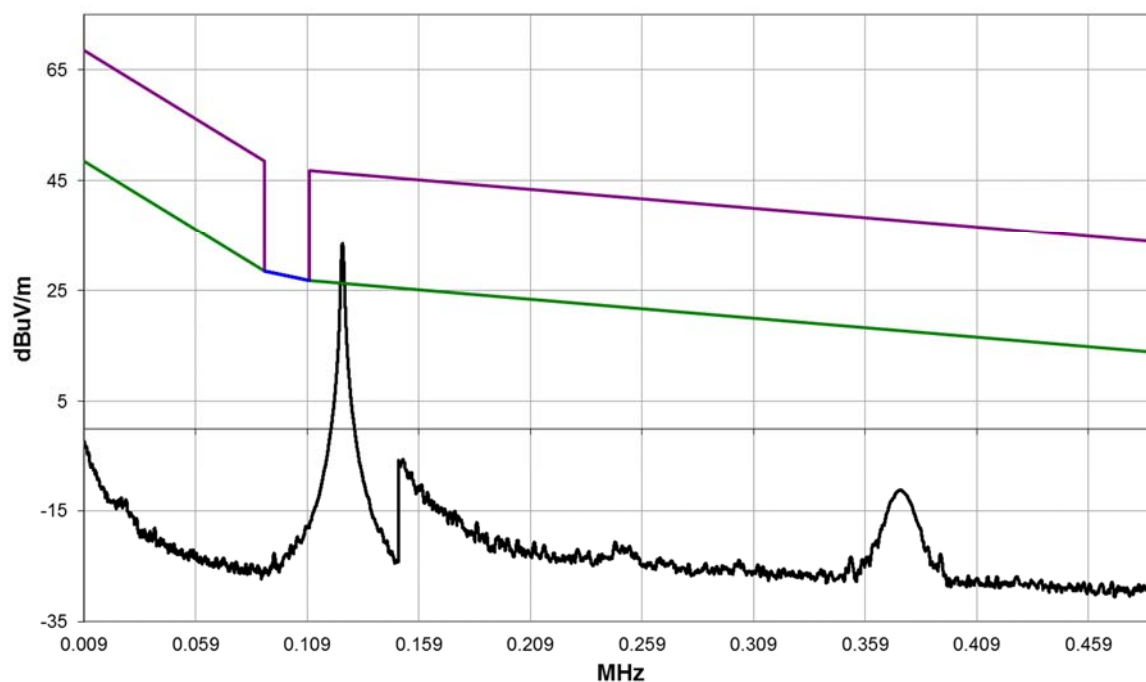
This field strength value is then compared with the regulatory limit.

Figure I Test Setup**10.5 Test Equipment**

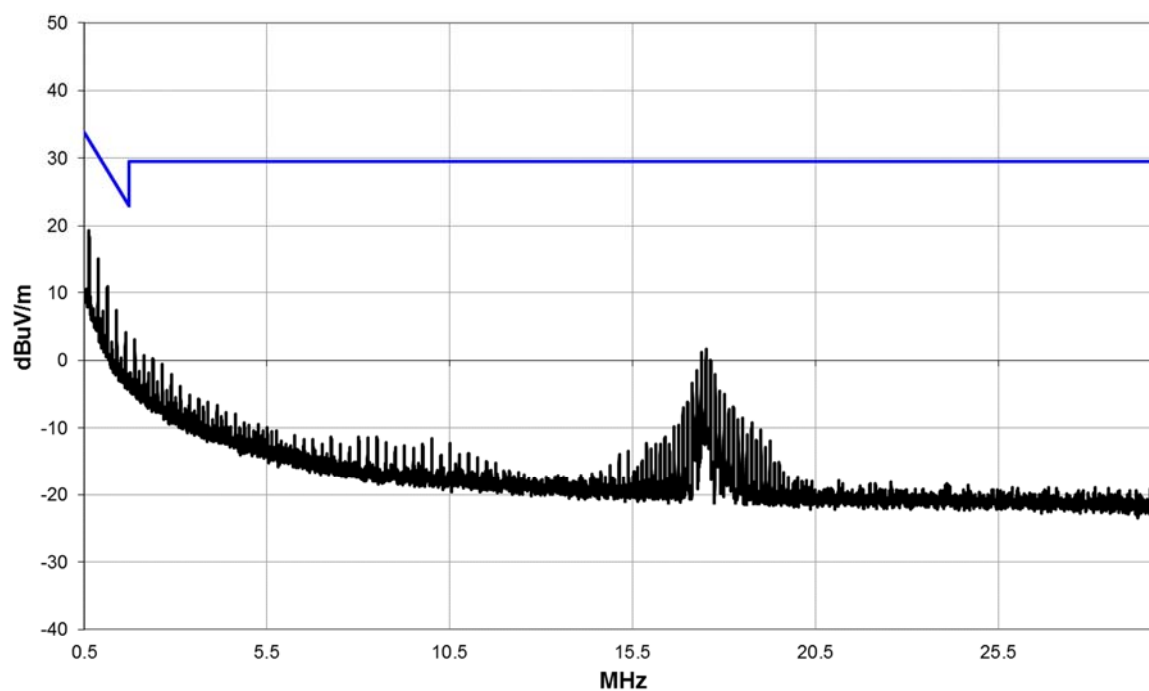
<i>Equipment Type</i>	<i>Manufacturer</i>	<i>Equipment Description</i>	<i>Element No</i>	<i>Due For Calibration</i>
Spectrum Analyser	R&S	FSU46	REF910	2021-11-18
Loop Antenna	The Elctro Mechanics Company	6502	R0079	2023-06-16
ATS	Rainford EMC	Radio Chamber – PP	REF940	2021-12-09

10.6 Test Results

Wi-Fi: 2437 MHz and LF: 125 kHz 9kHz-490 kHz



Wi-Fi: 2437 MHz and LF: 125 kHz 490 kHz to 30 MHz



All emissions on graphs are related to either the Wi-Fi 2.4 GHz or LF 125 kHz operation and are not intermodulation products.

11 Multi-radio Simultaneous Transmission Spurious Emissions above 30 MHz

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.

Intermodulation products

Emissions of two or more electromagnetic waves transmitted simultaneously through a nonlinear electronic system.

11.2 Test Parameters

Test Location:	Element Skelmersdale
Test Chamber:	SK03 radio chamber
Test Standard and Clause:	ANSI C63.10-2013, Clause 6.5 and 6.6
Frequencies Tested:	2437 MHz, (Wi-Fi) 916 MHz (UHF) 125 kHz (LF)
Deviations from Standard:	None
Measurement BW:	9 kHz to 150 kHz: 1 kHz 150 kHz to 30 MHz: 10 kHz 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: 20 °C	+15 °C to +35 °C (as declared)
Humidity: 50 % RH	20 % RH to 75 % RH (as declared)
Supply: 12 Vdc	12 Vdc (as declared)

11.3 Test Limits

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

Least stringent limit applied to any intermodulation products.

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 dB μ V/m at the regulatory distance, using:

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

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

Where,

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

CL is the cable loss in dB;

AF is the test antenna factor in dB/m;

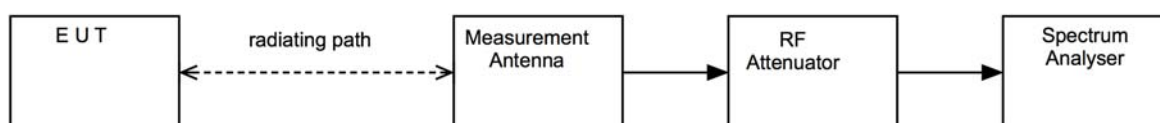
PA is the pre-amplifier gain in dB (where used);

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

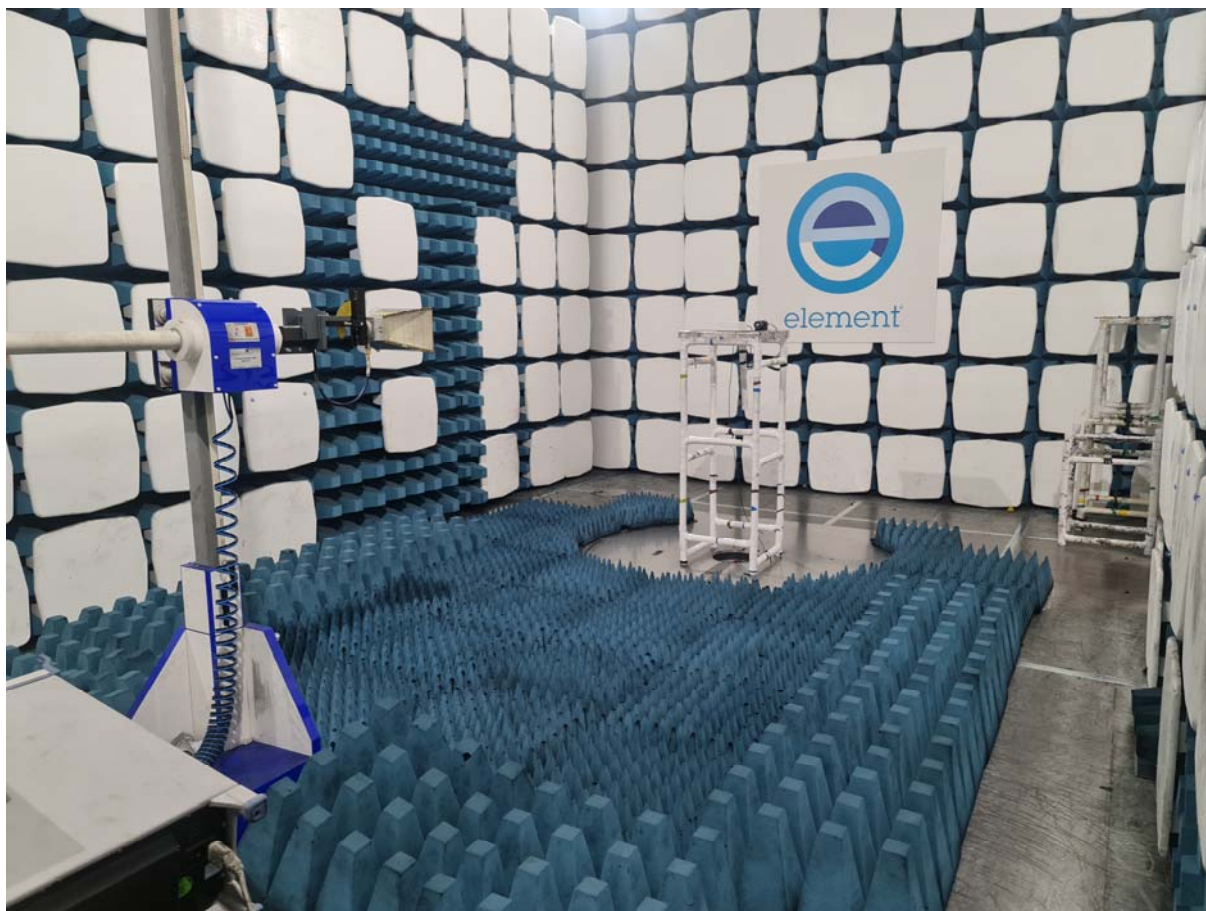
CF is the distance factor in dB (where measurement distance different to limit distance);

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

Figure i Test Setup



11.5 Test Set-up Photograph



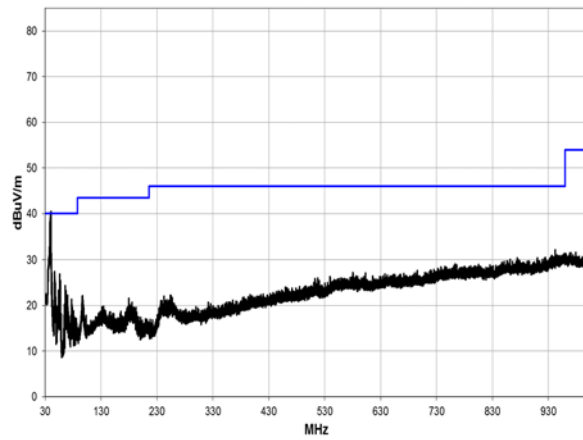
11.6 Test Equipment

<i>Equipment Description</i>	<i>Manufacturer</i>	<i>Equipment Type</i>	<i>Element No</i>	<i>Due For Calibration</i>
Spectrum Analyser	R&S	FSU46	REF910	2021-11-16
Bilog	Chase	CBL611/B	U573	2023-01-28
1-18GHz Horn	EMCO	3115	U223	2021-11-05
PreAmp	Watkins Johnson	6201-69	U372	2022-03-01
Pre Amp	Agilent	8449B	L572	2021-10-19
Horn 18-26GHz (&U330)	Flann	20240-20	L300	2022-04-23
Radio Chamber - PP	Rainford EMC	ATS	REF940	2021-12-09

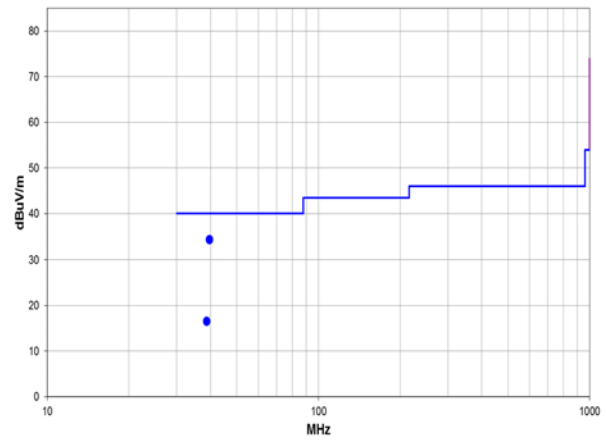
11.7 Results

Wi-Fi; 2437 MHz and LF: 125 kHz

30 MHz-1 GHz Pre-scan

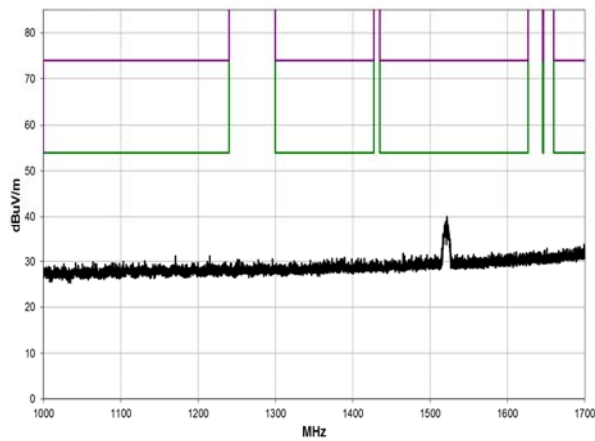


30 MHz-1 GHz Maximised

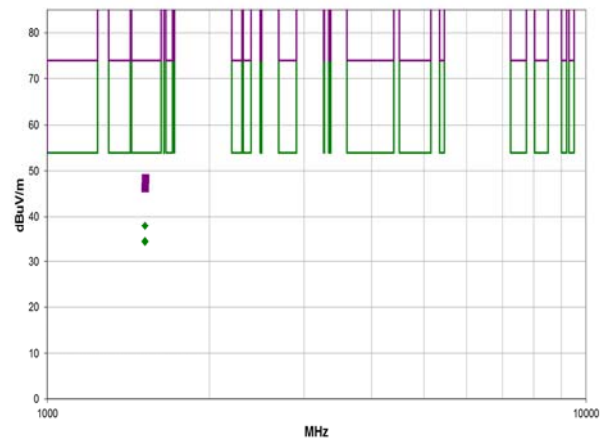


Freq (MHz)	Amplitude (dBuV)	Factor (dB/m)	Antenna Height (meters)	Azimuth (degrees)	Test Distance (meters)	External Attenuation (dB)	Polarity/ Transducer Type	Detector	Distance Adjustment (dB)	Adjusted (dBuV/m)	Spec. Limit (dBuV/m)	Compared to Spec. (dB)
39.644	43.8	-9.3	1.0	185.9	3.0	0.0	Vert	QP	0.0	34.5	40.0	-5.5
38.637	25.4	-8.8	1.45	349.9	3.0	0.0	Horz	QP	0.0	16.6	40.0	-23.4

1.0 GHz-1.7 GHz Pre-scan

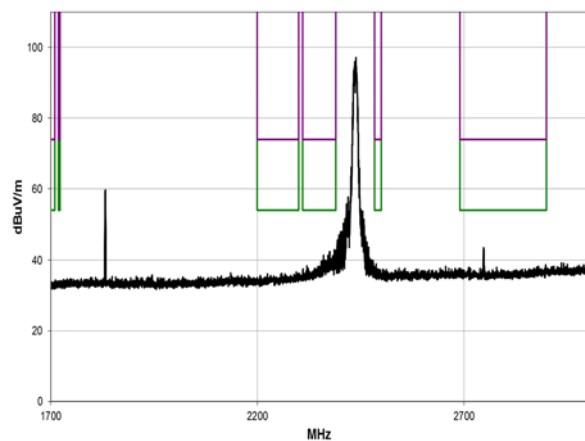


1.0 GHz-10 GHz Maximised

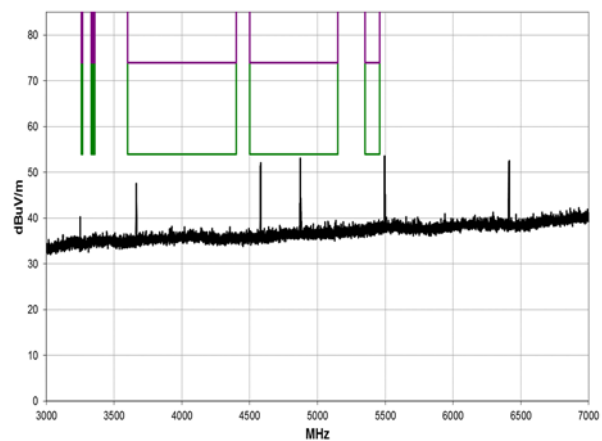


Freq (MHz)	Amplitude (dBuV)	Factor (dB/m)	Antenna Height (meters)	Azimuth (degrees)	Test Distance (meters)	External Attenuation (dB)	Polarity/ Transducer Type	Detector	Distance Adjustment (dB)	Adjusted (dBuV/m)	Spec. Limit (dBuV/m)	Compared to Spec. (dB)
1519.251	47.4	-9.5	1.38	231.0	3.0	0.0	Horz	AV	0.0	37.9	54.0	-16.1
1519.251	43.8	-9.5	1.03	138.2	3.0	0.0	Vert	AV	0.0	34.3	54.0	-19.7
1522.745	57.7	-9.4	1.38	231.0	3.0	0.0	Horz	PK	0.0	48.3	74.0	-25.7
1518.918	55.9	-9.5	1.03	138.2	3.0	0.0	Vert	PK	0.0	46.4	74.0	-27.6

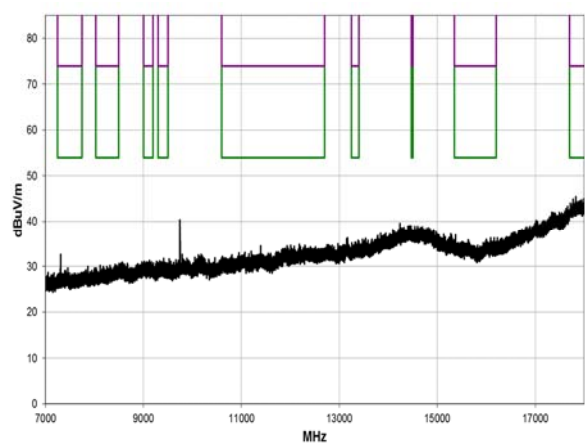
1.7 GHz-3 GHz Pre-scan



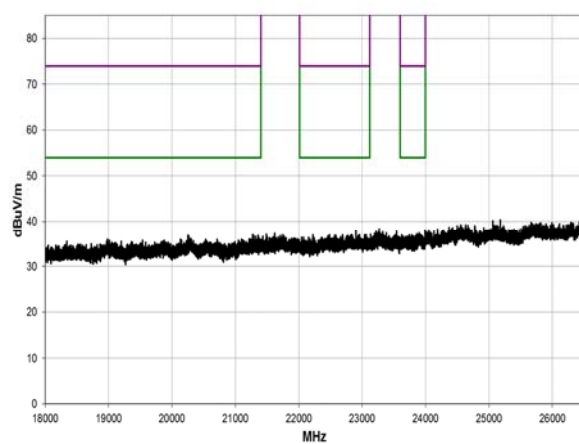
3 GHz-7 GHz Pre-scan



7 GHz-18 GHz Pre-scan

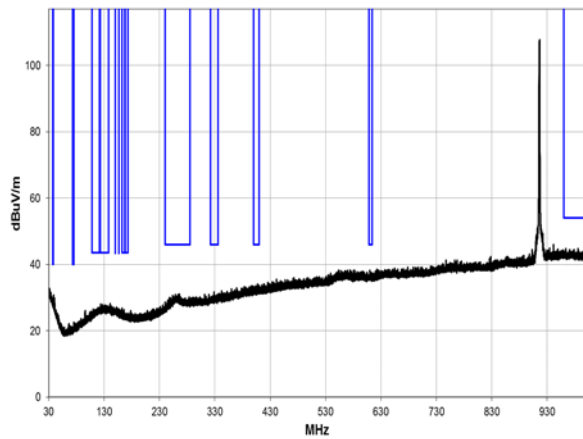


18 GHz-26.5 GHz Pre-scan

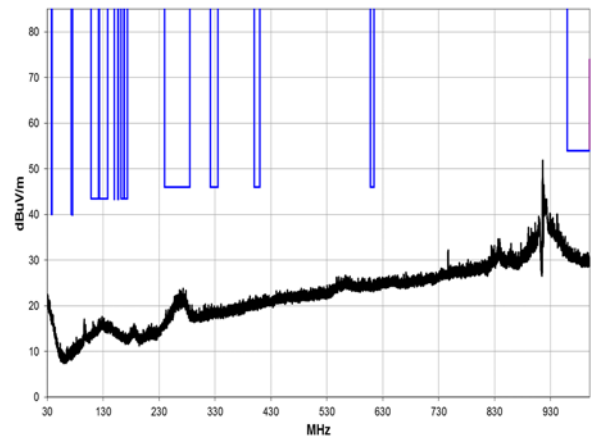


Wi-Fi; 2437 MHz and UHF 916 MHz

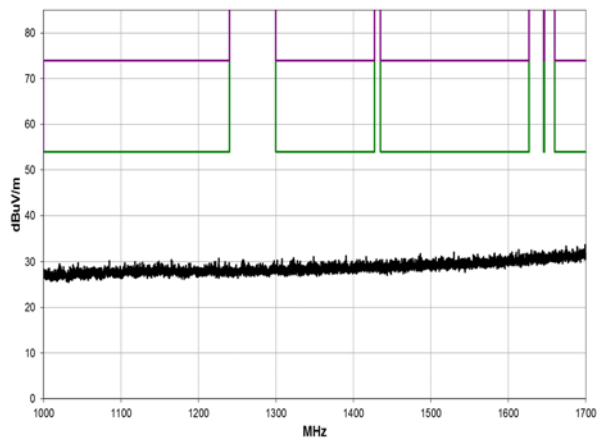
30 MHz-1 GHz Pre-scan no filter



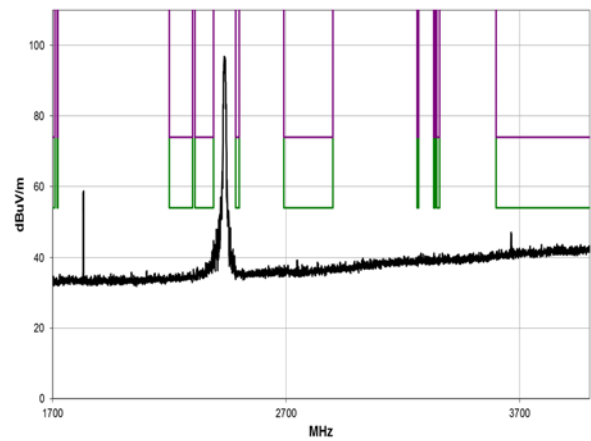
30 MHz-1 GHz notch filter fitted



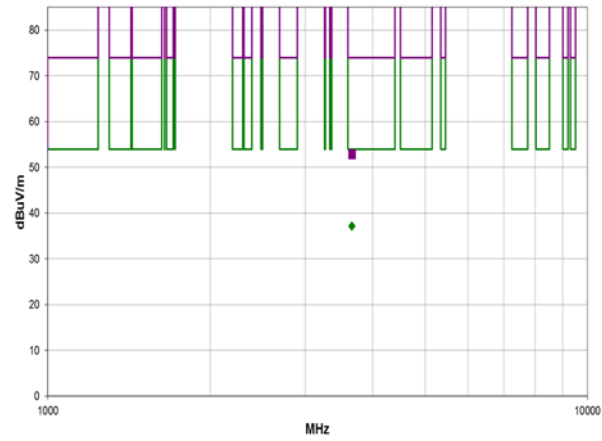
1 GHz -1.7 GHz Pre-scan



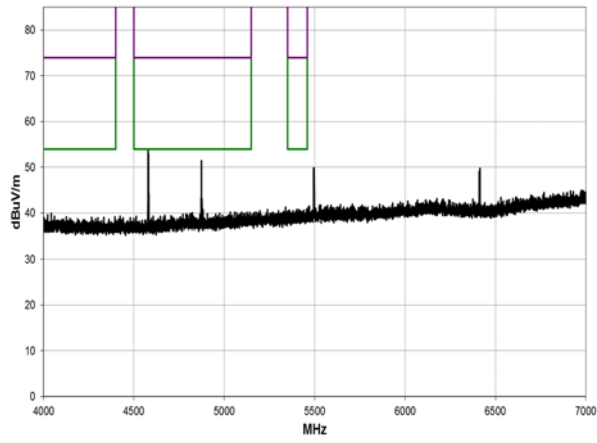
1.7 GHz-4 GHz Pre-scan



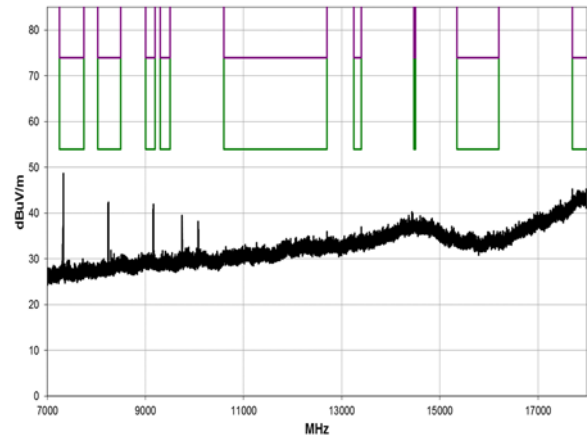
1.7 GHz-4 GHz Maximised



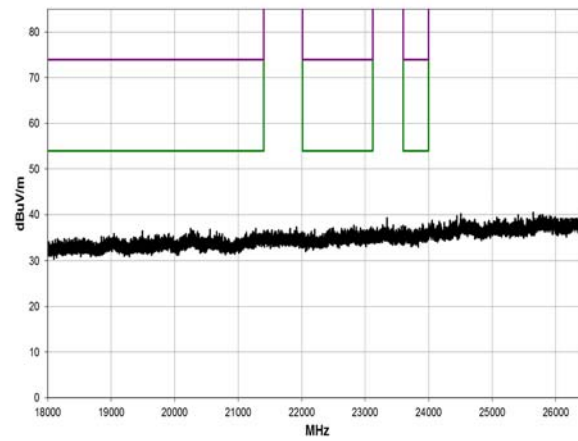
4 GHz-7 GHz Pre-scan



7 GHz-18 GHz Pre-scan



18GHz-26.5 GHz Pre-scan



12 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 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**