ELECTROMAGNETIC EMISSIONS TEST REPORT

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

Marconi Communications LTD.

EQUIPMENT UNDER TEST:

Subscriber Premises Radio Unit of Wireless Local Loop System (WipLL), model SPR-2.4

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ACCREDITED
839.01
Electrical

Description of equipment under test

Test items	Subscriber premises radio unit (frequency hopping transmitter)
Manufacturer	Marconi Communications Ltd.
Types (Models)	SPR-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
Telephone number	+972 8977 7015
Telefax number	+972 8977 7050

Test performance

Project Number:	14534
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, SPR-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
msec	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
sec	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 subscriber premises radio, SPR-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 transmits and receives data to and from the base station. The FSK type of modulation with
1 Mbps data rate is used The transceiver operates in 2402 MHz to 2480 MHz frequency range and is equipped with a 15 dBi gain directional internal antenna.
At the network layer, the SPR performs routing functions between the subscriber's Ethernet network and wireless network, and contains a routing table that can support up to 16 entries. The capacity of each SPR is up to 3 MBps.
The SPR is connected to a subscriber data adapter (SDA), which provides 48 V DC power.

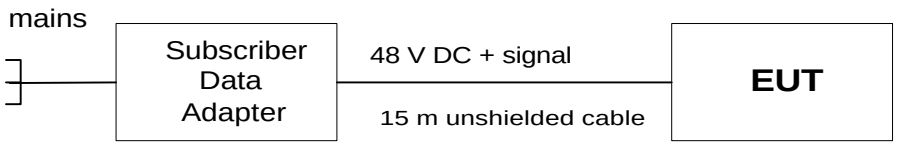
2.4 EUT test configuration

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).

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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 ▪ 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 ▪ Log periodic antenna: +5.71 dB/-5.56 dB ▪ 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 ▪ Log periodic antenna: +5.61 dB/-5.46 dB ▪ Biconilog antenna: +5.73 dB/-5.57 dB ▪ 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 8, 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 8, 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.

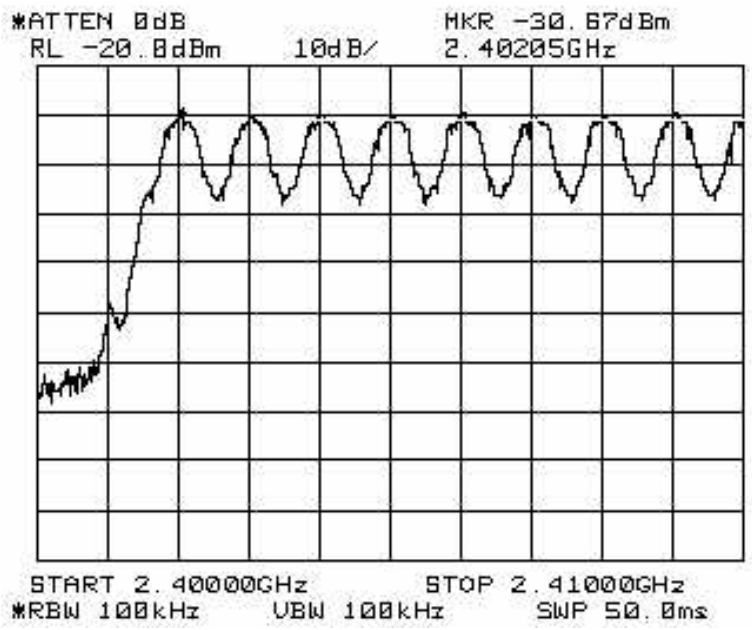
Reference numbers of test equipment used

HL 0057	HL 1424	

Full description is given in Appendix A.

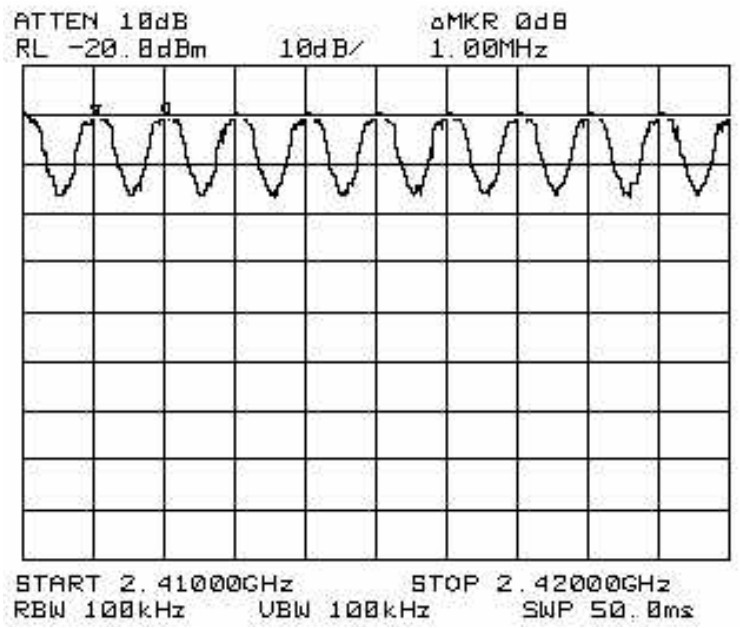
Plot 4.1.1

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



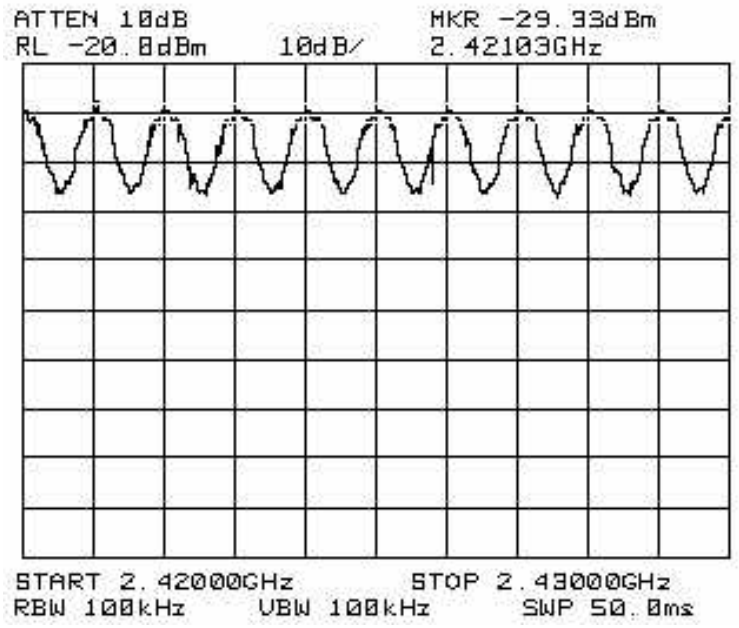
Plot 4.1.2

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



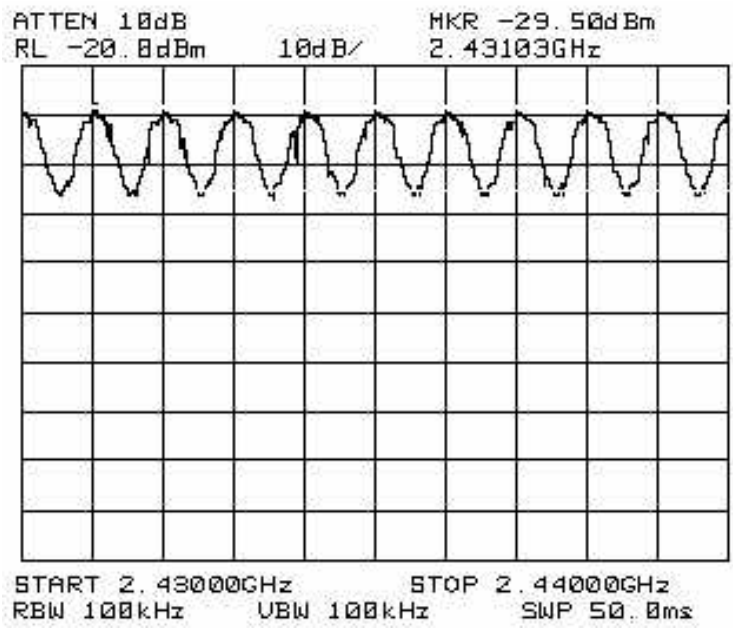
Plot 4.1.3

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



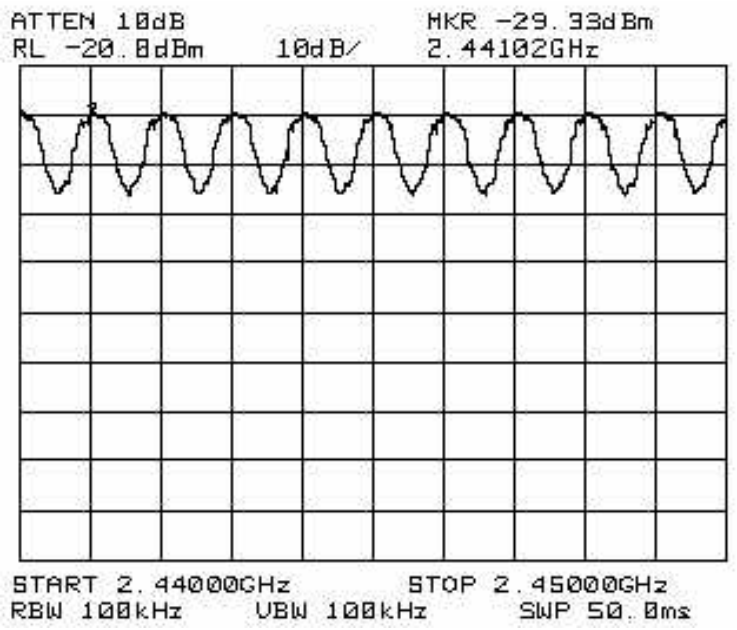
Plot 4.1.4

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



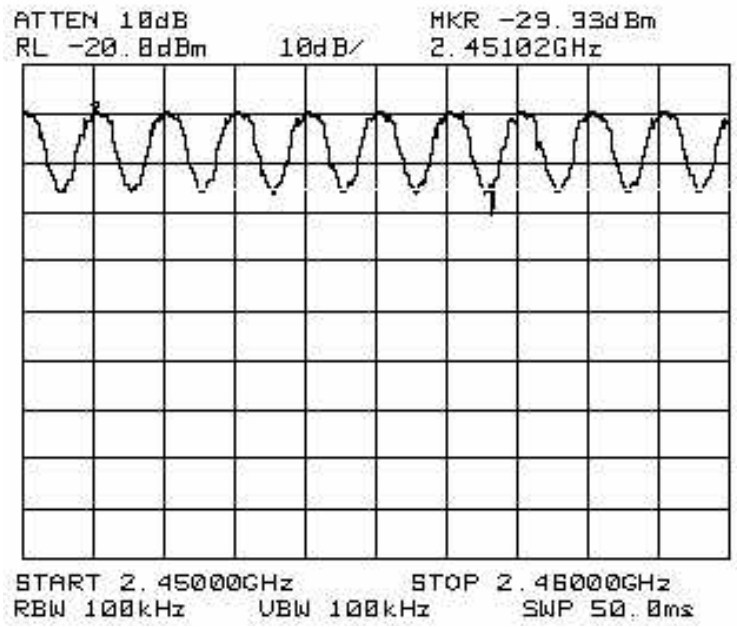
Plot 4.1.5

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



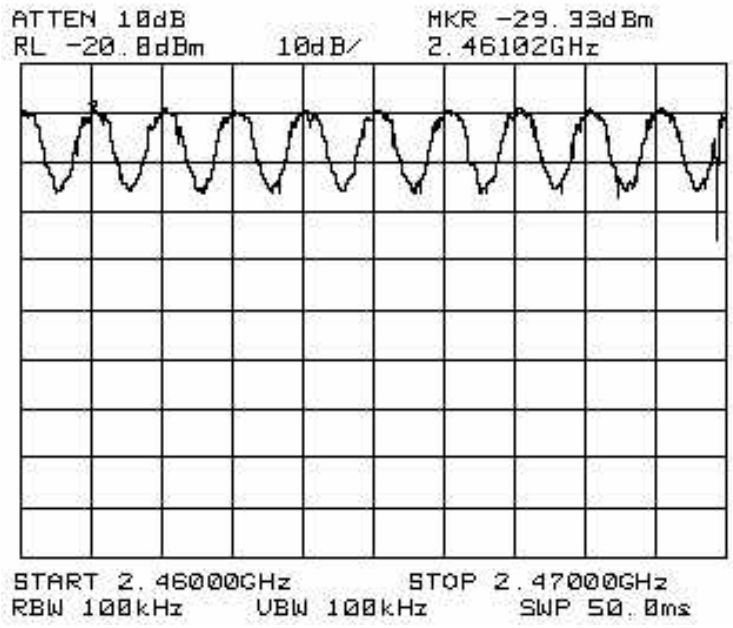
Plot 4.1.6

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



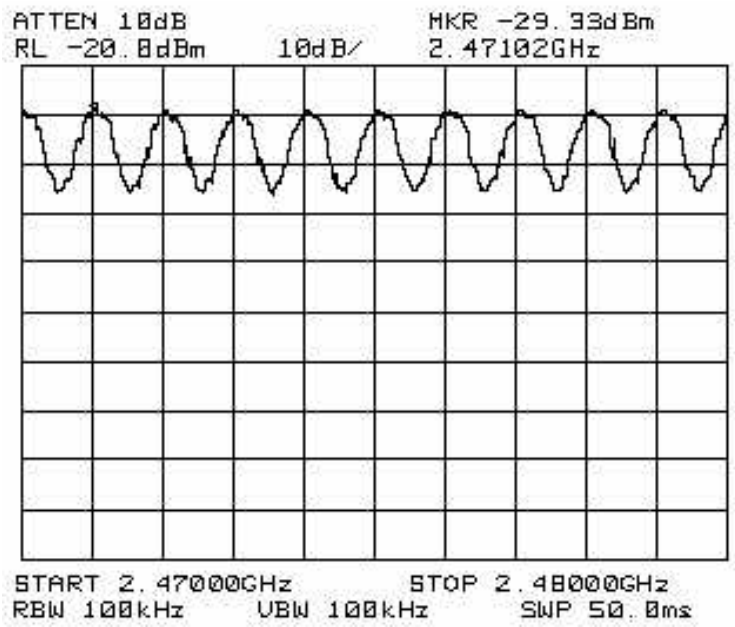
Plot 4.1.7

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

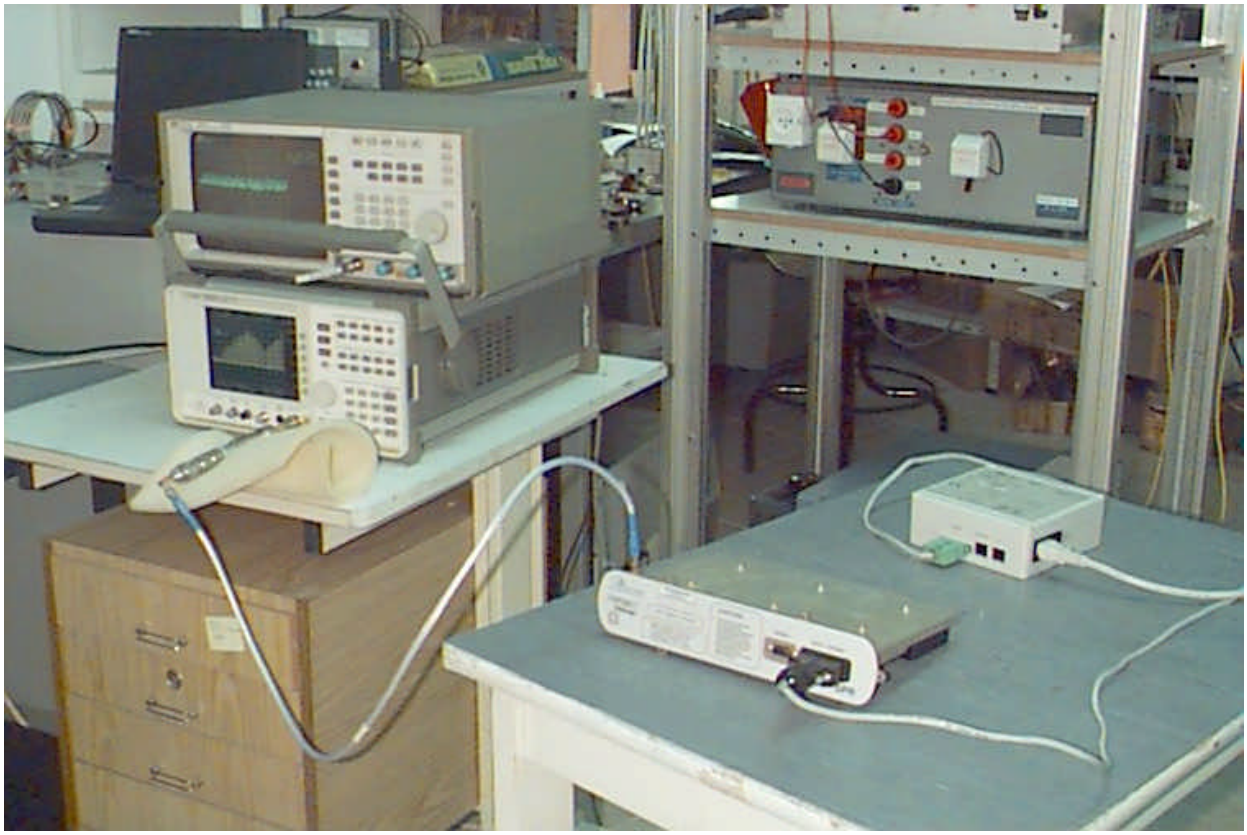


Plot 4.1.8

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

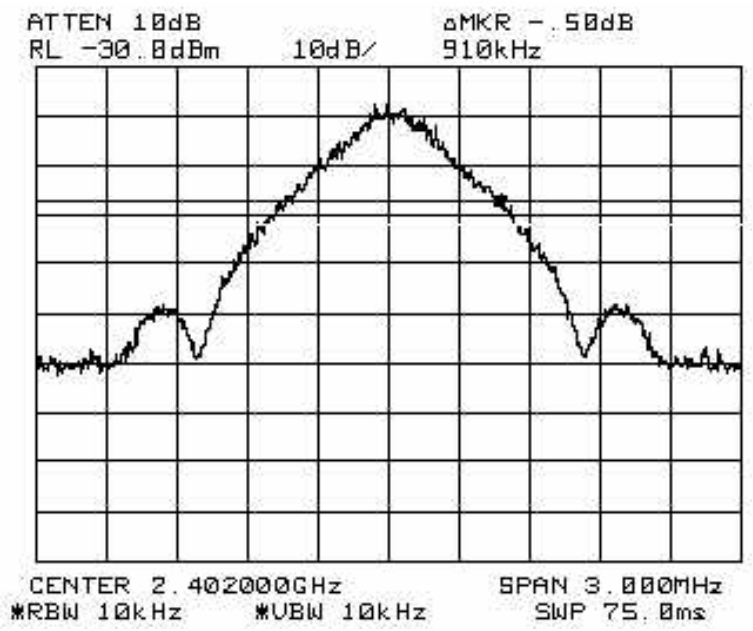
Carrier frequency, MHz	Measured 20 dB BW, kHz	Limit, kHz	Result
2402	910	1000	Pass
2450	975	1000	Pass
2480	955	1000	Pass

Reference numbers of test equipment used

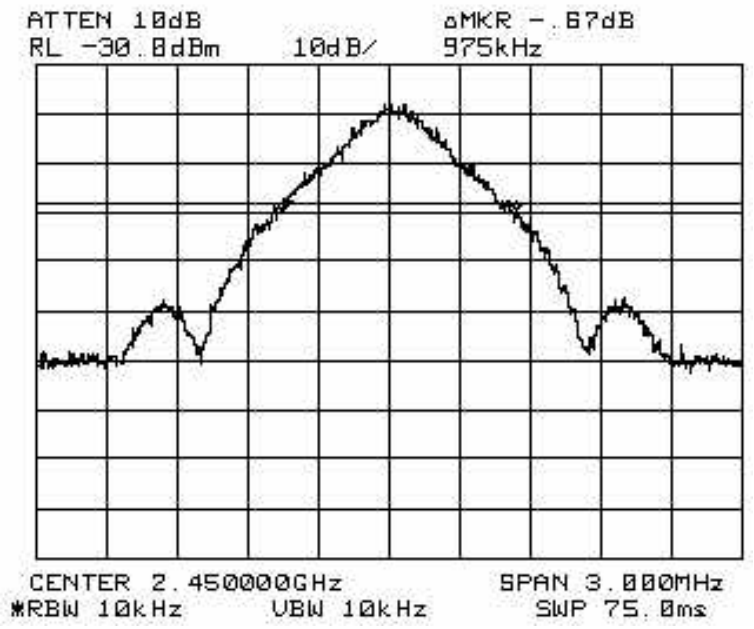
HL 0057	HL 1424	

Full description is given in Appendix A.

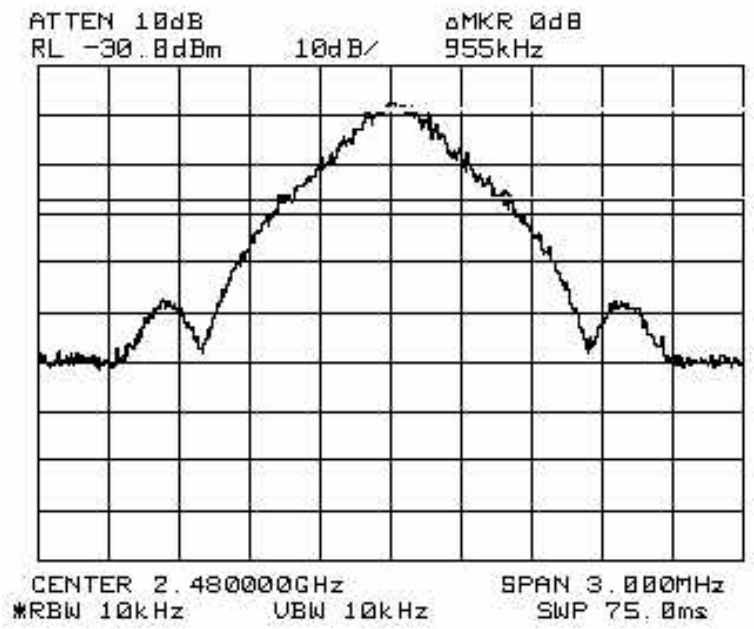
Plot 4.2.1
Test specification: § 15.247(a)(1)(ii)
Occupied bandwidth test results



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:

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

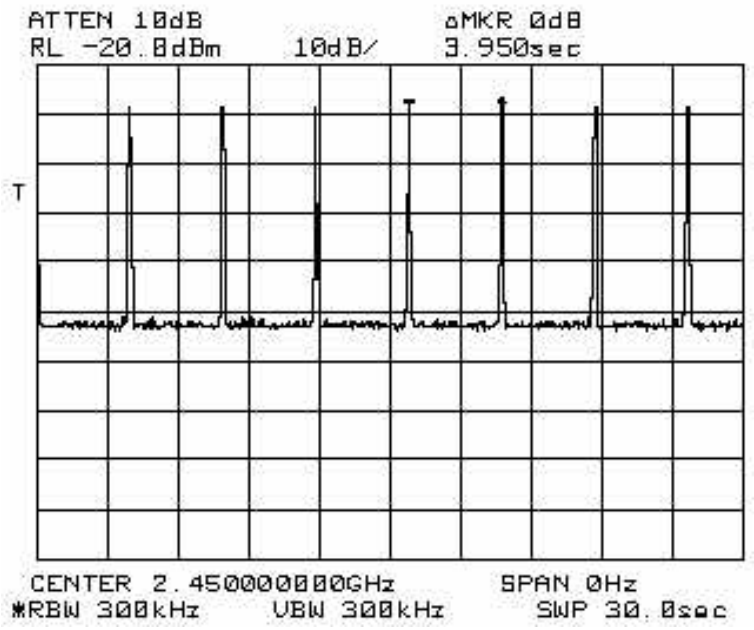
which is less than the required 0.4 s.

Reference numbers of test equipment used

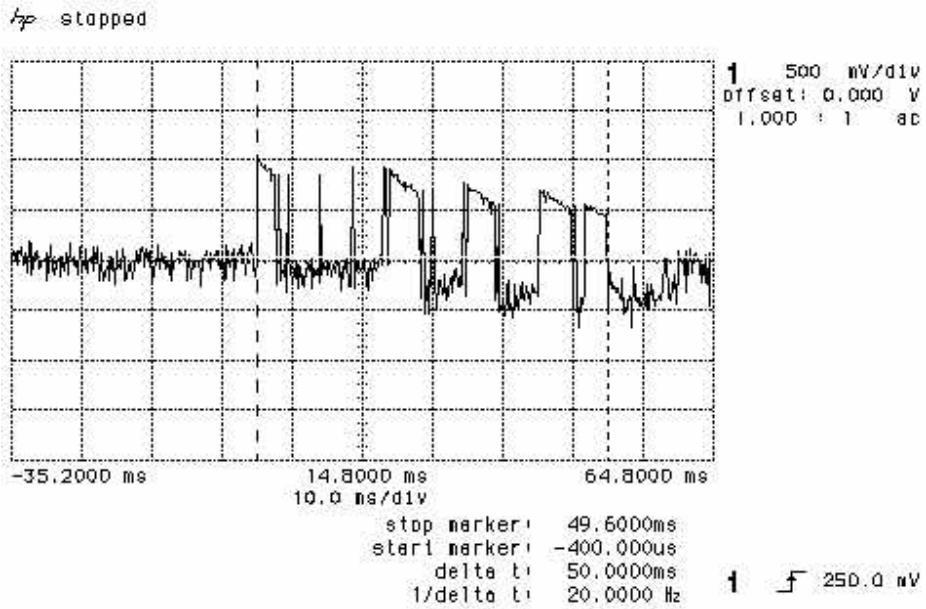
HL 0057	HL 0483	HL 1424	

Full description is given in Appendix A.

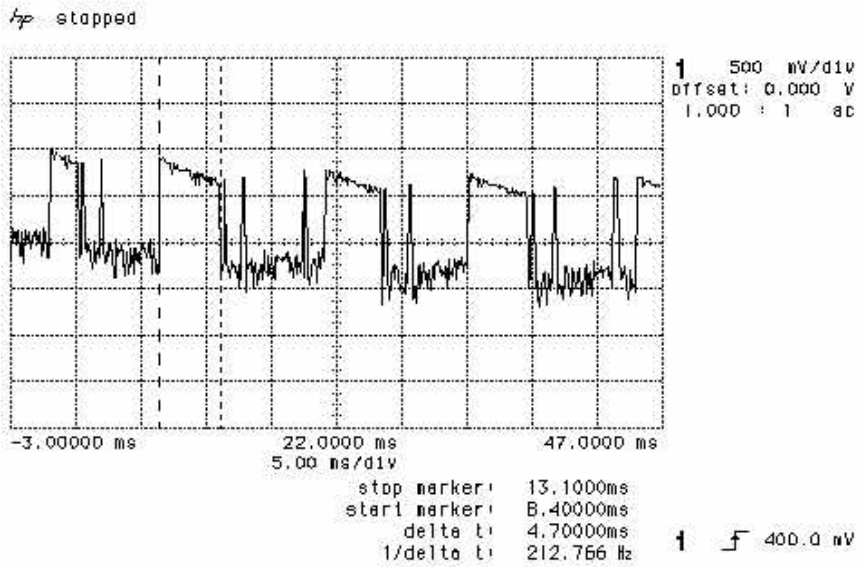
Plot 4.3.1
Test specification: §15.247(a)(1)(ii)
Average time of occupancy test results



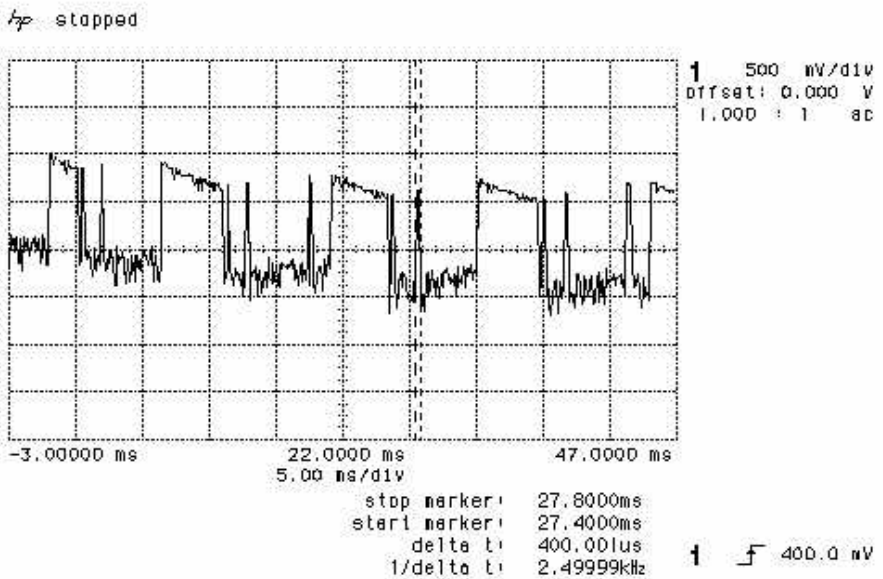
Plot 4.3.2
Test specification: §15.247(a)(1)(ii)
Average time of occupancy test results



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 15 dBi, hence the maximum peak output power of the transmitter shall not exceed 30 – (15-6) = 21 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	-32.17	18.33	21	2.67	Pass
2450	-32.17	18.33	21	2.67	Pass
2480	-31.83	18.67	21	2.33	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 18.67 dBm plus maximum antenna gain 15 dBi, the maximum equivalent isotropically radiated power (e.i.r.p.) is 34 dBm = 2512 mW.

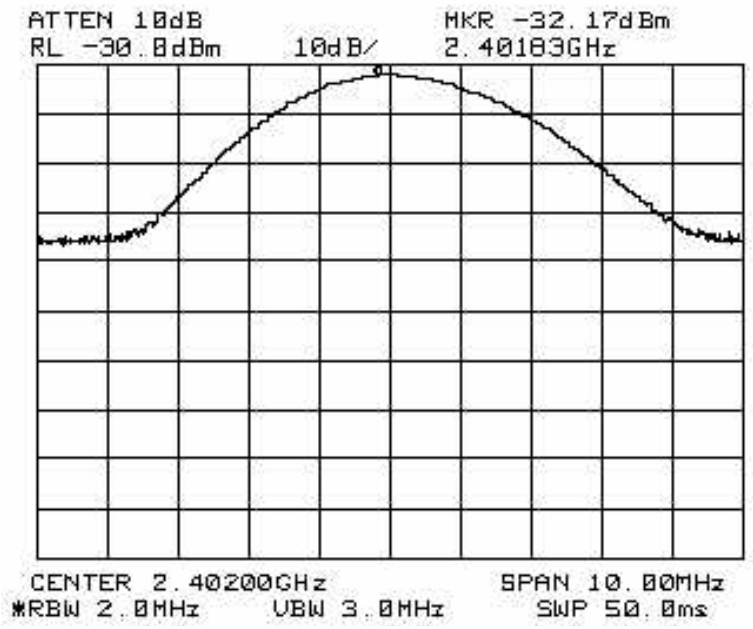
$$1(mW/cm^2) = 2512\ mW / 4\pi r^2$$

The allowed distance "r", where RF exposure limits may not be exceeded, is 14.1 cm:

$$r = \sqrt{P_T / 4\pi} = \sqrt{2512 / 4 \times 3.14} = 14.1\ (cm).$$

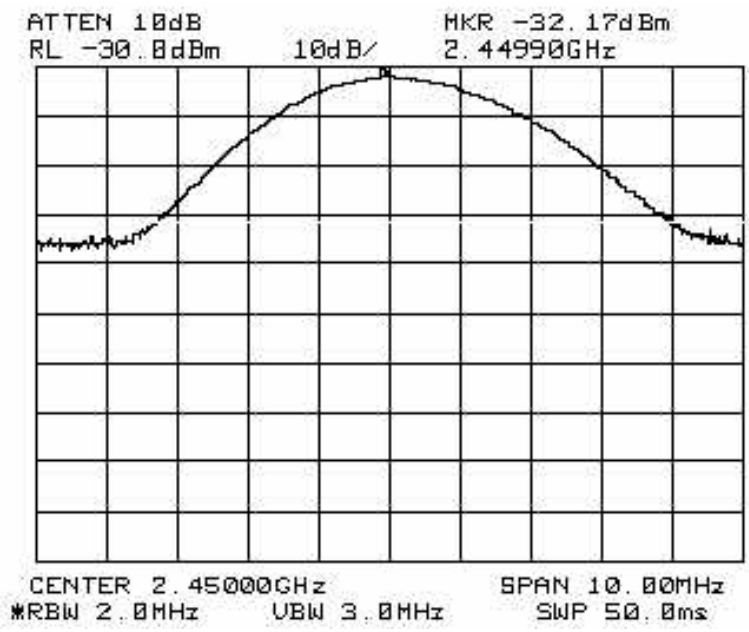
The public cannot be exposed to dangerous RF level.

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



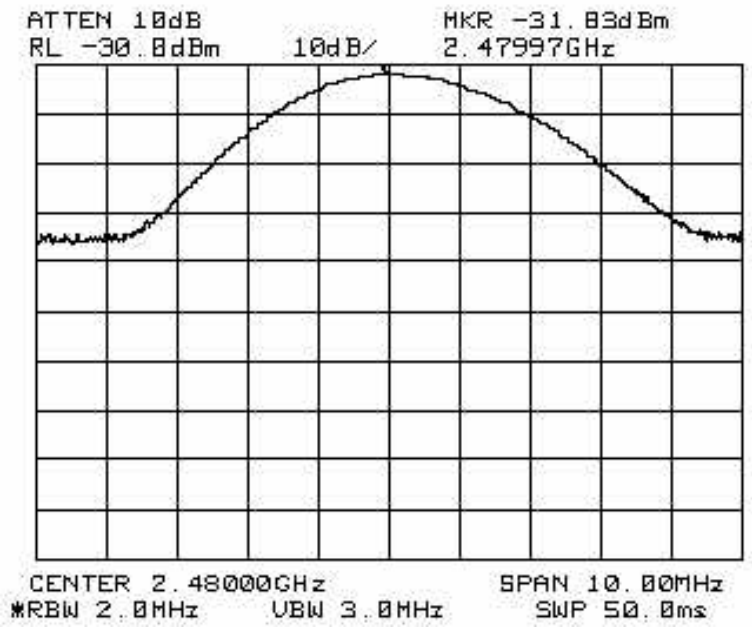
P =-32.17 +50.5 =18.33 dBm

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



P =-32.17 +50.5 =18.33 dBm

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



P = -31.83 + 50.5=18.67 dBm

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 4.5.19 show that the out of bands measured signals were attenuated more than 20 dBc.

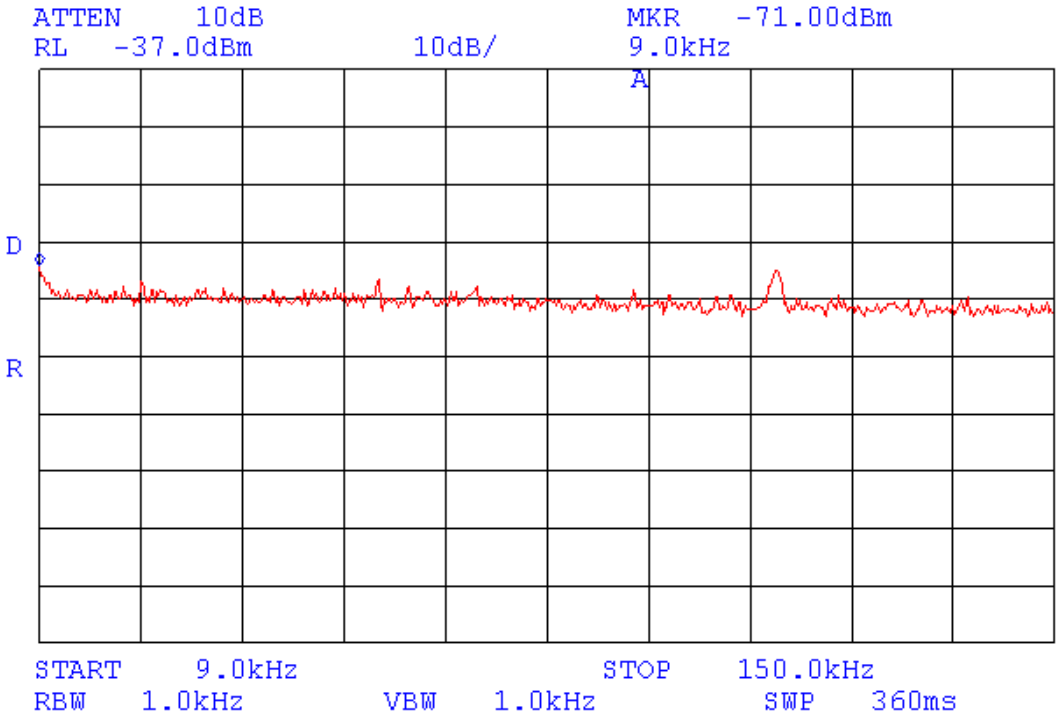
Reference numbers of test equipment used

HL 0057	HL 1650	HL 1651	HL 1424

Full description is given in Appendix A.

Plot 4.5.1

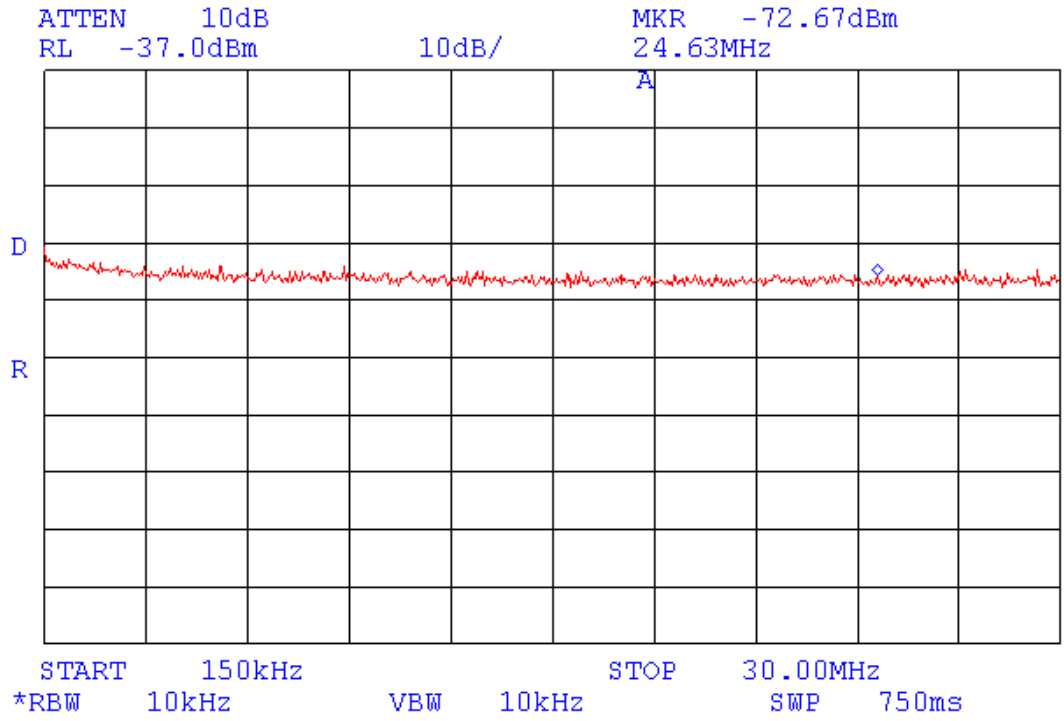
Test specification: § 15.247 (c)
Out-of-band emissions at the antenna output terminal
Frequency range 9 kHz - 150 kHz



Limit is 20 dB down from the carrier:
Limit = 18.33 dBm – 20 dB = -1.67 dBm

Plot 4.5.2

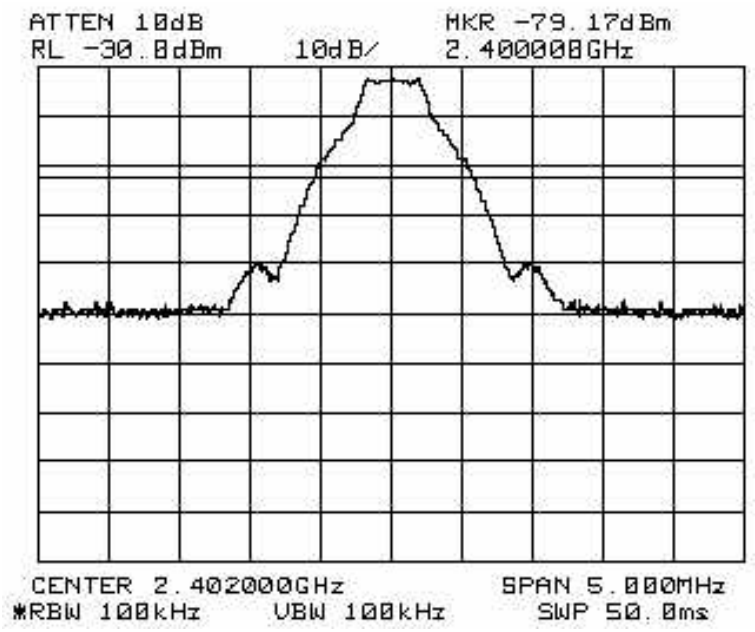
Test specification: § 15.247 (c)
Out-of-band emissions at the antenna output terminal
Frequency range 150 kHz – 30 MHz



Limit is 20 dB down from the carrier:
Limit = 18.33 dBm – 20 dB = -1.67 dBm

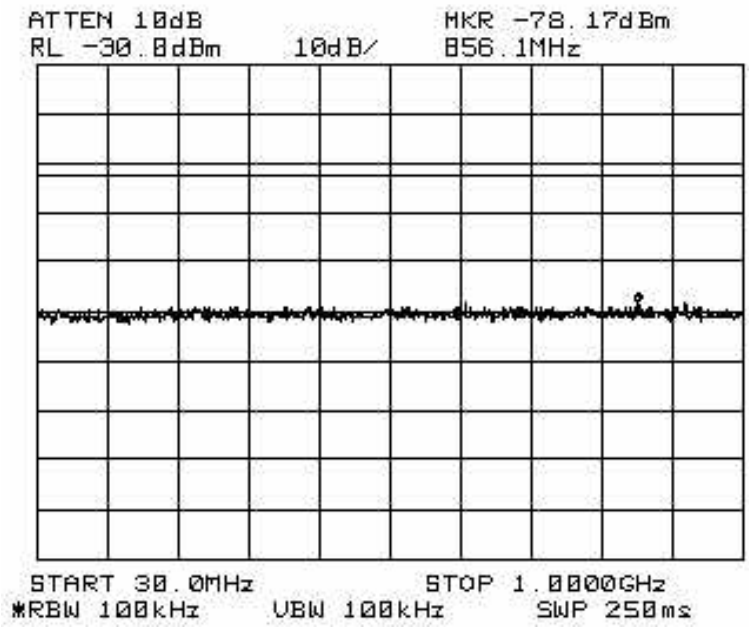
Plot 4.5.3

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



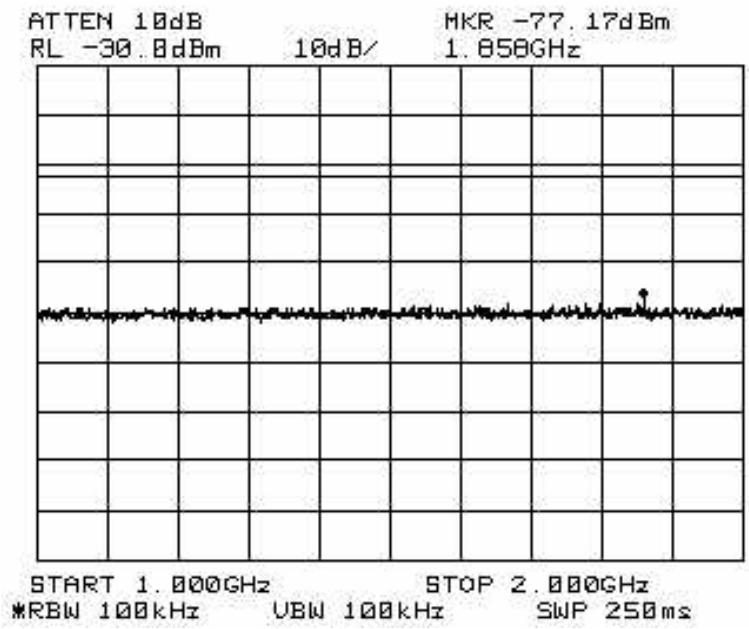
Plot 4.5.4

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



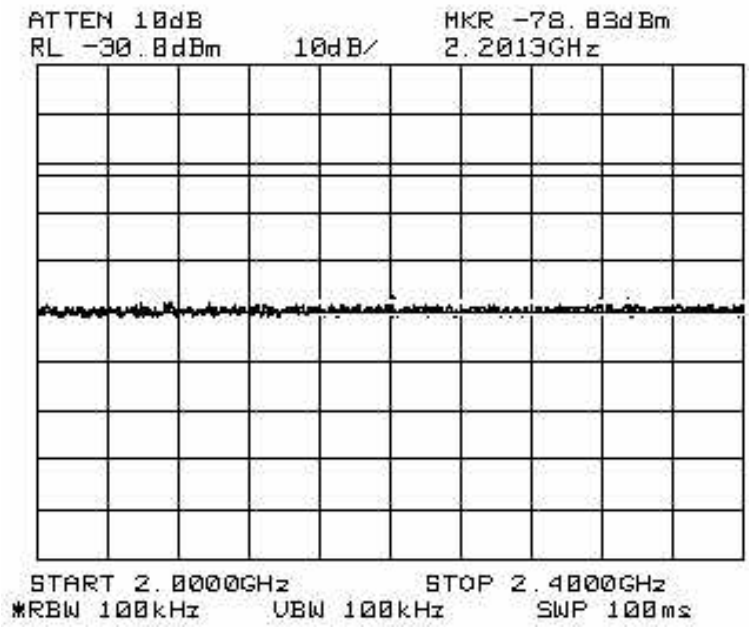
Plot 4.5.5

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



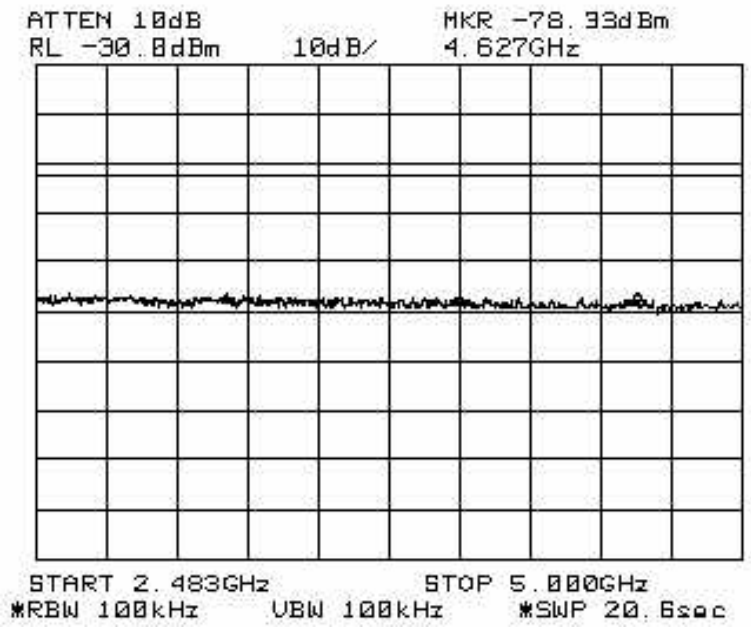
Plot 4.5.6

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



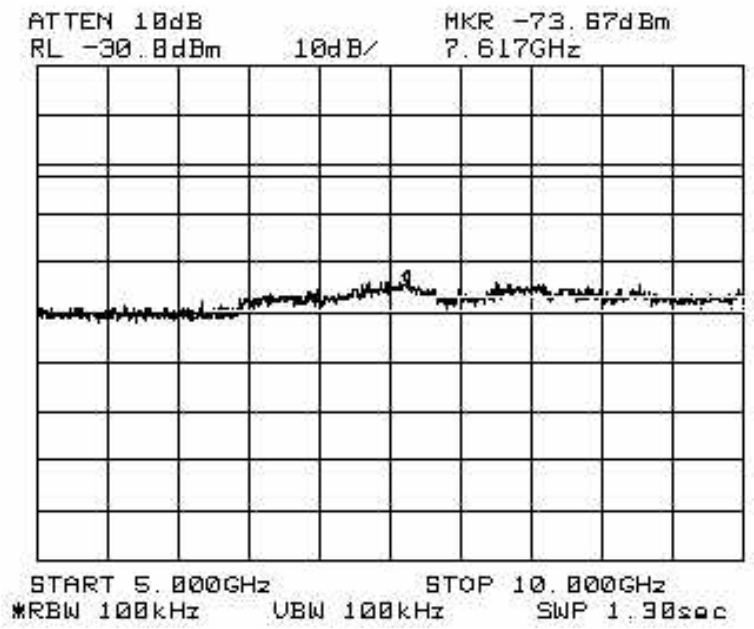
Plot 4.5.7

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



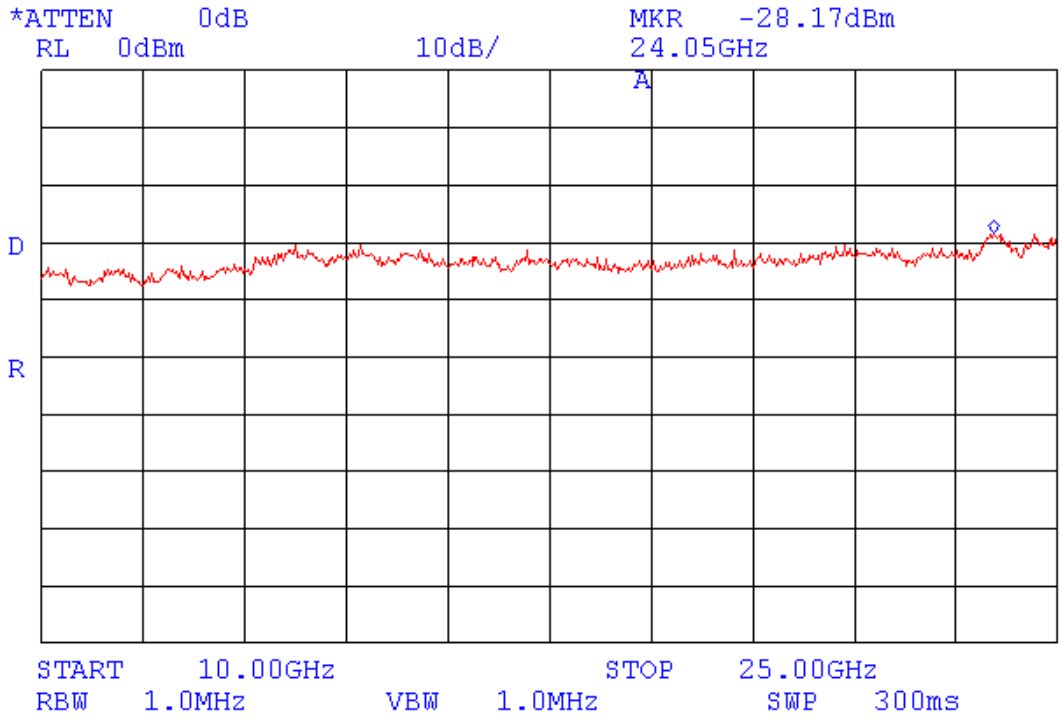
Plot 4.5.8

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



Plot 4.5.9

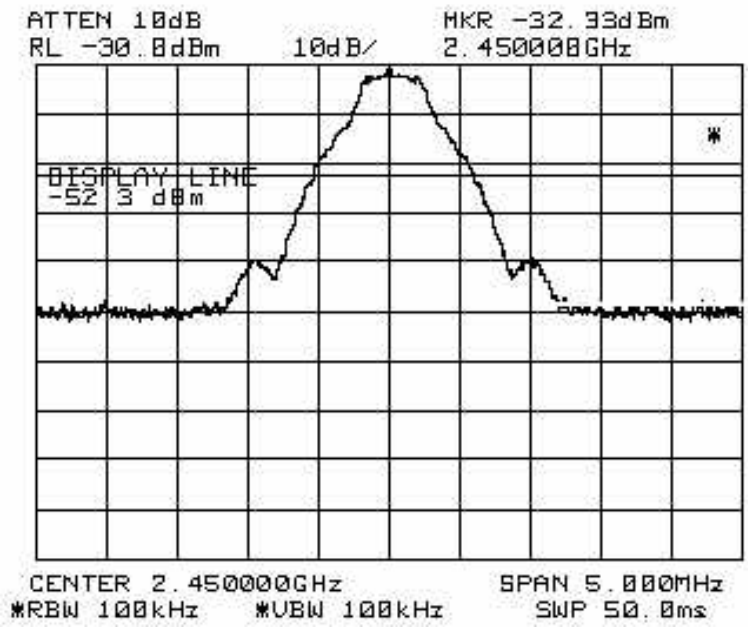
Test specification: § 15.247 (c)
Out-of-band emissions at the antenna output terminal
Frequency: 2.402 GHz



Limit is 20 dB down from the carrier:
Limit = 18.33 dBm – 20 dB = -1.67 dBm

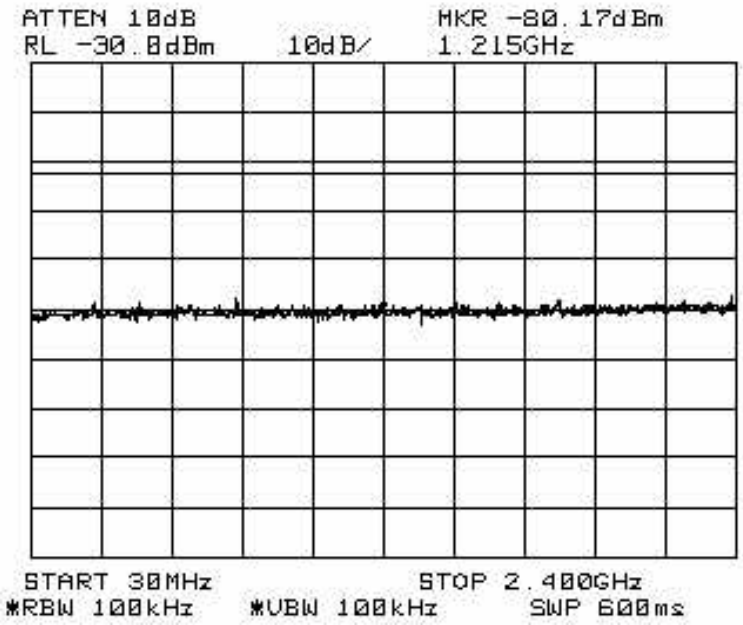
Plot 4.5.10

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



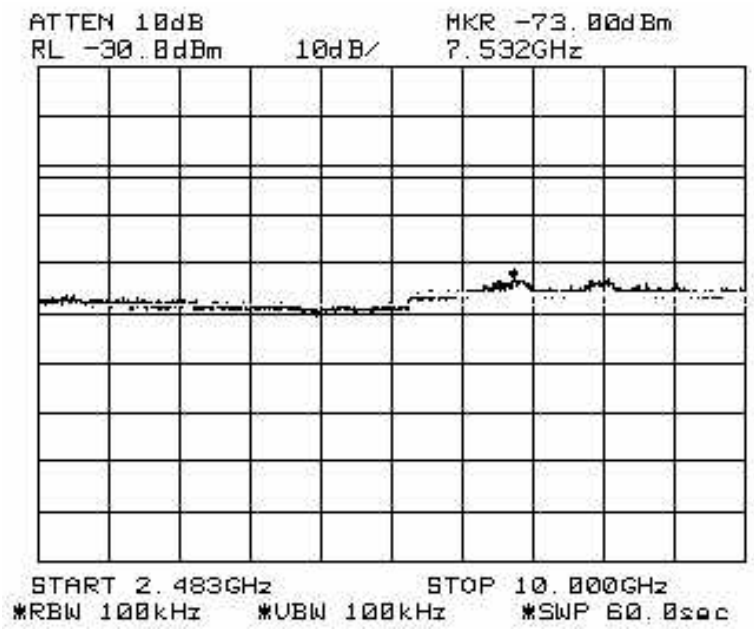
Plot 4.5.11

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



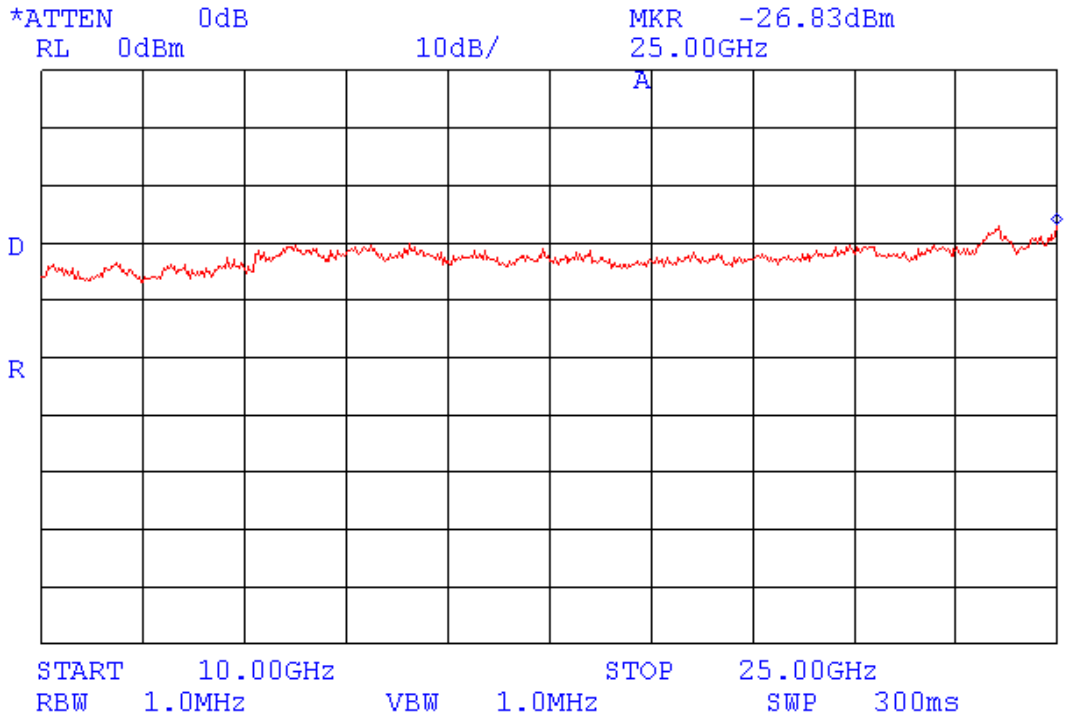
Plot 4.5.12

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



Plot 4.5.13

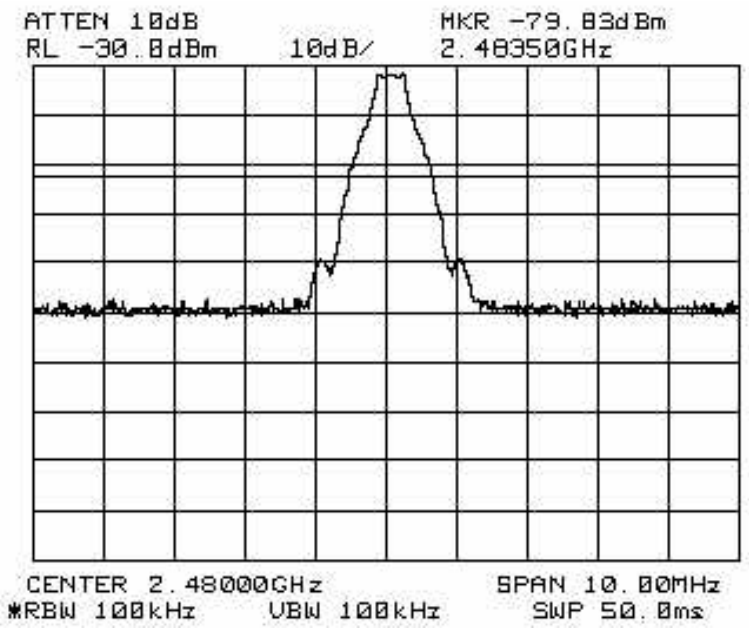
Test specification: § 15.247 (c)
Out-of-band emissions at the antenna output terminal
Frequency: 2.450 GHz



Limit is 20 dB down from the carrier:
Limit = 18.33 dBm – 20 dB = -1.67 dBm

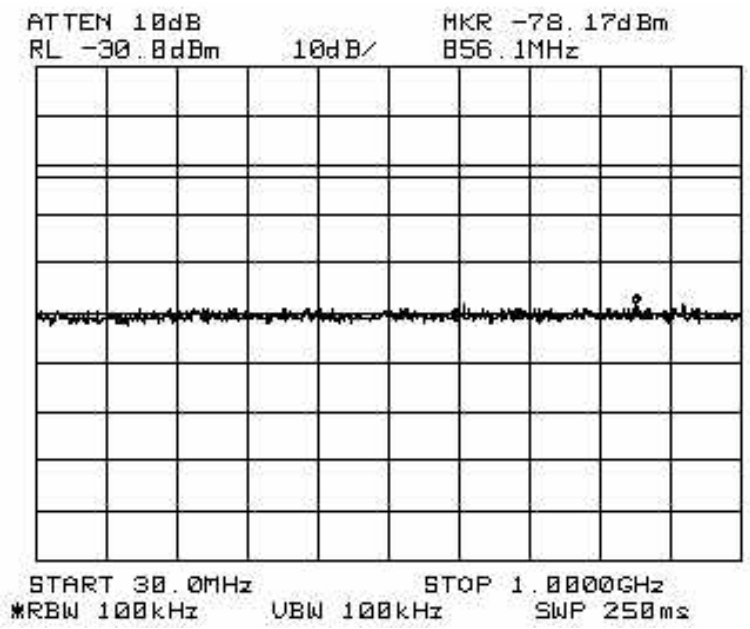
Plot 4.5.14

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



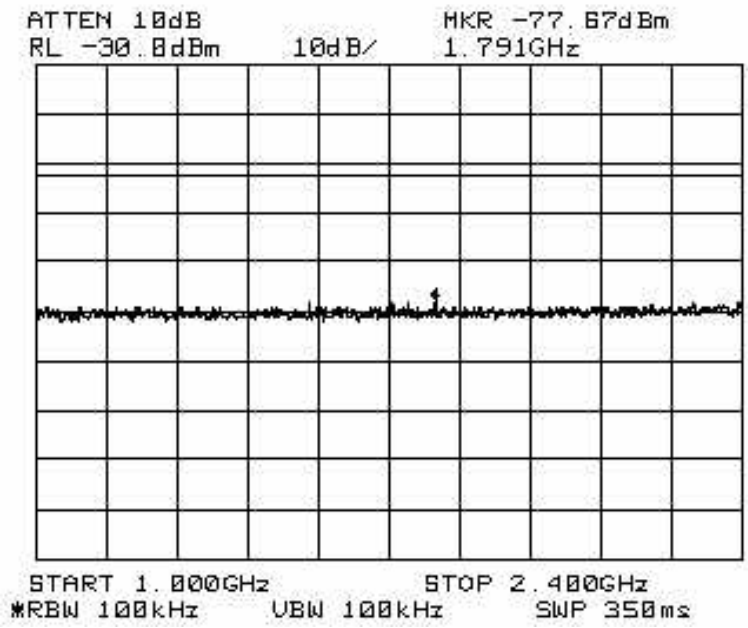
Plot 4.5.15

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



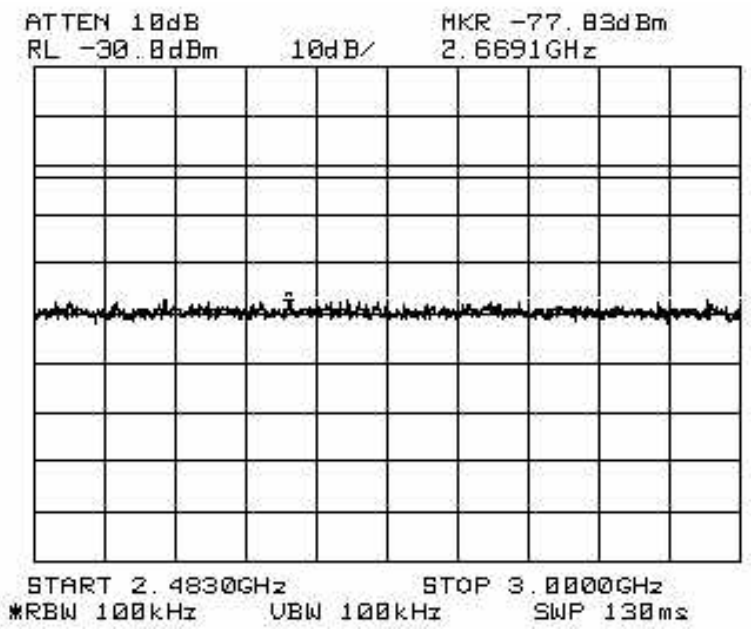
Plot 4.5.16

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



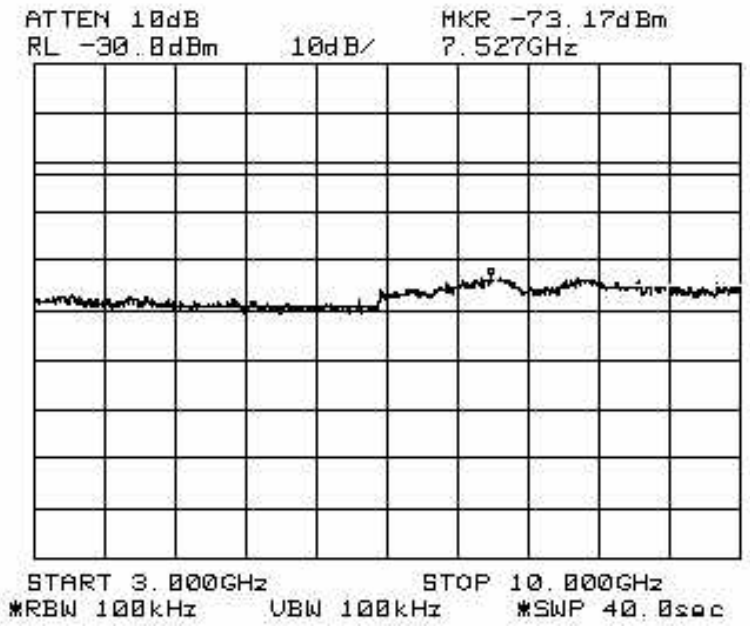
Plot 4.5.17

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



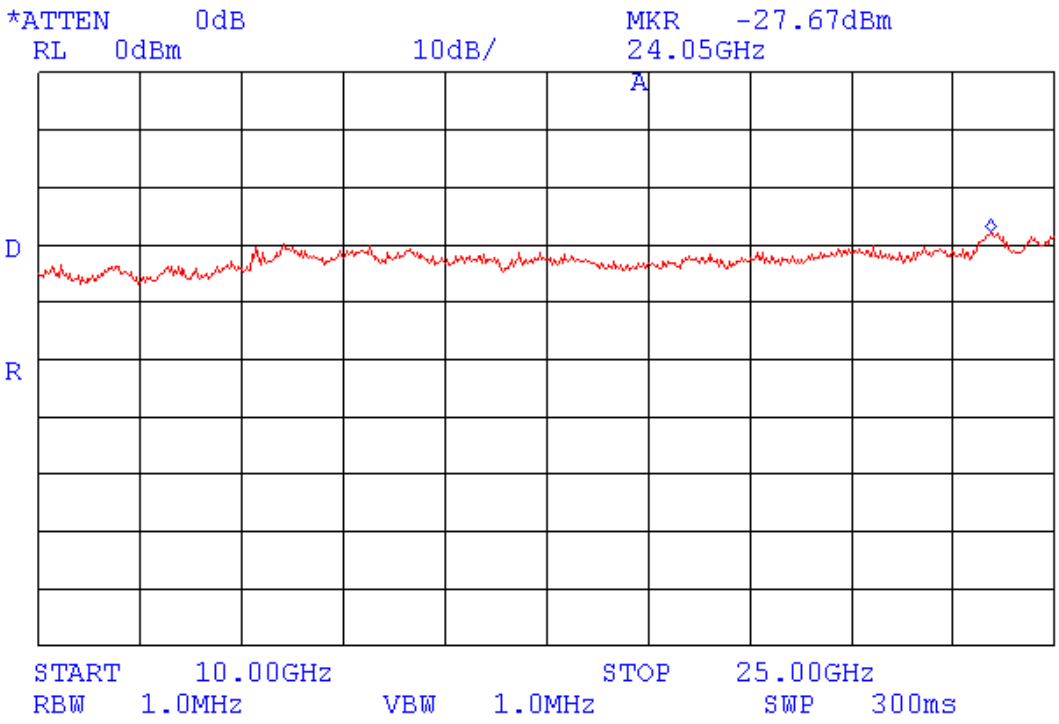
Plot 4.5.18

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



Limit is 20 dB down from the carrier:
Limit = 18.67 dBm – 20 dB = -1.33 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

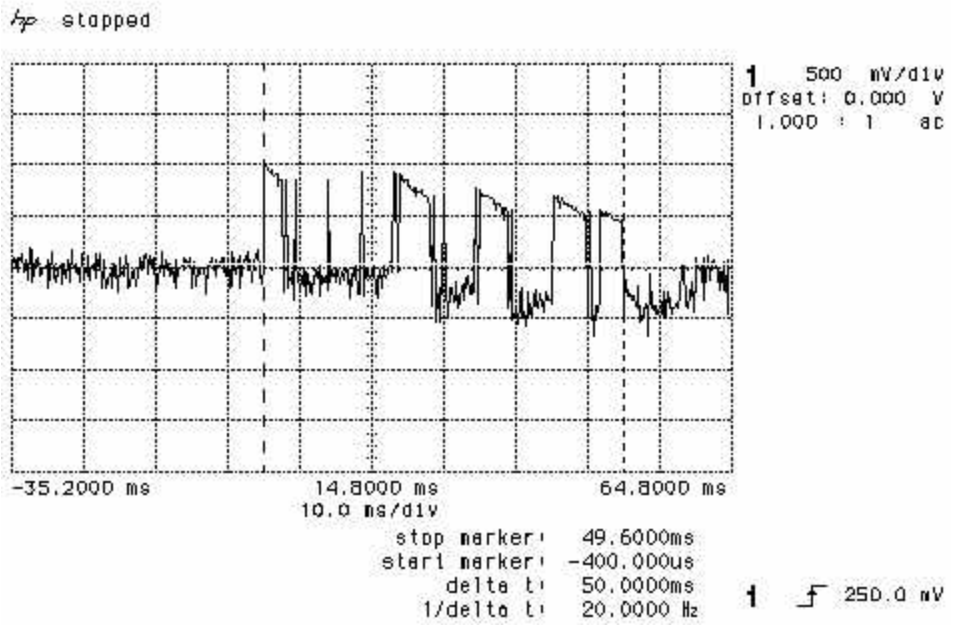
The test setup was the same as in test 4.1 with additionally connected oscilloscope to the spectrum analyzer video output.
The three plots from the oscilloscope demonstrate duty cycle measurements. The Plot 4.6.1 shows the pulse train in a 0.1 s interval measurement results. Two plots 4.6.2 and 4.6.3 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

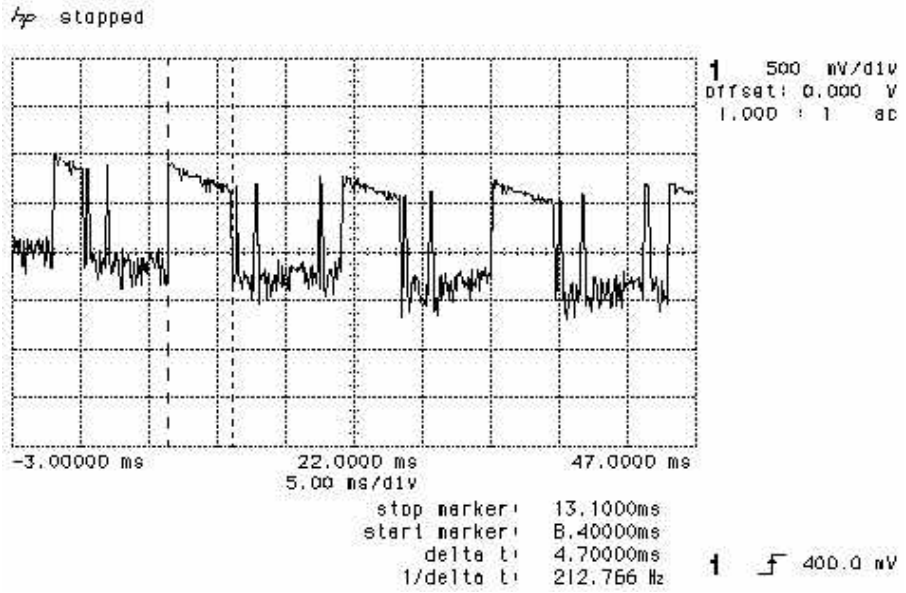
HL 0057	HL 0483	HL 1424	

Full description is given in Appendix A.

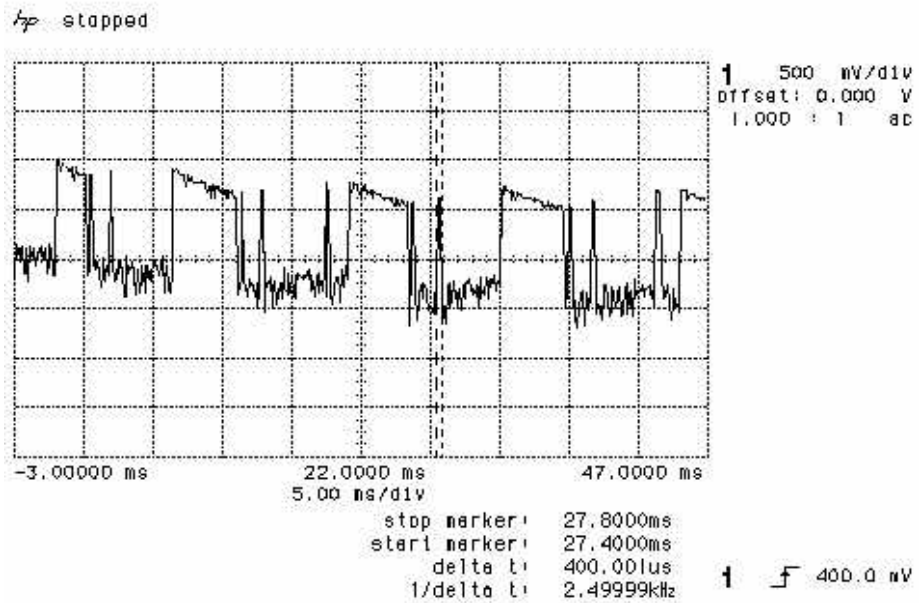
Plot 4.6.1
Duty cycle measurement test results



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

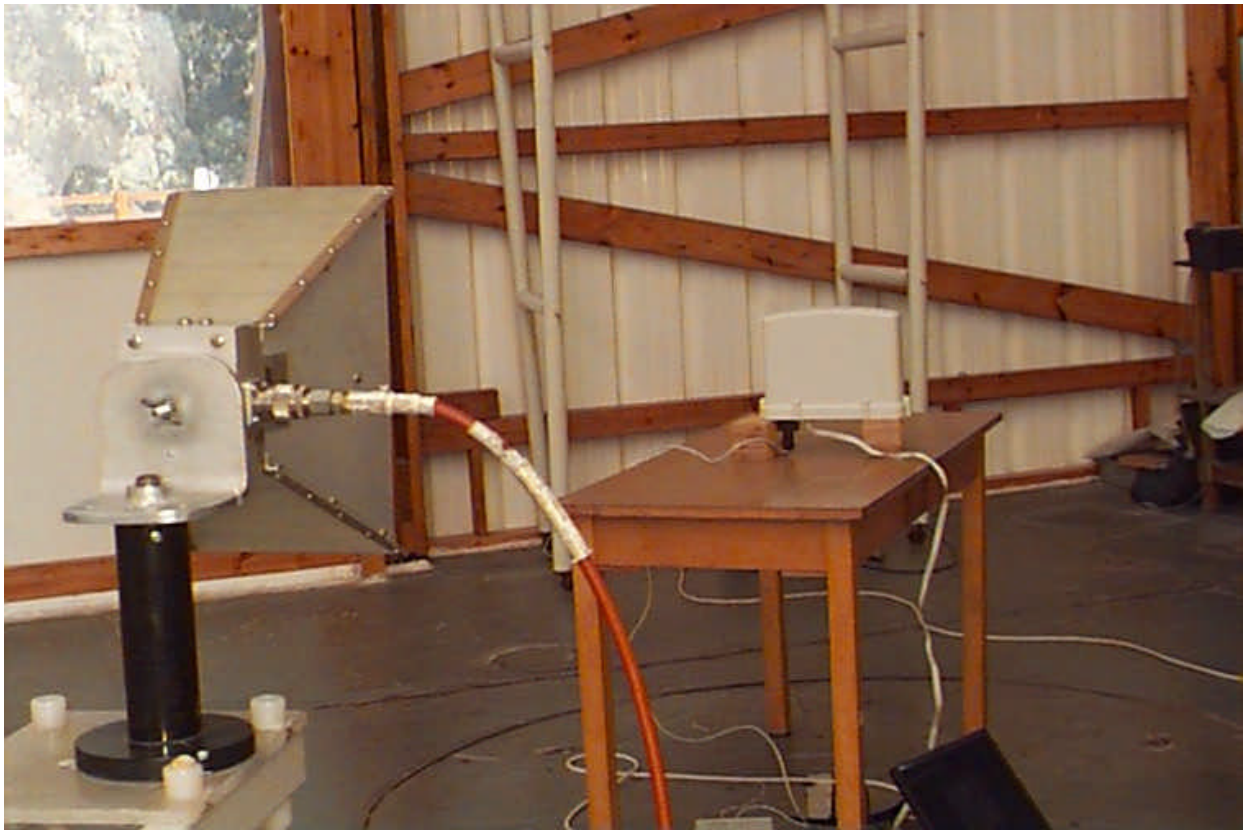
MEASUREMENTS PERFORMED AT 3 METRES DISTANCE

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	40.0	34.5	2.45	20	-11.9	45.05	54	8.95	Pass
4.900	40.0	34.5	2.45	20	-11.9	45.05	54	8.95	Pass
4.960	42.4	34.5	2.45	20	-11.9	47.45	54	6.55	Pass
7.350	39.0	35.7	3.8	20	-11.9	46.6	54	7.4	Pass
7.440	39.5	35.7	3.8	20	-11.9	47.1	54	6.9	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(mV/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

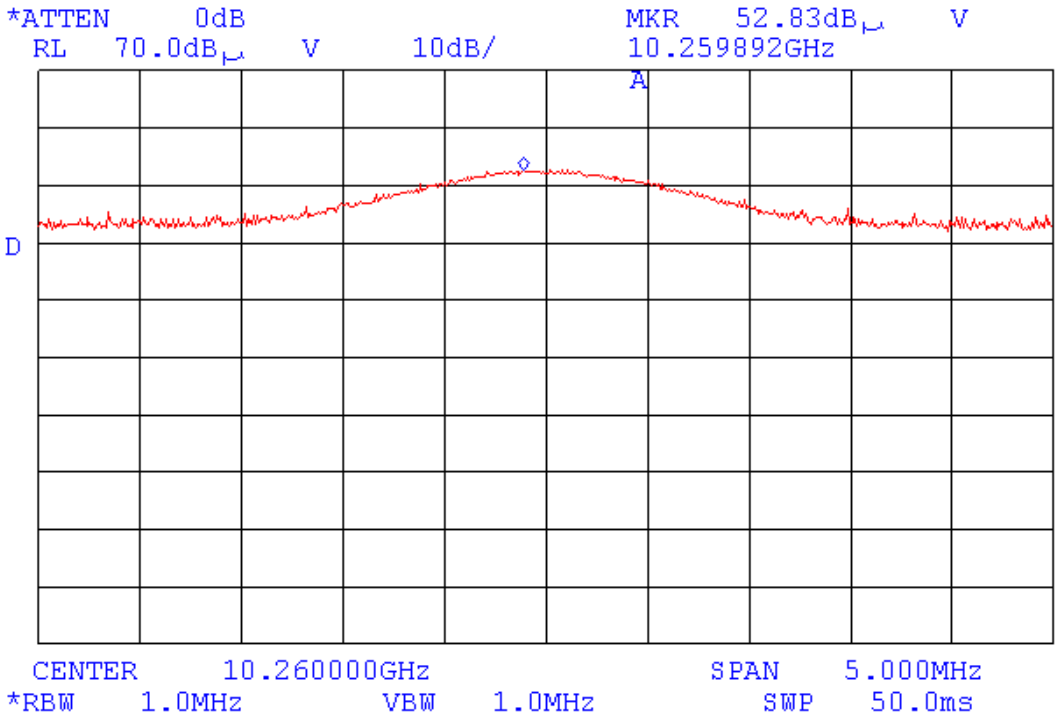
DATE: February 26, 2001
RELATIVE HUMIDITY: 54%
AMBIENT TEMPERATURE: 23°C

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
559.99	BL	H	1	QP	120	53	31.80	46.0	14.20	Pass
600.03	BL	H	1	QP	120	86	31.90	46.0	14.10	Pass
880.02	BL	H	1	QP	120	204	35.52	46.0	10.48	Pass
2099.96	DRG	V	1.1	average	1000	240	51.96	54.0	2.04	Pass
10260.00	DRG	V	1.1	average	1000	0	43.9	54.0	10.1	Pass
10500.00	DRG	V	1	average	1000	0	52.3	54.0	1.7	Pass
10650.00	DRG	H	1	average	1000	0	50.2	54.0	3.8	Pass

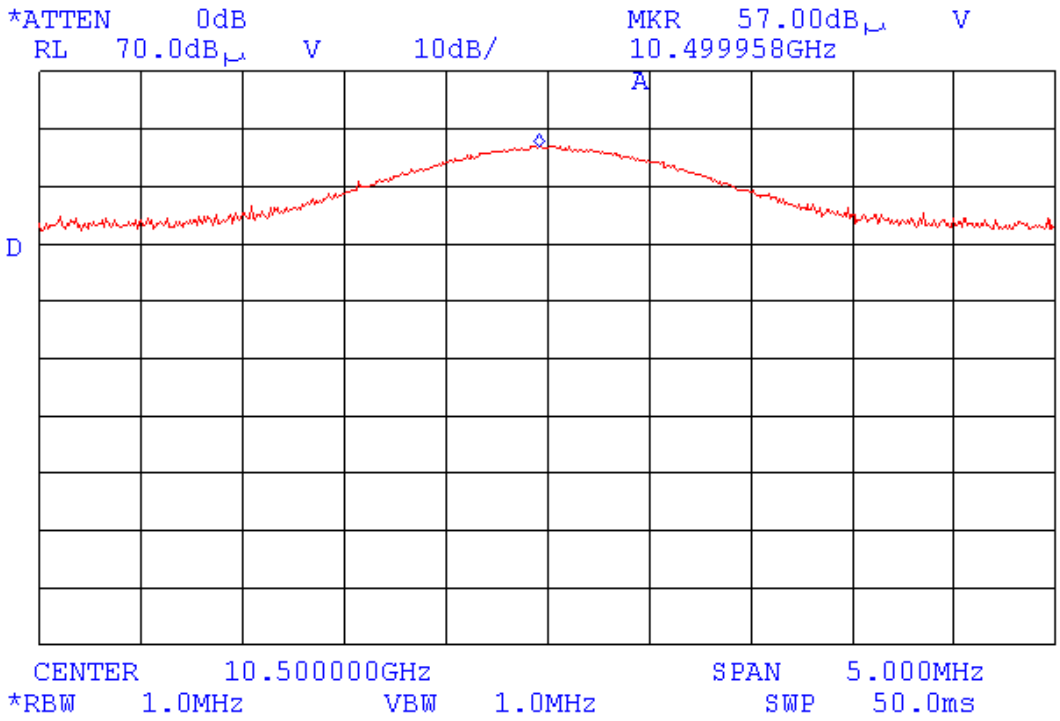
Notes to table calculations:
Antenna type: BL – biconilog, DRG – double ridged guide
Antenna polarization: H – horizontal, V – vertical
RBW = resolution bandwidth
Ant. Pol. = Antenna polarization (V-vertical, H-horizontal)
TT Pos. = turntable position in degrees, (EUT front panel = 0^o)
Margin = dB below (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



Vertical polarization
E=Usa+AF+CL-Ampl.gain-AF=52.8 dBuV+ 38.3 dB(1/m)+ 4.4 dB- 35 dB- 12.6 dB
E avr.= 43.9 dB(uV/m)
E peak.=56.5 dB(uV/m)

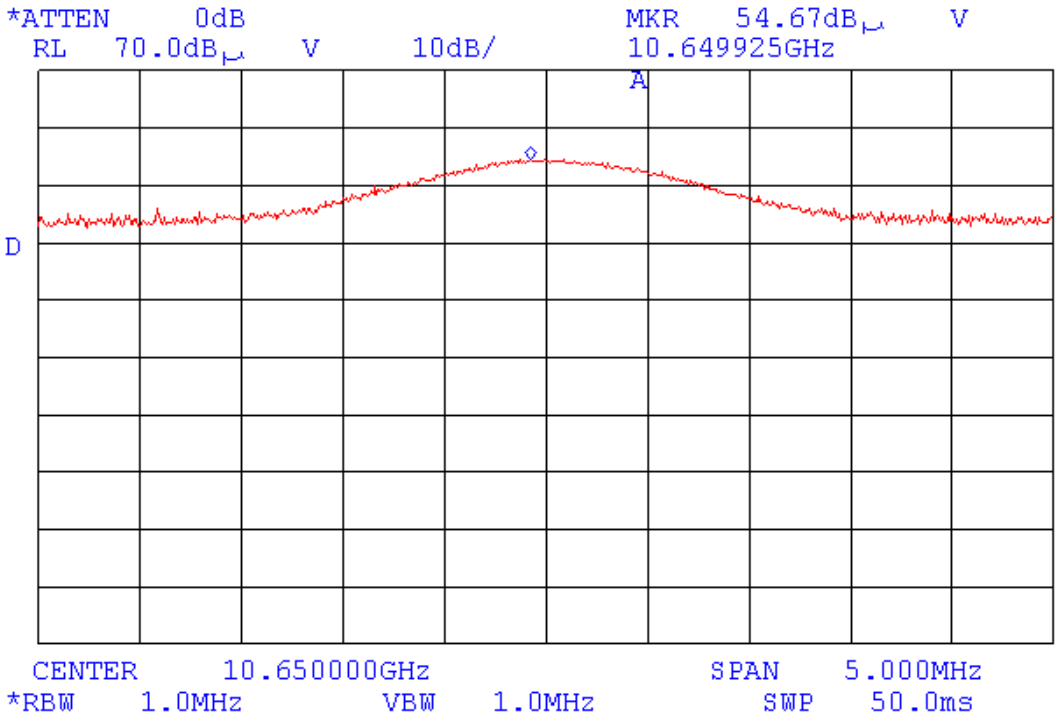
Plot 4.8.2
Test specification: §15.209
Radiated spurious emissions measurement in receive mode



Vertical polarization
E=Usa+AF+CL-Ampl.gain-AF=57.0 dBuV+ 38.5 dB(1/m)+ 4.4 dB- 35 dB- 12.6 dB
E avr.= 52.3 dB(uV/m)
E peak.=64.9 dB(uV/m)

Plot 4.8.3

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



Horizontal polarization
Usa+AF+CL-Ampl.gain-AF=54.7 dBuV+ 38.7 dB(1/m)+ 4.4 dB- 35 dB- 12.6 dB
E avr.= 50.2 dB(uV/m)
E peak.=62.8 dB(uV/m)

Figure 4.8.1
Radiated emission test setup

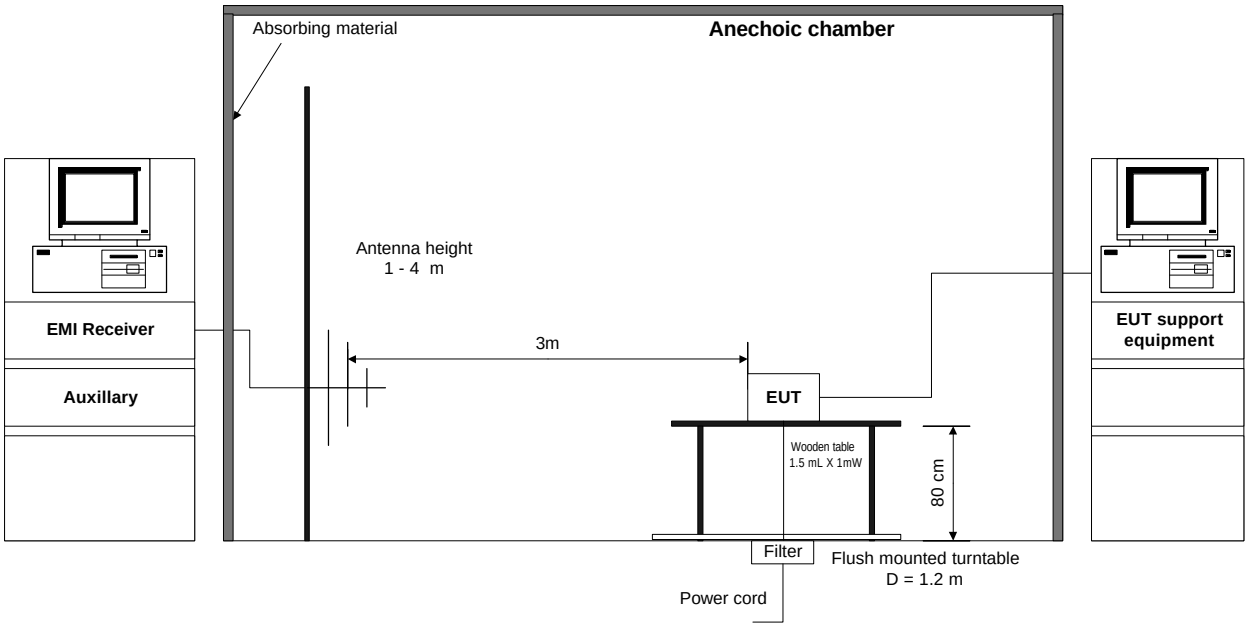
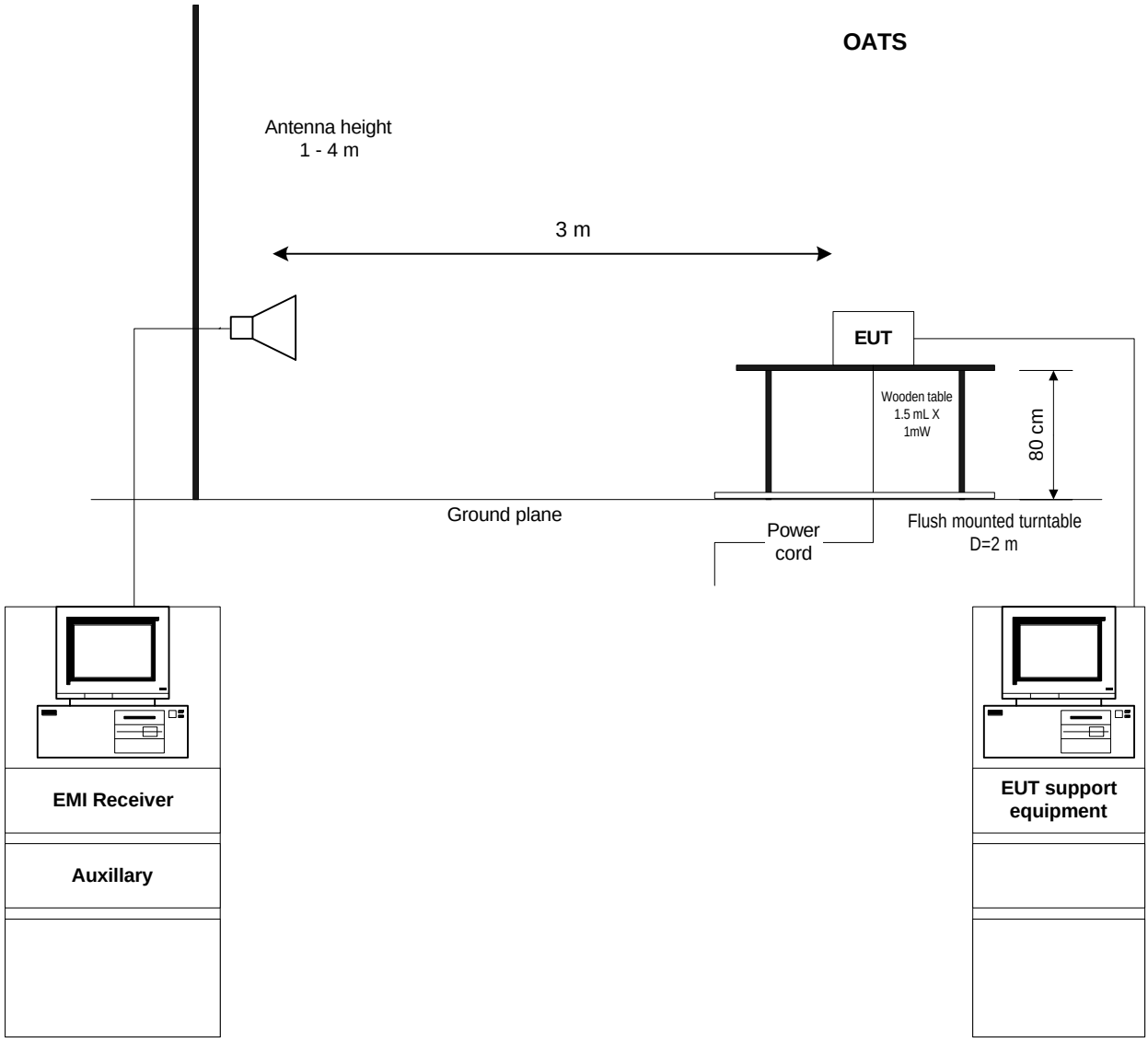
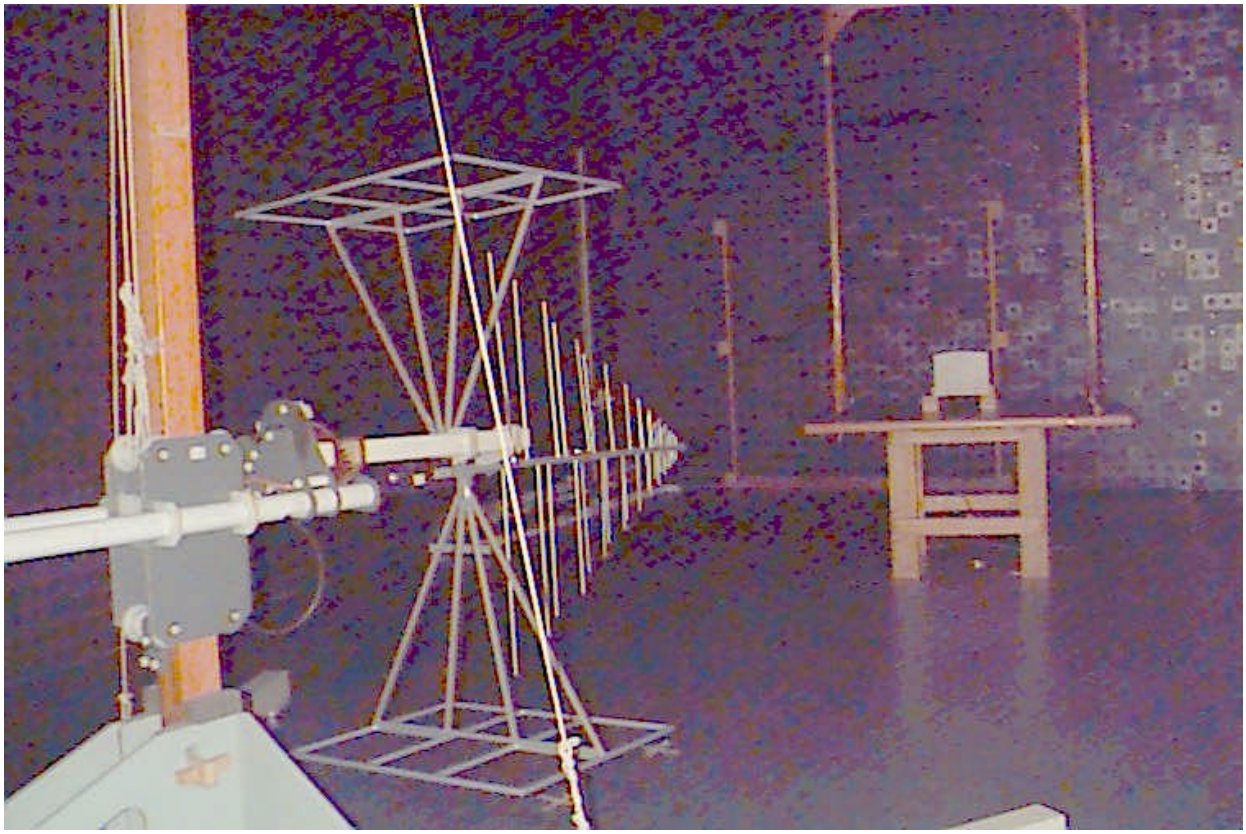


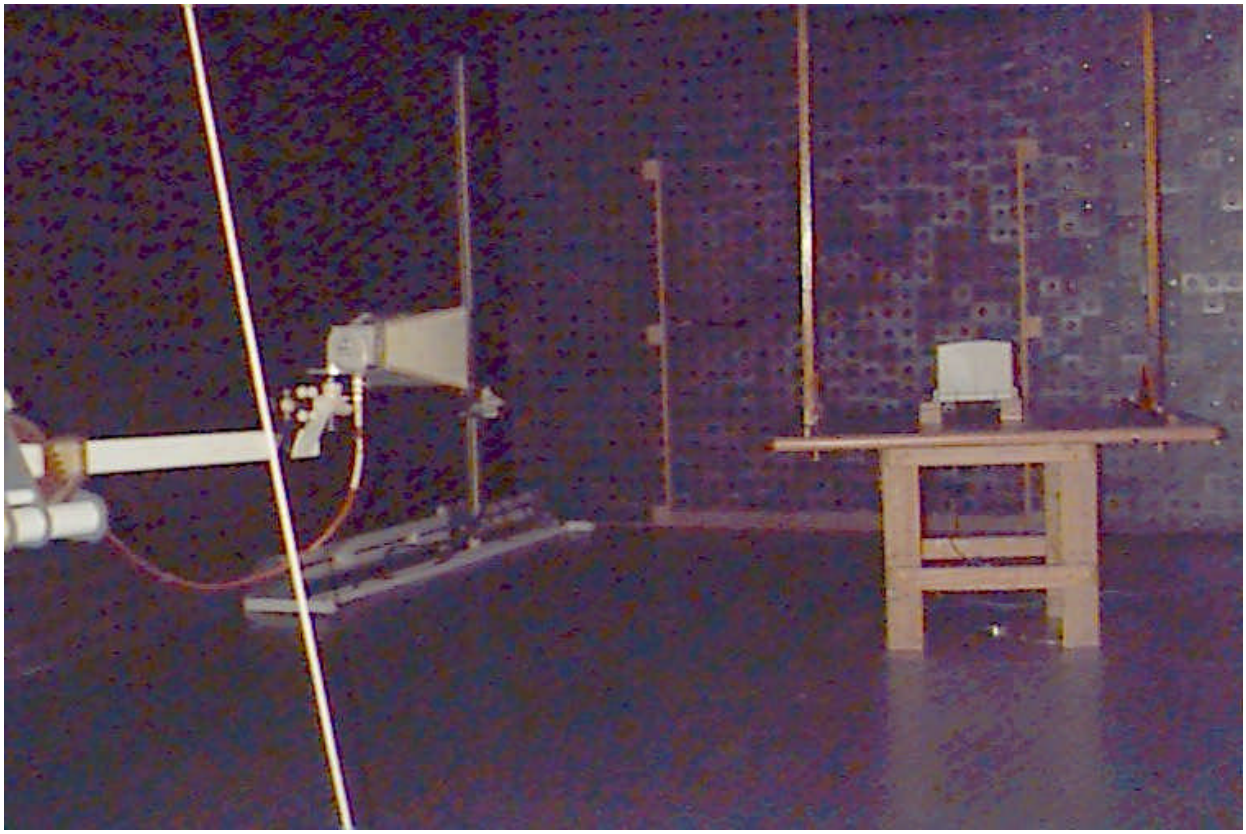
Figure 4.8.2
Radiated emission test setup



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

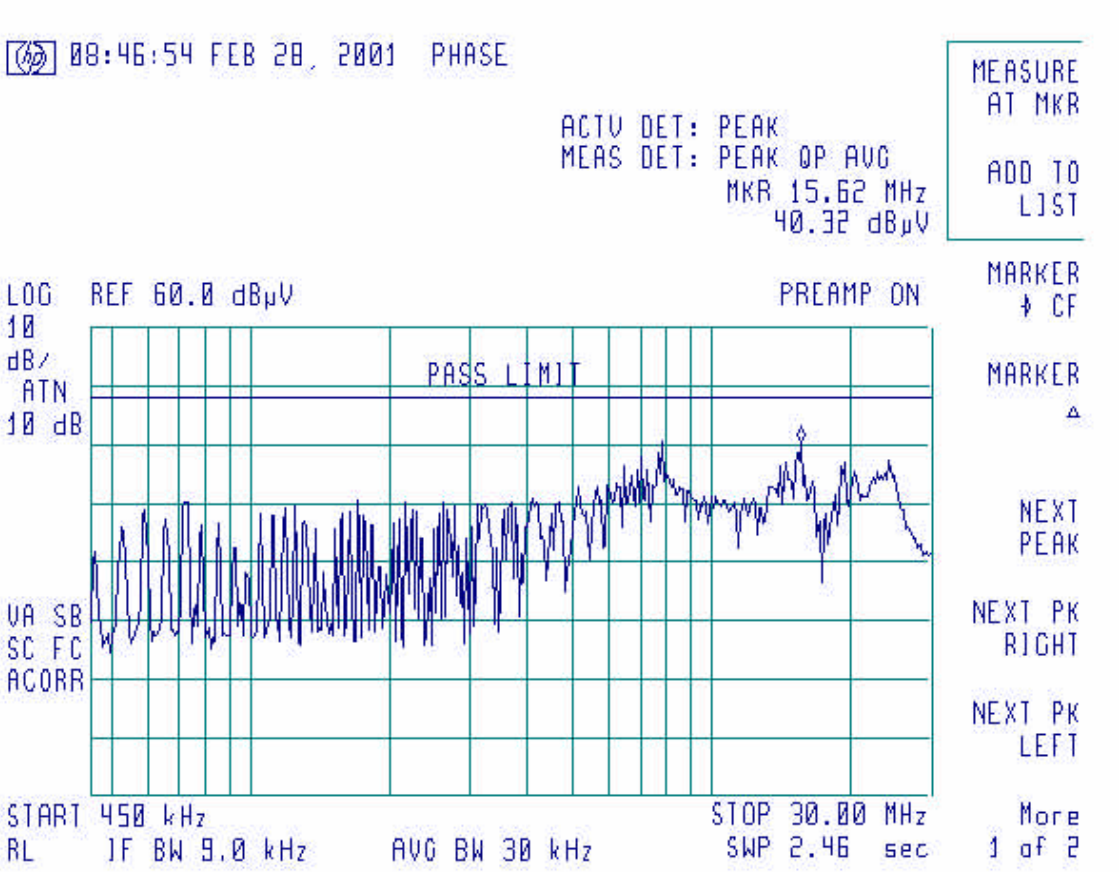
TEST SPECIFICATION: FCC, part 15, Class B
DATE: February 28, 2001
RELATIVE HUMIDITY: 52%
AMBIENT TEMPERATURE: 23°C
THE EUT WAS TESTED AS: TABLE-TOP EQUIPMENT
DETECTORS USED: QUASI-PEAK
FREQUECNY RANGE: 450 kHz – 30 MHz
RESOLUTION BANDWIDTH: 9 kHz

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
7.073	Ph	36.45	48	11.55	Pass
7.632	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
19.458	Ph	33.35	48	14.65	Pass
22.604	N	33.51	48	14.49	Pass
23.656	N	37.42	48	10.58	Pass
24.265	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

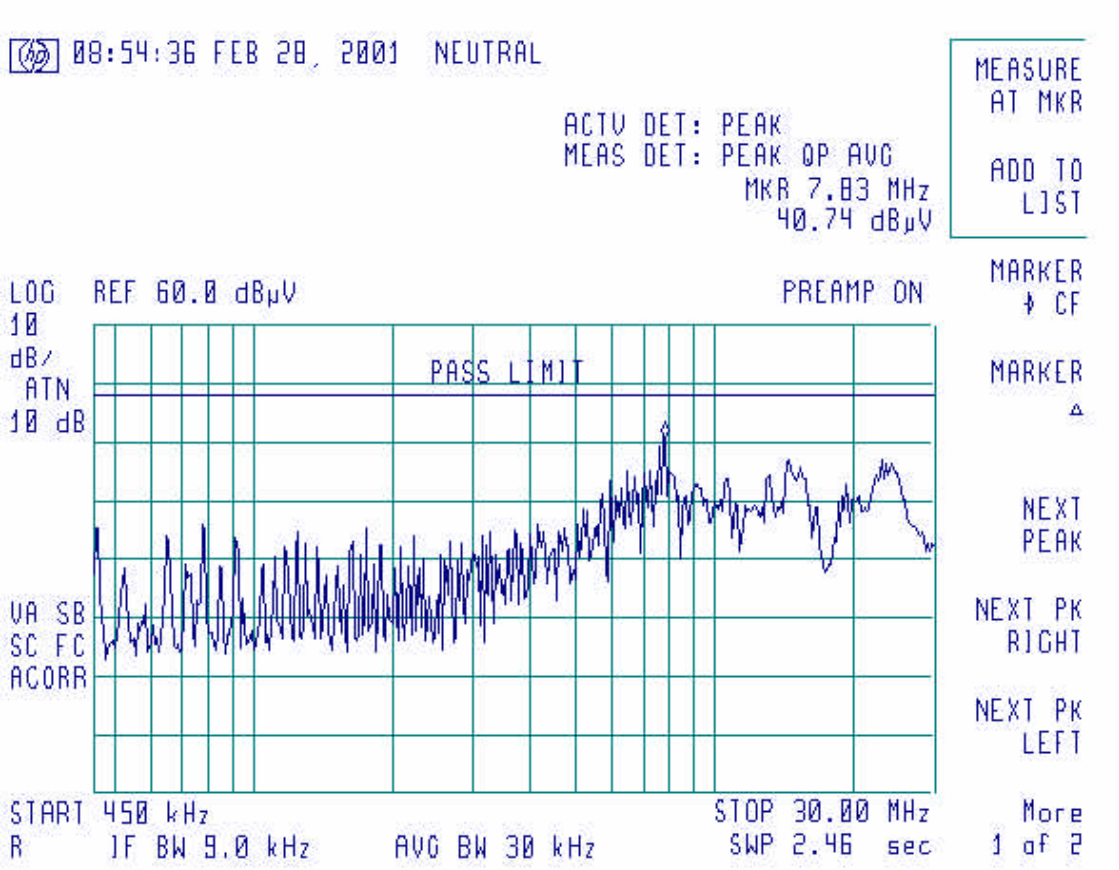
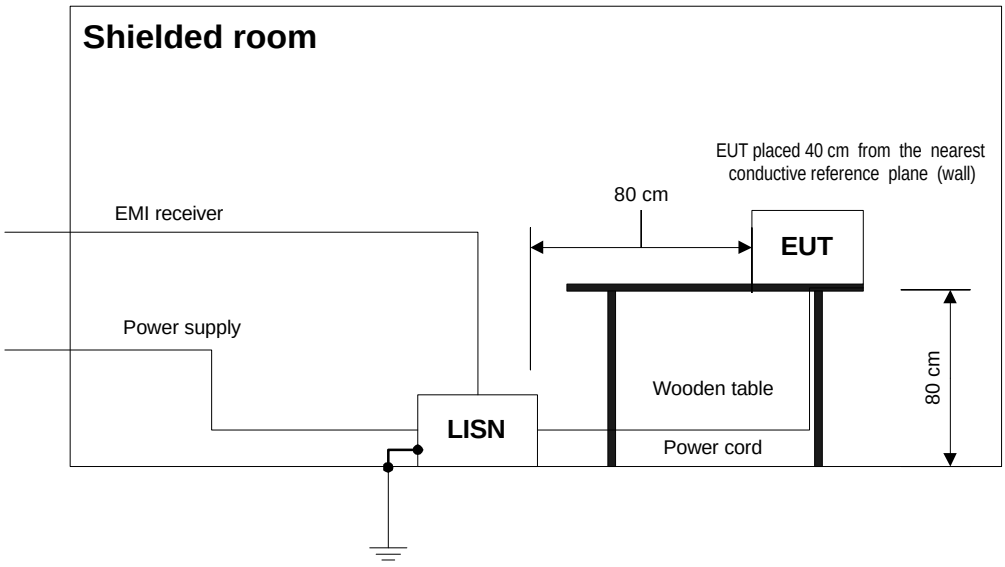
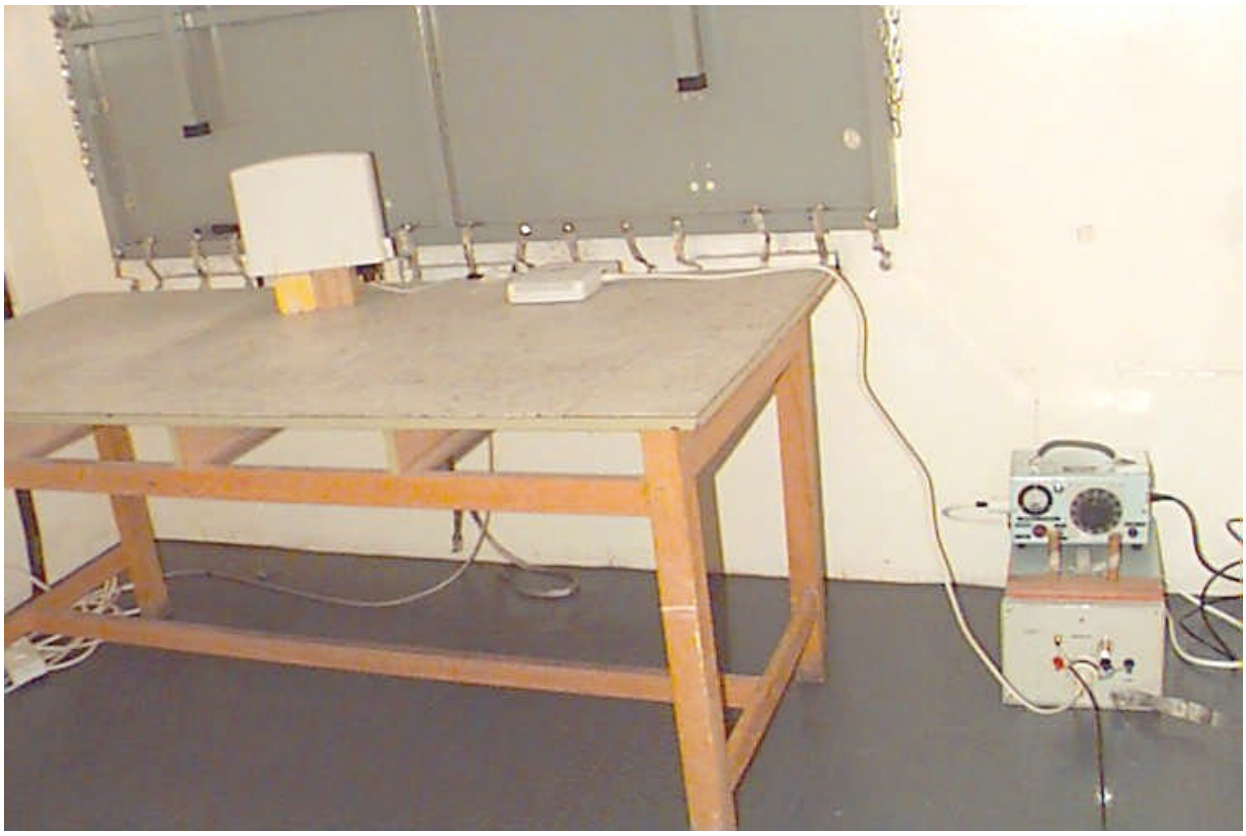


Figure 4.9.1
Conducted emissions test setup for table-top equipment



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).