Certificate Number: 1449-02

MOTOROLA

ACCREDITED

CGISS EME Test Laboratory
8000 West Sunrise Blvd
Fort Lauderdale, FL. 33322

MPE Compliance Test Report

Date of Report:	July 18, 2003
Report Revision(s):	Rev. A
Device Manufacturer:	Motorola
Device Description:	45W 4 channel Mobile Radio 146-174MHz
Classification:	Occupational/Controlled Exposure
FCC ID:	ABZ99FT3046
Device Model:	PMUD1875A

Test Period:	5/14/03, 6/23/03
Test Engineer:	Jim Fortier (Principle Staff Engineer)
Author:	Michael Sailsman (Global EME Regulatory Affairs Liaison)

Note: Based on the information and the testing results provided herein, the undersigned certifies that when used as stated in the operating instructions supplied, said product complies with all applicable national and international reference standards and guidelines.

Signature on File	7/18/03
Ken Enger Senior Resource Manager, Laboratory Director, CGISS EME Lab Phone: 954-723-6299 Fax: 954-723-3803	Date Approved

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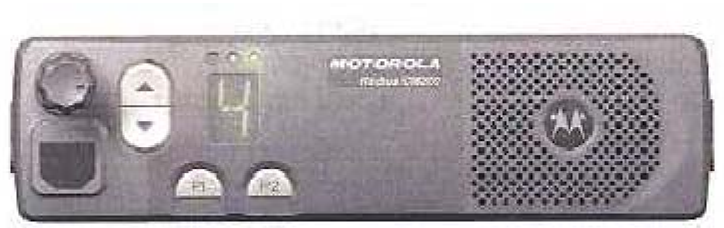
REVISION HISTORY

Date	Revision	Comments
6/5/03	O	Initial release Prototype results
7/18/03	A	Revised for general clarifications, added additional roof test results, and the expanded the SAR computational model in Appendix-B

1.0 Product Description



FCC ID: ABZ99FT3046, model PMUD1875A is a mobile transceiver that utilizes frequency modulation (FM) half duplex transmission technology. The intended use of the radio is Push-To-Talk (PTT) while the device is properly installed in a vehicle with the offered external antennas mounted at the center of the roof or trunk.
This device will be marketed to and used by employees solely for work-related operations, such as public safety agencies, e.g. police, fire and emergency medical. User training is the responsibility of these agencies, who can be expected to employ the usage instructions, safety information and operational cautions set forth in the user's manual, instructional sessions or other means. Motorola also makes available to its customers training classes on the proper use of two-way radios and wireless data devices. This device is classified as Occupational/Controlled Exposure. However, In accordance with FCC requirements, the passengers inside the vehicle and the bystanders external to the vehicle are evaluated to the General Population/Uncontrolled Exposure Limits. The transmit frequency band is 146-174 MHz. The rated power of the device is 45 watts with a maximum conducted power output of 54 watts.

2.0 Offered Options and Accessories

Antenna

HAD4009AR 162-174 MHz ¼ wave 0dBd antenna; 16.8 inches
HAD4014AR 140-174 MHz 3dBd gain antenna; 46.0 inches
HAD4007A   144-150.8 MHz ¼ wave 0dBd antenna; 19.3 inches
HAD4008A   150.8-162 MHz ¼ wave 0dBd antenna; 18.0 inches
RAD4000A   136-174 MHz 3dBd gain antenna; 52 inches un-trimmed

Note: The ¼ wave 0dBd antennas are identical except for the length which is frequency dependant.
The HAD4014AR 3 dBd gain antenna is a conventional base loaded antenna with spring mounting.
The RAD4000A is a 3 dBd gain Spectrum Series base loaded antennas trimmed for three different frequencies.

3.0 Measurement Standards

Measurements were performed according to FCC Limits Per 47 CFR 2.1091 (b) for General Population/Uncontrolled RF Exposure.
For frequencies ranging from 146-174 MHz the MPE (Maximum Permissible Exposure) limit to electromagnetic energy in equivalent plane wave free-space power density is 0.20 mW/cm^2.

4.0 Data Collection Consideration

Power density testing was performed with DUT installed in a 1991 Ford Taurus (4-door). Measurement data was taken with the vehicle running at idle and the vehicle battery measuring 14.0 volts.

5.0 Measurement System Uncertainty Levels

The information below presents an estimate of the possible errors that are associated with the measurement system.

Description	Error
NARDA Survey Meter	**± 3%**
Repeatability Accuracy	**± 7%**

6.0 Method of Measurement

6.1 EME measurements made on trunk mounted antennas

(for reference, see Antenna Location Layout drawings in Appendix)

6.1.1 External vehicle EME measurement

(Antenna mounted at trunk center)

With the survey meter and probe, take ten (10) measurements, at the standard test distance of 60 cm to the antenna, from the back of the vehicle in a vertical line and then average the results. These measurements are taken and recorded at every twenty (20) centimeters over a range starting at twenty (20) centimeters above ground and ending at 2.0 meters; this would be representative of a person standing behind a vehicle during a mobile radio transmission.
Note: the distance from the trunk-mounted antenna to the edge of the vehicle is 26cm and the distance from the edge of the vehicle's trunk to the MPE vertical line assessment is 34cm.

6.1.2 Internal vehicle EME measurement

(Antenna mounted at trunk center)

While rotating survey meter probe through 180 degrees to ensure that the highest level is found, scan the inside of the vehicle, both front and back seating areas, for the highest level in each location. After the highest level is found, scan vertically making two (2) additional measurements within an area approximately 40 cm wide (representing the width of a person) so as to have a total of three (3) measured points as indicated below that will be averaged.

a) Head area

b) Chest area

c) Lower Trunk area

6.2 EME measurements made on center roof mounted antennas

(for reference, see Antenna Location Layout drawings in Appendix)

6.2.1 External vehicle EME measurement

With the survey meter and probe, take ten (10) measurements, at the standard test distance of 60 cm from the vehicle-mounted antenna, in a vertical line and then average the results. These measurements are taken and recorded at every twenty (20) centimeters over a range starting at twenty (20) centimeters above ground and ending at 2.0 meters; this would be representative of a person standing next to a vehicle during a mobile radio transmission.

Note: Actual test distance was 110cm (60cm from antenna to roof edge; 30cm from roof edge to edge of car door; 20cm vertical test line to car door); this is the closest distance that can be achieved to an antenna mounted to the center of the vehicle used for MPE compliance assessment while maintaining the recommended minimum separation distance of 20cm (as specified in IEEE C95 and by NARDA) from the measurement probe to the vehicle body.

6.2.2 Internal vehicle EME measurement

While rotating survey meter probe through 180 degrees to ensure that the highest level is found, scan the inside of the vehicle, both front and back seating areas, for the highest level in each location. After the highest level is found, scan vertically making two (2) additional measurements within an area approximately 40 cm wide (representing the width of a person) so as to have a total of three (3) measured points as indicated below that will be averaged.

a) Head area

b) Chest area

c) Lower Trunk area

7.0 Test Site

The test site is the Motorola Commercial Government Industrial Solution Sector (CGISS) world wide electromagnetic exposure (EME) open area test site located at 8000 W. Sunrise Blvd., Plantation, FL. 33322.

8.0 Measurement System/Equipment

The minimum equipment required will mainly consist of a test vehicle, radio frequency radiation test set consisting of an Electromagnetic Radiation Survey Meter, E/H-Field Test Probes, and typical antenna configurations.
Below are the test equipment used to assess compliance:

a) Automobile: 1991 Ford Taurus, 4-Door

b) E-Field Survey Meter - NARDA Model 8718 (01108); Calibration date: 4/14/03

c) E-Field (Electric Field) Probe - NARDA Model 8722B (13001);

Calibration date: 5/6/03

d) H-Field (Magnetic Field) Probe - NARDA Model 8731 (03006);

Calibration date: 3/21/03

e) Antennas - (1/4 wave 0dBd and 3.0 dBd gain antennas)

9.0 Test Unit Description

Power density measurements were performed on a 45 watts mobile radio; model number PMUD1875A serial number 019PROTO01. The frequency band of the mobile was 146-174 MHz; the test frequencies were 146.000, 155.320, 164.670, and 174.000 MHz. The ¼ wave 0dBd, and 3.0dBd mobile antennas listed in section 2.0 were used to assess MPE compliance.

10.0 Test Set-Up Description

Following are the standard mobile antenna test configurations used for this product.
(for reference, see Antenna Location Layout drawings in Appendix)

a) ¼ wave antenna models HAD4009AR, HAD4007A, HAD4008A as well as a 3.0dBd gain antenna model HAD4014AR and 3.0dBd gain antenna model RAD4000A mounted on the center of the trunk.
b) ¼ wave antenna, model HAD4007A mounted on the center of the roof. This antenna was selected because it exhibited the highest MPE results during the 60 cm trunk testing.

11.0 Test Results

Measurements were taken with the antenna located in two areas: the roof center, and trunk center. Below is the raw MPE data for all measured grid points. Results are based on a 50%

duty cycle with the radio operating in accordance with the User Manual instructions. The bolded power density results represents the highest MPE results observed.

Raw MPE Data; Test Frequencies and measured Po (W):
146.000 MHz (Po=53.2), 155.320 MHz (Po=56.4), 164.670 MHz (Po=56.5), 174.000 MHz (Po = 52.5)
Meter reads in % of controlled limit; controlled limit = 1.00 mW/cm^2 for 30-300 MHz
(Cal factors presented herein are automatically accounted for in the meter used for assessments)
General Population MPE limits = 0.20 mW/cm^2 / 1.6mW/g (Bystanders & Passengers)
External Vehicle Power Density (Pwr. Den. (cal.)) = average over body/2
Internal Vehicle Power Density (Pwr. Den. (cal.)) = average over (head/chest/leg)/2

Note: The average over the body test methodology is consistent with IEEE/ANSI C95.1-1999 guidelines

Table 1

External Vehicle MPE Assessment @ 146.000 MHz						
Antenna Location	Antenna /gain	Meas. Distance (cm)	E/H Field	Calibration Factor	Average over Body (mW/cm^2)	Pwr. Density (mW/cm^2)
Trunk	HAD4007A/0dB	60	E	0.82	0.664	**0.33**

Measurement grid					
Test position	Height (cm)	% of control limit	Test position	Height (cm)	% of control limit
1	20	19.0	6	120	115.0
2	40	37.0	7	140	104.0
3	60	55.0	8	160	79.0
4	80	68.0	9	180	50.0
5	100	102.0	10	200	35.0

Table 2.

External Vehicle MPE Assessment @ 146.000 MHz						
Antenna Location	Antenna /gain	Meas. Distance (cm)	E/H Field	Calibration Factor	Average over Body (mW/cm^2)	Pwr. Density (mW/cm^2)
Trunk	RAD4000A/3dB	60	E	0.82	0.271	0.14

Measurement grid					
Test position	Height (cm)	% of control limit	Test position	Height (cm)	% of control limit
1	20	3.0	6	120	34.0
2	40	4.5	7	140	54.0
3	60	8.0	8	160	57.0
4	80	8.5	9	180	44.0
5	100	15.0	10	200	43.0

Table 3

External Vehicle MPE Assessment @ 146.000 MHz						
Antenna Location	Antenna /gain	Meas. Distance (cm)	E/H Field	Calibration Factor	Average over Body (mW/cm^2)	Pwr. Density (mW/cm^2)
Trunk	HAD4014AR/3dB	60	E	0.82	0.108	0.05

Measurement grid					
Test position	Height (cm)	% of control limit	Test position	Height (cm)	% of control limit
1	20	1.4	6	120	16.0
2	40	1.7	7	140	21.0
3	60	2.2	8	160	20.0
4	80	3.8	9	180	18.2
5	100	8.5	10	200	15.2

Table 4.

External Vehicle MPE Assessment @ 155.320 MHz						
Antenna Location	Antenna /gain	Meas. Distance (cm)	E/H Field	Calibration Factor	Average over Body (mW/cm^2)	Pwr. Density (mW/cm^2)
Trunk	HAD4008A/0dB	60	E	0.83	0.41	**0.20**

Measurement grid					
Test position	Height (cm)	% of control limit	Test position	Height (cm)	% of control limit
1	20	15.0	6	120	70.0
2	40	30.0	7	140	58.0
3	60	39.0	8	160	41.0
4	80	44.0	9	180	27.0
5	100	65.0	10	200	19.0

Table 5

External Vehicle MPE Assessment @ 155.320 MHz						
Antenna Location	Antenna /gain	Meas. Distance (cm)	E/H Field	Calibration Factor	Average over Body (mW/cm^2)	Pwr. Density (mW/cm^2)
Trunk	RAD4000A/3dB	60	E	0.83	0.407	**0.20**

Measurement grid					
Test position	Height (cm)	% of control limit	Test position	Height (cm)	% of control limit
1	20	2.5	6	120	58.0
2	40	4.0	7	140	87.0
3	60	7.0	8	160	81.0
4	80	11.0	9	180	69.0
5	100	25.0	10	200	62.0

Table 6

External Vehicle MPE Assessment @ 155.320 MHz						
Antenna Location	**Antenna /gain**	**Meas. Distance (cm)**	**E/H Field**	**Calibration Factor**	**Average over Body (mW/cm^2)**	**Pwr. Density (mW/cm^2)**
Trunk	HAD4014AR/3dB	60	E	0.83	0.489	**0.25**

Measurement grid					
Test position	**Height (cm)**	**% of control limit**	**Test position**	**Height (cm)**	**% of control limit**
1	20	2.5	6	120	70.0
2	40	4.5	7	140	102.0
3	60	8.0	8	160	95.0
4	80	17.0	9	180	82.0
5	100	27.0	10	200	81.0

Table 7

External Vehicle MPE Assessment @ 164.670MHz						
Antenna Location	**Antenna /gain**	**Meas. Distance (cm)**	**E/H Field**	**Calibration Factor**	**Average over Body (mW/cm^2)**	**Pwr. Density (mW/cm^2)**
Trunk	HAD4009AR/0dB	60	E	0.84	0.385	0.19

Measurement grid					
Test position	**Height (cm)**	**% of control limit**	**Test position**	**Height (cm)**	**% of control limit**
1	20	10.0	6	120	85.0
2	40	15.0	7	140	66.0
3	60	16.0	8	160	44.0
4	80	39.0	9	180	29.0
5	100	62.0	10	200	19.0

Table 8

External Vehicle MPE Assessment @ 164.670MHz						
Antenna Location	**Antenna /gain**	**Meas. Distance (cm)**	**E/H Field**	**Calibration Factor**	**Average over Body (mW/cm^2)**	**Pwr. Density (mW/cm^2)**
Trunk	RAD4000A/3dB	60	E	0.84	0.132	0.07

Measurement grid					
Test position	**Height (cm)**	**% of control limit**	**Test position**	**Height (cm)**	**% of control limit**
1	20	1.5	6	120	25.0
2	40	3.0	7	140	41.0
3	60	6.0	8	160	41.0
4	80	10.8	9	180	36.0
5	100	12.0	10	200	36.0

Table 9

External Vehicle MPE Assessment @ 164.670MHz						
Antenna Location	Antenna /gain	Meas. Distance (cm)	E/H Field	Calibration Factor	Average over Body (mW/cm^2)	Pwr. Density (mW/cm^2)
Trunk	HAD4014AR/3dB	60	E	0.84	0.463	**0.23**

Measurement grid					
Test position	Height (cm)	% of control limit	Test position	Height (cm)	% of control limit
1	20	2.6	6	120	59.0
2	40	7.0	7	140	91.0
3	60	12.0	8	160	84.0
4	80	20.0	9	180	75.0
5	100	28.0	10	200	84.0

Table 10

External Vehicle MPE Assessment @ 174.000MHz						
Antenna Location	Antenna /gain	Meas. Distance (cm)	E/H Field	Calibration Factor	Average over Body (mW/cm^2)	Pwr. Density (mW/cm^2)
Trunk	HAD4009AR/0dB	60	E	0.86	0.398	**0.20**

Measurement grid					
Test position	Height (cm)	% of control limit	Test position	Height (cm)	% of control limit
1	20	8.5	6	120	92.0
2	40	10.0	7	140	74.0
3	60	12.0	8	160	45.0
4	80	33.0	9	180	29.0
5	100	73.0	10	200	21.0

Table 11

External Vehicle MPE Assessment @ 174.000MHz						
Antenna Location	Antenna /gain	Meas. Distance (cm)	E/H Field	Calibration Factor	Average over Body (mW/cm^2)	Pwr. Density (mW/cm^2)
Trunk	RAD4000A/3dB	60	E	0.86	0.41	**0.21**

Measurement grid					
Test position	Height (cm)	% of control limit	Test position	Height (cm)	% of control limit
1	20	2.5	6	120	57.0
2	40	4.5	7	140	91.0
3	60	5.5	8	160	85.0
4	80	5.5	9	180	75.0
5	100	18.0	10	200	66.0

Table 12

External Vehicle MPE Assessment @ 174.000MHz						
Antenna Location	**Antenna /gain**	**Meas. Distance (cm)**	**E/H Field**	**Calibration Factor**	**Average over Body (mW/cm^2)**	**Pwr. Density (mW/cm^2)**
Trunk	HAD4014AR/3dB	60	E	0.86	0.073	0.04

Measurement grid					
Test position	**Height (cm)**	**% of control limit**	**Test position**	**Height (cm)**	**% of control limit**
1	20	0.8	6	120	9.0
2	40	1.3	7	140	15.0
3	60	2.1	8	160	13.0
4	80	4.2	9	180	11.0
5	100	4.2	10	200	12.0

Table 13

External Vehicle MPE Assessment @ 146.000MHz						
Antenna Location	**Antenna /gain**	**Meas. Distance (cm)**	**E/H Field**	**Calibration Factor**	**Average over Body (mW/cm^2)**	**Pwr. Density (mW/cm^2)**
Trunk	HAD4007A/0dB	60	H	0.98	0.471	**0.24**

Measurement grid					
Test position	**Height (cm)**	**Pwr. Density (mW/cm^2)**	**Test position**	**Height (cm)**	**Pwr. Density (mW/cm^2)**
1	20	0.20	6	120	1.10
2	40	0.23	7	140	0.56
3	60	0.30	8	160	0.24
4	80	0.56	9	180	0.23
5	100	1.07	10	200	0.22

Table 14

External Vehicle MPE Assessment @ 146.000MHz						
Antenna Location	**Antenna /gain**	**Meas. Distance (cm)**	**E/H Field**	**Calibration Factor**	**Average over Body (mW/cm^2)**	**Pwr. Density (mW/cm^2)**
Trunk	RAD4000A/3dB	60	H	0.98	0.343	0.17

Measurement grid					
Test position	**Height (cm)**	**Pwr. Density (mW/cm^2)**	**Test position**	**Height (cm)**	**Pwr. Density (mW/cm^2)**
1	20	0.08	6	120	0.02
2	40	0.08	7	140	0.18
3	60	0.10	8	160	0.63
4	80	0.15	9	180	1.08
5	100	0.11	10	200	1.00

Table 15

External Vehicle MPE Assessment @ 146.000MHz						
Antenna Location	Antenna /gain	Meas. Distance (cm)	E/H Field	Calibration Factor	Average over Body (mW/cm^2)	Pwr. Density (mW/cm^2)
Trunk	HAD4014AR/3dB	60	H	0.98	0.10	0.05

Measurement grid					
Test position	Height (cm)	Pwr. Density (mW/cm^2)	Test position	Height (cm)	Pwr. Density (mW/cm^2)
1	20	0	6	120	0.04
2	40	0	7	140	0.14
3	60	0	8	160	0.28
4	80	0	9	180	0.30
5	100	0	10	200	0.24

Table 16

External Vehicle MPE Assessment @ 155.320MHz						
Antenna Location	Antenna /gain	Meas. Distance (cm)	E/H Field	Calibration Factor	Average over Body (mW/cm^2)	Pwr. Density (mW/cm^2)
Trunk	HAD4008A/0dB	60	H	0.98	0.351	0.18

Measurement grid					
Test position	Height (cm)	Pwr. Density (mW/cm^2)	Test position	Height (cm)	Pwr. Density (mW/cm^2)
1	20	0.07	6	120	0.73
2	40	0.10	7	140	0.49
3	60	0.20	8	160	0.27
4	80	0.68	9	180	0.15
5	100	0.70	10	200	0.12

Table 17

External Vehicle MPE Assessment @ 155.320MHz						
Antenna Location	Antenna /gain	Meas. Distance (cm)	E/H Field	Calibration Factor	Average over Body (mW/cm^2)	Pwr. Density (mW/cm^2)
Trunk	RAD4000A/3dB	60	H	0.98	0.397	**0.20**

Measurement grid					
Test position	Height (cm)	Pwr. Density (mW/cm^2)	Test position	Height (cm)	Pwr. Density (mW/cm^2)
1	20	0.00	6	120	0.03
2	40	0.00	7	140	0.44
3	60	0.00	8	160	1.20
4	80	0.00	9	180	1.35
5	100	0.00	10	200	0.95

Table 18

External Vehicle MPE Assessment @ 155.320MHz						
Antenna Location	Antenna /gain	Meas. Distance (cm)	E/H Field	Calibration Factor	Average over Body (mW/cm^2)	Pwr. Density (mW/cm^2)
Trunk	HAD4014AR/3dB	60	H	0.98	0.549	**0.28**

Measurement grid					
Test position	Height (cm)	Pwr. Density (mW/cm^2)	Test position	Height (cm)	Pwr. Density (mW/cm^2)
1	20	0.02	6	120	0.55
2	40	0.03	7	140	0.81
3	60	0.10	8	160	1.20
4	80	0.14	9	180	1.59
5	100	0.13	10	200	0.92

Table 19

External Vehicle MPE Assessment @ 164.670MHz						
Antenna Location	Antenna /gain	Meas. Distance (cm)	E/H Field	Calibration Factor	Average over Body (mW/cm^2)	Pwr. Density (mW/cm^2)
Trunk	HAD4009AR/0dB	60	H	0.97	0.185	0.09

Measurement grid					
Test position	Height (cm)	Pwr. Density (mW/cm^2)	Test position	Height (cm)	Pwr. Density (mW/cm^2)
1	20	0.00	6	120	0.38
2	40	0.00	7	140	0.29
3	60	0.12	8	160	0.13
4	80	0.33	9	180	0.10
5	100	0.45	10	200	0.05

Table 20

External Vehicle MPE Assessment @ 164.670MHz						
Antenna Location	Antenna /gain	Meas. Distance (cm)	E/H Field	Calibration Factor	Average over Body (mW/cm^2)	Pwr. Density (mW/cm^2)
Trunk	RAD4000A/3dB	60	H	0.97	0.142	0.07

Measurement grid					
Test position	Height (cm)	Pwr. Density (mW/cm^2)	Test position	Height (cm)	Pwr. Density (mW/cm^2)
1	20	0.00	6	120	0.00
2	40	0.00	7	140	0.11
3	60	0.00	8	160	0.36
4	80	0.00	9	180	0.50
5	100	0.00	10	200	0.45

Table 21

External Vehicle MPE Assessment @ 164.670MHz						
Antenna Location	Antenna /gain	Meas. Distance (cm)	E/H Field	Calibration Factor	Average over Body (mW/cm^2)	Pwr. Density (mW/cm^2)
Trunk	HAD4014AR/3dB	60	H	0.97	0.321	0.16

Measurement grid					
Test position	Height (cm)	Pwr. Density (mW/cm^2)	Test position	Height (cm)	Pwr. Density (mW/cm^2)
1	20	0.02	6	120	0.01
2	40	0.03	7	140	0.35
3	60	0.05	8	160	0.78
4	80	0.07	9	180	1.15
5	100	0.00	10	200	0.75

Table 22

External Vehicle MPE Assessment @ 174.000MHz						
Antenna Location	Antenna /gain	Meas. Distance (cm)	E/H Field	Calibration Factor	Average over Body (mW/cm^2)	Pwr. Density (mW/cm^2)
Trunk	HAD4009AR/0dB	60	H	0.97	0.247	0.12

Measurement grid					
Test position	Height (cm)	Pwr. Density (mW/cm^2)	Test position	Height (cm)	Pwr. Density (mW/cm^2)
1	20	0.00	6	120	0.60
2	40	0.00	7	140	0.43
3	60	0.10	8	160	0.26
4	80	0.21	9	180	0.18
5	100	0.54	10	200	0.15

Table 23

External Vehicle MPE Assessment @ 174.000MHz						
Antenna Location	Antenna /gain	Meas. Distance (cm)	E/H Field	Calibration Factor	Average over Body (mW/cm^2)	Pwr. Density (mW/cm^2)
Trunk	RAD4000A/3dB	60	H	0.97	0.316	0.16

Measurement grid					
Test position	Height (cm)	Pwr. Density (mW/cm^2)	Test position	Height (cm)	Pwr. Density (mW/cm^2)
1	20	0.00	6	120	0.13
2	40	0.00	7	140	0.49
3	60	0.00	8	160	0.88
4	80	0.00	9	180	1.08
5	100	0.00	10	200	0.58

Table 24

External Vehicle MPE Assessment @ 174.000MHz						
Antenna Location	Antenna /gain	Meas. Distance (cm)	E/H Field	Calibration Factor	Average over Body (mW/cm^2)	Pwr. Density (mW/cm^2)
Trunk	HAD4014AR/3dB	60	H	0.97	0.059	0.03

Measurement grid					
Test position	Height (cm)	Pwr. Density (mW/cm^2)	Test position	Height (cm)	Pwr. Density (mW/cm^2)
1	20	0.00	6	120	0.00
2	40	0.00	7	140	0.03
3	60	0.00	8	160	0.13
4	80	0.00	9	180	0.23
5	100	0.00	10	200	0.20

Table 25

External Vehicle MPE Assessment @ 146.000MHz						
Antenna Location	Antenna /gain	Meas. Distance (cm)	E/H Field	Calibration Factor	Average over Body (mW/cm^2)	Pwr. Density (mW/cm^2)
Roof	HAD4007A/0dB	110 actual	E	0.82	0.132	0.07

Measurement grid					
Test position	Height (cm)	% of control limit	Test position	Height (cm)	% of control limit
1	20	6.0	6	120	13.0
2	40	8.5	7	140	18.8
3	60	6.6	8	160	22.0
4	80	6.3	9	180	22.5
5	100	9.8	10	200	19.0

Table 26

External Vehicle MPE Assessment @ 155.320 MHz						
Antenna Location	Antenna /gain	Meas. Distance (cm)	E/H Field	Calibration Factor	Average over Body (mW/cm^2)	Pwr. Density (mW/cm^2)
Roof	HAD4008A/0dB	110	E	0.83	0.107	0.05

Measurement grid					
Test position	Height (cm)	% of control limit	Test position	Height (cm)	% of control limit
1	20	3.00	6	120	12.00
2	40	2.00	7	140	19.00
3	60	3.00	8	160	22.00
4	80	2.00	9	180	22.00
5	100	5.00	10	200	17.00

Table 27

External Vehicle MPE Assessment @ 164.670 MHz						
Antenna Location	**Antenna /gain**	**Meas. Distance (cm)**	**E/H Field**	**Calibration Factor**	**Average over Body (mW/cm^2)**	**Pwr. Density (mW/cm^2)**
Roof	HAD4009A/0dB	110	E	0.84	0.160	0.08

Measurement grid					
Test position	**Height (cm)**	**% of control limit**	**Test position**	**Height (cm)**	**% of control limit**
1	20	2.50	6	120	19.00
2	40	2.00	7	140	31.00
3	60	0.50	8	160	34.00
4	80	4.00	9	180	32.00
5	100	10.00	10	200	25.00

Table 28

External Vehicle MPE Assessment @ 174.000 MHz						
Antenna Location	**Antenna /gain**	**Meas. Distance (cm)**	**E/H Field**	**Calibration Factor**	**Average over Body (mW/cm^2)**	**Pwr. Density (mW/cm^2)**
Roof	HAD4009A/0dB	110	E	0.86	0.159	0.08

Measurement grid					
Test position	**Height (cm)**	**% of control limit**	**Test position**	**Height (cm)**	**% of control limit**
1	20	1.50	6	120	18.00
2	40	1.00	7	140	32.00
3	60	0.20	8	160	32.00
4	80	11.00	9	180	35.00
5	100	11.00	10	200	17.00

Table 29

External Vehicle MPE Assessment @ 155.320 MHz						
Antenna Location	**Antenna /gain**	**Meas. Distance (cm)**	**E/H Field**	**Calibration Factor**	**Average over Body (mW/cm^2)**	**Pwr. Density (mW/cm^2)**
Roof	RAD4000A/3dB	110	E	0.83	0.09	0.05

Measurement grid					
Test position	**Height (cm)**	**% of control limit**	**Test position**	**Height (cm)**	**% of control limit**
1	20	2.00	6	120	4.20
2	40	2.50	7	140	10.00
3	60	1.50	8	160	17.00
4	80	1.00	9	180	23.00
5	100	1.50	10	200	28.00

Table 30

External Vehicle MPE Assessment @ 155.320 MHz						
Antenna Location	Antenna /gain	Meas. Distance (cm)	E/H Field	Calibration Factor	Average over Body (mW/cm^2)	Pwr. Density (mW/cm^2)
Roof	HAD4014AR/3dB	110	E	0.83	0.10	0.05

Measurement grid					
Test position	Height (cm)		Test position	Height (cm)	% of control limit
1	20	2.00	6	120	5.00
2	40	3.00	7	140	11.00
3	60	2.00	8	160	19.00
4	80	1.00	9	180	28.00
5	100	1.50	10	200	29.00

Table 31

External Vehicle MPE Assessment @ 146.000MHz						
Antenna Location	Antenna /gain	Meas. Distance (cm)	E/H Field	Calibration Factor	Average over Body (mW/cm^2)	Pwr. Density (mW/cm^2)
Roof	HAD4007A/0dB	110	H	0.98	0.119	0.06

Measurement grid					
Test position	Height (cm)	Pwr. Density (mW/cm^2)	Test position	Height (cm)	Pwr. Density (mW/cm^2)
1	20	0.00	6	120	0.16
2	40	0.00	7	140	0.20
3	60	0.00	8	160	0.25
4	80	0.04	9	180	0.22
5	100	0.13	10	200	0.19

Table 32

External Vehicle MPE Assessment @ 155.320 MHz						
Antenna Location	Antenna /gain	Meas. Distance (cm)	E/H Field	Calibration Factor	Average over Body (mW/cm^2)	Pwr. Density (mW/cm^2)
Roof	HAD4008A/0dB	110	H	0.98	0.185	0.09

Measurement grid					
Test position	Height (cm)	Pwr. Density (mW/cm^2)	Test position	Height (cm)	Pwr. Density (mW/cm^2)
1	20	0.03	6	120	0.15
2	40	0.02	7	140	0.24
3	60	0.04	8	160	0.37
4	80	0.06	9	180	0.40
5	100	0.10	10	200	0.44

Table 33

External Vehicle MPE Assessment @ 164.670 MHz						
Antenna Location	**Antenna /gain**	**Meas. Distance (cm)**	**E/H Field**	**Calibration Factor**	**Average over Body (mW/cm^2)**	**Pwr. Density (mW/cm^2)**
Roof	HAD4009A/0dB	110	H	0.97	0.232	0.12

Measurement grid					
Test position	**Height (cm)**	**Pwr. Density (mW/cm^2)**	**Test position**	**Height (cm)**	**Pwr. Density (mW/cm^2)**
1	20	0.02	6	120	0.20
2	40	0.02	7	140	0.36
3	60	0.06	8	160	0.51
4	80	0.08	9	180	0.47
5	100	0.12	10	200	0.48

Table 34

External Vehicle MPE Assessment @ 174.000 MHz						
Antenna Location	**Antenna /gain**	**Meas. Distance (cm)**	**E/H Field**	**Calibration Factor**	**Average over Body (mW/cm^2)**	**Pwr. Density (mW/cm^2)**
Roof	HAD4009A/0dB	110	H	0.97	0.217	0.11

Measurement grid					
Test position	**Height (cm)**	**Pwr. Density (mW/cm^2)**	**Test position**	**Height (cm)**	**Pwr. Density (mW/cm^2)**
1	20	0.01	6	120	0.19
2	40	0.02	7	140	0.35
3	60	0.03	8	160	0.46
4	80	0.04	9	180	0.49
5	100	0.10	10	200	0.49

Table 35

External Vehicle MPE Assessment @ 155.320 MHz						
Antenna Location	**Antenna /gain**	**Meas. Distance (cm)**	**E/H Field**	**Calibration Factor**	**Average over Body (mW/cm^2)**	**Pwr. Density (mW/cm^2)**
Roof	RAD4000A/3dB	110	H	0.98	0.136	0.07

Measurement grid					
Test position	**Height (cm)**	**Pwr. Density (mW/cm^2)**	**Test position**	**Height (cm)**	**Pwr. Density (mW/cm^2)**
1	20	0.02	6	120	0.05
2	40	0.02	7	140	0.17
3	60	0.02	8	160	0.26
4	80	0.02	9	180	0.39
5	100	0.02	10	200	0.40

Table 36

External Vehicle MPE Assessment @ 155.320 MHz						
Antenna Location	Antenna /gain	Meas. Distance (cm)	E/H Field	Calibration Factor	Average over Body (mW/cm^2)	Pwr. Density (mW/cm^2)
Roof	HAD4014AR/3dB	110	H	0.98	0.160	0.08

Measurement grid					
Test position	Height (cm)	Pwr. Density (mW/cm^2)	Test position	Height (cm)	Pwr. Density (mW/cm^2)
1	20	0.01	6	120	0.05
2	40	0.02	7	140	0.14
3	60	0.02	8	160	0.28
4	80	0.02	9	180	0.43
5	100	0.03	10	200	0.61

Table 37

Internal Vehicle MPE Assessment @ 146.000MHz						
Antenna Location	Antenna /gain	Meas. Distance (cm)	E/H Field	Calibration Factor	Average over Head, Chest, Leg Back/Front seats (mW/cm^2)	Pwr. Density (mW/cm^2)
Trunk	HAD4007A /0dB	Highest reading	E	0.82	1.22/0.103	**0.61**

Measurement grid			
Test position	% of control limit Head	% of control limit Chest	% of control limit Leg
Back seat	294	48	25
Front seat	15	9	7

Table 38

Internal Vehicle MPE Assessment @ 146.000MHz						
Antenna Location	Antenna /gain	Meas. Distance (cm)	E/H Field	Calibration Factor	Average over Head, Chest, Leg Back/Front seats (mW/cm^2)	Pwr. Density (mW/cm^2)
Trunk	RAD4000A/3dB	Highest reading	E	0.82	0.048/0.013	0.02

Measurement grid			
Test position	% of control limit Head	% of control limit Chest	% of control limit Leg
Back seat	10	2.7	1.7
Front seat	1.4	1.3	1.1

Table 39

Internal Vehicle MPE Assessment @ 146.000MHz						
Antenna Location	**Antenna /gain**	**Meas. Distance (cm)**	**E/H Field**	**Calibration Factor**	**Average over Head, Chest, Leg Back/Front seats (mW/cm^2)**	**Pwr. Density (mW/cm^2)**
Trunk	HAD4014AR/3dB	Highest reading	E	0.82	0.114/0.015	0.06

Measurement grid			
Test position	**% of control limit Head**	**% of control limit Chest**	**% of control limit Leg**
Back seat	24	8	2.2
Front seat	1.9	1.3	1.2

Table 40

Internal Vehicle MPE Assessment @ 155.320MHz						
Antenna Location	**Antenna /gain**	**Meas. Distance (cm)**	**E/H Field**	**Calibration Factor**	**Average over Head, Chest, Leg Back/Front seats (mW/cm^2)**	**Pwr. Density (mW/cm^2)**
Trunk	HAD4008A/0dB	Highest reading	E	0.83	1.10/0.197	**0.55**

Measurement grid			
Test position	**% of control limit Head**	**% of control limit Chest**	**% of control limit Leg**
Back seat	260	50	20
Front seat	34	14	11

Table 41

Internal Vehicle MPE Assessment @ 155.320MHz						
Antenna Location	**Antenna /gain**	**Meas. Distance (cm)**	**E/H Field**	**Calibration Factor**	**Average over Head, Chest, Leg Back/Front seats (mW/cm^2)**	**Pwr. Density (mW/cm^2)**
Trunk	RAD4000A/3dB	Highest reading	E	0.83	0.197/0.037	0.10

Measurement grid			
Test position	**% of control limit Head**	**% of control limit Chest**	**% of control limit Leg**
Back seat	42	12	5
Front seat	5.5	3	2.5

Table 42

Internal Vehicle MPE Assessment @ 155.32MHz						
Antenna Location	**Antenna /gain**	**Meas. Distance (cm)**	**E/H Field**	**Calibration Factor**	**Average over Head, Chest, Leg Back/Front seats (mW/cm^2)**	**Pwr. Density (mW/cm^2)**
Trunk	HAD4014AR/3dB	Highest reading	E	0.83	0.24/0.039	0.12

Measurement grid			
Test position	**% of control limit Head**	**% of control limit Chest**	**% of control limit Leg**
Back seat	50	16	6
Front seat	6	3	2.7

Table 43

Internal Vehicle MPE Assessment @ 164.670MHz						
Antenna Location	**Antenna /gain**	**Meas. Distance (cm)**	**E/H Field**	**Calibration Factor**	**Average over Head, Chest, Leg Back/Front seats (mW/cm^2)**	**Pwr. Density (mW/cm^2)**
Trunk	HAD4009AR/0dB	Highest reading	E	0.84	1.29/0.263	**0.64**

Measurement grid			
Test position	**% of control limit Head**	**% of control limit Chest**	**% of control limit Leg**
Back seat	298	74	14
Front seat	62	7	10

Table 44

Internal Vehicle MPE Assessment @ 164.670MHz						
Antenna Location	**Antenna /gain**	**Meas. Distance (cm)**	**E/H Field**	**Calibration Factor**	**Average over Head, Chest, Leg Back/Front seats (mW/cm^2)**	**Pwr. Density (mW/cm^2)**
Trunk	RAD4000A/3dB	Highest reading	E	0.84	0.067/0.040	0.03

Measurement grid			
Test position	**% of control limit Head**	**% of control limit Chest**	**% of control limit Leg**
Back seat	11	5	4
Front seat	6	2	4

Table 45

Internal Vehicle MPE Assessment @ 164.670MHz						
Antenna Location	**Antenna/gain**	**Meas. Distance (cm)**	**E/H Field**	**Calibration Factor**	**Average over Head, Chest, Leg Back/Front seats (mW/cm^2)**	**Pwr. Density (mW/cm^2)**
Trunk	HAD4014AR/3dB	Highest reading	E	0.84	0.170/0.113	0.09

Measurement grid			
Test position	**% of control limit Head**	**% of control limit Chest**	**% of control limit Leg**
Back seat	28	12	11
Front seat	18	5	11

Table 46

Internal Vehicle MPE Assessment @ 174.000MHz						
Antenna Location	**Antenna /gain**	**Meas. Distance (cm)**	**E/H Field**	**Calibration Factor**	**Average over Head, Chest, Leg Back/Front seats (mW/cm^2)**	**Pwr. Density (mW/cm^2)**
Trunk	HAD4009AR/0dB	Highest reading	E	0.86	0.817/0.123	**0.41**

Measurement grid			
Test position	**% of control limit Head**	**% of control limit Chest**	**% of control limit Leg**
Back seat	150	60	35
Front seat	9	15	13

Table 47

Internal Vehicle MPE Assessment @ 174.000MHz						
Antenna Location	**Antenna /gain**	**Meas. Distance (cm)**	**E/H Field**	**Calibration Factor**	**Average over Head, Chest, Leg Back/Front seats (mW/cm^2)**	**Pwr. Density (mW/cm^2)**
Trunk	HAD4000A/0dB	Highest reading	E	0.86	0.230/0.043	0.12

Measurement grid			
Test position	**% of control limit Head**	**% of control limit Chest**	**% of control limit Leg**
Back seat	37	22.0	10
Front seat	3.7	3.7	5.5

Table 48

Internal Vehicle MPE Assessment @ 174.000MHz						
Antenna Location	**Antenna /gain**	**Meas. Distance (cm)**	**E/H Field**	**Calibration Factor**	**Average over Head, Chest, Leg Back/Front seats (mW/cm^2)**	**Pwr. Density (mW/cm^2)**
Trunk	HAD4014AR/3dB	Highest reading	E	0.86	0.03/0.006	0.015

Measurement grid			
Test position	**% of control limit Head**	**% of control limit Chest**	**% of control limit Leg**
Back seat	3	4	2
Front seat	0.5	0.2	1

Table 49

Internal Vehicle MPE Assessment @ 146.000MHz						
Antenna Location	**Antenna /gain**	**Meas. Distance (cm)**	**E/H Field**	**Calibration Factor**	**Average over Head, Chest, Leg Back/Front seats (mW/cm^2)**	**Pwr. Density (mW/cm^2)**
Trunk	HAD4007A/0dB	Highest reading	H	0.98	0.807/0.193	**0.40**

Measurement grid			
Test position	**Pwr. Density (mW/cm^2) Head**	**Pwr. Density (mW/cm^2) Chest**	**Pwr. Density (mW/cm^2) Leg**
Back seat	1.5	0.55	0.37
Front seat	0.24	0.14	0.20

Table 50

Internal Vehicle MPE Assessment @ 146.000MHz						
Antenna Location	**Antenna /gain**	**Meas. Distance (cm)**	**E/H Field**	**Calibration Factor**	**Average over Head, Chest, Leg Back/Front seats (mW/cm^2)**	**Pwr. Density (mW/cm^2)**
Trunk	RAD4000A/0dB	Highest reading	H	0.98	0.01/0	0.01

Measurement grid			
Test position	**Pwr. Density (mW/cm^2) Head**	**Pwr. Density (mW/cm^2) Chest**	**Pwr. Density (mW/cm^2) Leg**
Back seat	0.03	0	0
Front seat	0	0	0

Table 51

Internal Vehicle MPE Assessment @ 146.000MHz						
Antenna Location	**Antenna /gain**	**Meas. Distance (cm)**	**E/H Field**	**Calibration Factor**	**Average over Head, Chest, Leg Back/Front seats (mW/cm^2)**	**Pwr. Density (mW/cm^2)**
Trunk	HAD4014AR/3dB	Highest reading	H	0.98	0.04/0	0.02

Measurement grid			
Test position	**Pwr. Density (mW/cm^2) Head**	**Pwr. Density (mW/cm^2) Chest**	**Pwr. Density (mW/cm^2) Leg**
Back seat	0.12	0	0
Front seat	0	0	0

Table 52

Internal Vehicle MPE Assessment @ 155.320MHz						
Antenna Location	**Antenna /gain**	**Meas. Distance (cm)**	**E/H Field**	**Calibration Factor**	**Average over Head, Chest, Leg Back/Front seats (mW/cm^2)**	**Pwr. Density (mW/cm^2)**
Trunk	HAD4008A/0dB	Highest reading	H	0.98	0.290/0.063	0.15

Measurement grid			
Test position	**Pwr. Density (mW/cm^2) Head**	**Pwr. Density (mW/cm^2) Chest**	**Pwr. Density (mW/cm^2) Leg**
Back seat	0.55	0.16	0.16
Front seat	0.14	0.05	0

Table 53

Internal Vehicle MPE Assessment @ 155.320MHz						
Antenna Location	**Antenna /gain**	**Meas. Distance (cm)**	**E/H Field**	**Calibration Factor**	**Average over Head, Chest, Leg Back/Front seats (mW/cm^2)**	**Pwr. Density (mW/cm^2)**
Trunk	RAD4000A/3dB	Highest reading	H	0.98	0.05/0	0.03

Measurement grid			
Test position	**Pwr. Density (mW/cm^2) Head**	**Pwr. Density (mW/cm^2) Chest**	**Pwr. Density (mW/cm^2) Leg**
Back seat	0.15	0	0
Front seat	0	0	0

Table 54

Internal Vehicle MPE Assessment @ 155.320MHz						
Antenna Location	**Antenna /gain**	**Meas. Distance (cm)**	**E/H Field**	**Calibration Factor**	**Average over Head, Chest, Leg Back/Front seats (mW/cm^2)**	**Pwr. Density (mW/cm^2)**
Trunk	HAD4014AR/3dB	Highest reading	H	0.98	0.16/0.016	0.08

Measurement grid			
Test position	**Pwr. Density (mW/cm^2) Head**	**Pwr. Density (mW/cm^2) Chest**	**Pwr. Density (mW/cm^2) Leg**
Back seat	0.30	0.10	0.08
Front seat	0.05	0	0

Table 55

Internal Vehicle MPE Assessment @ 164.670MHz						
Antenna Location	**Antenna /gain**	**Meas. Distance (cm)**	**E/H Field**	**Calibration Factor**	**Average over Head, Chest, Leg Back/Front seats (mW/cm^2)**	**Pwr. Density (mW/cm^2)**
Trunk	HAD4009A/0dB	Highest reading	H	0.97	0.25/0.113	0.13

Measurement grid			
Test position	**Pwr. Density (mW/cm^2) Head**	**Pwr. Density (mW/cm^2) Chest**	**Pwr. Density (mW/cm^2) Leg**
Back seat	0.58	0.10	0.07
Front seat	0.32	0.02	0

Table 56

Internal Vehicle MPE Assessment @ 164.670MHz						
Antenna Location	**Antenna /gain**	**Meas. Distance (cm)**	**E/H Field**	**Calibration Factor**	**Average over Head, Chest, Leg Back/Front seats (mW/cm^2)**	**Pwr. Density (mW/cm^2)**
Trunk	RAD4000A/3dB	Highest reading	H	0.97	0.007/0	0.00

Measurement grid			
Test position	**Pwr. Density (mW/cm^2) Head**	**Pwr. Density (mW/cm^2) Chest**	**Pwr. Density (mW/cm^2) Leg**
Back seat	0	0.01	0.01
Front seat	0	0	0

Table 57

Internal Vehicle MPE Assessment @ 164.670MHz						
Antenna Location	**Antenna /gain**	**Meas. Distance (cm)**	**E/H Field**	**Calibration Factor**	**Average over Head, Chest, Leg Back/Front seats (mW/cm^2)**	**Pwr. Density (mW/cm^2)**
Trunk	HAD4014AR/3dB	Highest reading	H	0.97	0.053/0.043	0.03

Measurement grid			
Test position	**Pwr. Density (mW/cm^2) Head**	**Pwr. Density (mW/cm^2) Chest**	**Pwr. Density (mW/cm^2) Leg**
Back seat	0.07	0.05	0.04
Front seat	0.11	0.02	0

Table 58

Internal Vehicle MPE Assessment @ 174.000MHz						
Antenna Location	**Antenna /gain**	**Meas. Distance (cm)**	**E/H Field**	**Calibration Factor**	**Average over Head, Chest, Leg Back/Front seats (mW/cm^2)**	**Pwr. Density (mW/cm^2)**
Trunk	HAD4009AR/0dB	Highest reading	H	0.97	0.30/0.057	0.15

Measurement grid			
Test position	**Pwr. Density (mW/cm^2) Head**	**Pwr. Density (mW/cm^2) Chest**	**Pwr. Density (mW/cm^2) Leg**
Back seat	0.55	0.20	0.15
Front seat	0.12	0.02	0.03

Table 59

Internal Vehicle MPE Assessment @ 174.000MHz						
Antenna Location	**Antenna /gain**	**Meas. Distance (cm)**	**E/H Field**	**Calibration Factor**	**Average over Head, Chest, Leg Back/Front seats (mW/cm^2)**	**Pwr. Density (mW/cm^2)**
Trunk	RAD4000A/3dB	Highest reading	H	0.97	0.05/0.038	0.03

Measurement grid			
Test position	**Pwr. Density (mW/cm^2) Head**	**Pwr. Density (mW/cm^2) Chest**	**Pwr. Density (mW/cm^2) Leg**
Back seat	0.10	0.03	0.02
Front seat	0.08	0.02	0.02

Table 60

Internal Vehicle MPE Assessment @ 174.000MHz						
Antenna Location	**Antenna /gain**	**Meas. Distance (cm)**	**E/H Field**	**Calibration Factor**	**Average over Head, Chest, Leg Back/Front seats (mW/cm^2)**	**Pwr. Density (mW/cm^2)**
Trunk	HAD4014AR/3dB	Highest reading	H	0.97	0.003/0.003	0.00
Measurement grid						
Test position	**Pwr. Density (mW/cm^2) Head**	**Pwr. Density (mW/cm^2) Chest**	**Pwr. Density (mW/cm^2) Leg**			
Back seat	0.01	0	0			
Front seat	0.01	0	0			

Table 61

Internal Vehicle MPE Assessment @ 146.000MHz						
Antenna Location	**Antenna /gain**	**Meas. Distance (cm)**	**E/H Field**	**Calibration Factor**	**Average over Head, Chest, Leg Back/Front seats (mW/cm^2)**	**Pwr. Density (mW/cm^2)**
Roof	HAD4007A/0dB	Highest reading	E	0.82	0.34/0.10	0.17
Measurement grid						
Test position	**% of control limit Head**	**% of control limit Chest**	**% of control limit Leg**			
Back seat	75	18	9			
Front seat	6	13	11			

Table 62

Internal Vehicle MPE Assessment @ 155.320 MHz						
Antenna Location	**Antenna /gain**	**Meas. Distance (cm)**	**E/H Field**	**Calibration Factor**	**Average over Head, Chest, Leg Back/Front seats (mW/cm^2)**	**Pwr. Density (mW/cm^2)**
Roof	HAD4008A/0dB	Highest reading	E	0.83	0.210/0.130	0.11
Measurement grid						
Test position	**% of control limit Head**	**% of control limit Chest**	**% of control limit Leg**			
Back seat	40.0	15.0	9.0			
Front seat	13.0	20.0	6.0			

Table 63

Internal Vehicle MPE Assessment @ 164.670 MHz						
Antenna Location	**Antenna /gain**	**Meas. Distance (cm)**	**E/H Field**	**Calibration Factor**	**Average over Head, Chest, Leg Back/Front seats (mW/cm^2)**	**Pwr. Density (mW/cm^2)**
Roof	HAD4009A/0dB	Highest reading	E	0.84	0.227/0.140	0.11

Measurement grid			
Test position	**% of control limit Head**	**% of control limit Chest**	**% of control limit Leg**
Back seat	42.0	15.0	11.0
Front seat	21.0	12.0	10.0

Table 64

Internal Vehicle MPE Assessment @ 174.000 MHz						
Antenna Location	**Antenna /gain**	**Meas. Distance (cm)**	**E/H Field**	**Calibration Factor**	**Average over Head, Chest, Leg Back/Front seats (mW/cm^2)**	**Pwr. Density (mW/cm^2)**
Roof	HAD4009A/0dB	Highest reading	E	0.86	0.100/0.147	0.07

Measurement grid			
Test position	**% of control limit Head**	**% of control limit Chest**	**% of control limit Leg**
Back seat	16.0	5.0	10.0
Front seat	21.0	15.0	8.0

Table 65

Internal Vehicle MPE Assessment @ 155.320 MHz						
Antenna Location	**Antenna /gain**	**Meas. Distance (cm)**	**E/H Field**	**Calibration Factor**	**Average over Head, Chest, Leg Back/Front seats (mW/cm^2)**	**Pwr. Density (mW/cm^2)**
Roof	RAD4000A/3dB	Highest reading	E	0.83	0.050/0.020	0.03

Measurement grid			
Test position	**% of control limit Head**	**% of control limit Chest**	**% of control limit Leg**
Back seat	9.0	4.0	2.0
Front seat	2.0	1.5	2.5

Table 66

Internal Vehicle MPE Assessment @ 155.320 MHz						
Antenna Location	Antenna /gain	Meas. Distance (cm)	E/H Field	Calibration Factor	Average over Head, Chest, Leg Back/Front seats (mW/cm^2)	Pwr. Density (mW/cm^2)
Roof	HAD4014AR/3dB	Highest reading	E	0.83	0.053/0.028	0.03

Measurement grid			
Test position	% of control limit Head	% of control limit Chest	% of control limit Leg
Back seat	11.0	3.0	2.0
Front seat	2.5	4.0	2.0

Table 67

Internal Vehicle MPE Assessment @ 146.000MHz						
Antenna Location	Antenna /gain	Meas. Distance (cm)	E/H Field	Calibration Factor	Average over Head, Chest, Leg Back/Front seats (mW/cm^2)	Pwr. Density (mW/cm^2)
Roof	HAD4007A/0dB	Highest reading	H	0.98	0.17/0.09	0.09

Measurement grid			
Test position	Pwr. Density (mW/cm^2) Head	Pwr. Density (mW/cm^2) Chest	Pwr. Density (mW/cm^2) Leg
Back seat	0.43	0.03	0.05
Front seat	0.18	0.06	0.03

Table 68

Internal Vehicle MPE Assessment @ 155.320MHz						
Antenna Location	Antenna /gain	Meas. Distance (cm)	E/H Field	Calibration Factor	Average over Head, Chest, Leg Back/Front seats (mW/cm^2)	Pwr. Density (mW/cm^2)
Roof	HAD4008A/0dB	Highest reading	H	0.98	0.070/0.080	0.04

Measurement grid			
Test position	Pwr. Density (mW/cm^2) Head	Pwr. Density (mW/cm^2) Chest	Pwr. Density (mW/cm^2) Leg
Back seat	0.15	0.05	0.01
Front seat	0.16	0.08	0.00

Table 69

Internal Vehicle MPE Assessment @ 164.670MHz						
Antenna Location	Antenna /gain	Meas. Distance (cm)	E/H Field	Calibration Factor	Average over Head, Chest, Leg Back/Front seats (mW/cm^2)	Pwr. Density (mW/cm^2)
Roof	RAD4009A/0dB	Highest reading	H	0.97	0.090/0.067	0.05

Measurement grid			
Test position	Pwr. Density (mW/cm^2) Head	Pwr. Density (mW/cm^2) Chest	Pwr. Density (mW/cm^2) Leg
Back seat	0.12	0.06	0.09
Front seat	0.06	0.10	0.04

Table 70

Internal Vehicle MPE Assessment @ 174.000 MHz						
Antenna Location	Antenna /gain	Meas. Distance (cm)	E/H Field	Calibration Factor	Average over Head, Chest, Leg Back/Front seats (mW/cm^2)	Pwr. Density (mW/cm^2)
Roof	HAD4009A/0dB	Highest reading	H	0.97	0.037/0.110	0.06

Measurement grid			
Test position	Pwr. Density (mW/cm^2) Head	Pwr. Density (mW/cm^2) Chest	Pwr. Density (mW/cm^2) Leg
Back seat	0.05	0.01	0.05
Front seat	0.12	0.15	0.06

Table 71

Internal Vehicle MPE Assessment @ 155.320 MHz						
Antenna Location	Antenna /gain	Meas. Distance (cm)	E/H Field	Calibration Factor	Average over Head, Chest, Leg Back/Front seats (mW/cm^2)	Pwr. Density (mW/cm^2)
Roof	RAD4000A/3dB	Highest reading	H	0.97	0.017/0.010	0.01

Measurement grid			
Test position	Pwr. Density (mW/cm^2) Head	Pwr. Density (mW/cm^2) Chest	Pwr. Density (mW/cm^2) Leg
Back seat	0.05	0.00	0.00
Front seat	0.02	0.01	0.00

Table 72

Internal Vehicle MPE Assessment @ 155.320 MHz						
Antenna Location	Antenna /gain	Meas. Distance (cm)	E/H Field	Calibration Factor	Average over Head, Chest, Leg Back/Front seats (mW/cm^2)	Pwr. Density (mW/cm^2)
Roof	HAD4014AR/3dB	Highest reading	H	0.97	0.013/0.013	0.01

Measurement grid			
Test position	Pwr. Density (mW/cm^2) Head	Pwr. Density (mW/cm^2) Chest	Pwr. Density (mW/cm^2) Leg
Back seat	0.04	0.00	0.00
Front seat	0.03	0.01	0.00

12.0 Conclusion

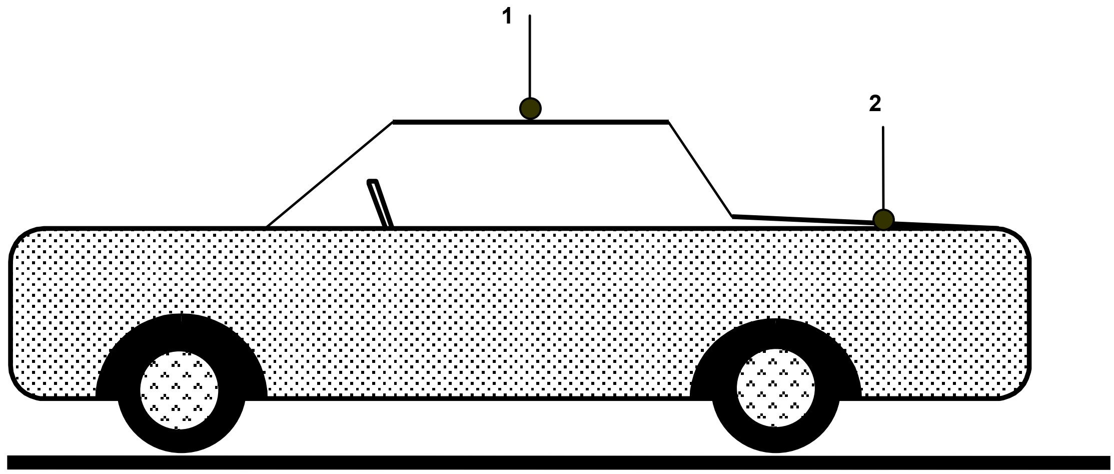
Depending on the test frequency, compliance assessments were performed with an output power range of 52.5W to 56.5W. The maximum RF power allowable will be equal to the upper limit of the final test factory transmit power specification of 54W. The highest power density result scaled to the maximum allowable power output is 0.64 mW/cm^2.

Note: Tables 1, 4, 5, 6, 9, 11, 13, 18, 27, 30, 33, 36, and 39 indicates that by-stander and passenger test conditions exceed the applicable MPE power density specification limits. Each of these test conditions was analyzed computationally to assess performance to the applicable S.A.R. exposure specification limits. APPENDIX B of this report presents computational EME compliance assessment results for FCC ID: ABZ99FT3046 performed by the Motorola Corporate Research Lab located in Plantation Florida using a commercial code based on FDTD (Finite Difference Time Domain) methodology. The computational results are provided herein in order to demonstrate the EME compliance of this device with respect to the IEEE Std C95.1-1999 specific absorption rate (S.A.R.) exposure limits. The computational results show that this device, when used with the offered antennas in accordance with the user manual instructions, exhibits a maximum peak 1-g S.A.R. of 0.73 mW/g for by-standers (less than half of the IEEE 1.6 mW/g limit for uncontrolled environments. The computational results for passengers internal to the vehicle were 0.73 mW/g 1-g average.

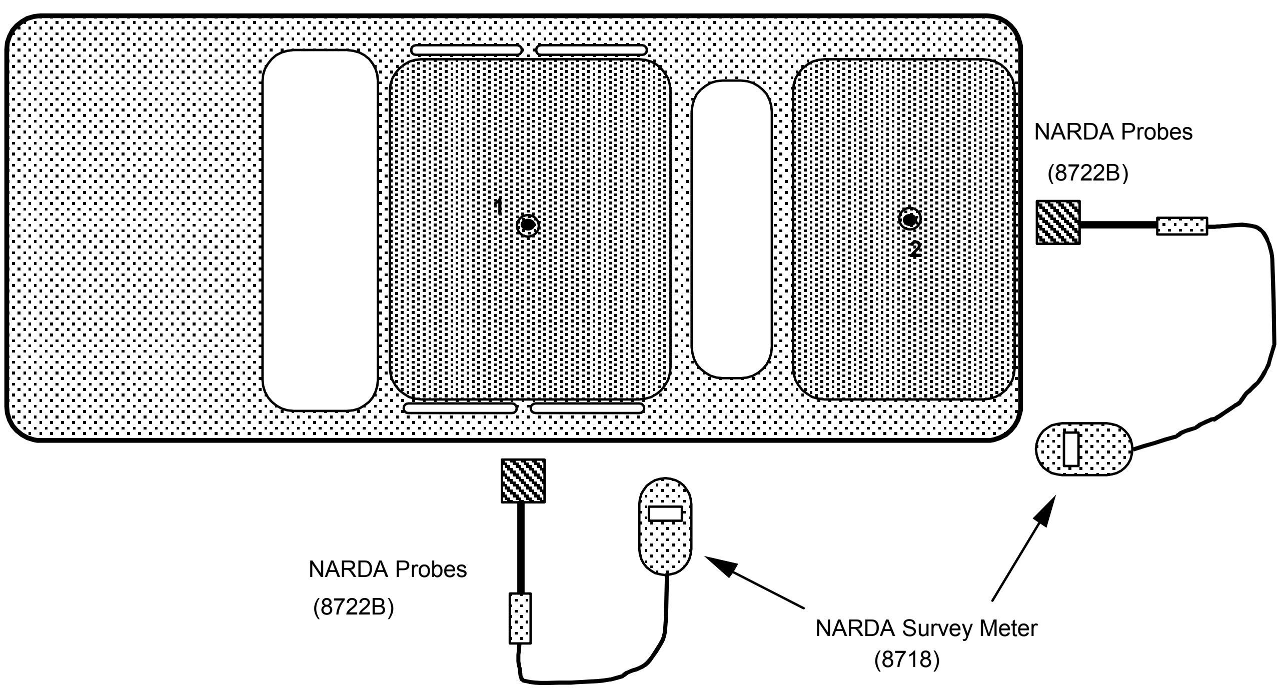
The MPE results presented herein demonstrate compliance to the applicable Occupational/Controlled exposure limits.
The computational assessment of the specific MPE non-compliant by-stander and passenger test conditions presented in APPENDIX B demonstrates compliance to the applicable General Population/Uncontrolled S.A.R. exposure limits.

APPENDIX A

ANTENNA LOCATION DRAWING



1 - Roof (center)
2 - Trunk (center)



APPENDIX B

By-Stander and Passenger
S.A.R. Computational Assessment Report

MOTOROLA LABS

COMPUTATIONAL EME COMPLIANCE ASSESSMENT OF THE CM200 VHF 4ch MOBILE RADIO, MODEL # PMUD1875A, FCC ID ABZ99FT3046

July 16, 2003

Giorgi Bit-Babik and Antonio Faraone

Motorola Corporate EME Research Lab, Plantation, Florida

Introduction

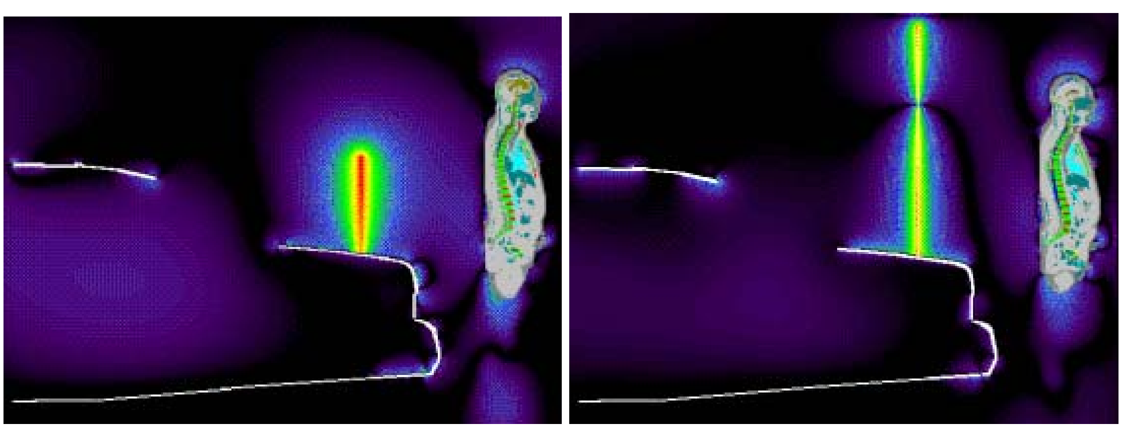
This report summarizes the computational [numerical modeling] analysis performed to document compliance of the CM200 VHF, Model Number PMUD1875A, Mobile Radio and vehicle-mounted antennas with the Federal Communications Commission (FCC) guidelines for human exposure to radio frequency (RF) emissions. The radio operates in the 146-174 MHz frequency band.

This computational analysis supplements the measurements conducted to evaluate the FCC *maximum permissible exposure* (MPE) limits for this mobile device. All test conditions (ten in total) that did not conform with applicable MPE limits were subdivided into two groups — bystander exposures and passenger exposures — and analyzed to determine whether those conditions complied with the *specific absorption rate* (SAR) limits for general public exposure (1.6 W/kg averaged over 1 gram of tissue) set forth in FCC guidelines, which are based on the IEEE standard [1]. For both groups, a commercial code based on Finite-Difference-Time-Domain (FDTD) methodology was used to carry out the computational analysis. It is well established and recognized within the scientific community that SAR is the primary dosimetric quantity used to evaluate the human body's absorption of RF energy and that MPEs are in fact derived from SAR. Accordingly, the SAR computations provide a scientifically valid and more accurate estimate of human exposure to RF energy.

Method

The simulation code employed is XFDTD™ v5.3, by Remcom Inc., State College, PA. This computational suite features a heterogeneous full body standing model, the so-called Visible Human [2], discretized in 5 mm voxels. The dielectric properties of 23 body tissues are automatically assigned by XFDTD™ at any specific frequency. The "seated" man model was obtained from the standing model by modifying the articulation angles at the hips and the knees. Details of the computational method and model are provided in the Appendix to this report, following the structure outlined in Appendix B.III of the Supplement C to the FCC OET Bulletin 65.

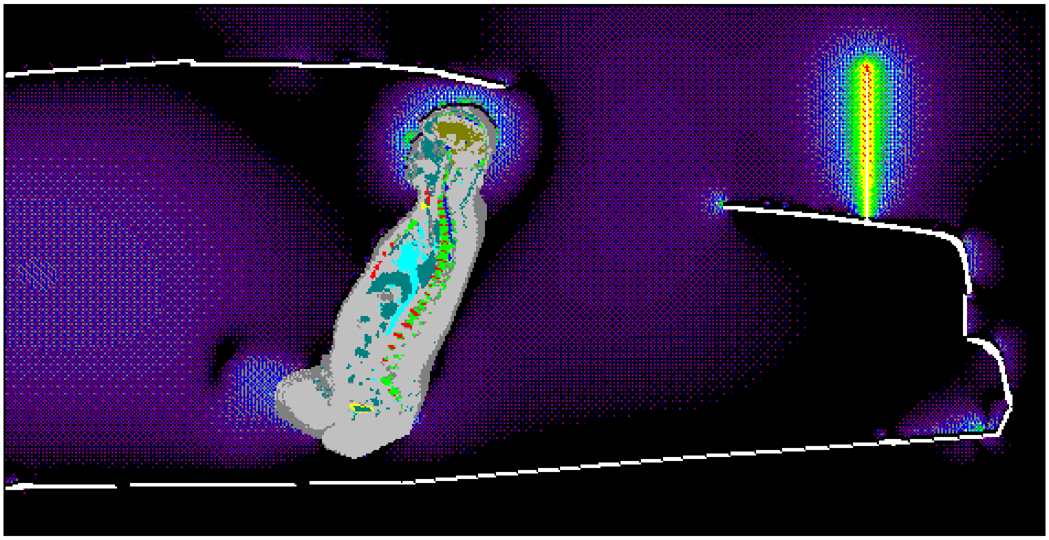
The car model has been imported into XFDTD™ from the CAD file of a sedan car having dimensions 4.98 m (L) x 1.85 m (W) x 1.18 m (H), and discretized in 5mm voxels. The wheels and part of the hood were omitted in order to fit within the computational memory (3 GB) available. These omissions would not be expected to affect the exposure calculations in any event. The antenna position is 26 cm from the end of the trunk, so as to replicate the experimental conditions used in MPE measurements. The frequency of the time-harmonic excitation used in the simulations has been rounded to the closest MHz to the frequencies of the radio channels used in the MPE measurements. Figures 1 and 2 show cross-sectional images of the XFDTD computational models for bystander and passenger, respectively.



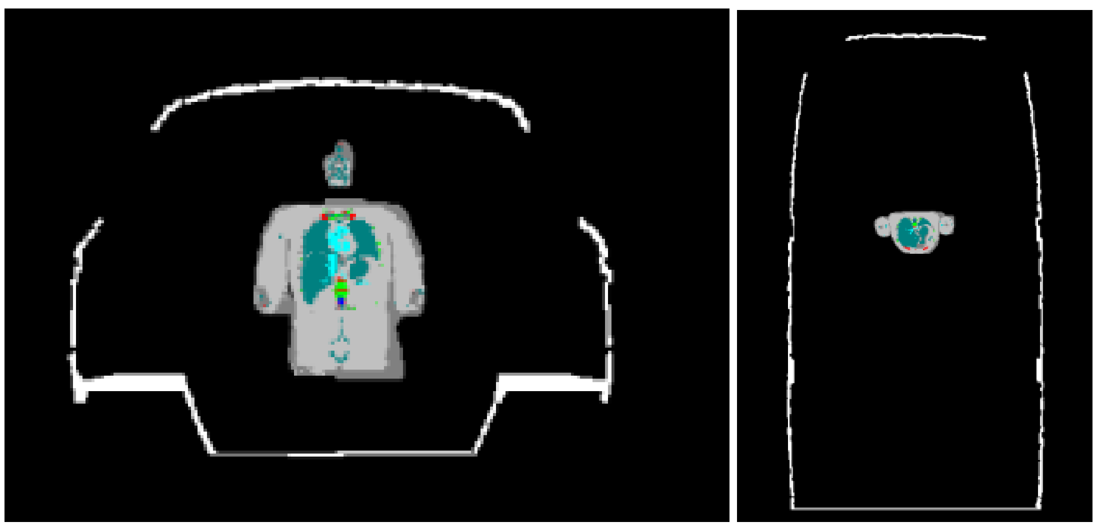
(a) (b)

Figure 1: Bystander models using (a) a quarter wave antenna operating at 146 MHz and (b) a 3 dBi gain antenna operating at 155 MHz. A time snapshot of the E-field is

displayed in both cases.



(a)



(b)

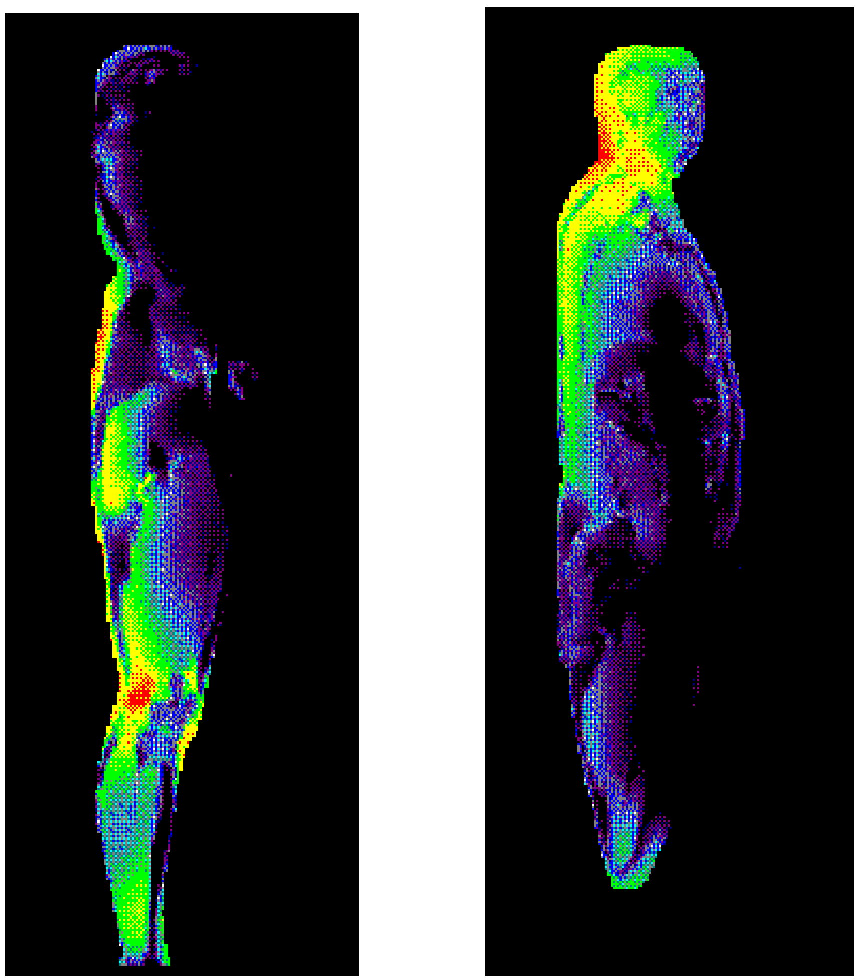
Figure 2: Car passenger model exposed to a quarter wave antenna operating at 164 MHz.

(a) Lateral view including a time snapshot of the E-field distribution. (b) Front and top views.

The computational code employs a time-harmonic excitation to produce a steady state electromagnetic field in the exposed body. Subsequently, the corresponding SAR distribution is automatically processed in order to determine the whole-body and 1-g average SAR. The product maximum output power is 54 W rms. Since the ohmic losses in the cable and in the car materials, as well as the mismatch losses at the antenna feed-point, are neglected, and 50% talk time is assumed, all computational results have been normalized to 27 W rms net output power.

Results of SAR computations for bystanders

The six test conditions requiring bystander SAR computations are summarized in Table I, together with other relevant information and the SAR results. The bystander is placed behind the car at 60 cm from the antenna, so as to replicate the conditions used in MPE measurements. All the transmit frequency and antenna length combinations reported in Table I have been simulated individually. As explained in the Appendix, the 1-gram SAR was derived from the SAR values computed by XFDTD through a simple interpolation.



(a) (b)

Figure 3: SAR distribution in bystander models produced by (a) a quarter wave antenna operating at 146 MHz (sagittal plane through the leg), and (b) a 3 dBi gain antenna operating at 155 MHz (mid sagittal plane), mounted on the trunk of the vehicle at 60 cm from the body.

Table I: Results of the SAR computations for bystander exposure to 54 W (50% talk-time) at 60 cm from the antenna.

	Antenna		SAR	
Frequency	Type	Length	1-g SAR	WB-SAR
146 MHz	HAD4007A	48 cm	0.27 W/kg	0.011 W/kg
155 MHz	HAD4008A	45 cm	0.28 W/kg	0.012 W/kg
155 MHz	RAD4000A(155)	118.5 cm	0.71 W/kg	0.011 W/kg
155 MHz	HAD4014AR	116 cm	0.68 W/kg	0.011 W/kg
164 MHz	HAD4014AR	116 cm	0.73 W/kg	0.015 W/kg
174 MHz	RAD4000A(174)	105 cm	0.72 W/kg	0.016 W/kg

The maximum peak 1-g SAR is 0.73 W/kg, about half of the 1.6 W/kg limit, while the maximum whole-body average SAR is 0.016 W/kg, i.e., one-fifth of the 0.08 W/kg limit. Examples of SAR distributions in the bystander model are reported in Fig. 3, showing that the increase in peak SAR in the case of the longer antennas is due to the narrowing of the RF current path in correspondence of the bystander's neck. For the short antenna, the increased current density occurs at the narrow cross sectional regions at the knee.

Results of SAR computations for car passengers

The four test conditions requiring passenger SAR computations are summarized in Table II, together with the antenna data and the SAR results. The passenger is located in the center of the rear seat, where the maximum power density was measured. We also analyzed one case with the passenger located near the door, to verify that the exposure level would not increase. All the transmit frequency, antenna length, and passenger location combinations reported in Table II have been simulated individually. The maximum peak 1-g SAR is 0.73 W/kg, while the maximum whole-body average SAR is 0.016 W/kg. An example of SAR distribution in the passenger model when it is located at the center of the rear seat is reported in Fig. 4. An example of the SAR distribution when the passenger is located on the side near the door is reported in Fig. 5a. In the latter case the peak exposure is not in the neck region of the passenger model, but around the knee due to its proximity to some metal features of the car model, as shown in Fig. 5b.

Table II: Results of SAR computations for passenger in the back seat exposed to 54 W (50% talk-time) from a trunk-mounted antenna.

	Antenna	Passenger Centered	Passenger near Door

Frequency	Type	Length	1-g SAR	WB-SAR	1-g SAR	WB-SAR
146 MHz	HAD4007A	48 cm	0.49 W/kg	0.008 W/kg		
155 MHz	HAD4008A	45 cm	0.43 W/kg	0.011 W/kg		
164 MHz	HAD4009A	42 cm	0.71 W/kg	0.012 W/kg		
174 MHz	HAD4009A	42 cm	0.73 W/kg	0.016 W/kg	0.37 W/kg	0.012 W/kg

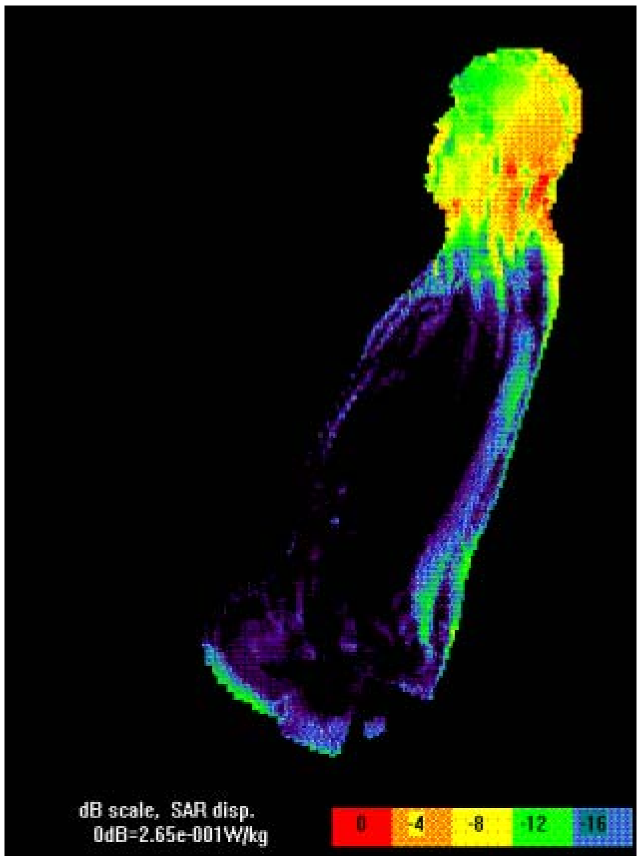
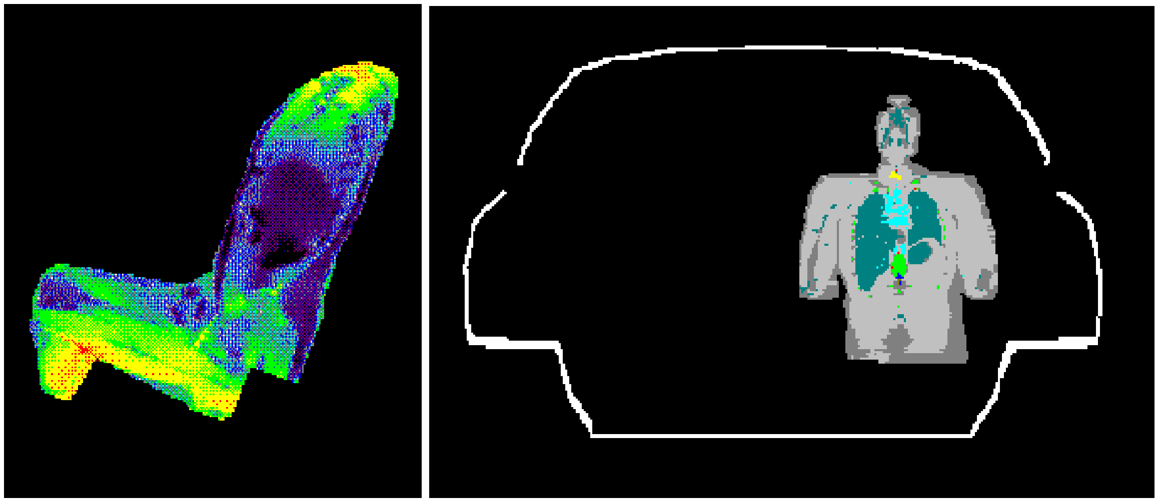


Figure 4: SAR distribution in the passenger model placed in the center of the rear seat, with a trunk-mount antenna operating at 164 MHz.



(a) (b)

Figure 5: SAR distribution in the passenger model through the plane where the peak SAR occurs (a) placed laterally in the back seat (b), with a trunk-mount antenna operating at 174 MHz.

Conclusions

Under the test conditions described for evaluating passenger and bystander exposure to the RF electromagnetic fields emitted by vehicle-mounted antennas used in conjunction with this mobile radio product, the present analysis shows that the computed SAR values are compliant with the FCC exposure limits for the general public.

References

[1] IEEE Standard C95.1-1999. *IEEE Standard for Safety Levels with Respect to Human Exposure to RF Electromagnetic Fields*, 3 kHz to 300 GHz.

[2] http://www.nlm.nih.gov/research/visible/visible_human.html

APPENDIX: SPECIFIC INFORMATION FOR SAR COMPUTATIONS

This appendix follows the structure outlined in Appendix B.III of the Supplement C to the FCC OET Bulletin 65. Most of the information regarding the code employed to perform the numerical computations has been adapted from the XFDTD v5.3 User Manual. Remcom Inc., owner of XFDTD, is kindly acknowledged for the help provided.

1) Computational resources

a) A four-processor server (Mod. PowerEdge 6650, by Dell Computers Inc.) equipped with four 1.4 GHz Xeon microprocessors and 4 GB D-RAM (3 GB available for running applications) was employed for all simulations.

b) The memory requirement was between 2 GB and 3 GB in all cases. Using the above-mentioned server with all four processors operating concurrently, the typical simulation would run for 16 hours.

2) FDTD algorithm implementation and validation

a) We employed a commercial code (XFDTD v5.3, by Remcom Inc.) that implements the classical Yee's FDTD formulation [1]. The solution domain was discretized according to a rectangular grid with a uniform 5 mm step in all directions. Sub-gridding was not used. Liao's absorbing boundary conditions [2] are set at the domain boundary to simulate free space radiation processes. The excitation is a lumped voltage generator with 50-ohm source impedance. The code allows selecting *wire objects* without specifying their radius. We used a wire to represent the antenna. The car body is modeled by solid metal.

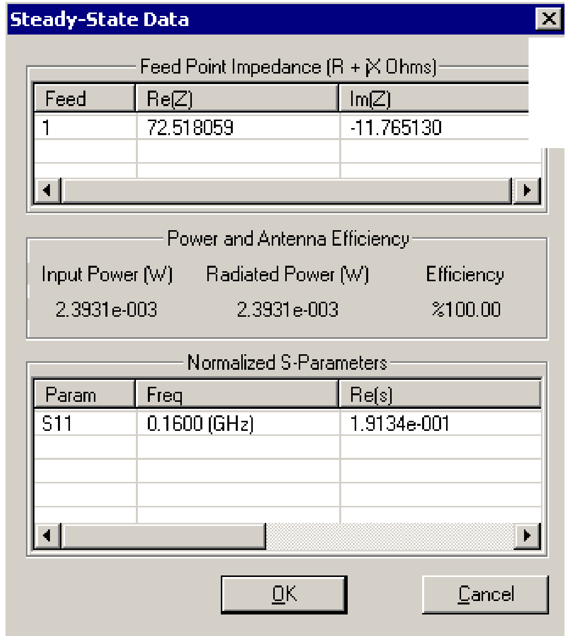
We did not employ the "thin wire" algorithm in XFDTD since the antenna radius was never smaller than one-fifth the voxel dimension. In fact, the XFDTD manual specifies that

"Thin Wire materials may be used in special situations where a wire with a radius much smaller than the cell size is required… However, in cases where the wire radius is important to the calculation and is less than approximately 1/5 the cell size, the thin wire material may be used to accurately simulate the correct wire dimensions."

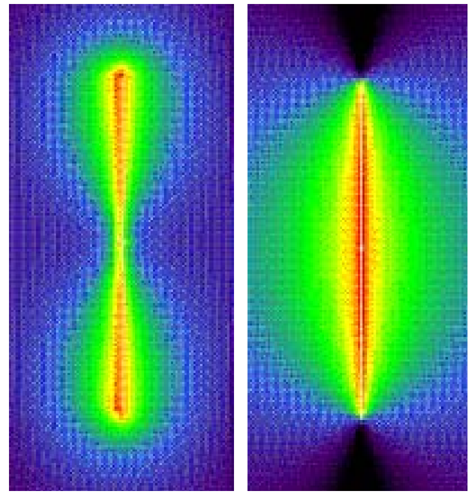
The voxel size in all our simulations was 5 mm, and the antenna radius is always at least 1 mm (1 mm for the short quarter-wave antennas and 1.5 mm for the long gain antennas), so there was no need to specify a "thin wire" material.

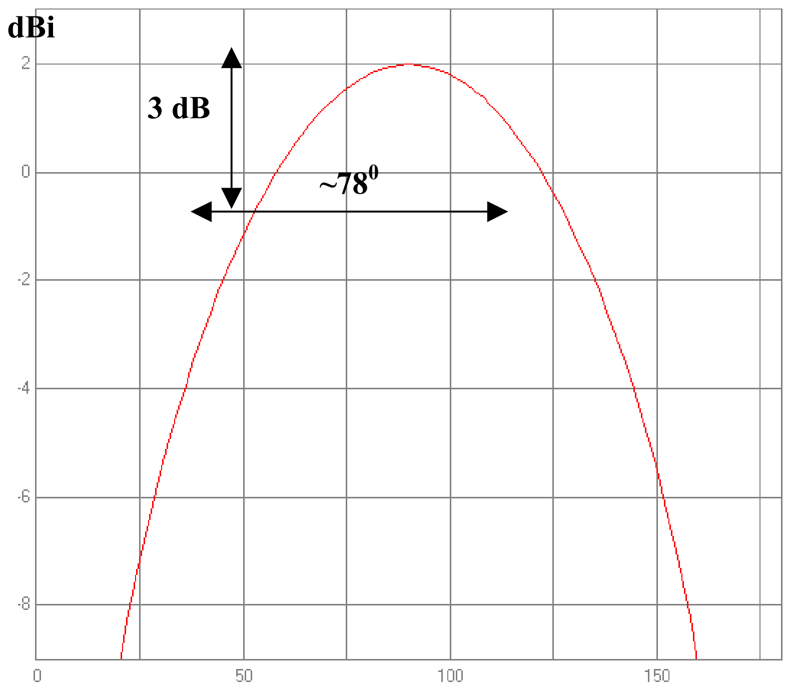
b) XFDTD is one of the most successful commercial codes for electromagnetic simulations. It has gone through extensive validation and has proven its accuracy over time in many different applications. One example is provided in [3].

We carried out a validation of the code algorithm by running the canonical test case involving a half-wave wire dipole. The dipole is 0.475 times the free space wavelength at 160 MHz, i.e., 88.5 cm long. The discretization used in the model was uniform in all directions and equal to 5 mm, so the dipole is 177 cells long. Also in this case, we did not use the "thin wire" model. The following picture shows XFDTD outputs regarding the antenna feed-point impedance (72.6 – j 11.8 ohm), as well as qualitative distributions of the total E and H fields near the dipole. The radiation pattern is shown as well (one elevation lobe). As expected, the 3 dB beamwidth is about 78 degrees.

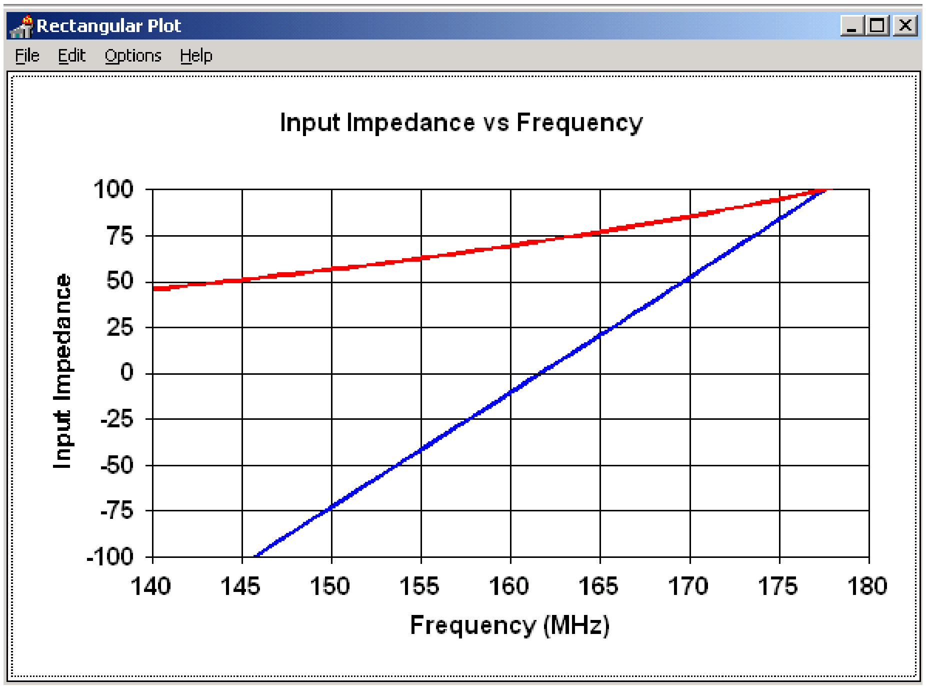


E-field ***H-field***





We also compared the XFDTD result with the results derived from NEC [4], which is a code based on the method of moments. In this case, we used a dipole with radius 1 mm, length 88.5 cm, and the discretization is 5 mm. The corresponding input impedance at 160 MHz is 69.5-j10.5 ohm. Its frequency dependence is reported in the following figure.



This validation ensures that the input impedance calculation is carried out correctly in XFDTD, thereby enabling accurate estimates of the radiated power. It further ensures that the wire model employed in XFDTD, which we used to model the antennas, produces physically meaningful current and fields distributions. Both these aspects ensure that the field quantities are correctly computed both in terms of absolute amplitude and relative distribution.

3) Computational parameters

a) The following table reports the main parameters of the FDTD model employed to perform our computational analysis:

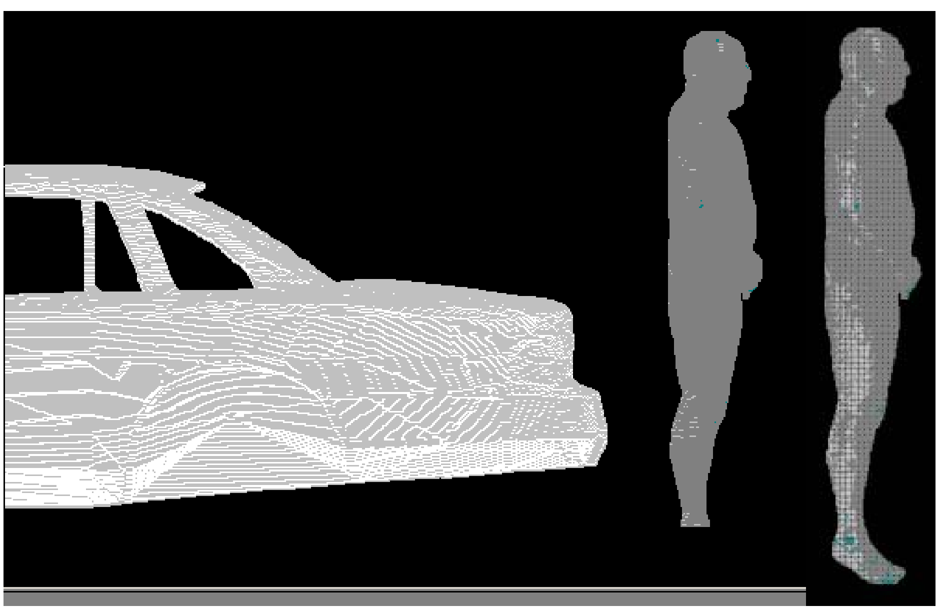
PARAMETER	X	Y	Z
Voxel size	5 mm	5 mm	5 mm
Domain size for bystander computations (in voxels)	404	550	414
Domain size for passenger computations (in voxels)	398	727	281
Time step	Exactly equal to Courant limit (typically 10 *ps* at this frequency, with the body model)		
Objects separation from FDTD boundary (voxels)	>10	>10	>10
Number of time steps	6000 in all simulations		
Excitation	Sinusoidal (approx. 10 periods)		

b) In order to fit the model within a grid size that would not use up the available memory, we chopped the hood of the car and the feet of the human model.

4) Phantom model implementation and validation

a) The FDTD mesh of a male human body was created using digitized data in the form of transverse color images. The data is from the *visible human project* sponsored by the National Library of Medicine (NLM) and is available via the Internet (http://www.nlm.nih.gov/research/visible/visible_human.html). The male data set consists of MRI, CT and anatomical images. Axial MRI images of the head and neck and longitudinal sections of the rest of the body are available at 4 mm intervals. The MRI images have 256 pixel by 256 pixel resolution. Each pixel has 12 bits of gray tone resolution. The CT data consists of axial CT scans of the entire body taken at 1 mm intervals at a resolution of 512 pixels by 512 pixels where each pixel is made up of 12 bits of gray tone. The axial anatomical images are 2048 pixels by 1216 pixels where each pixel is defined by 24 bits of color. The anatomical cross sections are also at 1 mm intervals and coincide with the CT axial images. There are 1871 cross sections. The XFDTD High Fidelity Body Mesh uses 5x5x5 mm cells and has dimensions 136 x 87 x 397. Dr. Michael Smith and Dr. Chris Collins of the Milton S. Hershey Medical Center, Hershey, Pa, created the High Fidelity Body mesh. Details of body model creation are given in the *methods* section in [5]. The body mesh contains 23 tissues materials. Measured values for the tissue parameters for a broad frequency range are included with the mesh data. The correct values are interpolated from the table of measured data and entered into the appropriate mesh variables. The tissue conductivity and permittivity variation *vs.* frequency is included in the XFDTD calculation by a multiple-pole approximation to the Cole-Cole approximated tissue parameters reported by Camelia Gabriel, Ph.D., and Sami Gabriel, M. Sc. (http://www.brooks.af.mil/AFRL/HED/hedr/reports/dielectric/home.html).

In order to fit the car and bystander model within the volume allowed by the available RAM, the feet of the XFDTD High Fidelity Body Mesh were cut away, thereby reducing the model length by about 16 cm (32 voxels). Notice that the original model's feet are not flat and parallel to ground as if he were standing, but are inclined downwards. Therefore, we estimated that the actual reduction in body length is 9 cm. The following figure shows the cross section of the model used in the bystander computations, compared with the original XFDTD High Fidelity Body Mesh.



b) The XFDTD High Fidelity Body Mesh model correctly represents the anatomical structure and the dielectric properties of body tissues, so it is appropriate for determining the highest exposure expected for normal device operation. We oriented the bystander model facing away from the transmitting antenna because the greatest possible amount of tissue is brought close to the antenna. In fact, the model's back is completely flat, so a plane can be precisely defined, thereby avoiding any ambiguity regarding the bystander distance from the antenna.

c) One example of the accuracy of XFDTD for computing SAR has been provided in [6]. The study reported in [6] is relative to a large-scale benchmark of measurement and computational tools carried out within the IEEE Standards Coordinating Committee 34, Sub-Committee 2.

5) Tissue dielectric parameters

a) The following table reports the dielectric properties used by XFDTD for the 23 body tissue materials in the High Fidelity Body Mesh at 160 MHz (mid-band for this VHF mobile radio product).

#	Tissue	ε_r	σ (S/m)	Density (kg/m^3)
1	skin	50.1	0.49	1125
2	tendon, pancreas, prostate, aorta, liver, other	59.0	0.63	1151
3	fat, yellow marrow	5.8	0.04	943
4	cortical bone	15.4	0.08	1850
5	cancellous bone	25.8	0.17	1080
6	blood	63.9	1.65	1057
7	muscle, heart, spleen, colon, tongue	73.1	0.85	1059
8	gray matter, cerebellum	70.6	0.74	1035.5
9	white matter	50.8	0.42	1027.4
10	CSF	74.0	2.29	1000
11	sclera/cornea	61.5	0.94	1151
12	vitreous humor	68.5	1.52	1000
13	bladder	19.0	0.28	1132
14	nerve	43.6	0.41	1112
15	cartilage	53.4	0.53	1171
16	gall bladder bile	86.0	1.50	928
17	thyroid	65.6	0.72	1035.5
18	stomach/esophagus	78.3	1.03	1126
19	lung	52.2	0.59	563
20	kidney	72.0	1.02	1147
21	testis	72.3	0.99	1158
22	lens	57.1	0.61	1163
23	small intestine	88.8	1.86	1153

b) The tissue types and dielectric parameters used in the SAR computation are appropriate for determining the highest exposure expected for normal device operation, because they are derived from measurements performed on real biological tissues (http://www.brooks.af.mil/AFRL/HED/hedr/reports/dielectric/home.html).

c) The tabulated list of the dielectric parameters used in phantom models is provided at point 5(a). As regards the device (car plus antenna), we used perfect electric conductors.

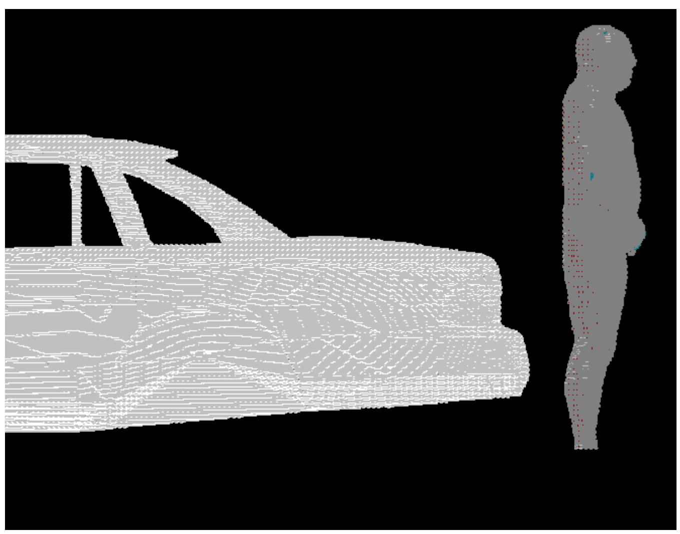
6) Transmitter model implementation and validation

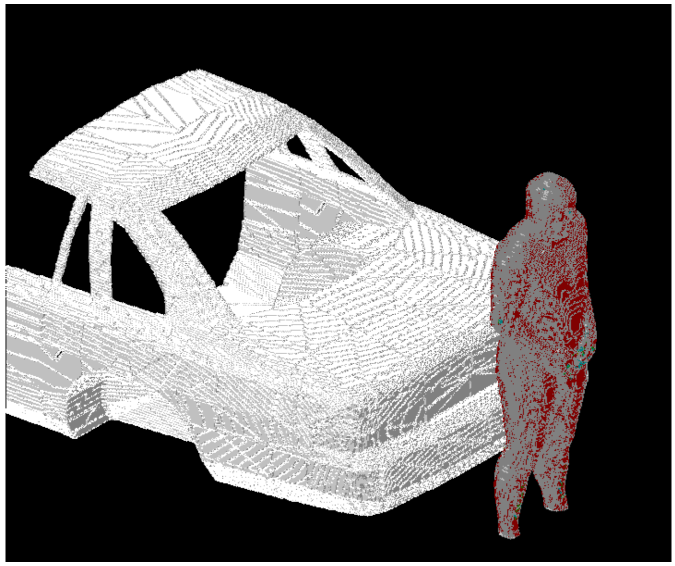
a) The essential features that must be modeled correctly for the particular test device model to be valid are:

- Car body. We developed one very similar to the car used for MPE measurements, so as to be able to correlate measured and simulated field values. The model was imported in XFDTD from a CAD model that is commercially available at http://www.3dcadbrowser.com/

- Antenna. We used a straight wire in all cases, even though the gain antenna has a base coil for tuning. All the coil does is compensate for excess capacitance due to the antenna being slightly longer than half a wavelength. We do not need to do that in the model, as we used normalization with respect to the net radiated power, which is determined by the input resistance only. In this way, we neglect mismatch losses and artificially produce an overestimation of the SAR, thereby introducing a conservative bias in the model.

- Antenna location. We used the same location, relative to the edge of the car trunk, used in the MPE measurements. The following pictures show a lateral and a perspective view of the whole model (XFDTD does not show wires in this views, that is why the antenna is not visible).

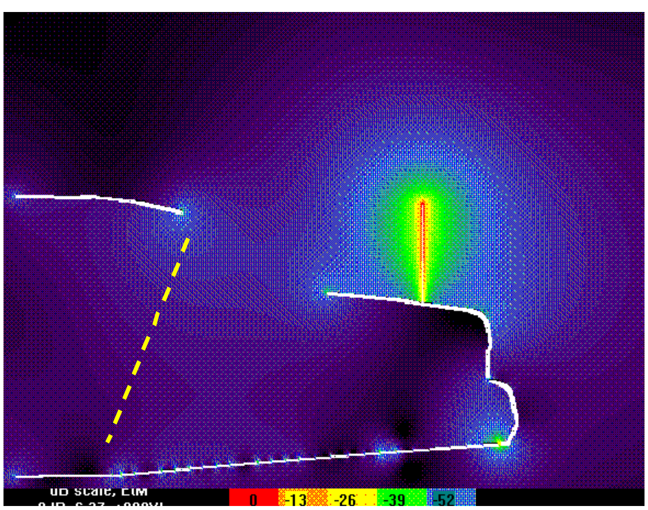


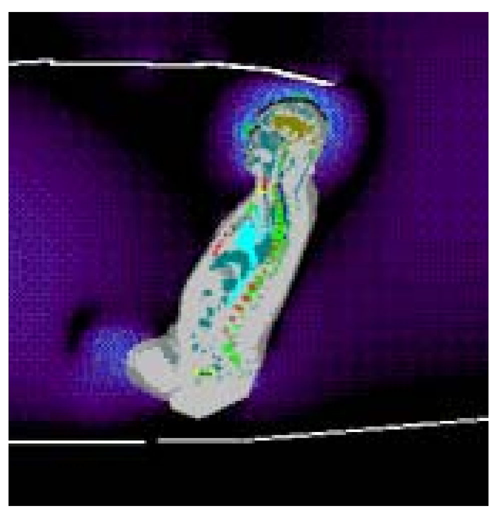


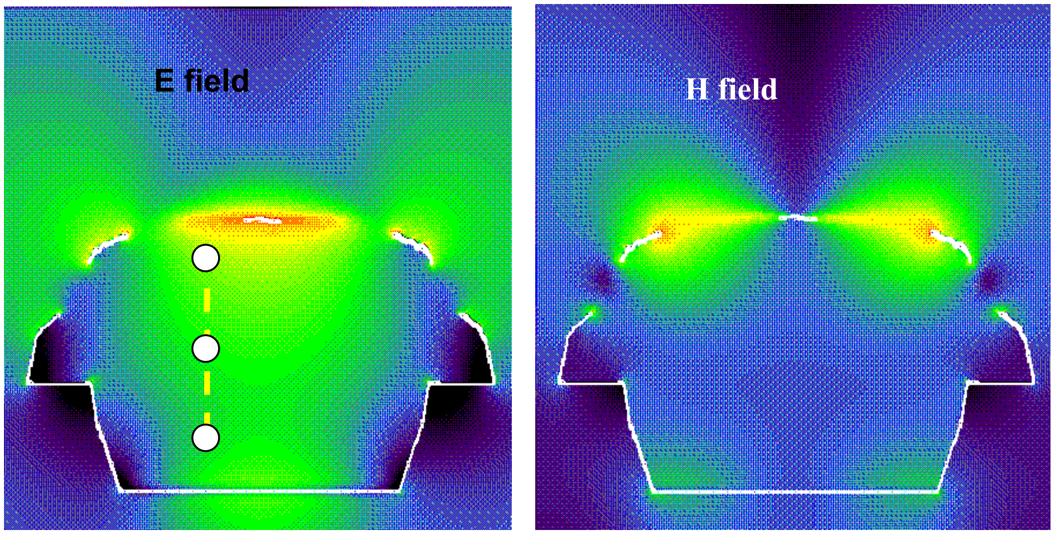
The car model does not include wheels in order to reduce its complexity. The pavement has not been included in the model. The model has been validated on the basis of a comparison between measured and computed field values at the passenger and bystander locations. In particular, we analyzed three cases that are relevant to the testing conditions that exhibited highest exposure: passenger with monopole antenna (164 MHz); bystander with monopole antenna (146 MHz); and bystander with long, gain antenna (155 MHz).

Passenger with 42 cm monopole antenna (164 MHz)

The following figures of the test model show the empty car model, where the yellow dotted line represents the back seat, as it can be observed from the right-hand side figure showing the passenger. The comparison has been performed by taking the computed steady-state field values at the locations corresponding to the head, chest, and legs along the yellow line and comparing them with the corresponding measurements. Such a comparison is carried out at the same rms power level (54 W) used in the measurements. Steady-state E-field and H-field distributions at a vertical plane transverse to the car and crossing the passenger's head are displayed as well.







The highest exposure occurs in the middle of the backseat, which is also the case in the measurements. Therefore, the field values were determined on the yellow line centered at the middle of the backseat, approximately at the three locations that are shown by white dots. In actuality, the line is inclined so as to follow the inclination of the passenger's back, as shown previously.

Because the peak exposure occurs in the center of the back seat, that was where we placed the passenger model to perform the SAR evaluations presented in the report. However, it can be observed that the H-field distribution features peaks near the lateral edges of the car. That is the reason why we also carried out one SAR computation by placing the passenger laterally in the back seat, in order to determine whether the SAR would be higher in this case.

As done in the measurements, the equivalent power density (S) is computed from the E-field, the H-field being much lower, by squaring the peak E-field magnitude and dividing by the free-space wave impedance (377 ohm). The following table reports the E-field values computed by XFDTD at the three locations, and the corresponding power density.

Location	E-field magnitude (V/m)	S (W/m^2)
Head	1.0	1.33E-03
Chest	0.45	2.69E-04
Legs	0.32	1.36E-04
	Average S	**5.77E-04**

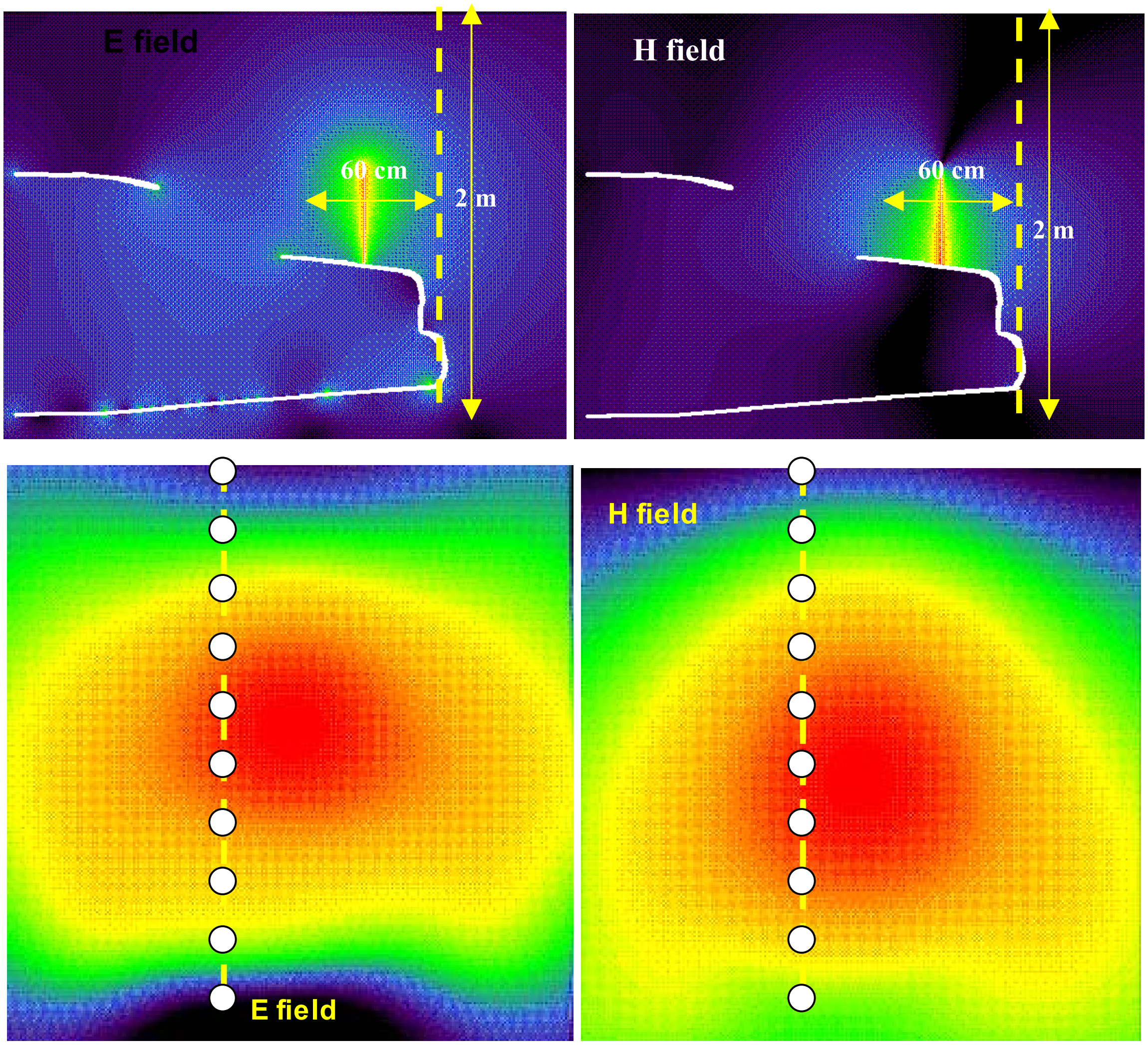
The input impedance is 28.2-j27 ohm, therefore the radiated power (considering the mismatch to the 50 ohm unitary voltage source) is 2.06E-3 W. The scaled-up power density for 54 W radiated power is 15.1 W/m^2, corresponding to 1.51 mW/cm^2. Measurements gave an average of 1.29 mW/cm^2, which is in good agreement.

<u>Bystander with 48 cm monopole antenna (146 MHz)</u>

The following figures show the E-field and H-field distributions across a vertical plane passing for the antenna and cutting the car in half. As done in the measurements, the MPE is computed from both E-field and H-field distributions, along the yellow dotted line at 10 points spaced 20 cm apart from each other up to 2 m in height. These lines and the field evaluation points are approximately indicated in the figures. The E-field and H-field distributions in the vertical plane placed at 60 cm from the antenna, behind the case, are shown as well. The points where the fields are sampled to determine the equivalent power density (S) are approximately indicated by the white dots.

The equivalent power density computation from either the E-field or the H-field is performed as follows:

$$S_E = \frac{|\mathbf{E}|^2}{2\eta}, \quad S_H = \frac{\eta}{2}|\mathbf{H}|^2, \quad \eta = 377\,\Omega$$



The following table reports the field values computed by XFDTD and the corresponding power density values. The average exposure levels are computed as well.

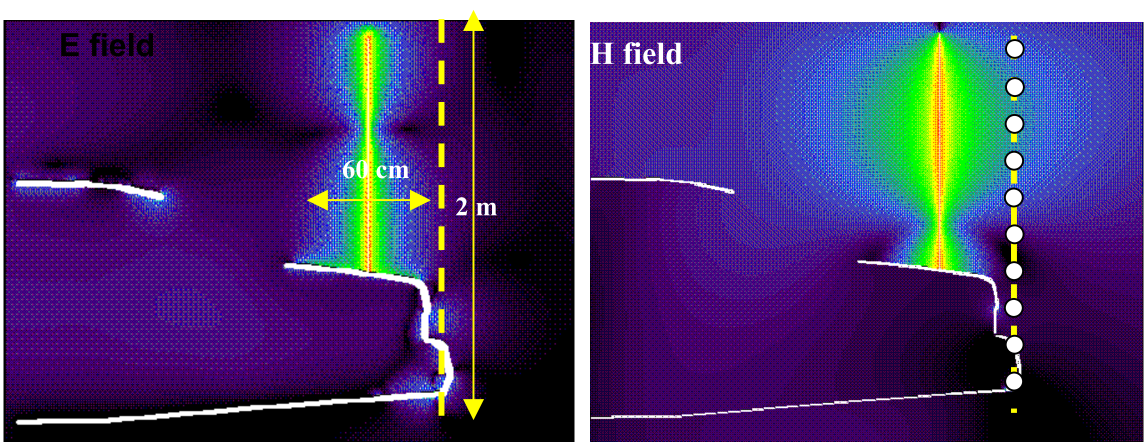
Height (cm)	E (V/m)	S_E (W/m^2)	H (A/m)	S_H (W/m^2)

20	2.12E-01	5.96E-05	5.14E-04	4.98E-05
40	3.81E-01	1.93E-04	8.67E-04	1.42E-04
60	4.43E-01	2.60E-04	1.35E-03	3.45E-04
80	5.36E-01	3.81E-04	1.73E-03	5.67E-04
100	6.17E-01	5.05E-04	1.84E-03	6.37E-04
120	6.28E-01	5.23E-04	1.57E-03	4.63E-04
140	5.59E-01	4.14E-04	1.11E-03	2.34E-04
160	4.41E-01	2.58E-04	6.99E-04	9.20E-05
180	3.24E-01	1.39E-04	3.73E-04	2.63E-05
200	2.31E-01	7.08E-05	1.86E-04	6.54E-06
	Average S_E	**2.80E-04**	**Average S_H**	**2.56E-04**

The input impedance is 27.3-j19.5 ohm, therefore the radiated power (considering the mismatch to the 50 ohm unitary voltage source) is 2.15E-3 W. The scaled-up power density values for 54 W radiated power are 7.1 W/m^2 (E), and 6.5 W/m^2 (H), that correspond to 0.71 mW/cm^2 (E), and 0.65 mW/cm^2 (H). Measurements yielded average power density of 0.664 mW/cm^2 (E), and 0.471 mW/cm^2 (H), i.e., which are in good agreement with the simulations.

<u>Bystander with 116 cm gain antenna (155 MHz)</u>

Also in this case the fields were averaged over a vertical line parallel to the antenna, at 60 cm from it, after taking ten field samples spaced 20 cm apart from each other. The following figures show the steady-state electric and magnetic field distributions and the approximate locations of the field points used in the assessment.



The following table reports the field values computed by XFDTD and the corresponding power density values. The average exposure levels are computed as well.

Height (cm)	E (V/m)	S_E (W/m^2)	H (A/m)	S_H (W/m^2)
20	4.68E-02	2.91E-06	7.22E-05	9.81E-07
40	5.74E-02	4.37E-06	1.12E-04	2.36E-06
60	5.60E-02	4.16E-06	1.49E-04	4.21E-06
80	1.14E-01	1.73E-05	1.68E-04	5.32E-06
100	1.97E-01	5.14E-05	2.77E-04	1.45E-05
120	2.47E-01	8.12E-05	5.22E-04	5.14E-05
140	2.47E-01	8.09E-05	7.56E-04	1.08E-04

160	2.30E-01	7.03E-05	8.51E-04	1.37E-04
180	2.25E-01	6.69E-05	7.76E-04	1.13E-04
200	2.12E-01	5.96E-05	5.71E-04	6.15E-05
	Average S_E	**4.39E-05**	**Average S_H**	**4.98E-05**

The input impedance is 95.2-j324 ohm, therefore the radiated power (considering the mismatch to the 50 ohm unitary voltage source) is 3.77E-4 W. The scaled-up power density values for 54 W radiated power are 6.3 W/m^2 (E), and 7.1 W/m^2 (H), that correspond to 0.63 mW/cm^2 (E), and 0.71 mW/cm^2 (H). Measurements yielded average power density of 0.489 mW/cm^2 (E), and 0.549 mW/cm^2 (H), i.e., which are in good agreement with the simulations.

The following table summarizes the results of this investigation to correlate field measurements and simulations for 54 W net radiated power.

	Average S_E (W/m^2)			**Average S_H (W/m^2)**		
Test conditions	MEAS	SIM	Δ [%]	MEAS	SIM	Δ [%]
Passenger & 42 cm monopole (164 MHz)	1.29	1.51	17%	N/A	N/A	N/A
Bystander & 48 cm monopole (146 MHz)	0.664	0.71	7%	0.471	0.65	38%
Bystander & gain antenna (155 MHz)	0.489	0.63	29%	0.549	0. 71	29%

The simulations tend to overestimate the average power density levels, which is understandable since there are no ohmic losses and perfect impedance matching is enforced in the computational models. Based on these results, we conclude that the simulation will produce slight exposure overestimates, in the range of 7% to 38%.

b) Descriptions and illustrations showing the correspondence between the modeled test device and the actual device, with respect to shape, size, dimensions and near-field radiating characteristics, are found in the report.

c) Verification that the test device model is equivalent to the actual device for predicting the SAR distributions descends from the fact that the car and antenna size and location in the numerical model correspond to those used in the measurements.

d) The peak SAR is in the neck region for the passenger, which is in line with MPE measurements and predictions. As regards the bystander, the peak SAR occurs in the upper side of the calf when the short monopole antenna is used, because in that case the near field energy density is higher in the lower portion of the body, and the calf is highly conductive compared with nearby tissues. For the longer gain antennas, the peak SAR occurs at the neck, which is in line with the distribution of the impinging RF energy.

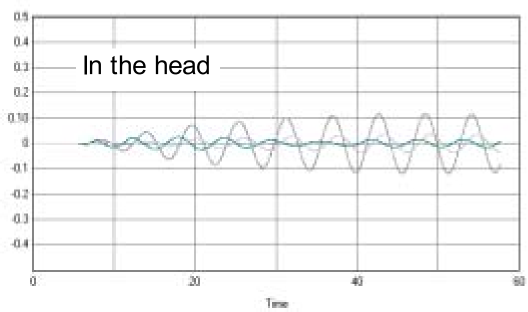
7) Test device positioning

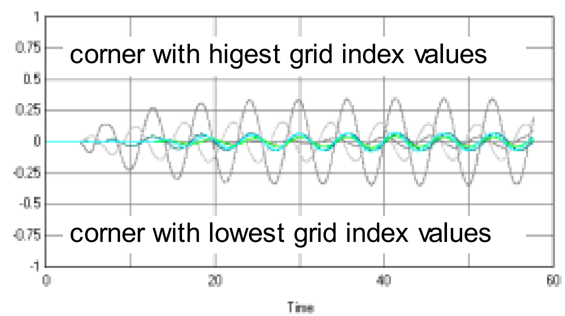
a) A description of the device test positions used in the SAR computations is provided in the SAR report.

b) Illustrations showing the separation distances between the test device and the phantom for the tested configurations are provided in the SAR report.

8) Steady state termination procedures

a) The criteria used to determine that sinusoidal steady-state conditions have been reached throughout the computational domain for terminating the computations are based on the monitoring of field points to make sure they converge. We placed one "field sensor" near the antenna, others between the body and the domain boundary at different locations, and one inside the head of the model. We used isotropic E and H field "sensors", meaning that all three components of the fields are monitored at these points. The following figures show an example of the time waveforms at the field point sensors in the head and in two opposite points in the computational domain. In the latter case, we selected points near the lowest and highest grid index points. They are shown together in the figure. The highest field levels are observed for higher index point, as it is closer to the antenna. In all cases, the field reaches the steady-state rapidly.





b) 6000 time steps were used, with a time step approximately equal to 10 *ps* (meeting the Courant criterion), which corresponds to approximately 10 wave cycles at 160 MHz.

c) The XFDTD algorithm establishes time-harmonic field phasors by using the so-called "two-equations two-unknowns" method. Details of the algorithm are explained in [7].

9) Computing peak SAR from field components

a) The twelve E-field phasors at the edges of each Yee voxel are combined to yield the SAR associated to that voxel. In particular, the average is performed on the SAR values computed at the 12 edges of each voxel. Notice that in XFDTD the dielectric tissue properties are assigned to the voxel edges, thereby allowing said averaging procedure.

b) The IEEE Standards Coordinating Committee 34, Sub-Committee 2 draft standard P1529 (June 2000) discusses several algorithms for volumetric SAR averaging. It states that "It is observed that while the 12 components algorithm is the most appropriate from the mathematical point of view, the differences in 1g SAR calculated with either the 12 or 6 component methods are negligible for practical mesh resolutions (below 5mm). On the other hand, it is shown that the 3 components approach may lead to significant errors." XFDTD employs the 12-component method, which is the one recommended in the draft standard, thus providing the best achievable accuracy.

10) One-gram averaged SAR procedures

a) XFDTD computes the Specific Absorption Rate (SAR) in each complete cell containing lossy dielectric material and with a non-zero material density. To be considered a complete cell, the twelve cell edges must be lossy dielectric material. The averaging calculation uses an interpolation scheme for finding the averages. Cubical spaces centered on a cell are formed and the mass and average SAR of the sample cubes are found. The size of the sample cubes increases until the total mass of the enclosed exceeds either 1 or 10 grams. The mass and average SAR value of each cube is saved and used to interpolate the average SAR values at either 1 or 10 grams. The interpolation is performed using two methods (polynomial fit and rational function fit) and the one with the lowest error is chosen. The sample cube must meet some conditions to be considered valid. The cube may contain some non-tissue cells, but some checks are performed on the distribution of the non-tissue cells. A valid cube will not contain an entire side or corner of non-tissue cells.

b) The sample cube increases in odd-numbered steps (1x1x1, 3x3x3, 5x5x5, etc) to remain centered on the desired cell. Since the visible human model employed herein has 5 mm resolution, the one-gram SAR is computed by averaging first over 1x1x1 voxels, corresponding to 0.125 cm^3 (not enough yet), and then over a 3x3x3 voxel cube, corresponding to about 3.4 cm^3, which is enough to include 1 g. The 1-g average SAR is computed by interpolating between these two data points.

c) As mentioned at points 10(a) and 10(b), the 1- gram average SAR is determined by interpolating the average SAR for the 1x1x1 and the 3x3x3 data points, corresponding to 0.125 cm^3 and 3.4 cm^3, respectively. Because the interpolation is carried out between two data points, the error introduced by this linear interpolation should be negligible because the interpolating line crosses exactly the data points.

11) Total computational uncertainty – We derived an estimate for the uncertainty of FDTD methods in evaluating SAR by referring to [6]. In Fig. 7 in [6] it is shown that the deviation between SAR estimates using the XFDTD code and those measured with a compliance system are typically within 10% when the probe is away from the phantom surface so that boundary effects are negligible. In that example, the simulated SAR always exceeds the measured SAR.

As discussed in 6(a), a conservative bias has been introduced in the model so as to reduce concerns regarding the computational uncertainty related to the car modeling, antenna modeling, and phantom modeling. The results of the comparison between measurements and simulations presented in 6(a) suggest that the present model produces an overestimate of the exposure between 7% and 38%. Such a conservative bias should eliminate the need for including uncertainty considerations in the SAR assessment.

12) Test results for determining SAR compliance

a) Illustrations showing the SAR distribution of dominant peak locations produced by the test transmitter, with respect to the phantom and test device, are provided in the SAR report.

b) The input impedance and the total power radiated under the impedance match conditions that occur at the test frequency are provided by XFDTD. XFDTD computes the input impedance by following the method outlined in [8], which consists in performing the integration of the steady-state magnetic field around the feed point edge to compute the steady-state feed point current (*I*), which is then used to divide the feed-gap steady-state voltage (*V*). The net *rms* radiated power is computed as

$$P_{XFDTD} = \frac{1}{2}\mathrm{Re}\left\{VI^*\right\}$$

Both the input impedance and the net rms radiated power are provided by XFDTD.

We normalize the SAR to such a power, thereby obtaining SAR per radiated Watt (*normalized SAR*) values for the whole body and the 1-g SAR. Finally, we multiply such normalized SAR values times the max power rating of the device under test. In this way, we obtain the exposure metrics for 100% talk-time, i.e., without applying source-based time averaging.

c) For mobile radios, 50% source-based time averaging is applied by multiplying the SAR values determined at point 12(b) times a 0.5 factor.

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