Research on the Influence of Electromagnetic Radiation in the Automobile on the SAR Value of Human Body

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Abstract—At present, the research on Evaluating Systematic Electromagnetic performance of automobile has gradually become a heated topic. With the deepening of research, personal safety in electromagnetic environment has been paid increasingly more attention. In terms of the complexity of the electromagnetic environment in the automobile, the automobile pole antenna, the wiring harness, the DC-DC converter, and the electromagnetic field distribution is simulated by the three-dimensional electromagnetic simulation software EMC studio, then the electric field intensity and the XZ plane current distribution at different seat positions can be obtained, and the SAR value absorption of human body at different seat positions and different human body sizes in the automobile is also calculated. The simulation results show that the electromagnetic radiation in the automobile will not do harm to the human body, which provides reference for the later research of human electromagnetic safety in electric automobile.

1. INTRODUCTION
With the rapid development of vehicle electronic technology, a large number of the electronic equipment and electrical systems have been widely applied. Because there are many high-power electrical systems and electronic devices on the automobiles, the frequency band occupation of these equipment and systems is very chaotic, and the electromagnetic environment pollution formed by the composite electromagnetic field and electromagnetic wave radiation is becoming increasingly serious [1]. An electromagnetic environmental pollution not only affects the safety and reliability of the electronic equipment and systems, but also the human health is threatened. All the cancer, behavior changes, memory loss, Parkinson's disease, Alzheimer's disease, and other diseases are thought be connected with the electromagnetic environment. Moreover, with the constantly emerging of the new frequency bands and applications, the electrical level of electromagnetic environment is also increasing significantly.

Its own size of transportation equipment such as automobiles, ships and warships, and aircraft is much larger than the radiation wavelength, which can be regarded as an electrically large size, the electromagnetic radiation of its internal high-power transmitting antenna and other components will pose potential hazards to the equipment and personnel [2]. At present, there are few studies in China on the influence of electromagnetic radiation of automobile content on human SAR value. The radiation characteristics of mobile phone PIFA antenna are mainly studied by the domestic scholars, the SAR value of the human head and body is simulated by use of the simulation software [3-5]. The radiation...
interference of vehicle roof antenna is studied by the foreign A.R.Uddle et al. using the FDTD method, and the body SAR values of vehicle occupants under the different frequencies are calculated [6-8].

The electromagnetic field distribution of complex integrated large systems such as the vehicles can be really simulated by the EMC Studio electromagnetic simulation software using the method of moment (MOM). Through simulating the electromagnetic field distribution of the vehicle rod-shaped antenna, in-vehicle wiring harness, DC-DC converter and motor in this paper, the electric field intensity and XZ surface current distribution at the different seat positions in the vehicle are obtained, and the SAR value absorption amount of human body at the different seat positions and under the conditions of different body sizes in the vehicle has been calculated.

2. THE ELECTROMAGNETIC ENVIRONMENT OF WHOLE VEHICLE

The whole vehicle rod-shaped antenna, in-vehicle wiring harness, DC-DC converter and motor electromagnetic simulation model are established, as shown in Figure 1. The small dielectric components such as the in-vehicle seats, steering wheel and interior decoration etc. are ignored, and the geometric size of the body is 4.3m, 1.7m and 1.5m.

![Fig. 1. Automobile electromagnetic model](image)

The wiring harness circuit in the vehicle is as shown in Figure 2, the impedance is set at two excitation ports, and the voltage source of 1V is set at one excitation port.

![Fig. 2. Wiring harness internal circuit setup](image)

DC-DC, motor and other electrical components on the vehicle are similar in nature to the antenna, so the DC-DC and motor in the vehicle can be equivalent to the antenna. The DC-DC converter is located in the rear of vehicle, and is designed as an antenna, at the same time, the excitation source is determined as the 50Ω resistances with the built-in frequency response. And that the motor chooses to use a dipole antenna with a radiation of 24V and a built-in resistance of 50Ω.

In order to study the current distribution conditions in the internal section of vehicle at a certain frequency, a flat grid is set in the EMC Studio software, and the length of each grid unit is set to be 0.25m, as shown in Figure 3.
3. ELECTROMAGNETIC RADIATION ABSORBED BY AN ADULT

The frequency radiation range of a conventional vehicle is 30~10000MHz, in order to verify the SAR value of specific absorption rate in the human body, it is necessary to simulate and calculate the SAR value of specific absorption rate in the different frequency band values respectively.

After the people enter the vehicle, the electromagnetic environment existed in the vehicle will produce the radiation for the people, the amount of radiation is different due to the different locations. If the environment in the vehicle and the human body are respectively regarded as the radiation source field and there is the model with a certain dielectric constant, then the amount of radiation received by the human body can be calculated.

Even if riding in the same vehicle, the different amounts of radiation would be received also by the different people, there are usually two factors that influence the amount of radiation, the first is the different location; the second is the difference in weight. And then, assuming that the weight factors are the same, and the radiation amount received by the human body at the different locations is mainly analyzed. In the analysis, the antenna interference source of vehicle body cannot be ignored, and then the thermal SAR value formed after the human exposed to the radiation at four positions can be calculated. At the same time, an antenna should be placed also on the rear of vehicle roof, so that the SAR value of human exposed to the radiation inside the vehicle is simulated, the values are as shown in Table 1.
Fig. 5. The model of human body in a car in EMC Studio software

Fig. 6. Schematic diagram of the adult body in different positions in the car

Tab. 1 SAR values of adult specific absorption rate at different seat positions and at different frequencies

| Frequency (MHz) | Left front | Right front | Left rear | Right rear |
|-----------------|------------|-------------|-----------|-----------|
|                 | SAR(W/kg) ($\times 10^7$) |             |           |           |
| 100             | 1.84       | 1.83        | 1.18      | 1.28      |
| 110             | 6.78       | 6.705       | 9.62      | 9.81      |
| 120             | 12.5       | 12.7        | 11.0      | 12.3      |
| 130             | 15.0       | 10.1        | 39.2      | 39.0      |
| 140             | 37.4       | 36.7        | 127       | 133       |
| 150             | 86.6       | 80.8        | 398       | 375       |
| 160             | 272        | 253         | 403       | 419       |
| 170             | 84.9       | 80.5        | 104       | 99.7      |
| 180             | 26.2       | 24.6        | 41.9      | 38.8      |
| 190             | 30.5       | 33.3        | 235       | 307       |
4. ELECTROMAGNETIC RADIATION ABSORBED BY A CHILD

Through the above simulation tests, it is found that the nonlinear ADRC tracking controller established in this paper can still control the actual vehicle yaw rate to track the ideal yaw rate when the parameters of the vehicle change, so as to ensure the actual running path to track the ideal planned path and the path tracking robustness in the avoidance process.

It can be found out by an analysis of the adults and children that they have the same density, but since there is the difference in the volumes, and so there is the difference in the masses. One DC-DC converter can be placed in the vehicle, and then the conditions of the human body exposed to the radiation are observed.

![Children in different positions in the car](image)

Fig. 7. Models of children in different positions in the car

Tab. 2 SAR values of child specific absorption rate at different seat positions and at different frequencies

| Frequency (MHz) | Left front | Right front | Left rear | Right rear |
|-----------------|------------|-------------|-----------|------------|
|                 | SAR(W/kg) ($\times 10^{-7}$) |             |           |            |
| 100             | 1.53       | 1.52        | 1.06      | 1.22       |
| 110             | 6.67       | 6.03        | 9.42      | 9.72       |
| 120             | 12.1       | 12.63       | 10.5      | 11.7       |
| 130             | 14.7       | 9.13        | 38.2      | 38.2       |
| 140             | 36.2       | 36.6        | 126       | 128        |
| 150             | 84.3       | 77.7        | 356       | 361        |
| 160             | 262        | 250         | 396       | 408        |
| 170             | 83.4       | 80.1        | 98.0      | 98.7       |
It can be seen from Table 1 and Table 2 that the amount of electromagnetic radiation received by the adults is significantly higher than that received by the children, because the adults are larger in the size and their density is also larger than that of children, and then more magnetic energy will be absorbed by the adults after exposed to the radiation. The variation trend of SAR value absorbed here is first increased and then decreased, when the frequency is 160MHz, the maximum adult SAR value is 2.5x10^{-5}W/kg.

5. CONCLUSION
(1) The electromagnetic radiation distribution generated by the electronic equipment of the whole vehicle can be truly simulated by three dimension electromagnetic simulation software EMC Studio.
(2) The SAR values of specific absorption ratio for the adults and children are different at the different seat positions and under the different frequencies.
(3) The electromagnetic radiation generated by the vehicle rod-shaped antenna, motor, DC/DC converter and in-vehicle wiring harness will not produce the harm for the human body.

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