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TEST REPORT

EMC DEPARTMENT

RAYMARINE LTD

Test of: Raymarine Ltd.
RD424 Analog 4kW Radome Scanner

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

(Leisure Marine Radar Equipment)

Test Report Serial No. 648/1065

Checked By: EMC Team Leader	Approved By: International Compliance manager
Tested By: Andy Little / Paul Pitt	Author: Andy Little EMC Engineer
Issue Date: **10th February, 2006**	**Test Dates:** **3rd January to 9th February 2006**

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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. P. Bowen, EMC Team Leader

2 Equipment Under Test (EUT)

2.1 Identification of Equipment Under Test (EUT)

Brand Name:	Raymarine
Model Name or Number:	RD424 Analog 4kW 24inch Radome Scanner Compatible with the Following Raymarine displays E120 12 inch Ultra Bright Multifunction Navigation Display E80 8 inch Ultra Bright Multifunction Navigation Display C70 7 inch Multifunction Navigation Display C80 8 inch Multifunction Navigation Display C120 12 inch Multifunction Navigation Display
Unique Type Identification:	RD424 4kW unit E52067 E120 12" Display E02013 E80 8" Display E02011 C120 12" Display E02022 C80 8" Display E02020 C70 7" Display E02018
Serial Number:	Scanner Unit EMC301105 Display Unit (E120) EMC041104b
Country of Manufacture:	Hungary
FCC ID Number:	PJ5-AD4D-8P
Date of Receipt:	30th November 2005

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 a 24 inch Flare antenna.
Display Unit: 12 inch Ultra Bright Multifunction Navigation Display with chart reader and with Seatalk/alarm, NMEA, Video in/out, Seatalk 2, and Seatalk High speed bus 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 12-32V DC supply
Intended Operating Environment:	Leisure Marine & Small Workboats
Weight:	424 Scanner: 7.5kg (16.5lbs) Display 7.35kg (16.2lbs)
Dimensions:	424 Scanner: 652mm dia x 247mm height Display: w355.5mm x h264mm x d140mm
Interface Ports:	Power Seatalk / Alarm Seatalk 2 Seatalk High Speed Bus NMEA Video In Video Out

2.5 Support Equipment

Support equipment used up to 2GHz

Item	Unique Type Identification & Serial Number
ST60 Multi Display	A22003 / EMC 101203b
C80 Display	E02020 / EMC 181103a
DSM 250 Sonar	E62007 / EMC031103e
B256 Sonar transducer	E66024
ST290 Data Display	E22056 / 430015

No support equipment was required to be used over 2GHz

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. 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 RD424 analog 4kW radome scanner with 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 C63.4-2001
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.Deviations from the Test Specification

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

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:

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

2. Conducted emissions: Transmitting into a fixed non-reflective load with the transmitter set to 75, 450 and 1000ns pulse widths.

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).

4. Transmitter power, pulse width, occupied bandwidth and P.R.F. Transmitting into a fixed non-reflective load.

5.3 Configuration and peripherals

1. The scanner unit was connected to the display unit with the standard cable of 15m length. A transmit dummy load was connected to the scanner unit antenna port. Over the frequency range 9kHs to 2GHz all interface ports were terminated with suitable instruments. Above 2GHz 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.

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 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

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

6.1.7 Transmitter Frequency Tolerance

Nominal Pulsewidth 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

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 70dBuV/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 60dBuv/m

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

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

Plots of measurement scans can be found in Appendix D.

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.

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

Frequency (GHz)	Antenna Polarization	Level (dBuV/m)	Limit (dBuV/m)	Margin (dB)	Result
18.790	Vertical	92.94	132.9	40	Complied

7.3 Conducted Emissions

7.3.1 Peak Detector measurements on RF port

The design of the RF coupling from the magnetron to the antenna forms an effective high pass/band pass 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.

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.

Measurements were performed from 6 GHz to 40GHz with the EUT set to 75ns, 450nS and 1000ns, measurements were performed within and around the transmitter frequency allocation.

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

All emissions were more than 20dB below the required limit.

7.4 Peak Power

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 (kW)
75	3.67
100	3.76
150	3.67
250	3.61
350	3.62
450	3.64
600	3.67
1000	3.76

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.

7.5 Pulse Width

Plots can be found in Appendix D.

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	77
100	107
150	156
250	259
350	359
450	458
600	595
1000	970

7.6 Pulse Repetition Frequency

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	3003
100	3003
150	3003
250	3003
350	2000
450	1502
600	1302
1000	739

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.

7.7 Average Power

Measured at the antenna port

Nominal Pulse Width (ns)	Peak Power (kW)	P.R.F. (Hz)	Measured Pulse Width (ns)	Average Power (Watts)
75	3.67	3003	77	0.85
100	3.76	3003	107	1.21
150	3.67	3003	156	1.72
250	3.61	3003	259	2.81
350	3.62	2000	359	2.60
450	3.64	1502	458	2.50
600	3.67	1302	595	2.84
1000	3.76	739	970	2.70

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

7.8 Variation of frequency with input voltage

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	9.394988
100% of 12.0	12.0	9.394756
100% of 32.0	32.0	9.394750
115% of 32.0	36.8	9.394731

1000ns

% of Nominal Volts	Volts (dc)	Measured Frequency (GHz)
85% of 12.0	10.2	9.39579
100% of 12.0	12.0	9.39585
100% of 32.0	32.0	9.39521
115% of 32.0	36.8	9.39530

Note: The equipment can be operated from any voltage within the nominal range 12 to 32V without requiring any adjustment. Therefore, the testing was performed from 85% of the lowest to 115% of the highest operating voltage.

7.9 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	9.434990
-10	9.433460
0	9.430500
+10	9.429385
+20	9.426325
+30	9.423505
+40	9.421340
+50	9.419835

1000ns

Temperature °C	**Measured Frequency (GHz)**
-20	9.432905
-10	9.430935
0	9.429570
+10	9.426435
+20	9.424165
+30	9.419270
+40	9.415580
+50	9.412355

7.10 Occupied Bandwidth

Plots can be found in Appendix D.

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	47.69
100	40.08
150	36.87
250	21.64
350	20.04
450	18.83
600	18.43
1000	18.43

7.11 Transmitter Frequency Tolerance

7.11.1 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."

7.11.2 Calculation

Authorised Bandwidth: 9300MHz to 9500MHz

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

Transmitter Frequency Tolerances

Nominal Pulse Width (ns)	Actual Pulse Width (ns)	Specification Limits (MHz) Lower	Upper
75	77	9.31948	9.48052
100	107	9.31402	9.48598
150	156	9.30962	9.49038
250	259	9.30579	9.49421
350	359	9.30418	9.49582
450	458	9.30328	9.49672
600	595	9.30252	9.49748
1000	970	9.30155	9.49845

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

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	--------------***
696	Environmental Chamber			1941	Due Wk41/06
318	Peak Power Analyser	H-P	8991A	3248A00128	06/10/05
376	60V Power Supply	Farnell	AP60-50	1140	--------------***
424	DVM	Fluke	83	63550394	05/11/05
-------	Analyser 0.1kHz -26.5GHz	H-P	70000 series	As below	-----------------*
425	Display Section	H-P	70004A	3040A01640	29/07/2005
426	I.F. Module	H-P	70902A	3206A03917	29/07/2005
427	I.F. Module	H-P	70903A	3331A02727	29/07/2005
428	L.O. Module	H-P	70900B	3345A01913	29/07/2005
429	External Mixer Interface	H-P	70907B	3533A00576	29/07/2005
430	Mainframe	H-P	70001A	3230A05180	29/07/2005
431	Digitizer Module	H-P	70700A	3716A01071	29/07/2005
432	Precision Freq. Reference	H-P	70310A	3127A02429	29/07/2005
433	RF Module	H-P	70909A	3136A00120	29/07/2005
434	Option 001 Preamplifier	H-P	70620B	3550A00850	29/07/2005
435	Receiver 9kHz-6.5GHz	H-P	8546A	3625A00329	27/10/2005
436	Filter Section	H-P	85460A	3448A00219	27/10/2005
1520	Microwave Sig. Gen. 0.01-40GHz	Rohde & Schwarz	SMR40	10-300074685	17/08/2005
440	PSU 3-15V 25A	Palstar	PS30M	92534722	18/06/2005
442	Antenna 0.09-30MHz	Schaffner	HLA6120	1122	06/01/2005*
479	Peak Power Sensor	H-P	84812A	3318A01050	04/10/2005
482	Antenna 18-26.5GHz	Credowan	20-R-2843-0007	36755	29/09/2005
483	Antenna 26.5-40GHz	Credowan	S.G. Horn	None	29/09/2005
789	Mixer 26.5-40GHz	Agilent	11970A	3003A08859	06/08/2003**
852	Antenna 1.0-18.0GHz	Schwarzbeck	BBHA9120D	128	29/03/2005
968	Antenna 30-300MHz	Schwarzbeck	VHBB9124	9124-285	06/08/2004
969	Antenna 0.3-2.0GHz	Emco	EM6946	112	06/08/2004
EM05	Microwave Cable	Agilent	5061-5458	EMC Cable 5	As Required
EM06	Microwave Cable	Agilent	5061-5458	EMC Cable 6	As Required
EM09	Microwave Cable	Agilent	5061-5458	EMC Cable 9	As Required
EM20	Low-loss RF cable 1.6m	Andrew	243290	EMC Cable 20	As Required
EM21	Low-loss RF cable 1.6m	Andrew	243290	EMC Cable 21	As Required
EM22	Low-loss RF cable 3m	Andrew	A06Y-75513	EMC Cable 22	As Required
RD14	Microwave Coupler	Flann	16270-40-23	116317	As Required
RD21	Inline Attenuator 10dB	Narda	4779-10	8	As Required
RD24	Inline Attenuator 20dB	Narda	4779-20	5	As Required
RD25	Inline Attenuator 20dB	Unknown	R411820	6	As Required
RD27	Inline Attenuator 10dB	Unknown	R411810	7	As Required
RD30	Inline Attenuator 50dB	Narda	4779-50	4	As Required
RD37	Rotary w/g to WG16 Adaptor	Raymarine	LAB5S-7SR	05	As Required
RD40	WG16 to N Adaptor	Flann	16094-NF10	100	As Required
RD42	WG16 to N Adaptor	Mitec Europe	M0926-7-11	3711-2	As Required
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.

*** 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 microwave signal generator in conjunction with the H-P analyzer.

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 - 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

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 3.79kW by conducted methods. Consequently, a level of 3.79mW 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 the 24 inch Flare antenna. The antenna was aligned with the horn antenna connected to the spectrum analyser and adjusted to peak the analyser response. A reading of 180.2dBuV/m was obtained.

The calculation for the radiated emissions limit line is:

$$180.2 - 43 - 10\log_{10} 2.7 = \mathbf{132.9\ dBuV/m}$$

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

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

$$\text{i.e., } 65.79 - 43 - 10\log_{10} 2.7 = \mathbf{18.47dBm}$$

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 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 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 6.5 GHz

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

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.

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.

B.4 Radiated Emissions 6.5 GHz to 40 GHz

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

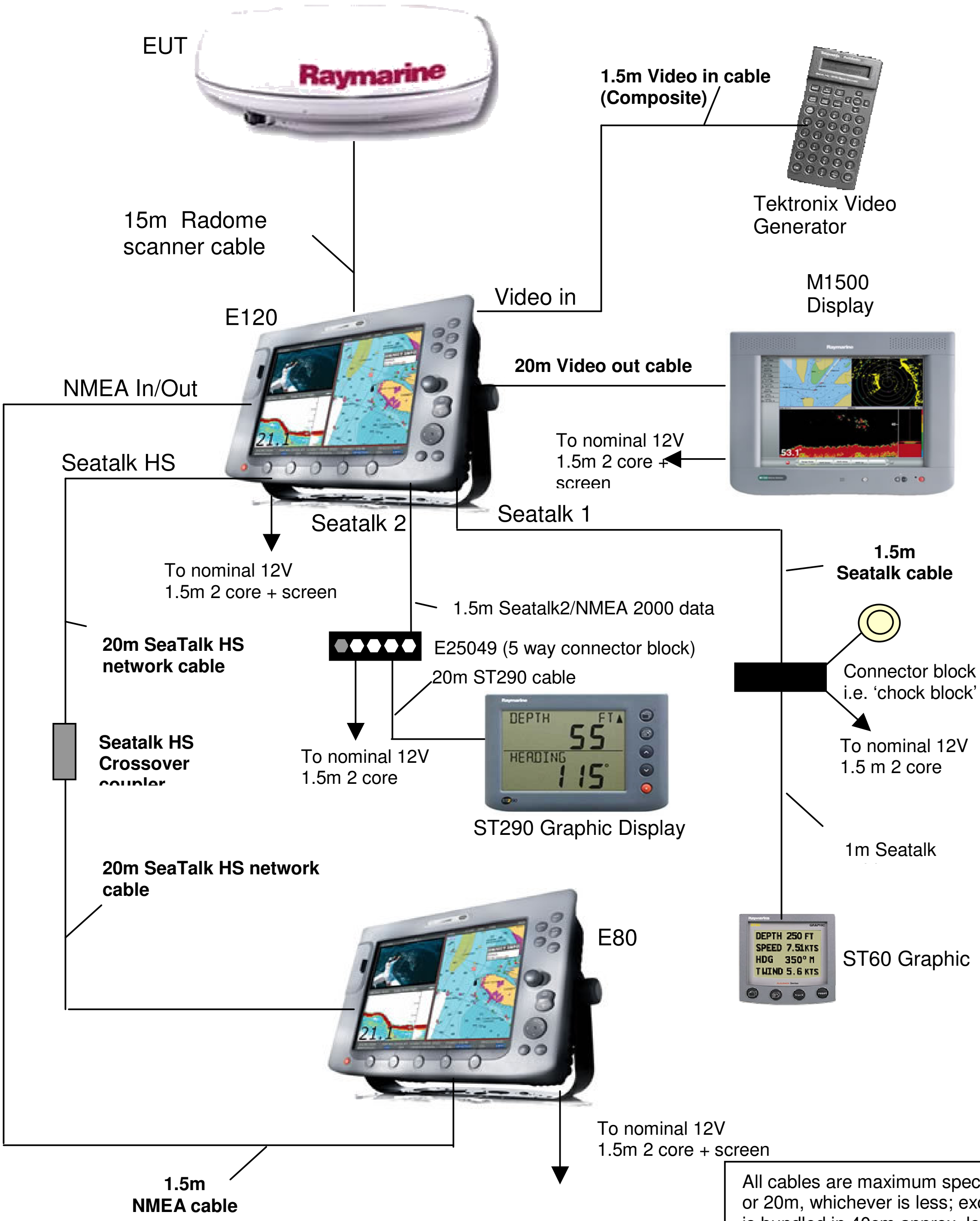
All testing was carried out within a semi-anechoic chamber at a distance of 3m. The conducting ground plane between the antenna and the EUT was covered with ferrite and pyramidal absorbing material. For all tests, the open array antenna was replaced with a rotating microwave load.

Measurements were split into 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

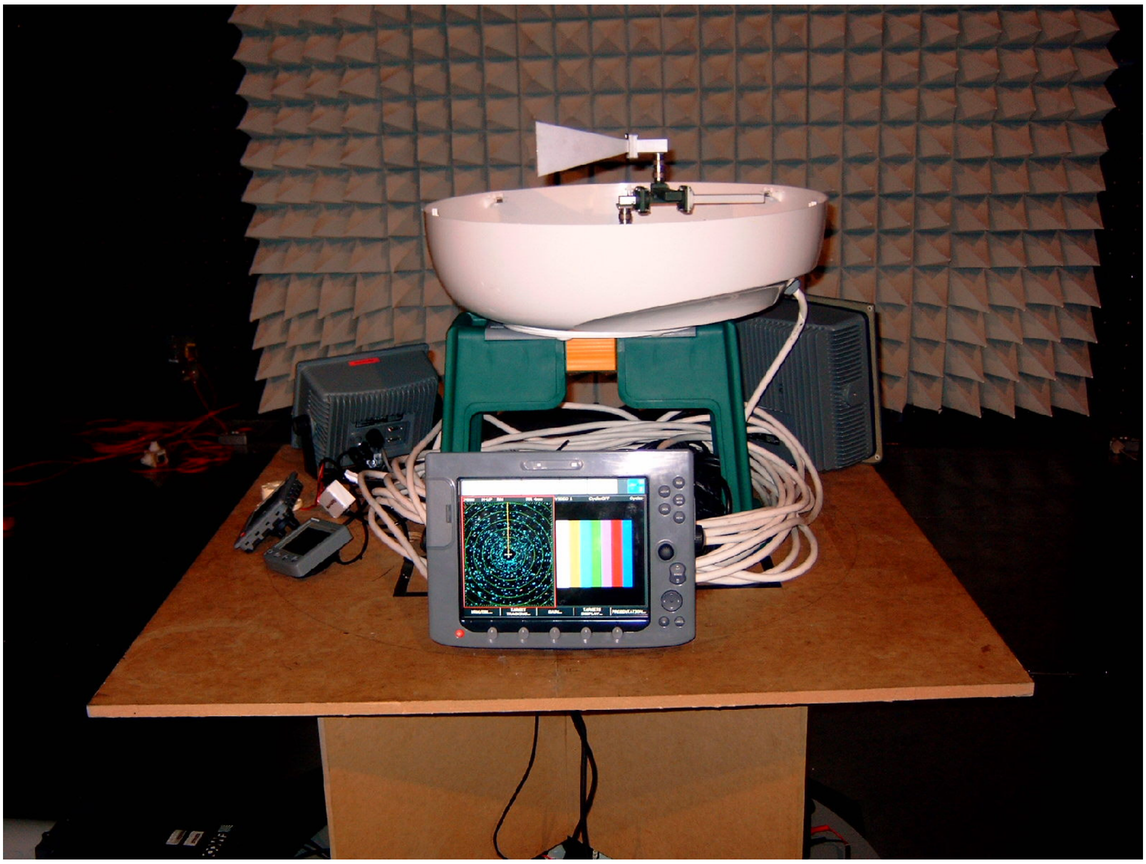
The scanner and display unit were arranged in as near a representative configuration as was practicable. The display unit, interface leads and excess scanner interconnection cable were placed upon a non-conducting support on the turntable such that the surface of the support was 0.8m above the ground 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/NMEA IN lead was connected to a 12V power supply placed on the turntable; the screen of this cable was connected to the ground plane. The Seatalk, HSB and NMEA Out cables 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



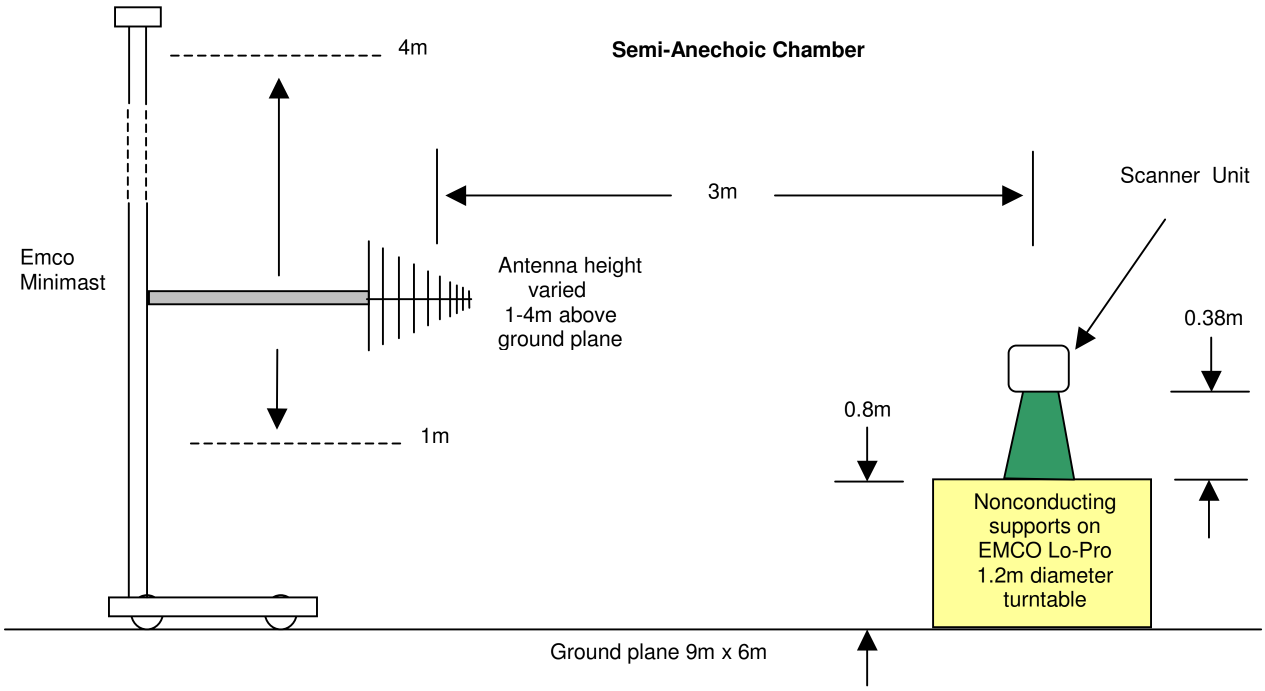
All cables are maximum specified length or 20m, whichever is less; excess cable is bundled in 40cm approx. loops. Exceptionally, the scanner interconnect cable is coiled in approx 1m diameter loops owing to its construction; small radius bends may permanently damage the screening properties of the sheath.

C.2 Radiated Emissions Setup – General Arrangement



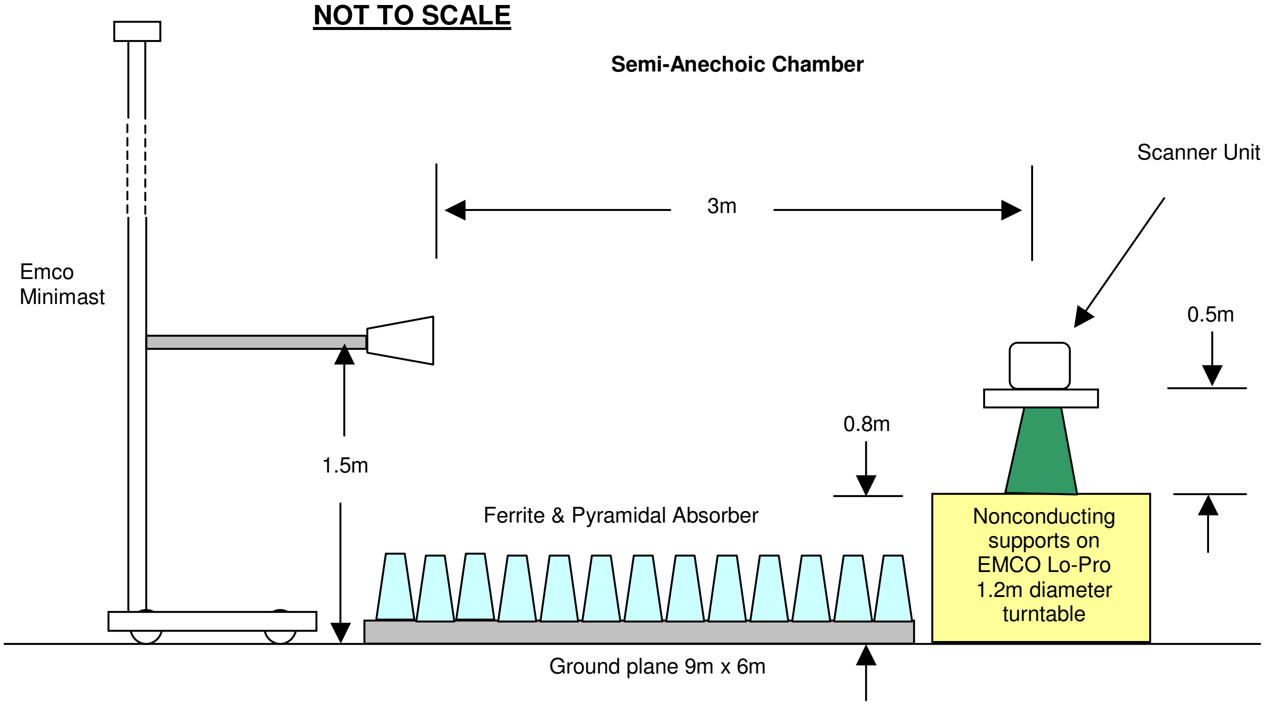
C.3 Radiated Emissions 9 kHz to 2 GHz – General Arrangement

NOT TO SCALE



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

NOT TO SCALE



Appendix D Graphical Test Results

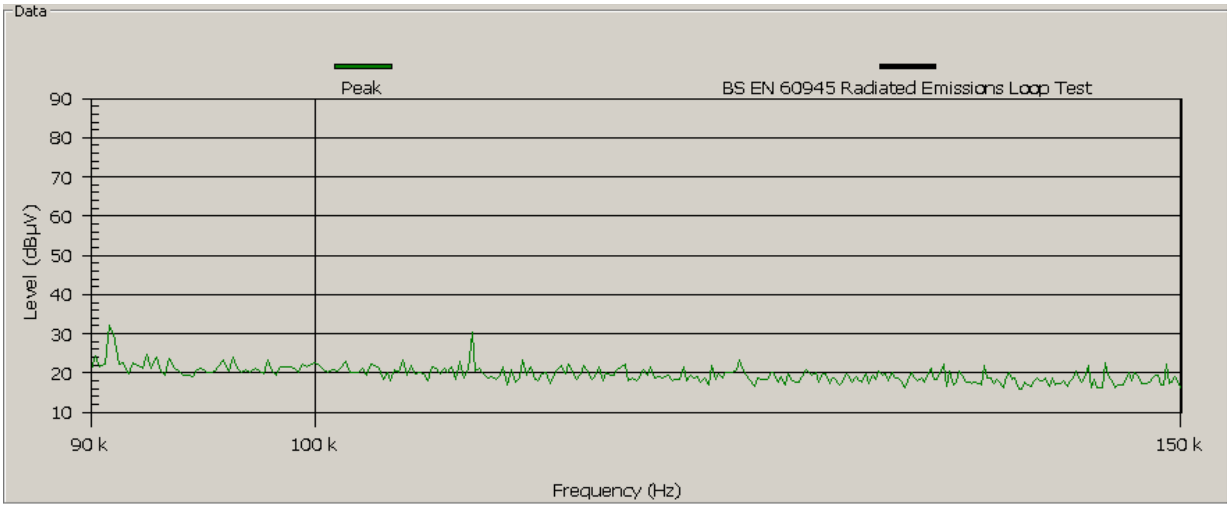


Figure 1 Radiated Emissions 9kHz to 150kHz Loop Face on

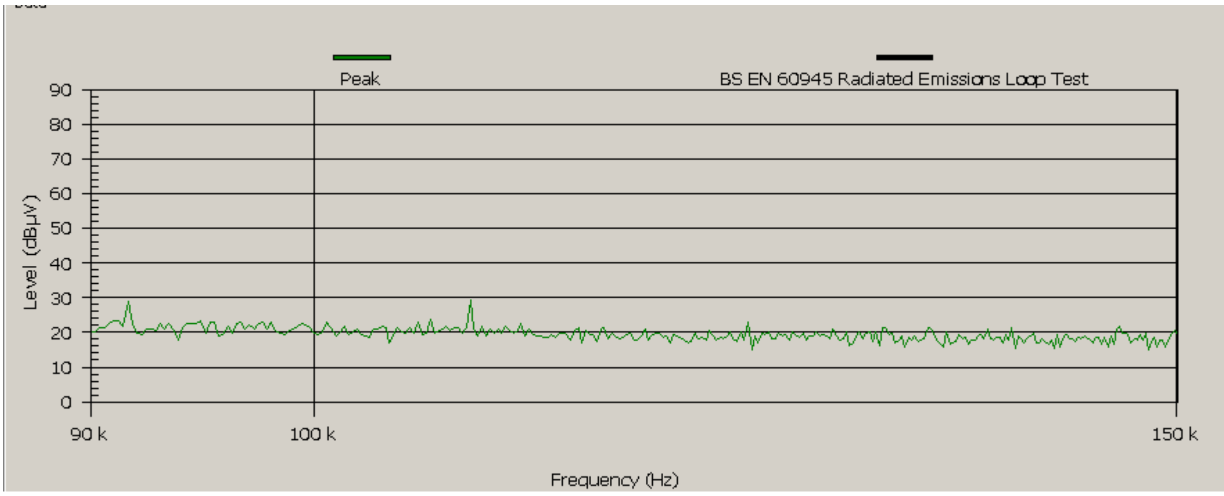


Figure 2 Radiated Emissions 9kHz to 150kHz Loop Side on

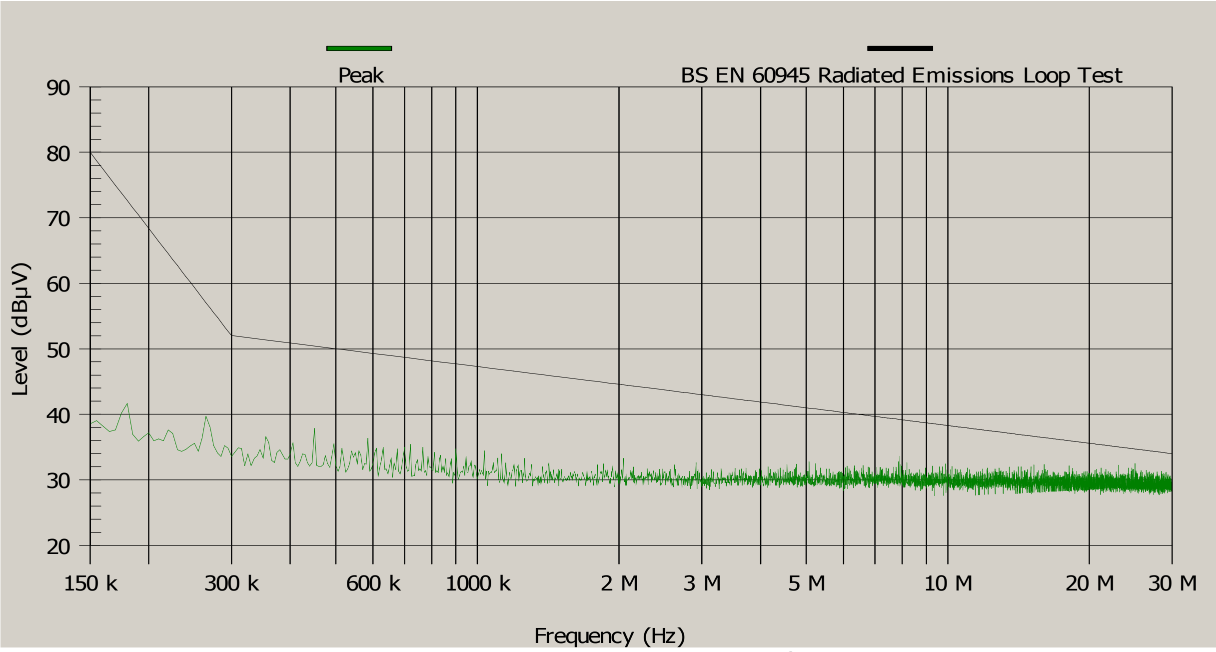


Figure 3 Radiated Emissions 150kHz to 30MHz Loop Side on

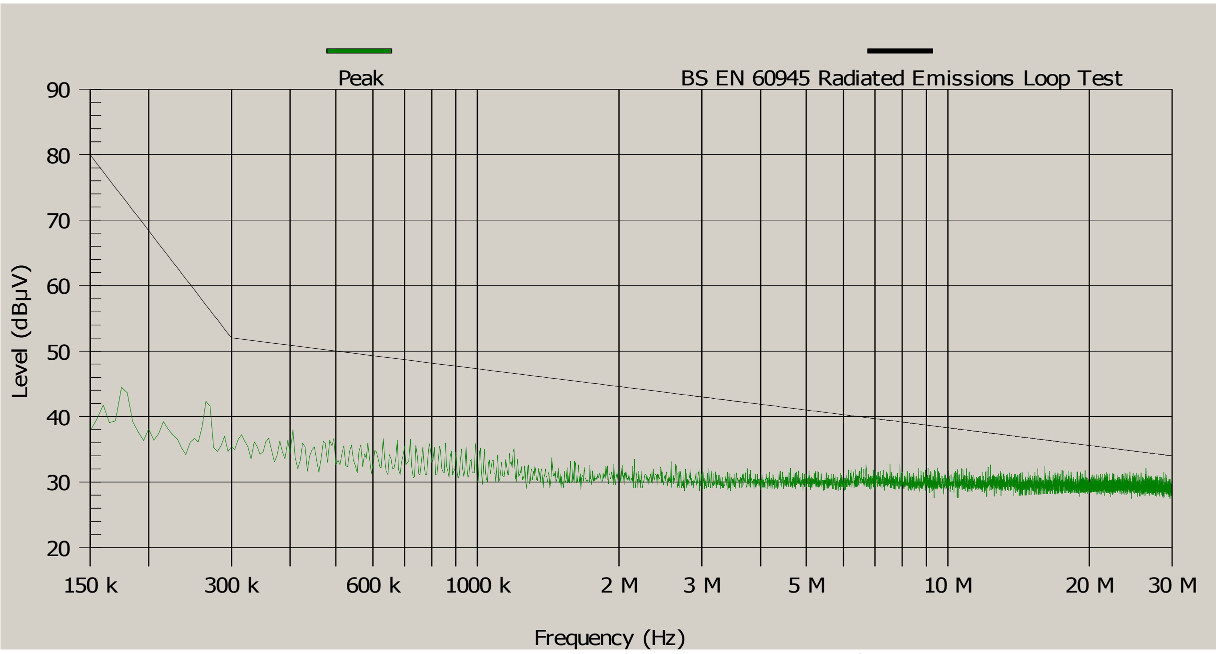


Figure 4 Radiated Emissions 150kHz to 30MHz Loop Face On

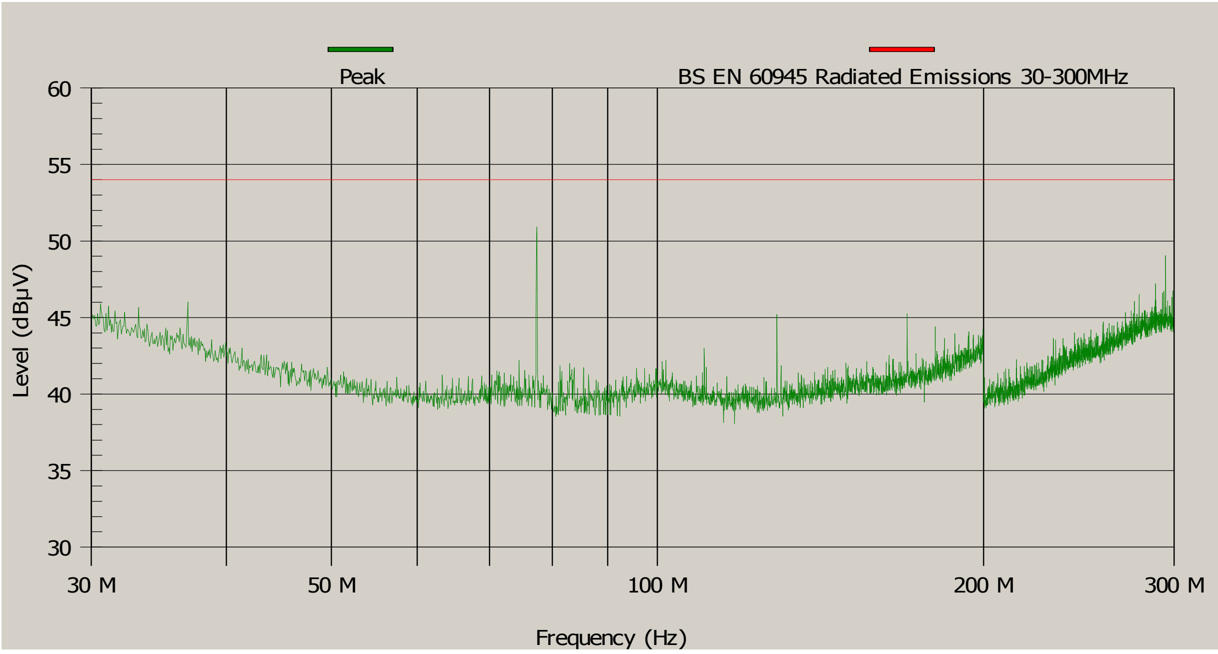


Figure 5 Radiated Emissions 30MHz to 300MHz

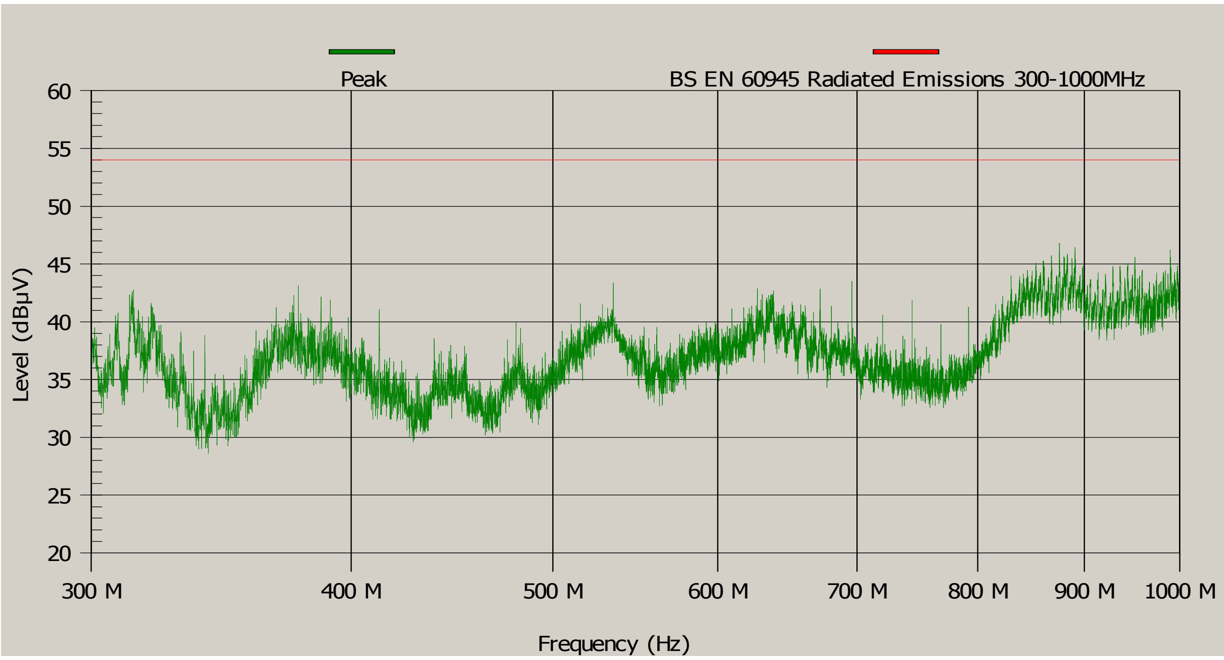


Figure 6 Radiated Emissions 300MHz to 1GHz

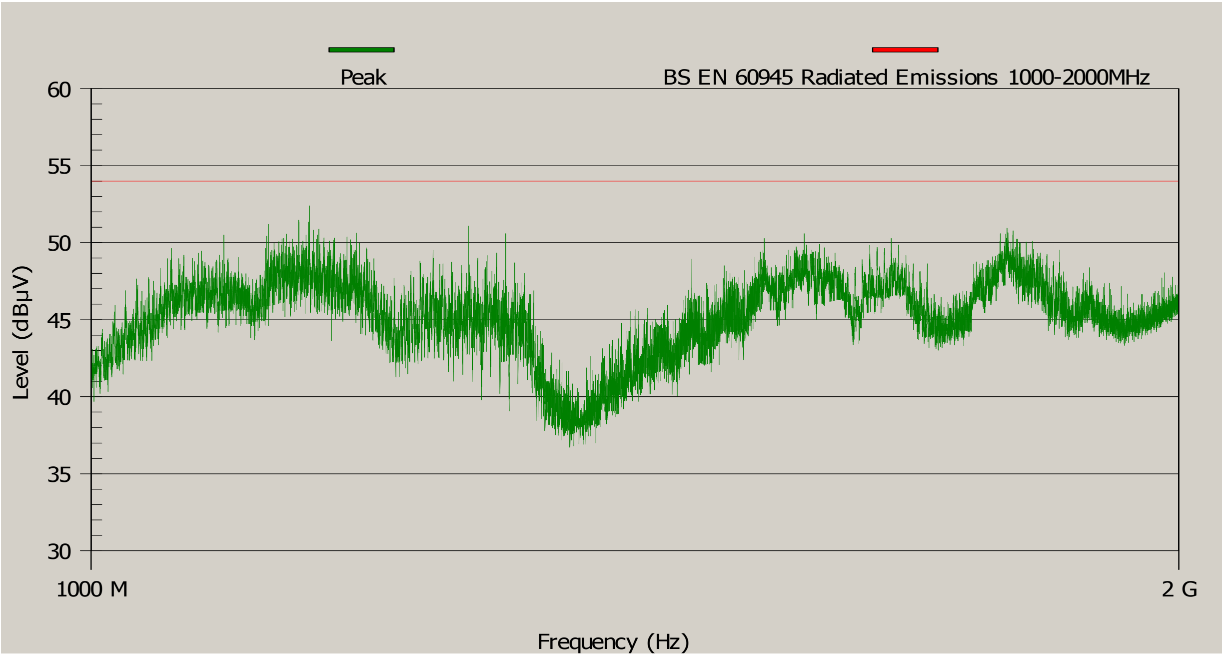


Figure 7 Radiated Emissions 1GHz to 2GHz

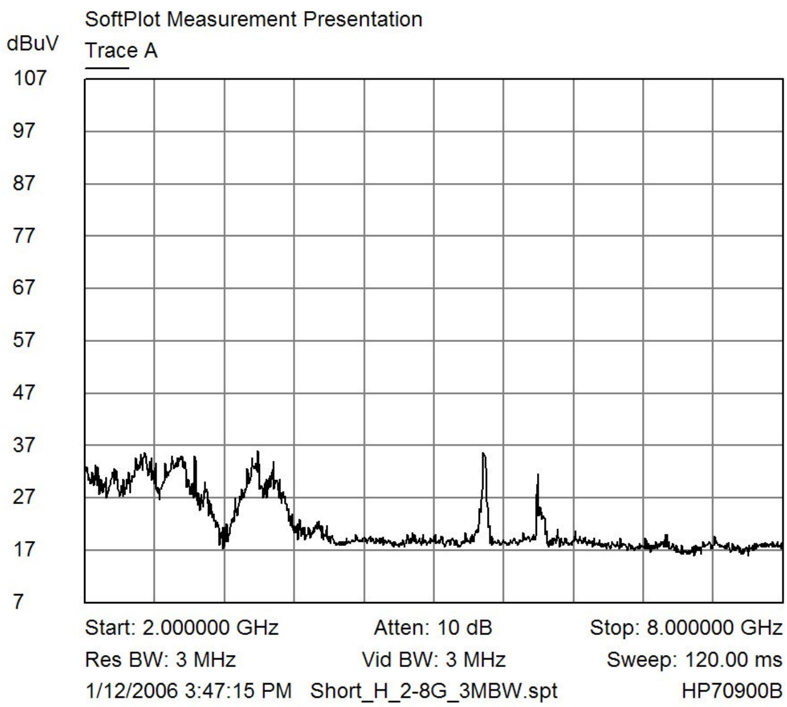


Figure 8 Radiated Emissions 450ns Pulse width 2GHz to 8GHz

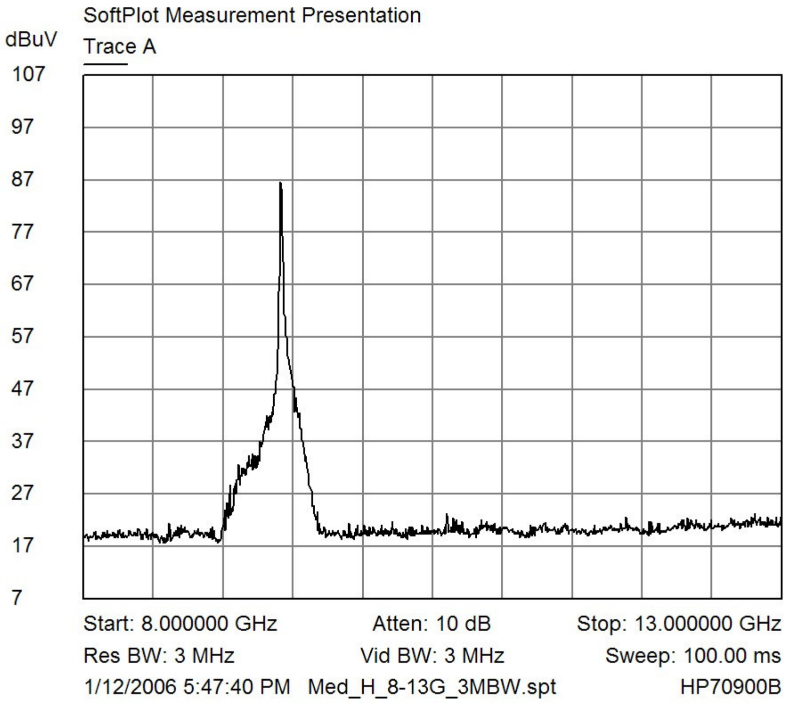


Figure 9 Radiated Emissions 450ns Pulse width 8GHz to 13GHz

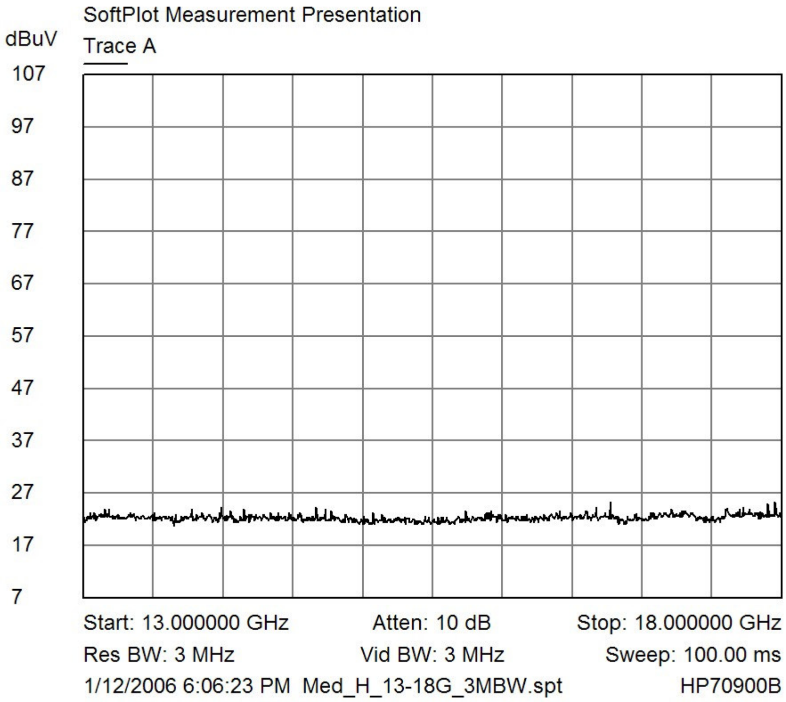


Figure 10 Radiated Emissions 450ns Pulse width 13GHz to 18GHz

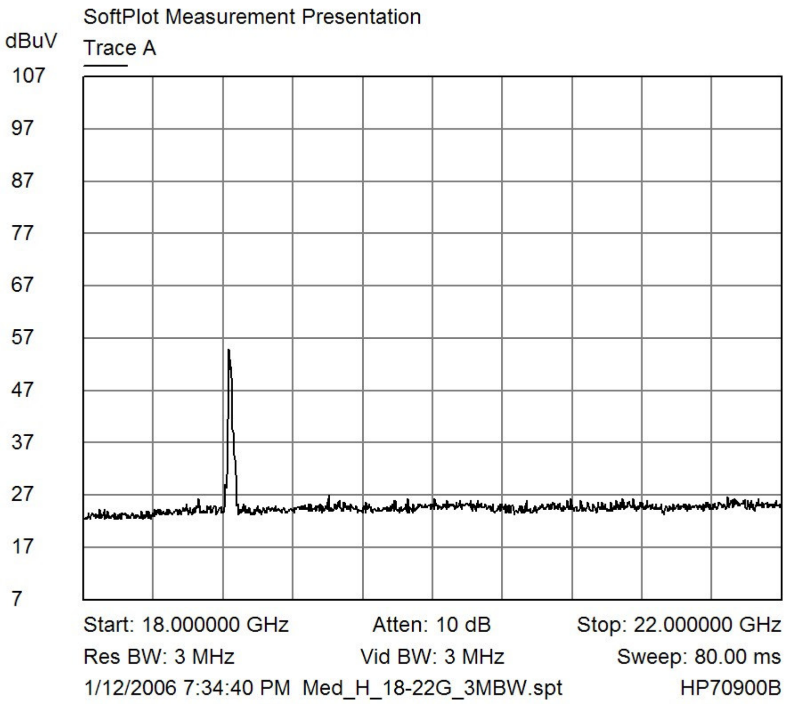


Figure 11 Radiated Emissions 450ns Pulse width 18GHz to 22GHz

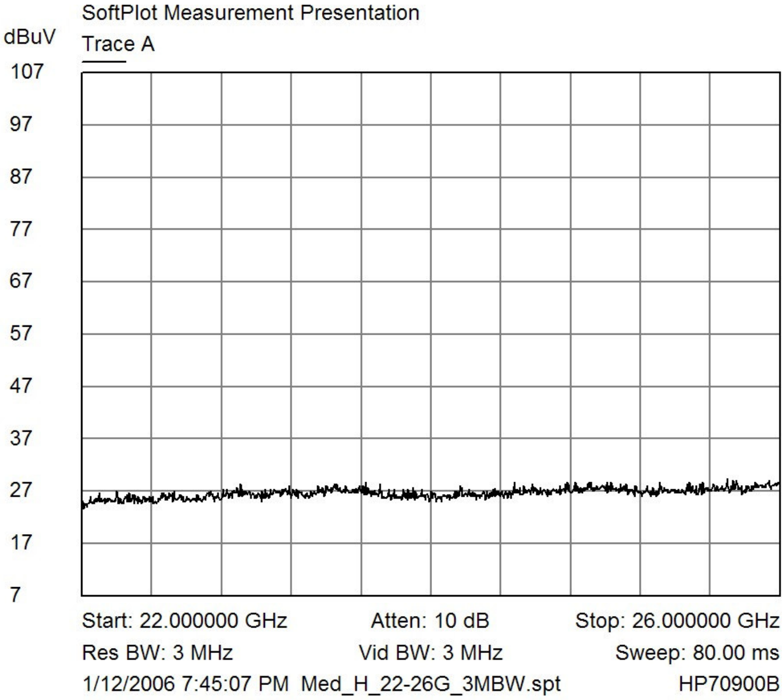


Figure 12 Radiated Emissions 450ns Pulse width 22GHz to 26GHz

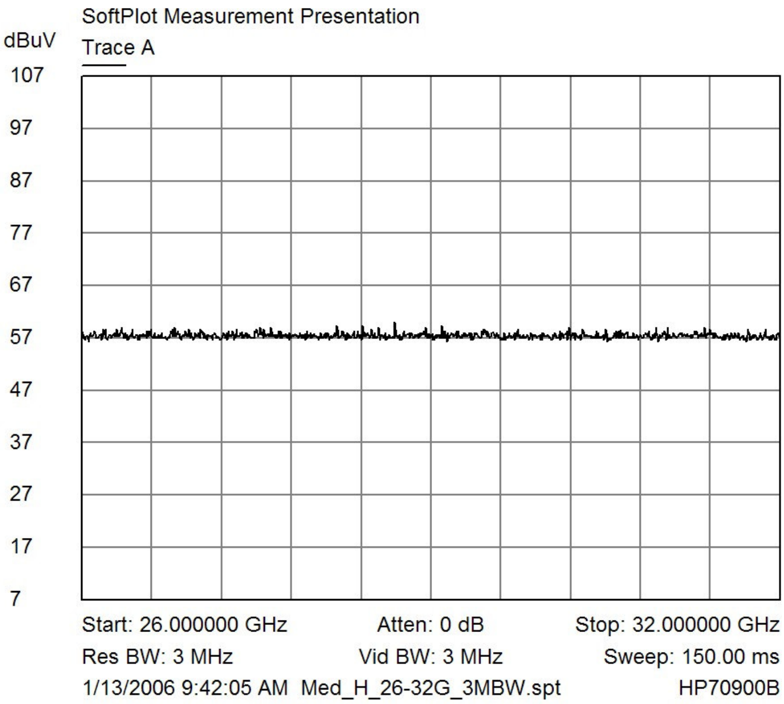


Figure 13 Radiated Emissions 450ns Pulse width 26GHz to 32GHz

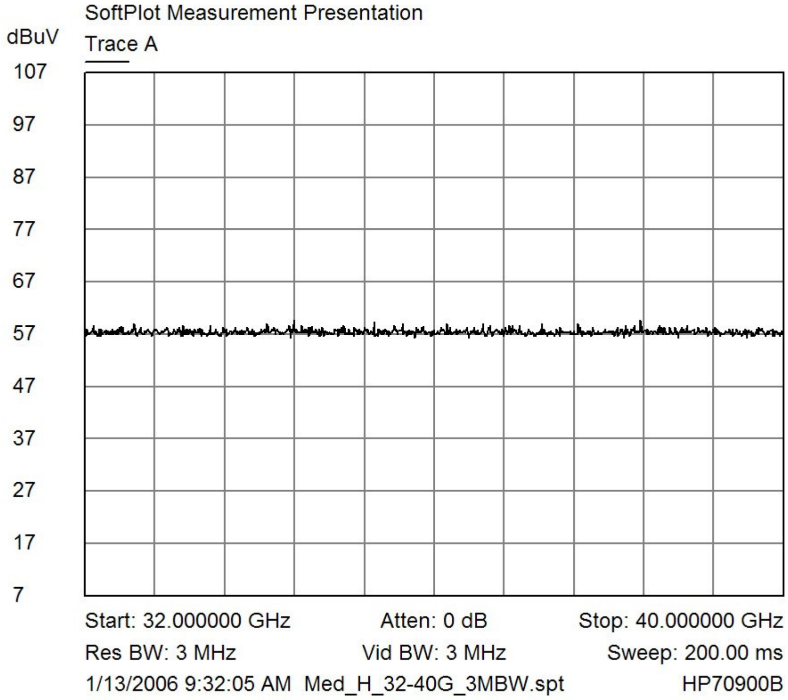


Figure 14 Radiated Emissions 450ns Pulse width 32GHz to 40GHz

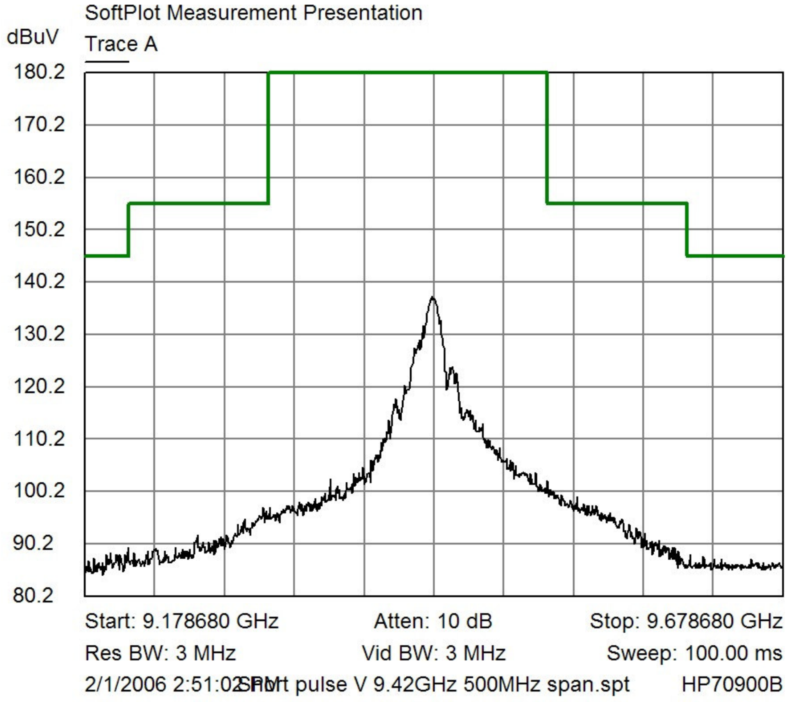


Figure 15 Main Pulse Measurement Short Pulse (Antenna Not fitted)

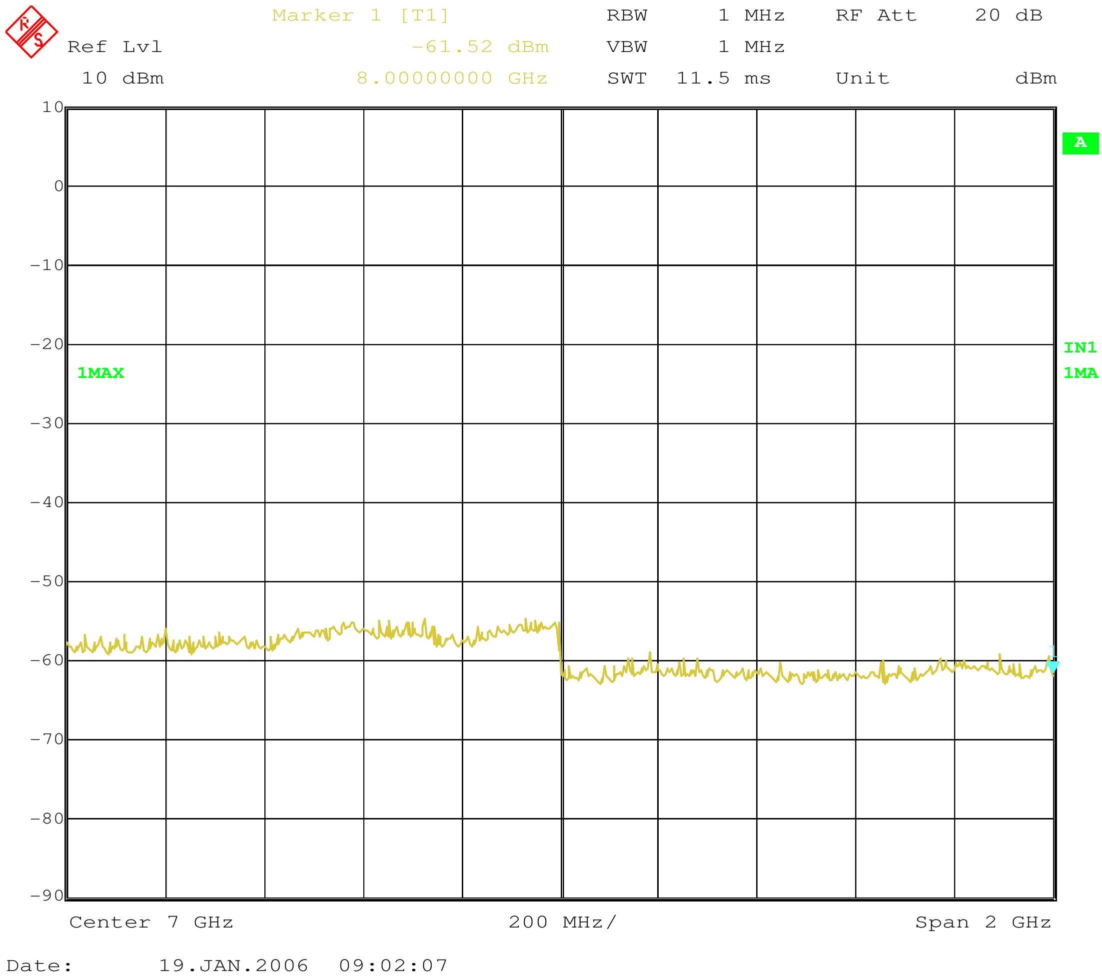


Figure 16 Conducted Emissions 450ns Pulse 6GHz to 8GHz

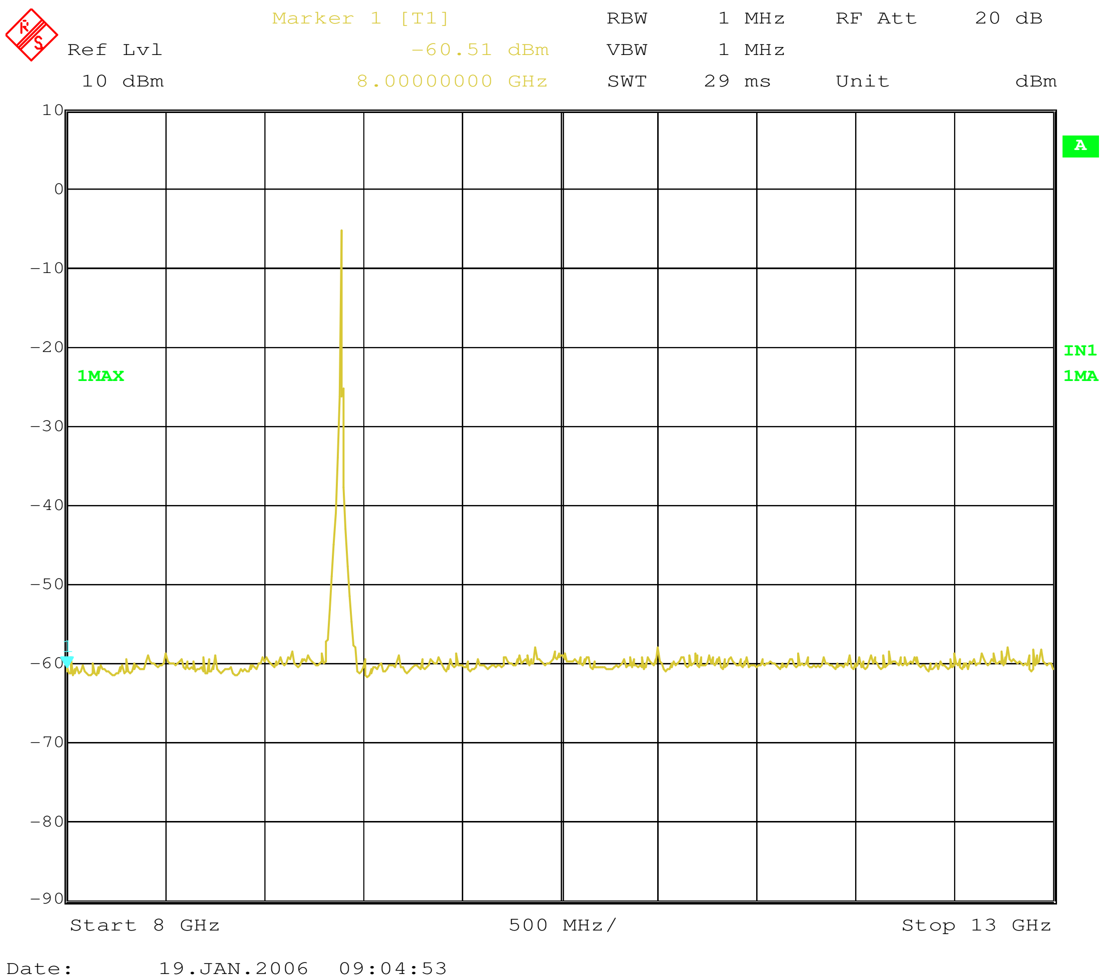


Figure 17 Conducted Emissions 450ns Pulse 8GHz to 13GHz

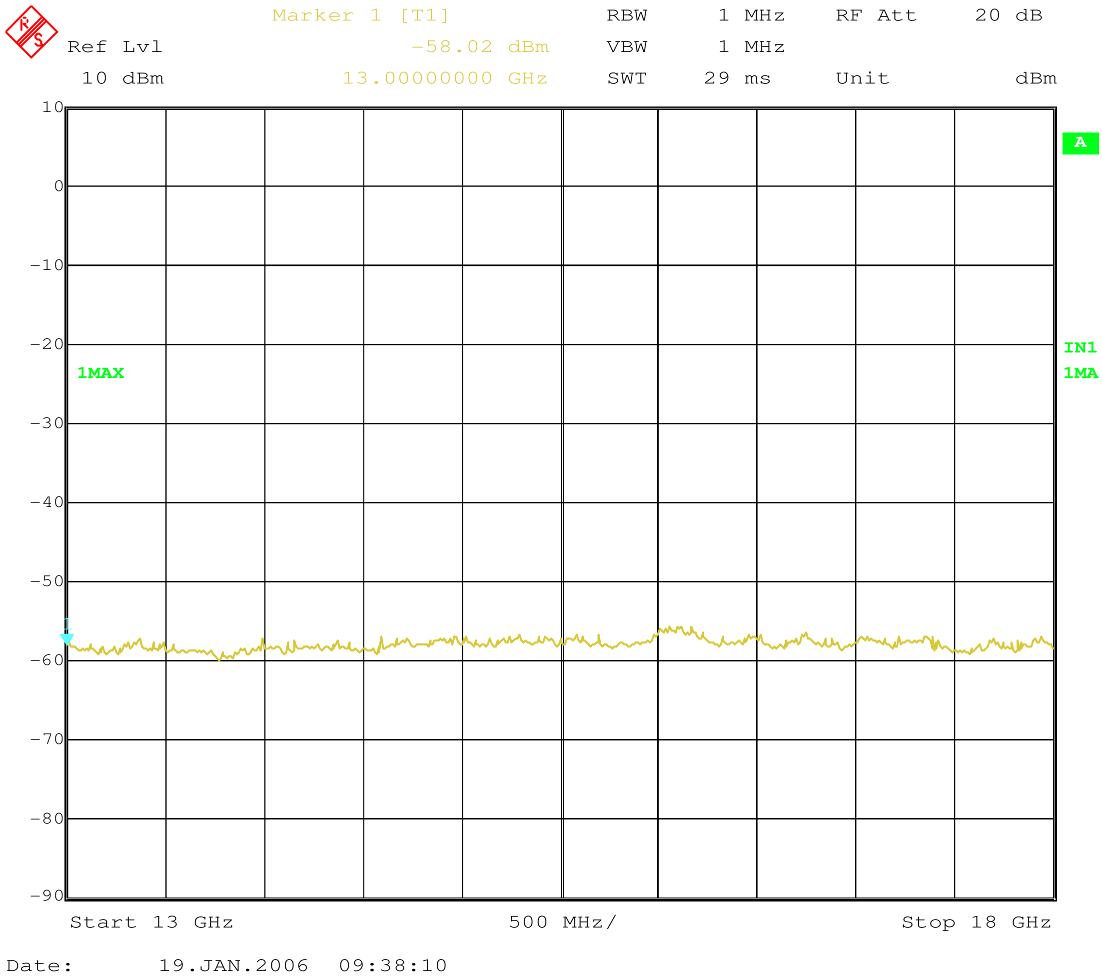


Figure 18 Conducted Emissions 450ns Pulse 13GHz to 18GHz

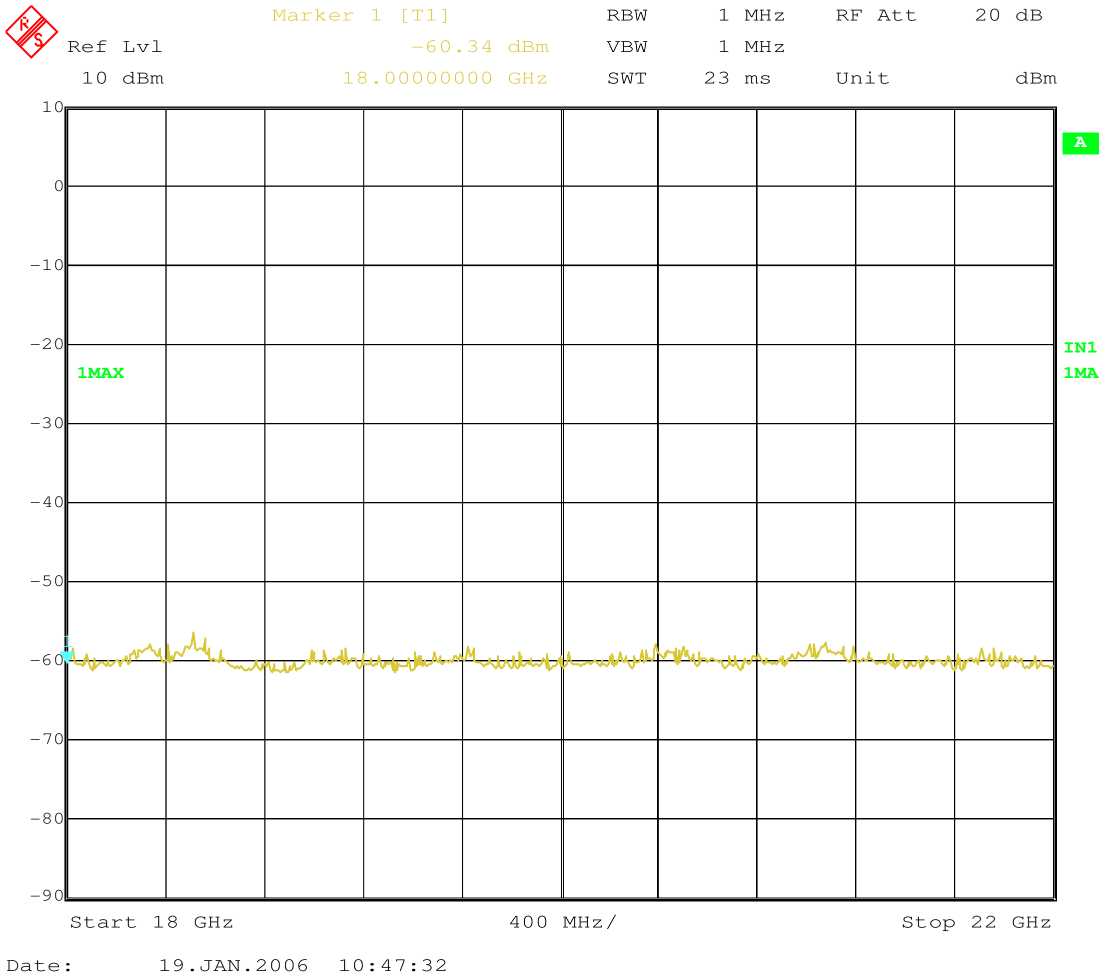


Figure 19 Conducted Emissions 450ns Pulse 18GHz to 22GHz

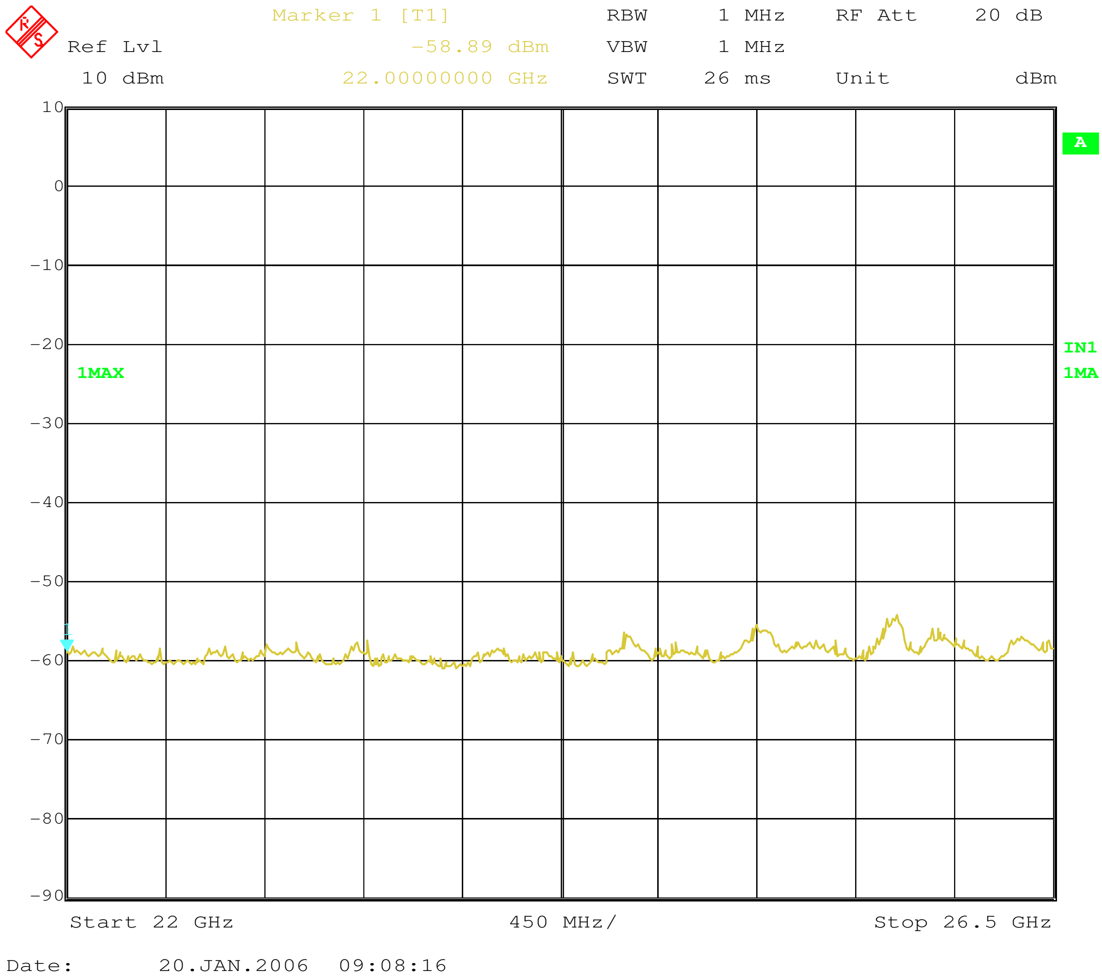


Figure 20 Conducted Emissions 450ns Pulse 22GHz to 26.5GHz

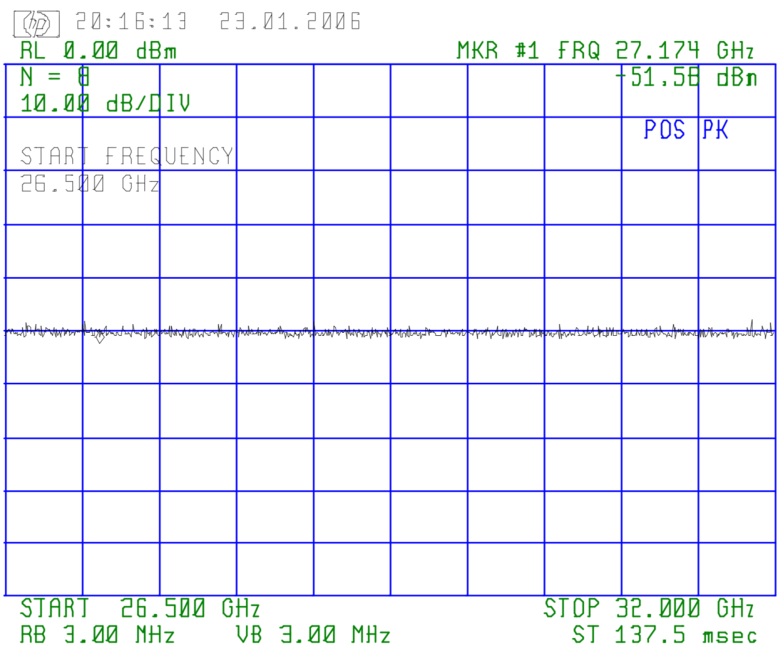


Figure 21 Conducted Emissions 450ns Pulse 26.5GHz to 32GHz

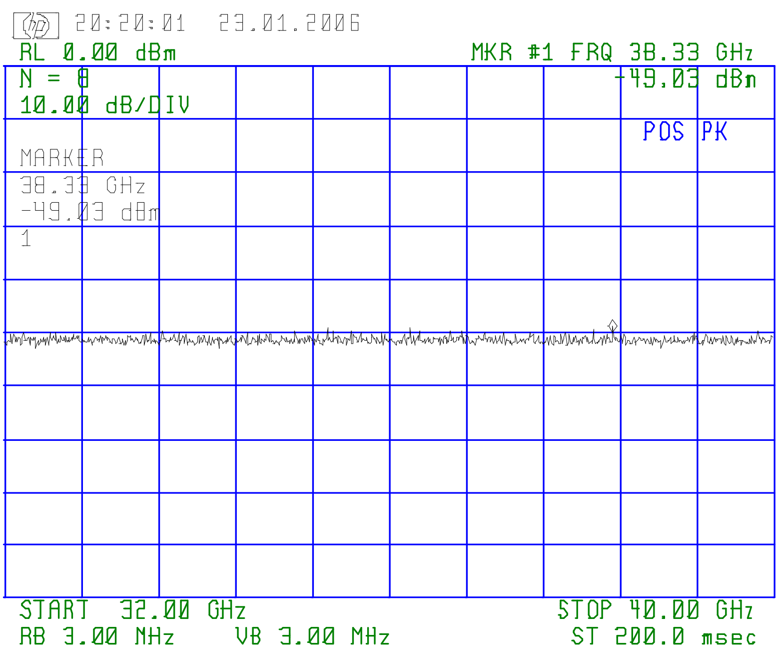


Figure 22 Conducted Emissions 450ns Pulse 32GHz to 40GHz

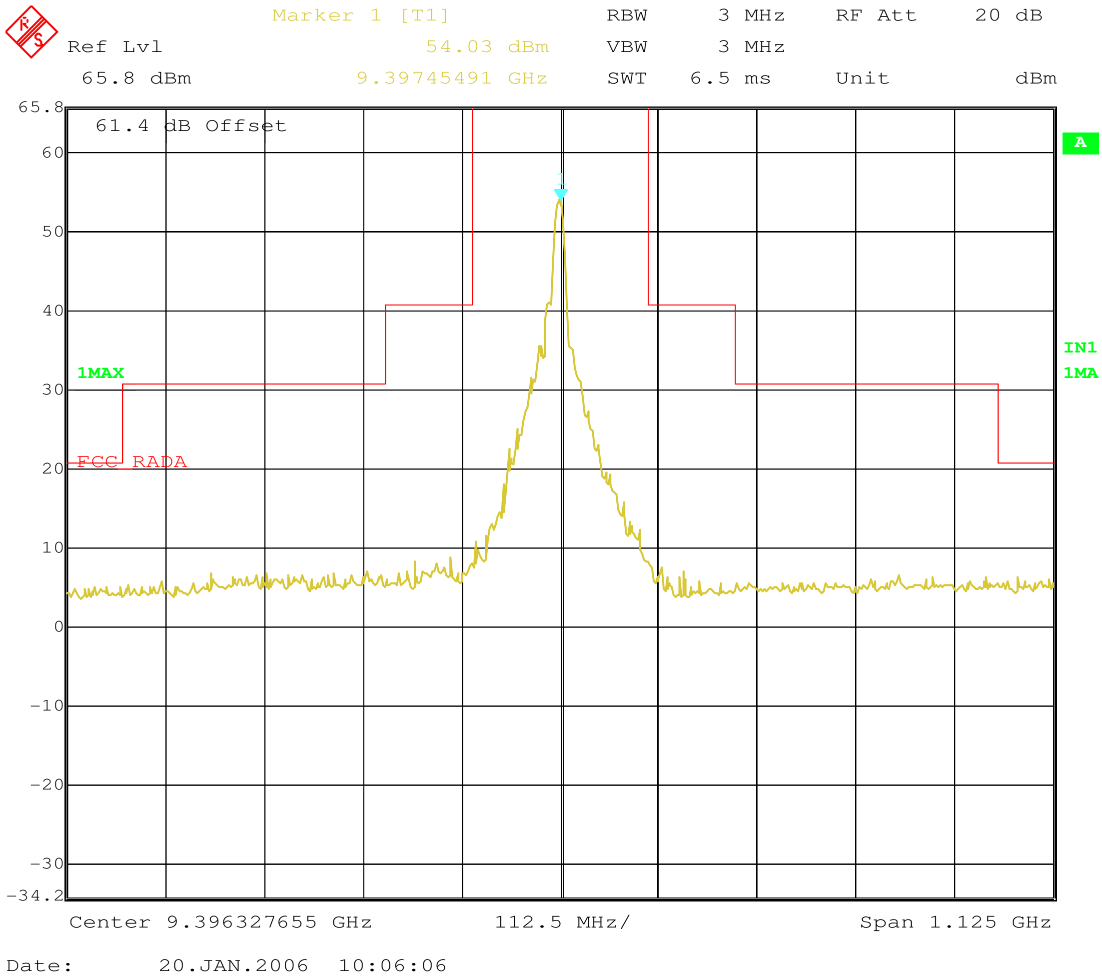


Figure 23 Main Pulse Measurement Short Pulse

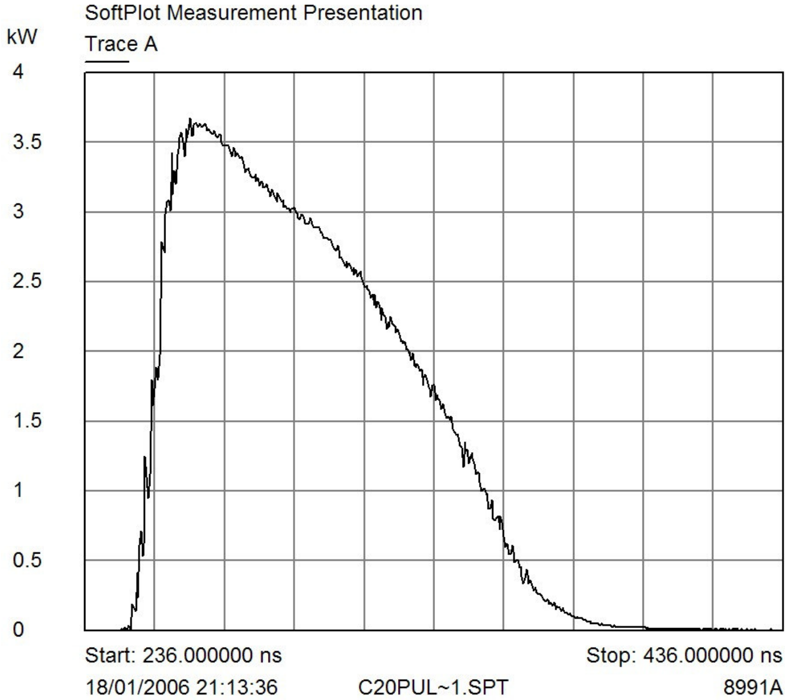


Figure 24 Pulse Characterisation 75ns

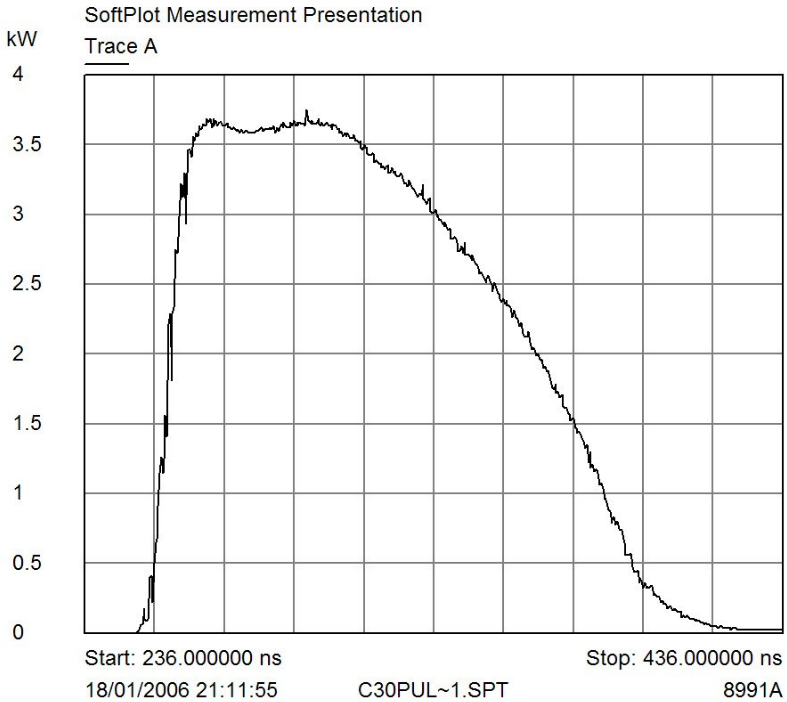


Figure 25 Pulse Characterisation 100ns

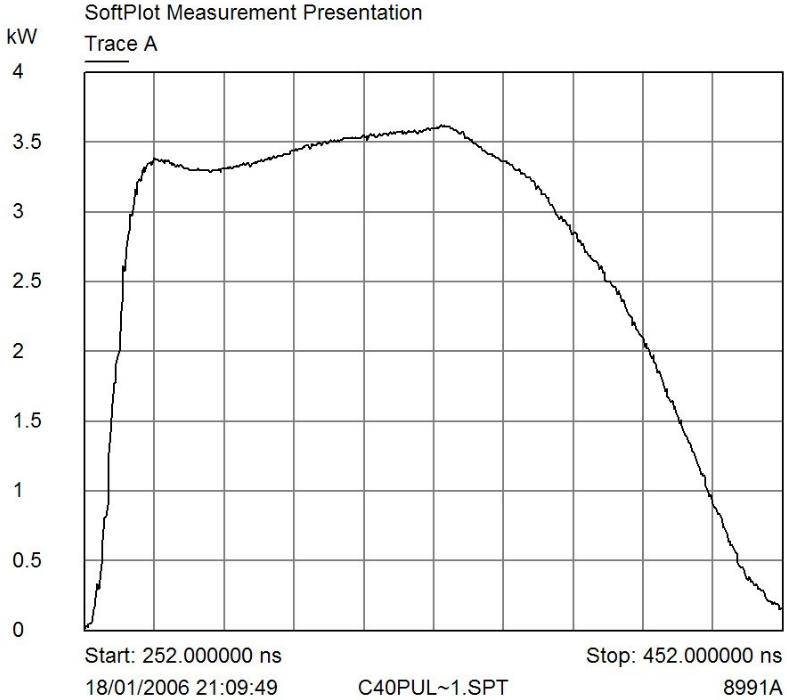


Figure 26 Pulse Characterisation 150ns

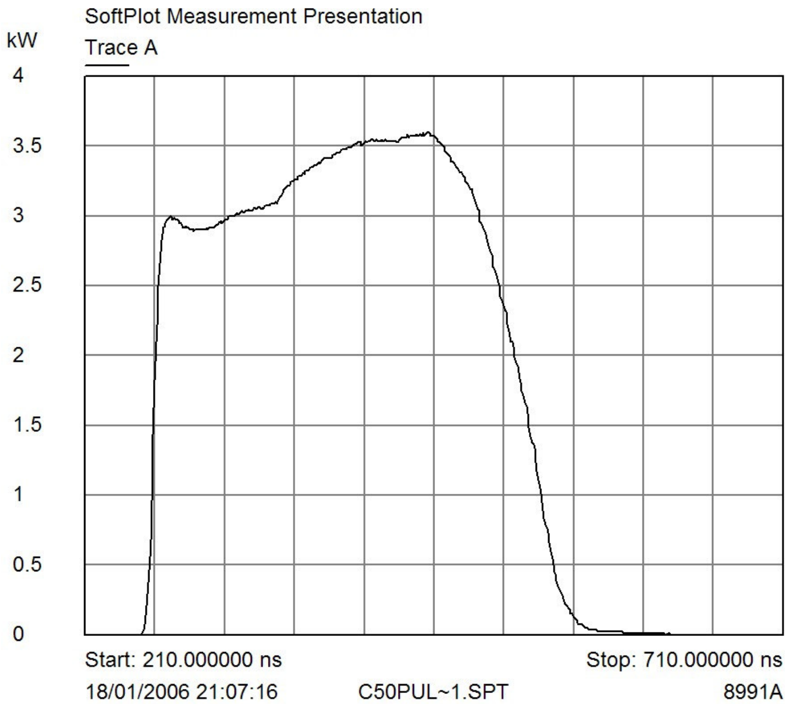


Figure 27 Pulse Characterisation 250ns

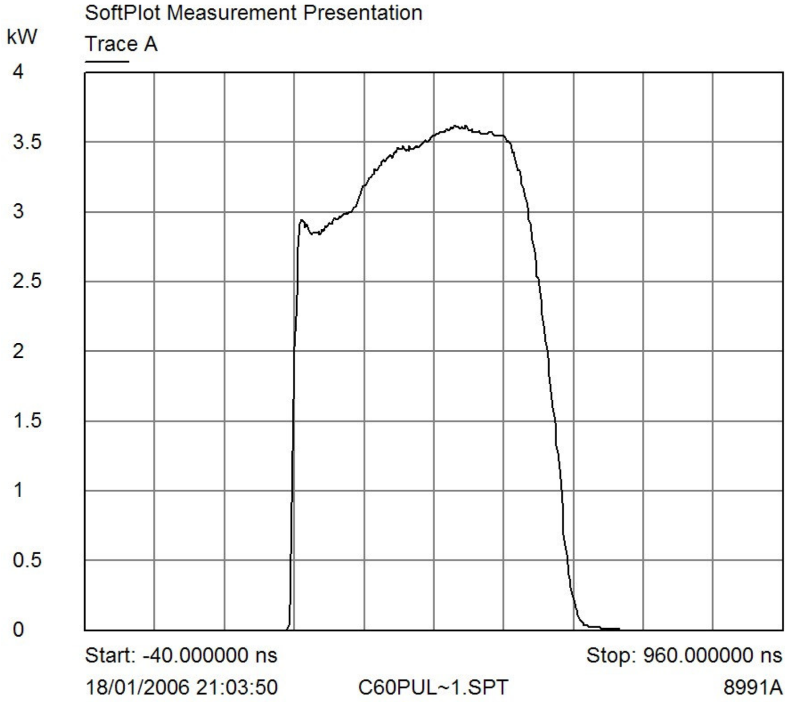


Figure 28 Pulse Characterisation 350ns

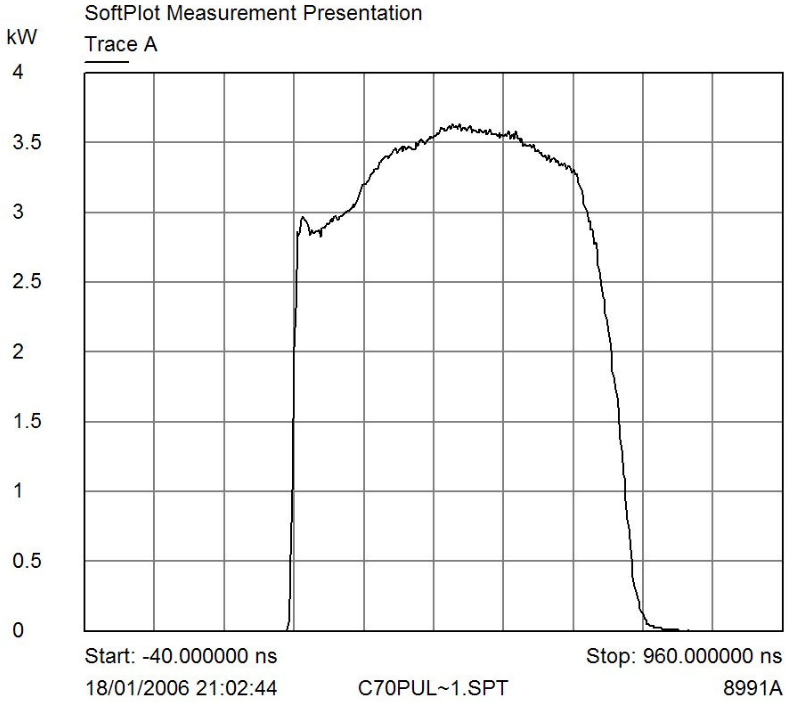


Figure 29 Pulse Characterisation 450ns

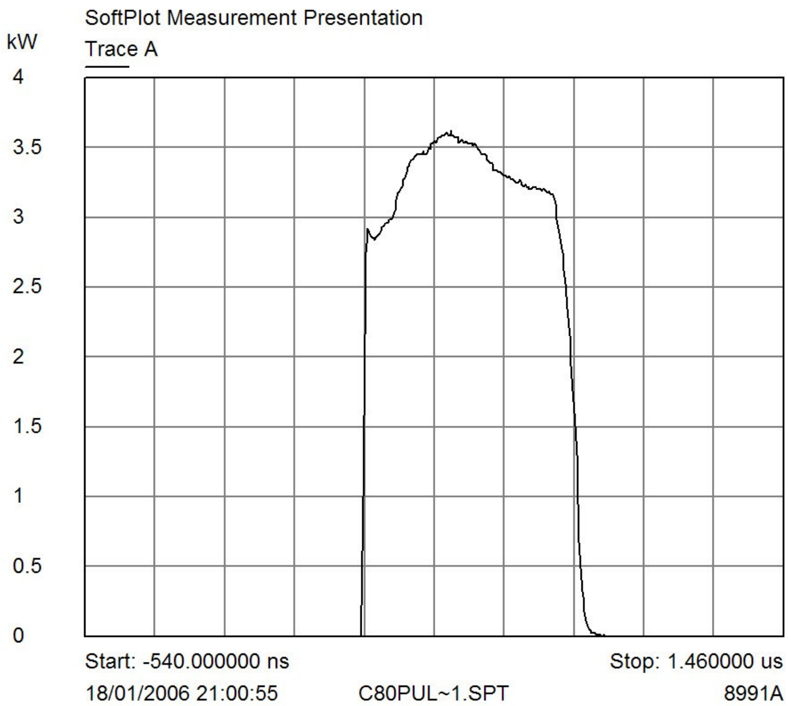


Figure 30 Pulse Characterisation 600ns

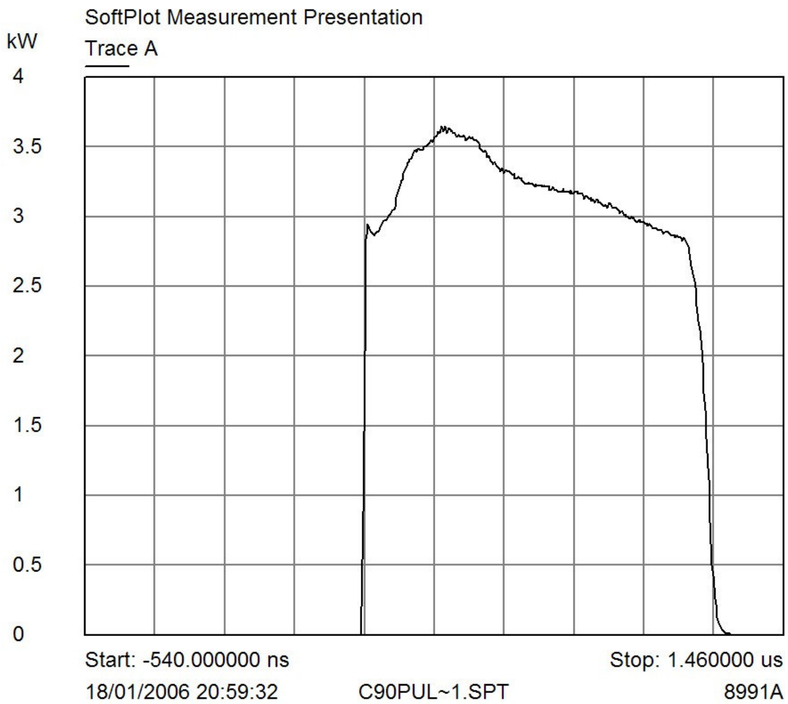


Figure 31 Pulse Characterisation 1000ns

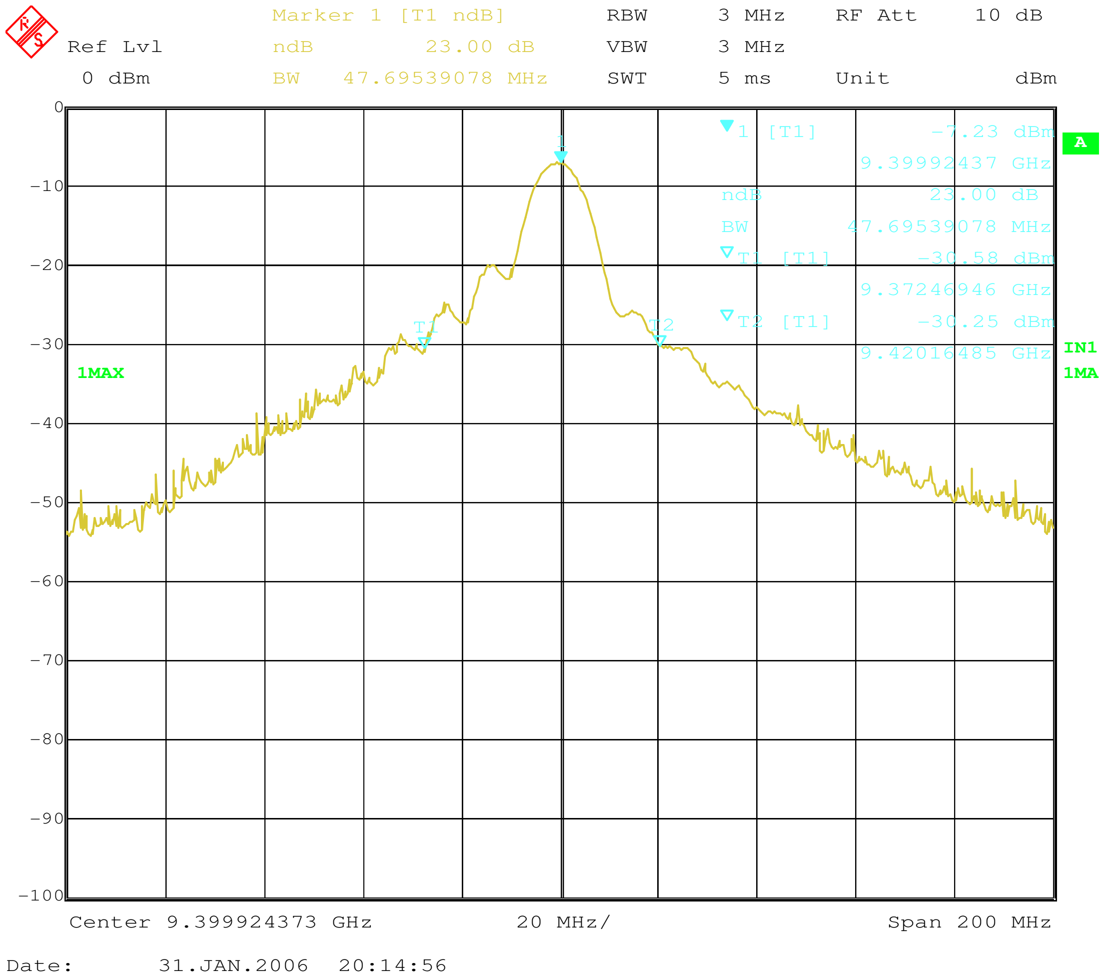


Figure 32 Occupied Bandwidth 75ns Pulse

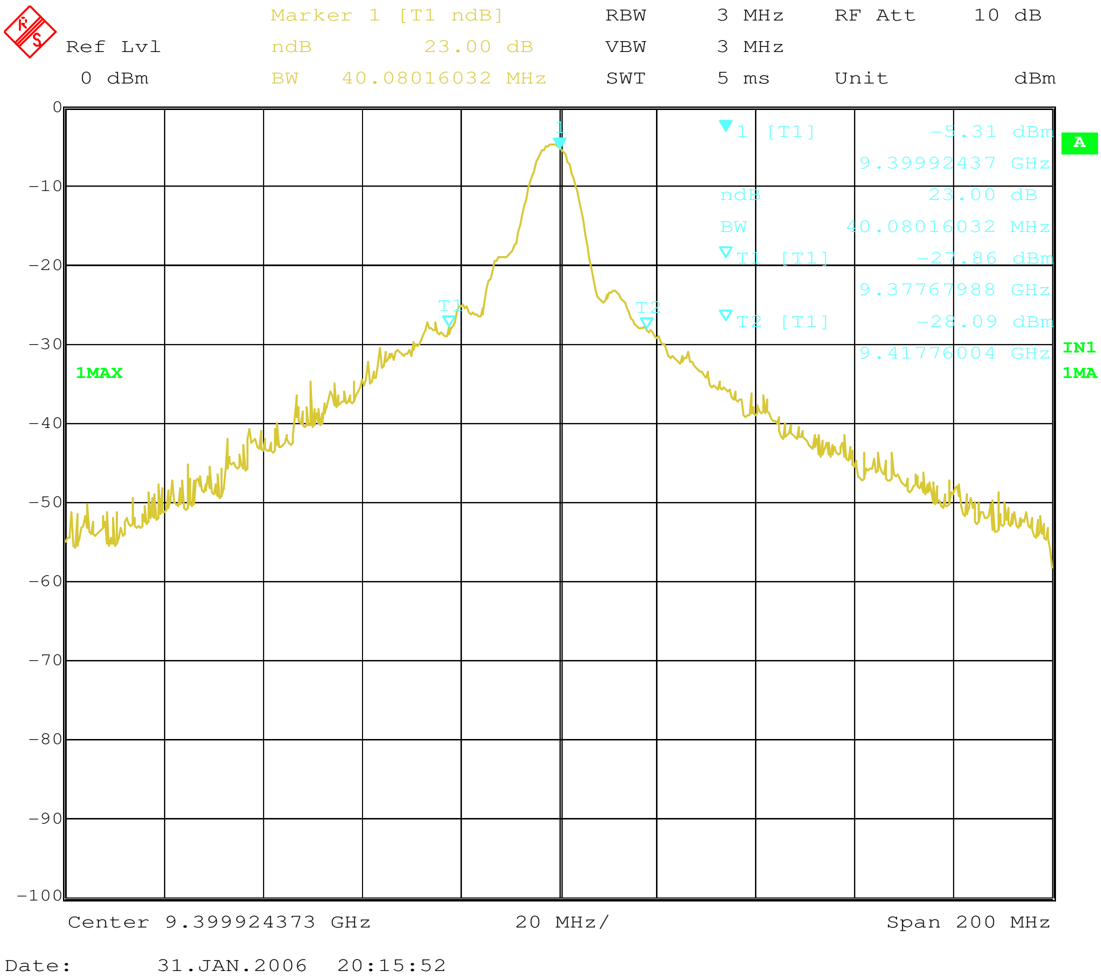


Figure 33 Occupied Bandwidth 100ns Pulse

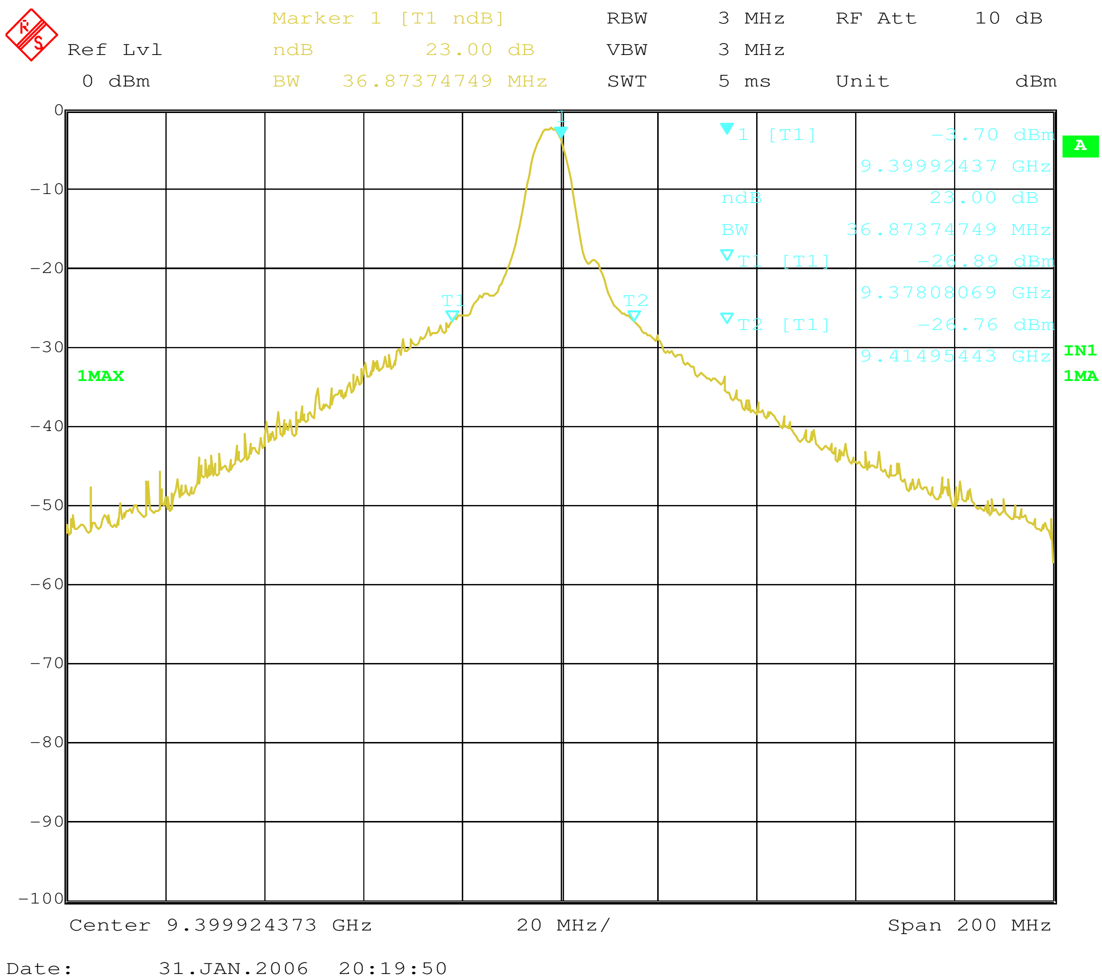


Figure 34 Occupied Bandwidth 150ns Pulse

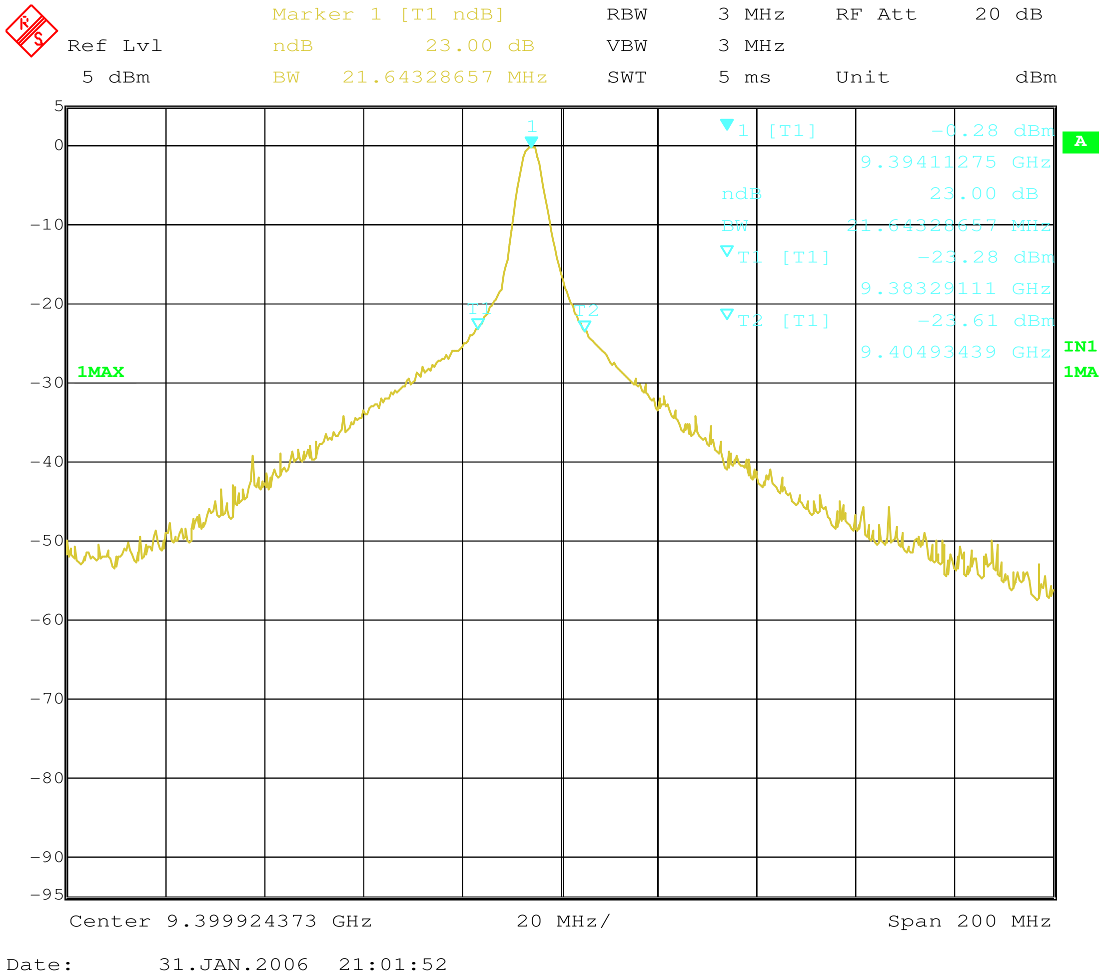


Figure 35 Occupied Bandwidth 250ns Pulse

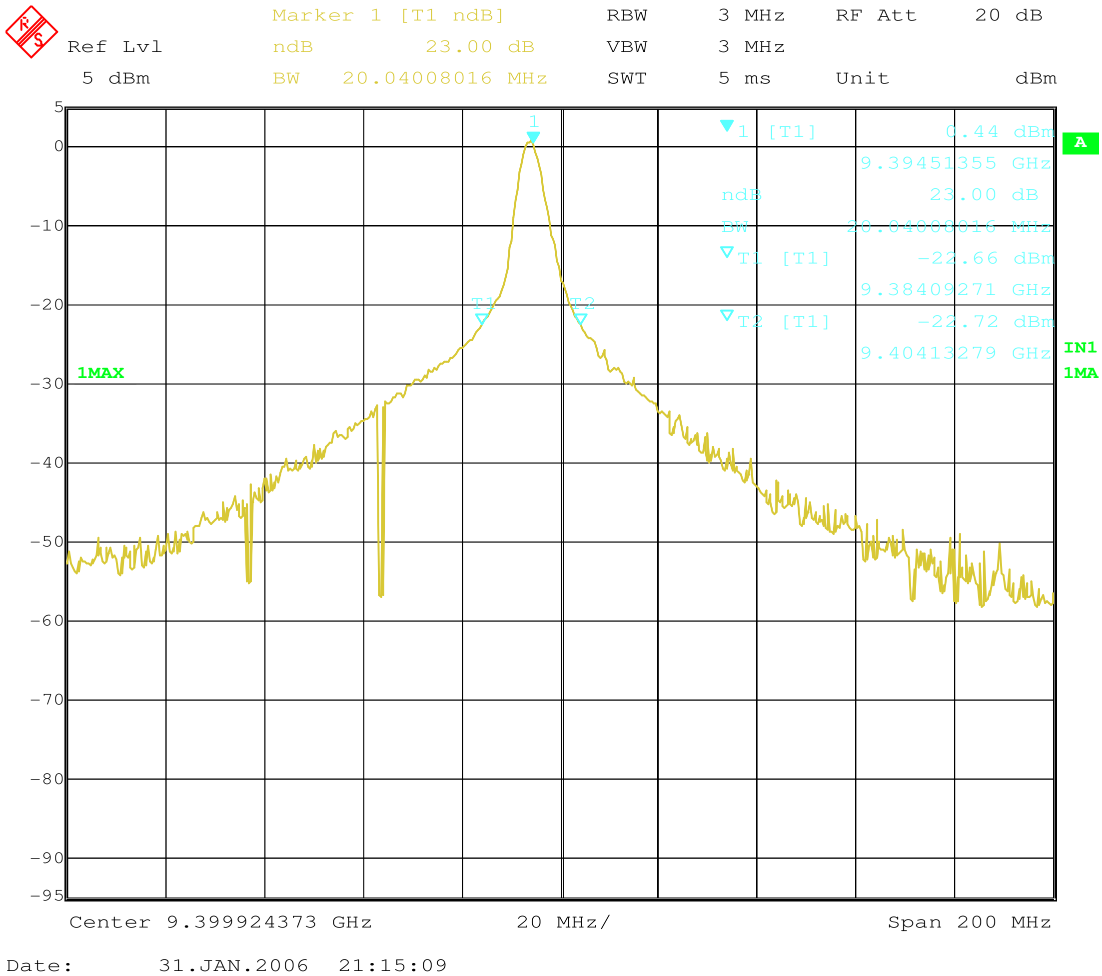


Figure 36 Occupied Bandwidth 350ns Pulse

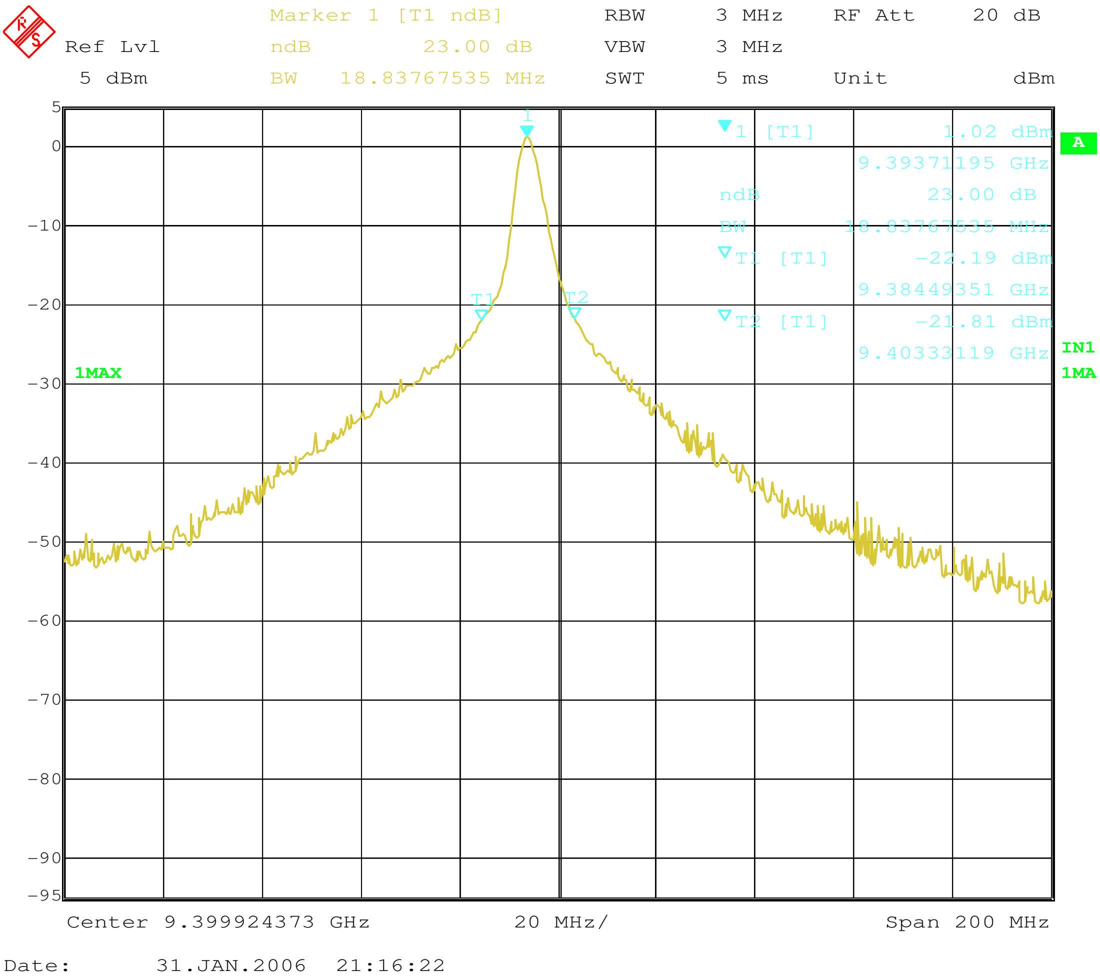


Figure 37 Occupied Bandwidth 450ns Pulse

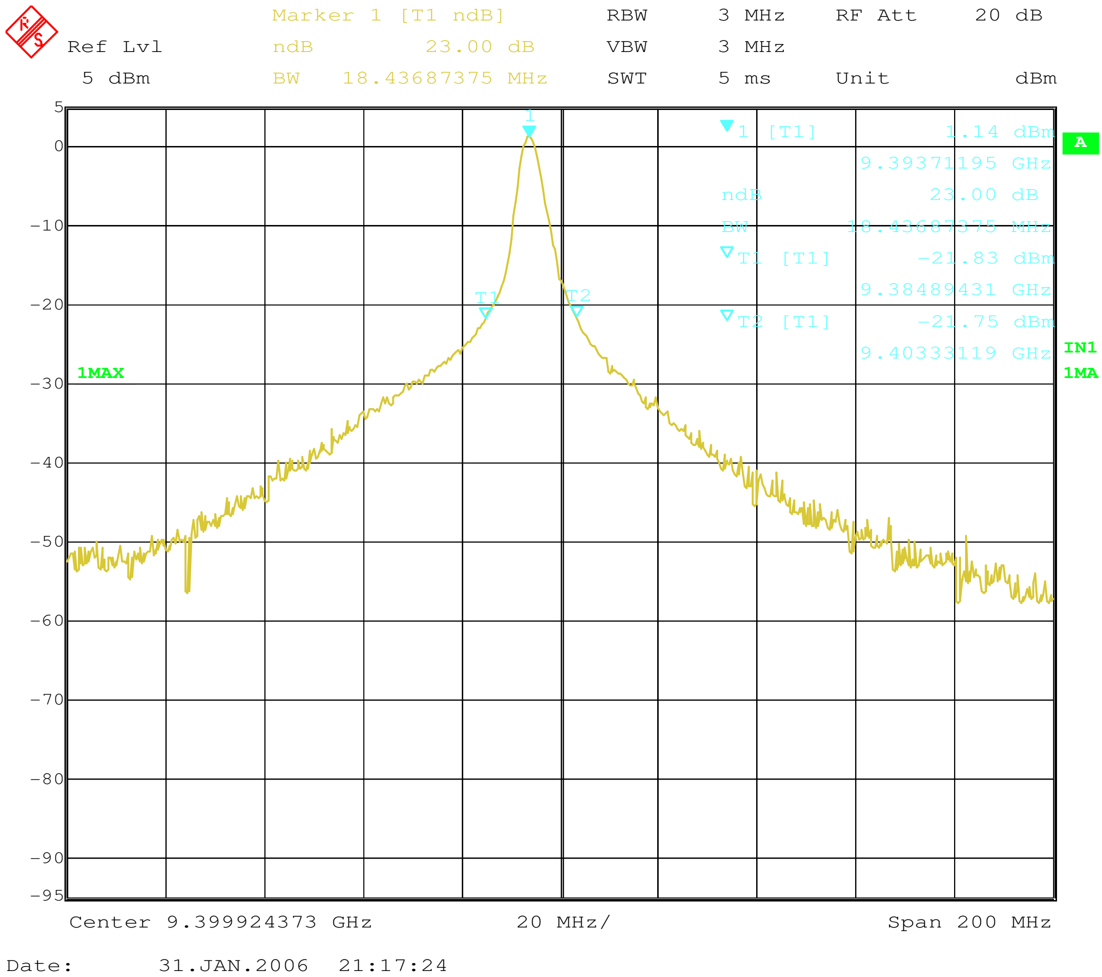


Figure 38 Occupied Bandwidth 600ns Pulse

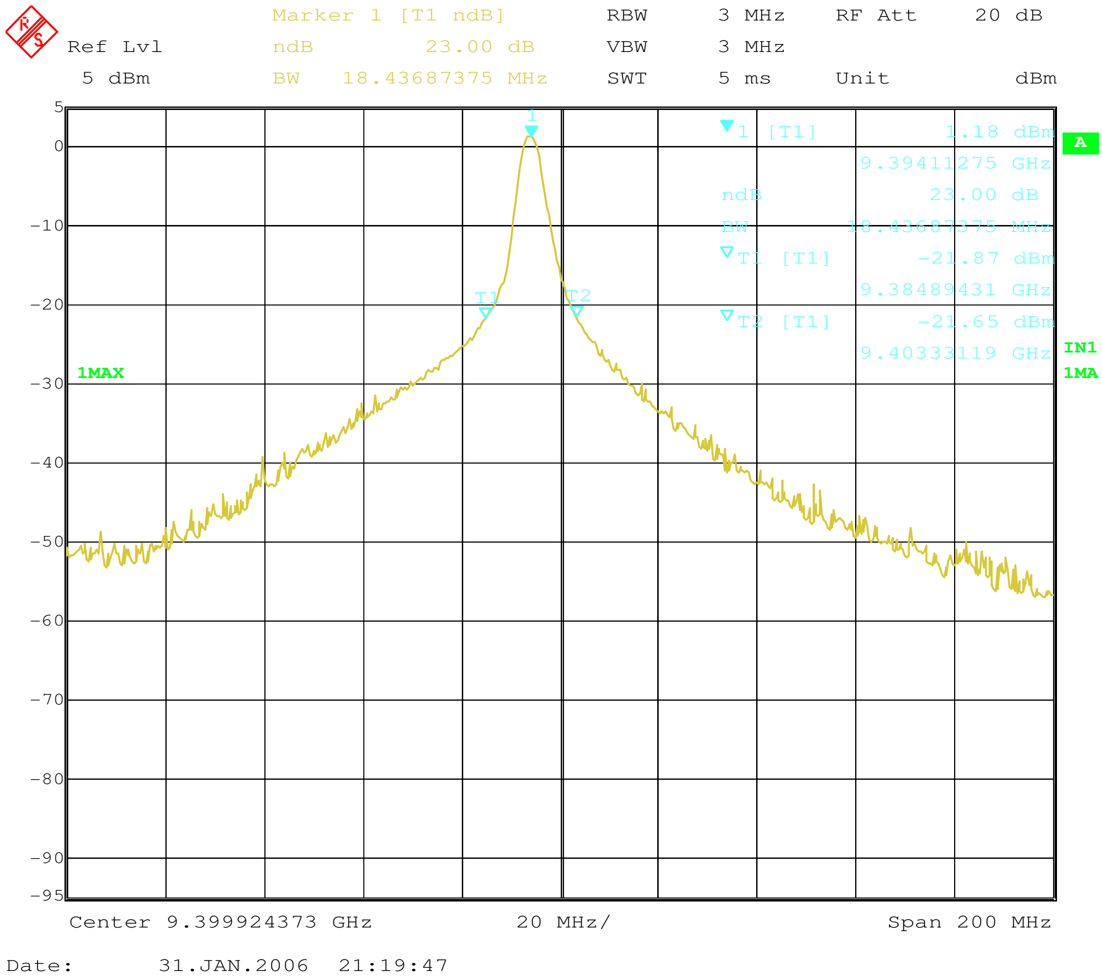


Figure 39 Occupied Bandwidth 1000ns Pulse

1.