# ELECTROMAGNETIC EMISSIONS TEST REPORT

**according to FCC Part 15 subpart C, §15.247 and subpart B**
**for**

## Marconi Communications LTD.

**EQUIPMENT UNDER TEST:**

**Base Station Radio Unit of Wireless Local Loop System (WipLL), model BSR-2.4**

**Hermon Laboratories Ltd.**
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ACCREDITED
839.01
**Electrical**

## Description of equipment under test

| | |
|---|---|
| Test items | Base station radio unit (frequency hopping transmitter) |
| Manufacturer | Marconi Communications Ltd. |
| Types (Models) | BSR-2.4 |
| Receipt date | February 19, 2001 |

## Applicant information

| | |
|---|---|
| Applicant's representative & responsible person | Mr. Shmuel Bleichman, VP engineering |
| Company | Marconi Communications Ltd. |
| Address | 1 Hamelacha street |
| Postal code | 71293 |
| City | Lod |
| Country | Israel |
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| Telefax number | +972 8977 7050 |

## Test performance

| | |
|---|---|
| Project Number: | 14551 |
| Location | Hermon Laboratories |
| Test performed | February 19 to February 28, 2001 |
| Purpose of test | EUT certification according to FCC requirements |
| Test specification(s) | FCC Part 15, subpart C, §15.247, §§15.205, 15.207, 15.209, subpart B §§15.107,15.109 |

# Table of Contents

# 1 Summary and signatures

The EUT, BSR-2.4 base station radio unit, was tested according to FCC part 15 subpart C, §.15.247, subpart B §§15.107, 15.109 and found to comply with the standard requirements.

**Test performed by:**

Mrs. E. Pitt, test engineer _____

**Test report prepared by:**

Mrs. M. Cherniavsky, certification engineer _____

**Test report approved by:**

Mr. M. Nikishin, EMC group leader _____

Dr. E. Usoskin, C.E.O. _____

The A2LA logo endorsement applies only to the test methods and the standards that are listed in the scope of Hermon Laboratories accreditation by A2LA.
Through this report period is used as decimal separator while thousands are separated by comma.
This report is in conformity with EN 45001 and ISO GUIDE 25.
The test results relate only to the items tested.

# 2 General information

## 2.1 Abbreviations and acronyms

The following abbreviations and acronyms are applicable to this test report:

| | |
|---|---|
| AC | alternating current |
| AF | antenna factor |
| AVRG | average (detector) |
| BER | bit error rate |
| BSDU | base station distribution unit |
| BW | bandwidth |
| CE | conducted emissions |
| CL | cable loss |
| cm | centimeter |
| CW | sine wave |
| dB | decibel |
| dBm | decibel referred to one milliwatt |
| dB(µA) | decibel referred to one microampere |
| dB(µV) | decibel referred to one microvolt |
| dB(µV/m) | decibel referred to one microvolt per meter |
| DC | direct current |
| EMC | electromagnetic compatibility |
| EUT | equipment under test |
| FSK | frequency shift keying |
| Gamp | amplifier gain |
| GHz | gigahertz |
| H | height |
| HL | Hermon Laboratories |
| Hz | hertz |
| IF | Intermediate frequency |
| kHz | kilohertz |
| L | length |
| LO | local oscillator |
| m | meter |
| Mbps | megabit per second |
| mm | millimeter |
| MHz | megahertz |
| ms | millisecond |
| NA | not applicable |
| NARTE | National Association of Radio and Telecommunications Engineers, Inc. |
| nF | nanofarad |
| Ω | ohm |
| QP | quasi-peak (detector) |
| PC | personal computer |
| RBW | resolution bandwidth |
| RF | radio frequency |
| RE | radiated emission |
| s | second |
| SPR | subscriber premises radio |
| TDMA | time division multiple access |
| V | volt |
| V/m | volt per meter |
| W | watt |

## 2.2 Specification references

| | |
|---|---|
| CFR 47 part 15:1999 | Radio Frequency Devices. |
| ANSI C63.2:1996 | American National Standard for Instrumentation-Electromagnetic Noise and Field Strength, 10 kHz to 40 GHz-Specifications. |
| ANSI C63.4:1992 | 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. |

## 2.3 EUT description

A base station radio, BSR-2.4, is a part of a broadband fixed cellular wireless access system WipLL. The system provides a radio link between the end-user of the telecom network (the subscriber) and the network itself to give high-speed data access. The EUT is an outdoor unit comprising a frequency hopping transceiver that controls the WipLL sector and has several roles. The transceiver operates in 2402 MHz to 2480 MHz frequency range and is equipped with an 11 dBi gain flat plane internal antenna.
Each BSR is a controller of the PPMA (Pre-emptive Polling Multiple Access) protocol within its sector. It polls SPRs according to requirements that are determined by applications, availability of resources and pre-defined policy. Policy is based on defining allowed delays and maximum bandwidth according to packet types, determination of priorities between applications and mode of polling mechanism – preemptive or time bounded.
Each BSR is optionally physically connected to a base station distribution unit, which provides 48 V DC power, data connectivity and local switching functionality as well synchronization between the BSRs. A BSDU can serve up to six BSRs, each BSR capacity is up to 3 Mbps, therefore a 6-BSR base-station-site capacity is about 18 Mbps.

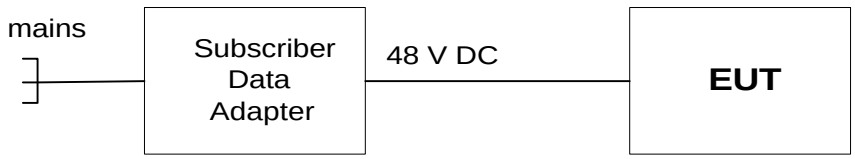
## 2.4 EUT test configuration

The EUT test configuration is given in Figure 2.4.1. Throughout the testing the EUT was powered via SDA. To withstand the standard requirements the following change was made in the EUT: a copper foil sticker was put near the power amplifier.
The device operating frequencies are given in table 2.4.1.

**Table 2.4.1**
**EUT operating and other frequencies**

| Frequency | Description | |
|---|---|---|
| | BSR/ SPR RF board | BSR/SPR Digital board |
| 2402 MHz to 2482 MHz - operating frequency | | |
| 20 MHz - clock | | |
| 2044 MHz to 2127 MHz - LO | | |
| 356 MHz - IF | | |
| 48 MHz - clock | | |

**Figure 2.4.1**
**EUT test configuration for conducted emission measurement**



# 3 Test facility description

## 3.1 General

Tests were performed at Hermon Laboratories Ltd., which is a fully independent, private EMC, Safety and Telecommunication testing facility. Hermon Laboratories is listed by the Federal Communications Commission (USA) for all parts of Code of Federal Regulations 47 (CFR 47) and by Industry Canada for radiated measurements (file numbers IC 2186-1 for OATS and IC 2186-2 for anechoic chamber), certified by VCCI, Japan (the registration numbers are R-808 for OATS, R-1082 for anechoic chamber, C-845 for conducted emissions site), assessed by NMi Certin B.V. (Netherlands) for a number of EMC, Telecommunications, Safety standards, and assessed by AMTAC (UK) for safety of Medical Devices. The laboratory is accredited by American Association for Laboratory Accreditation (USA) according to ISO GUIDE 25/EN 45001 for EMC (commercial and military standards), Telecommunications and Product Safety Information Technology Equipment (Certificate No. 839.01).

Address: PO Box 23, Binyamina 30550, Israel.
Telephone: +972-4628 8001
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Person for contact: Mr. Alex Usoskin, testing and QA manager.

## 3.2 Equipment calibration

The test equipment has been calibrated according to its recommended procedures and is within the manufacturer's published limit of error. The standards and instruments used in the calibration system conform to the present requirements of MIL-STD-45662A.
The laboratory standards are calibrated by the third party (traceable to NIST, USA) on a regular basis according to equipment manufacturer requirements.

### 3.2.1 Expanded uncertainty at 95% confidence in Hermon Labs EMC measurements

| | |
|---|---|
| Conducted emissions with LISN and HP 8542E/HP8546A receiver | ▪ 9 kHz to 150 kHz: +2.43 dB/-2.22 dB<br>▪ 150 kHz to 30 MHz: + 2.22 dB/-2.05 dB |
| Radiated emissions in the open field test site at 3 m measuring distance | ▪ Biconical antenna: +5.52 dB/-5.37 dB<br>▪ Log periodic antenna: +5.71 dB/-5.56 dB<br>▪ Biconilog antenna: +5.83 dB/-5.67 dB |
| Radiated emissions in the anechoic chamber at 3 m measuring distance | ▪ Biconical antenna: +5.42 dB/-5.26 dB<br>▪ Log periodic antenna: +5.61 dB/-5.46 dB<br>▪ Biconilog antenna: +5.73 dB/-5.57 dB<br>▪ Double ridged guide antenna: ± 2.36 dB |
| Conducted power measurements | ▪ +0.36 dB /-0.38 dB |
| Conducted frequency measurements | ▪ 0.18 ppm |
| Conducted spurious emissions measurements | ▪ ±2.5 dB |

## 3.3 Statement of qualification

The test measurement data supplied in this test measurement report having been received by me, is hereby duly certified. The following is a statement of my qualifications:
I am an engineer, graduated from the University in 1974 with an MScEE degree, have obtained 27 years experience in EMC measurements and have been with Hermon Laboratories since 1991. Also, I am an EMC accredited test laboratory engineer certified by the National Association of Radio and Telecommunications Engineers, Inc. (USA.), the certificate no. is ATL-0006-E.

Name: Mrs. Eleonora Pitt Signature: _____
Position: test engineer Date: March 5, 2001

I hereby certify that this test measurement report was prepared by me and is hereby duly certified. The following is a statement of my qualifications.
I am an engineer, graduated from university in 1971, with an MScEE degree, have obtained 27 years experience in electronic products design and development, have been with Hermon Laboratories since 1991. Also, I am a telecommunication class II engineer certified by the National Association of Radio and Telecommunications Engineers, Inc. (USA.), the certificate no. is E2-03410.

Name: Mrs. Marina Cherniavsky Signature: _____
Position: certif. engineer Date: March 5, 2001

# 4 Emission measurements

## 4.1 Frequency hopping channels separation and hopping frequency usage test according to §15.247(a)(1)(ii)

### 4.1.1 General

This test was performed to prove that the EUT frequency hopping system uses at least 75 hopping frequencies and has hopping channel carrier frequencies separation by a minimum of 25 kHz or by the 20 dB bandwidth of the hopping channel, whichever is greater.

### 4.1.2 Test procedure

The EUT RF output was connected to the spectrum analyzer via 50 dB external attenuator as shown in Photograph 4.1.1. The spectrum analyzer settings are shown in the plots.

The Plots 4.1.1 to 4.1.8 show 79 channels in occupied frequency band 2.402 to 2.480 MHz and the 1 MHz spacing between carriers which are greater than 75 channels and 20 dB channel occupied bandwidth separation. The EUT successfully passed this test.

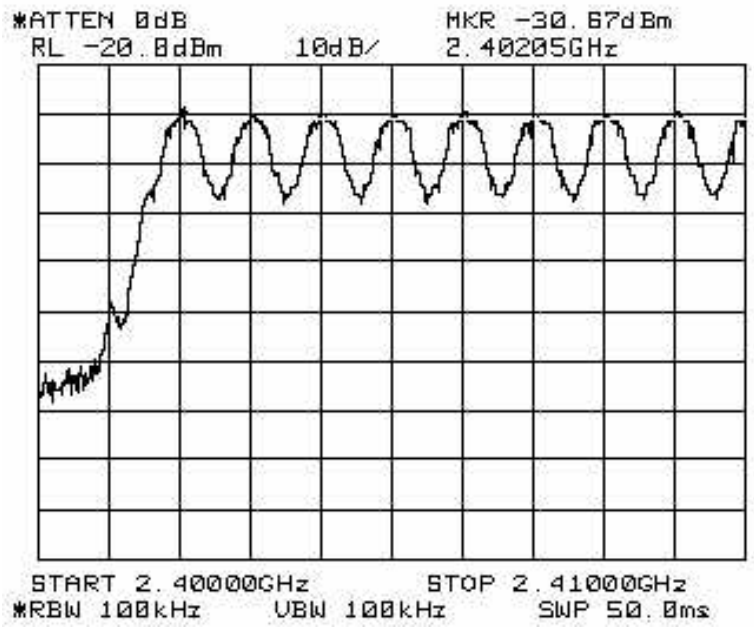
**Reference numbers of test equipment used**

| | | |
|---|---|---|
| HL 0057 | HL 1424 | |

Full description is given in Appendix A.

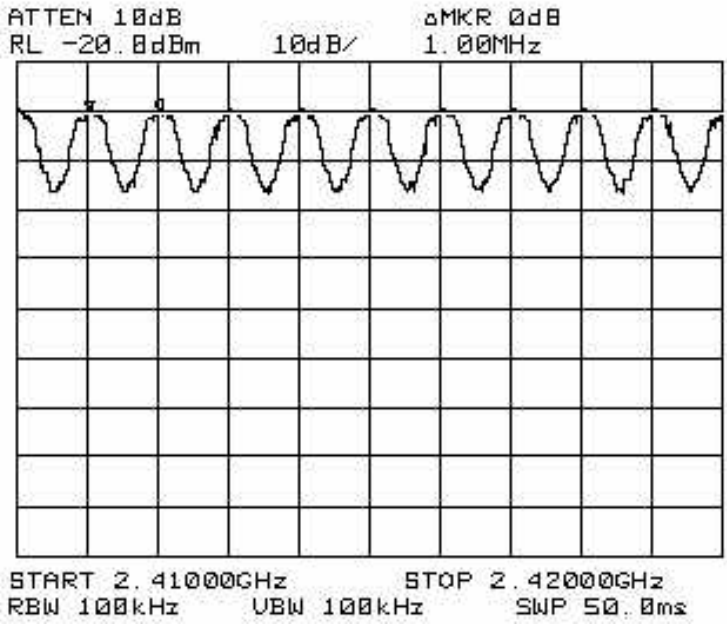
**Plot 4.1.1**

Test specification: §15.247(a)(1)(ii)
Hopping channels separation test results



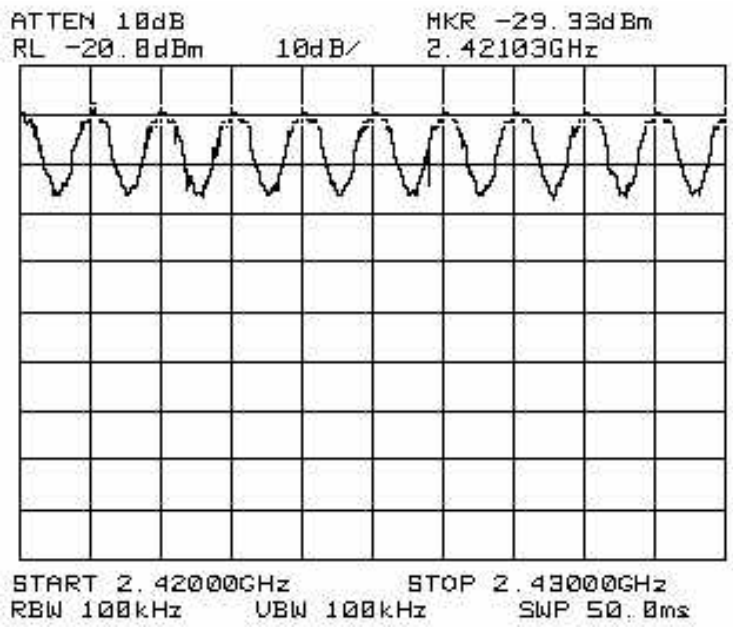
**Plot 4.1.2**

Test specification: §15.247(a)(1)(ii)
Hopping channels separation test results



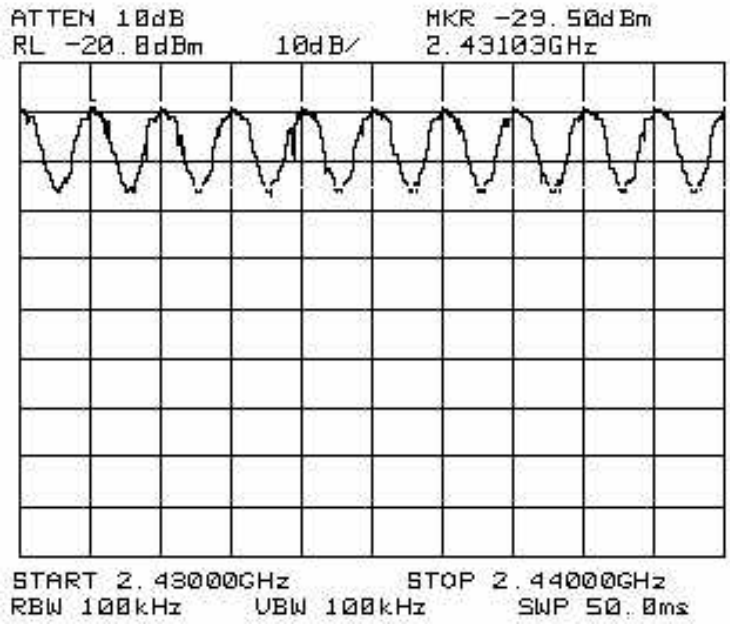
**Plot 4.1.3**

Test specification: §15.247(a)(1)(ii)
Hopping channels separation test results



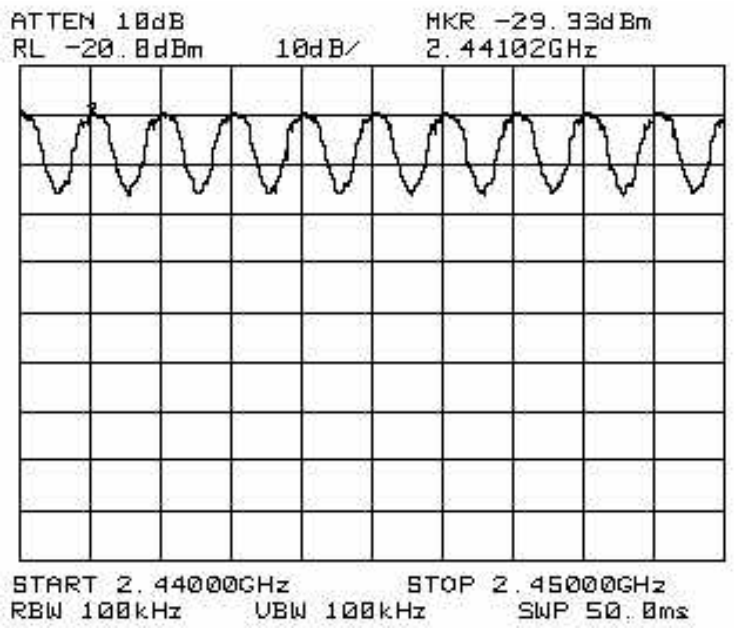
**Plot 4.1.4**

Test specification: §15.247(a)(1)(ii)
Hopping channels separation test results



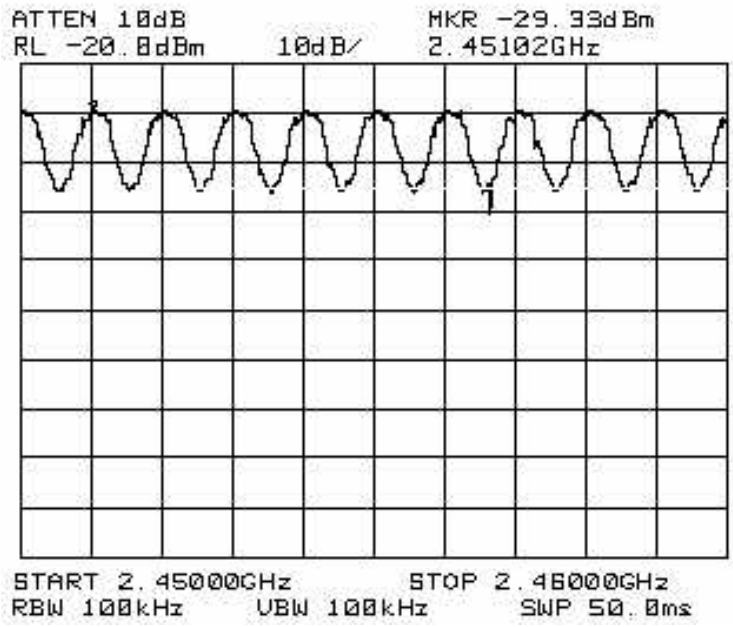
**Plot 4.1.5**

Test specification: §15.247(a)(1)(ii)
Hopping channels separation test results



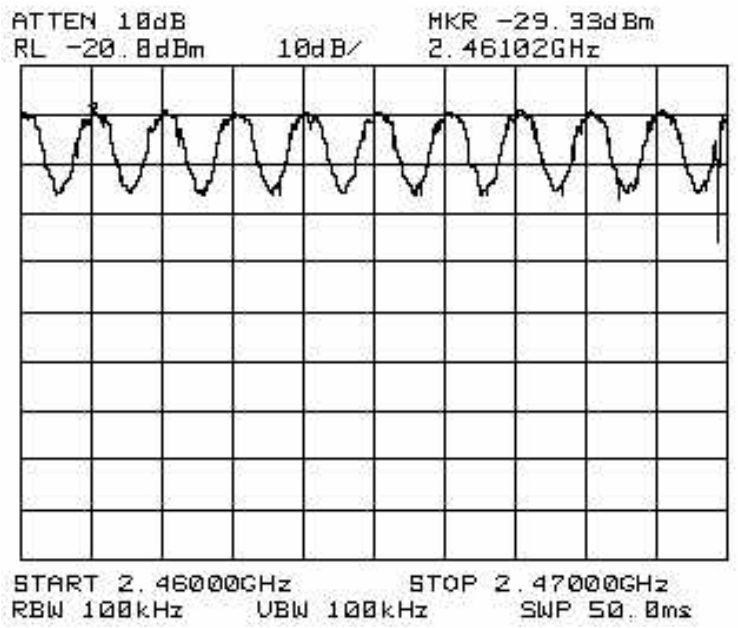
**Plot 4.1.6**

Test specification: §15.247(a)(1)(ii)
Hopping channels separation test results



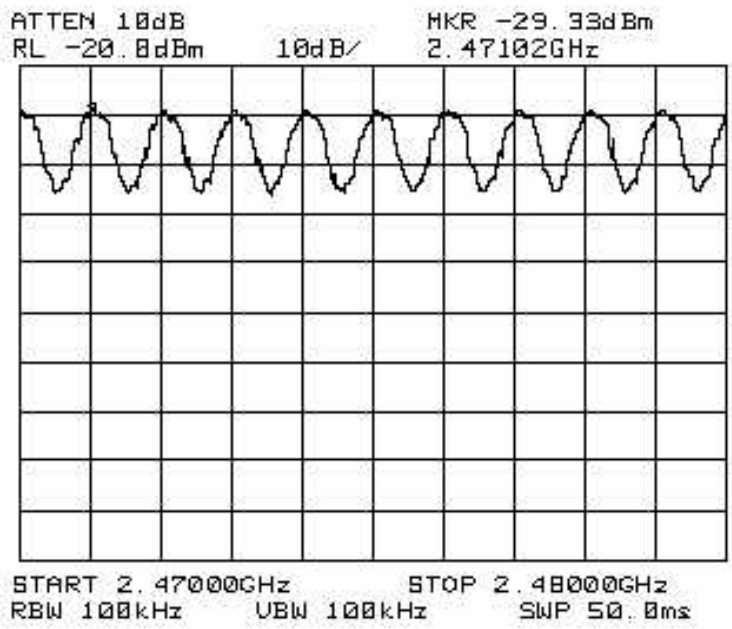
**Plot 4.1.7**

Test specification: §15.247(a)(1)(ii)
Hopping channels separation test results



**Plot 4.1.8**

Test specification: §15.247(a)(1)(ii)
Hopping channels separation test results



**Photograph 4.1.1**
**Conducted emissions measurement test setup**

## 4.2 Occupied bandwidth test according to §15.247(a)(1)(ii)

### 4.2.1 General

This test was performed to prove that the maximum 20 dB bandwidth of the hopping channel is less than 1 MHz.

### 4.2.2 Test setup and procedure

The test setup was the same as in test 4.1.
The measurements were performed in normal mode of operation with 3 Mbps rate. The occupied bandwidth measurement was performed for carrier (channel) frequency at low and high edges and at the middle of the frequency band. Table 4.2.1 and Plots 4.2.1 to 4.2.3 demonstrate the test results of the occupied bandwidth measurements. The spectrum analyzer settings are shown in plots.

**Table 4.2.1 Occupied bandwidth test results**

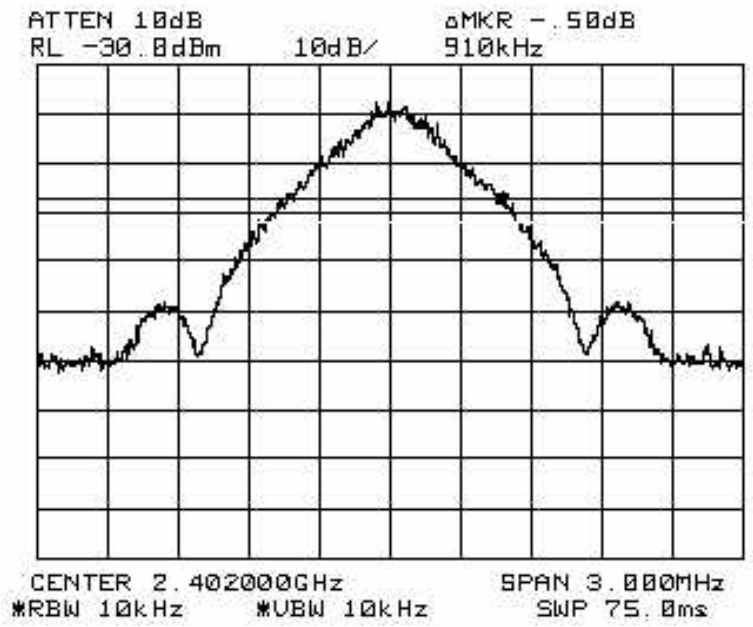
| Carrier frequency, MHz | Measured 20 dB BW, kHz | Limit, kHz | Result |
|---|---|---|---|
| 2402 | 910 | 1000 | Pass |
| 2450 | 915 | 1000 | Pass |
| 2480 | 980 | 1000 | Pass |

**Reference numbers of test equipment used**

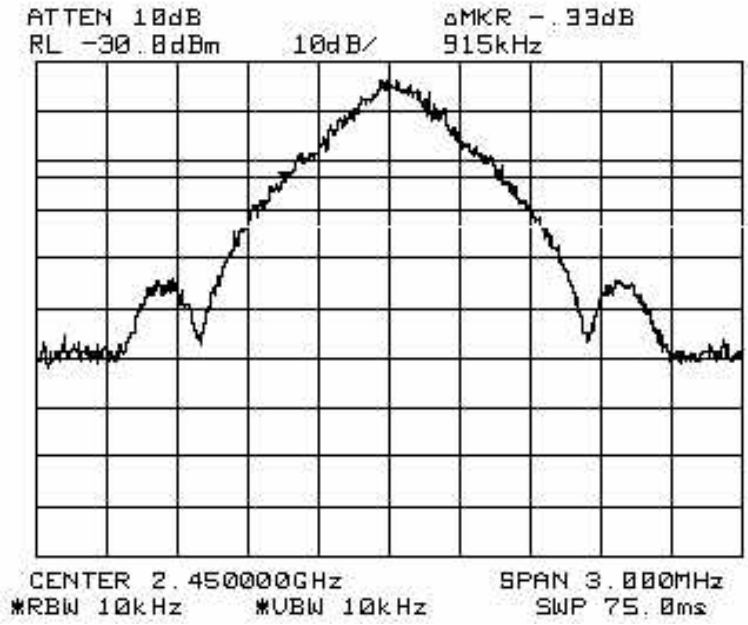
| | | |
|---|---|---|
| HL 0057 | HL 1424 | |

Full description is given in Appendix A.

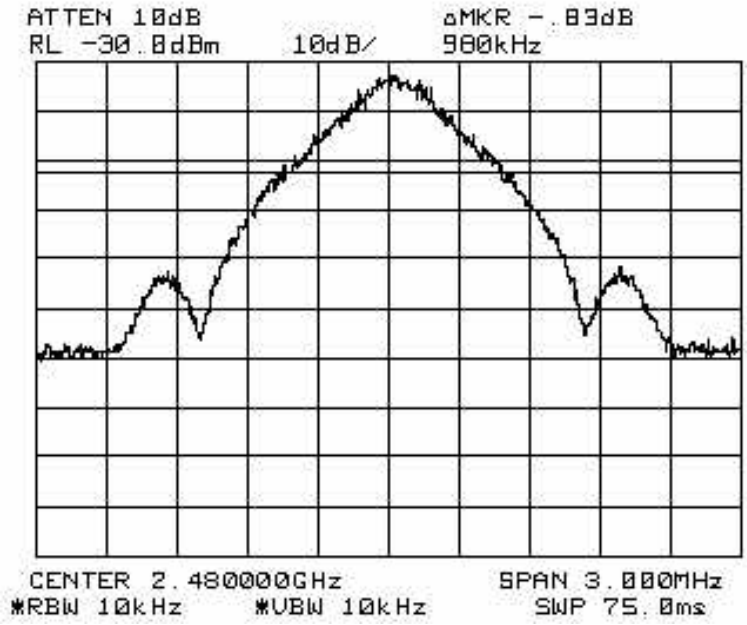
**Plot 4.2.1**
Test specification: § 15.247(a)(1)(ii)
Occupied bandwidth test results



**Plot 4.2.2**
Test specification: §15.247(a)(1)(ii)
Occupied bandwidth test results



**Plot 4.2.3**
Test specification: §15.247(a)(1)(ii)
Occupied bandwidth test results



## 4.3 Average time of occupancy, definition according to § 15.247(a)(1)(ii)

### 4.3.1 General

The test was performed to prove that the average time of occupancy at any frequency is not greater than 0.4 seconds within any 30 second period.

### 4.3.2 Test procedure

The test setup was the same as in test 4.1.
The time period between 2 successive transmissions on the same channel is 3.950 s as shown in Plot 4.3.1 and the total Tx on time is 25.3 ms within each transmission (see Plots 4.3.2 to 4.3.4). Upon this the average time of occupancy within any 30 second period per each channel is equal to:

$$30/3.95 \times 25.3 = 192.2 \text{ ms}$$

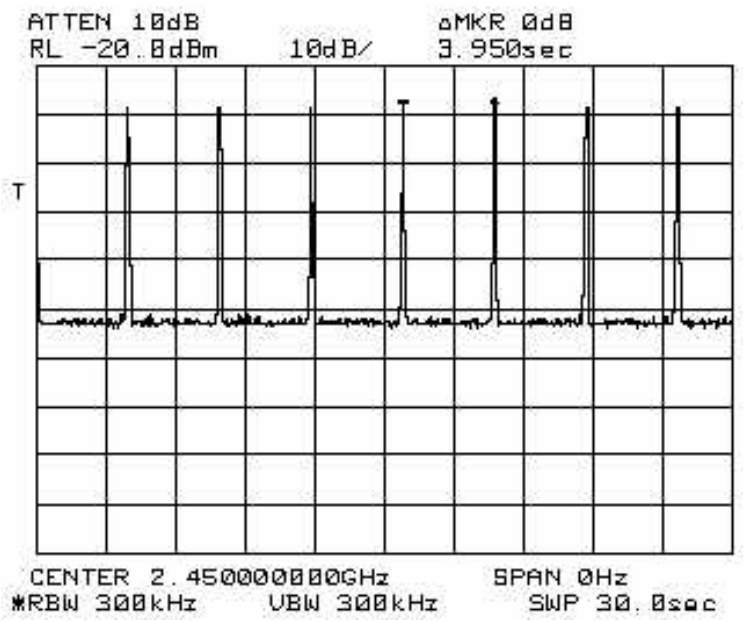
which is less than the required 0.4 s.

**Reference numbers of test equipment used**

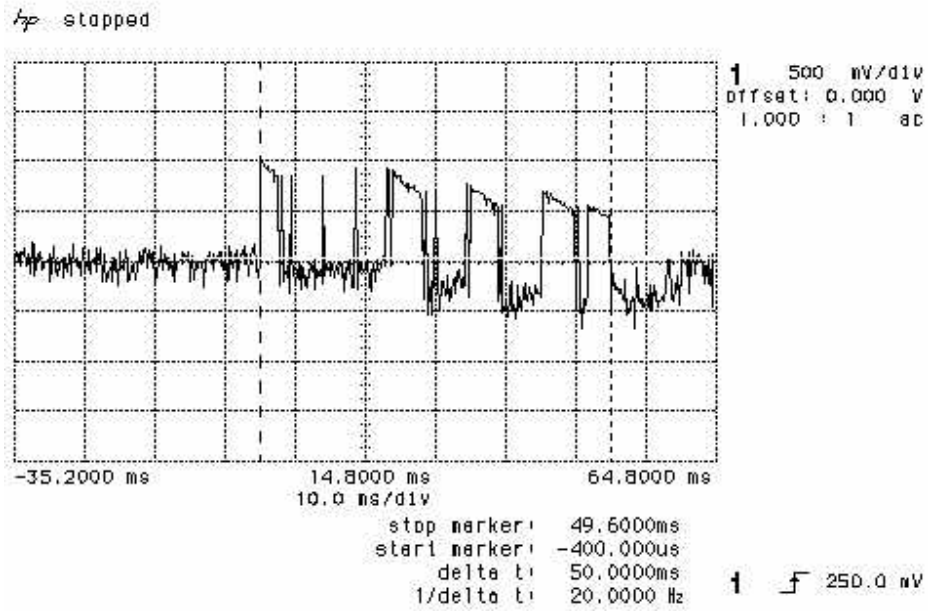
| | | | |
|---|---|---|---|
| HL 0057 | HL 0483 | HL 1424 | |

Full description is given in Appendix A.

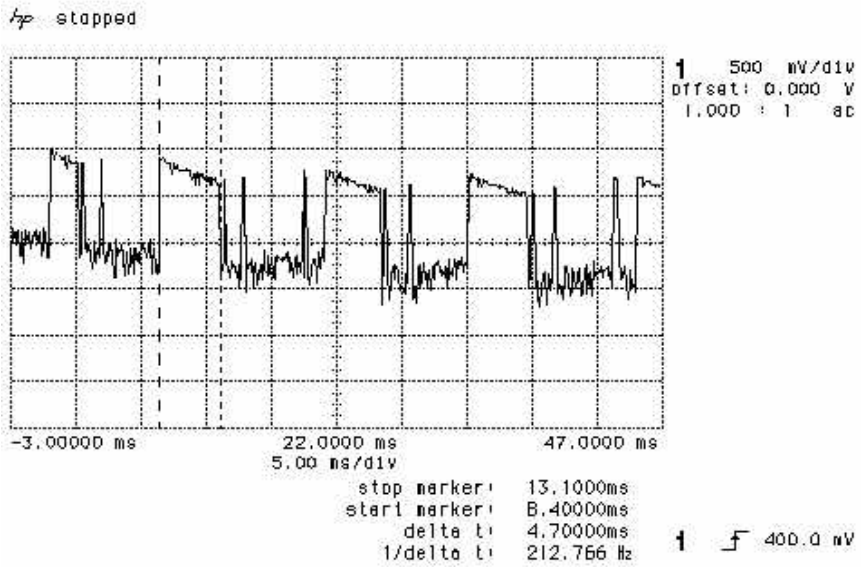
**Plot 4.3.1**
Test specification: §15.247(a)(1)(ii)
Average time of occupancy test results



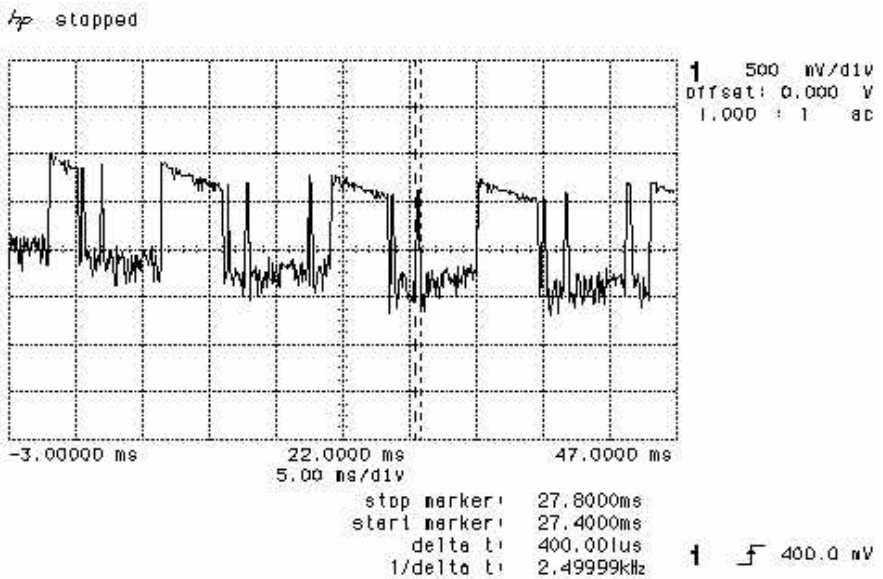

**Plot 4.3.2**
Test specification: §15.247(a)(1)(ii)
Average time of occupancy test results



**Plot 4.3.3**
Test specification: §15.247(a)(1)(ii)
Average time of occupancy test results




**Plot 4.3.4**
Test specification: §15.247(a)(1)(ii)
Average time of occupancy test results




Ton=2.5 + 4.7x4+0.4x10=25.3 ms

## 4.4 Maximum peak output power test according to §15.247 (b)(1), (3)(i)

### 4.4.1 General

This test was performed to demonstrate that the maximum RF peak output power of the transmitter does not exceed 1 W (30 dBm) (§15.247 (1)).
If the transmitting antenna of directional gain greater than 6 dBi is used, the peak output power of the intentional radiator shall be reduced below the stated value by the amount in dB that the directional gain of the antenna exceeds 6 dBi (§15.247 (3)).
In our case antenna gain is 11 dBi, hence the maximum peak output power of the transmitter shall not exceed 30 – (11-6) = 25 dBm.

### 4.4.2 Test procedure

The test setup was the same as in test 4.1.
All measured results are given in Plots 4.4.1 to 4.4.3 and in Table 4.4.1.

**Table 4.4.1**
**Transmitter output RF power test results**

| Frequency, MHz | Spectrum analyzer reading, dBm | Peak output power, dBm | Limit, dBm | Margin, dB | Result |
|---|---|---|---|---|---|
| 2402 | -30.0 | 20.5 | 25 | 4.5 | Pass |
| 2450 | -27.33 | 23.17 | 25 | 1.83 | Pass |
| 2480 | -27.17 | 23.33 | 25 | 1.67 | Pass |

Note: measurements were performed with 50.5 dB external attenuation.

**Reference numbers of test equipment used**

| | | |
|---|---|---|
| HL 0057 | HL 1424 | |

Full description is given in Appendix A.

### 4.4.3 Exposure limit according to part 1, §1.1310

Limit for power density for general population/uncontrolled exposure is 1 mW/cm$^2$.

$$\text{The power density } P\ (mW/cm^2) = \frac{P_T}{4\pi r^2}, \text{ where}$$

$P_T$ - the transmitted power, which is equal to the transmitter output power 23.33 dBm plus maximum antenna gain 11 dBi, the maximum equivalent isotropically radiated power (e.i.r.p.) is 34.33 dBm = 2710 mW.

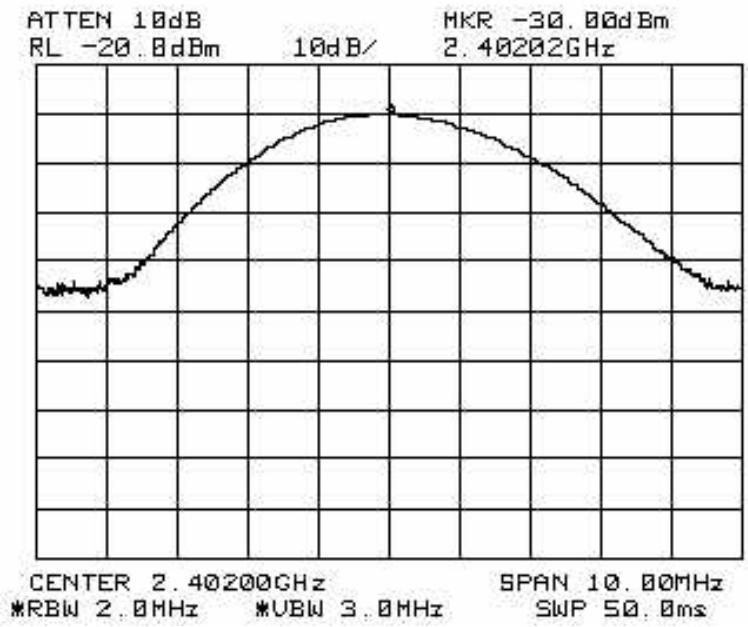
$$1(mW/cm^2) = 2710\ mW / 4\pi r^2$$

The allowed distance "r", where RF exposure limits may not be exceeded, is 14.7 cm:

$$r = \sqrt{P_T / 4\pi} = \sqrt{2710/ 4 \times 3.14} = 14.7(cm).$$

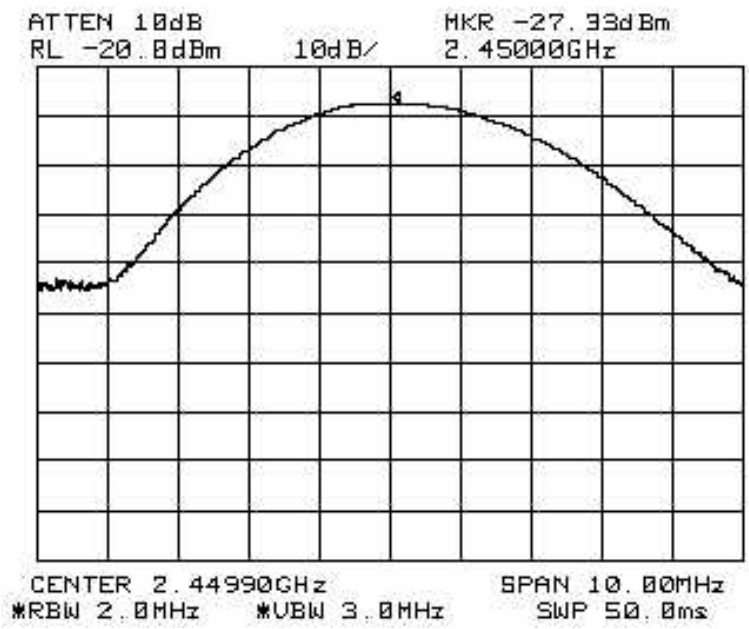
The public cannot be exposed to dangerous RF level.

**Plot 4.4.1**
**Transmitter output RF power test results**
**External attenuation=50 .5 dB**



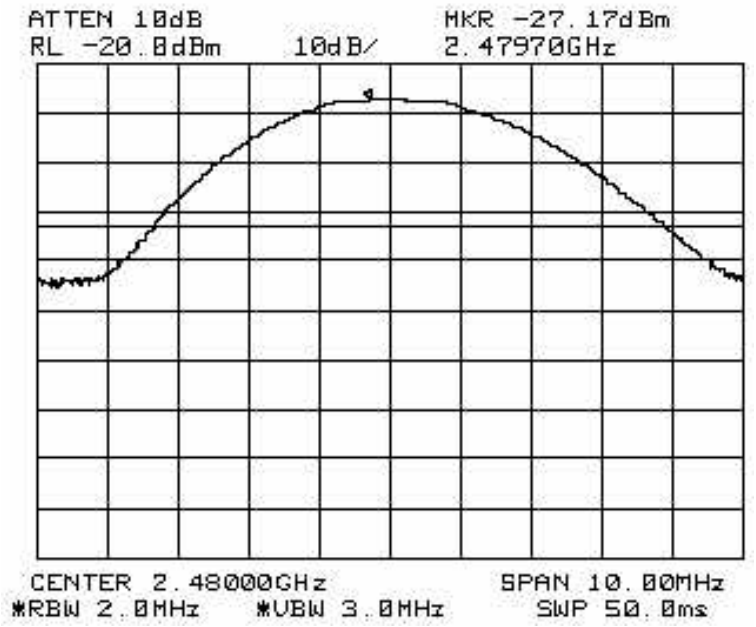

P =-30.00 +50.5 =20.05 dBm

**Plot 4.4.2**
**Transmitter output RF power test results**
**External attenuation=50 .5 dB**




P =-27.33 +50.5 =23.17 dBm

**Plot 4.4.3**
**Transmitter output RF power test results**
**External attenuation=50 .5 dB**




P =-27.17 +50.5 =23.33 dBm

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## 4.5 Out of band antenna conducted emissions test according to §15.247(c)

### 4.5.1 General

This test was performed to prove that the EUT out-of-band emissions in any 100 kHz bandwidth outside 2.400 to 2.4835 GHz are at least 20 dB below maximum power content as measured in any 100 kHz bandwidth within the band that contains the highest level of the desired power.

### 4.5.2 Test procedure

The test setup was the same as in test 4.1.
The test was performed for the EUT in transmitting and in receive mode with modulation and active hopping at 3 carrier (channels) frequencies 2402, 2450, 2480 MHz from 9 kHz to the $10^{th}$ harmonic. Plots 4.5.1 to 4.5.20 show that the out of bands measured signals were attenuated more than 20 dBc.

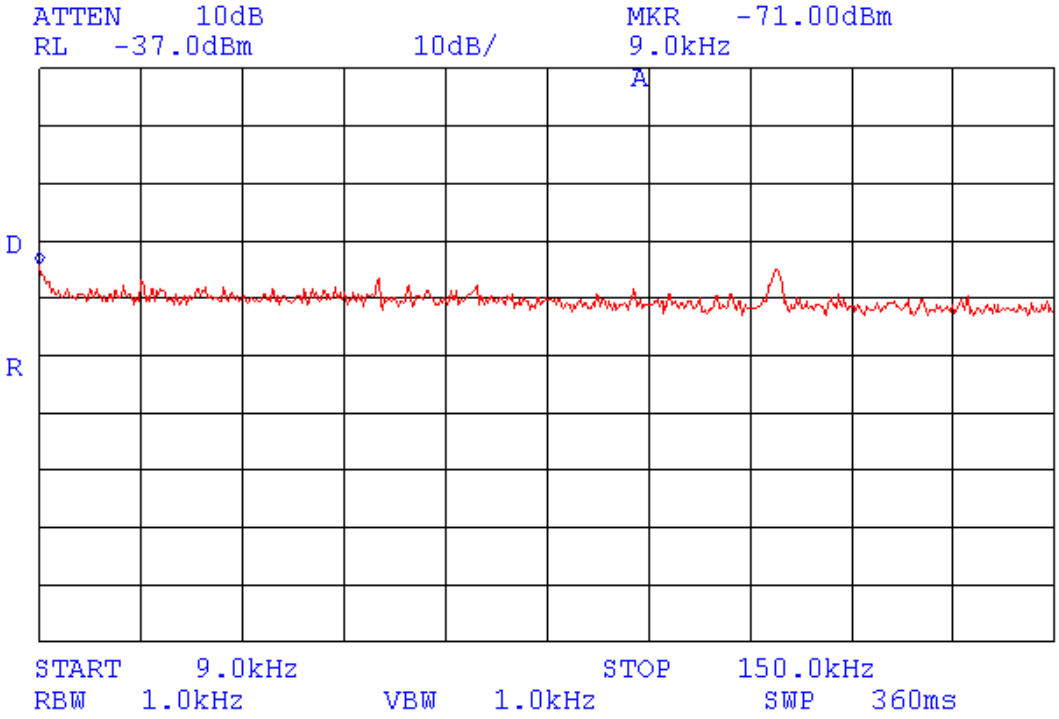
**Reference numbers of test equipment used**

| | | | |
|---|---|---|---|
| HL 0057 | HL 1424 | HL 1650 | HL 1651 |

Full description is given in Appendix A.

**Plot 4.5.1**

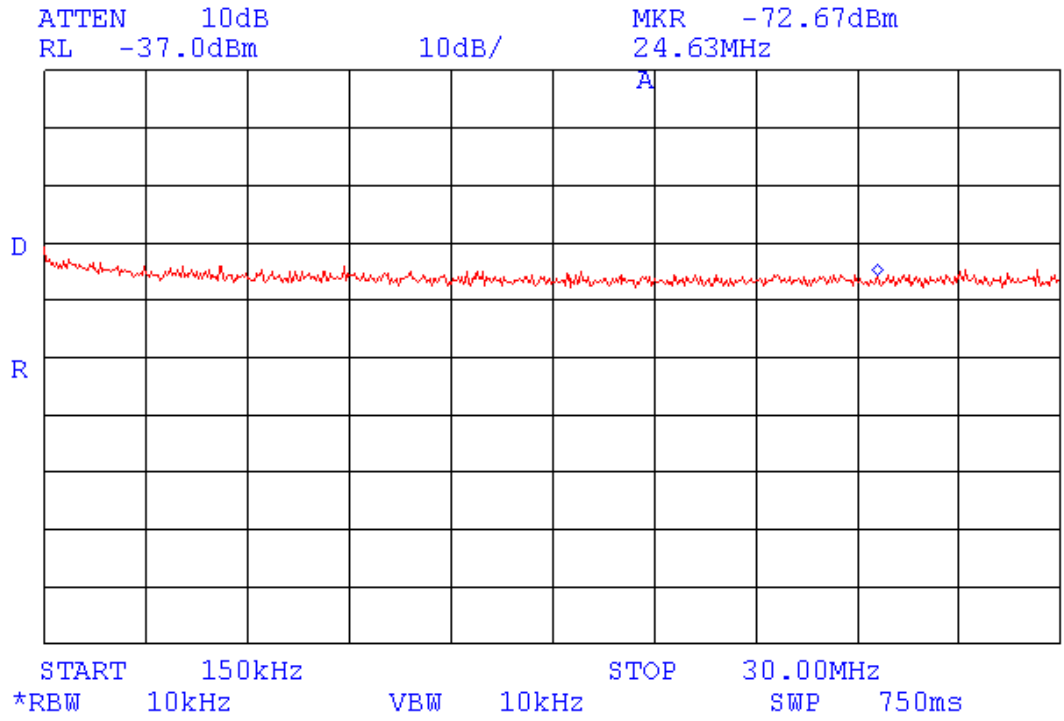
Test specification: § 15.247 (c)
Out-of-band emissions at the antenna output terminal
Frequency range 9 kHz - 150 kHz




Limit is 20 dB down from the carrier:
Limit = 20.05 dBm – 20 dB = 0.05 dBm

**Plot 4.5.2**

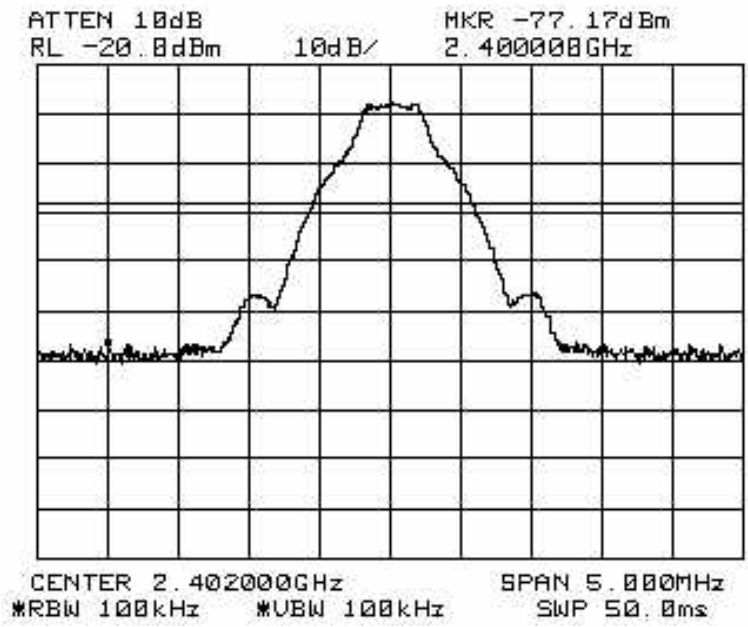
Test specification: § 15.247 (c)
Out-of-band emissions at the antenna output terminal
Frequency range 150 kHz – 30 MHz




Limit is 20 dB down from the carrier:
Limit = 20.05 dBm – 20 dB = 0.05 dBm

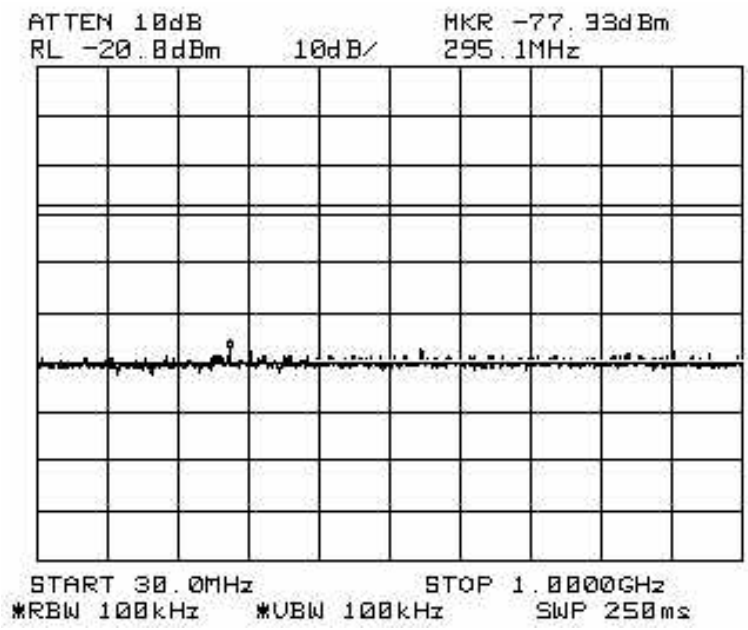
**Plot 4.5.3**

Test specification: § 15.247 (c)
Out-of-band emissions at the antenna output terminal
Frequency: 2.402 GHz



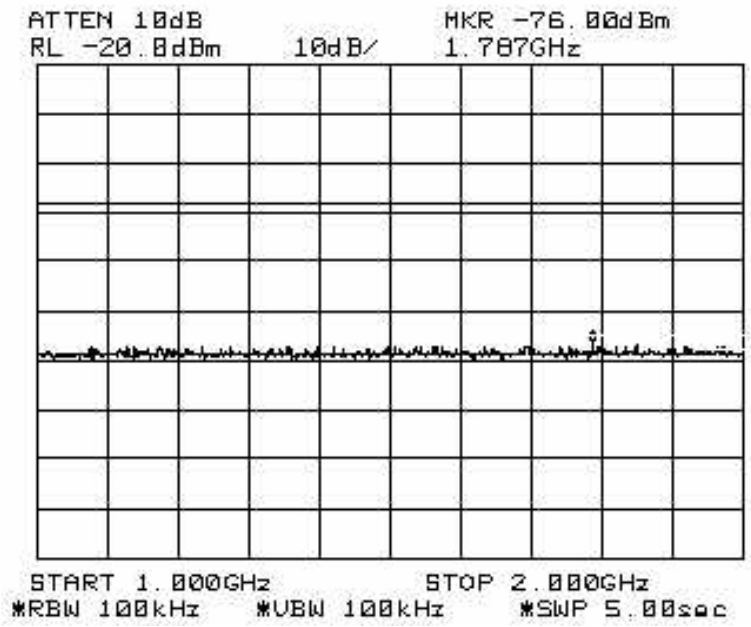
**Plot 4.5.4**

Test specification: § 15.247 (c)
Out-of-band emissions at the antenna output terminal
Frequency: 2.402 GHz



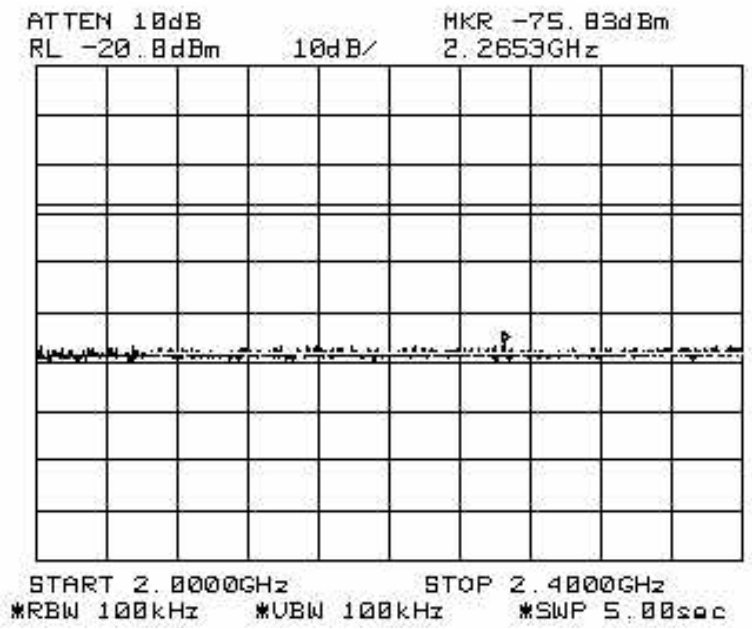
**Plot 4.5.5**

Test specification: § 15.247 (c)
Out-of-band emissions at the antenna output terminal
Frequency: 2.402 GHz



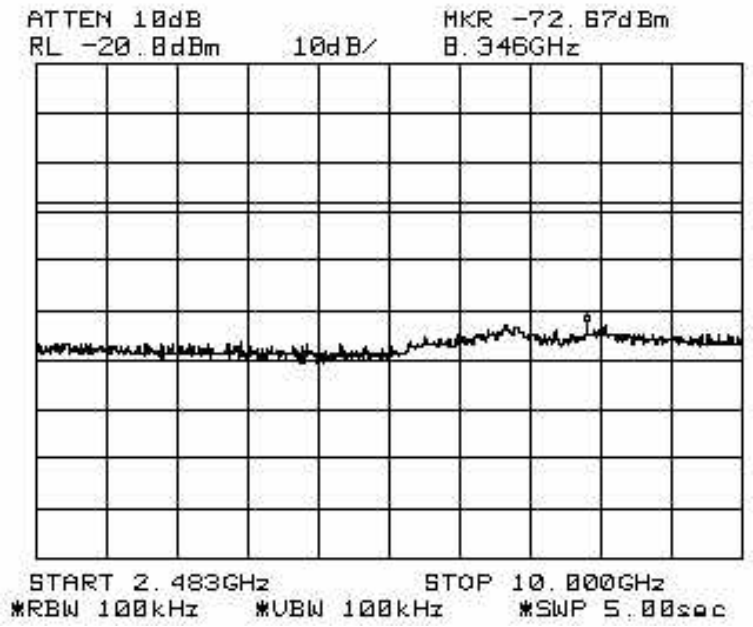
**Plot 4.5.6**

Test specification: § 15.247 (c)
Out-of-band emissions at the antenna output terminal
Frequency: 2.402 GHz



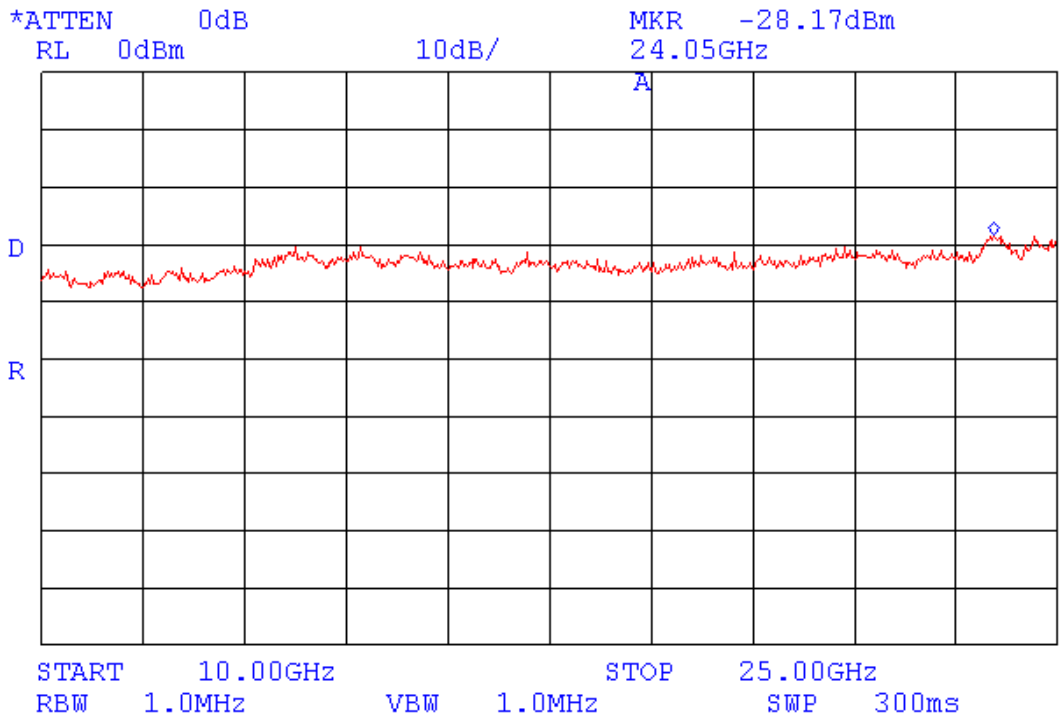
**Plot 4.5.7**

Test specification: § 15.247 (c)
Out-of-band emissions at the antenna output terminal
Frequency: 2.402 GHz



**Plot 4.5.8**

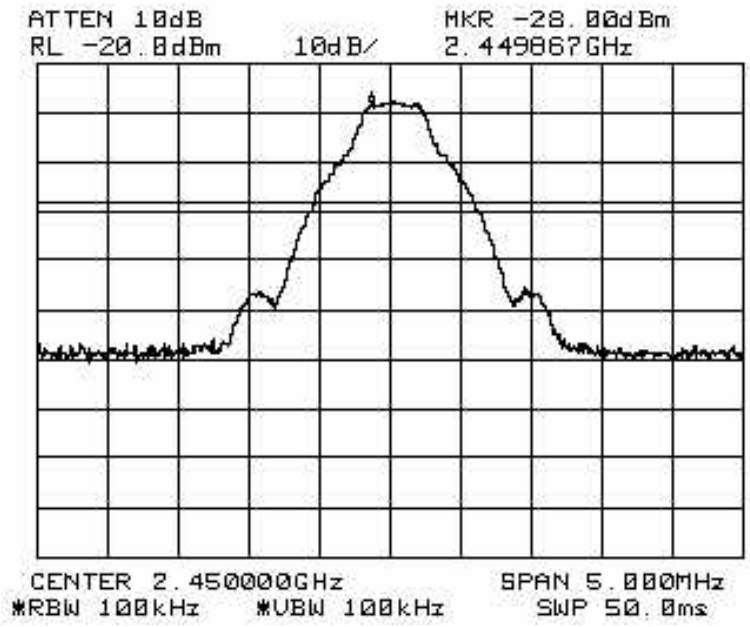
Test specification: § 15.247 (c)
Out-of-band emissions at the antenna output terminal
Frequency: 2.402 GHz




Limit is 20 dB down from the carrier:
Limit = 20.05 dBm – 20 dB = 0.05 dBm

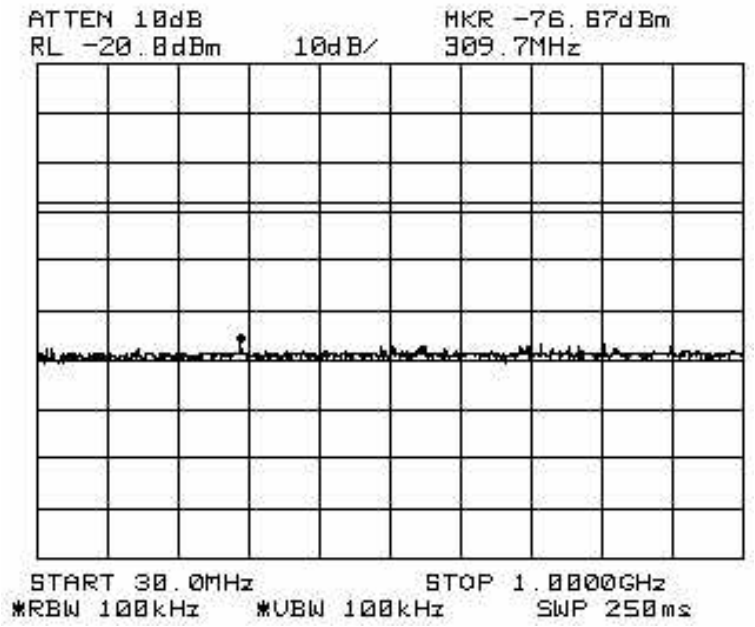
**Plot 4.5.9**

Test specification: § 15.247 (c)
Out-of-band emissions at the antenna output terminal
Frequency: 2.450 GHz



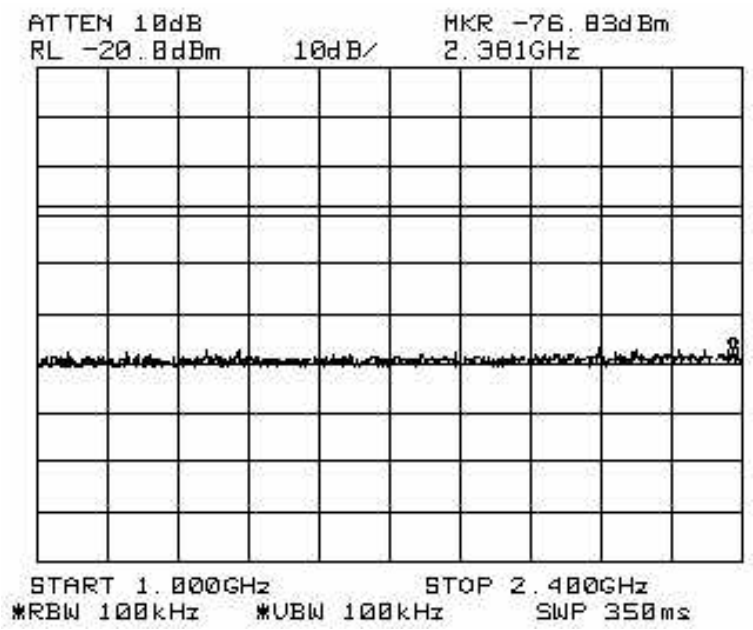
**Plot 4.5.10**

Test specification: § 15.247 (c)
Out-of-band emissions at the antenna output terminal
Frequency: 2.450 GHz



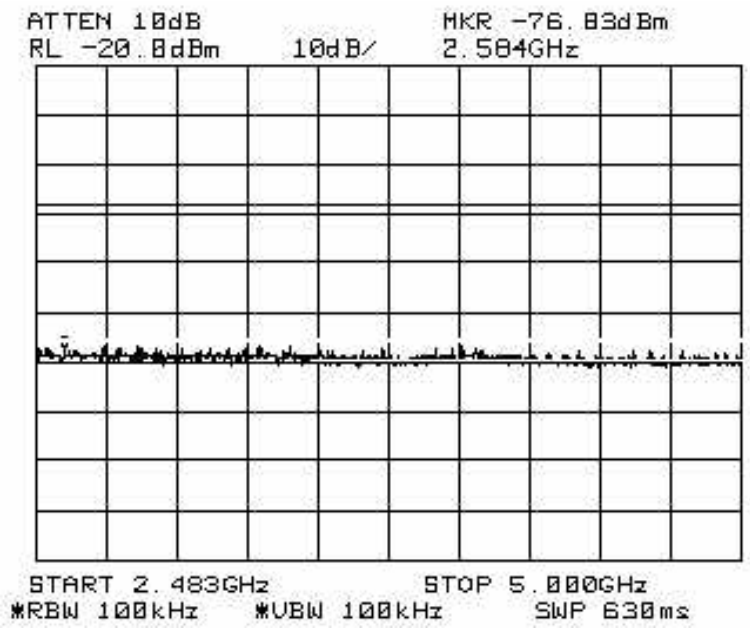
**Plot 4.5.11**

Test specification: § 15.247 (c)
Out-of-band emissions at the antenna output terminal
Frequency: 2.450 GHz



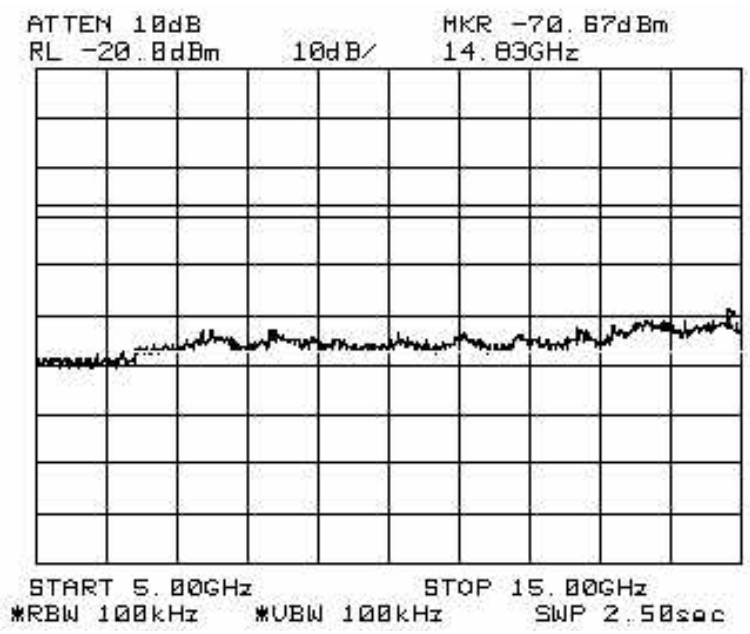
**Plot 4.5.12**

Test specification: § 15.247 (c)
Out-of-band emissions at the antenna output terminal
Frequency: 2.450 GHz



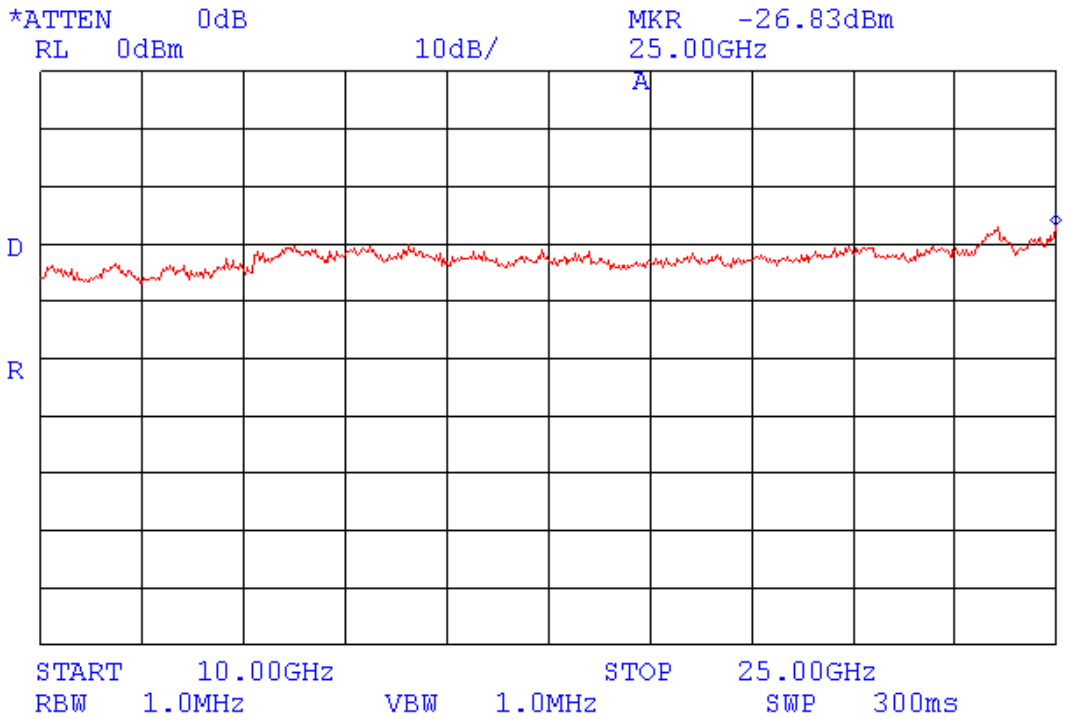
**Plot 4.5.13**

Test specification: § 15.247 (c)
Out-of-band emissions at the antenna output terminal
Frequency: 2.450 GHz



**Plot 4.5.14**

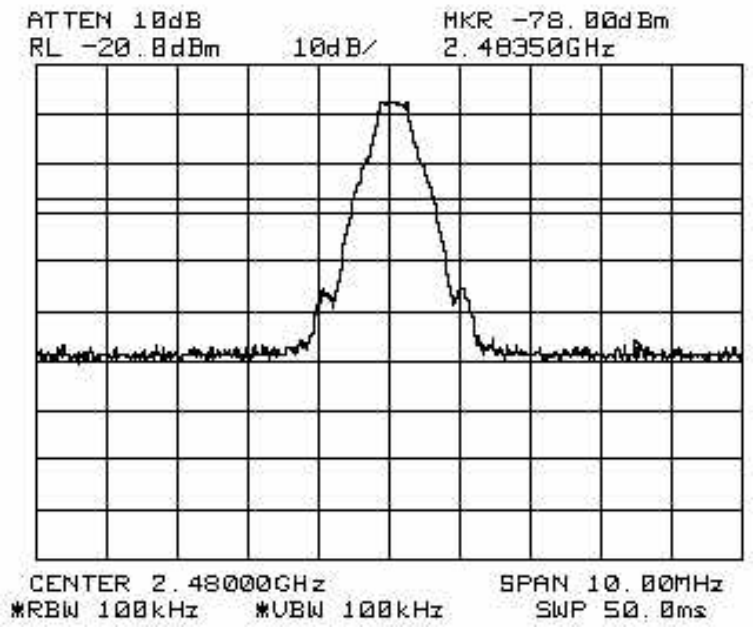
Test specification: § 15.247 (c)
Out-of-band emissions at the antenna output terminal
Frequency: 2.450 GHz




Limit is 20 dB down from the carrier:
Limit = 23.17 dBm – 20 dB = 3.17 dBm

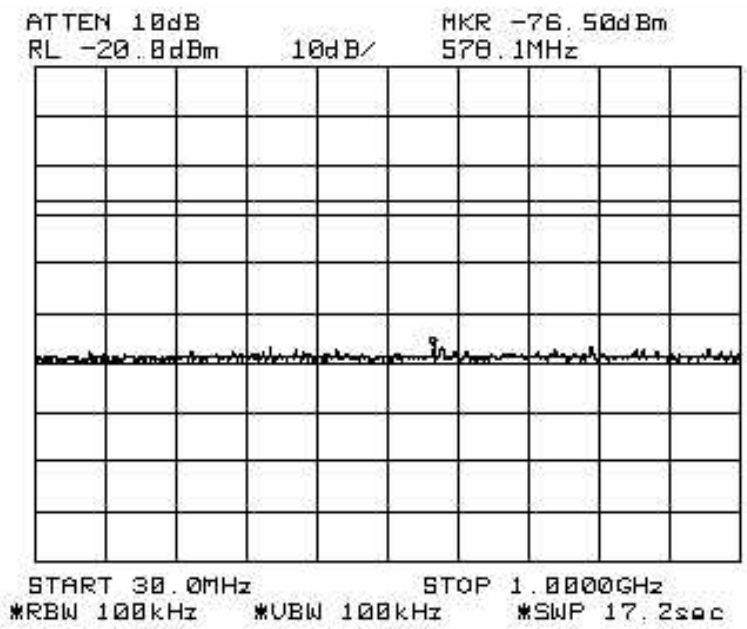
**Plot 4.5.15**

Test specification: § 15.247 (c)
Out-of-band emissions at the antenna output terminal
Frequency: 2.480 GHz



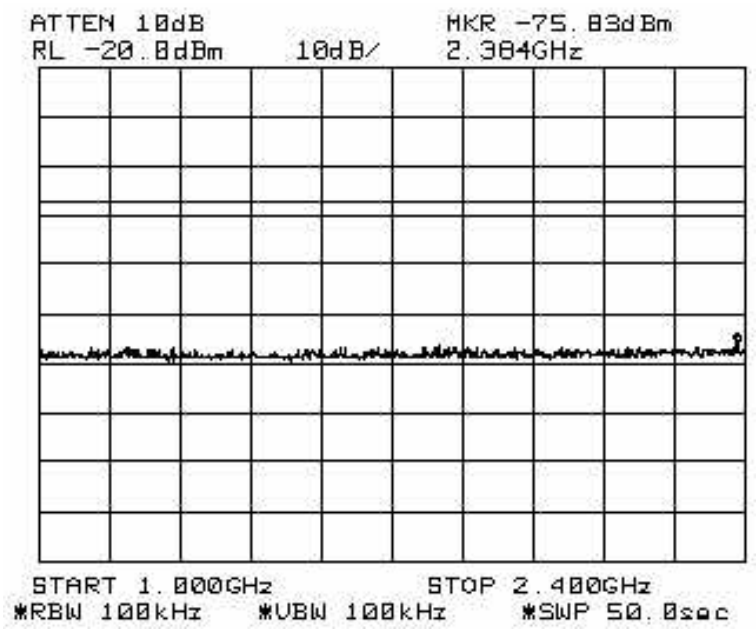
**Plot 4.5.16**

Test specification: § 15.247 (c)
Out-of-band emissions at the antenna output terminal
Frequency: 2.480 GHz



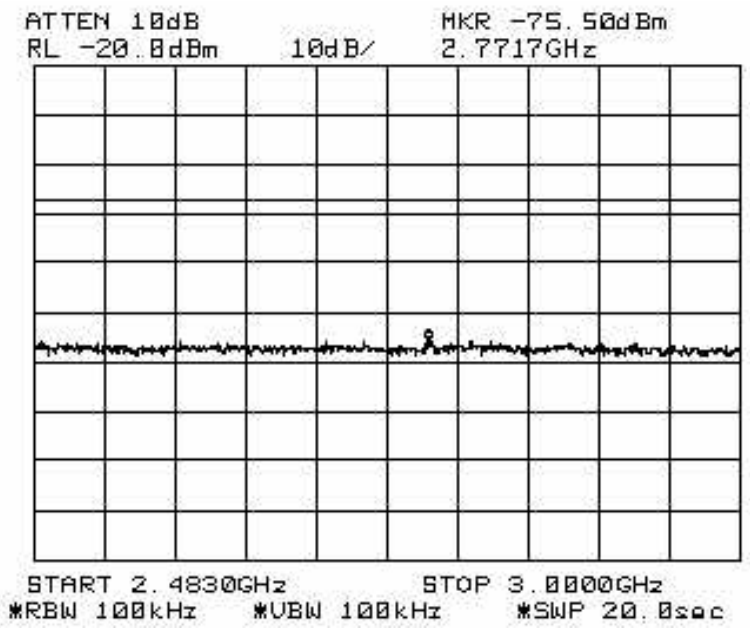
**Plot 4.5.17**

Test specification: § 15.247 (c)
Out-of-band emissions at the antenna output terminal
Frequency: 2.480 GHz



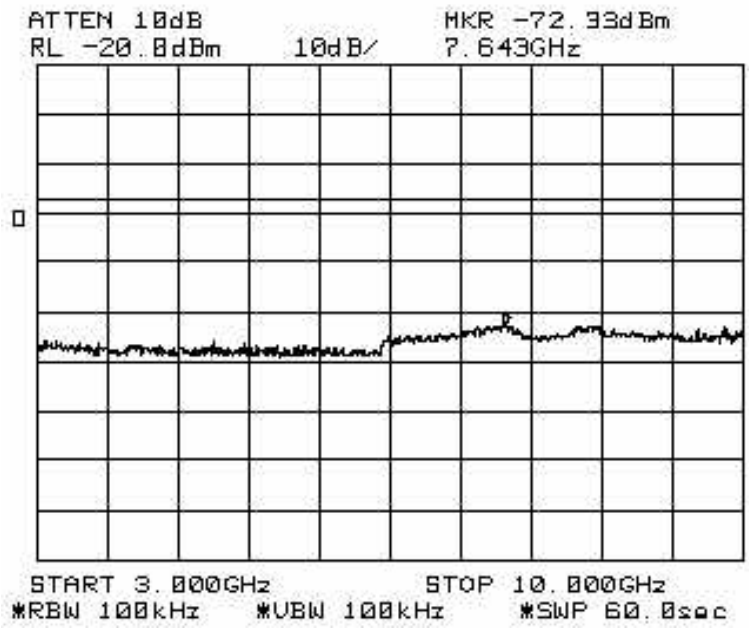
**Plot 4.5.18**

Test specification: § 15.247 (c)
Out-of-band emissions at the antenna output terminal
Frequency: 2.480 GHz



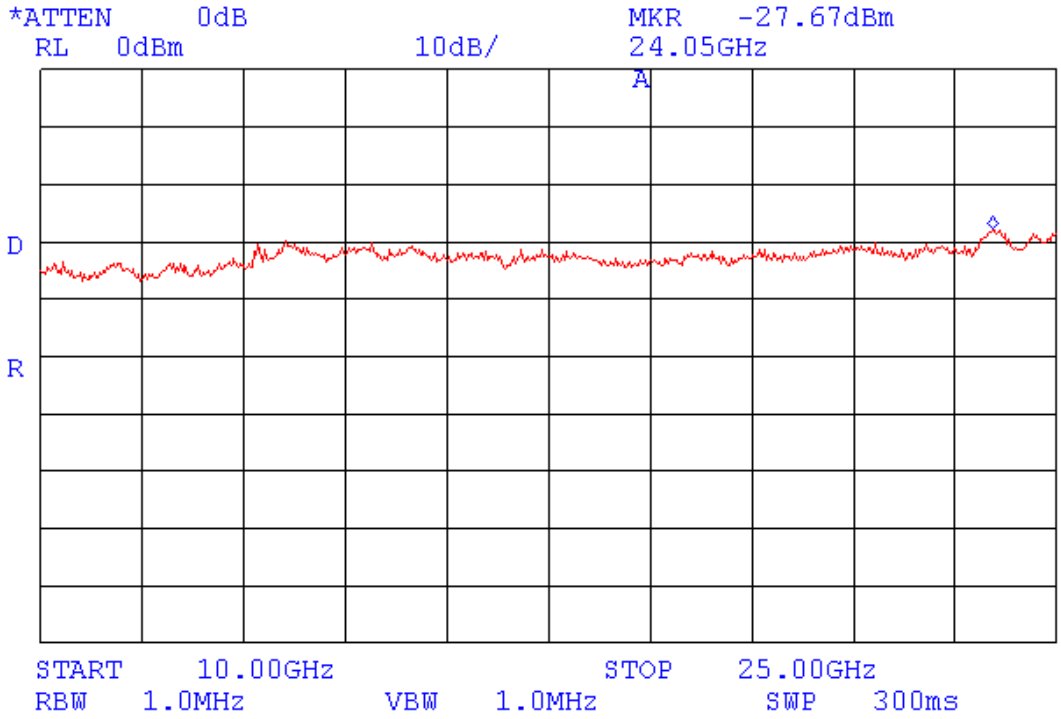
**Plot 4.5.19**

Test specification: § 15.247 (c)
Out-of-band emissions at the antenna output terminal
Frequency: 2.480 GHz



**Plot 4.5.20**

Test specification: § 15.247 (c)
Out-of-band emissions at the antenna output terminal
Frequency: 2.480 GHz




Limit is 20 dB down from the carrier:
Limit = 23.33 dBm – 20 dB = 3.33 dBm

## 4.6 Average factor (duty cycle correction) test §15.35(c)

### 4.6.1 Definition of the test

The test was performed to define total time of transmitting energy occupancy during any 0.1 s time interval.
This average factor is the actual transmission of the EUT during this 0.1 s time interval.

### 4.6.2 Test results

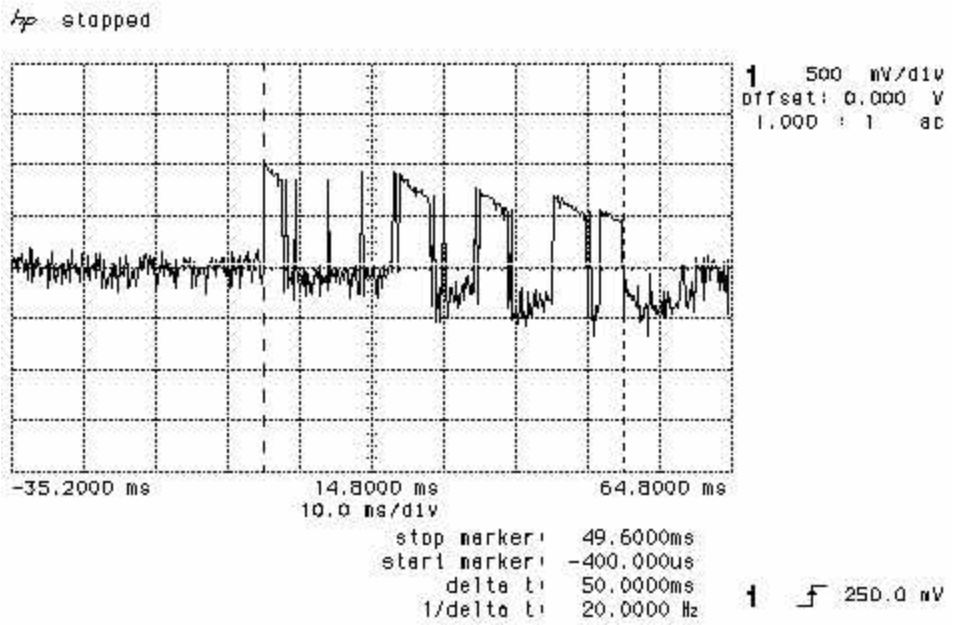
The test setup was the same as in test 4.1 with additionally connected oscilloscope to the spectrum analyzer video output.
The three plots from the oscilloscope demonstrate duty cycle measurements. The Plot 4.6.1 shows the pulse train in a 0.1 s interval measurement results. Two plots 4.6.2 and 4.6.3 represent the length of transmissions (delta marker) and the same transmitting time of 25.3 ms for total 100 ms time interval. The average factor is 20 log (25.3/100) = -11.9 dB.
The factor was used to average radiated emissions results got with peak detector measurements.

**Reference numbers of test equipment used**

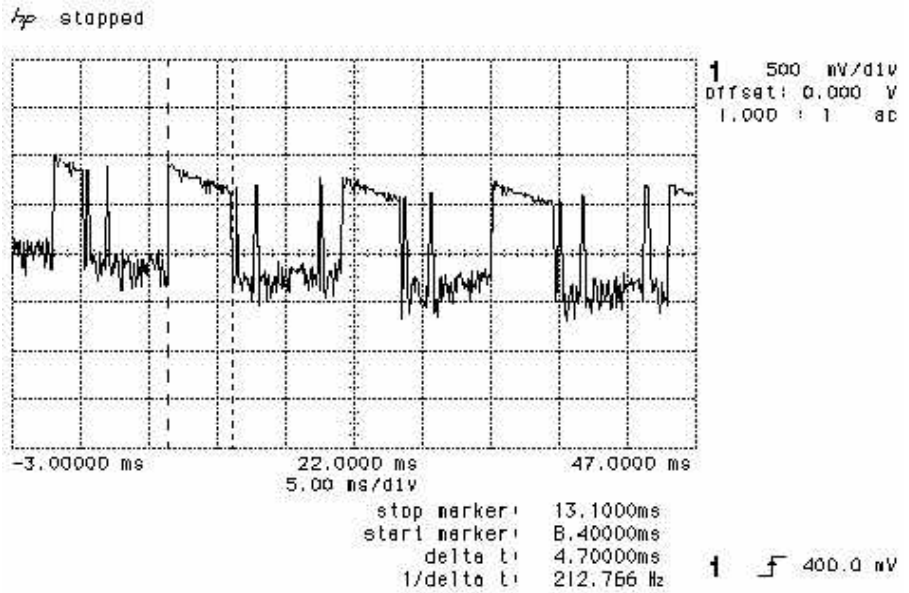
| | | | |
|---|---|---|---|
| HL 0057 | HL 0483 | HL 1424 | |

Full description is given in Appendix A.

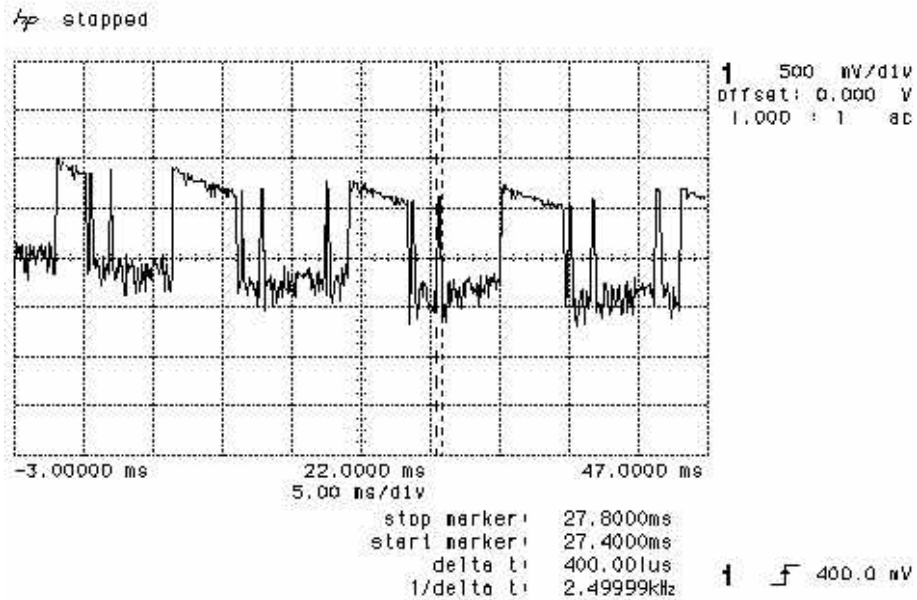
**Plot 4.6.1**
**Duty cycle measurement test results**



**Plot 4.6.2**
**Duty cycle measurement test results**




**Plot 4.6.3**
**Duty cycle measurement test results**




Ton=2.5 + 4.7x4+0.4x10=25.3 ms
AVR FACTOR=20 Log 25.3/100= -11.9 dB

## 4.7 Out of band radiated emissions test according to §15.247(c) and § 15.205, §15.209(a)

### 4.7.1 General

This test was performed to measure radiated emissions except carriers generated by the transmitter and to prove that radiated emissions which fall in the restricted bands shall comply with §15.209(a) limits.

### 4.7.2 Test procedure and results

Radiated emissions measurements were performed in the anechoic chamber with the biconilog antenna from 30 MHz to 2 GHz and at open field test site with double ridged guide antenna from 2 GHz to 24.8 GHz at 3 meters test distance as shown in Photograph 4.7.1.

The continuously operated EUT was set up on the 0.8 m high wooden table installed on the top of the metal turntable flush mounted with the ground plane. To find the maximum radiation measuring antenna height was changed from 1 to 4 m, the turntable was rotated 360° and the antennas polarization was changed from vertical to horizontal.

No spurious emissions except harmonics of carrier were found. Test results are recorded in Table 4.7.1. The average factor defined in §4.6 was less tan 20 dB, hence only an average limit was applied.
Emissions found in 30 - 2100 MHz range were due to unintentional radiator and are brought in section 4.8 of this test report.
The EUT met standard requirements and successfully passed the test.

**Reference numbers of test equipment used**

| | | | | | | |
|---|---|---|---|---|---|---|
| HL 0038 | HL 0041 | HL 0275 | HL 0287 | HL 0812 | HL 0813 | HL 1424 |

Full description is given in Appendix A.

**Table 4.7.1**
**Radiated emission measurements test results**

TEST SPECIFICATION: FCC part 15 subpart C § 15.247(c) 15.209(a)
DATE: February 27, 2001
Relative Humidity: 54%
Ambient Temperature: 23°C

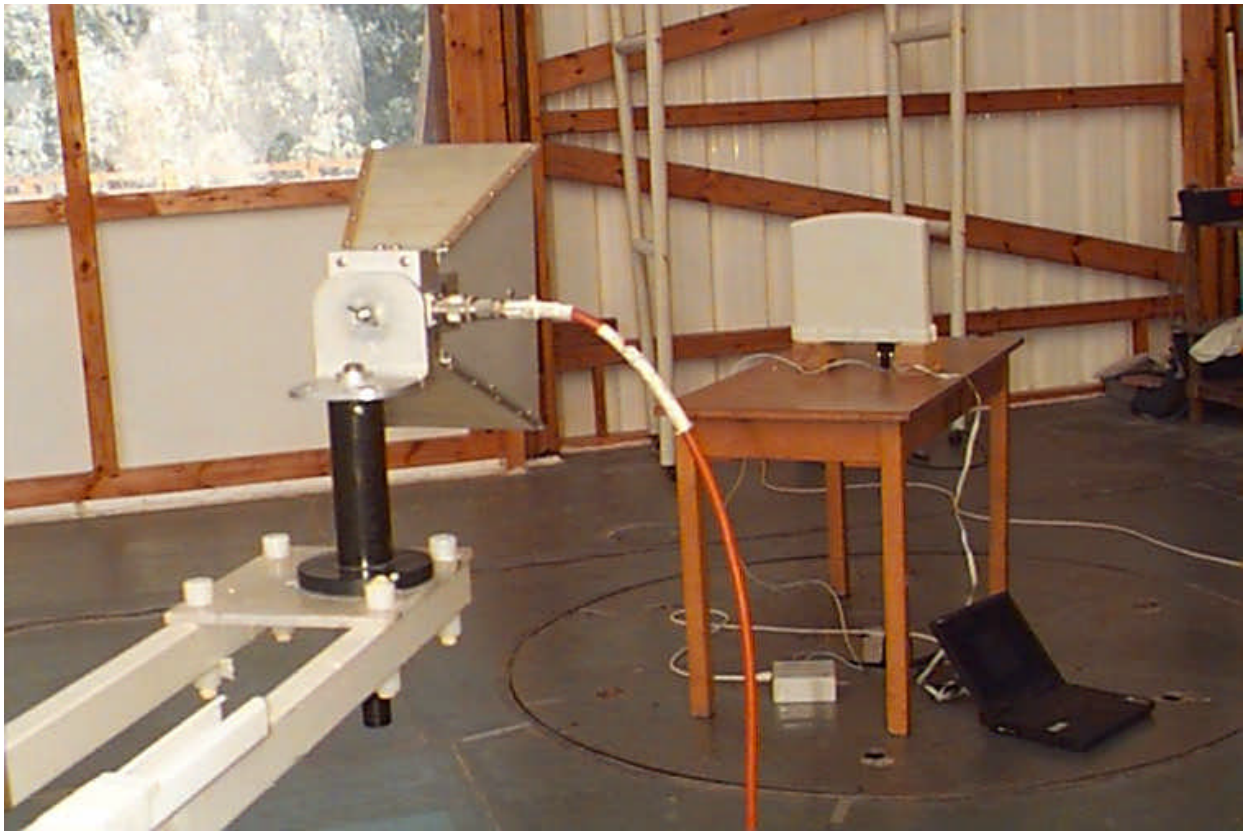
MEASUREMENTS PERFORMED AT 3 METRES DISTANCE

| Freq. GHz | Measured result dB (μV) | Antenna factor dB (1/m) | Cable loss dB | Amplifier gain dB | Average factor dB | Radiated emission dB (μV/m) | Limit dB(μV/m) | Margin dB | Pass/ Fail |
|---|---|---|---|---|---|---|---|---|---|
| 4.804 | 40.2 | 34.5 | 2.45 | 20 | -11.9 | 45.25 | 54 | 8.75 | Pass |
| 4.900 | 42.87 | 34.5 | 2.45 | 20 | -11.9 | 47.92 | 54 | 6.08 | Pass |
| 4.960 | 40.0 | 34.5 | 2.45 | 20 | -11.9 | 45.05 | 54 | 8.95 | Pass |
| 7.350 | 36.0 | 37.5 | 3.8 | 20 | -11.9 | 43.6 | 54 | 10.4 | Pass |
| 7.440 | 35.0 | 37.5 | 3.8 | 20 | -11.9 | 42.6 | 54 | 11.4 | Pass |

**Notes to table:**
Measurements were performed with double ridged guide antenna in horizontal polarization, peak detector was used, resolution bandwidth = 1 MHz, video bandwidth = 1 MHz.
Average radiated emission dB(μV/m) = measured result dB(μV) + antenna factor dB(1/m)+cable loss (dB)–amplifier gain (dB) + average factor (dB). During the measurements the received emissions were amplified
Average factor = -11.9 dB (see section 4.6.2).

**Table abbreviations:**
Margin = dB below (negative if above) specification limit.

**Photograph No. 4.7.1**
**Radiated emission measurement test setup**



## 4.8 Unintentional radiated emissions (class B digital device) test according to §15.109

### 4.8.1 General

This test was performed to measure radiated emissions from the receiver and incorporated digital device of the EUT and also to verify the EUT full compliance with §§15.109, 15.209.

Radiated emission measurements specification limits are given in Table 4.8.1 below:

**Table 4.8.1**
**Limits for electric field strength, quasi-peak detector**

| Frequency, MHz | Class B equipment @ 3 meter distance, dB(μV/m) |
|---|---|
| 30 - 88 | 40 |
| 88 - 216 | 43.5 |
| 216 - 960 | 46 |
| 960 - 40000 | 54 |

### 4.8.2 Test procedure

The radiated emissions measurements of the EUT incorporated digital device were performed in the anechoic chamber at 3 meters measuring distance with biconilog and double ridged guide antennas. The receiver measurements were performed at the open area test site. The measurements were performed in frequency range from 30 MHz to 11 GHz ($5^{th}$ harmonic of the receiver). The EUT was placed on the wooden table as shown in Figures 4.8.1, 4.8.2 and Photographs 4.8.1, 4.8.2, 4.7.1.
To find maximum radiation the turntable was rotated $360^{o}$, the measuring antenna height changed from 1 to 4 m, and the antennas polarization was changed from vertical to horizontal.

In frequency range from 30 to 1000 MHz the EMI receiver settings were: RBW=120 kHz, quasi-peak detector. The receiver radiated emission measurements from 1 GHz up to 11 GHz were performed with the spectrum analyzer settings: RBW= VBW =1 MHz, average detector was used. The results are recorded in Table 4.8.1 and shown in Plots 4.8.1 to 4.8.3.

**Reference numbers of test equipment used**

| | | | | | | |
|---|---|---|---|---|---|---|
| HL 0041 | HL 0465 | HL 0521 | HL 0547 | HL 0589 | HL 0593 | HL 0594 |
| HL 0604 | HL 1175 | HL 1424 | | | | |

Full description is given in Appendix A.

**Table 4.8.1 Radiated emission measurements test results, frequency range 30 MHz –11 GHz**

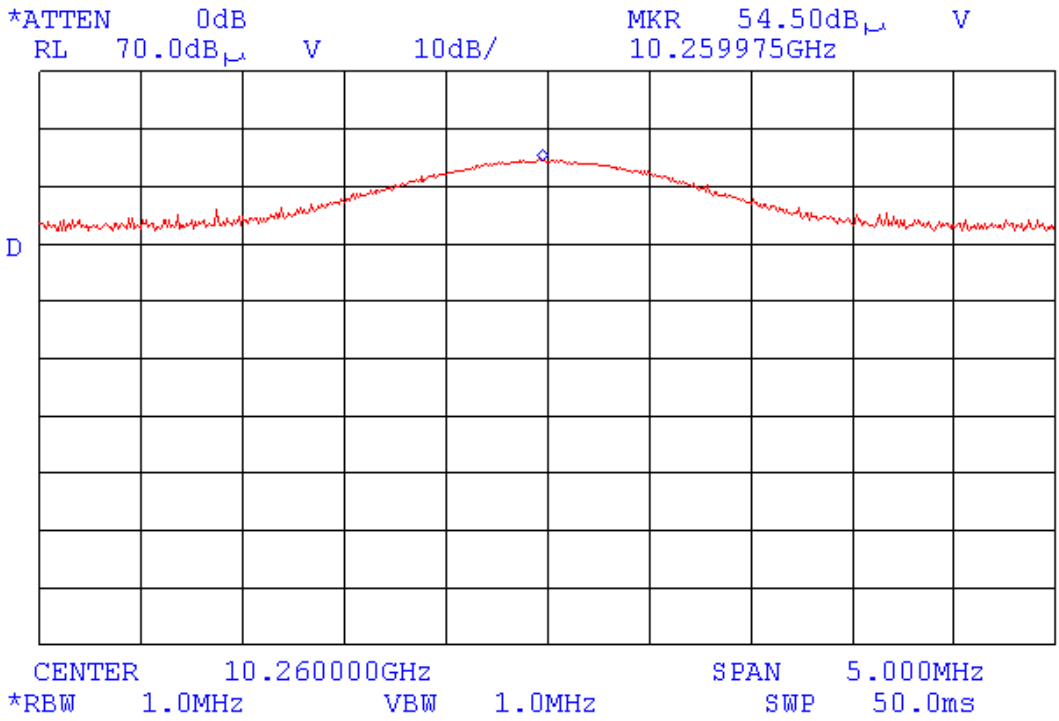
DATE: February 26, 2001
RELATIVE HUMIDITY: 54%
AMBIENT TEMPERATURE: 23°C

MEASUREMENTS PERFORMED AT 3 METRES DISTANCE

| Frequency MHz | Ant. type | Ant. Pol. | Antenna height m | Detector type | RBW kHz | TT Pos. ° | Radiated emissions dB (μV/m) | Specified limit dB (μV/m) | Margin dB | Pass/ Fail |
|---|---|---|---|---|---|---|---|---|---|---|
| 120.01 | BL | V | 1 | QP | 120 | 55 | 26.92 | 43.5 | 16.58 | Pass |
| 288.00 | BL | H | 1 | QP | 120 | 350 | 35.20 | 43.5 | 10.80 | Pass |
| 960.04 | BL | V | 1 | QP | 120 | 204 | 37.52 | 54.0 | 16.48 | Pass |
| 2099.96 | DRG | V | 1.3 | average | 1000 | 230 | 45.97 | 54.0 | 8.03 | Pass |
| 10260.00 | DRG | V | 1 | average | 1000 | 0 | 49.6 | 54.0 | 4.4 | Pass |
| 10500.00 | DRG | V | 1 | average | 1000 | 0 | 51.0 | 54.0 | 3.0 | Pass |
| 10650.00 | DRG | V | 1 | average | 1000 | 0 | 51.7 | 54.0 | 2.3 | Pass |

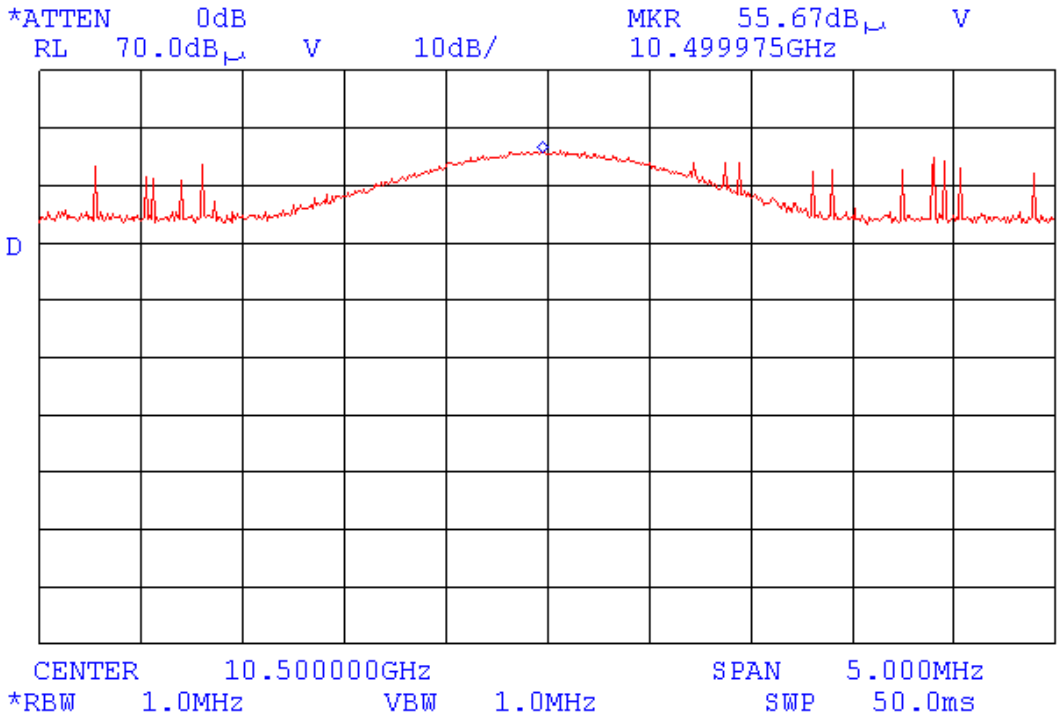
**Notes to table calculations:**
Antenna type: BL – biconilog, DRG – double ridged guide
Antenna polarization: H – horizontal, V – vertical
RBW = resolution bandwidth
Ant. Pol. = Antenna polarization (V-vertical, H-horizontal)
TT Pos. = turntable position in degrees, (EUT front panel = $0^o$)
Margin = dB below (negative if above) specification limit.
Measurements were performed with quasi-peak detector.

**Plot 4.8.1**
Test specification: §15.209
Radiated spurious emissions measurement in receive mode



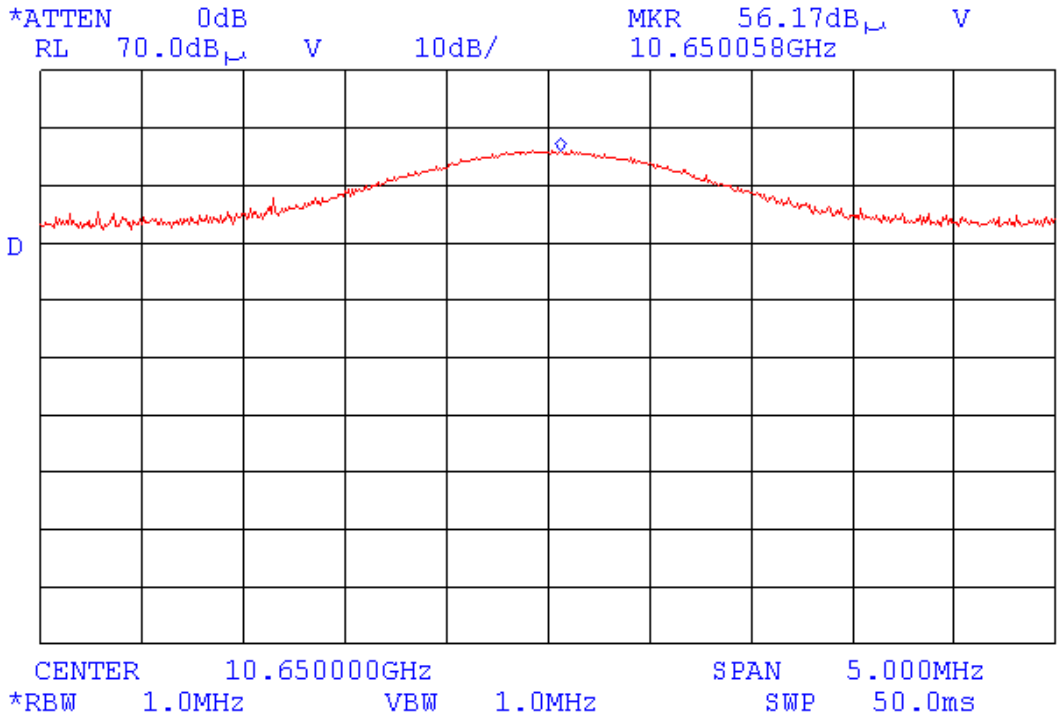

E=Usa+AF+CL-Ampl.gain-AF=54.5dBuV+ 38.3 dB(1/m)+ 4.4 dB- 35 dB- 12.6 dB
E avr.= 49.6 dB(uV/m)
E peak.=62.2 dB(uV/m)

**Plot 4.8.2**
Test specification: §15.209
Radiated spurious emissions measurement in receive mode




E= Usa+AF+CL-Ampl.gain-AF=55.7 dBuV+ 38.5 dB(1/m)+ 4.4 dB- 35 dB- 12.6 dB
E avr.= 51.0 dB(uV/m)
E peak.=63.6 dB(uV/m)

**Plot 4.8.3**
Test specification: §15.209
Radiated spurious emissions measurement in receive mode




E=Usa+AF+CL-Ampl.gain-AF=56.2 dBuV+ 38.7 dB(1/m)+ 4.4 dB- 35 dB- 12.6 dB
E avr.= 51.7 dB(uV/m)
E peak.=64.3 dB(uV/m)

**Figure 4.8.1**
**Radiated emission test setup**

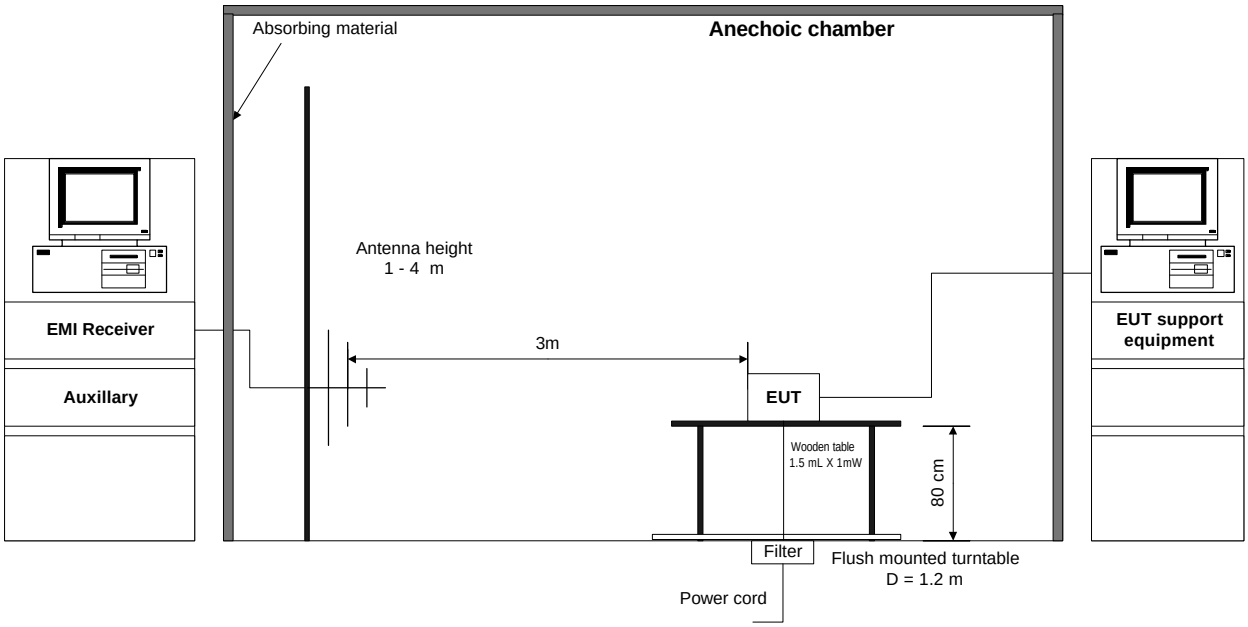
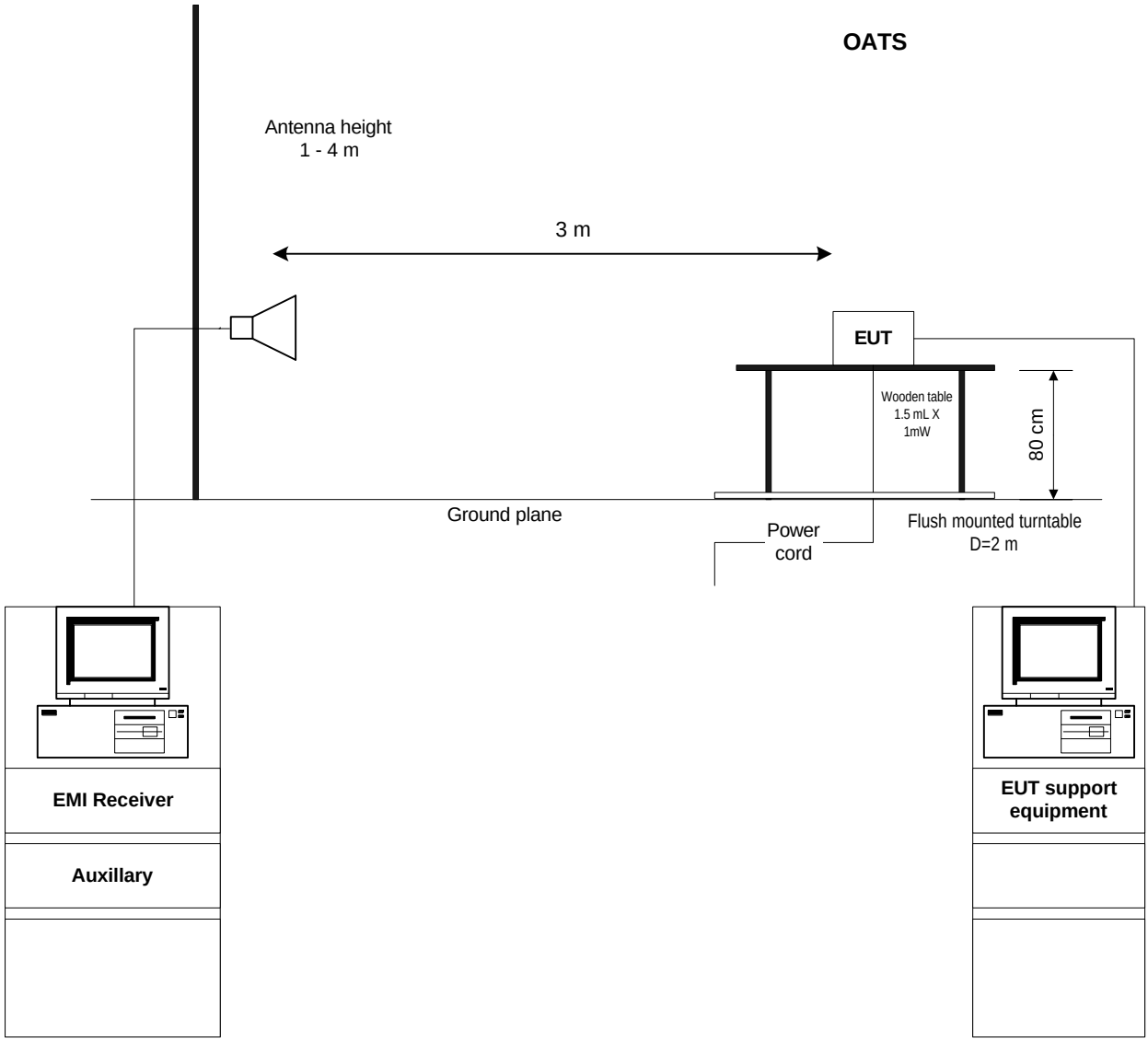
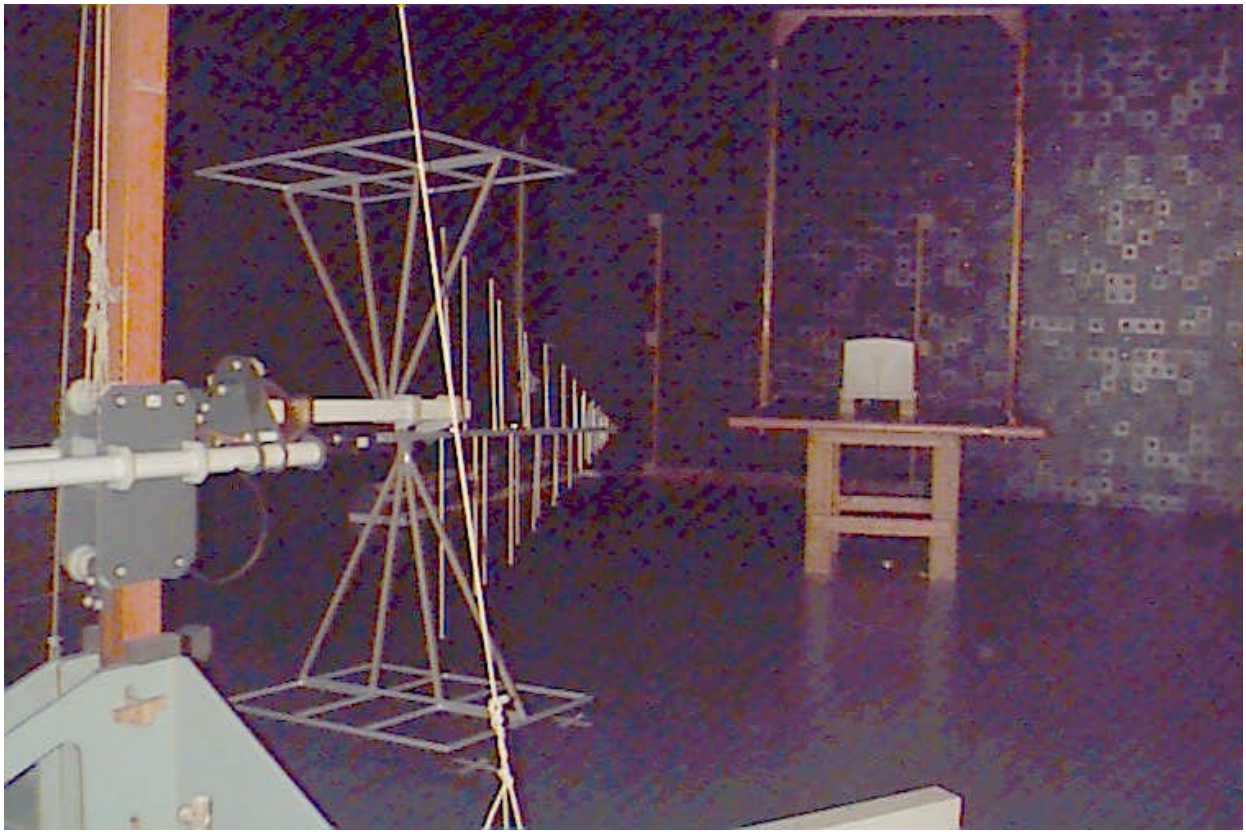


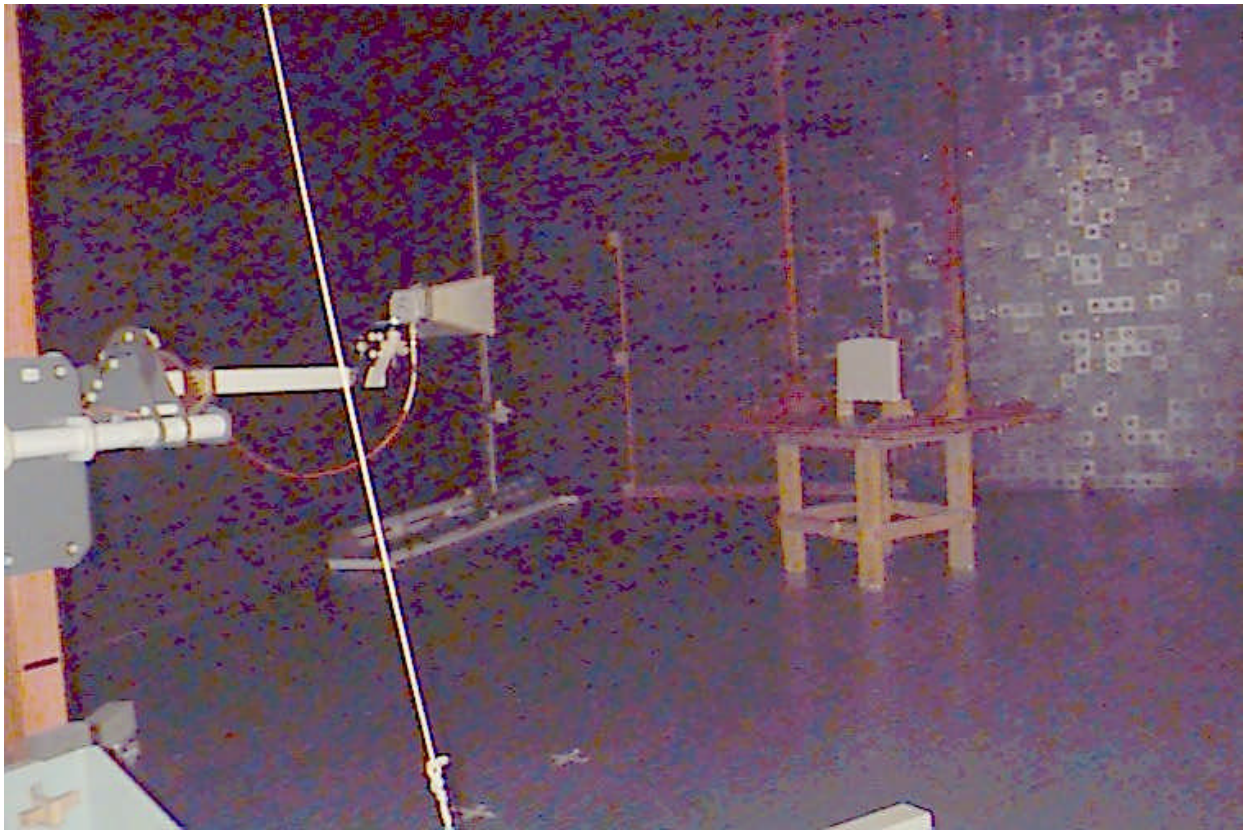
**Figure 4.8.2**
**Radiated emission test setup**



**Photograph No. 4.8.1**
**Radiated emission measurement test setup**



**Photograph No. 4.8.2**
**Radiated emission measurement test setup**



## 4.9 Unintentional conducted emissions (class B digital device) test according to §15.107

### 4.9.1 General

Conducted emission measurements specification limits are given in Table 4.9.1 below.

**Table 4.9.1**
**Limits for conducted emission on AC power lines**

| Frequency, MHz | Class B equipment limit, dB(μV) |
|---|---|
| 0.45 - 30 | 48 |

### 4.9.2 Test procedure

The test was performed in the shielded room. The EUT was set up on the wooden table as shown in Figure 4.9.1 and Photograph 4.9.1. Frequency range from 450 kHz to 30 MHz was investigated.
The measurements were performed on the 120 V AC 60 Hz power lines (both neutral and phase) by means of the LISN, connected to the spectrum analyzer. The unused coaxial connector of the LISN was resistively terminated with 50 Ω. The position of the EUT cable was varied to determine maximum emission level. Peak and quasi peak detectors (resolution bandwidth = 9 kHz) were used.

The test results are recorded in Table 4.9.2 and shown in Plots 4.9.1 to 4.9.2.

**Reference numbers of test equipment used**

| | | | | | |
|---|---|---|---|---|---|
| HL 0163 | HL 0466 | HL 0521 | HL 0580 | HL 0590 | HL 1175 |

Full description is in Appendix A.

**Table 4.9.2 Conducted emissions measurement test results**

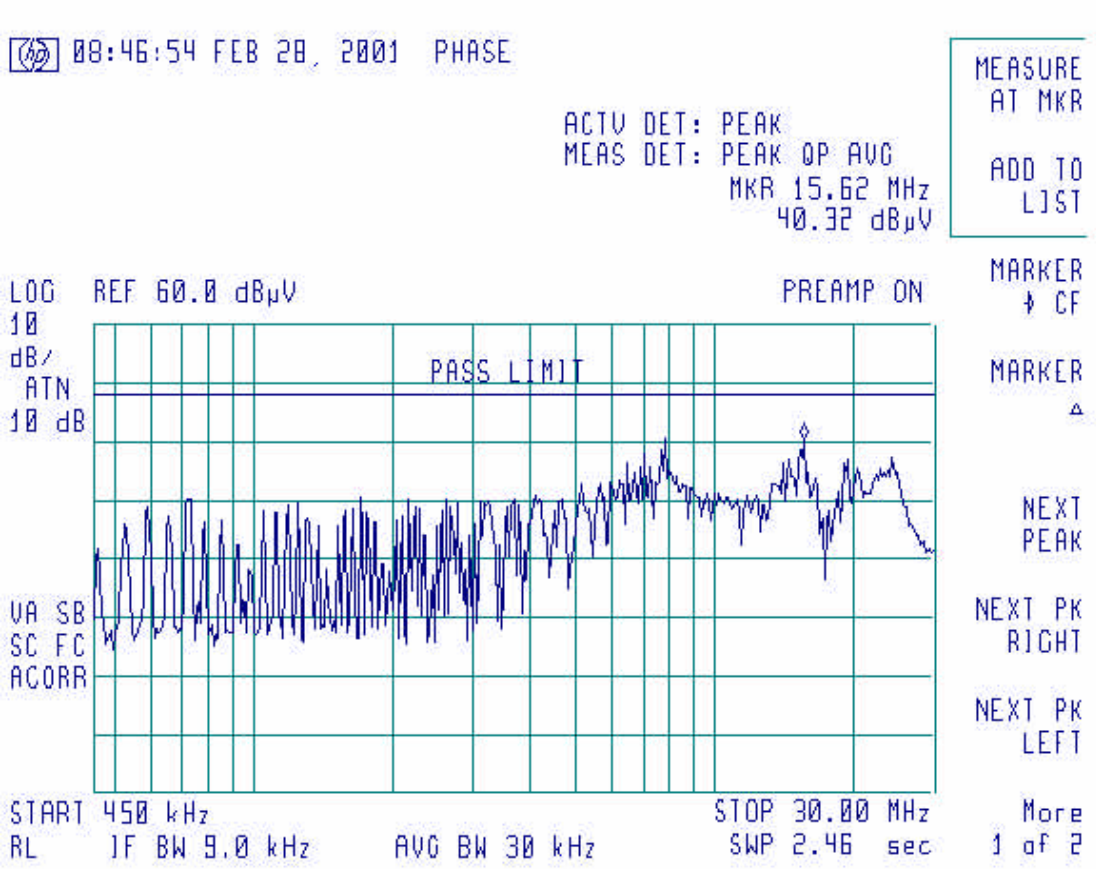
TEST SPECIFICATION: FCC, part 15, Class B
DATE: February 28, 2001
RELATIVE HUMIDITY: 52%
AMBIENT TEMPERATURE: 23°C
THE EUT WAS TESTED AS: TABLE-TOP EQUIPMENT
DETECTORS USED: QUASI-PEAK
FREQUECNY RANGE: 450 kHz – 30 MHz
RESOLUTION BANDWIDTH: 9 kHz

| Frequency, MHz | Line ID | Measured emissions, dB (uV) | Spec. limit, dB (uV) | Margin, dB | Pass/ Fail |
|---|---|---|---|---|---|
| 6.489 | N | 35.33 | 48 | 12.67 | Pass |
| 7.072 | Ph | 36.45 | 48 | 11.55 | Pass |
| 7.631 | N | 38.25 | 48 | 9.75 | Pass |
| 7.824 | N | 41.36 | 48 | 6.64 | Pass |
| 7.837 | Ph | 40.56 | 48 | 7.44 | Pass |
| 15.436 | Ph | 36.29 | 48 | 11.71 | Pass |
| 23.656 | N | 37.42 | 48 | 10.58 | Pass |
| 24.264 | Ph | 36.16 | 48 | 11.84 | Pass |

- Line ID = Line Identification (Ph - phase, N - neutral).
- Measured conducted emissions = EMI meter reading (dBμV) + Cable Loss (dB) + LISN correction factor (dB). For LISN correction factor refer to Appendix B.
- Margin = dB below (negative if above) specification limit.

**Plot 4.9.1**

Test Specification: § 15.107, § 15.207
Conducted emission measurements on power line
Frequency range: 450 kHz-30 MHz
Line: phase
Detector: peak



**Plot 4.9.2**

Test Specification: § 15.107, § 15.207
Conducted emission measurements on power line
Frequency range: 450 kHz-30 MHz
Line: neutral
Detector: peak

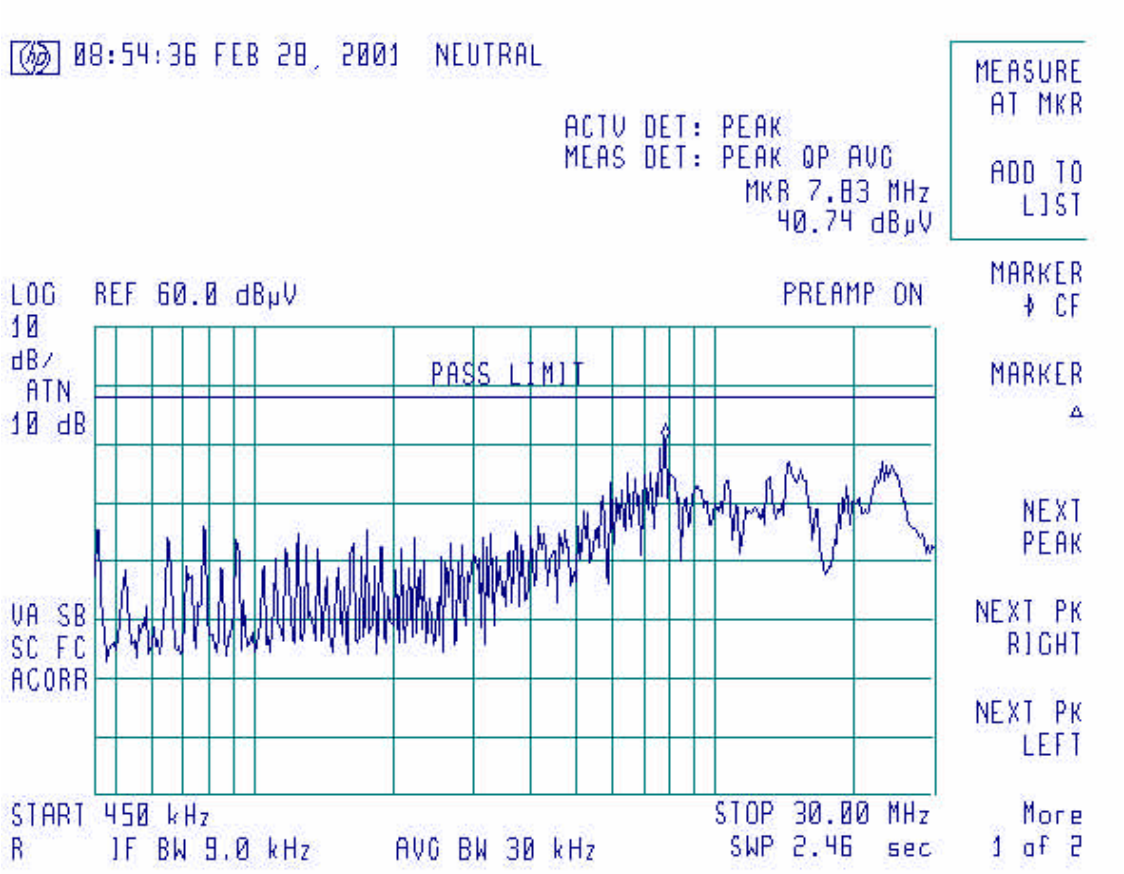
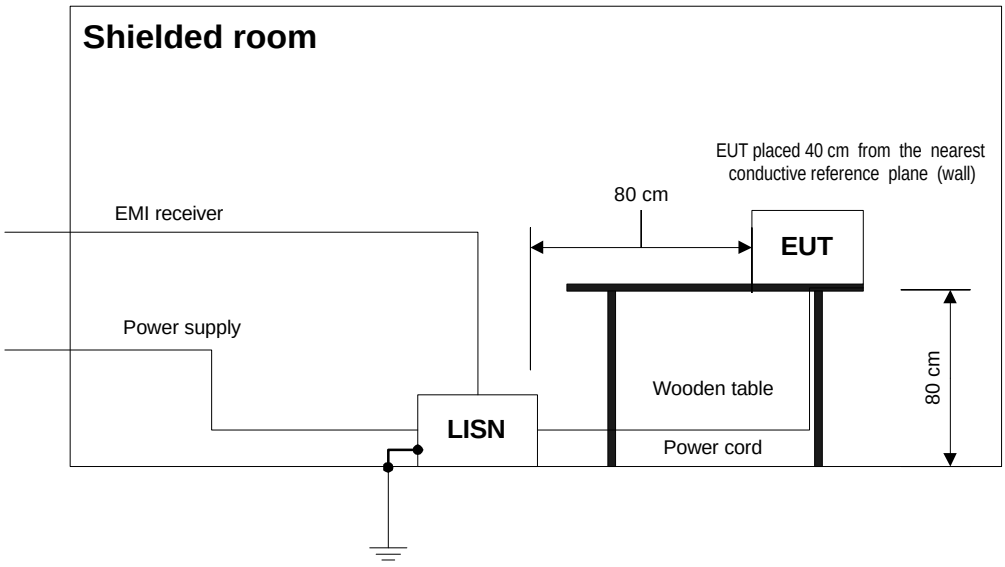
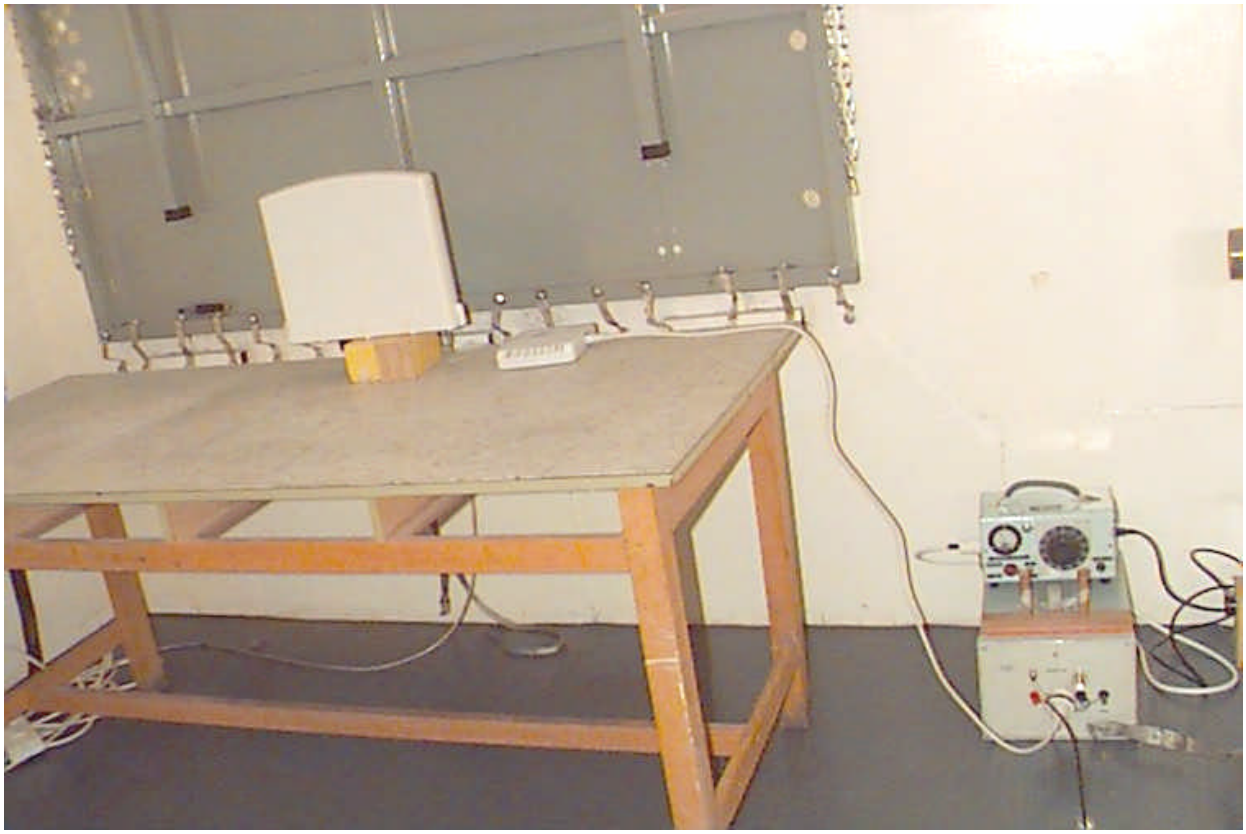


**Figure 4.9.1**
**Conducted emissions test setup for table-top equipment**



**Photograph 4.9.1**
**Conducted emission measurements test setup**



# APPENDIX A – Test equipment and ancillaries used for tests

| HL serial No. | Description | Manufacturer information | | | Due calibr. |
|---|---|---|---|---|---|
| | | Name | Model No. | Serial No. | |
| 0038 | Antenna Mast, 1-4 m | Hermon Labs | AM-1 | 028 | 2/02 Check |
| 0041 | Double ridged guide antenna, 1-18 GHz | Electro-Metrics | RGA 50/60 | 2811 | 8/01 |
| 0057 | Attenuator, 50 Ohm, 2 W, 0-18 GHz, 50 dB | Hewlett Packard | 8492A | 129 | 4/01 |
| 0163 | LISN FCC/VDE/MIL -STD | Electro-Metrics | ANS-25/2 | 1314 | 10/01 |
| 0275 | Table non-metallic, adjustable height, 1.5 x 1.0 x 0.8 m | Hermon Labs | TNM | 040 | 3/01 Check |
| 0287 | Turntable, motorized diameter, 2 m | Hermon Labs | TMD-2 | 042 | 4/01 Check |
| 0465 | Anechoic Chamber 9 (L) x 6.5 (W) x 5.5 (H) m | Hermon Labs | AC-1 | 023 | 3/03 |
| 0466 | Shielded Room 3 (L) x 3 (W) x 2.4 (H) m | Hermon Labs | SR-1 | 024 | 5/02 Check |
| 0483 | Oscilloscope, Digitizing, 100 MHz | Hewlett Packard | 54501A | 1325 | 11/01 |
| 0521 | Spectrum Analyzer with RF filter section (EMI Receiver 9 kHz - 6.5 GHz) | Hewlett Packard | 8546A | 0319 | 7/01 |
| 0547 | Amplifier, GaAs FET,RF, 6-18 GHz,2 W, 35 dB,12 V/1.2 A, N.F4.5 dB | Avantek | AMT - 12407M | 400 | 12/01 |
| 0580 | DC block adaptor 10 kHz-2.2 GHz | Anritsu | MA8601 A | 580 | 6/01 |
| 0589 | Cable Coaxial, GORE A2POL118.2, 3m | Hermon Labs | GORE-3 | 589 | 11/01 |
| 0590 | Attenuator 10 dB, 50 Ohm, N-type, 2 W | Elisra Electronic Systems | MW2100-N-Type | 10 | 6/01 |
| 0593 | Antenna Mast, 1-4 m/ 1-6 m Pneumatic | Hermon Labs | AM-F1 | 101 | 2/02 check |
| 0594 | Turntable for Anechoic Chamber, flush mounted, d=1.2 m, pneumatic | Hermon Labs | WDC1 | 102 | 11/01 |
| 0604 | Antenna Biconilog Log-Periodic/T Bow-Tie, 26 - 2000 MHz | EMCO | 3141 | 9611-1011 | 12/01 |
| 0812 | Cable, coax, RG-214, 11.5 m, N-type connectors | Hermon Labs | C214-11 | 148 | 8/01 |
| 0813 | Cable, coax, RG-214, 12 m, N-type connectors | Hermon Labs | C214-12 | 149 | 8/01 |
| 1175 | Microwave 5 m cable | Gore | 01C02245.2 | NA | 2/02 |
| 1424 | Spectrum analyzer | Agilent Technologies | 8564EC | 3946A00219 | 9/01 |
| 1650 | Attenuators Set (2, 3, 5, 20 dB), DC-18 GHz | M/A-COM | 2082 | 1650 | 3/02 |
| 1651 | Attenuators Set (2, 3, 5, 20 dB), DC-18 GHz | M/A-COM | 2082 | 1651 | 3/02 |

# APPENDIX B-Test equipment correction factors

**Correction Factor**
**Line Impedance Stabilization Network**
**Model LISN 16 - 1**
**Hermon Laboratories**

| Frequency, kHz | Correction Factor |
|---|---|
| 10 | 4.9 |
| 15 | 2.86 |
| 20 | 1.83 |
| 25 | 1.25 |
| 30 | 0.91 |
| 35 | 0.69 |
| 40 | 0.53 |
| 50 | 0.35 |
| 60 | 0.25 |
| 70 | 0.18 |
| 80 | 0.14 |
| 90 | 0.11 |
| 100 | 0.09 |
| 125 | 0.06 |
| 150 | 0.04 |

The correction factor dB is to be added to the meter readings (dB/μv) of the interference analyzer or spectrum analyzer.

**Antenna factor**
**Double ridged guide antenna**
**Electro-Metrics, model RGA-50/60**
**Ser.No.2811**

| Frequency, MHz | Antenna Factor, dB(1/m) | Frequency, MHz | Antenna Factor, dB(1/m) |
|---|---|---|---|
| 1000 | 24.3 | 10,000 | 38.2 |
| 1500 | 25.4 | 10,500 | 38.5 |
| 2000 | 28.4 | 11,000 | 39.0 |
| 2500 | 29.2 | 11,500 | 40.1 |
| 3000 | 30.5 | 12,000 | 40.2 |
| 3500 | 31.6 | 12,500 | 39.3 |
| 4000 | 33.7 | 13,000 | 39.9 |
| 4500 | 32.2 | 13,500 | 40.6 |
| 5000 | 34.5 | 14,000 | 41.1 |
| 5500 | 34.5 | 14,500 | 40.5 |
| 6000 | 34.6 | 15,000 | 39.9 |
| 6500 | 35.3 | 15,500 | 37.8 |
| 7000 | 35.5 | 16,000 | 39.1 |
| 7500 | 35.9 | 16,500 | 41.1 |
| 8000 | 36.6 | 17,000 | 41.7 |
| 8500 | 37.3 | 17,500 | 45.1 |
| 9000 | 37.7 | 18,000 | 44.3 |
| 9500 | 37.7 | | |

Antenna factor dB(1/m) is to be added to receiver meter reading in dB(μV) to convert to field intensity in dB(μV/meter)

**Antenna factor at 3m calibration**
**Biconilog antenna EMCO model 3141, Ser.No.1011**

| Frequency, MHz | Antenna Factor, dB(1/m) | Frequency, MHz | Antenna Factor, dB(1/m) |
|---|---|---|---|
| 26 | 7.8 | 940 | 24.0 |
| 28 | 7.8 | 960 | 24.1 |
| 30 | 7.8 | 980 | 24.5 |
| 40 | 7.2 | 1000 | 24.9 |
| 60 | 7.1 | 1020 | 25.0 |
| 70 | 8.5 | 1040 | 25.2 |
| 80 | 9.4 | 1060 | 25.4 |
| 90 | 9.8 | 1080 | 25.6 |
| 100 | 9.7 | 1100 | 25.7 |
| 110 | 9.3 | 1120 | 26.0 |
| 120 | 8.8 | 1140 | 26.4 |
| 130 | 8.7 | 1160 | 27.0 |
| 140 | 9.2 | 1180 | 27.0 |
| 150 | 9.8 | 1200 | 26.7 |
| 160 | 10.2 | 1220 | 26.5 |
| 170 | 10.4 | 1240 | 26.5 |
| 180 | 10.4 | 1260 | 26.5 |
| 190 | 10.3 | 1280 | 26.6 |
| 200 | 10.6 | 1300 | 27.0 |
| 220 | 11.6 | 1320 | 27.8 |
| 240 | 12.4 | 1340 | 28.3 |
| 260 | 12.8 | 1360 | 28.2 |
| 280 | 13.7 | 1380 | 27.9 |
| 300 | 14.7 | 1400 | 27.9 |
| 320 | 15.2 | 1420 | 27.9 |
| 340 | 15.4 | 1440 | 27.8 |
| 360 | 16.1 | 1460 | 27.8 |
| 380 | 16.4 | 1480 | 28.0 |
| 400 | 16.6 | 1500 | 28.5 |
| 420 | 16.7 | 1520 | 28.9 |
| 440 | 17.0 | 1540 | 29.6 |
| 460 | 17.7 | 1560 | 29.8 |
| 480 | 18.1 | 1580 | 29.6 |
| 500 | 18.5 | 1600 | 29.5 |
| 520 | 19.1 | 1620 | 29.3 |
| 540 | 19.5 | 1640 | 29.2 |
| 560 | 19.8 | 1660 | 29.4 |
| 580 | 20.6 | 1680 | 29.6 |
| 600 | 21.3 | 1700 | 29.8 |
| 620 | 21.5 | 1720 | 30.3 |
| 640 | 21.2 | 1740 | 30.8 |
| 660 | 21.4 | 1760 | 31.1 |
| 680 | 21.9 | 1780 | 31.0 |
| 700 | 22.2 | 1800 | 30.9 |
| 720 | 22.2 | 1820 | 30.7 |
| 740 | 22.1 | 1840 | 30.6 |
| 760 | 22.3 | 1860 | 30.6 |
| 780 | 22.6 | 1880 | 30.6 |
| 800 | 22.7 | 1900 | 30.6 |
| 820 | 22.9 | 1920 | 30.7 |
| 840 | 23.1 | 1940 | 30.9 |
| 860 | 23.4 | 1960 | 31.2 |
| 880 | 23.8 | 1980 | 31.6 |
| 900 | 24.1 | 2000 | 32.0 |
| 920 | 24.1 | | |

Antenna factor is to be added to receiver meter reading in dB(μV) to convert to field intensity in dB(μV/meter).