APPENDIX A: MPE EVALUATION REPORT-FCC PART 1.1307, 1.1310, 2.1091, & 2.1093

Please see the report on the following pages.

Engineering and Testing for EMC and Safety Compliance

TEST REPORT

FOR EVALUATION OF MPE
FROM ACCESS POINT, MODEL AP1200

PREPARED ON BEHALF OF CISCO SYSTEMS, INC.

320 SPRINGSIDE DRIVE

AKRON, OH 44333

PHONE: 1-330-664-7362, FAX: 1-330-664-7301

CONTACT PERSON: JIM NICHOLSON

Reference Number: 2002115

June 25th, 2002

Testing Performed and a Test Report is Written by:	Galina G. Yushina
Testing Authorized by:	Desmond A. Fraser

360 Herndon Parkway, Suite 1400
Herndon, VA 20170
703 689-0368 FAX 703 689-2056

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360 Herndon PKWY
Suite 1400
Herndon, VA 20170
http://www.rheintech.com

FCC:	OET Bulletin 65, 47 CFR Part 1 and Part 2
Quote NO:	QRTL02- 461
Report NO:	2002115
Model NO:	AP1200
Customer:	Cisco Systems, Inc.

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1 GENERAL INFORMATION

1.1 SCOPE OF TESTING

During testing described in this test report Maximum Permissible Exposure (MPE)[1] characteristics of the Access Point transmitter model AP1200 were investigated. The tests were performed in accordance with the requirements of OET Bulletin 65: "Evaluating compliance with FCC-Specified guidelines for Human Exposure to Radio Frequency Radiation", Subpart I of Part 1 of the 47 CFR: " Procedures Implementing the National Environmental Policy Act of 1969", Subpart J of Part 2 of the 47 CFR: "Equipment Authorization Procedures", 47 CFR paragraph 1.1310: "Radiofrequency radiation exposure limits", 47 CFR paragraph 2.1091: "Radiofrequency radiation exposure evaluation: mobile and unlicensed devices" and Australia's Radiocommunication (Electromagnetic Radiation - Human Exposure Standard 1999), as well as AS/NZS 2772.1(Int.):1998—Radiofrequency fields Part 1: Maximum exposure levels - 3 kHz to 300 GHz.
Tests were performed by Rhein Tech Laboratories, Inc. (RTL), located at 360 Herndon Parkway, Suite 1400, Herndon, Virginia, 20170, USA. This facility is accepted by the National as well as International Regulatory Agencies as the facility, where measurement can be performed on a contractual basis. MPE measurements were conducted in the shielded semi-anechoic chamber with dimensions of 6 m by 4.2 m by 3 m (3 m - is the height of the chamber). The walls and the ceiling of this chamber are covered with the absorbing material.

1.2 RELATED SUBMITAL(S) / GRANTS

The related submittal/grant for the Equipment Under Test (hereafter referred as the EUT) is FCC application with FCC ID: LDK102045 currently at the Commission, and granted FCC application LDK102042 respectively.

1.3 TESTS METHODOLOGY

All tests were performed in accordance with the FCC requirements presented in the documents shown in sub-section 1.1 of this test report. Descriptions of the test setup, test performance and test results are given in Section 3, Section 4 and Section 5 of this test report correspondingly.
The instrumentation utilized for the measurements was timely calibrated by the calibration laboratories. This calibration was traceable to the National Institute of Standard and Technology (NIST). Calibrations due dates are shown in the Test Equipment List in Section 3.
Environment conditions of the test area were controlled. Temperature and relative humidity of the test area were measured with the Digital Hygro-Thermometer, SPER SCIENTIFIC, model 800041, showing maximum and minimum values of these parameters during time of testing. Atmospheric pressure was measured with the barometer manufactured by Infinity Instruments, model 2010B-MS. Information about environmental conditions during the test is given in subsection 4.3.

[1] By definition, maximum permissible exposure (MPE) is rms and peak electric and magnetic field strength, or the plane-wave equivalent power densities associated with these fields to which a person may be exposed without harmful effect and with an acceptable safety factor.

2 EQUIPMENT INFORMATION

2.1 EQUIPMENT SPECIFICATION RELATED TO THE TESTS

The EUT is a low power wireless transmitter / receiver, intended to be used in uncontrolled environment. Two ports are available for connection to the 2.4 GHz antennas. These ports (providing diversity transmitting and receiving) are intended for connection of antennas operating in the frequency band of 2.412 GHz to 2.462 GHz. To these ports any of the applicable certified antennas could be connected. The EUT was tested with two 2.2 dBi Dipole antennas model AIR-ANT-4941 (one was a receiving antenna and another was a transmitting antenna) and then also with the transmitting 13.5 dBi Yagi antenna model AIR-ANT-1949. The Integral antenna model AIR-RM20A-A-K9 transmitting in the frequency band of 5.15 GHz to 5.35 GHz is solidly attached to the EUT. The 2.2 dBi Dipole antennas are mounted directly to the EUT ports and they, as well as the integral antenna have two positions with respect to the top surface of the EUT: horizontal and vertical, referenced as H and V correspondingly in the report. The Yagi antenna is connected to the EUT with a RF cable of at least 1 meter long; this antenna is intended for wall-mounted installation.

When the EUT is connected to the Dipoles, it belongs to the mobile devices, with recommended distance of 20 cm between the device and the body of nearby person. When the EUT is connected to the Yagi antenna the last could be fixed-mounted indoor or outdoor. In the case when this antenna is used outdoor a separation distance of 2 m between a user and this antenna could be provided. But when the Yagi antenna is used indoor there is a possibility that a distance of 20 cm will be maintained between this antenna and the body of the nearby person. That's why during MPE measurements of the EUT with the Yagi antenna the worst case for the user was investigated – when a distance of 20 cm between the possible user and the Yagi antenna was maintained.

Any of two antennas intended for transmission in the different frequency range could transmit separately as well as simultaneously. Based on the manufacturer specification shown in Cisco Aironet 1200 Series Access Point Hardware Installation Guide, the EUT could be installed by a user in any of the following positions: in a desktop position, in a wall-mounted position and in a ceiling-mounted position. All applicable options for the antennas and the EUT were investigated during the MPE measurements.

2.2 JUSTIFIICATIONS

2.2.1 JUSTIFICATION CONCERNING THE TESTED POSITIONS

The EUT was tested in two positions: in a desktop position and in a wall-mounted position. Investigation of the ceiling mounded position was not performed, as the final MPE measurements were conducted with respect to the height from the EUT, and the MPE test data above the EUT set in the desktop positions are similar to the data under the EUT for the ceiling-mounted position. Details of the test setup are given in Section 3 of this test report.

2.2.2 JUSTIFICATION CONCERNING ANTENNAS OF THIS APPLICATION

MPE investigations were performed on the EUT connected either to the highest 2.4 GHz gain antenna described in the FCC ID LDK102042 report and approved by the Commissions or to the

newly added by the manufacturer and described in Section 2.1 - 2.2 dBi Dipole antenna. Table 2.2.1 of this report shows types of all approved antennas of the FCC LDK102042 report as well as the 2.2 dBi Dipole together with environment of their intended use, with the antenna gains and the EIRP[2] values. Since the maximum EIRP for any antenna type yields the highest MPE value, the following justification was made:
If the EUT with the antennas tested for MPE complies with the MPE FCC limit it shall comply with the MPE FCC limit being connected to any of all other antennas listed in Table 2.2.1 and referred to as the antenna of this application.

TABLE 2.2.1: LIST OF THE ANTENNAS APPLICABLE FOR CONNECTION TO THE EUT.

Antenna type	EIRP, dBm	Antenna Gain, dBi	Environment
AIR-ANT 1949	30.1	13.5	Outdoors
AIR-ANT 4121	24.2	12.0	Outdoors
AIR-ANT 2506	20.4	5.1	Outdoors
AIR-ANT 3549	23.1	8.5	Indoors/ Outdoors
AIR-ANT 2012	23.9	6.5	Indoors/ Outdoors
AIR-ANT1729	23.2	6.0	Indoors/ Outdoors
AIR-ANT 3213	20.7	5.0	Indoors/ Outdoors
AIR-ANT 1728	20.7	5.0	Indoors/ Outdoors
AIR-ANT 5959	17.4	2.0	Indoors/ Outdoors
AIR-ANT-4941	20.5	2.2	Indoors/ Outdoors

2.3 MODIFICATIONS

No modifications were made during testing of the EUT.

2.4 EXERSICING THE EUT

The EUT was supplied with the software used to set either one of the WLAN or U-NII radio or the two radios in continuous transmitting mode at any one of the chosen channel or at two channels (one – from the low frequency band and another – in from the high frequency band). This gave possibility to set the EUT at any regime required for investigation.

2.5 A CHOICE OF CHANNELS FOR MPE MEASUREMENTS

To eliminate a set of MPE measurements, a choice of the channels for the MPE investigations was based on the investigations of EIRP. EIRP test results from the FCC test reports referenced to in section 1.2 showed the channels with the highest transmitting power for the investigated antennas, which were chosen for the MPE investigations. The EIRP results, having the accuracy of ± 0.5 dB for the 2.2 dBi Dipole antenna and the Integral antenna and ± 1.5 dB for the Yagi antenna, are shown in Table 2.5.1 through Table 2.5.3 of this test report. They demonstrate that the highest level of EIRP is transmitted by channel 11 when the 2.2 dBi Dipole antenna is used, by channel 6 when the 13.5 dBi Yagi antenna is used; channels 36 and 52 in the high frequency band have approximately the same level of EIRP. For the MPE measurements channels 11, 6 and 52 were

[2] EIRP is a term for expression of the performance of an antenna in a given direction relative to the performance of a theoretical (isotropic) antenna.

chosen for the 2.2 dBi Dipole antenna, Yagi antenna and the Integral antenna correspondingly. It shall be noted that the Integral antenna consists of two dipole antennas and two patch antennas. Therefore there are two columns with the EIRP in the Table 2.5.2.

TABLE 2.5.1: RESULTS OF EIRP MEASUREMENTS FOR THE 2.2 DBI DIPOLE ANTENNAANTENNA

Channel number	Frequency, GHz	EIRP, dBm
1	2.412	15.0
6	2.437	20.3
11	2.4 62	20.5

TABLE 2.5.2: RESULTS OF EIRP MEASUREMENTS FOR THE INTEGRAL ANTENNA

Channel number	Frequency, GHz	EIRP for the dipole antenna of the integral antenna, dBm	EIRP for the patch antenna of the integral antenna, dBm
36	5.15	19.6	18.7
52	5.25	19.5	18.7
64	5.35	19.0	18.2

TABLE 2.5.3: RESULTS OF EIRP MEASUREMENTS FOR THE YAGI ANTENNA

Channel number	Frequency, GHz	EIRP, dBm
1	2.412	27.5
6	2.437	30.1
11	2.4 62	29.0

3 TEST CONFIGURATION

3.1 TEST SETUP DIAGRAM

Test setup diagrams for the desktop and wall-mounted positions of the EUT with the 2.2 dBi Dipole antennas are shown in Figure 3.1.1 and Figure 3.1.2 correspondingly. Test setup diagram for the EUT with the Yagi antenna is shown in Figure 3.1.3. In all test setups the EUT was connected to the adjustable wooden stand. This stand was installed in the center of the rotated wooden platform and it was solidly connected to this platform when the test setups shown in Figure 3.1.1 or 3.1.2 were investigated. When the Yagi antenna was investigated the stand with the Yagi antenna was installed in the center of the rotated platform, and the stand with the EUT was close to the center of this platform. There was one more accessory wooden stand in the chamber, 90 cm in height, placed on the floor, where a laptop computer running the EUT software was placed. The probe sensitive to radiation was connected to the radiation meter installed on the mast made of plastic. There was a possibility to choose the height of any stand (or mast) as well as the angle (azimuth) and a distance between the EUT (or the Yagi antenna) and the test probe. The stands height were chosen such that during the tests the EUT and the Yagi antenna were located between the grounded ceiling and the floor covered with the ground plane. In the desktop position of Figure 3.1.1 the bottom of the EUT was 85 cm above the wooden platform; in the wall-mounted position shown in Figure 3.1.2 the middle point of the EUT surface was 110 cm from the platform. The

platform itself was 35 cm from the floor of the chamber. Distance of the stand from the wall was more than 1.5 m. In the test setup with the Yagi antenna shown in Figure 3.1.3 this antenna was at the height of 120 cm from the rotating platform. The distance between the Yagi antenna and the EUT was 75 cm during investigation of the Yagi antenna pattern, and distance of 20 cm between the Yagi antenna and the EUT was maintained during investigation of co-location of antennas.

FIGURE 3.1.1: TEST SETUP DIAGRAM FOR THE DESKTOP POSITION OF THE EUT WITH THE 2.2 DBI DIPOLE ANTENNA

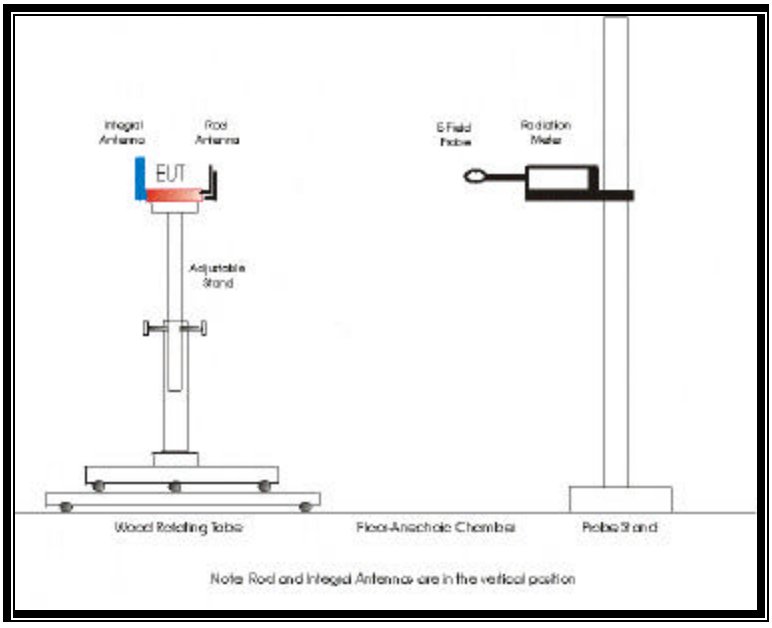


FIGURE 3.1.2: TEST SETUP DIAGRAM FOR THE WALL-MOUNTED POSITION OF THE EUT WITH THE 2.2 DBI DIPOLE ANTENNA

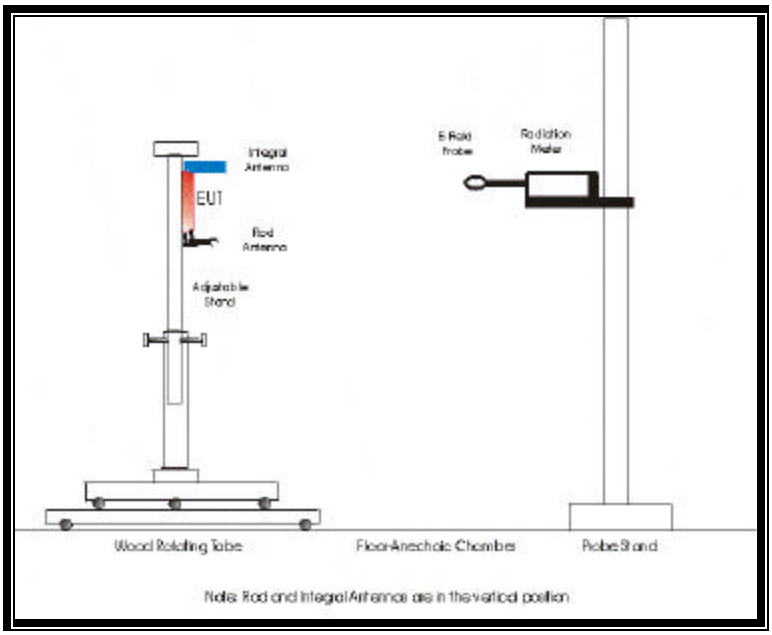
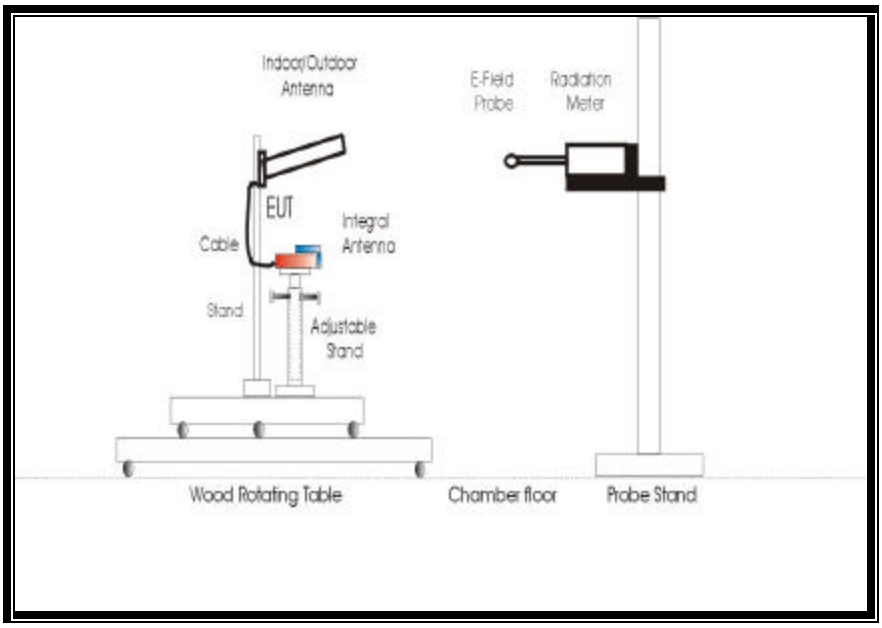


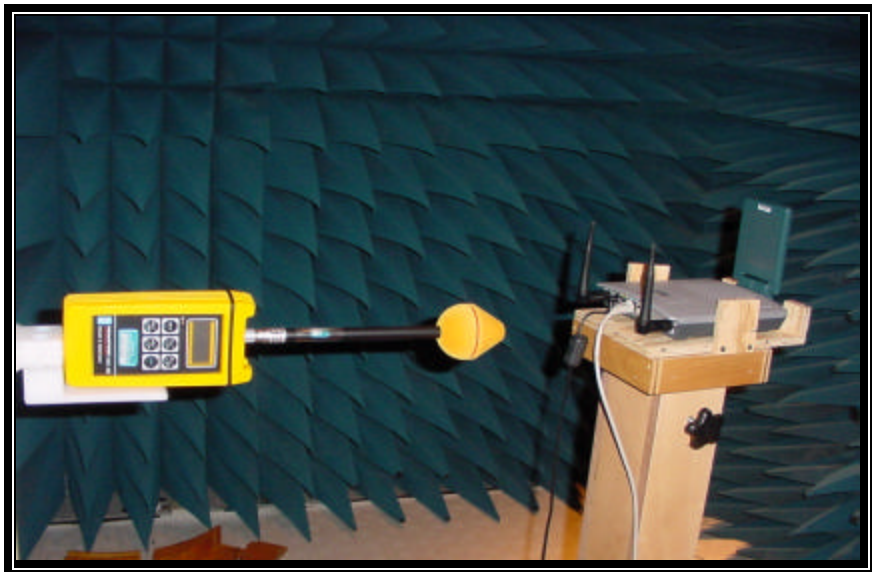
FIGURE 3.1.3: TEST SETUP DIAGRAM FOR THE DESKTOP POSITION OF THE EUT WITH THE YAGI ANTENNA



3.2 TEST SETUP PHOTOGRAPHS

Photographs 3.2.1 through 3.2.3 show important parts of the test setup as well as absorbing cover of the walls in the semi-anechoic chamber[3].

PHOTOGRAPH 3.2.1: DESKTOP EUT WITH THE 2.2 DBI DIPOLE ANTENNA, ANTENNAS ARE IN THE VERTICAL POSITIONS



[3] During testing test equipment was at bigger distance from the walls of the chamber, than it is shown in the photographs

PHOTOGRAPH 3.2.2: WALL-MOUNTED EUT WITH THE 2.2 DBI DIPOLE ANTENNAS; ALL ANTENNAS ARE IN THE HORIZONTAL POSITION

PHOTOGRAPH 3.2.3: TEST SETUP WITH THE YAGI ANTENNA

3.3 TEST EQUIPMENT

Test Equipment used for the MPE measurements is shown in Table 3.3.1.

TABLE 3.3.1: TEST EQUIPMENT LIST

RTL BARCODE	MANUFACTURER	MODEL	EQUIPMENT TYPE	SERIAL NUMBER	CALIBRATION DUE DATE
901177	Wandel & Goltermann	TYPE-9	E-Field Probe, 10 MHz to 18GHz	N-0050	05/16/2003
901182	Wandel & Goltermann	TYPE-8	E- Field Probe, 10 kHz to 3 GHz	AH-0021	05/16/2003
901183	Wandel & Goltermann	EMR 200	Radiation Meter	AE-0024	05/16/2003
901020	Hewlett Packard	8564E	Portable Spectrum Analyzer (9 kHz - 40 GHz)	3943A01719	07/07/2002
901262	ETS	3115	Double Ridged Guide Horn Antenna (1-18 GHz)	6748	02/04/2003

MPE measurements were made with the electric strength field / power density monitor, represented by the filed sensor/ probe and the radiation meter. The radiation meter shows radiation as the filed strength and as the power density, it may show the result of maximum radiation averaged during certain time or the average value averaged during the same time. Conversion of the field strength into a power density in this device is based on the far-field approximation. A spectrum analyzer connected to the horn antenna was used for verification of the transmitting frequency / frequencies during the tests.

4 MPE TEST DESCRIPTION AND LIMITS

4.1 MPE LIMITS

The FCC-adopted limits for MPE are based on the recommended exposure guidelines published by the National Council on Radiation Protection and Measurements in “Biological Effects and Exposure Criteria for Radiofrequency Electromagnetic Fields”. Based on these recommendations MPE limits depend on the investigated frequency range and on intended use of the tested device, such as occupational / controlled environment or general population / uncontrolled environment. The environment of intended use influences the measurement averaging time. MPE limits and averaging time for occupational MPE and for general population MPE are shown in Table 4.1.1 and Table 4.1.2 correspondingly.

TABLE 4.1.1: LIMITS FOR MPE DATA FOR OCUPATIONAL / CONTROLLED EXPOSURE

Frequency Range, MHz	Electric Field Strength (E), V/m	Magnetic Field Strength (H), A/m	Power Density (S)[4], mW/cm²	Averaging Time for ½E½², ½H½² or S, min
0.3-3.0	614	1.63	(100)	6
3.0-30	1842/f	4.89/f	(900/f²)	6
30-300	61.4	0.163	1.0	6
300-1500	-	-	f/300	6
1500-100,000	-	-	5	6

TABLE 4.1.2: LIMITS FOR MPE DATA FOR GENERAL POPULATION / UNCONTROLLED EXPOSURE

Frequency Range, MHz	Electric Field Strength (E), V/m	Magnetic Field Strength (H), A/m	Power Density (S), mW/cm²	Averaging Time for ½E½², ½H½² or S, min
0.3-3.0	614	1.63	(100)	30
3.0-30	824/f	2.19/f	(180/f²)	30
30-300	27.5	0.073	0.2	30
300-1500	-	-	f/1500	30
1500-100,000	-	-	1.0	30

The FCC accepts the distance of 20cm[5] as the minimum separation distance where reliable field measurements to determine adherence to MPE limits can be made.
As it is written in Section 2, the EUT belongs to the mobile devices used by general population. Based on the transmitted frequencies, applicable limit for power density shall be 1.0 mW/cm², which is the equivalent to the electric strength limit of 61.4 V/m. Averaging time for MPE measurements shall be 30 min.

4.2 DESCRIPTION OF THE MPE TEST PERFORMED FOR THE EUT CONNECTED TO THE 2.2 DBI DIPOLE ANTENNA

For the frequencies transmitted by the EUT the 20-cm distance from the EUT is the far-field distance when the 2.2 dBi Dipole antenna and the integral antennas are used. In the far-field region both field strength or power density measurements are applicable, and in most case power density measurements were made when the EUT was connected to the 2.2 dBi Dipole antenna.

For each position of the EUT (desktop or wall-mounted) and for each position of its antennas the test was conducted as the three-part test performed in the following sequence:

- First of all preliminary investigation was conducted, such as MPE measurements at the fixed 20 cm distance between the probe and the reference / zero point[6] of the investigated antenna versus azimuth. Averaging time in these measurements was 6 min. As the results of the measurements the angle corresponding to the highest directivity of the

4The values for power density in the near field of a transmitting antenna in the frequency range of 0.3 MHz to 30 MHz are given for reference purposes. They were calculated as if the region was the far field region

[5] Differentiation between mobile and portable devices is based on 20-cm distance: For "mobile" devices this is the distance, that is maintained between the body of a user or nearby person and the radiating structure. "Portable" devices can be used such that any part of radiating structure could be in direct contact with the body of the user or within 20 cm of the body of the user. For portable devices MPE measurements are not applicable.

[6] The reference point for the 2.2 dBi Dipole antenna was its bending point, the reference point for the integral antenna was the middle point of its bending line.

antenna was established; and this position of the EUT was chosen as the basic position for the second and third parts of the measurements.

- In the second part of investigation MPE measurements were conducted versus height. The basic position for these measurements for the EUT and the probe was established during preliminary measurements (see above). The MPE test data were taken above and below the reference / zero point of the transmitting antenna in the vertical plane having distance from the reference point of 20 cm and the height of 2 meters. Measurements were taken at every 10 cm along this height; averaging time for the measurements was set to 30 min.
- In the third part of the test investigation of influence of co-location of another antenna was made. The EUT and the probe were set in the same reference position as in the second part of the test. Both antennas were set to transmit simultaneously. MPE measurements were made versus height at a few points below and above the zero point at averaging time of 30 min. These test data were compared with the data received in the second part of the test to make a conclusion about influence of co-location.

4.3 DESCRIPTION OF THE MPE TEST PERFORMED FOR THE EUT CONNECTED TO THE YAGI ANTENNA.

The highest dimension of the Yagi antenna is 44.5 cm, and the FCC "safe" distance of 20 cm is the near-filed distance for the radiated frequency of 2.437 GHz. Therefore measurements of radiation from this antenna at the 20-cm distance between the probe and the antenna were conducted as electric field strength measurements. The same three-part test as described above in subsection 4.2 was conducted for the EUT connected to this antenna.

4.4 ENVIRONMENT CONDITIONS DURING MPE TESTS

Ambient conditions during MPE testing were as the following: temperature varied from 25 to 27 ^{0}C, relative humidity from 30 to 40 %, and atmospheric pressure from 90 kPa to 100 kPa. These conditions were in line with environmental conditions specified by the manufacturer.

5 MPE MEASUREMENT RESULTS

5.1 INVESTIGATION OF INFLUENCE THE POSITION OF THE NON-TRANSMITTING ANTENNA TO THE MPE RESULTS FOR THE EUT CONNECTED TO THE 2.2 DBI DIPOLE ANTENNA

Investigation of influence the position of the non-transmitting antenna to the MPE created by the transmitting antenna was made in the beginning of the tests. This investigation showed that position of a non-transmitting antenna could influence the MPE produced by a transmitting antenna, but this influence was within the limits of error of measurements equal to $\pm$ 10%. Nevertheless in the most of the test results described in this test report we showed position of a non-transmitting antenna.

5.2 MPE TEST RESULTS FOR THE DESKTOP POSITION OF THE EUT CONNECTED TO THE 2.2 DBI DIPOLE ANTENNA

5.2.1 2.2 DBI DIPOLE ANTENNA PATTERN FOR THE DESKTOP POSITION OF THE EUT

Directivity of 2.2 dBi Dipole antenna radiation was investigated for both positions of the 2.2 dBi Dipole antenna with the integral antenna in the horizontal position. In these measurements zero angle between the 2.2 dBi Dipole antenna and the probe corresponded to the position of the probe in front of the EUT and directly in front of the transmitting antenna. During the rotation of the test desk from 0^0 to 180^0 (this was the so-called "positive" angle rotation) the EUT with the respect to the probe was moved such that at the few first set of angles the receiving antenna "moved" to the probe and then was moved from the probe. During the "negative" angle rotation (from 0^0 to -170^0) the receiving antenna first moved from the probe. The test results are shown in Table 5.2.1.1. The main part of these measurements was conducted at the distance of 20 cm between the probe and the reference point of the 2.2 dBi Dipole antenna. But it was impossible to keep this distance for the angle range of 120^0 to 200^0, when the probe was directed to the back part of the EUT. This impossibility was connected with the use of the wood fixture having thickness of 1 cm, and proximity of the EUT, providing distance up to 23 cm between the reference point and certain points of the back of the EUT. Therefore for the angles between the probe and the 2.2 dBi Dipole antenna in the range of 120^0 to 200^0 a real distance between the probe and the antenna was different. It is shown in the column for the notes in the Table 5.2.1. It was also found that close proximity of the EUT and the wooden fixture to the probe influences the results. Therefore we made the calculations shown in Table 5.2.2, where the results for the 20-cm distance were based on the results of measurements made at 40 cm from the reference point. At some positions these data do not correlate with the results of measurements shown in Table 5.2.1.

TABLE 5.2.1: DESKTOP POSITION. MPE DATA VERSUS AZIMUTH WITH THE 2.2 DBI DIPOLE ANTENNA TRANSMITTING

Angle, degree	MPE, mW/cm²		
	2.2 dBi Dipole antenna V transmits, Integral H does not transmit	2.2 dBi Dipole antenna H transmits, Integral H does not transmit	Notes
180	0.0155	0.0100	A probe was 1 cm from the wooden fixture, a distance between the probe and the reference point was 24 cm
170	0.0175	0.0145	A probe was 0.5 cm from the wooden fixture, a distance between the probe and the reference point was 24 cm
160	0.0179	0.0143	A probe was 1 cm from the wooden fixture, a distance between the probe and the reference point was 24 cm
150	0.0067	0.0125	A probe was 0.8 cm from the wooden fixture, a distance between the probe and the reference point was 25.5 cm
140	0.0158	0.0040	A distance between the probe and the reference point is 25 cm
130	0.0125	0.0025	A distance between the probe and the reference point is 23 cm
120	0.0120	0.0012	A distance between the probe and the reference point is 21 cm
110	0.0110	0.0016	
100	0.0109	0.0025	
90	0.0100	0.0035	
80	0.0079	0.0063	
70	0.0090	0.0072	
60	0.0116	0.0082	
50	0.0144	0.0087	
40	0.0151	0.0086	
30	0.0119	0.0047	
20	0.0093	0.0056	
10	0.0078	0.0037	
0 (360)	0.0107	0.0020	
350 (-10)	0.0091	0.0023	
340 (-20)	0.0108	0.0019	
330 (-30)	0.0109	0.0038	
320 (-40)	0.0111	0.0078	
310 (-50)	0.0109	0.0073	
300 (-60)	0.0111	0.0129	
290 (-70)	0.0108	0.0132	
280 (-80)	0.0106	0.0118	
270 (-90)	0.0093	0.0119	
260 (-100)	0.0133	0.0072	
250 (-110)	0.0132	0.0044	
240 (-120)	0.0124	0.0028	
230 (-130)	0.0115	0.0028	
220 (-140)	0.0135	0.0032	
210 (-150)	0.0166	0.0044	
200 (-160)	0.0210	0.0200	A distance between the probe and the reference point is 20 cm, but the probe almost touches the fixture
190 (-170)	0.0148	0.0116	A probe was 1 cm from the wooden fixture, a distance between the probe and the reference point was 24 cm

TABLE 5.2.2: DESKTOP POSITION. CALCULATED MPE RESULTS

Angle, degree	Calculated MPE results for the 2.2 dBi Dipole antenna, mW/cm^2		
	2.2 dBi Dipole antenna V transmits,	2.2 dBi Dipole antenna H transmits,	Notes
150	0.0192	0.0172	Based on the test results for the distance of 40 cm between the probe and the reference point
160	0.0216	0.0216	Based on the test results for the distance of 40 cm between the probe and the reference point
170	0.0180	0.0130	Based on the test results for the distance of 40 cm between the probe and the reference point
180	0.0240	0.0065	Based on the test results for the distance of 40 cm between the probe and the reference point
190	0.0180	0.0100	Based on the test results for the distance of 40 cm between the probe and the reference point
200	0.0166	0.0110	Based on the test results for the distance of 40 cm between the probe and the reference point
360	0.0110	0.0020	Based on the test results for the distance of 40 cm between the probe and the reference point

5.2.2 DESKTOP POSITION. MPE FOR THE TRANSMITTING 2.2 DBI DIPOLE ANTENNA. INVESTIGATING OF CO-LOCATION OF THE INTEGRAL ANTENNA.

Based on the results shown in 5.2.1 a decision was made to conduct final measurements at the angles with the highest MPE at the distance of 20 cm between the probe and the reference point when the probe was not too close to the EUT, and also for the angles where the probe almost touched the fixture. Therefore MPE measurements versus height for the 2.2 dBi Dipole antenna V were conducted at two azimuth angles of 40^0 and at 200^0 and the MPE measurements for the 2.2 dBi Dipole antenna H versus height were conducted at 290^0 and at 200^0. For both antenna positions investigation of co-location was made at the position of the EUT corresponding to 200^0. Measurement results are shown in Table 5.2.3 through Table 5.2.5.

TABLE 5.2.3: DESKTOP POSITION. MPE VERSUS HEIGHT FOR THE TRANSMITTING 2.2 DBI DIPOLE ANTENNA V/H

Height, cm	MPE, mW/cm^2	
	2.2 dBi Dipole antenna V transmits, Integral H does not radiate. The angle between the 2.2 dBi Dipole antenna and the probe is 40^0.	2.2 dBi Dipole antenna H transmits, Integral H does not radiate. The angle between the 2.2 dBi Dipole antenna and the probe is 290^0.
100	0.0001	0.0008
90	0.0002	0.0010
80	0.0003	0.0014
70	0.0005	0.0018
60	0.0007	0.0022
50	0.0010	0.0028
40	0.0019	0.0038
30	0.0040	0.0054
20	0.0090	0.0086
10	0.0125	0.0129
0	0.0166	0.0125
-10	0.0055	0.0087
-20	0.0023	0.0072
-30	0.0010	0.0050
-40	0.0007	0.0043
-50	0.0005	0.0033
-60	0.0004	0.0020
-70	0.0002	0.0007
-80[1]	0.0002	0.0003

TABLE 5.2.4: DESKTOP POSITION. MPE VERSUS HEIGHT AND INFLUENCE OF CO-LOCATION TO RADIATING 2.2 DBI DIPOLE V

Height, cm	MPE[7], mW/cm^2				
	2.2 dBi Dipole V transmits. Integral H does not radiate. The angle between the 2.2 dBi Dipole and the probe is 200.	2.2 dBi Dipole V + Integral V	2.2 dBi Dipole V + Integral H	Only Integral V radiates	Only Integral H radiates
100	0.0001				
90	0.0001				
80	0.0001				
70	0.0002				
60	0.0005				
50	0.0012				
40	0.0020				
30	0.0043				
20	0.0082	0.0090	0.0100	0.0001	0.0024
10	0.0200	0.0200	0.0245	0.0005	0.0055
0	0.0210	0.0200	0.0248	0.0006	0.0040
-10	0.0020*	0.0022	0.0025	0.0001	0.0006
-20	0.0006*				
-30	0.0006*				
-40	0.0003*				
-50	0.0002*				
-60	0.0001*				
-70	0.0001*				
-80	0.0001*				

TABLE 5.2.5 DESKTOP POSITION. MPE VERSUS HEIGHT AND INFLUENCE OF CO-LOCATION TO RADIATING 2.2 DBI DIPOLE H.

Height, cm	MPE, mW/cm^2				
	2.2 dBi Dipole H transmits. Integral H does not radiate. The angle between the 2.2 dBi Dipole and the probe is 200.	2.2 dBi Dipole H + Integral V	2.2 dBi Dipole H + Integral H	Only Integral V radiates	Only Integral H radiates
100	0.0007				
90	0.0008				
80	0.0009				
70	0.0010				
60	0.0007				
50	0.0008				
40	0.0011				
30	0.0010				
20	0.0021	0.0019	0.0040	0.0001	0.0024
10	0.0043	0.0043	0.0090	0.0003	0.0050
0	0.0200[2]	0.0190	0.0230	0.0001	0.0040
-10	0.0033	0.0028	0.0029	0.0001	0.0005
-20	0.0012				
-30	0.0006				
-40	0.0003				
-50	0.0002				
-60	0.0001				
-70	0.0001				
-80[1]	0.0001				

[7] The values marked with the star are the results of the test setup, when the probe was directed to the wooden stand. In reality these values could be higher, but based on the results for the heights above the EUT they should be significantly below the limits.

NOTE 1: At the height of –80 cm the bottom part of the probe was 6 cm from the upper part of the rotating desk. Therefore measurements at the heights of –90cm and –100cm were not performed, but this could not influence the test results, as the data could be lower than at –80cm, which is far below the limits
NOTE 2: Data presented for the transmitting 2.2 dBi Dipole antenna H at the angle of 200^0 are significantly higher than in Table 5.2.2.1; the difference was caused to the close proximity of the probe to the EUT at 200^0.

The test results described in this subsection show that the values of the MPE from the 2.2 dBi Dipole antenna are significantly below the FCC limits, and that influence of co-location of the integral antenna is non-significant, it is in the range of the experiment accuracy, which was ± 10%.

5.2.3 DESKTOP POSITION. INTEGRAL ANTENNA PATTERN.

Directivity of integral antenna radiation was investigated for both positions of this antenna with the 2.2 dBi Dipole antenna horizontal. In these measurements zero angle between the Integral antenna and the probe corresponded to the position of the probe in front of the EUT, such that the Dipole antennas were closer to the probe than the integral antenna. The middle point of the bending line of the integral antenna was chosen as the zero / reference point. Rotation of the test desk was made in the same way as it was described in subsection 5.2.1. The test results are shown in Table 5.2.6. At certain positions of the EUT some parts of the integral antenna were closer to the probe than the reference point of the antenna for this test. A column with the Notes shows some of these distances.

TABLE 5.2.6: DESKTOP POSITION OF THE EUT. MPE DATA VERSUS AZIMUTH WITH THE INTEGRAL ANTENNA TRANSMITTING

Angle, degree	MPE, mW/cm^2		
	Integral V transmits, 2.2 dBi Dipole H does not transmit	Integral H transmits, 2.2 dBi Dipole H does not transmit	Notes
180	0.0005	0.0004	A probe is directed to the back of the EUT
170	0.0006	0.0005	
160	0.0006	0.0004	
150	0.0005	0.0005	
140	0.0006	0.0004	
130	0.0007	0.0003	
120	0.0007	0.0002	
110	0.0007	0.0003	
100	0.0006	0.0004	
90	0.0006	0.0005	
80	0.0005	0.0005	
70	0.0004	0.0005	
60	0.0004	0.0007	
50	0.0003	0.0006	
40	0.0007	0.0012	
30	0.0012	0.0017	
20	0.0013	0.0020	
10	0.0014	0.0023	
0 (360)	0.0008	0.0016	A probe is 8.5 cm from the top edge of the Integral H
350 (-10)	0.0008	0.0013	A probe is 9.5 cm from the top edge of the Integral H
340 (-20)	0.0006	0.0010	
330 (-30)	0.0004	0.0006	
320 (-40)	0.0002	0.0003	
310 (-50)	0.0003	0.0003	A probe is 10.5 cm from the top edge of the Integral H
300 (-60)	0.0001	0.0002	
290 (-70)	0.0001	0.0003	A probe is 16 cm from the side edge of Integral V
280 (-80)	0.0001	0.0005	A probe is 14.5 cm from the side edge of Integral V
270 (-90)	0.0001	0.0008	
260 (-100)	0.0001	0.0006	
250 (-110)	0.0002	0.0004	
240 (-120)	0.0004	0.0005	
230 (-130)	0.0005	0.0003	
220 (-140)	0.0006	0.0003	
210 (-150)	0.0008	0.0005	
200 (-160)	0.0008	0.0006	
190 (-170)	0.0007	0.0007	

5.2.4 DESKTOP POSITION. MPE VERSUS HEIGHT FOR THE INTEGRAL ANTENNA. INVESTIGATION OF CO-LOCATION OF THE 2.2 DBI DIPOLE ANTENNA.

Based on the results described in subsection 5.2.3, investigations of MPE versus height for the Integral antenna in vertical and horizontal positions were made at $+10^0$ azimuth between the EUT and the probe. Influence of co-location of the 2.2 dBi Dipole antenna was investigated for a few heights from the EUT[8]. The test results for the Integral V and Integral H are shown in Table 5.2.7 and Table 5.2.8 correspondingly.

[8] It shall be pointed out that to make measurements versus height the EUT was moved front with the respect to the position it had when the antenna pattern was investigated, otherwise it was impossible to take measurements below ""zero" level: the probe touched the wood of the stand.

TABLE 5.2.7: DESKTOP POSITION. MPE VERSUS HEIGHT AND INFLUENCE OF CO-LOCATION OF THE 2.2 DBI DIPOLE FOR THE INTEGRAL V

Height, cm	MPE, mW/cm²				
	Integral V transmits. 2.2 dBi Dipole H does not transmit.	Both 2.2 dBi Dipole H + Integral V transmit	Both 2.2 dBi Dipole V + Integral V transmit	2.2 dBi Dipole V transmits, Integral V does not transmit	2.2 dBi Dipole H transmits, Integral V does not transmit
80	0.0001				
70	0.0001				
60	0.0002				
50	0.0003				
40	0.0003				
30	0.0004				
20	0.0005				
10	0.0006	0.0317	0.0247	0.0242	0.0315
0	0.0014	0.0715	0.0740	0.0720	0.0690
-10	0.0006	0.0330	0.0198	0.0186	0.0330
-20	0.0002				
-30	0.0002				
-40	0.0001				
-50	0.0001				
-60	0.0001				
-70	0.0001				
-80*	0.0001				

Higher MPE levels from the 2.2 dBi Dipole antenna with respect to the data received in subsection 5.2.2 were connected with the closeness of the 2.2 dBi Dipole antenna to the probe: for example, at “zero” level the probe was 9 cm from the transmitting rod.

TABLE 5.2.8: DESKTOP POSITION. MPE VERSUS HEIGHT AND INFLUENCE OF CO-LOCATION OF THE 2.2 DBI DIPOLE FOR THE INTEGRAL H

Height, cm	MPE, mW/cm²				
	Integral H transmits. 2.2 dBi Dipole H does not transmit.	Both 2.2 dBi Dipole H + Integral H transmit	Both 2.2 dBi Dipole V + Integral H transmit	2.2 dBi Dipole V transmits, Integral H does not transmit	2.2 dBi Dipole H transmits, Integral H does not transmit
80	0.0003				
70	0.0003				
60	0.0004				
50	0.0007				
40	0.0008				
30	0.0009				
20	0.0010				
10	0.0023	0.0355	0.0333	0.0334	0.0336
0	0.0025	0.0700	0.0835	0.0785	0.0680
-10	0.0006	0.0330	0.0200	0.0200	0.0363
-20	0.0001				
-30	0.0001				
-40	0.0001				
-50	0.0001				
-60	0.0001				
-70	0.0001				
-80*	0.0001				

The test results show that the 2.2 dBi Dipole antenna influences significantly the MPE values from the Integral antenna. But it shall be noted though that based on the data it is difficult to say that a summary of MPE from the 2.2 dBi Dipole antenna and the Integral antenna is really higher than MPE from a 2.2 dBi Dipole, as the data describing co-location are within the accuracy of the experiment.

5.3 MPE TEST RESULTS FOR THE WALL-MOUNTED EUT CONNECTED TO 2.2 DBI DIPOLE ANTENNA.

5.3.1 WALL-MOUNTED POSITION. 2.2 DBI DIPOLE ANTENNA PATTERN

Directivity of 2.2 dBi Dipole antenna radiation was investigated for horizontal and vertical positions of the 2.2 dBi Dipole antenna with the Integral antenna in the horizontal position. The test results are shown in Table 5.3.1.

TABLE 5.3.1: WALL-MOUNTED EUT. MPE DATA VERSUS AZIMUTH WITH THE 2.2 DBI DIPOLE ANTENNA TRANSMITTING

Angle, degree	Measured power, mW/cm^2	
	2.2 dBi Dipole V transmits. Integral H does not transmit	2.2 dBi Dipole H transmits. Integral H does not transmit.
90	0.0074	0.0031
80	0.0070	0.0055
70	0.0077	0.0072
60	0.0081	0.0139
50	0.0088	**0.0148**
40	0.0117	0.0133
30	0.0106	0.0142
20	0.0069	0.0135
10	0.0046	0.0130
0	0.0036	0.0120
-10	0.0035	0.0115
-20	0.0049	0.0093
-30	0.0069	0.0085
-40	0.0103	0.0089
-50	0.0133	0.0097
-60	0.0143	0.0097
-70	**0.0166**	0.0117
-80	0.0132	0.0111
-90	0.0113	0.0075

5.3.2 WALL-MOUNTED EUT. INVESTIGATION OF MPE FROM THE 2.2 DBI DIPOLE ANTENNA VERSUS HEIGHT. INVESTIGATION OF CO-LOCATION

Investigation of power density transmitted by the 2.2 dBi Dipole antenna V and 2.2 dBi Dipole antenna H versus height, as well as influence of co-location of the Integral antenna were made at the angle equal to -70^0 between the 2.2 dBi Dipole antenna H and a test probe and at the angle equal to 50^0 for the 2.2 dBi Dipole antenna H. These angles were chosen based on the test results described in subsection 5.3.1. Reference point (0 cm height) established for this test was described in subsection 4.2. The test results are shown in Table 5.3.2. and Table 5.3.3

TABLE 5.3.2: WALL-MOUNTED EUT. MPE VERSUS HEIGHT AND INFLUENCE OF CO-LOCATION FOR 2.2 DBI DIPOLE V

Height, cm	MPE, mW/cm²					
	2.2 dBi Dipole V radiates, Integral H does not radiate	2.2 dBi Dipole V transmits, Integral V does not radiate	Both 2.2 dBi Dipole V and Integral V transmit	Both 2.2 dBi Dipole V and Integral H transmit	Only Integral V radiates	Only Integral H radiates
100	0.0004					
90	0.0007					
80	0.0010					
70	0.0020					
60	0.0032					
50	0.0045					
40	0.0054					
30	0.0063	0.0052	0.0053	0.0063	0.0007	0.0003
20	0.0089	0.0090	0.0095	0.0091	0.0011	0.0002
10	0.0120	0.0125	0.0122	0.0130	0.0009	0.0002
0	0.0157	0.0128	0.0126	0.0157	0.0006	0.0001
-10	0.0113	0.0112	0.0113	0.0114	0.0001	0.0003
-20	0.0080	0.0086-	0.0087	0.0072	0.0001	0.0001
-30	0.0056	0.0057-	0.0057	0.0058	0.0001	0.0001
-40	0.0048					
-50	0.0035					
-60	0.0026					
-70	0.0016					
-80	0.0010					
-90	Could not make measurements at this and lower height, as 5 cm below –80 cm there was a surface of the wooden desk.					

Comparison of the test data when only the 2.2 dBi Dipole antenna V transmits with the data when both the 2.2 dBi Dipole antenna V and the Integral antennas transmit does not show any influence of co-location of the integral antenna, as the differences in the data are in the limits of ±10% error of the experiment

TABLE 5.3.3: WALL-MOUNTED EUT. MPE VERSUS HEIGHT AND INFLUENCE OF CO-LOCATION FOR 2.2 DBI DIPOLE H

Height, cm	Measured power, mW/cm²					
	2.2 dBi Dipole H, Integral H does not radiate	2.2 dBi Dipole H, Integral V does not radiate	Both 2.2 dBi Dipole H + Integral V radiate	Both 2.2 dBi Dipole H + Integral H radiate	Only Integral V radiates	Only Integral H radiates
100	0.0003					
90	0.0004					
80	0.0005					
70	0.0007					
60	0.0009					
50	0.0018					
40	0.0011					
30	0.0006	0.0006	0.0008	0.0027	0.0005	0.0021
20	0.0015	0.0016	0.0028	0.0040	0.0009	0.0025
10	0.0040	0.0037	0.0036	0.0065	0.0004	0.0035
0	0.0144	0.0142	0.0144	0.0165	0.0004	0.0024
-10	0.0180	0.0184	0.0185	0.0201	0.0005	0.0020
-20	0.0096	0.0092	0.0098	0.00106	0.0004	0.0012
-30	0.0046					
-40	0.0018					
-50	0.0010					
-60	0.0005					
-70	0.0003					
-80	0.0003					

Results of the measurements presented in Table 5.3.3 show that co-location of the Integral antenna slightly increases the MPE values from the 2.2 dBi Dipole antenna H when the Integral antenna is in the horizontal position. When the Integral antenna is in the vertical position there is no influence of co-location, as the differences in the data are in the limits of the +/- 10% error of the experiment.

5.3.3 WALL-MOUNTED EUT. INTEGRAL ANTENNA PATTERN

Directivity of Integral antenna radiation was investigated for both positions of the Integral antenna with the 2.2 dBi Dipole antenna in the horizontal position. The test results are shown in Table 5.3.4.

TABLE 5.3.4: WALL-MOUNTED EUT. MPE VERSUS AZIMUTH WITH THE INTEGRAL ANTENNA TRANSMITTING

Angle, degree	Measured power, mW/cm^2	
	Integral H transmits*	Integral V transmits*
90	0.0014	**0.0006**
80	0.0012	0.0005
70	0.0016	0.0004
60	0.0018	0.0002
50	0.0013	0.0001
40	0.0009	0.0001
30	0.0003	0.0001
20	0.0005	0.0003
10	0.0007	0.0002
0	0.0012	0.0004
-10	0.0010	0.0004
-20	0.0006	0.0004
-30	0.0009	0.0005
-40	0.0010	0.0003
-50	0.0016	0.0002
-60	0.0020	0.0001
-70	**0.0026**	0.0001
-80	0.0022	0.0002
-90	0.0020	0.0001

5.3.4 WALL-MOUNTED EUT. MPE VERSUS HEIGHT AND INVESTIGATION OF CO-LOCATION OF 2.2 DBI DIPOLE FOR THE INTEGRAL ANTENNA.

Investigations of the power transmitted by the Integral antenna versus height, as well as influence of co-location of the 2.2 dBi Dipole antenna were made at the angle equal to $+90^0$ between the Integral antenna V and a test probe and at the angle equal to -70^0 for the Integral H. These angles were chosen based on the test results described in subsection 5.3.3. Reference point (0 cm height) this test was described in subsection 4.2. The test results are shown in Table 5.3.5 and Table 5.3.6. As it is seen from the results, co-location of the 2.2 dBi Dipole antenna increases the MPE values from the Integral antenna, but MPE remains significantly below the limits.

TABLE 5.3.5: WALL-MOUNTED EUT. MPE VERSUS HEIGHT AND INVESTIGATION OF CO-LOCATION OF 2,2 DBI DIPOLE FOR THE INTEGRAL V.

Height, cm	Measured power, mW/cm²					
	Integral V ransmits, 2.2 dBi Dipole H does not transmit	Integral V transmits, 2.2 dBi Dipole V does not radiate	Both Integral V and 2.2 dBi Dipole H transmit	Both Integral V and 2.2 dBi Dipole V transmit	Only 2.2 dBi Dipole V transmits	Only 2.2 dBi Dipole H transmits
100	0.0000					
90	0.0001					
80	0.0001					
70	0.0001					
60	0.0002					
50	0.0003					
40	0.0007					
30	0.0004					
20	0.0006	0.0006	0.0021	0.0029	0.0025	0.0017
10	0.0007	0.0007	0.0021	0.0064	0.0058	0.0017
0	0.0007	0.0007	0.0011	0.0100	0.0090	0.0007
-10	0.0005	0.0005	0.0018	0.0079	0.0072	0.0011
-20	0.0002	0.0003	0.0017	0.0036	0.0030	0.0013
-30	0.0002	0.0002	0.0011	0.0047	0.0046	0.0011
-40	0.0002					
-50	0.0001					
-60	0.0001					
-70	0.0001					
-80	0.0001					
-90	0.0001					
-100	0.0001					

TABLE 5.3.6: WALL-MOUNTED EUT. MPE VERSUS HEIGHT AND INVESTIGATION OF CO-LOCATION OF 2.2 DBI DIPOLE FOR THE INTEGRAL H.

Height, cm	Measured power, mW/cm²					
	Integral H radiates, 2.2 dBi Dipole H does not radiate	Integral H radiates, 2.2 dBi Dipole V does not radiate	Both Integral H and 2.2 dBi Dipole H transmit	Both integral H and 2.2 dBi Dipole V transmit	Only 2.2 dBi Dipole V transmits	Only 2.2 dBi Dipole H transmits
100	0.0000					
90	0.0001					
80	0.0001					
70	0.0001					
60	0.0002					
50	0.0003					
40	0.0007					
30	0.0010	0.0010	0.0046	0.0051	0.0037	0.0039
20	0.0011	0.0012	0.0052	0.0070	0.0050	0.0046
10	0.0007	0.0008	0.0047	0.0069	0.0042	0.0029
0	0.0023	0.0025	0.0041	0.0082	0.0067	0.0017
-10	0.0024	0.0023	0.0057	0.0170	0.0140	0.0028
-20	0.0009	0.0010	0.0112	0.0250	0.0242	0.0093
-30	0.0003	0.0005	0.0128	0.0165	0.0154	0.0110
-40	0.0003					
-50	0.0003					
-60	0.0001					
-70	0.0001					
-80	0.0001					
-90	0.0001					
-100	0.0002					

5.4 INVESTIGATION OF THE EUT WITH THE YAGI ANTENNA

5.4.1 YAGI ANTENNA PATTERN AND MPE VERSUS HEIGHT

As it is written in subsection 4.3 of this report measurements of radiation from the Yagi antenna at the 20-cm distance between the probe and the antenna were conducted as electric field strength measurements. Zero azimuth angle corresponded to the location of the probe in front of the tip of the antenna, as it was shown in the preliminary investigation that the highest field is radiated from the tip. Results of the Yagi antenna pattern shown in Table 5.4.1 are significantly below the limit equal to 61.4 V/m at the frequencies above 1.5 GHz.

TABLE 5.4.1: RADIATION PATTERN FOR YAGI ANTENNA

Azimuth, degree	MPE, V/m		Azimuth, degree	MPE, V/m
180	0.0		180	0.0
170	0.0		190 (-170)	0.0
160	0.0		200 (-160)	0.0
150	0.0		210 (-150)	0.0
140	0.0		220 (-140)	0.0
130	0.0		230 (-130)	1.4
120	0.0		240 (-120)	2.0
110	1.95		250 (-110)	2.7
100	0.0		260 (-100)	4.0
90	0.0		270 (-90)	2.7
80	1.95		280 (-80)	3.4
70	3.2		290 (-70)	1.9
60	1.7		300 (-60)	4.0
50	1.5		310 (-50)	2.0
45	5.1		315 (-45)	4.5
40	3.9		320 (-40)	3.0
35	1.8		325 (-35)	1.1
30	5.6		330 (-30)	4.6
25	5.4		335 (-25)	4.7
20	2.3		340 (-20)	1.4
15	6.7		345 (-15)	7.5
10	12.2		350 (-10)	11.9
5	16.4		355 (-5)	16.9
0 (360)	18.1		0 (360)	18.1

Results of the MPE measurements from the Yagi antenna versus height are shown in Table 5.4.2. The choice of the reference point was made based on the test results shown in Table 5.4.1: superposition of the antenna and the probe corresponded to zero azimuth between them.

TABLE 5.4.2: MPE FROM THE YAGI ANTENNA VERSUS HEIGHT

Height, cm	MPE, V/m		Height, cm	MPE, V/m
0	18.4		0	18.4
10	15.35		-10	12.35
20	7.46		-20	3.88
30	1.72		-30	2.10
40	2.00		-40	1.41
50	2.20		-50	0.80
60	1.92		-60	0.85
70	1.65		-70	0.66
80	1.72		-80	0.51
90	1.40		-90	0.61
100	1.10		-100	0.30

The measurement results show that at the "FCC safe" distance the MPE values from the Yagi antenna are below the FCC limit.

5.4.2 INFLUENCE OF CO-LOCATION OF THE INTEGRAL ANTENNA

Results of investigation of co-location of the Yagi antenna and the Integral antenna are shown in Table 5.4.3 and Table 5.4.4. Table 5.4.3 describes influence of the Yagi antenna to the MPE from the Integral antenna and Table 5.4.4 describes influence of the Integral antenna to the MPE from Yagi antenna. During these investigation 20 cm distance was maintained between the probe and the reference point of one of the antennas: When investigation of influence of the Yagi antenna to the Integral antenna was conducted 20cm distance was maintained between the probe and the reference point of the Yagi antenna described earlier. When influence of the Integral antenna to the MPE from Yagi was investigated 20-cm distance was maintained between the probe and the reference point for the Yagi antenna described in subsection 5.4.1.

Four setups were investigated:

1. The EUT in the desktop position was 20 cm below the Yagi antenna
2. The EUT in the desktop position was 20 cm to the left from the Yagi antenna
3. The EUT in the wall-mounted position was 20 cm below the Yagi antenna
4. The EUT in the wall-mounted position was 20 cm to the left from the Yagi antenna

TABLE 5.4.3: INFLUENCE OF CO-LOCATION OF THE YAGI ANTENNA TO MPE RESULTS FROM THE INTEGRAL ANTENNA

Position of the Yagi antenna	MPE, V/m				
	Integral H radiates, Yagi does not radiate	Integral V radiates, Yagi does not radiate	Both Integral H and Yagi transmit	Both integral V and Yagi transmit	Only Yagi transmits
Desktop position of the EUT					
Yagi is 20 cm above the EUT	0.77	0.43	2.03	1.95	1.9
Yagi 20 cm to the right from the EUT	0.48	0.42	3.73	3.74	3.6
Wall-mounted position of the EUT					
Yagi is 20 cm above the EUT	1.67	0.90	2.41	2.08	1.88
Yagi 20 cm to the right from the EUT	1.73	1.02	3.75	3.25	2.95

TABLE 5.4.4: INFLUENCE OF CO-LOCATION OF THE INTEGRAL ANTENNA TO THE MPE RESULTS FROM THE YAGI ANTENNA

Position of the Yagi antenna	MPE, V/m				
	Integral H radiates, Yagi does not radiate	Integral V radiates, Yagi does not radiate	Both Integral H and Yagi transmit	Both integral V and Yagi transmit	Only Yagi transmits
Desktop position of the EUT					
Yagi is 20 cm above the EUT	1.18	0.61	18.56	17.90	18.00
Yagi 20 cm to the right from the EUT	0.33	0.29	17.44	17.75	17.40
Wall-mounted position of the EUT					
Yagi is 20 cm above the EUT	2.4	0.51	18.78	18.70	18.50
Yagi 20 cm to the right from the EUT	1.00	0.30	17.66	18.12	17.90

5.5 DETERMINATION OF A "SAFE" DISTANCE FOR THE EUT.

5.5.1 DETERMINATION OF THE SAFE DISTANCE FROM THE EUT CONNECTED TO THE 2.2 DBI DIPOLE ANTENNA.

To find the lowest "safe" distance from the EUT in the meaning of the FCC MPE limits the following shall be taken in consideration:

1. Test results described in sections 5.2 and 5.3:

Based on these results it is possible to calculate the MPE values at any far-field distance from the antenna and to find MPE at the distances closer than 20 cm from the EUT.

2. Near-field and Far-filed distance:

Evaluation of MPE at the distance closer than 20 cm could be made using the far-filed approximation. Therefore it is required to know what is the near-field and what is the far-field for the 2.2 dBi Dipole antenna and the Integral antennas: It is easy to show that for the 2.2 dBi Dipole antenna with the highest dimension of 11 cm and transmitting at 2.4 GHz the near-field distance is the distance within 2.5 cm to the antenna; for the Integral antenna with the highest dimension of 10 cm and transmitting at 5.2 GHz the near-field distance is the distance within 5 cm from the antenna. Calculations show that MPE at the distance of 2.5 cm from the 2.2 dBi Dipole antenna and at the distance of 5 cm from the Integral antenna are within the FCC MPE limits.

It is impossible to make calculation of MPE in the near-field distance based on the results in the far-field distances. Therefore MPE measurements were conducted at the distance of 1 cm from the antenna. These measurements were conducted versus azimuth between the dipole antenna and the probe and as the electric-field strength measurements. Similar investigation was not made for the Integral antenna, as the power from the transmitting Integral antenna was significantly lower than from the 2.2 dBi Dipole antenna and co-location of the Integral antenna did not influence the MPE results for the Dipole antenna. As it was found that the highest level of radiation from the 2.2 dBi Dipole antenna was associated with its tip (it was 20-30% higher near the tip than at any other part of the antenna), measurements were conducted around the 2.2 dBi Dipole antenna near its tip. The results of the measurements made for the wall-mounted EUT are shown in Table 5.5.1. It

shall be noted once again that shall be no correlation of these results with any other data in this test reports, as the measurements were conducted in the near field.

TABLE 5.5.1: MPE NEAR THE RADIATING 2.2 DBI DIPOLE FOR THE WALL-MOUNTED EUT

Angle, ^{0}	MPE for the 2.2 dBi Dipole antenna V, V/m	MPE for the 2.2 dBi Dipole antenna H, V/m
0	40	28
10	36	24
20	27	28
30	42	28
40	42	28
50	41	29
60	40	28
70	32	27
80	34	28
90	34	28
-10	34	24
-20	32	24
-30	34	24
-40	33	25
-50	37	25
-60	40	24
-70	36	25
-80	40	25
--90	40	26

Results of this test demonstrate that the EUT connected to the determined 2.2 dBi Dipole antenna is safe for the user even in a close proximity to the device.

5.5.2 DETERMINATION OF A "SAFE" DISTANCE FROM THE EUT CONNECTED TO THE YAGI ANTENNA

The same consideration, which was made for the EUT connected to the 2.2 dBi Dipole antenna, is applicable for the EUT connected to the Yagi antenna. But for the Yagi antenna even a distance of 20 cm is a near-field distance. Therefore no calculation could be performed to find the MPE values at the closer distances. Results of the MPE measurements made as electric-field strength versus distance from the tip of the antenna[9] are shown in the Table 5.5.2. It is impossible to find some correlation of these results with the results shown in subsection 5.4, as any calculations are based on the far-field approximation. Results of the measurements show that any short distance from the Yagi antenna is a safe distance, as field strength are lower than applicable FCC limits.

TABLE 5.5.2: MPE VERSUS DISTANCE FROM RADIATING YAGI ANTENNA

Distance from the tip of the Yagi antenna, cm	MPE, V/m
27.0	15.7
20.0	19.8
16.0	19.6
12.0	24.4
6.0	31.1
2.0	34.8
1.0	39.2

[9] Preliminary investigations showed that the highest field is radiated by the Yagi antenna near this tip, in front of it

6 CONCLUSION

MPE levels at the FCC recommended 20 cm distance from the EUT connected either to the 2.2 dBi Dipole antenna, model AIR-ANT-2506, or to the Yagi antenna, model AIR-ANT-1949, are significantly below the limits. The EUT passed the test.
Co-location of the Integral antenna, model AIR-RM20A-A-K9, did not change significantly the MPE values from the 2.2 dBi Dipole antenna or from the Yagi antennas and did not influence the pass/fail criteria for the EUT.

The FCC requires a RF safety warning to be placed in the user manual and / or the EUT. Please, see an example of the warning below valid for all antennas of this application[10]

"The radio module has been evaluated under FCC Bulletin IET 65C and found compliant to the requirements as set forth in CFR 47 Section 2.1091, 2.1093 and 15.247 (b) (4) addressing RF Exposure from radio frequency devices. For antennas AIR-ANT4121 and AIR-ANT1949, the equipment should be positioned more than 2 m (78.7 in) from your body or nearby persons. All other antennas should be installed 20 cm (11.8 in) from your body or nearby persons.
The FCC approved indoor / outdoor 2.4 GHz antennas, with the exception of 2.2 dBi Dipole antenna must be installed to maintain a minimum 30 cm co-located separation distance for the access point of 5 GHz Integrated antenna. The access point's co-located 2.4 GHz 22 dBi Dipole antenna and 5 GHz Integrated antennas support a minimum separation distance of 10 cm (3.9 in) and are compliant with the applicable FCC RF exposures limit when transmitting simultaneously."

[10] "Antennas of this application" are shown in section 2.2.2 of this report