Engineering and Testing for EMC and Safety Compliance

RF Maximum Permissible Exposure (MPE) Report for Controlled and Uncontrolled Environments

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Model: M5300 900 MHz Mobile Radio

FCC ID: OWDTR-0049-E
IC: 3636B-0049

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1 MPE Measurements and Applicable Regulations

This test report presents the results of Maximum Permissible Exposure (MPE)[1] measurements performed on the M/A-Com, Inc. mobile radio, Model 5300, operating in the frequency ranges 896-901 MHz and 935-940 MHz. The tests were performed in accordance with TCB training material and the following parts of the FCC Rules and Regulations and Industry Canada Radio Standard Specification:

- IEEE Std C95.1: 1999: "IEEE Standard for Safety Levels with Respect to Human Exposure to Radio Frequency Electromagnetic Fields, 3 kHz – 300 GHz"
- IEEE Std C95.3: 2002: "IEEE Recommended Practice for Measurements and Computations of Radio Frequency Electromagnetic Fields with Respect to Human Exposure to Such Fields, 100 kHz – 300 GHz"
- FCC OET Bulletin 65, Edition 97-01: "Evaluating Compliance with FCC Guidelines for Human Exposure to Radiofrequency Electromagnetic Fields"
- FCC Supplement C to OET Bulletin 65, Edition 01-01: "Additional Information for Evaluating Compliance of Mobile and Portable Devices with FCC Limits for Human Exposure to Radiofrequency Emission."
- Subpart I, Part 1 of 47 CFR FCC Rules and Regulations, Edition 10-1-06: "Procedures Implementing the National Environmental Policy Act of 1969." Specifically, Paragraph 1.1310: "Radiofrequency Radiation Exposure Limits"
- Subpart J, Part 2 of 47 CFR FCC Rules and Regulations, Edition 10-1-06: "Equipment Authorization Procedures." Specifically, Paragraph 2.1091: "Radiofrequency Radiation Exposure Evaluation: Mobile Devices"
- RSS-102, Issue 2, November 2005: "Spectrum Management and Telecommunications Radio Standards Specification. Radiofrequency Exposure Compliance of Radiocommunication Apparatus (All Frequency Bands.)"

[1] By definition, maximum permissible exposure (MPE) is rms or peak electric (or 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 Identification of the EUT[2]

The EUT is a mobile radio operating in two frequency bands, 896-901 MHz and 935-940 MHz, an RF antenna inserted into the antenna base, and a control unit. The antenna base has an RF cable for connection to the EUT. The GPS RX antenna base has two cables: an RF cable and a GPS cable.

General information about the EUT is shown below.

Manufacturer's Name	M/A-COM, Inc.
Manufacturer's Address	221 Jefferson Ridge Parkway Lynchburg, VA 24501, USA
Device Type	Mobile radio with the antennas listed below
EUT Model	M5300
Serial # of the Radio	ET19LL09U
Model #/ Serial # of the Control Head	CU23218-0004 / 96000165
FCC ID of the EUT	OWDTR-0049-E
IC ID of the EUT	3636B-0049
Operating Frequency Ranges	896-901 MHz and 935-940 MHz
RF Max Power, Rated	30 W
TX Duty Cycle	100%
Antennas Tested	See nested table below
Year of Manufacture	2007

Model #	Antenna Type	Antenna Gain, dBd
AN-025177-004	Combined GPS/900 MHz, Elevated Base	3
AN-025177-005	900 MHz with Magnetic Mount	3
AN-025177-009	900 MHz with Low Profile Roof Mount	3

[2] Equipment Under Test would be referenced hereafter as EUT

3 Modifications

No modifications were made to the EUT during testing.

4 Test Laboratory

Rhein Tech Laboratories, Inc. (RTL) test personnel performed testing for which the company is accredited by NVLAP. Testing was performed at the RTL test facility located at 360 Herndon Parkway, Suite 1400, Herndon, VA 20170. Different regulatory bodies, including the FCC and IC, approved this facility for conducting tests and measurements on a contractual basis.

5 Turnaround Time

The EUT was ready for the MPE investigation on 05/14/07. The investigation was finished on 05/23/07.

6 Test Equipment, Accessories and Test Setup

The test equipment used for the measurements is shown in Table 6-1.

Table 6-1: Test Equipment

RTL Barcode	Manufacturer	Model	Equipment Type	Serial #	Calibration Due Date
901182	Wandel & Goltermann	TYPE-8	E- Field Probe, 10 kHz to 3 GHz	AH-0021	01/06/08
901183	Wandel & Goltermann	EMR 200[3]	Radiation Meter	AE-0024	01/06/08
901109	SPER Scientific	800041	Digital Higro Thermometer	NA	12/19/07
901366	Control Company	PTB210 Class A	Barometer	W2940009	01/23/08
901184	Agilent Technologies	E4416A	EPM-P Power Meter, Single Channel	GB41050573	10/03/07
901356	Agilent Technologies	E9323A	Power Sensor	31764-264	10/03/07
900819	Weinschel Corporation	BF0830	Attenuator 10 db	N/A	12/02/08

During testing, RTL used EUT accessories such as power supplies, a fan, and a control head. Table 6-2 shows detailed information about the M/A-Com-provided parts of the EUT and necessary accessories.

[3] Per Operating Manual for the EMR 200 radiation meter, the device with the Type 8 probe might measure electromagnetic power in the range of 0.00027 - 170 mW/cm^2. The recommended environment is the following: ambient temperature: (23 ± 3) °C, ambient relative humidity: 25% - 75%.

Table 6-2: EUT and Accessories

Part	Manufacturer	Model	Serial #	FCC ID	IC ID
Radio	M/A-Com, Inc.	M5300	ET19LL09U	OWDTR-0049-E	3636B-0049
Power Supply	Samplex America, Inc.	SEC 1212	03051-2K07-00197	N/A	NA
Power Supply	Samplex America, Inc.	SEC 1223	03061-2K07-00197	NA	NA
Control Head	M/A-Com, Inc.	CU23218-0004	96000165	N/A	NA
Antenna # 1	M/A-Com, Inc.	AN-025177-004	N/A	N/A	NA
Antenna # 2	M/A-Com, Inc.	AN-025177-005	N/A	N/A	NA
Antenna # 3	M/A-Com, Inc.	AN-025177-009	N/A	N/A	NA
Fan	Electrix	3037	K128	N/A	NA

To avoid influence of ambient radiation, RTL conducted MPE measurements in a semi-anechoic chamber. Details of the test setup are as follows:

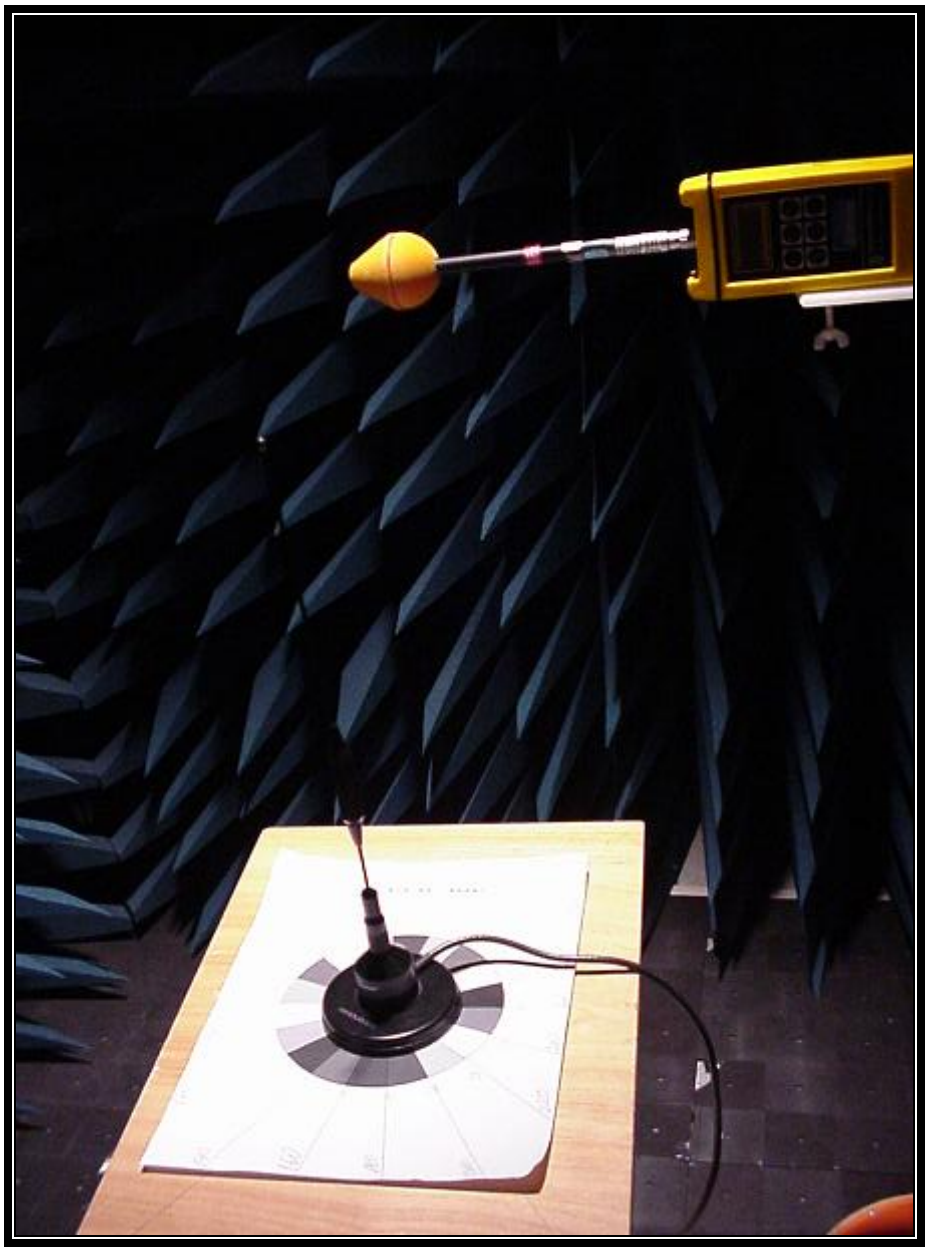
- The antenna under test was installed on the appropriate antenna base and was connected to the EUT with either the RF cable or with two cables: an RF cable and a GPS cable[4], if the GPS RX antenna base was used.
- When the antenna on the magnetic base was tested, the base was placed in the center of the 20x20 cm^2 metal plate (simulating the actual installation environment on the car roof) located on the 80 cm tall wood table. The metal plate was labeled with 18 azimuth angles (every 20°) the specific angle of the antenna to the RF probe.
- When the elevated or low profile antennas were tested, a metal plate was used that had a circular cutout so that the cables could be routed through the plate. The label with the angles was on the floor under the table and the table was rotated versus azimuth.
- The EUT, its power supplies, control unit, and fan were located on the same wooden platform on which the table was placed.
- The test probe was solidly connected to the radiation meter attached to the plastic mast in front of the EUT's antenna.
- During the MPE measurements, the EUT was set to transmit at maximum RF power and 100% duty cycle.

The typical test setups with different antennas are shown in Photographs 6-1 and 6-2. The antennas under test are shown in Photograph 6-3. Note that the height of the elevated antenna base is comparative with the antenna length.

[4] The GPS RX base contained a GPS receiving antenna and a preamplifier. Its internal devices receive power through the GPS coax connected to the transceiver.

Photograph 6-1: MPE Test Setup for the GPS/900 MHz Antenna in the Elevated Base

Photograph 6-2: Part of the MPE Test Setup with the Magnetic Base Antenna



Photograph 6-3: Tested Antennas on Their Masts

Note to Photograph 6-3:

The following antennas in their bases are shown in the photograph, from left to right:

- AN-025177-009
- AN-025177-005
- AN-025177-004 (this antenna is shown installed in the elevated antenna base)

7 Justification of the Chosen Transmitting Mode and Frequency

The EUT is able to transmit with a non-modulated carrier and with five types of modulations: voice (analog) modulation and the following digital frequency modulations: P25, OTP, 4800N, and 9600N. To determine the worst case operating mode, we made the following test:

- We measured the output power of the EUT set to transmit with the unmodulated carrier at maximum RF power at different frequencies. These measurements showed that the frequency with the highest power level was 900.675 MHz.
- Setting the EUT to transmit at maximum RF power at 900.675 MHz, we measured the RF output power with the unmodulated carrier and with different types of modulations in sequence. The test results showed that the RF output power of the EUT was constant and equal to 33.1 W.

We conducted MPE measurements with the EUT set to transmit at 900.675 MHz at the highest RF power and P25 modulation.

8 MPE Limits for the EUT

The FCC and IC have the same MPE limits for the EUT's frequency range, which are shown for controlled and uncontrolled environments, together with the recommended averaging time required for MPE measurements in Tables 8-1 and 8-2 below. The limits are based on the recommended MPE Guidelines published by the National Council on Radiation Protection and Measurements in "Biological Effects and Exposure Criteria for Radiofrequency Electromagnetic Fields."

Table 8-1: FCC/IC MPE Limit and Averaging Time in Uncontrolled Environment

Frequency Range, MHz	Power Density (S), mW/cm^2	Averaging Time, min
300-1500	f / 1500	30
Note that "f" in the column for power density is the frequency in MHz		

Table 8-2: FCC/IC MPE Limit and Averaging Time in Controlled Environment

Frequency Range, MHz	Power Density (S), mW/cm^2	Averaging Time, min
300-1500	f / 300	6
Note that "f" in the column for power density is the frequency in MHz		

The MPE limits for the EUT at 900.675 MHz are shown in Table 8-3.

Table 8-3: MPE Limits for the Frequency Transmitted by the EUT

Frequency, MHz	MPE Limit for Controlled Environment, mW/cm^2	MPE Limit for Uncontrolled Environment, mW/cm^2
900.675	3.0	0.6

9 Calculating the Safe Distance from the EUT's Antenna

Before starting MPE measurements, we calculated the safe distance, R_{safe} using a common formula for a far-field region (see Equation 9-1):

$$R_{safe} = \sqrt{(P_{max} \times G_N \times \eta / 4\pi S,} \qquad 9\text{-}1,$$

where G_N is a numerical antenna gain, P_{max} and S are the maximum power input to an antenna and the MPE limit for a power density, respectively; η is the duty cycle (in percentage) divided by 100; η = 1 in our case.

However, since the cable loss of a long RF cable connecting the EUT and the antenna under test decreases the output power delivered to the antenna and influences the value of the safe distance, we have to adjust the power delivered to the antenna in equation 9-1.

Antennas # AN-025177-004 and AN-025177-009 are connected to the EUT via the attached Belden cable 8259 RG-58/U 4.6 m long. In accordance with the manufacturer's specification, this cable has a 3 dB insertion loss. Antenna # AN-025177-005 is connected to the EUT with the attached Belden cable 8240 RG-58/U 3.5 m long. This cable decreased the output power to the antenna by 1.6 dB.
We incorporated the cable loss into equation 9-1 through the output power value.

The R_{safe} calculations, including the power reduction for cable loss, are shown in Table 9-1.

Table 9-1: Calculated R_{safe} for different environments

Cable Type/ Loss, dB	Antenna model	R_{safe} for Controlled Environment, cm	R_{safe} for Uncontrolled Environment, cm
8259 RG-58/3	AN-025177-004, AN-025177-009	38.0	84.9
8240 RG-58/1.6	AN-025177-005	44.5	99.5

10 Standard Test Conditions and Engineering Practices

Except as noted herein, the following conditions and procedures were fulfilled during the testing:

1. ANSI C63.4 requires the ambient temperature and relative humidity to be within the ranges of 10°C to 40°C and 10% to 90%, respectively. With respect to the narrower ranges recommended for the power meter used for the measurements, ambient conditions shall be in line with the power meter ranges. Actual values of ambient temperature and relative humidity are shown in Section 12 of this test report.

2. Measurement results presented in Section 12 MPE, unless otherwise noted, show the highest measured level of MPE.

11 Measurement Procedure

1. The test setup was as described in Section 6 of this test report. The EUT, the control head, two power supplies (one for the EUT and another for the control head) were located at a distance of at least 1.5 meters from the transmitting antenna and at a larger distance from the power density meter in order to minimize interference with the measurements.
2. Polarization of the EUT's antenna located on the test desk was vertical, which is its polarization in actual use.
3. The EUT at the chosen modulation was set to transmit at the chosen frequency and modulation at maximum RF power. During preliminary measurements, we set the distance between the power density probe and the EUT's antenna equal to the calculated R_{safe} (Table 9-1) applicable either for controlled or uncontrolled environments.
4. Power density measurements were taken at different heights of the probe from the ground (0.1 to 2 meters) while rotating versus azimuth (from 0° to 360°) either the antenna under test (if it was connected to a magnetic base) or the desk on which the other type of antenna was fixed.
5. The azimuth between the probe and the antenna position corresponding to the highest MPE level was chosen as the "worst case" position for the final measurements.
6. For the final measurements, we also adjusted the distance between the test probe and the tested antenna to the real safe distance, R_{real}, such that the measured highest power density in the "worst case" position was slightly less than the test limit.
7. Final measurements were conducted at the chosen azimuth and different heights of the probe above the ground. The measurement results are shown in Section 12.
8. Average values of power density were calculated for the imaginary whole human body (0.1–2.0 m), for the lower part of the body (0.1–0.9 m) and for the upper part of the body (1.0–2.0 m). The results of calculations are shown in Section 12.

12 Test Results

The MPE measurements were conducted 05/14/07-05/21/05 by Galina Yushina.

Ambient conditions during the MPE investigation varied in the following ranges:

- Temperature varied from 23 to 25°C.
- Relative humidity varied from 35 to 45%
- Atmospheric pressure varied from 750 to 755 mmHg.

The MPE measurement procedure was in line with the description in Section 11. The EUT was tuned to the chosen frequency, to the maximum transmitting RF power and was set to P25 modulation.

Tables 12-1 through 12-4 demonstrate the test results for the EUT with the AN-025177-005 antenna.

Table 12-1: MPE for AN-025177-005 Antenna, Controlled Environment

MPE, mW/cm^2, measured at the distance of **38 cm** betwee										
10	20	30	40	50	60	70	80	90	100	
0.01	0.03	0.06	0.08	0.11	0.22	0.62	1.25	2.38	2.52	

Table 12-2: MPE for Body Parts for AN-025177-005 Antenna, Controlled Environment

Part of the body / averaging points	Averaged Power Density at the **R_{real} = 38 cm**, mW/cm^2
Whole body (0.1 m to 2.0 m)	0.47
Lower body (0.1 m to 0.9 m)	0.53
Upper body (1.0 m to 2.0 m)	0.43

Table 12-3: MPE for AN-025177-005 Antenna, Uncontrolled Environment

MPE, mW/cm^2, measured at the distance of **85 cm** betwee										
10	20	30	40	50	60	70	80	90	100	
0.03	0.02	0.03	0.04	0.04	0.07	0.16	0.23	0.39	0.58	

Table 12-4: MPE for Body Parts for AN-025177-005 Antenna, Uncontrolled Environment

Part of the body / averaging points	Averaged Power Density at the **R_{real} = 85 cm**, mW/cm^2
Whole body (0.2 m to 2.0 m)	0.18
Lower body (0.2 m to 0.9 m)	0.11
Upper body (1.0 m to 2.0 m)	0.23

Tables 12-5 through 12-8 demonstrate the test results for the EUT with the AN-025177-009 antenna

Table 12-5: MPE for AN-025177-009 Antenna, Controlled Environment

MPE, mW/cm^2, measured at the distance of **25 cm** between the probe and the antenna and at the height (cm) below																		

Table 12-6: MPE for Body Parts for AN-025177-009 Antenna, Controlled Environment

Part of the body / averaging points	Averaged Power Density at the **R_{real} = 25 cm**, mW/cm^2
Whole body (0.1 m to 2.0 m)	0.52
Lower body (0.1 m to 0.9 m)	0.35
Upper body (1.0 m to 2.0 m)	0.67

Table 12-7: MPE for AN-025177-009 Antenna, Uncontrolled Environment

MPE, mW/cm^2, measured at the distance of **60 cm** betwee										
10	20	30	40	50	60	70	80	90	100	
0.06	0.05	0.05	0.12	0.16	0.17	0.23	0.32	0.52	0.58	

Table 12-8: MPE for Body Parts for AN-025177-009 Antenna, Uncontrolled Environment

Part of the body / averaging points	Averaged Power Density at the **R_{real} = 60 cm**, mW/cm^2
Whole body (0.1 m to 2.0 m)	0.24
Lower body (0.1 m to 0.9 m)	0.19
Upper body (1.0 m to 2.0 m)	0.28

Tables 12-9 through 12-12 demonstrate the test results received for the EUT with the AN-025177-004 antenna.

Table 12-9: MPE for AN-025177-004 Antenna, Controlled Environment

MPE, mW/cm^2, measured at the distance of **24 cm** betwee										
10	20	30	40	50	60	70	80	90	100	
0.11	0.02	0.04	0.07	0.05	0.08	0.12	0.20	0.36	0.83	

Table 12-10: MPE for Body Parts for AN-025177-004 Antenna, Controlled Environment

Part of the body / averaging points	Averaged Power Density at the $\mathbf{R_{real}}$ **= 24 cm**,, mW/cm^2
Whole body (0.1 m to 2.0 m)	0.56
Lower body (0.1 m to 0.9 m)	0.12
Upper body (1.0 m to 2.0 m)	0.92

Table 12-11: MPE for AN-025177-004 Antenna, Uncontrolled Environment

MPE, mW/cm^2, measured at the distance of **70 cm** betwee										
10	20	30	40	50	60	70	80	90	100	
0.03	0.02	0.01	0.03	0.02	0.04	0.04	0.04	0.08	0.19	

Table 12-12: MPE for Body Parts for AN-025177-004 Antenna, Uncontrolled Environment

Part of the body / averaging points	Averaged Power Density at the $\mathbf{R_{real}}$ **= 70 cm**, mW/cm^2
Whole body (0.1 m to 2.0 m)	0.14
Lower body (0.1 m to 0.9 m)	0.03
Upper body (1.0 m to 2.0 m)	0.23

13 Conclusion

1. The MPE measurements for controlled and uncontrolled environments shown in this report were conducted per the applicable FCC/IC Rules, Regulations and Guidance, and were used to determine the minimum safe distance between the EUT antennas and a user.

2. As is shown in Section 12, the measured MPE are below the maximum allowed limits.

3. The User Manual shall have a statement regarding the safe distance similar to the one shown below:

"Based on the highest radiated RF power and with respect to the cables supplied with the antennas, the following distances are considered as safe distances for controlled and uncontrolled environments for the EUT antennas:

Antenna Model/Cable Model and Length	Safe Distance, R_{safe}, cm for Different Environments	
	Controlled Environment	Uncontrolled Environment
AN-025177-004/Belden 8259 RG-58 4.6 m	24	70
AN-025177-005/Belden 8240 RG-58 3.6 m	38	85
AN-025177-009/Belden 8259 RG-58 4.6 m	25	60