

Report on the Intermodulation Testing

For

Renishaw Plc

on

RMI-QE

Report no. TRA-046260-47-07A

22 March 2021

Report Number: TRA-046260-47-07A
Issue: A

REPORT ON THE INTERMODULATION TESTING OF A
Renishaw Plc
RMI-QE
WITH RESPECT TO SPECIFICATIONS
47CFR PARTS 15.247 and RSS-247
INTERMODULATION EMISSIONS INVESTIGATION

TEST DATE: 15th December 2020

Written by:

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Approved by:

John Charters
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Date: 22 March 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	22 March 2021	Original

2 Summary

TEST REPORT NUMBER: TRA-046260-47-07A

WORKS ORDER NUMBER: TRA-0046260-01

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.

Canada: Testing of radio apparatus for TAC (technical acceptance certificate) per subsections 4(2) of the Radiocommunication Act and 21(1) of the Radiocommunication Regulations.

TEST SPECIFICATION(S): Intermodulation emissions investigation using 47CFR Part 15.247, RSS-247 and RSS-GEN.

EQUIPMENT UNDER TEST (EUT): RMI-QE

ISED IDENTIFIER: 3928A-RMIQE

FCC IDENTIFIER: KQGRMI-QE

EUT SERIAL NUMBER: 2G9J50

MANUFACTURER/AGENT: Renishaw Plc

ADDRESS: New Mills
Wotton Under Edge
Gloucestershire
GL12 8JR
United Kingdom

CLIENT CONTACT: Rich Warren
☎ 01453 523240
✉ richard.warren@renishaw.com

ORDER NUMBER: PU03514022

TEST DATE: 15th December 2020

TESTED BY: Steve Garwell
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>RSS</i>	<i>47CFR</i>		
Intermodulation spurious emissions	Gen, 8.10	Parts 15.247	☒	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-046260-47-07A presents the results of the Radio testing on a Renishaw Plc, RMI-QE to specification 47CFR15 Radio Frequency Devices.

The RMI-QE contains Radio modules that are able to operate simultaneously.

The testing was carried out for Renishaw Plc 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 Skemersdale 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:

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

IC Registration Number(s):

Element Hull	3483A
Element North West	3930B

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 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.
- Industry Canada RSS-247, Issue 2, February 2017 – Digital Transmission Systems (DTSS), Frequency Hopping Systems (FHSs) and Licence-Exempt Local Area Network (LE-LAN) Devices
- Industry Canada RSS-Gen, Issue 5, March 2019 – General Requirements for Compliance of Radio Apparatus.

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
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: RMI-QE
- Serial Number: 2G9J50
- Model Number: RMI-QE
- 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:

Radios were set to transmit permanently in 2 channel combinations:

- Bottom channel modem A and top channel modem B
- Top channel modem A and bottom channel modem B

As per customers declaration the unit will never work on the same channel in both modules.

7.4 EUT Radio Parameters

7.4.1 General

Radio	Modem A	Modem B
Frequency of operation:	2404 MHz-2480 MHz	2404 MHz-2480 MHz
Modulation type(s):	Mode 2: 2 Mbps Binary GFSK Frequency Hopping Mode 2: 2 Mbps Binary GFSK DSSS	Mode 2: 2 Mbps Binary GFSK Frequency Hopping Mode 2: 2 Mbps Binary GFSK DSSS
Occupied channel bandwidth(s):	Mode 2: 2 MHz	Mode 2: 2 MHz
Channel spacing:	Mode 2: 2 MHz	Mode 2: 2 MHz
Declared output power(s):	Mode 2: +4dBm	Mode 2: +4dBm
Antenna type:	PCB Patch Antenna	PCB Patch Antenna
Antenna gain:	4.43 dBi	4.43 dBi
Nominal Supply Voltage:	24 Vdc	24 Vdc

7.5 EUT Description

The EUT is a dual modem hub of a mechanical measuring system. The device utilizes 2 modems working as DTS and frequency hopping devices on the 2400 MHz - 2483.5 MHz frequency band.

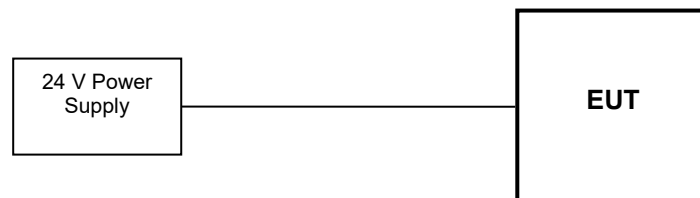
8 Modifications

No modifications were performed during this assessment.

9 EUT Test Setup

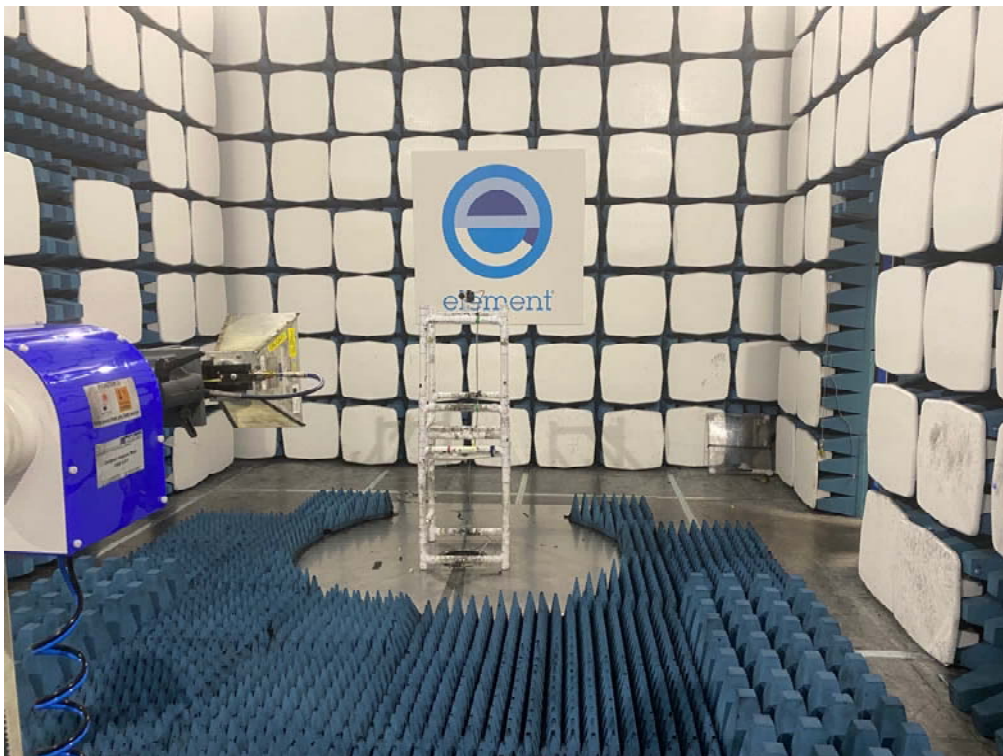
9.1 Block Diagram

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:



10 General Technical Parameters

10.1 Normal Conditions

The RMI-QE was tested under the normal environmental conditions of the test laboratory, except where otherwise stated. The normal power source applied was 24V dc from a power supply.

11 Radiated emissions, intermodulation products

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:	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: 23 °C	+15 °C to +35 °C (as declared)
Humidity: 28 % RH	20 % RH to 75 % RH (as declared)
Supply: 24 V dc	24 V dc (as declared)

11.3 Test Limits

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

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

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:

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

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;

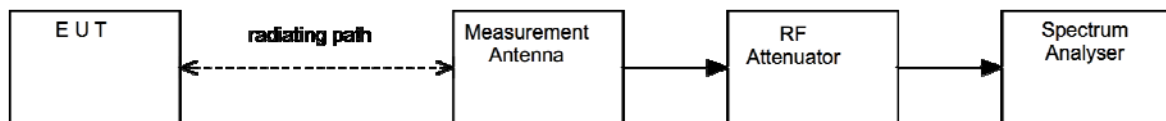
PA is the pre-amplifier gain in dB (where used);

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

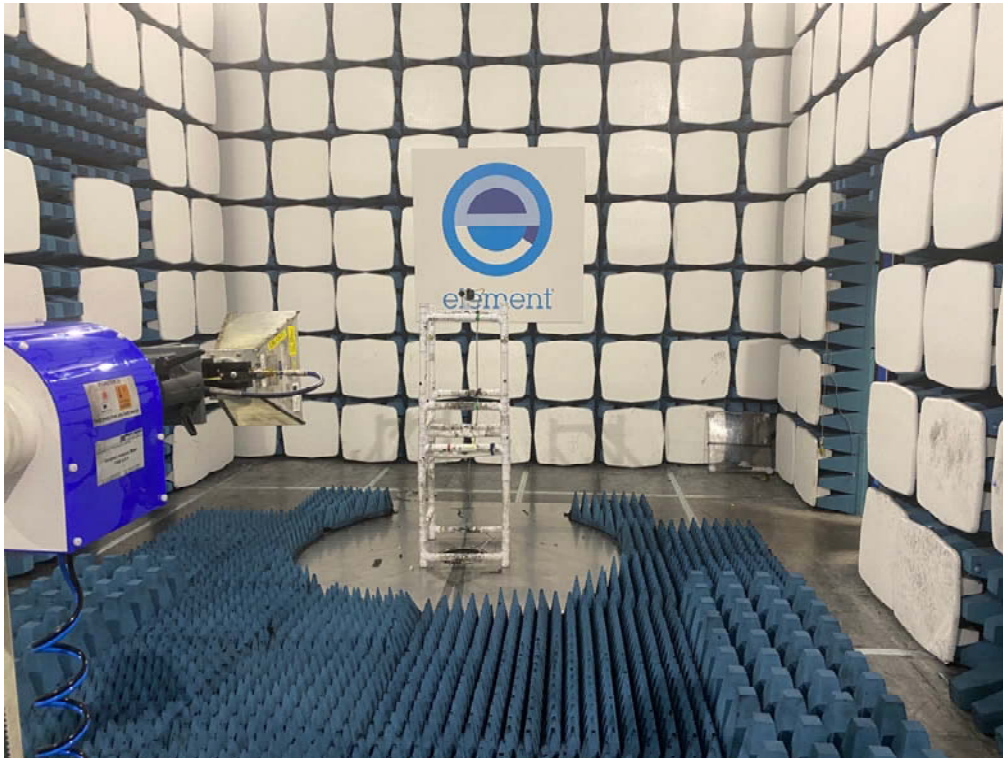
CF is the distance factor in dB (where measurement distance different to limit distance);

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

Figure i Test Setup



11.5 Test Set-up Photograph

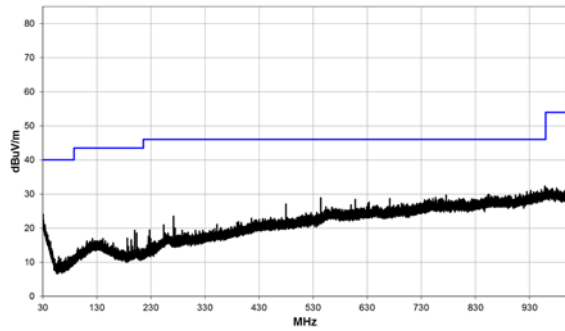


11.6 Test Equipment

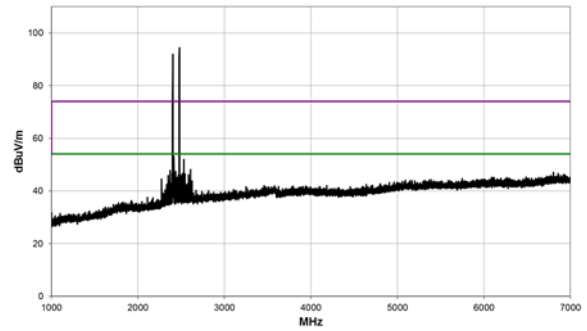
<i>Equipment Description</i>	<i>Manufacturer</i>	<i>Equipment Type</i>	<i>Element No</i>	<i>Due For Calibration</i>
Spectrum Analyser	R&S	FSU26	REF909	2021-07-09
Bilog	Chase	CBL611/A	U573	2021-09-19
PreAmp	Watkins Johnson	6201-69	U372	2021-02-26
8449B	Agilent	Pre Amp	L572	2021-08-26
Horn 18-26GHz	Flann	20240-20	L300	2022-04-23
1-18GHz Horn	EMCO	3115	L139	2021-07-16

11.7 Test Results;

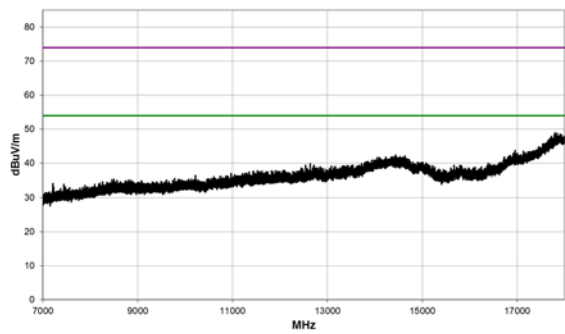
Modem A; Frequency: 2404 MHz; Modem; B Frequency: 2480 MHz.



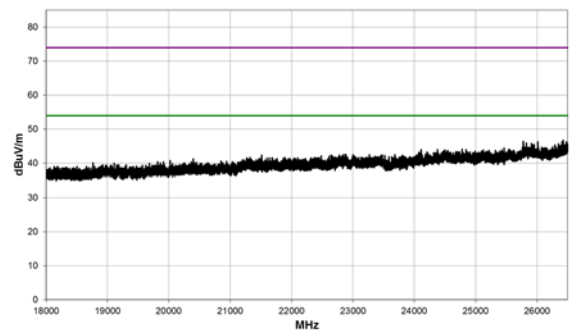
30 MHz to 1 GHz



1 GHz to 7 GHz



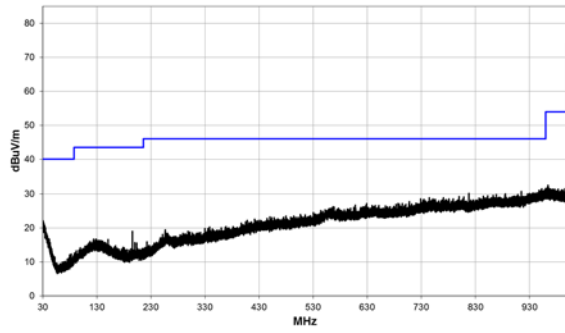
7 GHz to 18 GHz



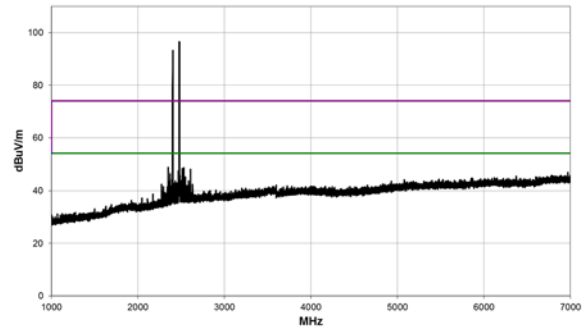
18 GHz to 26.5 GHz

No intermodulation products were found. All the emissions on the graphs were from either of the modules but not a result of both working simultaneously.

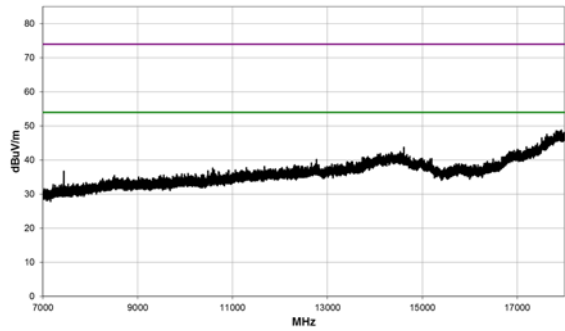
Modem A; Frequency: 2480 MHz; Modem; B Frequency: 2404 MHz.



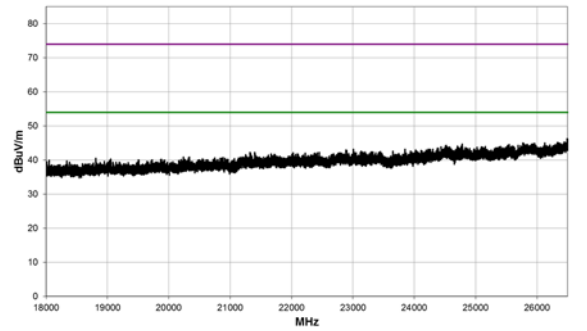
30 MHz to 1 GHz



1 GHz to 7 GHz



7 GHz to 18 GHz



18 GHz to 26.5 GHz

No intermodulation products were found. All the emissions on the graphs were from either of the modules but not a result of both working simultaneously.

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**