Measurement Report

Date:	14 March, 2006
Testname:	Garmin Marine Radar
Test House:	RF Metrics Corporation
Test number:	06-001
Author:	Brad Ramsey, RF Metrics

Introduction

This report contains measurement results for a marine radar applicable to standard EN 60936-1 and ITU-SM.1541. The in-band, out-of-band, and spurious measurement procedure is based on the direct method as described in ITU-RM1177. The EUT characteristics presented in this report include:

1. Pulsewidth;
2. Risetime;
3. The peak-detected spectral emissions from the EUT including in-band, out-of-band (OOB), and spurious emissions.

The applicable emission mask has been determined according to ITU-SM.1541 and overlaid on the spectrum measurement results.

Test House Information

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Test House Accreditation

No formal accreditation standards exist in the U.S. for making measurements according to the M1177 procedure. The principal engineer, Brad Ramsey, has prior experience with the development of measurement procedures for use in making measurements intended for RSEC compliance. These procedures are the predecessor to the M1177 standard.

Manufacturer Information

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EUT Information

Model Designation:	GMR40x Pedestal – 6 foot antenna
Serial Number:	Proto D
Emissions Classification:	Un-modulated pulsed radar
EUT waveguide and cutoff:	WR90, 6571 MHz
Received by RF Metrics:	30 Jan, 2006
Start of testing:	6 Feb, 2006

Summary of Results

The EUT meets the criteria as documented in EU 60936 and it's references, including:

1. The criteria specifying that the necessary bandwidth be within the allocated band,
2. The criteria specifying that the in-band (IB), out-of-band (OOB), and spurious emissions be less than the emission mask.

The -40 dB bandwidth falls outside of the allocated band and has been shifted to allow for spectrum asymmetry in accordance with EN 60936 Section D.5.3.

Test Setup Diagram

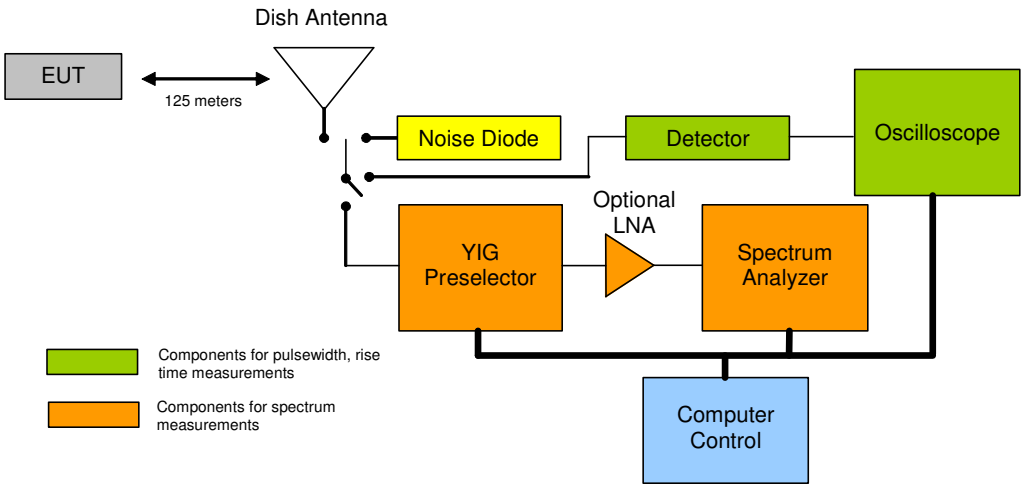

Figure 1. Measurement diagram.

Equipment:

Antenna:	ARA 126/A2, 1 – 26 GHz, SN 1034 / 1198
Preselector:	ITS integrated YIG preselector / attenuator
Detector:	Agilent 8474B Wideband detector, S/N MY4224 0104
Oscilloscope:	Tektronix 2430, S/N B014414
Spectrum Analyzer:	Agilent E4440A, S/N US40420684
Noise Diode:	Noise/Com NC346E S/N Q729

Location:

Table Mountain NRQZ, Boulder, Colorado, USA

Table Mountain NRQZ is a National Radio-Quiet Zone administered by the U.S. Department of Commerce as a research facility for radio measurements and experiments. The site is an open-air test range approximately 2 miles by 2 miles in area.

Procedure:

1. Setup
   a. The EUT was placed on a platform 210 meters from the measurement system.
   b. The EUT was configured for its normal operating mode.
   c. The measurement system was configured according to Figure 1.
2. Pulse measurements
   a. The EUT was powered on and configured for the shortest pulsewidth operating mode.
   b. The measurement system was configured to measure the emissions using the wideband detector and oscilloscope. The oscilloscope voltage scaling and time base were set to optimize the pulse collection.
   c. The trigger point of the oscilloscope was adjusted to trigger on the peak of the EUT's rotational emission pattern.
   d. The captured pulse was measured for width and rise time, then saved to the computer.
   e. Ten pulses were measured.
3. Background Spectrum Measurement
   a. The EUT was powered off.
   b. Spectrum analyzer parameters:
      RWB: 8 MHz
      VBW: 8 MHz
      DETECTOR: Positive Peak
      ATTENUATION: 0 dB
   c. The spectrum analyzer was stepped in frequency across the measurement range in accordance with the direct method in M1177.
   d. The resulting spectrum was saved to the computer.

4. Spectrum Measurements
   a. The EUT was powered on and configured for the shortest pulsewidth operating mode.
   b. Spectrum analyzer parameters:
      RWB: 8 MHz
      VBW: 8 MHz
      DETECTOR: Positive Peak
      ATTENUATION: 0 dB
   c. The spectrum analyzer was stepped in frequency across the measurement range in accordance with the direct method in M1177. At each step the analyzer was swept for a period that exceeds the rotation rate of the EUT. The peak value was saved. After each step, the operator determined if attenuation should be invoked or removed from the preselector (see Figure 1) to maintain the proper signal level at the analyzer.
   d. The measurement was conducted from 2 GHz to 26 GHz.
   e. The resulting spectrum was saved to the computer.

Results:

Figure 2 shows a typical pulse measurement using the HP wideband detector and the oscilloscope.

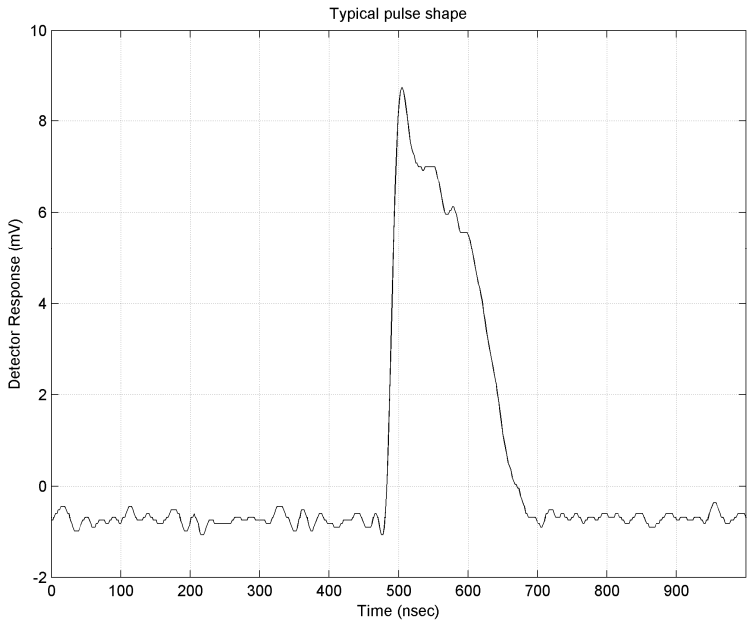

Figure 2. Typical pulse from EUT using wideband detector.

Trial	Pulsewidth (ns)	Rise Time (ns)
1	131.6	15.6
2	132.2	13.7
3	127.5	15.6
4	130.5	14.0
5	128.0	14.8
6	132.1	13.0
7	126.8	13.6
8	128.2	15.0
9	132.0	14.9
10	130.0	13.2
Mean	129.9	14.3

Table 1. Pulse width and rise time measurements.

Results (cont.):

The following plots are the corrected results of the measurements. Each plot shows three data sets: the measured emissions from the EUT, a measurement of the background emissions when the EUT is powered off, and the emission mask as defined in ITU-SM.1541. The parameters and process used to create these data sets are as follows:

Necessary Bandwidth:

According to ITU-SM.1541 the necessary bandwidth is the smaller of:

$$B_N = \frac{1.79}{\sqrt{t \cdot t_r}} \text{ or } \frac{6.36}{t}$$

For t = 129.9 ns and t_r = 14.3 ns, B_N = 41.5 MHz. This bandwidth falls within the 9300 to 9500 MHz band as shown in Figure 5 below.

40 dB Bandwidth:

According to ITU-SM.1541 B_{-40} is the smaller of:

$$B_{-40} = \frac{K}{\sqrt{t \cdot t_r}} \text{ or } \frac{64}{t}, \text{ where } K = 7.6$$

For t = 129.9 ns and t_r = 14.3 ns, B_{-40} = 176.0 MHz. This bandwidth falls inside the 9300 to 9500 MHz band as shown in Figure 5 below.

Measurement Data Processing:

The raw measured power values at each frequency were processed to correct for external system gain and antenna aperture deviation. The external system gain is determined via direct noise diode calibration at the time of measurement. The deviation from a constant antenna aperture is determined using a calibration curve from the manufacturer. For measurement points that occur in between calibration and aperture data points, a linear interpolation was used.

The data sets are normalized to place the maximum corrected value at 0 dB.

Three separate calibrated signal paths were used during the measurement. For the 2-18 GHz measurements a YIG-tuned filter was used. Above 18 GHz an LNA preamplifier was connected directly to a frequency-selective feed on the antenna and the output was connected directly to the spectrum analyzer. Both of these paths were calibrated independently prior to the measurement. Both paths provided a different overall system noise figure as reflected by the changes in noise floor in figures 3-5.

Results (cont.):

Background Data Set

As shown by the background data sets in figures 3-5, ambient signals were measured that were not produced by the EUT. The most significant of these were wireless point-to-point microwave systems from 2.0 to 2.7 GHz, S-band radars operating from 2.8 to 2.9 GHz, and weather radars operating near 5.5 GHz. In addition to the background measurement, these signals were individually identified. They did not exhibit a periodicity associated with the EUT rotation.

Emissions near the mask limit

In figures 6 and 7 measurement data, background data, and emission mask limits are plotted in detail near the points where the emission levels approach the mask limits.

Results (cont.):

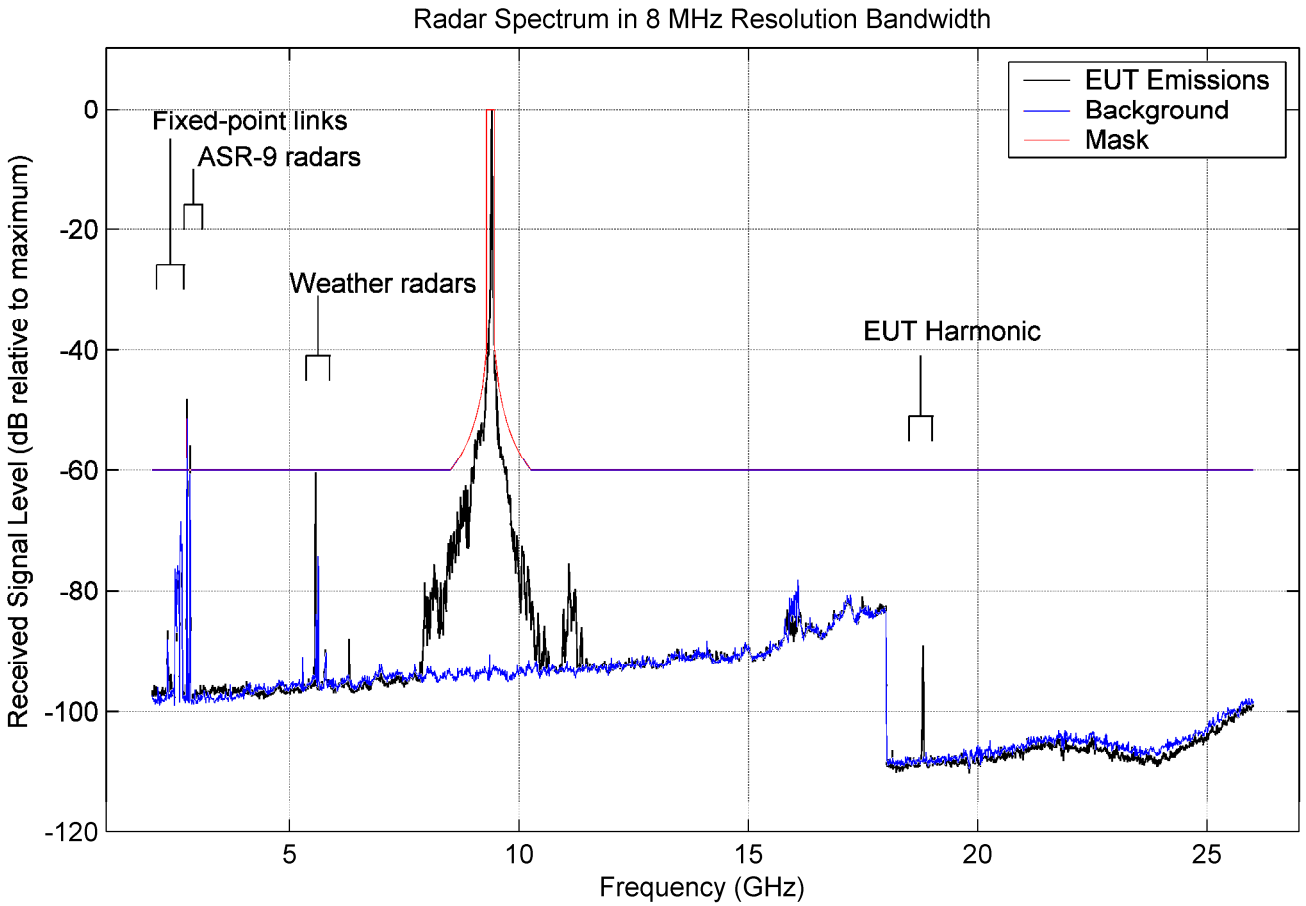

Figure 3. EUT Emissions 2 – 26 GHz.

Results (cont.):

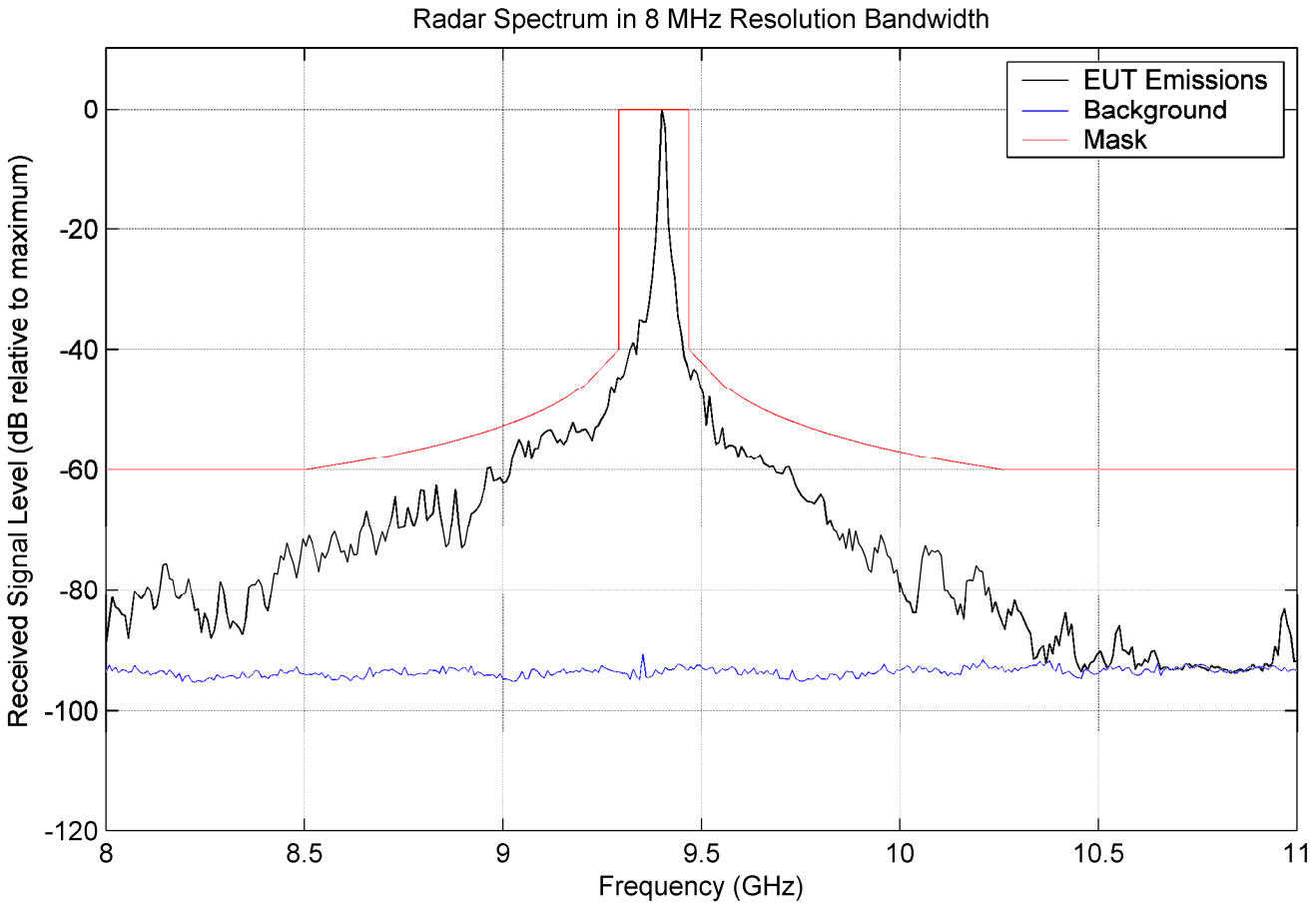

Figure 4. Center frequency portion of the spectrum.

Results (cont.):

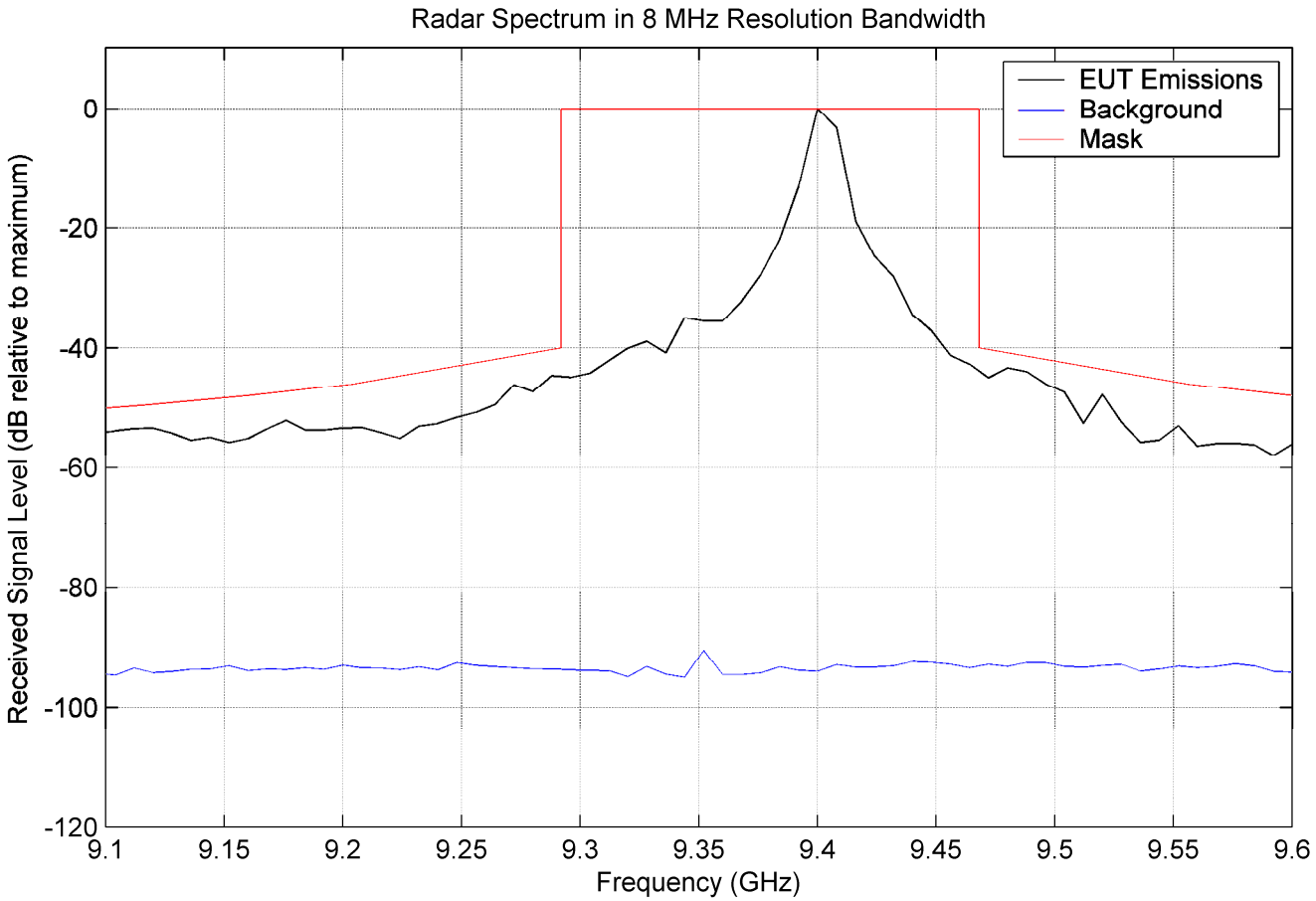

Figure 5. 9.3 to 9.5 GHz band.

Results (cont.):

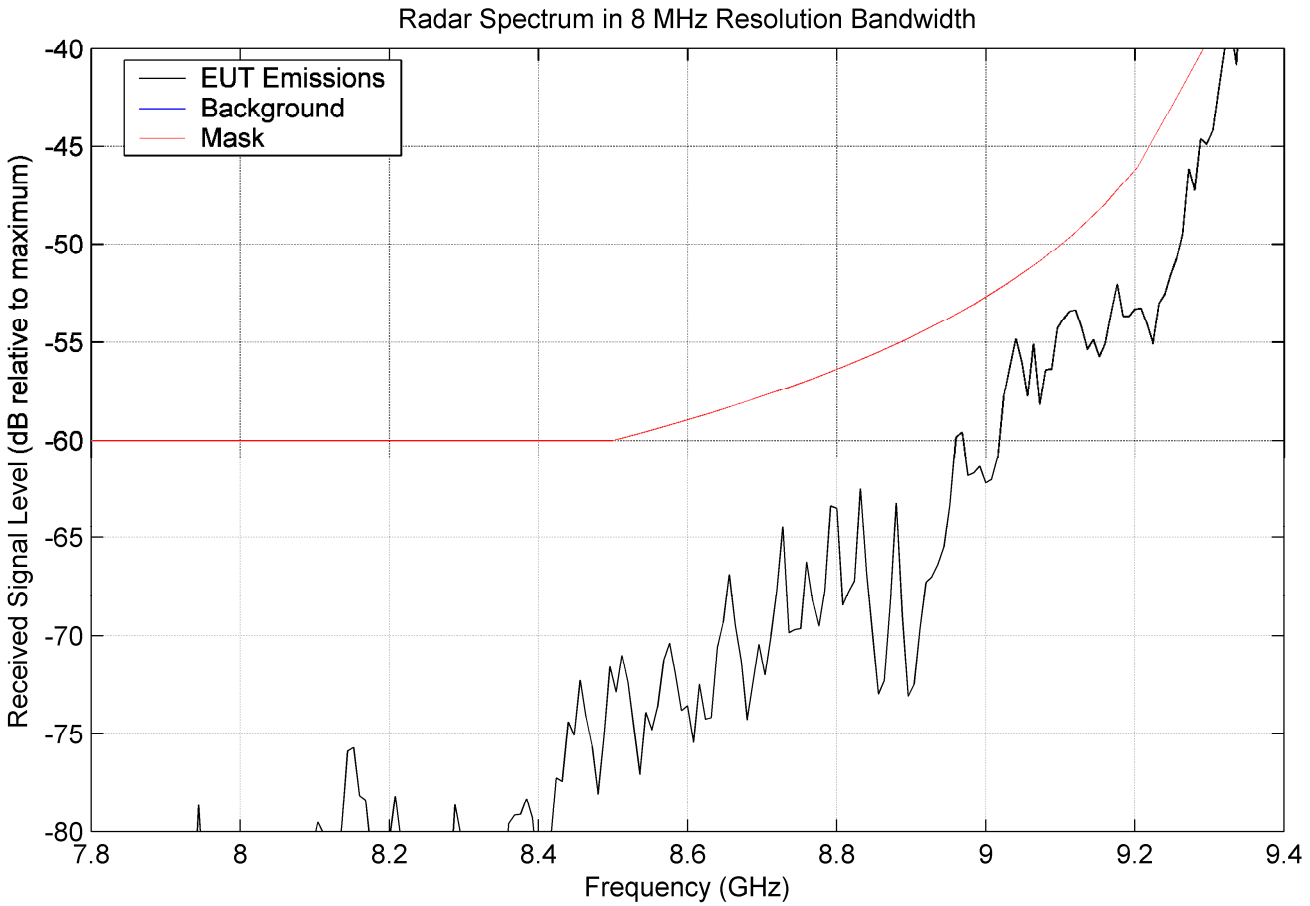

Figure 6. Emission measurement data detail from 7.8 to 9.4 GHz.

Results (cont.):

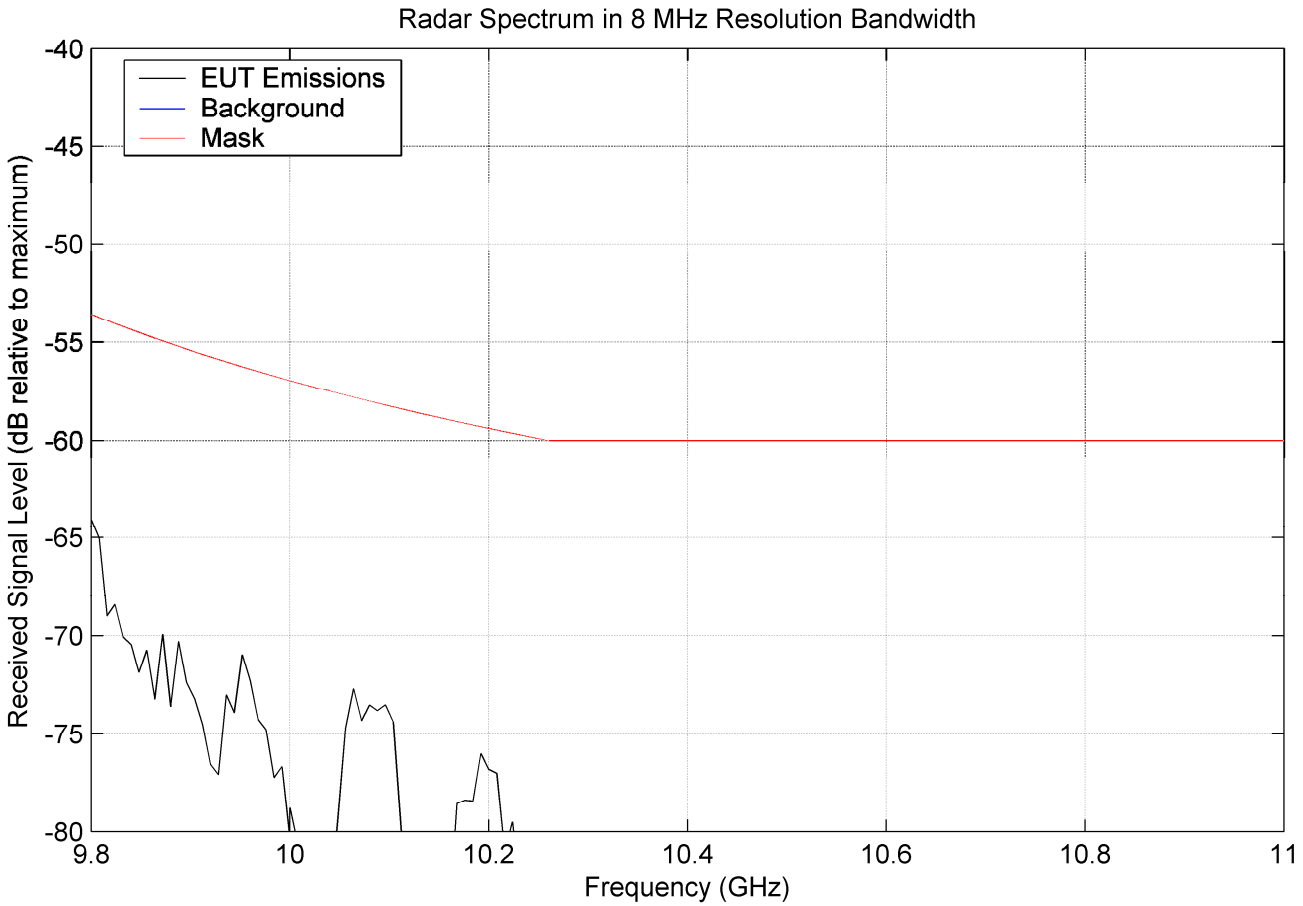

Figure 7. Emission measurement data detail from 9.8 to 11 GHz.

Photographic Annex

Figure 8. EUT mounted on the test platform.

Figure 9. Interior of EUT. The radiating element is 180 cm between endpoints.