# TEST REPORT

# EMC DEPARTMENT

# RAYMARINE UK LTD

## Test of: Raymarine UK Ltd.
## 12kW Digital Radar with 6ft Open Array

**To: FCC Part 80: 2007**
**and FCC Part 2: 2007**

**(Leisure Marine Radar Equipment)**

**Test Report Serial No. 649/1087**

| | |
|---|---|
| Checked By: **Mike Thompson**<br>  <br>EMC Engineer | Approved By: **Peter Bowen**<br>  <br>Compliance Manager |
| Tested By: Michael Howes | Author: **Michael Howes**<br>  <br>EMC Engineer |
| **Issue Date:**<br>**15th February, 2008** | **Test Dates:**<br>**11th February to 13th February 2008** |

## Table of Contents

# 1 Client Information

| | |
|---|---|
| **Company Name** | Raymarine UK Ltd. |
| **Address:** | Robinson Way<br>Anchorage Park<br>Portsmouth<br>Hampshire<br>PO3 5TD<br>England, U.K. |
| **Contact Name:** | Mr. P. Bowen, Compliance Manager |

# 2 Equipment Under Test (EUT)

## 2.1 Identification of Equipment Under Test (EUT)

| | | |
|---|---|---|
| **Brand Name:** | Raymarine | |
| **Model Name or Number:** | 12kW Open Array Digital Radar | |
| **Unique Type Identification:** | 12kW Super High Definition Pedestal | E52082 |
| **Serial Number:** | 12kW Super High Definition Pedestal | EMC071219a |
| | Voltage Converter Module | EMC071219c |
| **Country of Manufacture:** | Hungary | |
| **FCC ID Number:** | FCC ID: PJ5-DP12KW | |
| **Date of Receipt:** | 19th December 2007 | |

## 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: 12kW X-band transmitter with 6ft open array antenna.
Display Unit: Compatible with E Series and G Series
Voltage Converter Module

## 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 12-24V DC supply |
| **Intended Operating Environment:** | Leisure Marine & Small Workboats |
| **Weight:** | 12kW Pedestal (72" OA): 29kg (63.9lbs) |
| **Dimensions:** | 12kW Pedestal: 412mm x 324mm x 402mm |
| **Interface Ports:** | Combined Power and Network |

## 2.5 Support Equipment

Support equipment used throughout test:

| **Item** | **Unique Type Identification & Serial Number** |
|---|---|
| E120 Display | EMC071219d |
| Seatalk$^{HS}$ Switch | EMC081104a |
| Compaq Laptop | LT1367 |

# 3 Test Specification, Methods and Procedures

## 3.1 Test Specification

| | |
|---|---|
| **Reference:** | FCC Part 80: 2007 and FCC Part 2: 2007 |
| **Title:** | Code of Federal Regulations, Part 80 (47CFR): 2007<br>Stations in the maritime services<br><br>Code of Federal Regulations, Part 2 (47CFR): 2007<br>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 C63.4-2003, being a 3m test range within a semi-anechoic chamber, with antenna height scanning from 1 – 4 metres and meeting the +/-4dB NSA criterion. It is registered with the FCC under the 2.948 (47CFR) listing procedure with Reference Number 970522. |
| **Purpose of Test:** | To demonstrate compliance of the 12kW Open Array Digital Radar to the appropriate clauses of Parts 2 and 80 of the FCC Rules. |

## 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 C63.4-2003
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 C63.5-2006
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

None.

# 5 Operation of the EUT during Testing

## 5.1 Operating Conditions

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)

2. During testing, the EUT was powered by a nominal 12V DC supply.

## 5.2 Operating Modes

The EUT was tested in the following operating modes:

1. Radiated emissions: Transmitting into a rotating non-reflective load with the transmitter set to 75, 450 and 1000ns pulse widths.

## 5.3 Configuration and peripherals

1. The 12kW Pedestal was powered via the Voltage Converter Module. The Pedestal was connected to a Seatalk$^{HS}$ Switch with the standard cable of 15m length. The Seatalk$^{HS}$ Switch was also connected to an E120 display unit with a standard 10m CAT 5 network cable. A transmit dummy load was connected to the radar antenna port. A 12V DC supply was connected to the Radar, Seatalk$^{HS}$ Switch and Display Unit.

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

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 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 UK Ltd., Robinson Way, Anchorage Park, Portsmouth, Hampshire PO3 5TD, England, U.K.

# 7 Measurements, Examinations and Derived Results

## 7.1 General Comments

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

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

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 Measurements: Frequency Range 9 kHz to 30 MHz

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

No emissions exceeded a level of 55dBuV/m.

Details of the limit line calculation can be seen in Appendix B.

### 7.2.2 Electric Field Measurements: Frequency Range 30 MHz to 2000 MHz

Plots of measurements can be found in Appendix D.

The highest peak levels measured were less than 55dBuv/m

Details of the limit line calculation can be seen in Appendix B.

### 7.2.3 Electric Field Measurements: Frequency Range: 2GHz to 40GHz

The following table lists frequencies at which significant emissions were measured using Peak detector functions.

Details of the limit line calculation can be seen in Appendix B.

Plots of measurement scans can be found in Appendix D.

| Frequency (GHz) | Antenna Polarization | Level (dBuV/m) | Limit (dBuV/m) | Margin (dB) | Result |
|---|---|---|---|---|---|
| 18.848 | Vertical | 111.36 | 131.69 | 20.33 | Complied |
| 28.267 | Vertical | 106.43 | 131.69 | 25.26 | Complied |

# 8 Measurement Uncertainty

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)<br><br>5.2dB(>300MHz) | +2.3dB(<300MHz)<br><br>+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. | Next Cal Due |
|---|---|---|---|---|---|
| 318 | Peak Power Analyser | HP | 8991A | 3248A00128 | 01/10/2008 |
| 1721 | Receiver | Rohde & Schwarz | ESU 40 | 100017 | 23/10/2008 |
| 886 | Receiver | Rohde & Schwarz | ESI 26 | 832692/006 | 08/01/2008 |
| 424 | DVM | Fluke | 83 | 63550394 | 02/10/2008 |
| 1520 | Microwave Sig. Gen. 0.01-40GHz | Rohde & Schwarz | SMR40 | 10-300074685 | 02/10/2008* |
| 440 | PSU 3-15V 25A | Palstar | PS30M | 92534722 | Not Reqd *** |
| 442 | Antenna 0.09-30MHz | Schaffner | HLA6120 | 1122 | 11/02/2010* |
| 482 | Antenna 18-26.5GHz | Credowan | 20-R-2843-0007 | 36755 | 29/09/2008** |
| 483 | Antenna 26.5-40GHz | Credowan | S.G. Horn | None | 29/09/2008** |
| 1719 | Antenna 1.0-18.0GHz | Schwarzbeck | BBHA9120D | 578 | 20/10/2008* |
| 1802 | Antenna 30-2000MHz | Chase | CBL6141A | 22932 | 04/12/2008* |
| n/a | Microwave Cable | Agilent | 5061-5458 | EMC Cable 6 | As Required |
| n/a | Microwave Cable | Agilent | 5061-5458 | EMC Cable 11 | As Required |
| RD14 | Microwave Coupler | Flann | 16270-40-23 | 116317 | As Required |
| n/a | Inline Attenuator 10dB | Narda | MOD 768-10 | 47 | As Required |
| n/a | Inline Attenuator 10dB | Narda | MOD 768-10 | 75 | As Required |
| n/a | Inline Attenuator 10dB | Suhner | 6810.17.B | 13 | As Required |
| n/a | WG16 to N Adaptor | Flann | 16094-NF10 | 100 | As Required |
| n/a | Microwave Power Load | Mitec Europe | EM2190 | 3731-1 | As Required |
| n/a | Microwave Power Load | n/a | n/a | EMC Coupler 1 | Not Required |

**Notes**:

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

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

*** Voltage monitored using Item 424

All test equipment, except cables, wave guide components and attenuators, are on a calibration cycle in accordance with UKAS requirements. Items marked calibration as required are calibrated during the test setup using the R&S ESU40 receiver and SMR40 signal generator (under ESU40 control as a pseudo-tracking generator).

# Appendix B Measurement Methods.

## B.1 Calculating Emissions Limit Lines

For both radiated emissions and conducted spurious emissions from the antenna port, with an Assigned Frequency of 9410MHz (Authorised Band 9310 - 9500MHz), 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

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.

The signal generator was unable to reproduce the actual peak power output of the intentional radiator – measured as 11.9kW by conducted methods. Consequently, a level of 11.9mW was reproduced at the antenna port, requiring a factor of +60dB to be applied at the analyser.

The rotating joint adaptor, attenuator and power measurement equipment were removed and replaced with a 6ft 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 184.79dBuV/m was obtained.

The calculation for the radiated emissions limit line is:

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

184.79 – 43 – $10\log_{10}$ 10.22 = **131.69dBuV/m**

## B.2 Radiated Emissions (9 kHz to 2 GHz)

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

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.

Measurements were split into five sub ranges 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 ground plane to further maximise the signal before remeasurement.

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

## B.3 Radiated Emissions 2 GHz to 40 GHz

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

All testing was carried out within a semi-anechoic chamber at a distance of 3m. The conducting ground plane 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.

Measurements were split into sub ranges to accommodate antenna 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 12kW Pedestal and Voltage Converter Module were arranged in as near a representative configuration as was practicable. The display unit, which is not directly part of the test, was placed on the turntable floor. The Pedestal, VCM100 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 ground plane. 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 lead was connected to a 12V power supply; the screen of this cable was connected to the ground plane. The radar interconnection cable was coiled around the Pedestal support. Due to its size and construction, this cable cannot be bundled.

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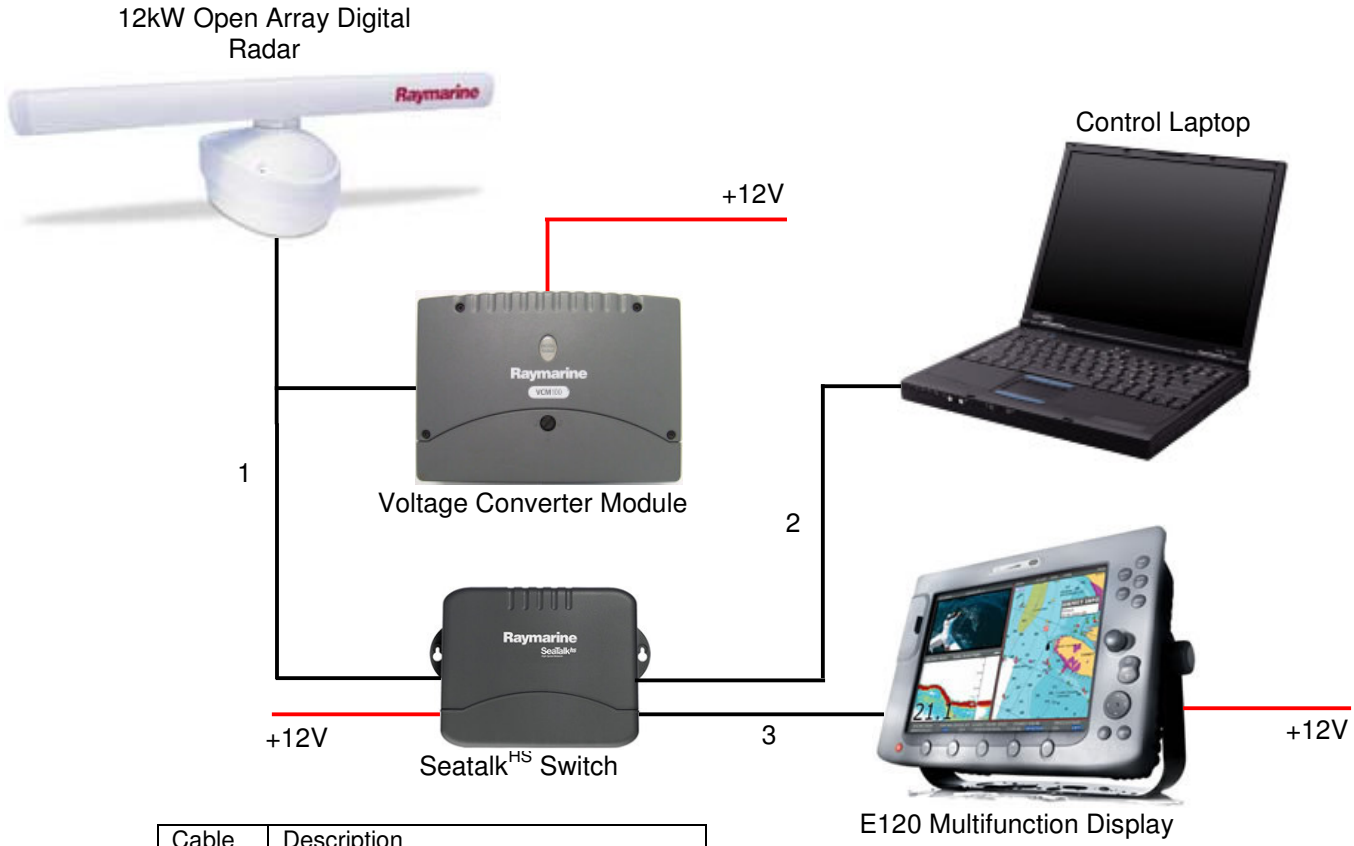
## Connection diagram

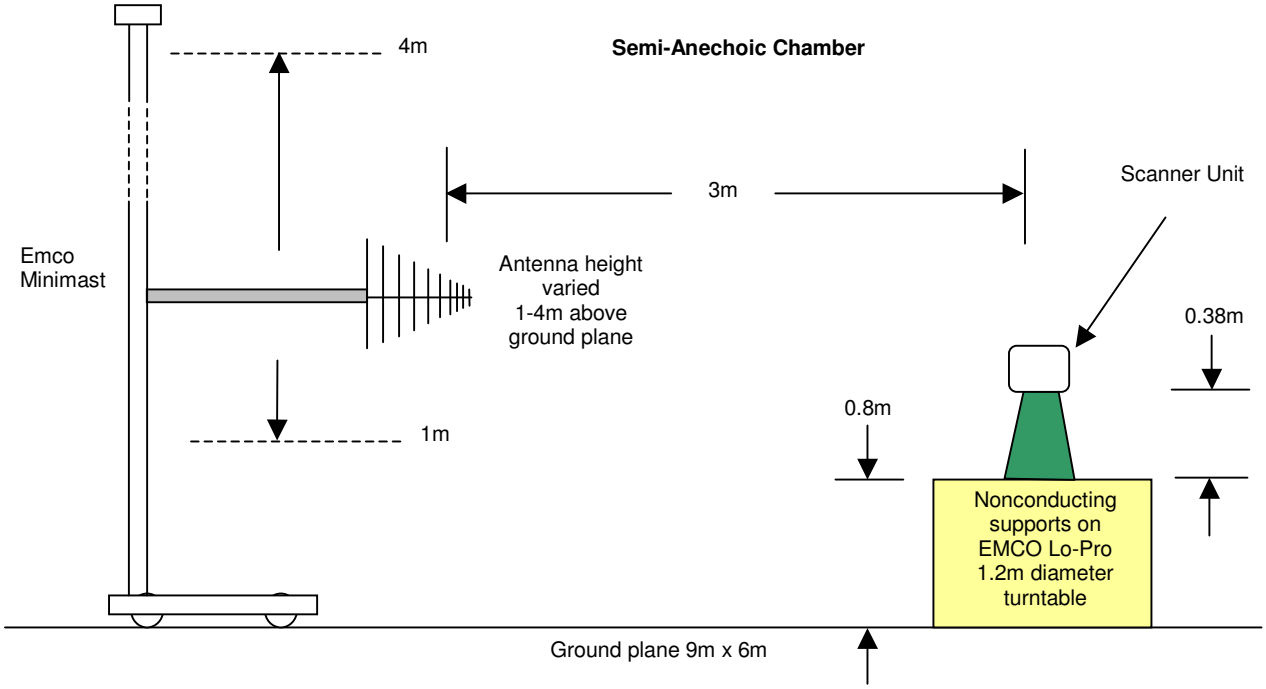



| Cable | Description |
|---|---|
| 1 | 15m Combined Ethernet/Power cable |
| 2,3 | 10m CAT 5 Ethernet cable |

## C.1 Radiated Emissions Setup – General Arrangement

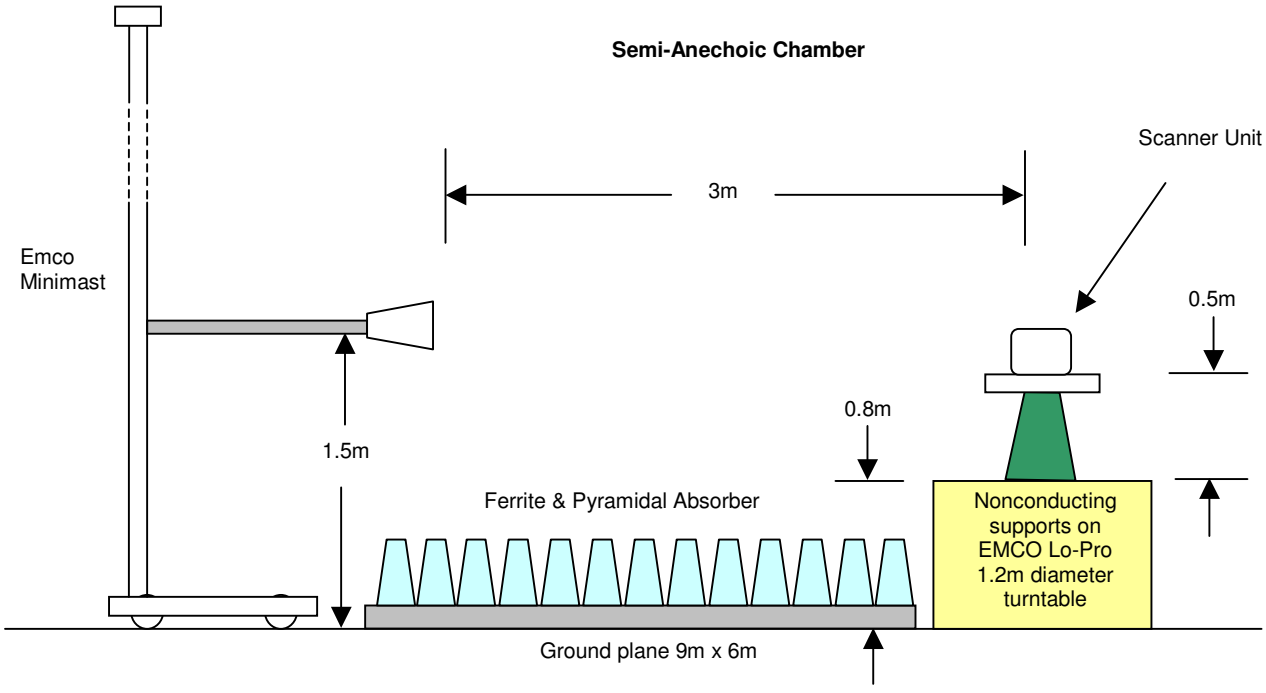
## C.2 Radiated Emissions 9 kHz to 2 GHz – General Arrangement

**NOT TO SCALE**




## C.3 Radiated Emissions 2GHz to 40 GHz – General Arrangement

**NOT TO SCALE**



# Appendix D Graphical Test Results

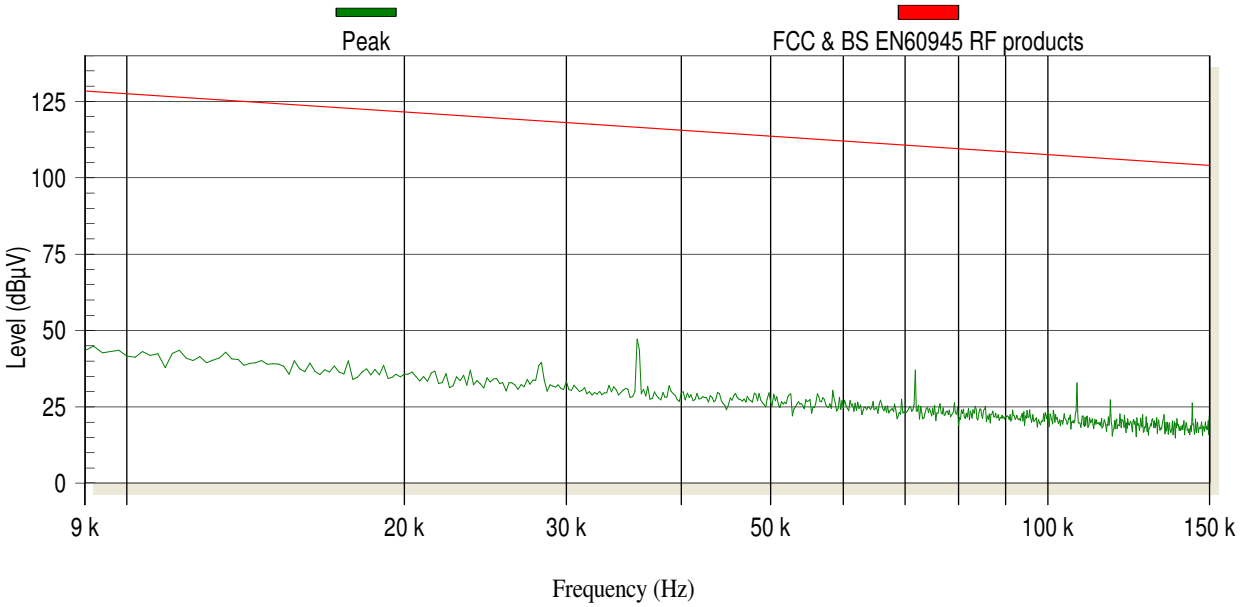



**Figure 1 Radiated Emissions 9kHz to 150kHz Loop Face on**

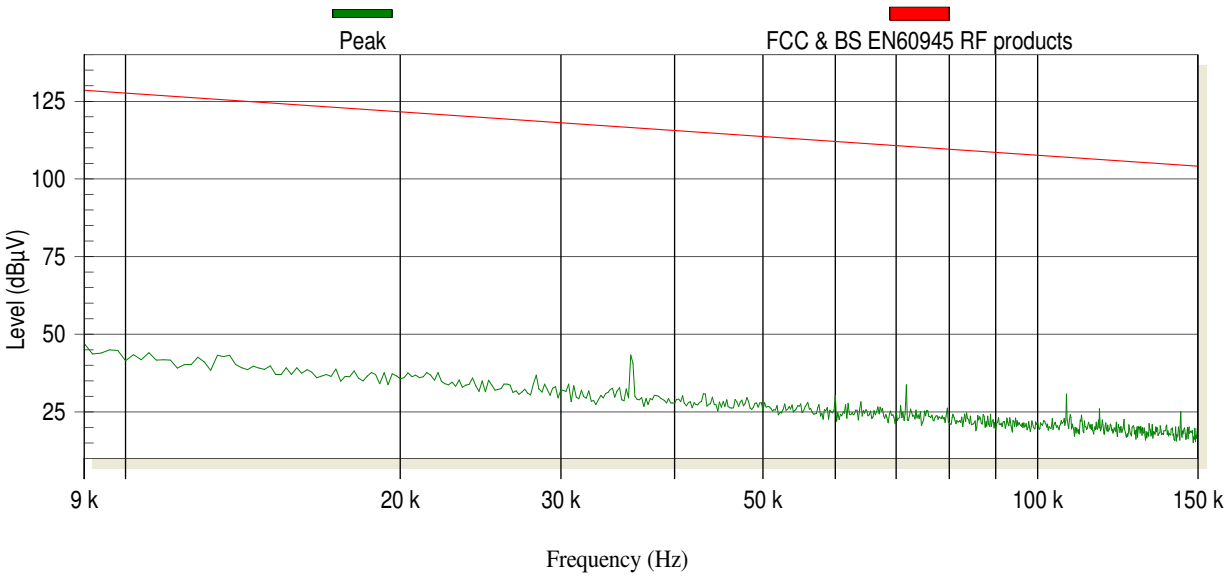



**Figure 2 Radiated Emissions 9kHz to 150kHz Loop Side on**

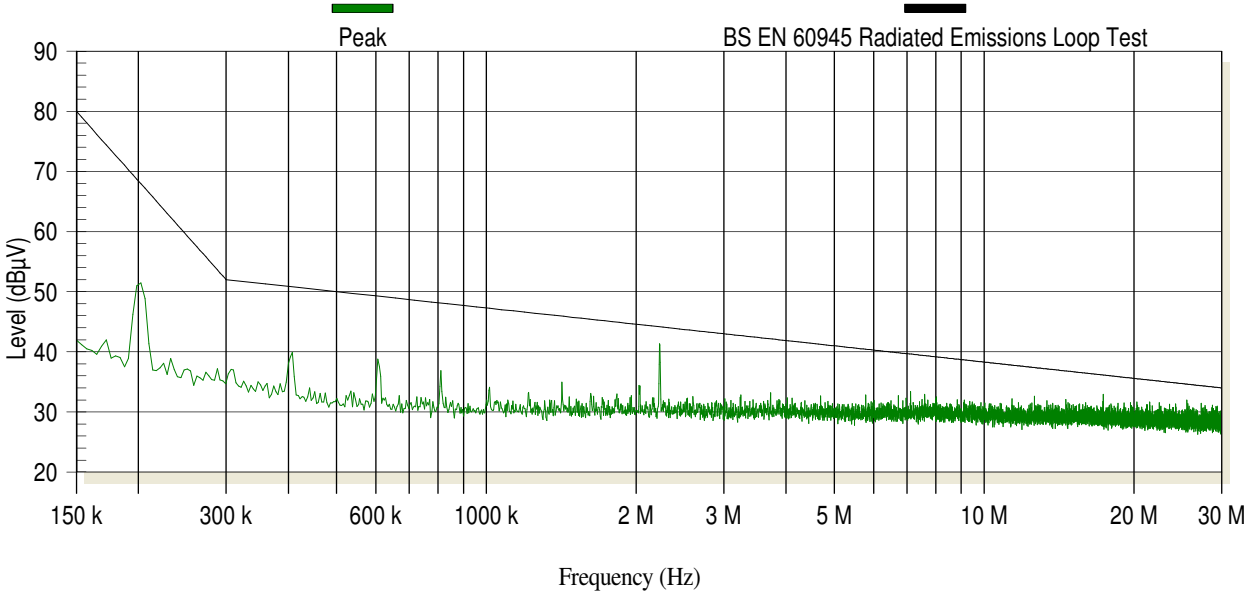



**Figure 3 Radiated Emissions 150kHz to 30MHz Loop Side on**

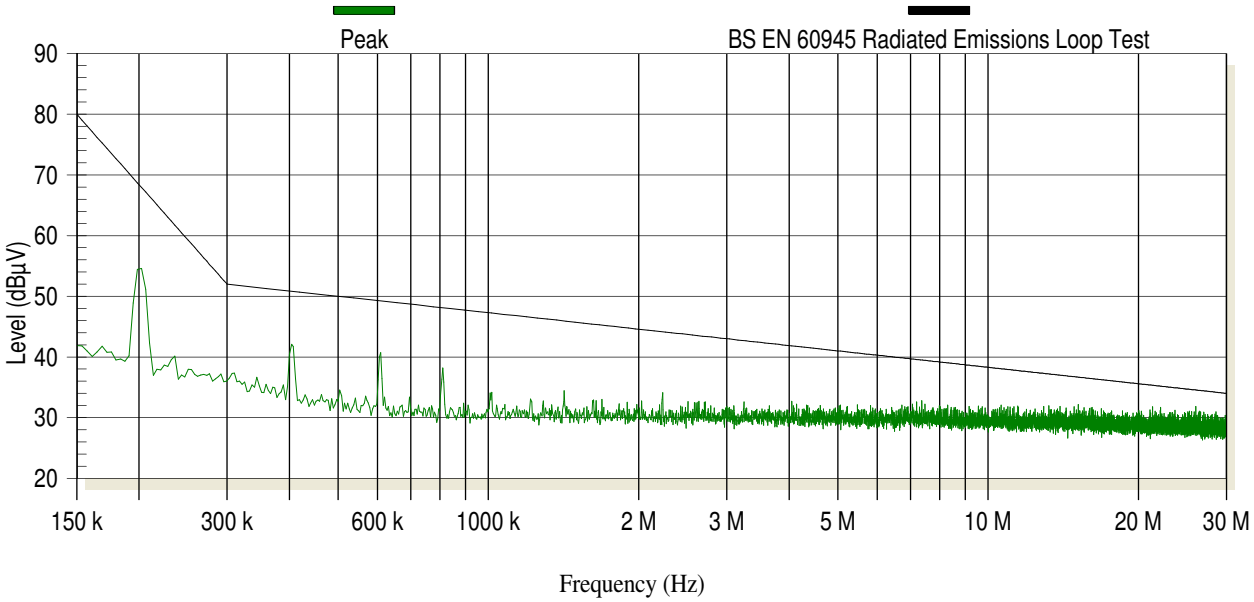



**Figure 4 Radiated Emissions 150kHz to 30MHz Loop Face On**

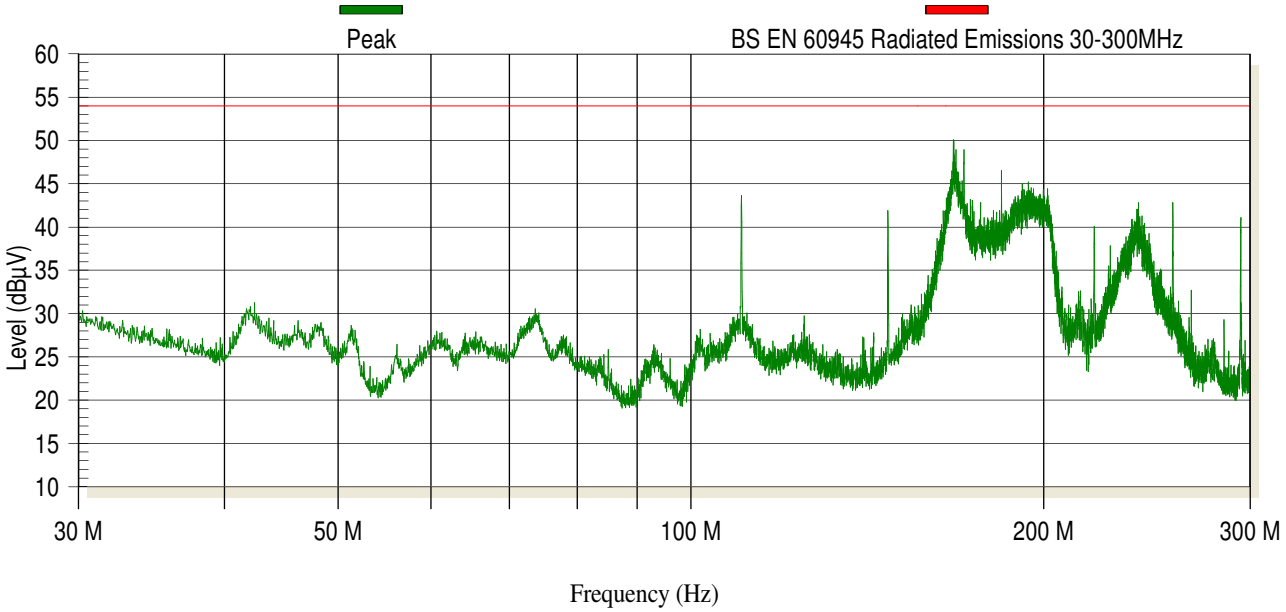



**Figure 5 Radiated Emissions 30MHz to 300MHz**

| Frequency (MHz) | Angle | Polarisation | Height (m) | QP Level (dBµV/m) | QP Margin (dB) |
|---|---|---|---|---|---|
| 166.767 | 157.5 | V | 2.4 | 39.2 | -14.77 |
| 167.43 | 0 | H | 1.5 | 37.3 | -16.7 |
| 167.612 | 150 | V | 2.3 | 40.7 | -13.29 |
| 167.998 | 120 | V | 2.2 | 40.6 | -13.38 |
| 168.245 | 145 | V | 2.3 | 41.7 | -12.34 |
| 168.483 | 125 | V | 2.6 | 41.1 | -12.95 |
| 168.974 | 157.5 | V | 2.8 | 41 | -13.03 |
| 169.34 | 135 | V | 2.2 | 40 | -13.97 |
| 170.995 | 140 | V | 2.7 | 49.3 | -4.7 |
| 184.081 | 120 | V | 2 | 41.4 | -12.57 |

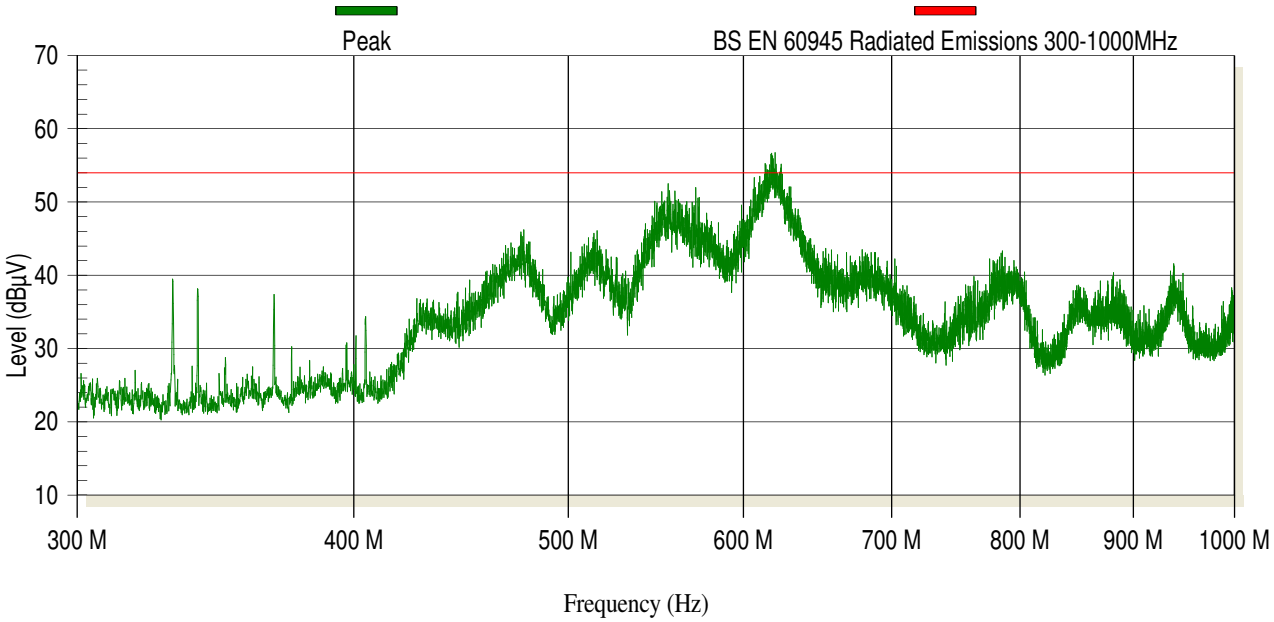



**Figure 6 Radiated Emissions 300MHz to 1GHz**

| Frequency (MHz) | Angle | Polarisation | Height (m) | QP Level (dBµV/m) | QP Margin (dB) |
|---|---|---|---|---|---|
| 613.636 | 320 | V | 1.5 | 46.4 | -7.6 |
| 614.645 | 325 | V | 1.5 | 45.9 | -8.14 |
| 615.219 | 315 | V | 1.5 | 47.1 | -6.89 |
| 617.5 | 315 | V | 1.5 | 47.5 | -6.48 |
| 618.021 | 315 | V | 1.5 | 47.3 | -6.66 |
| 618.702 | 315 | V | 1.5 | 47.6 | -6.4 |
| 619.36 | 315 | V | 1.5 | 47.8 | -6.22 |
| 619.829 | 325 | V | 1.5 | 47.4 | -6.64 |
| 622.206 | 315 | V | 1.5 | 46.8 | -7.25 |
| 623.085 | 315 | V | 1.5 | 46.3 | -7.71 |

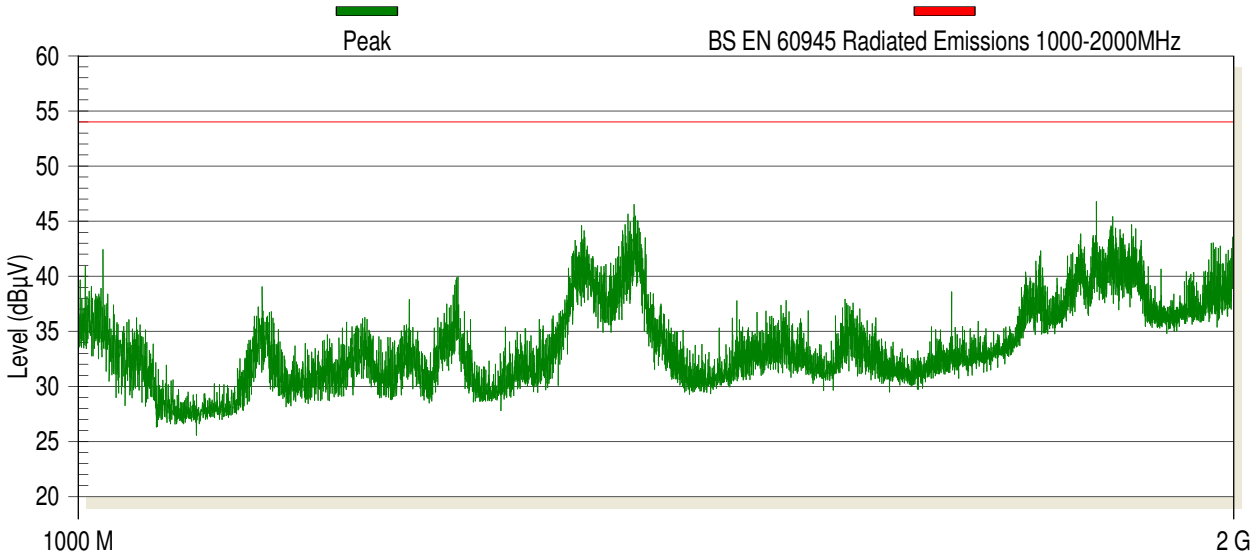



**Figure 7 Radiated Emissions 1GHz to 2GHz**

| Frequency (MHz) | Angle | Polarisation | Height (m) | QP Level (dBµV/m) | QP Margin (dB) |
|---|---|---|---|---|---|
| 1389.278 | 222.5 | V | 1.6 | 36.9 | -17.07 |
| 1392.075 | 227.5 | V | 2 | 37.2 | -16.8 |
| 1393.077 | 225 | V | 2.1 | 37.1 | -16.89 |
| 1393.436 | 222.5 | V | 1.9 | 37.6 | -16.44 |
| 1395.114 | 227.5 | V | 1.5 | 36.7 | -17.29 |
| 1396.064 | 237.5 | V | 1.5 | 36.9 | -17.07 |
| 1397.181 | 227.5 | V | 1.5 | 37.8 | -16.18 |
| 1399.259 | 225 | V | 1.5 | 37 | -16.97 |
| 1841.144 | 90 | V | 2.5 | 35.9 | -18.13 |
| 1857.194 | 315 | V | 1.5 | 35.6 | -18.39 |

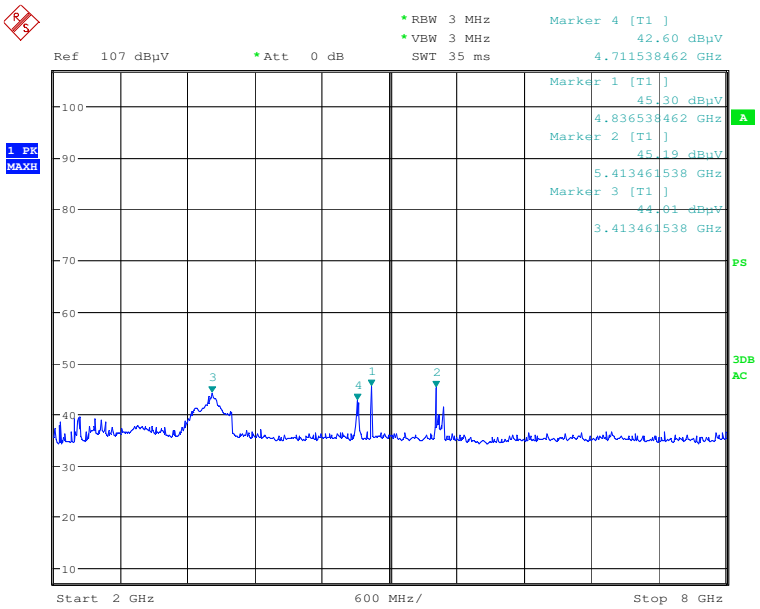



**Figure 8 Radiated Emissions 450ns Pulse width 2GHz to 8GHz**

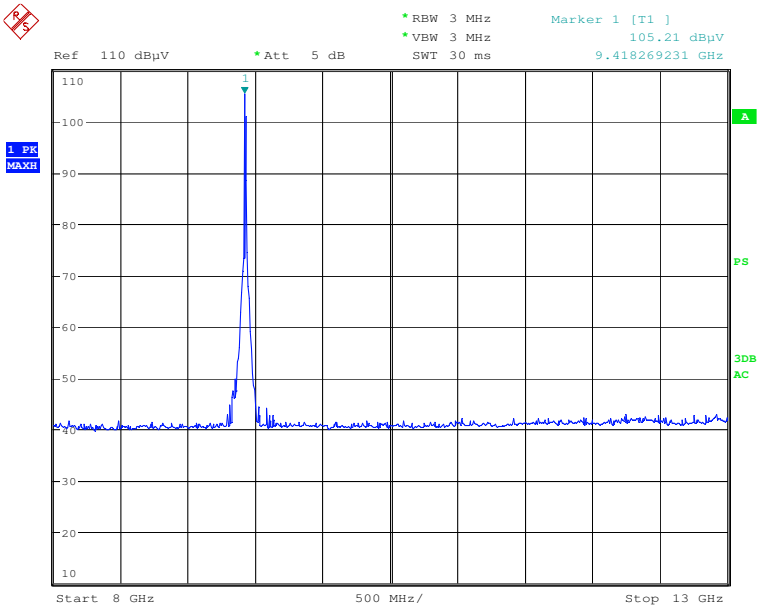



**Figure 9 Radiated Emissions 1000ns Pulse width 8GHz to 13GHz**

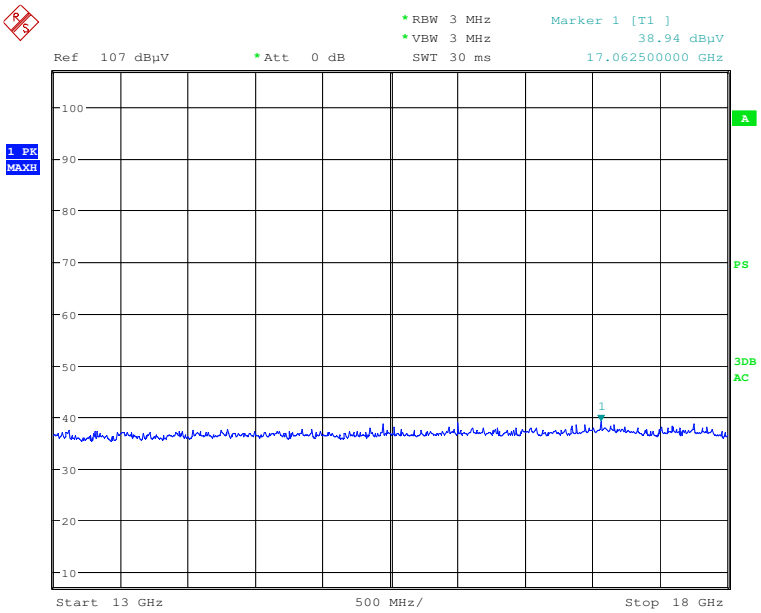



**Figure 10 Radiated Emissions 450ns Pulse width 13GHz to 18GHz**

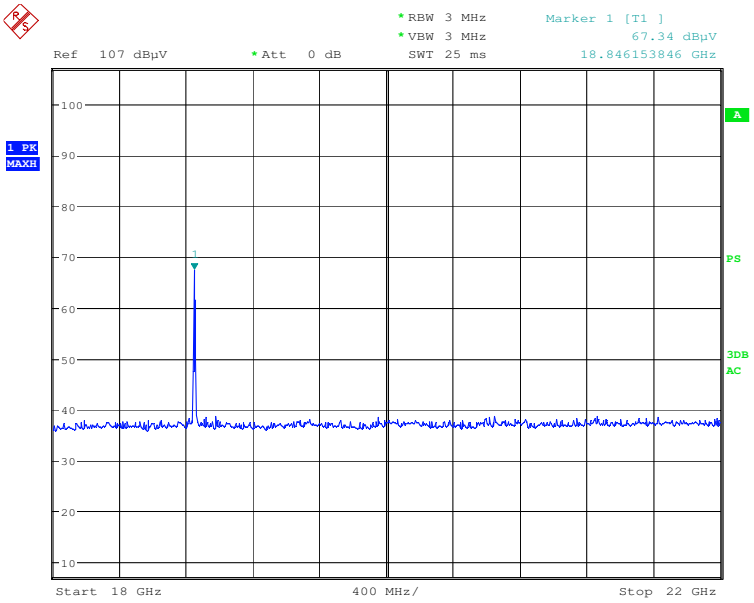



**Figure 11 Radiated Emissions 450ns Pulse width 18GHz to 22GHz**

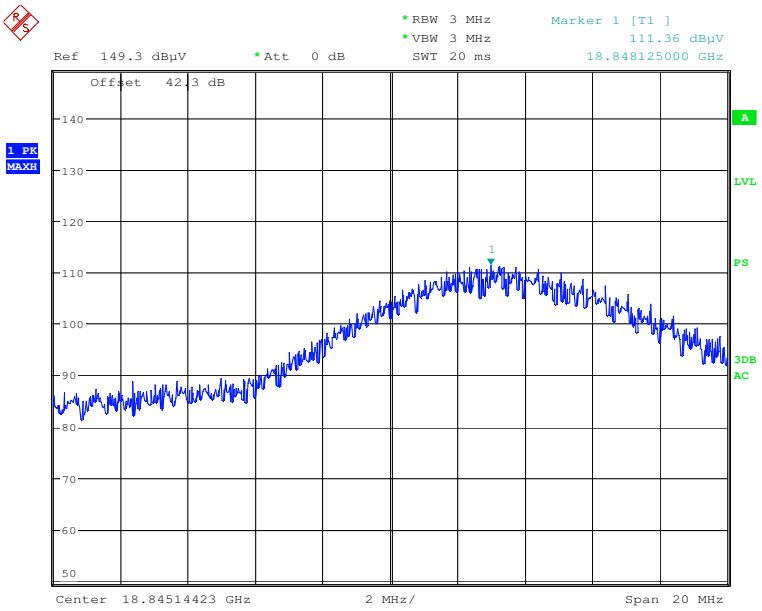



**Figure 12 Radiated Emissions 450ns Pulse width 18.8GHz**

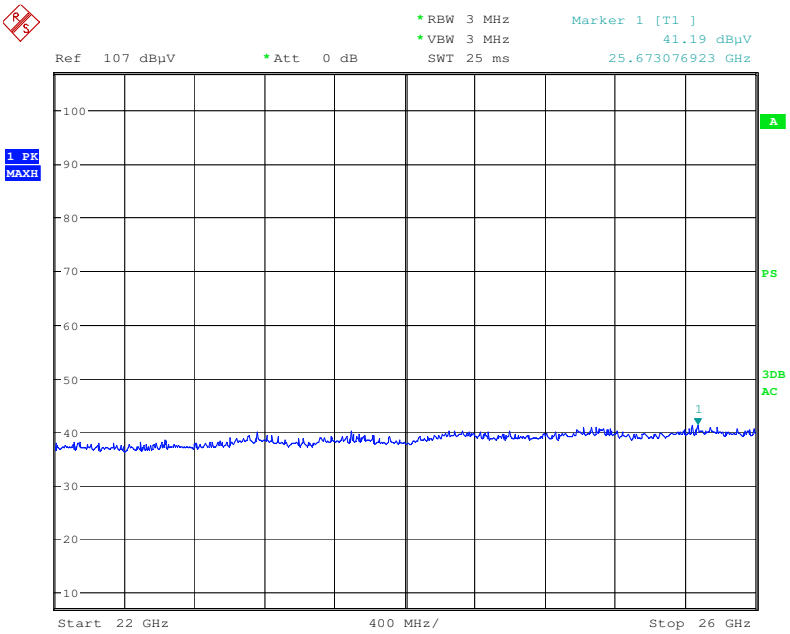



**Figure 13 Radiated Emissions 1000ns Pulse width 22GHz to 26GHz**

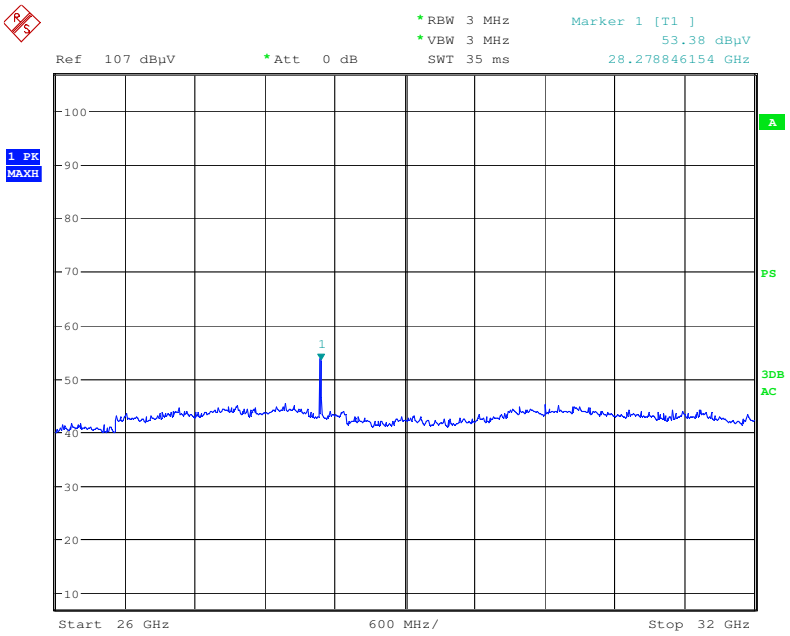



**Figure 14 Radiated Emissions 1000ns Pulse width 26GHz to 32GHz**

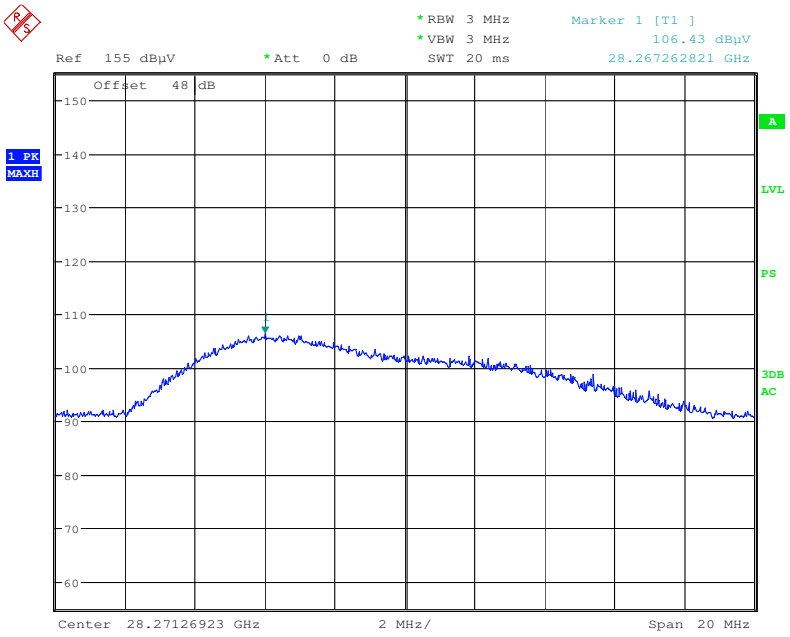



**Figure 15 Radiated Emissions 1000ns Pulse width 28.2GHz**

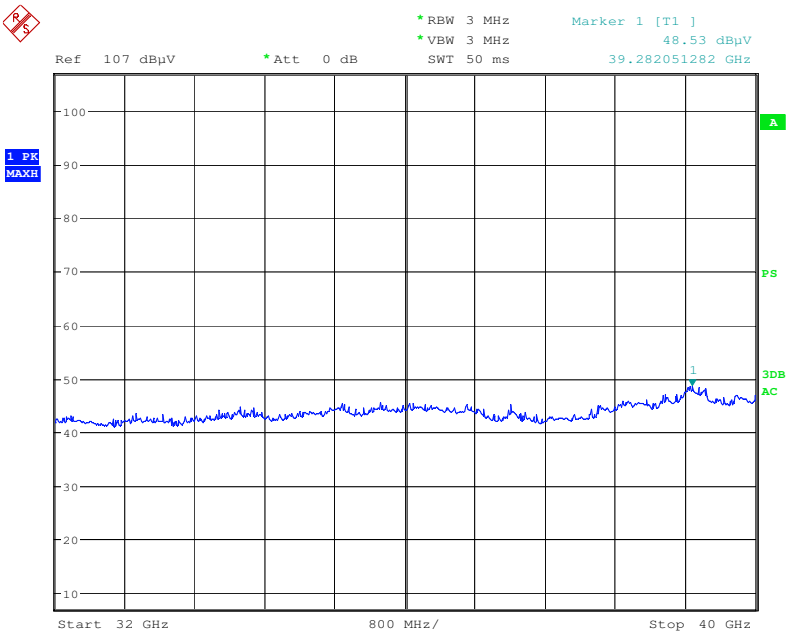



**Figure 16 Radiated Emissions 75ns Pulse width 32GHz to 40GHz**

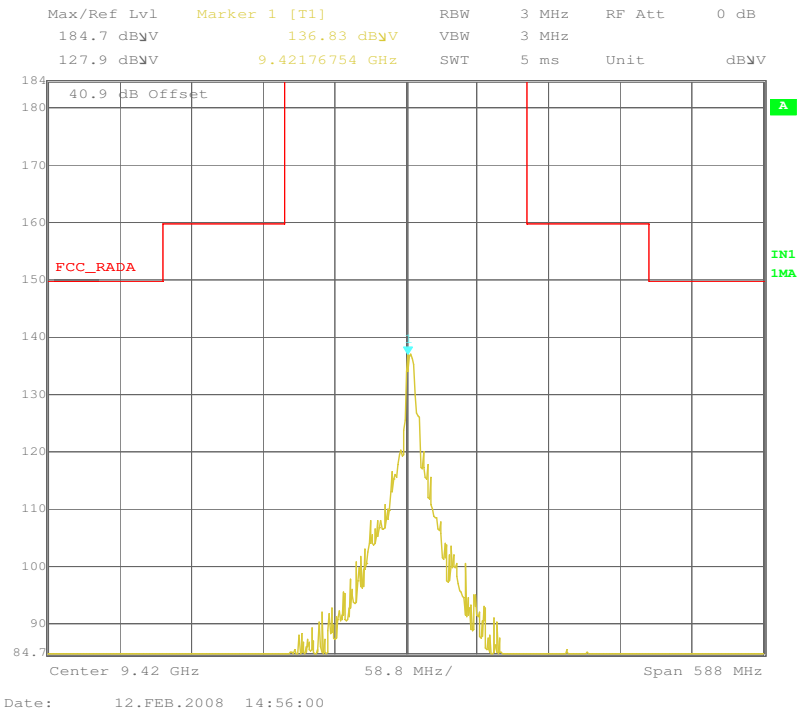



**Figure 17 Main Pulse Radiated Measurement 1000ns Pulse (Antenna Not fitted)**