



TEST REPORT

EMC DEPARTMENT
RAYMARINE LTD

Test of: Raymarine Ltd.
Pathfinder RL74CRC HB PLUS

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

(Leisure Marine Radar Equipment)

Test Report Serial No. 555/1001

| | |
|--|--|
| <p>This Test Report is issued under the authority of: Chris Bird, Approvals Manager</p> <p><i>Chris Bird</i></p> | <p>Checked By: P. Pitt</p> <p><i>P. D. Pitt</i></p> |
| <p>Tested By: P. Bowen</p> <p><i>P. Bowen</i></p> | |
| <p>Issue Date:</p> <p>29th October, 2002</p> | <p>Test Dates:</p> <p>11th October to to 28th October 2002</p> |

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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 |

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2. Equipment Under Test (EUT)

2.1. Identification of Equipment Under Test (EUT)

| | |
|------------------------------------|--|
| Brand Name: | Raymarine |
| Model Name or Number: | 'Pathfinder' RL74CRC HB PLUS (Comprised of a Scanner with micropatch antenna and a Display Unit/Chartplotter) |
| Unique Type Identification: | 4D 4kW Scanner with 24" patch antenna M92652 RL70CRC HB Plus Display/Chartplotter E52034 |
| Serial Number: | Scanner Unit: EMC210 Display/Chartplotter: EMC201 |
| Country of Manufacture: | England, U.K. |
| FCC ID Number: | PJ5MTX4-S3 |
| Date of Receipt: | 2 nd September, 2002 |

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: 4kW X-band transmitter with 24 inch microstrip patch array antenna.
 Display Unit: 7 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.

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2.4. Additional information related to Testing

| | |
|--|---|
| Power Supply Requirement: | Nominal 12-24V DC supply |
| Intended Operating Environment: | Leisure Marine & Small Workboats |
| Weight: | Scanner: 7.5kg (16.5lbs) Display 3.5kg (7.7lbs) |
| Dimensions: | Scanner: 599mm dia x 227mm height Display: : w 223mm x h 205mm x d 152mm |
| Interface Ports: | Power and 2 x NMEA in Seataik NMEA out hsb ² |

2.5. Support Equipment

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

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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 and meeting the NSA +/-4dB criterion with antenna height scanning from 1 – 4 metres. |
| 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 1 st 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

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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.

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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 12V 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, 1.4kHz PRF. This mode is defined as being likely to be the worst case as regards EMC. Additionally, the longest and shortest pulse widths (1000ns 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, 1.4kHz PRF. This mode is defined as being likely to be the worst case as regards EMC. Additionally, the longest and shortest pulse widths (1000ns 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 (1000ns pulse width).

5.2.4. Transmitter power, pulsewidth 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 12V 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.

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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 1000 | 2.1046(a) and 80.215(a) | Complied |

6.1.3.2. Average Power

| Nominal Pulsewidth Range (ns) | Specification Reference | Compliance Status |
|-------------------------------|-------------------------|-------------------|
| 75 to 1000 | 2.1046(a) and 80.215(a) | Complied |

6.1.3.3. Pulse Width

| Nominal Pulsewidth Range (ns) | Specification Reference | Compliance Status |
|-------------------------------|-------------------------|-------------------|
| 75 to 1000 | 2.1046(a) and 80.215(a) | Complied |

6.1.3.4. PRF

| Nominal Pulsewidth Range (ns) | Specification Reference | Compliance Status |
|-------------------------------|-------------------------|-------------------|
| 75 to 1000 | 2.1047(d) and 80.213(g) | Complied |

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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. 1000ns

| Nominal Pulsewidth (ns) | Specification Reference | Compliance Status |
|-------------------------|-------------------------|-------------------|
| 1000 | 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. 1000ns

| Nominal Pulsewidth (ns) | Specification Reference | Compliance Status |
|-------------------------|-------------------------|-------------------|
| 1000 | 2.1055(a and b) | Complied |

6.1.6. Occupied Bandwidth

| Nominal Pulsewidth Range (ns) | Specification Reference | Compliance Status |
|-------------------------------|-------------------------|-------------------|
| 75 to 1000 | 2.1049(i) and 80.205 | Complied |

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6.1.7. Transmitter Frequency Tolerance

| Nominal Pulswidth Range (ns) | Specification Reference | Compliance Status |
|-------------------------------------|--------------------------------|--------------------------|
| 75 to 1000 | 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 50dBuV/m.
- 7.2.1.3. Details of the limit line calculation can be seen in Appendix B (B1.1 – B1.5).

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7.2.2. Electric Field Strength Measurements: Frequency Range 30 MHz to 1000 MHz

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

7.2.2.2. The following table lists frequencies at which emissions were measured using a Quasi-Peak detector. All peak levels were less than 55dBuV/m

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

| Frequency (MHz) | Antenna Polarization | QP Level (dBuV/m) | Limit (dBuV/m) | Margin (dB) | Result |
|------------------------|-----------------------------|--------------------------|-----------------------|--------------------|---------------|
| 165.22 | Horizontal | 33.4 | 106.2 | 72.8 | Complied |
| 228.03 | Vertical | 34.1 | 106.2 | 72.1 | Complied |
| 266.04 | Vertical | 41.8 | 106.2 | 64.4 | Complied |
| 504.76 | Vertical | 44.7 | 106.2 | 61.5 | Complied |
| 864.34 | Vertical | 38.2 | 106.2 | 68.2 | Complied |

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7.2.3. Electric Field Strength Measurements: Frequency Range: 1GHz to 40GHz

7.2.3.1. Plots of measurements using a peak detector can be found in Appendix D. Plots of the scans can be found in Appendix D.

7.2.2.2. The following table lists frequencies at which emissions were measured using Peak detector functions, and were found to be less than 20dB from the limit line. Levels which were found to be greater than 20dB below the limit line were not recorded.

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

| Frequency (GHz) | Antenna Polarization | Peak Level (dBuV/m) | Peak Limit (dBuV/m) | Margin (dB) | Result |
|------------------------|-----------------------------|----------------------------|----------------------------|--------------------|---------------|
| 18.80 | Vertical | 102.6 | 106.2 | 3.6 | Complied |
| 28.21 | Vertical | 87.1 | 106.2 | 19.1 | Complied |
| 28.89 | Vertical | 87.6 | 106.2 | 18.6 | Complied |
| 35.984 | Vertical | 92.7 | 106.2 | 13.5 | Complied |

7.3 Conducted Emissions

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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 floor 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 1000ns, measurements were performed within and around the transmitter frequency allocation.

450ns Pulse

| Frequency (GHz) | Level (dBm) | Limit (dBm) | Margin (dB) | Result |
|-----------------|-------------|-------------|-------------|----------|
| 8.888 | -24.5 | -13 | 11.5 | Complied |
| 18.81 | -20.6 | -13 | 7.6 | Complied |
| 28.20 | -27.9 | -13 | 14.9 | Complied |
| 37.47 | -25.3 | -13 | 12.3 | Complied |

75ns Pulse

| Frequency (GHz) | Level (dBm) | Limit (dBc) | Margin (dB) | Result |
|-----------------|-------------|-------------|-------------|----------|
| 9.3099 | 1.7 | -25 | 15.3 | Complied |
| 9.5104 | -17.1 | -25 | 34.1 | Complied |

1000ns Pulse

| Frequency (GHz) | Level (dBm) | Limit (dBc) | Margin (dB) | Result |
|-----------------|-------------|-------------|-------------|----------|
| 9.3099 | 2.1 | -25 | 14.9 | Complied |
| 9.5242 | -16.2 | -25 | 33.2 | Complied |

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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 | 63.12 | 2051.16 |
| 100 | 63.99 | 2506.11 |
| 150 | 64.35 | 2722.70 |
| 250 | 64.91 | 3097.42 |
| 350 | 65.27 | 3365.12 |
| 450 | 65.27 | 3365.12 |
| 600 | 65.47 | 3523.71 |
| 1000 | 65.47 | 3523.71 |

Note 1: Power is measured at the antenna port and is less than the nominal 4kW 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 | 78.842 |
| 100 | 101.796 |
| 150 | 154.691 |
| 250 | 259.481 |
| 350 | 359.281 |
| 450 | 455.090 |
| 600 | 608.783 |
| 1000 | 1041.92 |

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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. (kHz) |
|------------------|-----------------------|
| 75 | 3.06748 |
| 100 | 3.06748 |
| 150 | 3.06748 |
| 250 | 3.06748 |
| 350 | 2.00000 |
| 450 | 1.50150 |
| 600 | 1.30378 |
| 1000 | 0.74184 |

Note 1: As the P.R.F. is jittered, the average interval between pulses was measured in order to determine the P.R.F.

7.6. Average Power

| Nominal Pulse Width (ns) | Peak Power (kW) | P.R.F. (kHz) | Measured Pulse Width (ns) | Average Power (Watts) |
|--------------------------|-----------------|--------------|---------------------------|-----------------------|
| 75 | 2.05116 | 3.06748 | 78.842 | 0.496 |
| 100 | 2.50611 | 3.06748 | 101.796 | 0.783 |
| 150 | 2.72270 | 3.06748 | 154.691 | 1.292 |
| 250 | 3.09742 | 3.06748 | 259.481 | 2.465 |
| 350 | 3.36512 | 2.00000 | 359.281 | 2.418 |
| 450 | 3.36512 | 1.50150 | 455.090 | 2.299 |
| 600 | 3.52371 | 1.30378 | 608.783 | 2.797 |
| 1000 | 3.52371 | 0.74184 | 1041.92 | 2.724 |

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

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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 12.0 | 10.2 | 9.406875 |
| 100% of 12.0 | 12.0 | 9.406994 |
| 100% of 24.0 | 24.0 | 9.406781 |
| 115% of 24.0 | 27.6 | 9.406338 |

1000ns

| % of Nominal Volts | Volts (dc) | Measured Frequency (GHz) |
|---------------------------|-------------------|---------------------------------|
| 85% of 12.0 | 10.2 | 9.403431 |
| 100% of 12.0 | 12.0 | 9.403606 |
| 100% of 24.0 | 24.0 | 9.403381 |
| 115% of 24.0 | 27.6 | 9.403300 |

Note: The equipment can be operated from any voltage within the nominal range 12 to 24V without requiring any adjustment. Therefore, the testing was performed from 85% of the lowest to 115% of the highest operating voltage.

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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 | 9.418344 |
| -10 | 9.415856 |
| 0 | 9.414706 |
| +10 | 9.410444 |
| +20 | 9.410381 |
| +30 | 9.407550 |
| +40 | 9.404138 |
| +50 | 9.401606 |

1000ns

| Temperature C | Measured Frequency (GHz) |
|---------------|--------------------------|
| -20 | 9.414175 |
| -10 | 9.411419 |
| 0 | 9.409975 |
| +10 | 9.407013 |
| +20 | 9.405800 |
| +30 | 9.402394 |
| +40 | 9.401431 |
| +50 | 9.398956 |

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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 and bandwidth marker 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 | 51.80 |
| 100 | 41.13 |
| 150 | 33.94 |
| 250 | 24.75 |
| 350 | 20.70 |
| 450 | 14.21 |
| 600 | 12.34 |
| 1000 | 6.76 |

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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 PJ5MTX4-S3 | | | |
|---|--|-----------------------------------|--------------|
| Nominal Pulse Width (ns) | Actual Pulse Width (ns) | Specification Limits (MHz) | |
| | | Lower | Upper |
| 75 | 78.842 | 9319.03 | 9480.97 |
| 100 | 101.796 | 9314.74 | 9485.26 |
| 150 | 154.691 | 9309.70 | 9490.30 |
| 250 | 259.481 | 9305.78 | 9494.22 |
| 350 | 359.281 | 9304.18 | 9495.83 |
| 450 | 455.090 | 9303.30 | 9496.70 |
| 600 | 608.783 | 9302.46 | 9497.54 |
| 1000 | 1041.92 | 9301.44 | 9498.56 |

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.

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8. Measurement Uncertainty

- 8.1 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 U_{cispr} , 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 | U_{cispr} | 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.

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Appendix A. Test Equipment Used

| Ref. No. | Device | Manufacturer | Model No. | Serial No. | Last Calibration |
|----------|----------------------------|--------------|----------------|--------------|------------------|
| 013 | Dual PSU 0-30V @ 10A | TTI | CPX200 | 112718 | Uncalibrated* |
| 304 | Environmental Chamber | Des.Env. Ltd | BS120-40 | 11-94-1830 | Uncalibrated** |
| 318 | Peak Power Analyser | H-P | 8991A | 3248A00128 | 29.10.2001 |
| 400 | Receiver 9kHz-30MHz | R & S | ESHS-10 | 840046/014 | 06.11.2002 |
| 401 | Receiver 20MHz-1000MHz | R & S | ESVS-10 | 840241/002 | 07.11.2002 |
| 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 | 13.11.2001 |
| 436 | Filter Section | H-P | 85460A | 3448A00219 | 13.11.2001 |
| | | | | | |
| 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 | 30.10.2001 |
| 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 |
| EM04 | Microwave Cable | Agilent | 5061-5458 | EMC Cable 4 | 02.08.2002 |
| EM08 | Microwave Cable | Agilent | 5061-5458 | EMC Cable 8 | 02.08.2002 |
| EM14 | Microwave Cable | Agilent | 5061-5458 | EMC Cable 14 | 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 | | 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 |
| RD33 | Rotary w/g to N Adaptor | Raymarine | LAB2D-4DR | 02 | 02.08.2002 |
| RD36 | Rotary w/g to WG16 Adaptor | Raymarine | LAB2D-4DF | 04 | 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 | Mitec Europe | M0929-7-11 | 6689/1 | Uncalibrated |
| RD90 | Thermocouple Module | Fluke | 80TK | R90 | 23.10.2001 |

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Test Equipment Used (continued)

Notes: * Temperature settings monitored using Items 424 and RD90.

** Voltages set using Item 424.

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

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

Appendix B. Measurement Methods.

B1. Calculating Radiated Emissions Limit Line

B1.1 In defining the 106.2dBuV/m limit for the product, the EUT was placed on the test site with the measuring equipment located at a distance of three metres.

B1.2 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 3.523kW by conducted methods. Consequently, a level of 3.523mW 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 24 inch microstrip patch antenna. The patch antenna was aligned with the horn antenna connected to the spectrum analyser and adjusted to peak the analyser response. A reading of 184.69dBuV/m was obtained.

B1.5 The calculation for the limit line is: $184.69 - 43 - 10\log_{10} 3523 = 106.22\text{dBuV/m}$

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 24" patch 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 the antenna height was then varied between 1 and 4m above the groundplane to further maximise the signal before remeasurement.

B2.4. All measurements were performed using broadband antennas.

B3. Radiated Emissions 2 GHz to 40 GHz

B3.1. Radiated emissions measurements were performed in accordance with the standard, 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 24" patch antenna was replaced with a rotating microwave load.

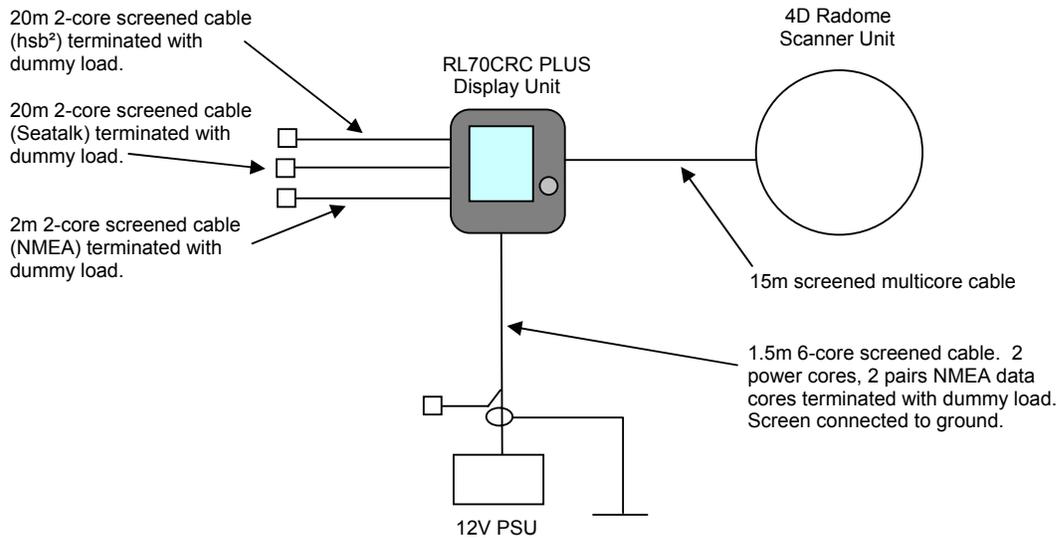
B3.3. Measurements were split into subranges to accommodate antenna and mixer changes. Over each range, the same measurement procedure was used. The antenna was set to a height of 1.5m. The analyser was set to sweep through the appropriate frequency range in "Peak and Hold" mode, with the antenna in 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.

B3.4. All measurements were performed using horn antennas.

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 0.65m, aligning the magnetron and circulator assembly height with the receiving horn antenna. The power/NMEA IN lead was connected to a 12V power supply placed on the turntable; the screen of this cable was connected to the groundplane. The Seataalk, 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



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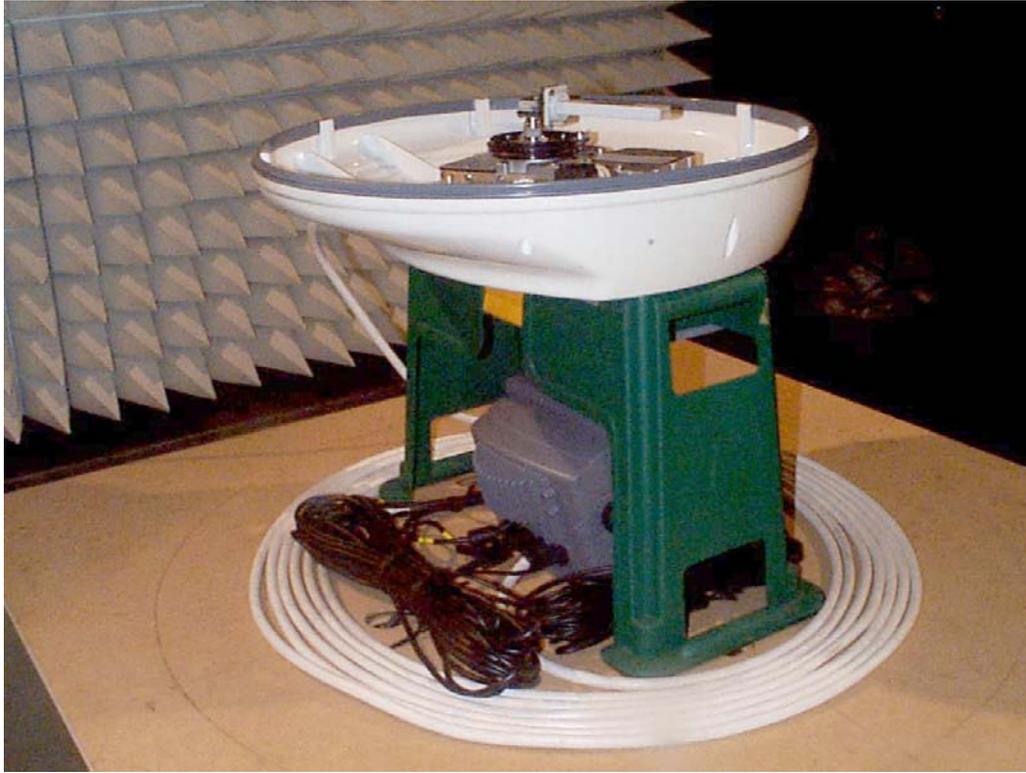
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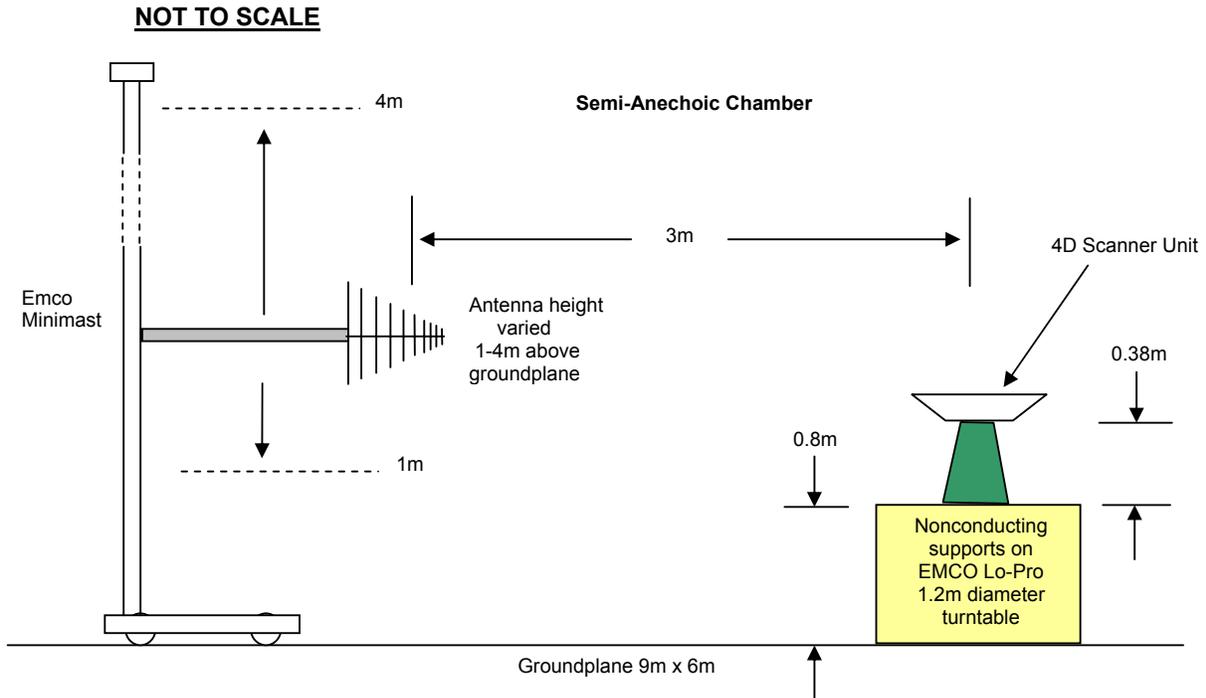
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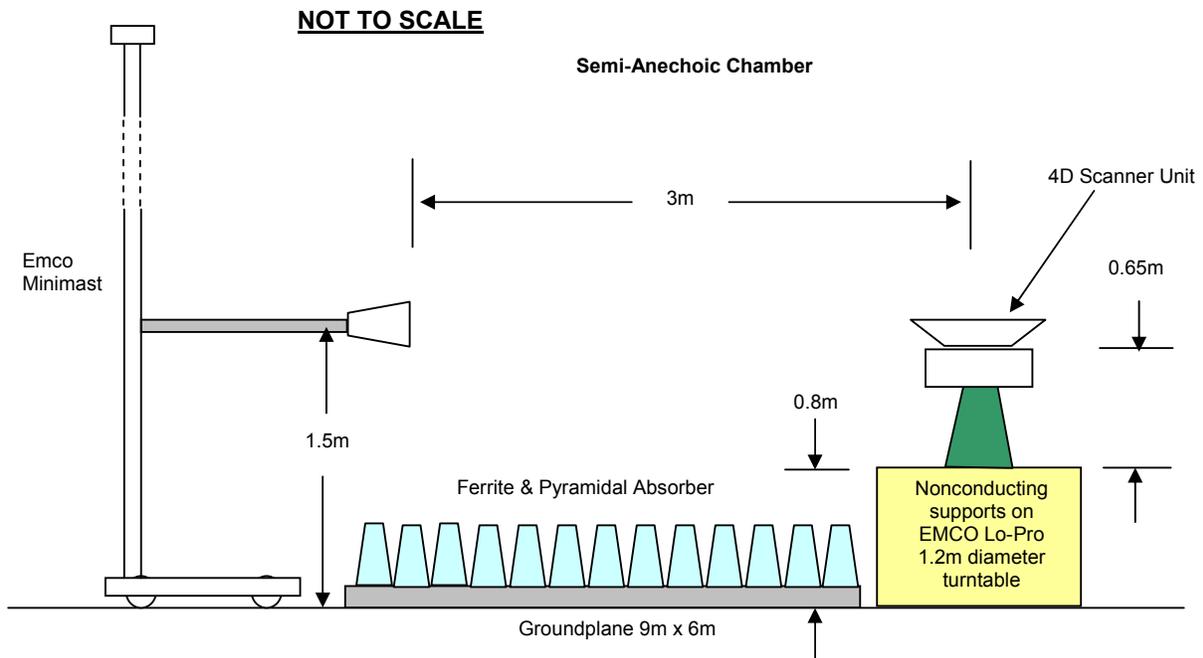
C2. Radiated Emissions Setup – General Arrangement



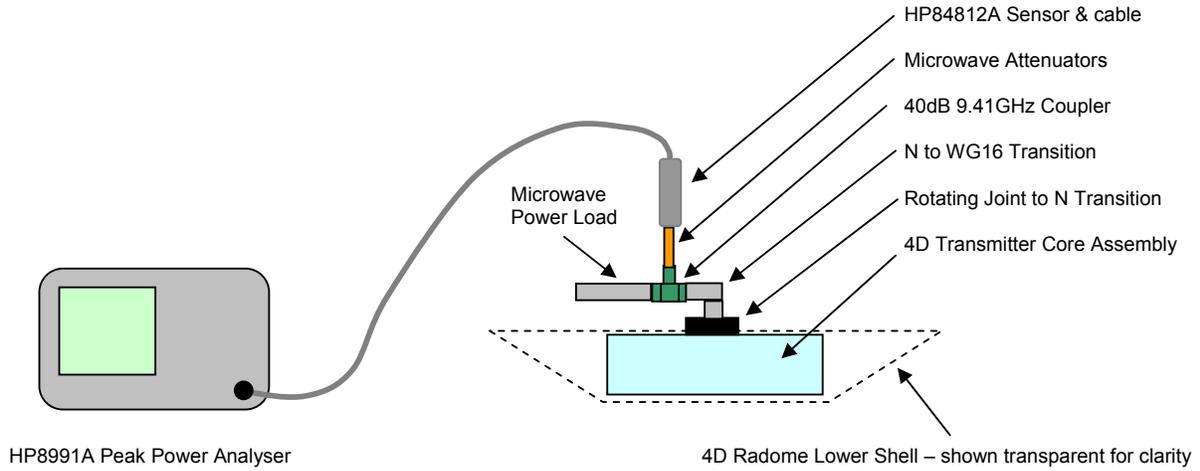
C.3. Radiated Emissions 9 kHz to 1 GHz – General Arrangement



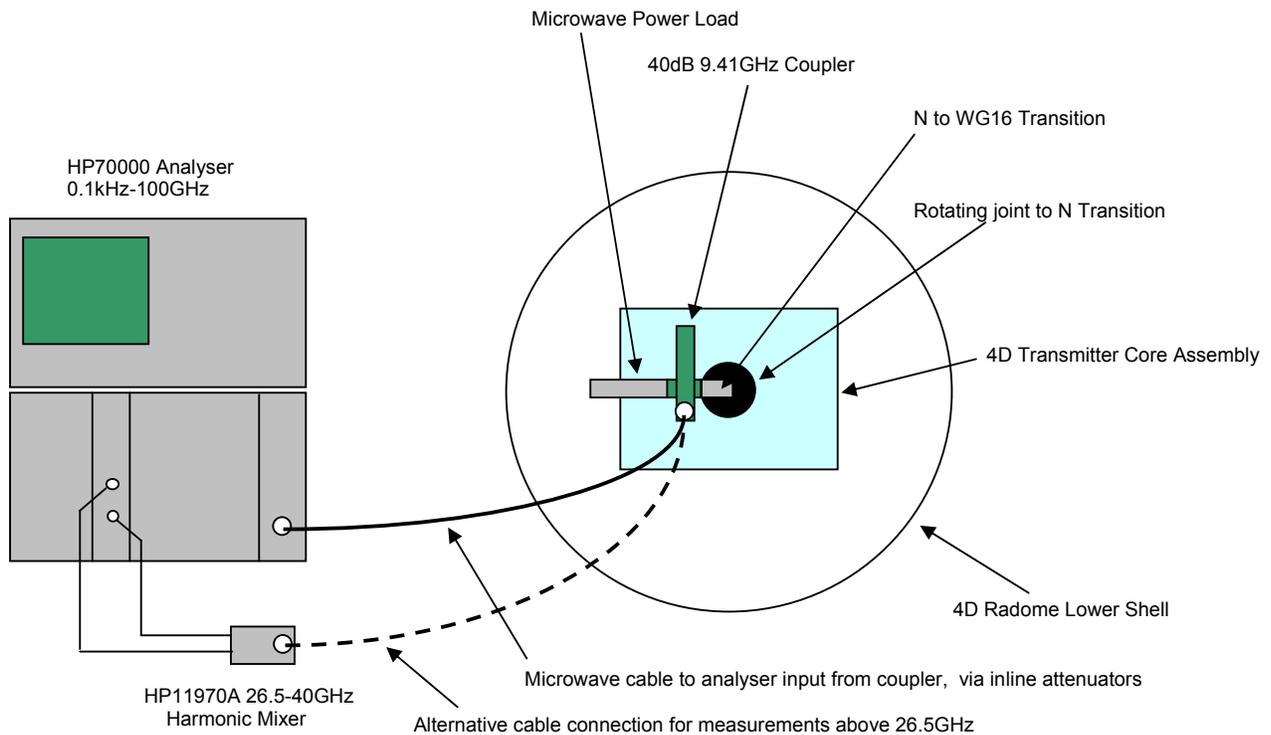
C.4. Radiated Emissions 1GHz to 40 GHz – General Arrangement



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



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



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