TEST REPORT

EMC DEPARTMENT

RAYMARINE LTD

Test of: Raymarine Ltd.
Pathfinder RL89CRC PLUS
and
Pathfinder RL811CRC PLUS

To: FCC Part 80: 1998
and FCC Part 2:1998

(Leisure Marine Radar Equipment)

Test Report Serial No. 555/1009

This Test Report is issued under the authority of: Chris Bird, Approvals Manager	**Checked By:** A. Little
Tested By: P.Bowen	**Approved By:** C. J. Bird
Issue Date: 18th February, 2003	**Test Dates:** 8th February to 17th February 2003

Table of Contents

1. Client Information

Company Name	Raymarine Ltd.
Address:	Robinson Way Anchorage Park Portsmouth Hampshire PO3 5TD England, U.K.
Contact Name:	Mr. C. Bird, Approvals Manager

2. Equipment Under Test (EUT)

2.1. Identification of Equipment Under Test (EUT)

Brand Name:	Raymarine	
Model Name or Number:	'Pathfinder' RL89CRC PLUS (Comprised of a 10kW Pedestal Scanner with 48 inch antenna and a 10 inch Colour LCD Display Unit/Chartplotter) 'Pathfinder' RL811CRC PLUS (Comprised of a 10kW Pedestal Scanner with 72 inch antenna and a 10 inch Colour LCD Display Unit/Chartplotter)	
Unique Type Identification:	9S – 10kW open array scanner unit with 48 inch antenna 11S – 10kW open array scanner unit with 72 inch antenna RL80CRC PLUS Display/Chartplotter	M92655 M92693 M92655 M92743 E52038
Serial Number:	Scanner Unit: Display/Chartplotter:	EMC004 PA0076
Country of Manufacture:	England, U.K.	
FCC ID Number:	PJ5MTX9-S3	
Date of Receipt:	20th January, 2003	

2.2. Description of EUT

The equipment under test is an X-band marine radar intended for use on leisure craft and small workboats, and is comprised of:

Scanner Unit: 10kW X-band transmitter with either a 48 inch or a 72 inch open array antenna.
Display Unit: 10.4 inch colour LCD with chart reader and with Seatalk, NMEA and hsb² interface ports.

2.3. Modifications incorporated in EUT

The EUT has not been modified from what is described by the Model Name and Unique Type Identification stated above.

2.4. Additional information related to Testing

Power Supply Requirement:	Nominal 24-32V DC supply
Intended Operating Environment:	Leisure Marine & Small Workboats
Weight:	9S Scanner: 30kg (66.2lbs) 11S Scanner: 33.4kg (73.7lbs) Display 5.8kg (12.7lbs)
Dimensions:	9S Scanner: 1306mm dia x 406mm height 11S Scanner: 1928mm dia x 406mm height Display: w 292mm x h 289mm x d 139mm
Interface Ports:	Power and 2 x NMEA in Seatalk NMEA out hsb²

2.5. Support Equipment

No support equipment was required to exercise the EUT during testing.

3. Test Specification, Methods and Procedures

3.1. Test Specification

Reference:	FCC Part 80: 1998 and FCC Part 2:1998
Title:	Code of Federal Regulations, Part 80 (47CFR): 1998 Stations in the maritime services Code of Federal Regulations, Part 2 (47CFR): 1998 Frequency Allocations and radio treaty matters; general rules and regulations
Comments:	The test facility used for the radiated emissions portions of these tests is an alternative test site as described in ANSI C63.4-2001, being a 3m test range within a semi-anechoic chamber, with antenna height scanning from 1 – 4 metres and meeting the +/-4dB NSA criterion.
Purpose of Test:	To determine, for the purposes of certification, whether the equipment complied with the requirements of the specification following transmitter design changes to comply with ITU-R M1177, which is effective from January 1st 2003.

3.2. Methods and Procedures

The methods and procedures used were as detailed in:

ANSI C63.2-1996
Title: American National Standard for Electromagnetic Noise and Field Strength Instrumentation, 10 Hz to 40 GHz – Specifications

ANSI C63.4-2001
Title: 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

ANSI C63.5-1998
Title: American National Standard for Electromagnetic Compatibility – Radiated Emission Measurements in Electromagnetic Interference (EMI) Control – Calibration of Antennas (9 kHz to 40 GHz)

CISPR 16-1 (1999)
Title: Specification for radio disturbance and immunity measuring apparatus and methods
Part 1: Radio disturbance and immunity measuring apparatus

CISPR 16-4 (2002)
Title: Specification for radio disturbance and immunity measuring apparatus and methods
Part 4: Uncertainty in EMC measurements

3.3. Definition of Measurement Equipment

The measurement equipment used complied with the requirements of the standards referenced in the Methods and Procedures section above. Appendix A contains a list of the test equipment used.

4. Deviations from the Test Specification

2.1047(d) Modulation characteristics – *Other types of equipment*. No curves supplied

5. Operation of the EUT during Testing

5.1. Operating Conditions

5.1.1. Radiated Emissions, 9kHz to 40GHz: The EUT was located on a non-conducting support above a turntable on a 3m test range within a semi-anechoic chamber (Raymarine Site 3)

5.1.2. The EUT was located in a laboratory environment for all other tests.

5.1.3. During testing, the EUT was powered by a nominal 24V DC supply except when measuring Frequency Variation with Voltage. [FCC Part 2, 1055(d)]

5.2. Operating Modes

The EUT was tested in the following operating modes:

5.2.1. Radiated emissions: Transmitting into a rotating non-reflective load with the transmitter set to a 450ns pulse width, 1.6kHz PRF. This mode is defined as being likely to be the worst case as regards EMC. Additionally, the longest and shortest pulse widths (1050ns and 75ns) were used, with the PRF appropriate to the pulse width in use, when measuring emissions in the vicinity of the magnetron frequency.

5.2.2. Conducted emissions: Transmitting into a fixed non-reflective load with the transmitter set to a 450ns pulse width, 1.6kHz PRF. This mode is defined as being likely to be the worst case as regards EMC. Additionally, the longest and shortest pulse widths (1050ns and 75ns) were used, with the PRF appropriate to the pulse width in use, when measuring emissions in the vicinity of the magnetron frequency.

5.2.3. Variation of transmit frequency with voltage and temperature: The transmitter was set to the half nautical mile range (75ns pulse width) and the six nautical mile range (1050ns pulse width).

5.2.4. Transmitter power, pulsewidth, occupied bandwidth and P.R.F. Transmitting into a fixed non-reflective load.

5.3. Configuration and peripherals

5.3.1. The scanner unit was connected to the display unit with the standard cable of 15 m length. A transmit dummy load was connected to the scanner unit antenna port. All display unit interface ports were connected to dummy loads using the maximum length of cable specified for the particular port, or 20 m where this is less than the maximum specified. A 24V DC supply was connected to the Display Unit.

5.3.2. This configuration is defined as being likely to be the worst case as regards emissions.

5.3.3. Appendix A of this report contains a full list of test equipment used and Appendix C contains a schematic diagram of the test configuration.

6. Summary of Test Results

6.1 Summary of Tests

6.1.1. Radiated Spurious Emissions

Frequency Range	Specification Reference	Compliance Status
9kHz to 40GHz	2.1053 and 80.211(f)	Complied

6.1.2.Conducted Spurious Emissions

Frequency Range	Specification Reference	Compliance Status
9kHz to 40GHz	2.1051 and 80.211(f)	Complied

6.1.3.RF Power Output

6.1.3.1.Peak Power

Nominal Pulsewidth Range (ns)	Specification Reference	Compliance Status
75 to 1050	2.1046(a) and 80.215(a)	Complied

6.1.3.2. Average Power

Nominal Pulsewidth Range (ns)	Specification Reference	Compliance Status
75 to 1050	2.1046(a) and 80.215(a)	Complied

6.1.3.3. Pulse Width

Nominal Pulsewidth Range (ns)	Specification Reference	Compliance Status
75 to 1050	2.1046(a) and 80.215(a)	Complied

6.1.3.4. PRF

Nominal Pulsewidth Range (ns)	Specification Reference	Compliance Status
75 to 1050	2.1047(d) and 80.213(g)	Complied

6.1.4. Variation of Frequency with Voltage

6.1.4.1. 75ns

Nominal Pulsewidth (ns)	Specification Reference	Compliance Status
75	2.1055(d)	Complied

6.1.4.2. 1050ns

Nominal Pulsewidth (ns)	Specification Reference	Compliance Status
1050	2.1055(d)	Complied

6.1.5. Variation of Frequency with Temperature

6.1.5.1. 75ns

Nominal Pulsewidth (ns)	Specification Reference	Compliance Status
75	2.1055(a and b)	Complied

6.1.5.2. 1050ns

Nominal Pulsewidth (ns)	Specification Reference	Compliance Status
1050	2.1055(a and b)	Complied

6.1.6. Occupied Bandwidth

Nominal Pulsewidth Range (ns)	Specification Reference	Compliance Status
75 to 1050	2.1049(i) and 80.205	Complied

6.1.7. Transmitter Frequency Tolerance

Nominal Pulsewidth Range (ns)	Specification Reference	Compliance Status
75 to 1050	80.209(b)	Complied

6.1.8. Suppression of Interference Aboard Ships

80.217. When the radar is in the Standby mode of operation, the local oscillator is automatically switched off.

6.2. Location of Tests

All the measurements described in this report were performed in the EMC Department at the premises of Raymarine Ltd., Robinson Way, Anchorage Park, Portsmouth, Hampshire PO3 5TD, England, U.K.

7. Measurements, Examinations and Derived Results

7.1. General Comments

7.1.1. This section contains test results only. Details of the test methods and procedures can be found in Appendix B of this report.

7.1.2. Measurement uncertainties are stated in accordance with the requirements of CISPR 16-4:2002. Please refer to Section 8 for details of measurement uncertainties.

7.1.3. The highest frequency generated by the EUT is 9.4GHz. Consequently, tests were performed up to 40GHz.

7.2. Field Strength Measurements

7.2.1. Magnetic Field Strength: Frequency Range 9 kHz to 30 MHz

7.2.1.1. Plots of measurements using a peak detector can be found in Appendix D.

7.2.1.2. No emissions exceeded a level of 70dBuV/m.

7.2.1.3. Details of the limit line calculation can be seen in Appendix B (B1.1 – B1.5).

7.2.2.Electric Field Strength Measurements: Frequency Range 30 MHz to 2000 MHz

7.2.2.1. Plots of measurements can be found in Appendix D.

7.2.2.2. The highest peak levels measured were less than 60dBuv/m

7.2.2.3. Details of the limit line calculation can be seen in Appendix B (B1.1 – B1.5)

7.2.3. Electric Field Strength Measurements: Frequency Range: 2GHz to 40GHz

7.2.3.1. Plots of measurement scans can be found in Appendix D.

7.2.2.2. The following table lists frequencies at which significant emissions were measured using Peak detector functions. Although these emissions are not required to be recorded, being more than 20dB lower than the limit line, they are included for completeness as they are all magnetron-related.

7.2.2.3. Details of the limit line calculation can be seen in Appendix B (B1.1 – B1.5).

Frequency (GHz)	Antenna Polarization	Level (dBuV/m)	Limit (dBuV/m)	Margin (dB)	Result
18.790	Vertical	102.8	131.3	28.5	Complied
28.193	Vertical	103.1	131.3	28.2	Complied
31.428	Vertical	98.1	131.3	33.2	Complied
37.587	Vertical	101.4	131.3	29.9	Complied

7.3 Conducted Emissions

7.3.1. Peak Detector measurements on RF port

7.3.1.1. The design of the RF coupling from the magnetron to the antenna forms an effective high pass/bandpass filter arrangement. The peak energy level of radar requires considerable attenuation in order to prevent the analyser from going into compression. This limits the maximum dBc figure that can be obtained without changing the resolution bandwidth of the analyser. Since the signal is wideband compared to the resolution bandwidth, it is critical to the measurement accuracy that the resolution bandwidth settings remain consistent throughout the testing where possible.

7.3.1.2. Due to the use of waveguide on the antenna port, the lowest frequency of measurement was increased to 6GHz. The following table lists frequencies at which emissions or the highest noise floors were measured using a Peak Detector. Note that for measurements above 26.5GHz, the mixer conversion process may produce a “true” and “spurious” response for each signal, depending on which analyser local oscillator harmonic is selected. Only the true responses are detailed in the table below. These are clearly identifiable as harmonics of the magnetron frequency. Plots of the scans can be found in Appendix D.

7.3.1.3. Measurements were performed from 6 GHz to 40GHz with the EUT set to 450nS. With the EUT set to both 75ns and 1050ns, measurements were performed within and around the transmitter frequency allocation.

7.3.1.4. Details of the limit line calculation can be found in Appendix B, section B.1.6.

450ns Pulse

Frequency (GHz)	Level (dBm)	Limit (dBm)	Margin (dB)	Result
18.780	7.91	18.13	10.22	Complied
28.223	-4.96	18.13	23.09	Complied
37.510	0.95	18.13	17.18	Complied

75ns Pulse

Frequency (GHz)	Level (dBc)	Limit (dBc)	Margin (dB)	Result
9.3099	-32.7	-25	7.7	Complied
9.5104	-43.6	-25	18.6	Complied

1050ns Pulse

Frequency (GHz)	Level (dBc)	Limit (dBc)	Margin (dB)	Result
9.3099	-47.7	-25	22.7	Complied
9.5144	-56.3	-25	31.3	Complied

7.4 Peak Power

7.4.1. These measurements were performed with the HP Peak Power Analyser and sensor connected to the EUT antenna port via a coupler and in-line attenuator.

Pulse Width (ns)	Measured Power (dBm)	Corrected Power (kW)
75	67.72	5.91562
100	68.32	6.79204
150	69.11	8.33681
250	69.67	9.26830
350	69.62	9.16220
450	69.80	9.54993
600	69.85	9.66051
1050	69.96	9.90832

Note 1: Power is measured at the antenna port and will be less than the nominal magnetron output due to normal losses in the circulator and rotating joint.
Note 2: The power at the shorter pulse widths has been deliberately reduced to enhance short-range radar performance.

7.4.1. Pulse Width

7.4.1.1. Plots can be found in Appendix D.

7.4.1.2. In order to determine the characteristics of the various pulses, the HP Peak Power Analyser was connected to the EUT antenna port via a coupler and inline attenuator.

Nominal Pulse Width (ns)	Measured Pulse Width (ns)
75	74.850
100	100.798
150	150.699
250	249.501
350	351.297
450	453.094
600	602.794
1050	1049.900

7.5. Pulse Repetition Frequency

7.5.1. Plots can be found in Appendix D.

7.5.2. In order to determine the characteristics of the various pulses, the HP Peak Power Analyser and sensor was connected to the EUT antenna port via a coupler and in-line attenuator.

Pulse Width (ns)	Measured P.R.F. (Hz)
75	3058.10
100	3058.10
150	3058.10
250	3058.10
350	2000.00
450	1602.56
600	1201.92
1050	741.84

Note 1: The P.R.F. is jittered as part of the interference rejection circuit. The Interference Rejection circuit was switched off while making P.R.F. measurements.

7.6. Average Power

Nominal Pulse Width (ns)	Peak Power (kW)	P.R.F. (kHz)	Measured Pulse Width (ns)	Average Power (Watts)
75	5.91562	3.0581	74.850	1.3541
100	6.79204	3.0581	100.798	2.0936
150	8.33681	3.0581	150.699	3.8420
250	9.26830	3.0581	249.501	7.0717
350	9.16220	2.0000	351.297	6.4373
450	9.54993	1.60256	453.094	6.9343
600	9.66051	1.20192	602.794	6.9991
1050	9.90832	0.74184	1049.900	7.7172

Note 1: The previous subsections detail the results required to make the above calculation.

7.7. Variation of frequency with input voltage

7.7.1.The frequency of the EUT was measured at each voltage.

75ns

% of Nominal Volts	Volts (dc)	Measured Frequency (GHz)
85% of 24.0	20.4	9.411944
100% of 24.0	24.0	9.410756
100% of 32.0	32.0	9.410650
115% of 32.0	36.8	9.409731

1050ns

% of Nominal Volts	Volts (dc)	Measured Frequency (GHz)
85% of 24.0	20.4	9.399919
100% of 24.0	24.0	9.399881
100% of 32.0	32.0	9.399819
115% of 32.0	36.8	9.399875

Note: The equipment can be operated from any voltage within the nominal range 24 to 32V without requiring any adjustment. Therefore, the testing was performed from 85% of the lowest to 115% of the highest operating voltage.

7.8. Variation of frequency with temperature

The EUT scanner unit was situated in an environmental test chamber and set for normal operation at the shortest pulse width. The antenna port was connected via a coupler and in-line attenuator to the input of the HP70000 analyser, which is equipped with a precision frequency reference module.
The chamber was then set to –20C. After a 30-minute delay to allow for temperature stabilisation, the EUT frequency was monitored until there was no measurable frequency change. The frequency was recorded. The EUT was then set for normal operation at the longest pulse width, and the frequency monitored until there was no measurable frequency change. The frequency was recorded.
The chamber temperature was then increased by 10C and the process repeated at this temperature and at further increments of 10C up to and including +50C.

75ns

Temperature C	Measured Frequency (GHz)
-20	9.416656
-10	9.416444
0	9.415856
+10	9.415475
+20	9.412781
+30	9.411538
+40	9.409231
+50	9.407700

1050ns

Temperature C	Measured Frequency (GHz)
-20	9.403606
-10	9.403600
0	9.402775
+10	9.401038
+20	9.399450
+30	9.398425
+40	9.396700
+50	9.394869

7.9.Occupied Bandwidth

7.9.1. Plots can be found in Appendix D.

7.9.2. The 99.5% (-23dBc) power bandwidth was measured for each pulse width using the delta function of the HP70000 analyser. Owing to the shape of the pulse it was not always possible to measure the bandwidth at the exact –23db point. Consequently, the next lower point was taken. This has the effect of slightly increasing the measured bandwidth above the actual 99.5% bandwidth.

Nominal Pulse Width (ns)	99.5% Power Bandwidth (MHz)
75	64.40
100	57.20
150	56.90
250	34.70
350	24.81
450	21.07
600	13.88
1050	9.19

7.10. Transmitter Frequency Tolerance

7.10.1. Specification: 80.209(b) – *"When pulse modulation is used in land and ship radar stations operating in the bands above 2.4GHz the frequency at which maximum emission occurs must be within the authorised bandwidth and must not be closer than* ***1.5/T MHz*** *to the upper and lower limits of the authorised bandwidth where "T" is the pulse duration in microseconds."*

7.10.2. Calculation

Authorised Bandwidth: 9300MHz to 9500MHz

Specification Limits: [Lower] 9300 + 1.5/T
[Upper] 9500 - 1.5/T

Transmitter Frequency Tolerances FCC ID PJ5MTX9-S3			
Nominal Pulse Width (ns)	**Actual Pulse Width (ns)**	**Specification Limits (MHz)**	
		Lower	**Upper**
75	75.850	9.31978	9.48022
100	100.798	9.31488	9.48512
150	150.699	9.30995	9.49005
250	249.501	9.30601	9.49399
350	351.297	9.30427	9.49573
450	453.094	9.30333	9.49667
600	602.794	9.30249	9.49751
1050	1049.90	9.30143	9.49857

From examining the transmitter frequency data from the Variation of Frequency with Voltage and Variation of Frequency with Temperature results pages, it can be seen that the transmitter is within the calculated specification.

8. Measurement Uncertainty

6.1 Measurement uncertainty was calculated after reference to CISPR 16-4:2002. In order to determine compliance with the limit for emissions tests, the specification states that, where the calculated uncertainty exceeds the value of Ucispr, the difference in dB is to be added to the instrument reading. The corrections shown in the table below are therefore added to the reported measurements before assessing compliance with the limits.

Measurement Type	Confidence Level (*k* = 2)	Calculated Uncertainty	Ucispr	Correction
Radiated Emissions: Electric Field Strength 30MHz-1GHz	95%	+/- 6.8dB	4.5dB(<300MHz) 5.2dB(>300MHz)	+2.3dB(<300MHz) +1.6dB(>300MHz)
Radiated Emissions: Electric Field Strength 1GHz-26.5GHz	95%	+/- 7.3dB	Under consideration (5.2dB assumed)	+2.1dB
Radiated Emissions: Electric Field Strength 26.5-40GHz	95%	+/-7.6dB	Under consideration (5.2dB assumed)	+2.4dB

Note 1. All test equipment and antennae used for the tests described in this report have current traceable calibration to UKAS or equivalent standard.

Note 2. All reported measurements include the appropriate offsets for antenna factors, coupler and cable losses, etc.

Appendix A. Test Equipment Used

Ref. No.	Device	Manufacturer	Model No.	Serial No.	Last Calibration
013	Dual PSU 0-30V @ 10A	TTI	CPX200	112718	24.10.2002
304	Environmental Chamber	Des.Env. Ltd	BS120-40	11-94-1830	17.12.2002
318	Peak Power Analyser	H-P	8991A	3248A00128	21.10.2002
400	Receiver 9kHz-30MHz	R & S	ESHS-10	840046/014	06.11.2002
401	Receiver 20MHz-1000MHz	R & S	ESVS-10	840241/002	23.12.2002
424	DVM	Fluke	83	63550394	08.05.2002
-------	Analyser 0.1kHz -26.5GHz	H-P	70000 series	As below	-----------------*
425	Display Section	H-P	70004A	3040A01640	03.12.2001
426	I.F. Module	H-P	70902A	3206A03917	03.12.2001
427	I.F. Module	H-P	70903A	2923A02140	03.12.2001
428	L.O. Module	H-P	70900B	3345A01913	03.12.2001
429	External Mixer Interface	H-P	70907B	3533A00576	03.12.2001
430	Mainframe	H-P	70001A	3230A05180	03.12.2001
431	Digitizer Module	H-P	70700A	3716A01071	03.12.2001
432	Precision Freq. Reference	H-P	70310A	3127A02429	03.12.2001
433	RF Module	H-P	70909A	3136A00120	03.12.2001
434	Option 001 Preamplifier	H-P	70620B	3550A00850	03.12.2001
435	Receiver 9kHz-6.5GHz	H-P	8546A	3625A00329	05.11.2002
436	Filter Section	H-P	85460A	3448A00219	05.11.2002
440	PSU 3-15V 25A	Palstar	PS30M	92534722	22.05.2002
442	Antenna 0.09-30MHz	Schaffner	HLA6120	1122	15.11.2001*
479	Peak Power Sensor	H-P	84812A	3318A01050	21.10.2002
482	Antenna 18-26.5GHz	Credowan	20-R-2843-0007	36755	19.08.2002
483	Antenna 26.5-40GHz	Credowan	S.G. Horn	None	19.08.2002
789	Mixer 26.5-40GHz	Agilent	11970A	3003A08859	01.07.2001**
852	Antenna 1.0-18.0GHz	Schwarzbeck	BBHA9120D	128	19.08.2002
968	Antenna 30-300MHz	Schwarzbeck	VHBB9124	9124-285	12.08.2002
969	Antenna 0.3-2.0GHz	Emco	EM6946	112	12.08.2002
EM05	Microwave Cable	Agilent	5061-5458	EMC Cable 5	02.08.2002
EM06	Microwave Cable	Agilent	5061-5458	EMC Cable 6	02.08.2002
EM09	Microwave Cable	Agilent	5061-5458	EMC Cable 9	02.08.2002
EM20	Low-loss RF cable 1.6m	Andrew	243290	EMC Cable 20	12.07.2002
EM21	Low-loss RF cable 1.6m	Andrew	243290	EMC Cable 21	12.07.2002
EM22	Low-loss RF cable 3m	Andrew	A06Y-75513	EMC Cable 22	12.07.2002
RD14	Microwave Coupler	Flann	16270-40-23	116317	02.08.2002
RD21	Inline Attenuator 10dB	Narda	4779-10	8	04.08.2002
RD24	Inline Attenuator 20dB	Narda	4779-20	5	04.08.2002
RD25	Inline Attenuator 20dB	Unknown	R411820	6	04.08.2002
RD27	Inline Attenuator 10dB	Unknown	R411810	7	04.08.2002
RD30	Inline Attenuator 50dB	Narda	4779-50	4	04.08.2002
RD37	Rotary w/g to WG16 Adaptor	Raymarine	LAB5S-7SR	05	02.08.2002
RD40	WG16 to N Adaptor	Flann	16094-NF10	100	02.08.2002
RD42	WG16 to N Adaptor	Mitec Europe	M0926-7-11	3711-2	02.08.2002
RD50	Microwave Power Load	CMT	MPT90-1A	942117-003	Uncalibrated

Test Equipment Used (continued)

Notes:

* 2 year calibration cycle in accordance with manufacturer's recommendations.

** 3 year calibration cycle in accordance with manufacturer's recommendations.

All test equipment, except item RD50, is on a calibration cycle in accordance with UKAS requirements.

Appendix B. Measurement Methods.

B1. Calculating Emissions Limit Lines

B1.1 For both radiated emissions and conducted spurious emissions from the antenna port, with an Assigned Frequency of 9410MHz (Authorised Band 9310 - 9510MHz), the limits close to the magnetron frequency are:

Over the ranges 9210 - 9310MHz and 9510 - 9610MHz: -25dBc
Over the ranges 8910 - 9210MHz and 9610 - 9910MHz: -35dBc

B1.2 To establish the radiated emissions limit for the product on frequencies outside the range 8910 - 9910MHz, the EUT was placed on the test site with the measuring equipment located at a distance of three metres.
The magnetron was disconnected and replaced with a WG16 to N-type coaxial connector adaptor, which was connected to a signal generator with an unmodulated output at 9.4GHz. The rotating joint was connected, via an adaptor and attenuator, to a power meter and sensor.

B1.3 The signal generator was unable to reproduce the actual peak power output of the intentional radiator – measured as 9.90832kW by conducted methods. Consequently, a level of 9.91mW was reproduced at the antenna port, requiring a factor of +60dB to be applied at the analyser.

B1.4 The rotating joint adaptor, attenuator and power measurement equipment were removed and replaced with the 48 inch open array antenna. The antenna was aligned with the horn antenna connected to the spectrum analyser and adjusted to peak the analyser response. A reading of 183.18dBuV/m was obtained. The antenna was then removed and the 72 inch open array antenna fitted, and the measurement procedure was repeated. A reading of 184.89 dBuV/m was obtained.

B1.5 The calculation for the radiated emissions limit line is:

$$183.18 - 43 - 10\log_{10} 7.717 = \mathbf{131.31\ dBuV/m}$$

B1.6 For conducted spurious emissions from the antenna port, the calculation to establish the limit line for frequencies outside the range 8910 - 9910MHz is:

Po(peak)dBm – 43 – $10\log_{10}$ P(mean)watts,

i.e., $69.96 - 43 - 10\log_{10} 7.717 = \mathbf{18.13dBm}$

B2. Radiated Emissions (9 kHz to 2 GHz)

B2.1. Radiated emissions measurements were performed in accordance with the standard, against appropriate limits for a Peak detector.

B2.2. All testing was carried out within a semi-anechoic chamber at a distance of 3m. For all tests, the open array antenna was replaced with a rotating microwave load.

B2.3. Measurements were split into five subranges to accommodate receiver bandwidth and antenna changes. Over each range, the same measurement procedure was used. The antenna was initially set to a height of 1.5m. The receiver was set to step through the appropriate frequency range in “Peak and Hold” mode, with the antenna firstly in vertical polarisation and then in horizontal polarisation. The EUT was then rotated clockwise through 90 degrees, then 180 degrees and finally 270 degrees, with the measurement process repeated at each 90 degree point, thus building up a profile of peak emissions. Emissions of significance were noted. For each of these emissions, the antenna polarisation was changed to give the higher reading; the turntable was then rotated through 360 degrees to find the area of the EUT radiating the highest level and, for frequencies above 30MHz, the antenna height was then varied between 1 and 4m above the groundplane to further maximise the signal before remeasurement.

B2.4. Measurements above 30MHz were performed using broadband antennas. Below 30MHz, a magnetic loop antenna was used.

B3. Radiated Emissions 2 GHz to 6.5 GHz

B3.1 Radiated emissions measurements were performed using a horn antenna, against appropriate limits for a Peak detector.

B3.2 All testing was carried out within a semi-anechoic chamber at a distance of 3m. The conducting groundplane between the antenna and the EUT was covered with ferrite and pyramidal absorbing material. For all tests, the open array antenna was replaced with a rotating microwave load.

B3.3 The horn antenna was set to a height of 1.5m. The analyser was set to sweep through the appropriate frequency range in “Max Hold” mode, with the antenna firstly in vertical polarisation and then in horizontal polarisation. The EUT was then rotated clockwise through 90 degrees, then 180 degrees and finally 270 degrees, with the measurement process repeated at each 90 degree point, thus building up a profile of peak emissions. Emissions of significance were noted. For each of these emissions, the antenna polarisation was changed to give the higher reading; the turntable was then rotated through 360 degrees to find the area of the EUT radiating the highest level.

B4. Radiated Emissions 6.5 GHz to 40 GHz

B4.1. Radiated emissions measurements were performed against appropriate limits for a Peak detector. All measurements were carried out using horn antennas.

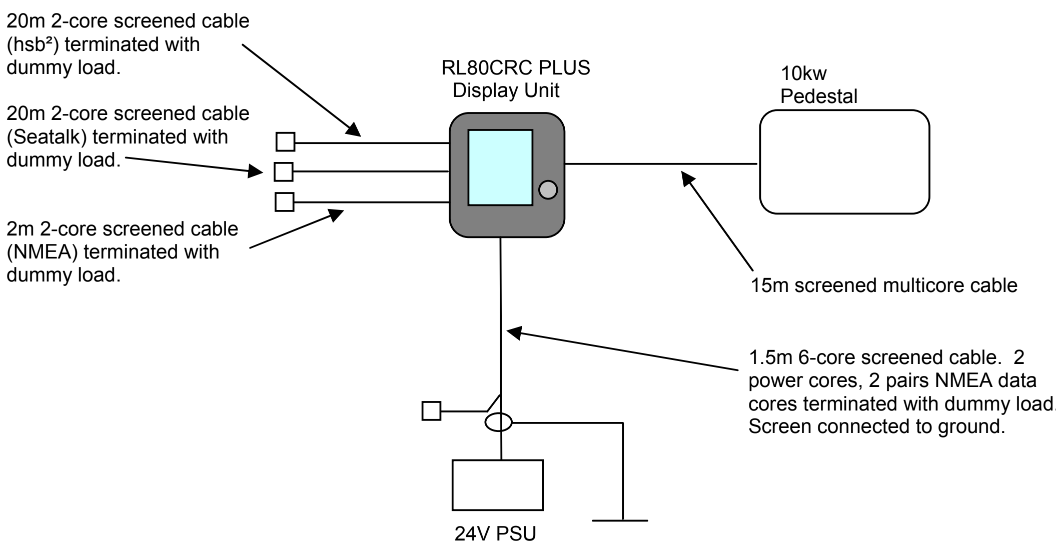
B4.2. All testing was carried out within a semi-anechoic chamber at a distance of 3m. The conducting groundplane between the antenna and the EUT was covered with ferrite and pyramidal absorbing material. For all tests, the open array antenna was replaced with a rotating microwave load.

B4.3. Measurements were split into subranges to accommodate antenna and mixer changes. Over each range, the same measurement procedure was used. The antenna was set to a height of 1.5m. The analyser was set to sweep through the appropriate frequency range in “Max Hold” mode, with the antenna in vertical polarisation. The EUT was slowly rotated clockwise through 360 degrees and then back to 000 degrees, thus building up a profile of peak emissions. The antenna was then changed to horizontal polarisation and the process continued. Emissions of significance were noted. For each of these emissions, the antenna polarisation was changed to give the higher reading; the turntable was then rotated to find the area of the EUT radiating the highest level. Measurements within 20dB of the limit line were recorded.

Appendix C. Test Configuration Drawings

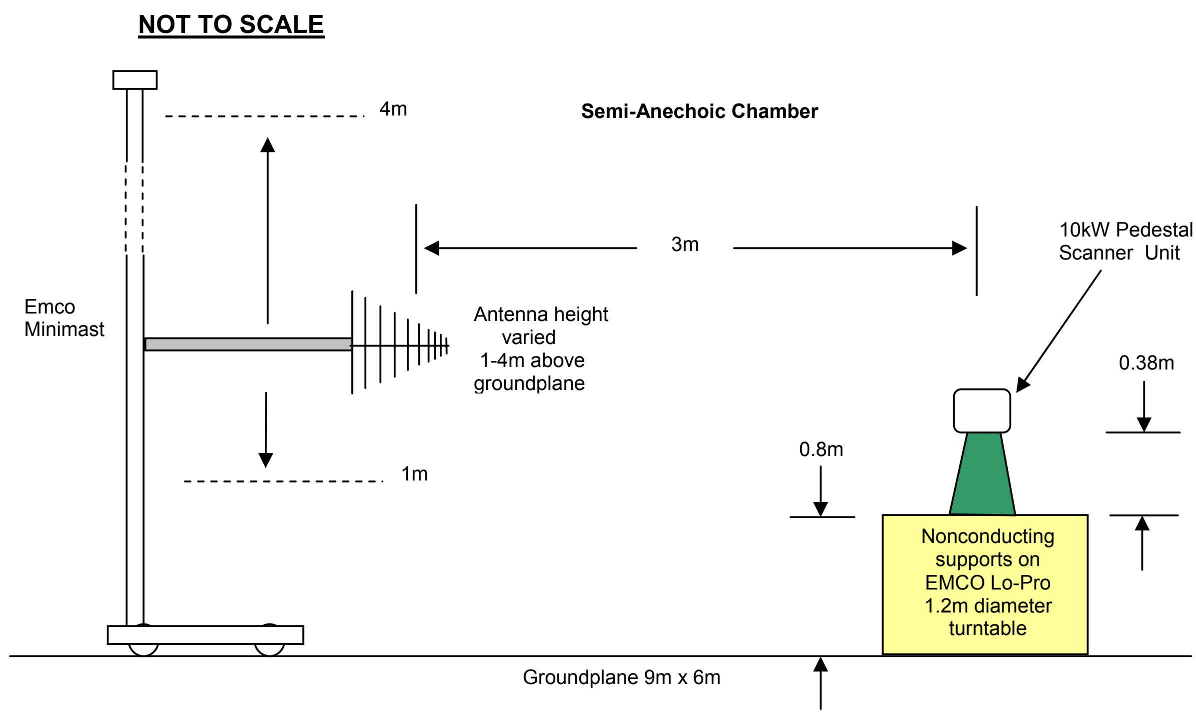
The scanner and display unit were arranged in as near a representative configuration as was practicable. The display unit, interface leads and excess scanner interconnection cable were placed upon a non-conducting support on the turntable such that the surface of the support was 0.8m above the groundplane. For tests below 1GHz, the scanner unit was placed centrally above the display unit on a non-conducting support 0.38m high. Above 1GHz, this support was increased to 0.5m, aligning the magnetron and circulator assembly height with the receiving horn antenna. The power/NMEA IN lead was connected to a 24V power supply placed on the turntable; the screen of this cable was connected to the groundplane. The Seatalk, HSB and NMEA Out cables, terminated with dummy loads, were bundled with 0.4m loops and placed around the display unit. The scanner interconnection cable was coiled around the scanner support. Due to its size and construction, this cable cannot be bundled in the same manner as the other cables.

C.1. Connection diagram

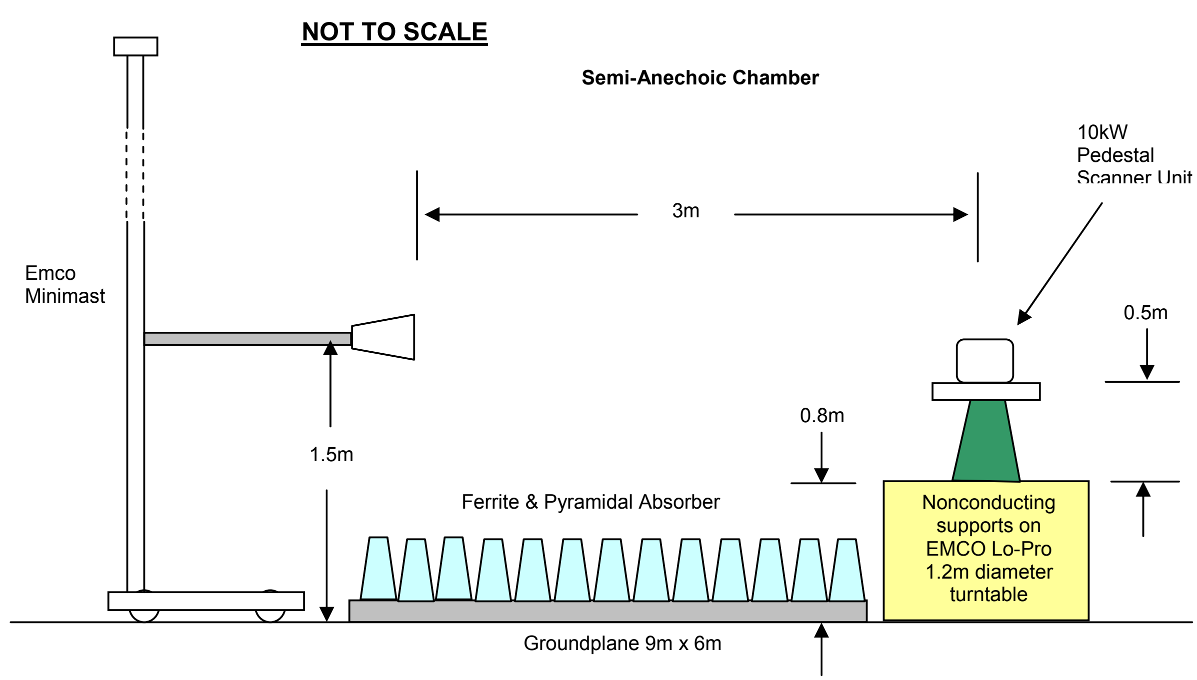


C2. Radiated Emissions Setup – General Arrangement

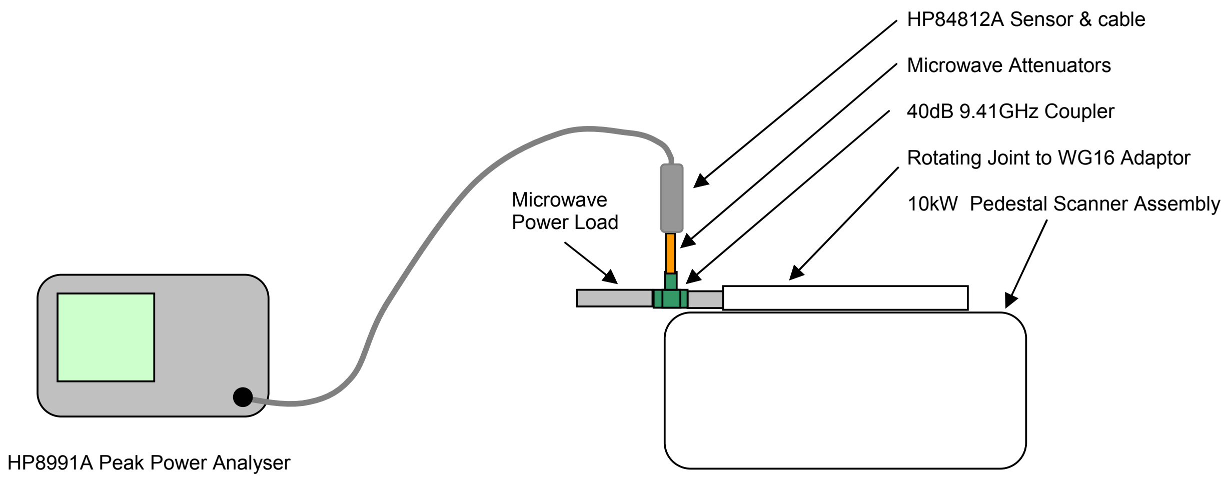
C.3. Radiated Emissions 9 kHz to 2 GHz – General Arrangement



C.4. Radiated Emissions 2GHz to 40 GHz – General Arrangement



C.5. Power, Pulsewidth and P.R.F. Measurements – General Arrangement



C.6. Occupied Bandwidth, Frequency Variation & Antenna Port Conducted Emissions – General Arrangement