COMPUTATIONAL EME COMPLIANCE ASSESSMENT OF THE XPR MODEL AAM28JNN9RA1AN (PMUD2566C)(IC MODEL: PMUD2566CBMNAA) MOBILE RADIO

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Introduction

This report summarizes the computational [numerical modeling] analysis performed to document compliance of the XPR Series Model Number AAM28JNN9RA1AN (PMUD2566C)(IC MODEL: PMUD2566CBMNAA) Mobile Radio and vehicle-mounted antennas with the US Federal Communications Commission (FCC), Innovation, Science and Economic Development (ISED) Canada and ICNIRP guidelines for human exposure to radio frequency (RF) emissions. The radio operates in the following frequency bands:

Regions	Bands	Frequency Band (MHz)
FCC US	LMR VHF	150.8-173.4
ISED Canada	LMR VHF	138-174
Overall (Other regions)	LMR VHF	136-174

This computational analysis supplements the measurements conducted to evaluate the compliance of the exposure from this mobile radio with respect to applicable *reference levels*, which in the following will be referred to as *maximum permissible exposure* (MPE) limits.[1] A total of 2 test conditions that did not conform with FCC MPE limit and 3 test conditions did not conform with ISED MPE limit were considered 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 and 0.08 W/kg averaged over the whole body) set forth in FCC guidelines [2] and Health Canada guidelines [1]. A total of 2 test conditions did not conform with ICNIRP

[1] This choice is made for process efficiency, since “MPE” is used in the United States. In this way, chances of making editorial mistakes that may then require extended interactions with the report examiner are reduced.

guideline MPE limit were considered to determine whether those conditions complied with SAR limits set forth in, ICNIRP guidelines [4] and IEEE Std. C95.1-2019 standard [5] (2.0 W/kg averaged over 10 gram of tissue and 0.08 W/kg averaged over the whole body).

Consequently, a total of 3 configurations (requiring a total of 6 numerical simulations) have been performed, all of them addressing the exposure of the back seat passenger to the VHF mobile radio featuring trunk-mount antennas.

For all simulations a commercial code (XFDTD™ v7.6.0, by Remcom Inc, State College, PA, USA) based on the Finite-Difference-Time-Domain (FDTD) methodology was employed to carry out the computational analysis. It is well established and recognized within the scientific community that SAR represents the basic restriction for RF energy exposure up to 6 GHz and that MPE limits are in fact derived from SAR limits. Accordingly, the SAR computations provide a scientifically valid and more relevant estimate of RF energy exposures.

Method

The XFDTD™ v7.6.0 computational suite enable simulating the heterogeneous full human body model defined according to the IEC/IEEE 62704-2:2017 standard and derived from the so-called Visible Human [3], discretized in 3 mm cubic-edge voxels. The IEC/IEEE 62704-2:2017 dielectric properties for 39 body tissues are automatically assigned by XFDTD™ at the specific simulation frequency. The “seated” man model representing the passenger 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 A to this report. The evaluation of the computational uncertainties and results of the benchmark validations are provided in the Appendix B attached to this report. The XFDTD code validation performed by Remcom Inc. according to the IEEE/IEC 62704-2:2017 standard requirements are provided in conjunction with this report.

The car model has been imported into XFDTD™ from the CAD file of the sedan vehicle defined in the IEEE/IEC 62704-2:2017 standard, having dimensions 4.98 m (L) x 1.85 m (W) x 1.18 m (H), and discretized with the minimum resolution of 3 mm and the maximum resolution of 8 mm. Figure 1 below shows both the vehicle CAD model and a picture of the actual vehicle.

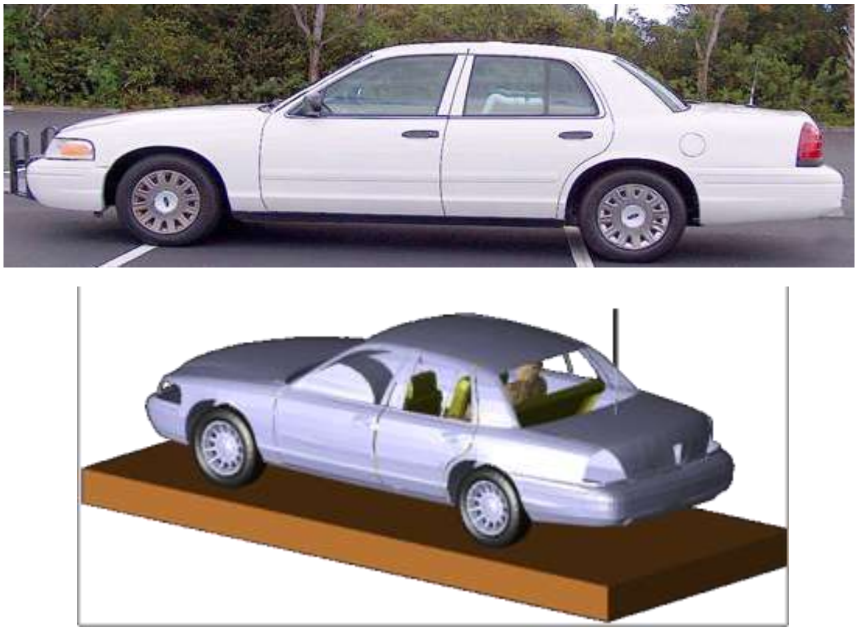


Figure 1: Picture of the vehicle and corresponding CAD model used in XFDTD™ simulations

For back seat passenger exposures, the antenna is positioned on the trunk at 85 cm distance from the passenger model head when the passenger model is located in the center of the back seat, replicating the experimental conditions used in MPE measurements. Figure 2 shows the XFDTD™ computational models used for passenger exposure to trunk mount antennas.

According to the IEC/IEEE 62704-2:2017 standard a lossy dielectric slab featuring 30 cm thickness, relative dielectric constant 8 and conductivity 0.01 S/m has been introduced in the computational model to properly account for the effect of the ground (pavement) on exposure.

The computational code employs a time-harmonic field excitation to produce a steady-state electromagnetic field in the exposed body model. Subsequently, the corresponding SAR distribution is automatically processed in order to determine the whole-body SAR and peak spatial average SAR distribution.

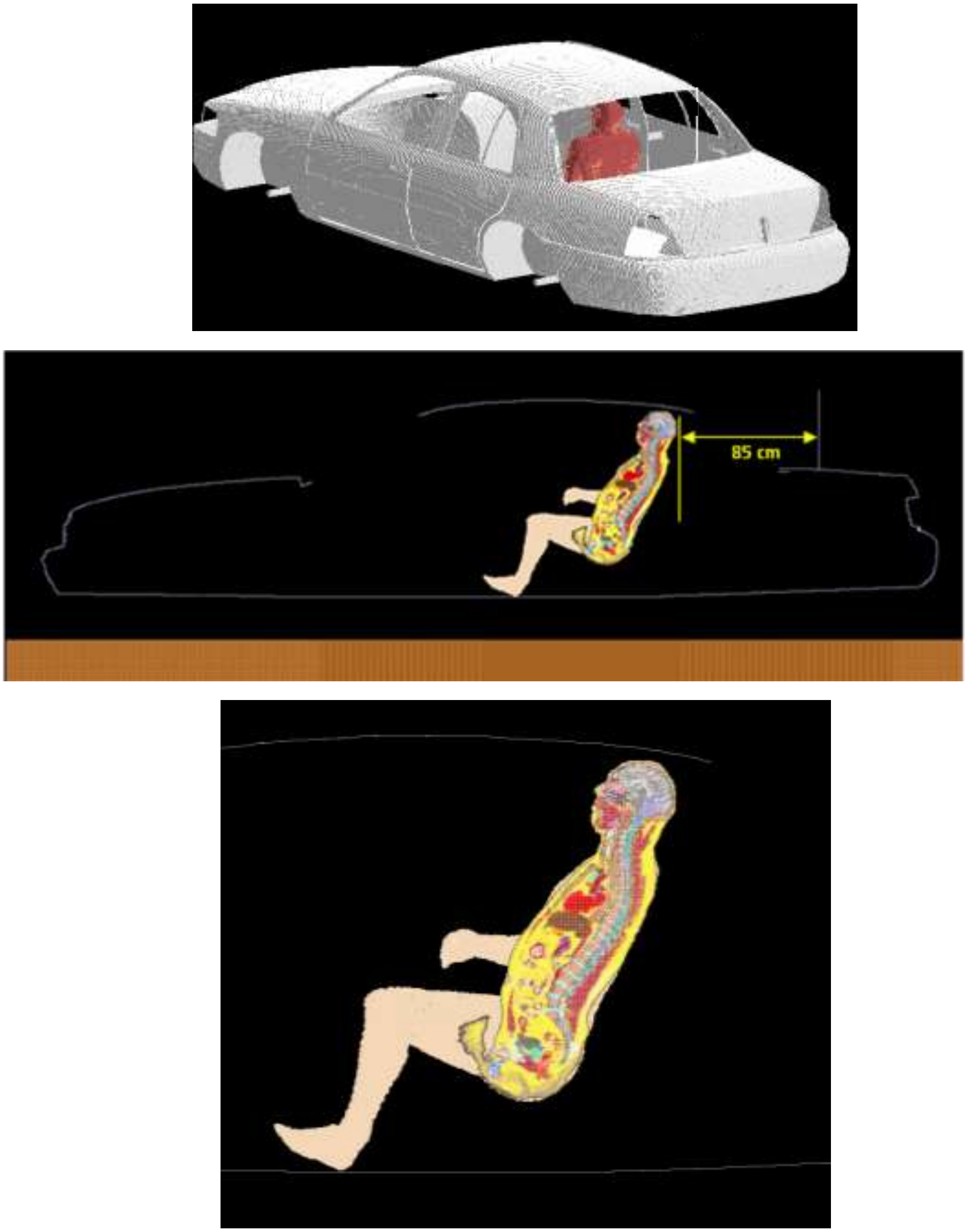


Figure 2: Passenger (back seat) model exposed to a trunk-mount antenna: XFDTD™ geometry. The antenna is installed at 85 cm from the passenger located in the center of the back seat.

The maximum average output power from mobile radio antenna is 30W (136-174 MHz). Since the ohmic losses in the vehicle materials, as well as the mismatch losses at the antenna feed-point are neglected, while source-based time averaging (50% talk time for to push-to-talk operation) for the VHF mobile radio were employed, all computational results are normalized to half of the VHF mobile radio maximum average net output power, i.e., 15W (136-174 MHz), minus the corresponding minimum insertion loss in excess of 0.5 dB of the feed cables supplied with the antennas, in accordance with the IEC/IEEE 62704-2:2017 standard provisions.

Results of SAR computations for car passengers

The test conditions requiring SAR computations are summarized in Table 1 (Passengers), together with the antenna data, the SAR results, and power density (P.D.) as obtained from the MPE measurements in the corresponding test conditions. The conditions are for antennas mounted on the center of the trunk. The antenna length listed in the tables includes the height of the 1.8 cm magnetic mount base used in MPE measurements to position the antenna on the vehicle. The same length was then used in the corresponding simulation model.

The passenger is located in the center or on the side of the rear seat corresponding to the respective configurations defined in the IEC/IEEE 62704-2-2017 standard.

All the transmit frequency, antenna length, and passenger location reported in Table 1 have been simulated individually. This table also includes the interpolated adjustment factor and corresponding SAR scaled values following requirement of the IEC/IEEE 62704-2-2017 standard.

Table 1a: Computed and adjusted SAR results for Passenger exposure
(Configurations exceeding FCC MPE limits)

Mount Location	Antenna Kit#	Antenna Length (cm)	Freq (MHz)	P.D. (mW/cm^2)	Exposure Location	Computed SAR (W/kg)		Interpolated Adjustment Factors		Adjusted SAR Results (W/kg)	
						1 g	WB	1 g	WB	1 g	WB
Trunk	*HAD4022A, 5/8 Wave (132 -174 MHz)	98.3	165.0125	0.22	Back Center	0.16	0.007	1.93	2.42	0.31	0.017
					Back Side **(Figure 3 & 4)**	0.11	0.005	4.09	2.98	**0.46**	0.016
Trunk	*HAD4022A, 5/8 Wave (132 -174 MHz)	97.1	173.0125	0.32	Back Center	0.14	0.007	1.94	2.43	0.27	0.018
					Back Side	0.11	0.006	4.03	2.97	0.43	**0.018**

Notes:
Bold Blue – the highest adjusted SAR results for the respective frequency band.
* - Antenna length trimmed to frequency

Table 1b: Computed and adjusted SAR results for Passenger exposure
(Configurations exceeding ISED MPE limits)

Mount Location	Antenna Kit#	Antenna Length (cm)	Freq (MHz)	P.D. (mW/cm^2)	Exposure Location	Computed SAR (W/kg)		Interpolated Adjustment Factors		Adjusted SAR Results (W/kg)	
						1 g	WB	1 g	WB	1 g	WB
Trunk	*HAD4022A, 5/8 Wave (132 -174 MHz)	104.5	158.0125	0.16	Back Center	0.14	0.006	1.91	2.41	0.27	0.015
					Back Side	0.10	0.005	4.14	2.99	0.43	0.016
Trunk	*HAD4022A, 5/8 Wave (132 -174 MHz)	98.3	#165.0125	0.22	Back Center	0.16	0.007	1.93	2.42	0.31	0.017
					Back Side **(Figure 3 & 4)**	0.11	0.005	4.09	2.98	**0.46**	0.016
Trunk	*HAD4022A, 5/8 Wave (132 -174 MHz)	97.1	#173.0125	0.32	Back Center	0.14	0.007	1.94	2.43	0.27	0.018
					Back Side	0.11	0.006	4.03	2.97	0.43	**0.018**

Notes:
Bold Blue – the highest adjusted SAR results for the respective frequency band.
* - Antenna length trimmed to frequency
# - Same SAR simulation configuration as Table 1a

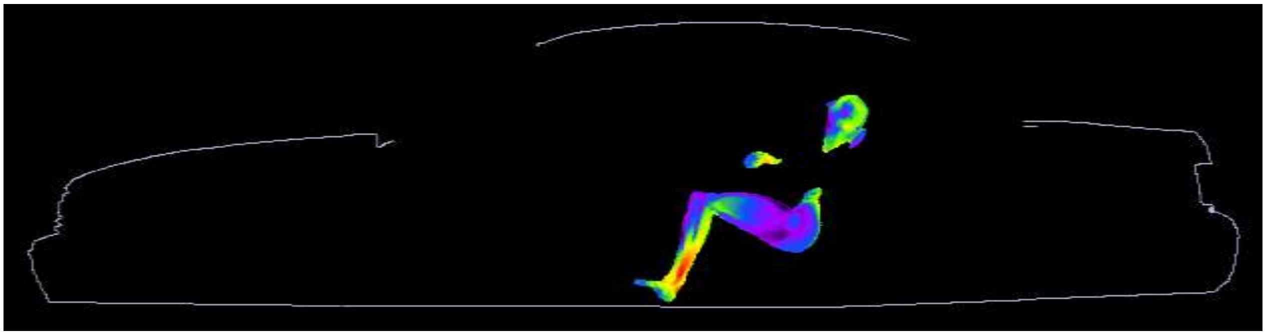
Table 1c: Computed and adjusted SAR results for Passenger exposure

(Configurations exceeding ICNIRP MPE limits)

Mount Location	Antenna Kit#	Antenna Length (cm)	Freq (MHz)	P.D. (mW/cm^2)	Exposure Location	Computed SAR (W/kg)		Interpolated Adjustment Factors		Adjusted SAR Results (W/kg)	
						10 g	WB	10 g	WB	10 g	WB
Trunk	*HAD4022A, 5/8 Wave (132 -174 MHz)	98.3	165.0125	0.22	Back Center	0.10	0.007	2.02	2.42	0.20	0.017
					Back Side **(Figure 3 & 4)**	0.10	0.005	4.29	2.98	**0.42**	0.016
Trunk	*HAD4022A, 5/8 Wave (132 -174 MHz)	97.1	173.0125	0.32	Back Center	0.09	0.007	2.03	2.43	0.18	0.018
					Back Side	0.07	0.006	4.24	2.97	0.29	**0.018**

Notes:
Bold Blue – the highest adjusted SAR results for the respective frequency band.
* - Antenna length trimmed to frequency

The SAR distribution in the passenger exposure condition that gave highest adjusted 1-g SAR (VHF mobile radio) for FCC, ISED and ICNIRP is reported in Figure 3. (165.0125 MHz, passenger on the side of the back seat, HAD4022A antenna installed on the trunk).



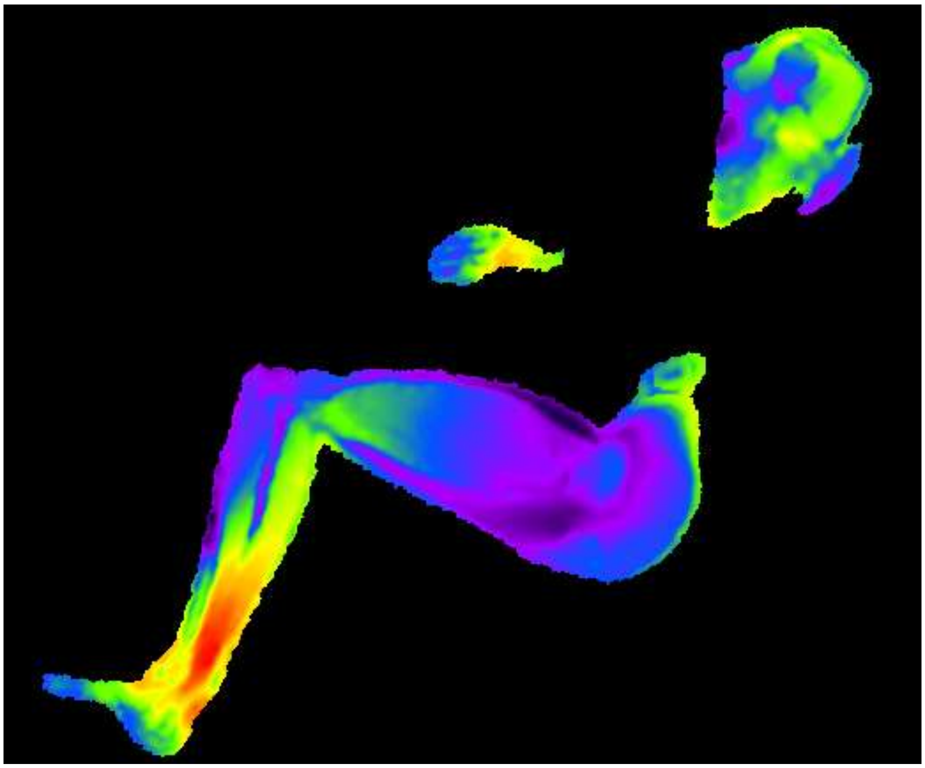
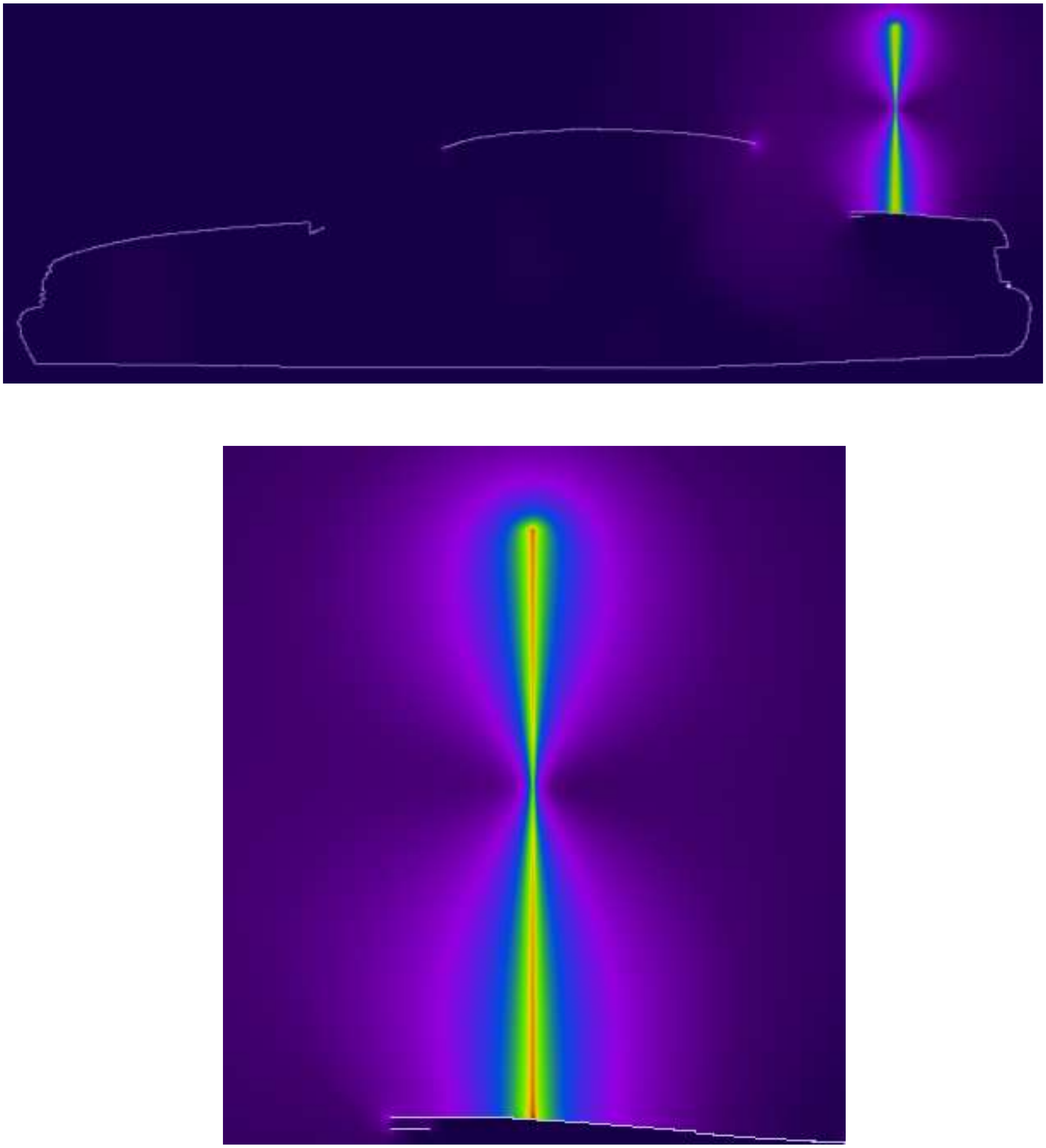
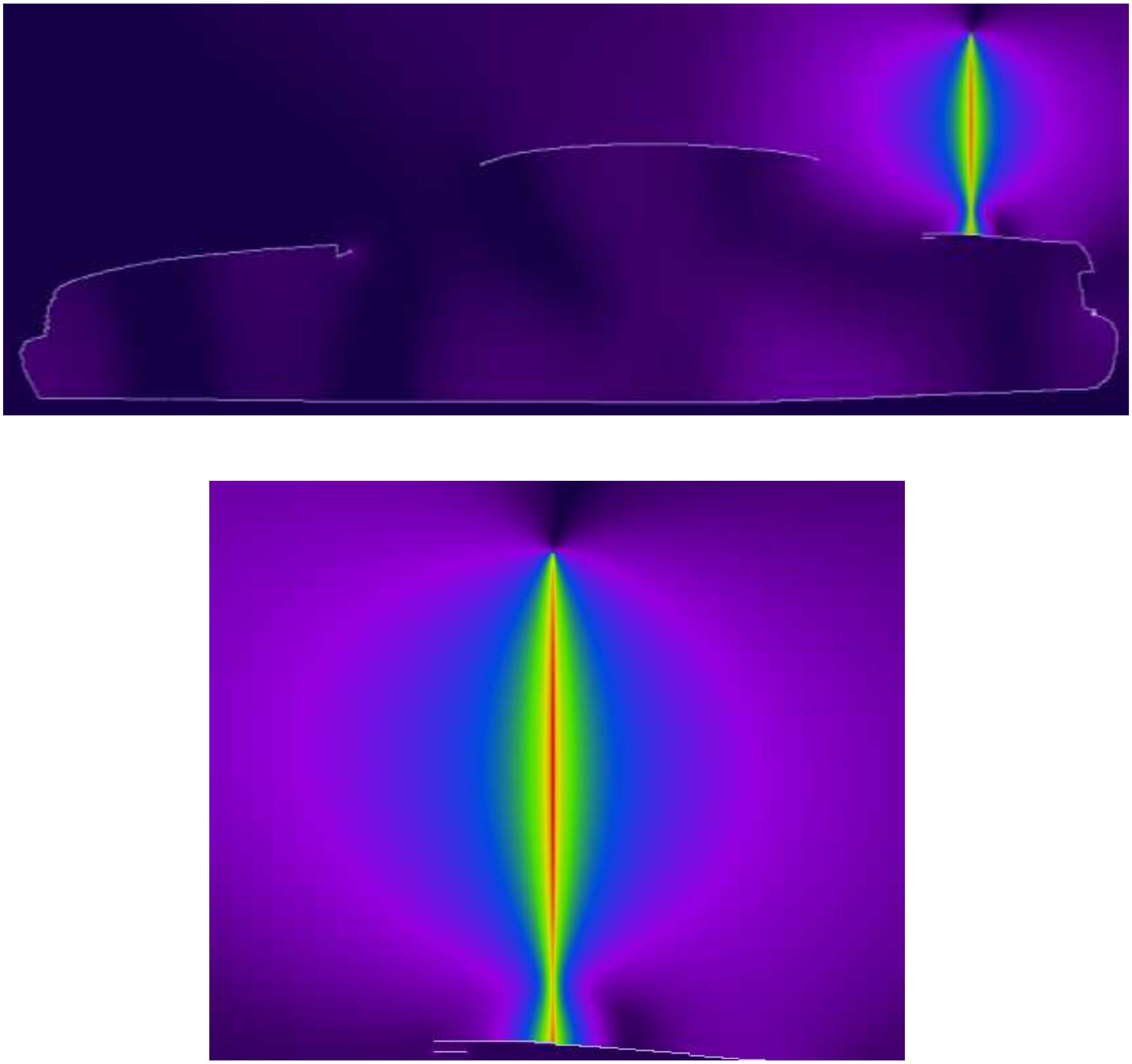


Figure 3. SAR distribution 165.0125 MHz in the passenger model located on the side of the back seat, produced by the trunk-mount HAD4022A antenna. The SAR distribution plot is relative to the plane where the peak 1-g average SAR for this exposure condition occurs.

The plots in Figure 4 illustrate the E and H field distributions in the plane of the antenna corresponding to the exposure condition resulting in the SAR distribution in Figure 3.



a)



b)

Figure 4. (a) E-field magnitude distribution corresponding to exposure condition of Figure 3, and (b) H-field magnitude distribution corresponding to exposure condition of Figure 3.

Results of SAR Computations

From all simulated results, the highest peak 1-g, peak 10-g and whole-body average SAR values were identified. The maximum peak 1-g SAR is 0.46 W/kg, less than the 1.6 W/kg limit, the maximum peak 10-g SAR is 0.42 W/kg, less than the 2.0 W/kg limit, and the maximum whole-body average SAR for is 0.018 W/kg, less than the 0.08 W/kg limit.

Conclusions

Under the test conditions described for evaluating passenger exposure to the RF electromagnetic fields emitted by vehicle-mounted antennas used in conjunction with this product, the present analysis shows that the computed SAR values are compliant with the FCC and ISED Canada exposure limits for the general public as well as with the corresponding ICNIRP and IEEE Std. C95.1-2019 SAR limits.

References

[1] Health Canada Safety Code 6 (2015). Limits of Human Exposure to Radiofrequency Electromagnetic Energy in the Frequency Range from 3 kHz to 300 GHz.

[2] United States Federal Communication Commission, "Evaluating compliance with FCC guidelines for human exposure to radiofrequency electromagnetic fields," OET Bulletin 65 (Ed. 97-01), August 1997.

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

[4] ICNIRP (International Commission on Non-Ionising Radiation Protection) 1998. *Guidelines for limiting exposure to time-varying electric, magnetic and electromagnetic fields (up to 300 GHz)*. Health Phys. 74:494–522.

[5] IEEE Standard for Safety Levels with Respect to Human Exposure to Electric, Magnetic, and Electromagnetic Fields, 0 Hz to 300 GHz. IEEE Std C95.1-2019 (Revision of IEEE Std C95.1-2005/ Incorporates IEEE Std C95.1-2019/Cor 1-2019)