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.

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TABLE OF CONTENT

TABLE OF TABLES

TABLE OF FIGURES

TABLE OF PHOTOGRAPHS

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 the distance of 20 cm will be maintained between this antenna and the body of the nearby person. That's why during the MPE measurements of the EUT with the Yagi antenna the worst case for the user was investigated – when the 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 MODIFICATIONS

No modifications were made during testing of the EUT.

2.3 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.

2.4 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[2]. EIRP test results either from the FCC test reports referenced to in section 1.2 or as the results of the new investigation (for the 2.2 dBi Dipole) 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 2.4.1 through Table 2.4.3 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 where Integral antenna radiates have approximately the same level of EIRP. For the MPE measurements channels 11, 6 and 52 were 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 2.4.2.

TABLE 2.4.1: RESULTS OF EIRP MEASUREMENTS FOR THE 2.2 DBI DIPOLE ANTENNA

Channel number	Frequency, GHz	EIRP, dBm
1	2.412	15.0
6	2.437	20.3
11	2.462	20.5

TABLE 2.4.2: 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 2.4.3: 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	2.462	29.0

2.5 JUSTIFIICATIONS

2.5.1 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

[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.

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.

2.5.2 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[3] together with environment of their intended use, with the antenna gains and the EIRP 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 2.5.1: 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

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 the 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

[3] For the AIR-ANT-4941 antenna the EIRP measurements were conducted recently, before the MPE measurements were performed

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

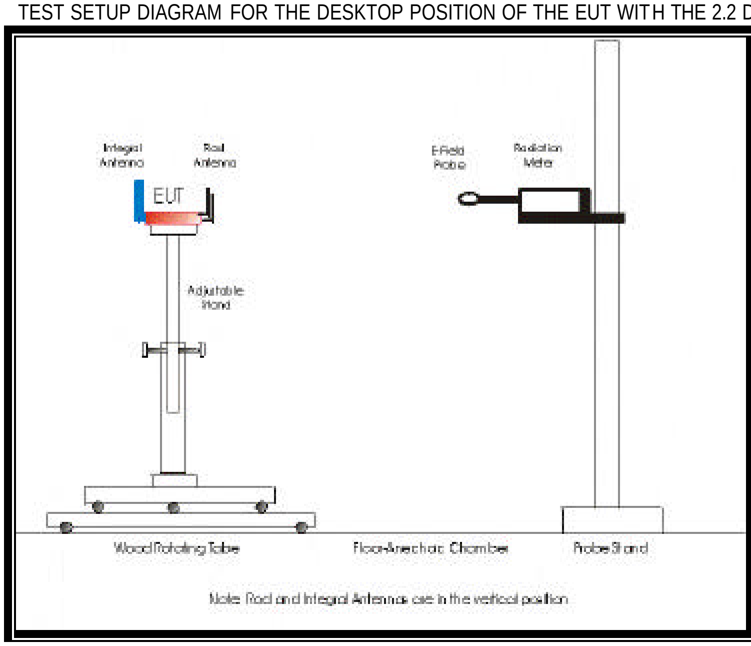


FIGURE 3.1.2: TEST SETUP DIAGRAM FOR THE WALL-MOUNTED POSITION OF THE EUT WITH THE 2.2 DBI DIPOLE ANTENNA

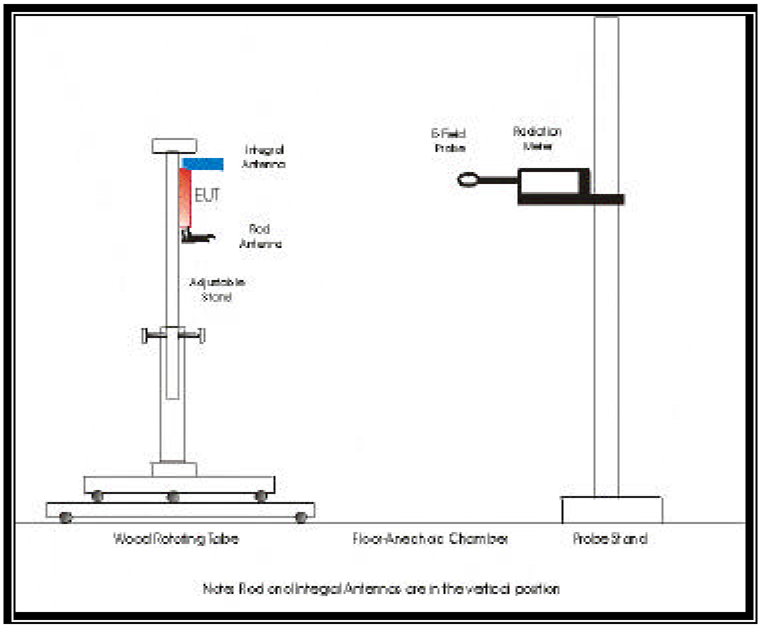
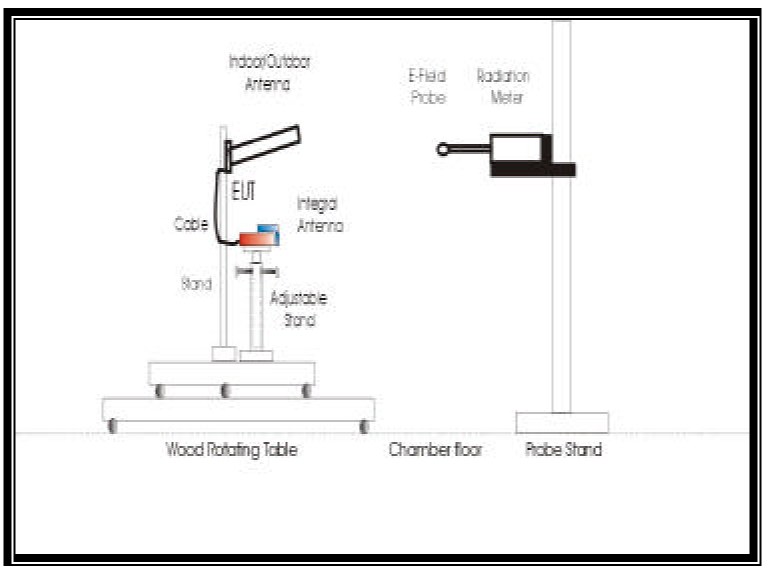


FIGURE 3.1.3: TEST SETUP DIAGRAM FOR THE DESKTOP POSITION OF THE EUT WITH THE YAGI ANTENNA

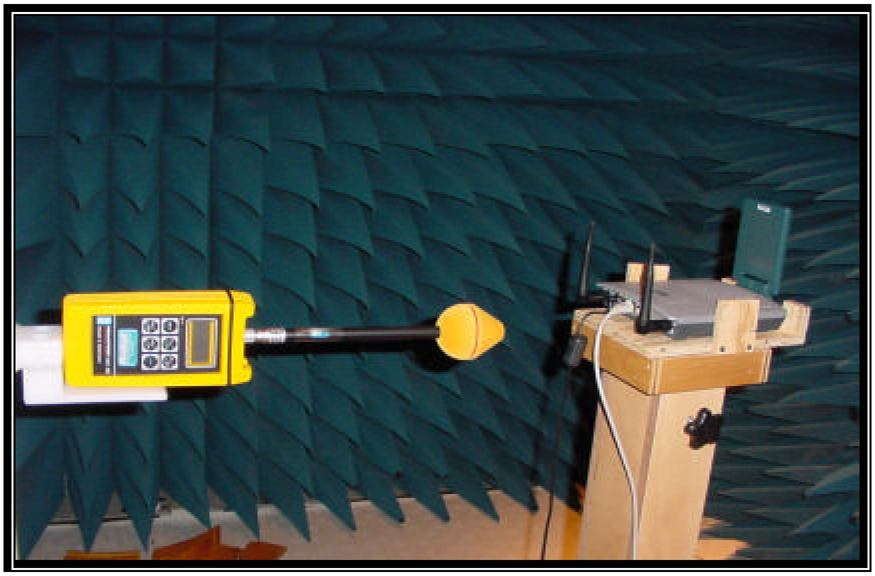


3.2 TEST SETUP PHOTOGRAPHS

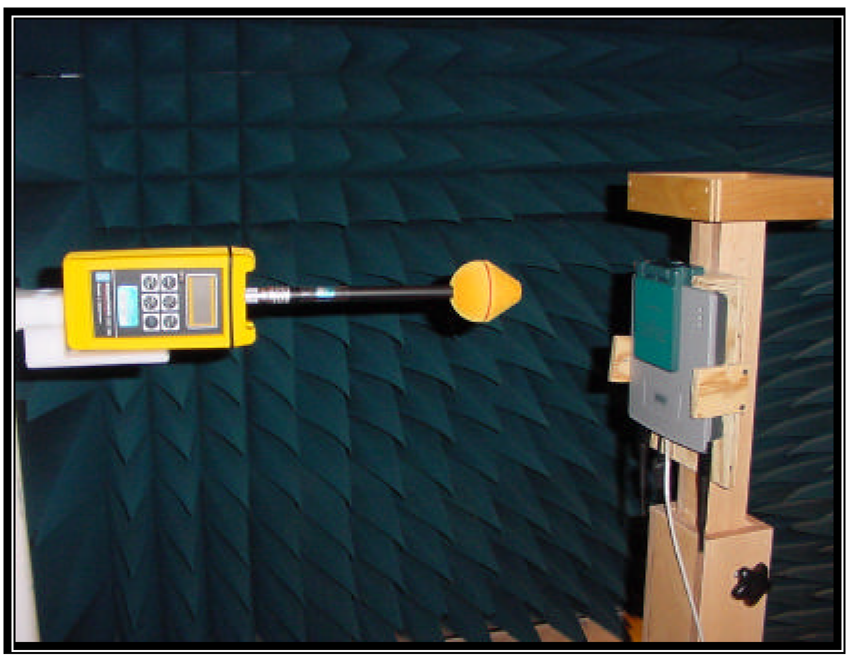
Photographs 3.2.1 through 3.2.3 show important parts of the test setup as well as absorbing cover of the walls in the semi-anechoic chamber[4].

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

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



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
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

The MPE measurements were made with the electric strength field / power density monitor, represented by the filed sensor/ probe and the radiation meter. 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 AND AVERAGING TIME

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 also 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)[5], mW/cm^2	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	$(900/f^2)$	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/cm^2	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	$(180/f^2)$	30
30-300	27.5	0.073	0.2	30
300-1500	-	-	f/1500	30
1500-100,000	-	-	1.0	30

But 47 CFR part 2.1091 of the FCC Rules and Regulations states that "time-averaging provisions may not be used in determining typical exposure levels for devices intended for use by consumers in general population / uncontrolled environments. However, "source-base" time-averaging based on an inherent property or duty-cycle of a device is allowed. An example of this is the determination of exposure from a device that uses digital technology such as a time-division multiple-access scheme for transmitting of a signal. In general, maximum average power levels must be used to determine compliance". Relative to the EUT this statement requires that MPE measurements were conducted as the peak (max) measurements.

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/cm^2, which is equivalent to the electric strength limit of 61.4 V/m in the far-field region, where the equation (4.1.1) is applicable:

$$S = E^2 / (377*10), \qquad (4.1.1)$$

In (4.1.1) S is the power density in mW/cm^2, E is the electric filed strength in V/m and 377 is the impedance of free space, measured in ohms. The FCC accepts the distance of 20cm[6] as the

5 The 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

6 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

minimum separation distance where reliable field measurements to determine adherence to MPE limits can be made.

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

The radiating power meter EMR 200 used at RTL for the MPE measurements measures the field strength and gives the reading either as the field strength or as the power density. Conversion of the measured field strength into the power density is based on the far-field approximation. For the frequencies transmitted by the EUT connected to Dipole antenna the 20-cm distance from the EUT is the far-field distance. Therefore measurements of MPE could be made and were made as power density measurements.

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[7] of the investigated antenna versus azimuth. As the results of the measurements the angle corresponding to the highest directivity of the 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 the 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.
- In the third part of the test investigation of influence of co-location of the Integral 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. 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 JUSTIFICATION OF USE THE EMR 200 FOR THE MPE TEST PERFORMED WITH THE YAGI ANTENNA.

The highest dimension of the Yagi antenna radiating at 2.4 GHz, is 44.5 cm, therefore the FCC "safe" distance of 20 cm is the near-field region for this antenna[8]. In the near-field region the equation (4.1.1) is not applicable, as the connection between the power density and the electric

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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.

[7] 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.

[8] To find a boundary R_{ff} between the near-field and the far-field an equation $R_{ff} = 2 \times L^2/\lambda$, was used, where L is the longest dimension of the physical antenna and λ is the wavelength

field strength is more complicated. At the same time, the FCC gives the MPE limits only as the power density limits for the frequencies above 300 MHz. To use the EMR-200 for power density measurements in the near-field region, which is required for the Yagi antenna, we considered the following: there are substantial scientific evidence that power density in the near-field region has lower value than a power density derived from equation (4.1.1). That means that MPE power density data received with the EMR-200 in the near-field region are higher than real power density values in this region. Based on this consideration the following justification was made:
If the MPE data for any antenna measured with the EMR 200 in the near-field region and presented in power density units have enough margins below the FCC MPE limits, the actual MPE data would have higher margins, and therefore complies with the FCC limits.

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.

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

Angle, degree	MPE, mW/cm^2		
	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	0.0180	0.0115	A probe was 1 cm from the wooden fixture, the distance between the probe and the reference point was 24 cm
170	0.0193	0.0160	A probe was 0.5 cm from the wooden fixture, the distance between the probe and the reference point was 24 cm
160	0.0199	0.0162	A probe was 1 cm from the wooden fixture, the distance between the probe and the reference point was 24 cm
150	0.0082	0.0153	A probe was 0.8 cm from the wooden fixture, the distance between the probe and the reference point was 25.5 cm
140	0.0188	0.0048	The distance between the probe and the reference point is 25 cm
130	0.0137	0.0031	The distance between the probe and the reference point is 23 cm
120	0.0130	0.0014	The distance between the probe and the reference point is 21 cm
110	0.0118	0.0018	
100	0.0129	0.0030	
90	0.0110	0.0039	
80	0.0089	0.0073	
70	0.0110	0.0082	
60	0.0132	0.0091	
50	0.0161	0.0099	
40	0.0171	0.0096	
30	0.0128	0.0051	
20	0.0111	0.0070	
10	0.0091	0.0042	
0 (360)	0.0117	0.0025	
350 (-10)	0.0105	0.0024	
340 (-20)	0.0119	0.0021	
330 (-30)	0.0131	0.0039	
320 (-40)	0.0122	0.0082	
310 (-50)	0.0118	0.0080	
300 (-60)	0.0119	0.0131	
290 (-70)	0.0119	0.0141	
280 (-80)	0.0119	0.0122	
270 (-90)	0.0099	0.0128	
260 (-100)	0.0148	0.0082	
250 (-110)	0.0150	0.0048	
240 (-120)	0.0144	0.0032	
230 (-130)	0.0135	0.0033	
220 (-140)	0.0156	0.0035	
210 (-150)	0.0177	0.0048	
200 (-160)	0.0235	0.0212	The distance between the probe and the reference point is 20 cm, but the probe almost touches the fixture

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
190 (-170)	0.0172	0.0131	A probe was 1 cm from the wooden fixture, the distance between the probe and the reference point was 24 cm

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 40⁰ and at 200⁰ and the MPE measurements for the 2.2 dBi Dipole antenna H versus height were conducted at 290⁰ and at 200⁰. For both antenna positions investigation of co-location was made at the position of the EUT corresponding to 200⁰. Measurement results are shown in Table 5.2.2 through Table 5.2.4

TABLE 5.2.2: DESKTOP POSITION. MPE VERSUS HEIGHT FOR THE TRANSMITTING 2.2 DBI DIPOLE ANTENNA V/H

Height, cm	MPE, mW/cm²	
	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 40⁰.	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 290⁰.
100	0.0002	0.0008
90	0.0002	0.0012
80	0.0004	0.0015
70	0.0006	0.0019
60	0.0008	0.0024
50	0.0012	0.0030
40	0.0022	0.0040
30	0.0048	0.0059
20	0.0099	0.0089
10	0.0134	0.0139
0	0.0179	0.0140
-10	0.0066	0.0099
-20	0.0030	0.0083
-30	0.0015	0.0065
-40	0.0008	0.0052
-50	0.0006	0.0040
-60	0.0005	0.0028
-70	0.0003	0.0008
-80[1]	0.0003	0.0004

TABLE 5.2.3: DESKTOP POSITION. MPE VERSUS HEIGHT AND INFLUENCE OF CO-LOCATION TO RADIATING 2.2 DBI DIPOLE V

Height, cm	MPE[9], mW/cm²				
	2.2 dBi Dipole V transmits. Integral H does not radiate. The angle between the 2.2 dBi Dipole and the probe is 200⁰.	**2.2 dBi Dipole V + Integral V**	**2.2 dBi Dipole V + Integral H**	**Only Integral V radiates**	**Only Integral H radiates**
100	0.0002				
90	0.0002				
80	0.0002				
70	0.0003				
60	0.0006				
50	0.0017				
40	0.0025				
30	0.0048				
20	0.0089	0.0095	0.0116	0.0001	0.0028
10	0.0215	0.0210	0.0266	0.0006	0.0059
0	0.0225	0.0212	0.0270	0.0007	0.0044
-10	0.0022*	0.0026	0.0035	0.0002	0.0009
-20	0.0007*				
-30	0.0007*				
-40	0.0004*				
-50	0.004*				
-60	0.0002*				
-70	0.0002*				

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

Height, cm	MPE, mW/cm²				
	2.2 dBi Dipole H transmits. Integral H does not radiate. The angle between the 2.2 dBi Dipole and the probe is 200⁰.	**2.2 dBi Dipole H + Integral V**	**2.2 dBi Dipole H + Integral H**	**Only Integral V radiates**	**Only Integral H radiates**
100	0.0008				
90	0.0009				
80	0.0011				
70	0.0012				
60	0.0008				
50	0.0009				
40	0.0013				
30	0.0013				
20	0.0025	0.0022	0.0052	0.0002	0.0028
10	0.0049	0.0048	0.0105	0.0004	0.0058
0	0.0215[2]	0.0199	0.0241	0.0002	0.0045
-10	0.0036	0.0031	0.0033	0.0002	0.0006
-20	0.0015				
-30	0.0007				
-40	0.0004				
-50	0.0003				
-60	0.0002				
-70	0.0002				
-80[1]	0.0002				

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 200⁰ 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 200⁰.

[9] 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.

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 5.2.5. 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 5.2.5: 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	0.0006	0.0005	The probe is directed to the back of the EUT
170	0.0007	0.0005	
160	0.0007	0.0005	
150	0.0006	0.0007	
140	0.0007	0.0005	
130	0.0008	0.0004	
120	0.0008	0.0003	
110	0.0009	0.0004	
100	0.0007	0.0005	
90	0.0008	0.0006	
80	0.0007	0.0006	
70	0.0006	0.0006	
60	0.0005	0.0007	
50	0.0003	0.0007	
40	0.0008	0.0015	
30	0.0014	0.0021	
20	0.0016	0.0028	
10	0.0017	0.0024	
0 (360)	0.0010	0.0019	The probe is 8.5 cm from the top edge of the Integral H
350 (-10)	0.0011	0.0015	The probe is 9.5 cm from the top edge of the Integral H
340 (-20)	0.0009	0.0014	
330 (-30)	0.0005	0.0009	
320 (-40)	0.0003	0.0004	
310 (-50)	0.0003	0.0004	The probe is 10.5 cm from the top edge of the Integral H
300 (-60)	0.0002	0.0003	
290 (-70)	0.0002	0.0003	The probe is 16 cm from the side edge of Integral V
280 (-80)	0.0002	0.0006	The probe is 14.5 cm from the side edge of Integral V
270 (-90)	0.0002	0.0009	
260 (-100)	0.0002	0.0007	
250 (-110)	0.0004	0.0007	

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
240 (-120)	0.0005	0.0006	
230 (-130)	0.0005	0.0004	
220 (-140)	0.0007	0.0004	
210 (-150)	0.010	0.0006	
200 (-160)	0.0011	0.0007	
190 (-170)	0.0008	0.0009	

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[10]. The test results for the Integral V and Integral H are shown in Table 5.2.6 and Table 5.2.7correspondingly.

TABLE 5.2.6: DESKTOP POSITION. MPE VERSUS HEIGHT AND INFLUENCE OF CO-LOCATION OF THE 2.2 DBI DIPOLE TO THE INTEGRAL V

Height, cm	MPE, mW/cm^2				
	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	0.0002				
70	0.0002				
60	0.0003				
50	0.0004				
40	0.0003				
30	0.0005				
20	0.0006				
10	0.0006	0.0342	0.0268	0.0262	0.0344
0	0.0017	0.0743	0.0765	0.0742	0.0699
-10	0.0009	0.0338	0.0215	0.0205	0.0339
-20	0.0003				
-30	0.0002				
-40	0.0002				
-50	0.0002				
-60	0.0002				
-70	0.0002				
-80*	0.0003				

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 dipole.

[10] 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 TO 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	0.0004				
70	0.0003				
60	0.0005				
50	0.0008				
40	0.0009				
30	0.0010				
20	0.0012				
10	0.0025	0.0376	0.0356	0.0353	0.0353
0	0.0029	0.0733	0.0855	0.099	0.0698
-10	0.0007	0.0356	0.0220	0.0224	0.0382
-20	0.0002				
-30	0.0002				
-40	0.0002				
-50	0.0002				
-60	0.0002				
-70	0.0002				
-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/cm²	
	2.2 dBi Dipole V transmits. Integral H does not transmit	2.2 dBi Dipole H transmits. Integral H does not transmit.
90	0.0079	0.0040
80	0.0078	0.0059
70	0.0082	0.0083
60	0.0085	0.0156
50	0.0092	**0.0178**
40	0.0133	0.0153
30	0.0125	0.0156
20	0.0084	0.0159

Angle, degree	Measured power, mW/cm²	
	2.2 dBi Dipole V transmits. Integral H does not transmit	2.2 dBi Dipole H transmits. Integral H does not transmit.
10	0.0056	0.0135
0	0.0042	0.0128
-10	0.0044	0.0129
-20	0.0052	0.0102
-30	0.0073	0.0099
-40	0.0124	0.0098
-50	0.0143	0.0109
-60	0.0153	0.0112
-70	**0.0198**	0.0126
-80	0.0153	0.0124
-90	0.0124	0.0083

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	0.0005					
90	0.0009					
80	0.0012					
70	0.0024					
60	0.0039					
50	0.0049					
40	0.0059					
30	0.0068	0.0059	0.0066	0.0072	0.0007	0.0003
20	0.0095	0.0098	0.0112	0.0102	0.0012	0.0003
10	0.0150	0.0131	0.0138	0.0150	0.0011	0.0003
0	0.0167	0.0137	0.0139	0.0168	0.0007	0.0002
-10	0.0129	0.0125	0.0124	0.0125	0.0002	0.0004
-20	0.0090	0.0093-	0.0099	0.0079	0.0002	0.0002
-30	0.0069	0.0061-	0.0068	0.0064	0.0002	0.0003
-40	0.0055					
-50	0.0042					
-60	0.0031					
-70	0.0019					
-80	0.0015					
-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[11]

Angle, degree	Measured power, mW/cm²	
	Integral H transmits*	Integral V transmits*
90	0.0016	**0.0008**
80	0.0013	0.0006
70	0.0019	0.0005
60	0.0019	0.0003
50	0.0015	0.0002
40	0.0011	0.0002
30	0.0004	0.0002
20	0.0006	0.0005

[11] See footnote 4

Angle, degree	Measured power, mW/cm²	
	Integral H transmits*	Integral V transmits*
10	0.0008	0.0002
0	0.0013	0.0005
-10	0.0012	0.0004
-20	0.0007	0.0005
-30	0.0010	0.0006
-40	0.0012	0.0004
-50	0.0019	0.0003
-60	0.0028	0.0002
-70	**0.0036**	0.0002
-80	0.0028	0.0003
-90	0.0024	0.0002

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.[12]

Height, cm	Measured power, mW/cm²					
	Integral V transmits, 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	0.0001					
90	0.0002					
80	0.0002					
70	0.0002					
60	0.0003					
50	0.0005					
40	0.0009					
30	0.0006					
20	0.0008	0.0008	0.0035	0.0032	0.0026	0.0021
10	0.0008	0.0008	0.0026	0.0071	0.0059	0.0022
0	0.0008	0.0008	0.0013	0.0120	0.0090	0.0009
-10	0.0007	0.0006	0.0019	0.0091	0.0076	0.0014
-20	0.0004	0.0004	0.0019	0.0050	0.0045	0.0016
-30	0.0003	0.0003	0.0015	0.0052	0.0049	0.0015
-40	0.0002					
-50	0.0002					
-60	0.0002					
-70	0.0002					
-80	0.0002					
-90	0.0002					
-100	0.0002					

[12] See footnote 4

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	0.0001					
90	0.0002					
80	0.0002					
70	0.0002					
60	0.0003					
50	0.0004					
40	0.0009					
30	0.0011	0.0013	0.0056	0.0058	0.0050	0.0040
20	0.0013	0.0015	0.0062	0.0079	0.0059	0.0049
10	0.0009	0.0010	0.0055	0.0073	0.0045	0.0033
0	0.0027	0.0029	0.0050	0.0089	0.0073	0.0025
-10	0.0029	0.0026	0.0061	0.0185	0.0159	0.0033
-20	0.0011	0.0013	0.0129	0.0277	0.0260	0.0105
-30	0.0005	0.0007	0.0138	0.0182	0.0174	0.0126
-40	0.0004					
-50	0.0004					
-60	0.0002					
-70	0.0002					
-80	0.0002					
-90	0.0002					
-100	0.003					

5.4 INVESTIGATION OF THE EUT WITH THE YAGI ANTENNA

5.4.1 YAGI ANTENNA PATTERN AND MPE VERSUS HEIGHT

MPE measurements from the Yagi antenna at the 20-cm distance between the probe and the antenna were conducted as the electric field strength measurements and the results were converted to the power density measurements based on the far-filed approximation. 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 1 mW/cm² at the frequencies above 1.5 GHz.

TABLE 5.4.1: RADIATION PATTERN FOR YAGI ANTENNA[13]

Azimuth, degree	MPE, V/m	MPE, mW/cm²		Azimuth, degree	MPE, V/m	MPE, mW/cm²
180	0.0	0.0		180	0.0	0.0
170	0.0	0.0		190 (-170)	0.0	0.0
160	0.0	0.0		200 (-160)	0.0	0.0
150	0.0	0.0		210 (-150)	0.0	0.0
140	0.0	0.0		220 (-140)	0.0	0.0
130	0.0	0.0		230 (-130)	1.5	0.00060
120	0.0	0.0		240 (-120)	2.2	0.00128
110	2.05	0.0012		250 (-110)	2.8	0.00208
100	0.0	0.0		260 (-100)	4	0.00424

[13] See footnote 4

Azimuth, degree	MPE, V/m	MPE, mW/cm²		Azimuth, degree	MPE, V/m	MPE, mW/cm²
90	0.0	0.0		270 (-90)	2.9	0.0022
80	2.05	0.0011		280 (-80)	3.6	0.0034
70	3.3	0.0029		290 (-70)	2.0	0.0011
60	1.9	0.0010		300 (-60)	4.3	0.0049
50	1.6	0.0007		310 (-50)	2.0	0.0011
45	5.3	0.0075		315 (-45)	4.5	0.0054
40	4.1	0.0045		320 (-40)	3.3	0.0029
35	1.9	0.0010		325 (-35)	1.3	0.0004
30	5.8	0.0089		330 (-30)	4.7	0.0059
25	5.6	0.0083		335 (-25)	4.9	0.0064
20	2.4	0.0015		340 (-20)	1.6	0.0007
15	6.8	0.0123		345 (-15)	7.9	0.0166
10	12.4	0.0408		350 (-10)	12.5	0.0411
5	16.8	0.0749		355 (-5)	17.6	0.0822
0 (360)	18.5	0.0908		0 (360)	19.8	0.1040

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[14]

Height, cm	MPE, V/m	MPE, mW/ cm²		Height, cm	MPE, V/m	MPE, mW/ cm²
0	18.5	0.0908		0	18.9	0.0948
10	15.80	0.0662		-10	12.5	0.0411
20	7.55	0.0151		-20	4.00	0.0042
30	1.97	0.0010		-30	2.35	0.0015
40	2.24	0.0013		-40	1.55	0.0006
50	2.35	0.0015		-50	0.95	0.0002
60	1.99	0.0011		-60	0.99	0.0003
70	1.77	0.0008		-70	0.76	0.0002
80	1.79	0.0009		-80	0.61	0.0001
90	1.52	0.0006		-90	0.70	0.0002
100	1.24	0.0004		-100	0.40	0.0001

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.

[14] See footnote 4

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[15]

Position of the Yagi antenna	MPE, V/m / mW/cm²				
	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	0.81 / 0.0002	0.48 / 0.0001	2.13 / 0.0012	2.05/ 0.0011	2.0 /0.0012
Yagi 20 cm to the right from the EUT	0.51/ 0.0001	0.47 / 0.0001	3.83 / 0.0042	3.79 / 0.0040	3.8 /0.0039
Wall-mounted position of the EUT					
Yagi is 20 cm above the EUT	1.74 / 0.0009	1.11 / 0.0043	2.61 / 0.0018	2.32 / 0.0014	2.12 / 0.0012
Yagi 20 cm to the right from the EUT	1.85 / 0.0010	1.25 / 0.0004	3.99 / 0.0042	3.54 / 0.0033	3.24 / 0.0028

TABLE 5.4.4: INFLUENCE OF CO-LOCATION OF THE INTEGRAL ANTENNA TO THE MPE RESULTS FROM THE YAGI ANTENNA[16]

Position of the Yagi antenna	MPE, V/m / mW/cm²				
	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	1.33 / 0.0005	0.68 / 0.0001	19.88 / 0.105	18.66 / 0.0924	18.99 / 0.0957
Yagi 20 cm to the right from the EUT	0.39 / 0.0000	0.35 / 0.0000	18.55 / 0.0913	18.88 / 0.0946	17.89 / 0.0849
Wall-mounted position of the EUT					
Yagi is 20 cm above the EUT	2.6 / 0.0018	0.55 / 0.0001	18.98 / 0.0959	19.88 / 0.1048	19.50 / 0.1009
Yagi 20 cm to the right from the EUT	1.20 / 0.0004	0.36 / 0.0000	18.56 / 0.0915	19.12 / 0.0970	18.90 / 0.0948

[15] See footnote 4

[16] See footnote 4

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.
An example of the FCC required a RF safety warning for the user manual for all antennas of this application[17] is shown below:

"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 20 cm co-located separation distance for the access point of 5 GHz Integrated antenna. The access point's co-located 2.4 GHz 2.2 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."

[17] "Antennas of this application" are shown in section 2.5.2 of this report