FDTD Simulation of a Mobile Phone Operating Near Metals

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***Abstract*—This paper presents Finite Difference Time Domain (FDTD) simulation results of operating mobile phone near metal wall sheet and near a one metal cell. Results show that placing a one metal cell closed to a mobile phone is more harmful to human health than a metal wall sheet. The one metal cell is the Yee's cell that has a metal characteristic, high conductivity and low permittivity. In general, the mobile phone was modeled by a dipole antenna so the one metal cell's characteristic can be chosen as the dipole's characteristic. This simulation uses Finite Difference Time Domain (FDTD) scheme. It's domain is divided into two parts: the physical domain and the artificial domain. The physical domain consists of a dipole antenna located at 1 cm from a human head model and a one metal cell varied distance (Δl) from the dipole. In addition, the dipole antenna operated at 900 MHz and 1800 MHz was used in the simulation. The artificial domain is a Perfectly Matched Layer (PML). The PML acts as an electromagnetic field absorbing layer and was backed by a Perfect Electric Conductor (PEC). The Specific Absorption Rate (SAR) was computed and averaged on a tissue mass of one gram and ten grams, SAR 1-g and SAR 10-g, respectively. Also, the average power (Pavg) absorbed in various human tissues is computed with a distance between the dipole antenna and a one metal cell as a varying parameter (Δl). Simulation results from a one metal cell will be compared to referenced values. There are three reference SAR values: the standard SAR 1-g (FCC, Federal Communications Commission), the simulation in an open area and the simulation with the metal wall. In this case, results from the simulation show that the computed SAR 1-g and SAR 10-g values are not exceed the limitation values established by various standard institutes (1.6 Watt/kg), however, for Δl = 0-5 cm, both of the SAR and the average power absorb are higher than the simulation with the metal wall and the simulation in an open area.**

Keywords-FDTD, PML, metal wall ,one metal cell

I. INTRODUCTION

In recent years mobile phones or smart phones have gained popularity because of its versatility: internet capabilities, navigation and cameras. All of the smart phones integrate with built in antenna and cases: metallic case, plastic case and plastic case with metallic decorations. Sometime, the metallic case and the plastic case with metallic decorations can be a reflector of the built in antenna by accident. This paper assumes the metallic case is something like an infinite metal wall [1] located at 0-1 cm from the antenna. This implies that the plastic case with metallic decorations is something like a one metal cell located at 0-1 cm from the antenna. In addition, the one metal cell is the one Yee's cell that has a metal characteristic, high conductivity and low permittivity. The mobile phone is represented as the dipole antenna corresponding to the operating frequencies: 900 MHz and 1800 MHz.

The results of the simulation of a mobile phone operating near a metal wall show that the computed SAR 1-g and SAR 10-g values are not exceed the limitation values (1.6 Watt/kg) establish by Federal Communications Commission (FCC). Especially, the metal wall located at 0-5 cm from the dipole gives both SAR values lower than the standard. Then using the mobile phone covered with metallic case is safer than using the mobile phone covered with plastic case (the open area). As describe above, this research compares SAR 1-g, SAR 10-g and average power absorbed in human head of simulation the mobile phone operating near a one metal cell and a metal wall model.

II. THE REFERENCE SAR VALUES

There are three reference SAR values: the standard SAR 1-g = 1.6 Watt/kg (FCC, Federal Communications Commission), the simulation in an open area (the plastic case) and the simulation with the metal wall (the metallic case). The open area model and the metal wall model are shown in Fig. 1 and Fig. 2, respectively.

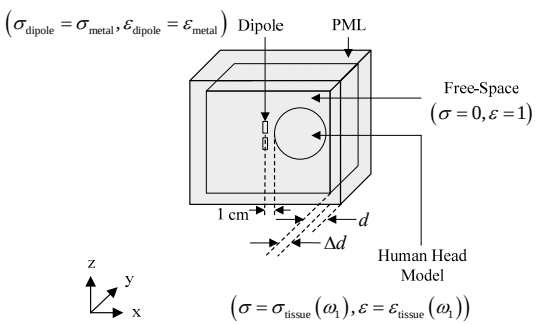

FIGURE I. THE SIMULATION IN AN OPEN AREA

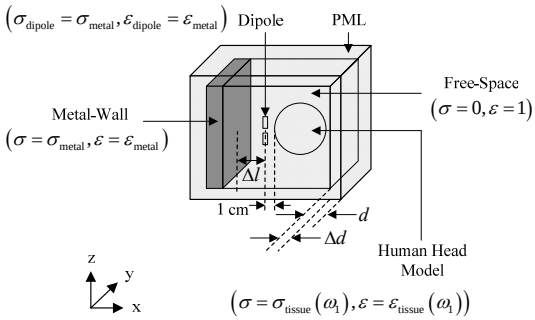

FIGURE II. THE SIMULATION WITH THE METAL WALL

III. THE SIMULATION MODEL

In general, mathematical theory and various implementations of FDTD were presented in [1]-[11]. Also, for comparison, results of FDTD simulation with the metal wall model were presented in [1]. The one metal cell model is shown in Fig. 3. The one metal cell is located next to the dipole and varied distance (Δl) between the dipole and the one metal cell. For Δl = 0-10 cm, this paper computes the SAR 1-g, the SAR 10-g and the average power absorbed in human head.

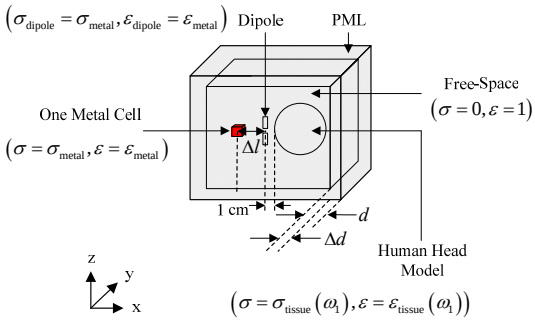

FIGURE III. THE SIMULATION WITH THE ONE METAL CELL.

IV. THE SIMULATION RESULTS

Fig. 4-5 shows top view of the tangential electric field in the simulated physical domain of the one metal cell.

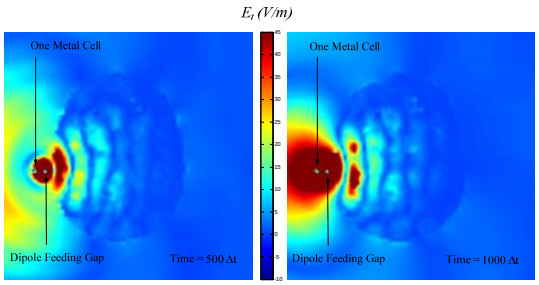

FIGURE IV. TOP VIEW OF ET IN THE SIMULATED PHYSICAL DOMAIN AT 900 MHZ

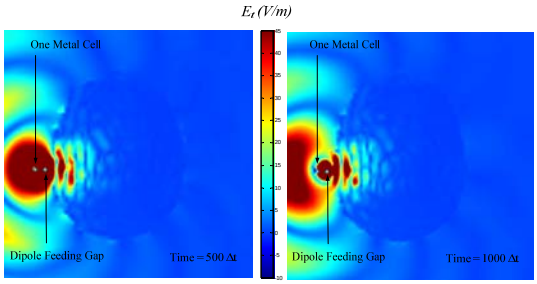

FIGURE V. TOP VIEW OF ET IN THE SIMULATED PHYSICAL DOMAIN AT 1800 MHZ

Spatial-average SAR 1-g, SAR 10-g and average power absorbed are shown as the following figures

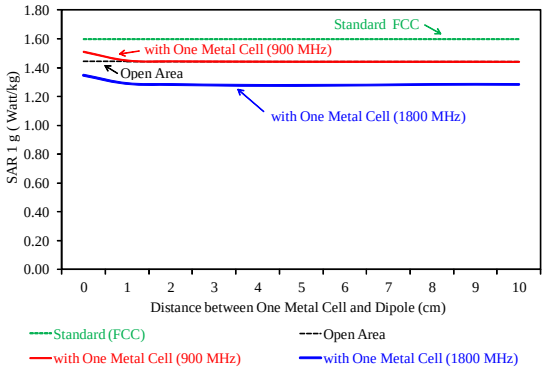

FIGURE VI. SPATIAL-AVERAGE SAR 1-G FROM THE ONE METAL CELL SIMULATION

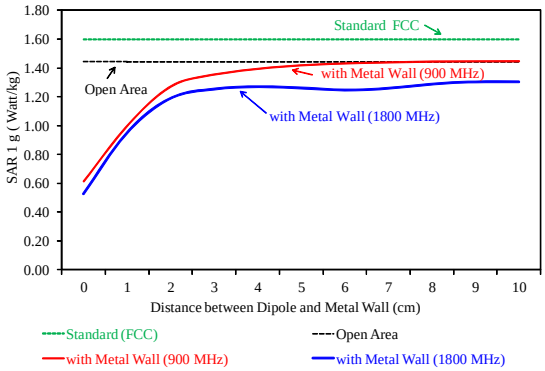

FIGURE VII. SPATIAL-AVERAGE SAR 1-G FROM THE METAL WALL SIMULATION

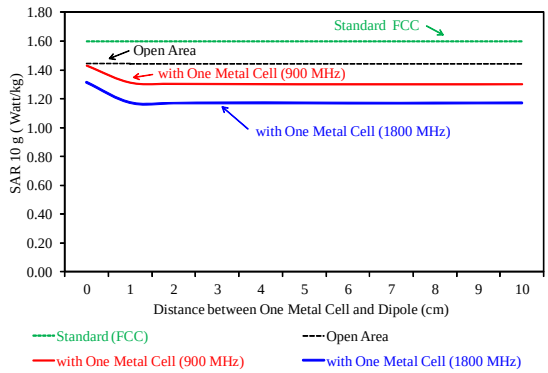

FIGURE VIII. SPATIAL-AVERAGE SAR 10-G FROM THE ONE METAL CELL SIMULATION.

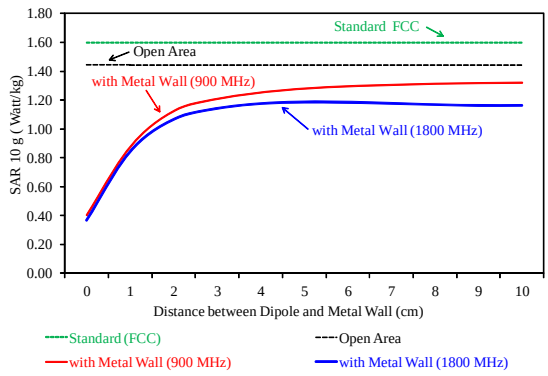

FIGURE IX. SPATIAL-AVERAGE SAR 10-G FROM THE METAL WALL SIMULATION.

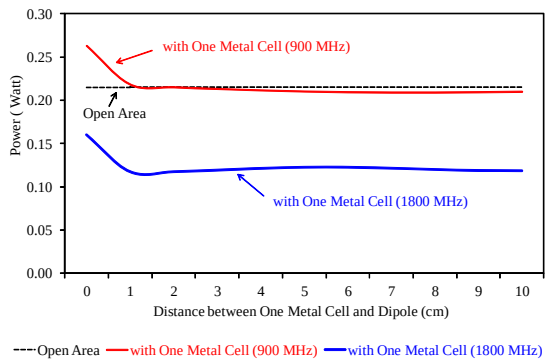

FIGURE X. THE AVERAGE POWER ABSORBED IN HUMAN HEAD FROM THE ONE METAL CELL SIMULATION.

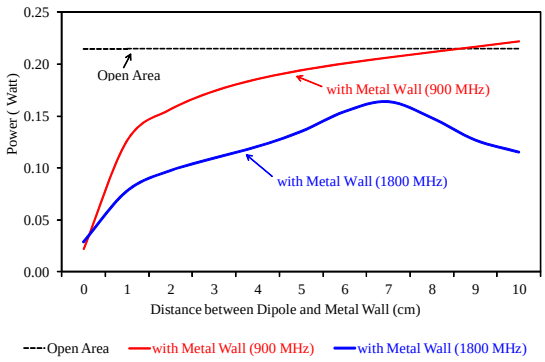

FIGURE XI. THE AVERAGE POWER ABSORBED IN HUMAN HEAD FROM THE METAL WALL SIMULATION.

V. CONCLUSION

The FDTD scheme have been applied to the one metal cell and a metal wall simulation model .Operated frequencies are 900 MHz and 1800 MHz. Results of the simulation of a mobile phone operating near a metal wall and a one metal cell show that SAR 1-g and SAR 10-g do not exceed the ANSI/IEEE standard. Surprisingly, both SARs and the average power absorbed in human head are higher than the metal wall simulation model. In brief, placing a one metal cell closed to a mobile phone is more harmful to human health than a metal wall sheet

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