Dipole antenna in the car model by HFSS10.1 simulation

2006-07-13 to 26 simulations. Henghua Deng. Refer to Ant_Car_20060713.doc.

In this report we will show the results when a half-wavelength dipole is placed in the car. Three sets of calculations are performed by running Ant_Car_20060718.hfss:

1. **Dipole antenna in the free space;**
2. **Dipole antenna with the whole car;**
3. **Dipole antenna with a part of the car;**

Throughout this report, the frequency is chosen as 900MHz, therefore the free-space wavelength is 33.33 cm, a quarter wavelength is 8.33cm (For higher frequencies such as 2.4GHz, in previous simulations of the car model with the dipole antenna placed at the position of the back mirror in the front, 2G memory is insufficient for the whole car).

Part 1. Dipole antenna in the free space

The half-wavelength dipole is designed for frequency 900MHz. The geometry of the dipole is shown in Fig 1. For each arm of the dipole, the radius is 1mm, the length is 78.279mm (0.235*c0/$Freq*1000mm), and the gap between the two arms is 0.1mm. The length of the dipole is designed as 0.47 wavelengths according to [Balanis, 1997, Antenna Theory, pp. 162]. The material is selected as copper (relative permittivity = 1, relative permeability = 0.999991, bulk conductivity = 58000000s/m, and Lande G factor = 2).

The HFSS solution type is Driven Modal. The excitation of the antenna is chosen as lumped port feed, as in Fig. 2. The full port resistance is 50 ohm, reactance is 0, and integration line is along the Z-axis.

The radiation boundary is set on the outer box with dimensions 626.23mm * 626.23mm * 626.23mm (each side is 8 times larger than a dipole arm) as Fig. 3.

For the mesh on the dipole, the maximum length is set to 2mm, maximum elements is set to 20000. For the mesh on the radiation box, the maximum length is set to 120mm, maximum elements is set to 30000.

The iteration passes is set to 6, maximum Delta S requirement is set to 0.02. The minimum number of passes and minimum converged passes are both set to 2.

The simulation finished for Adaptive passes = 4, run 40.39 minutes on on Maxwell.uwaterloo.ca. Converged for Target Maximum Delta S = 0.02 (Currently 0.0021504 for 41064 tetrahedral).

The far field pattern of the half-wavelength antenna in free space is shown in Fig. 4. The S parameter and impedance are **S11=0.19824-j*0.031265, Z11=74.537-j*4.8564 ohm**.

Part 2. Dipole antenna in the whole car

Now we put the half-wavelength dipole into the car, as shown in Fig. 5. The antenna is moved from (0,0,0) to (1200, 180, -600)mm without any rotation. The detailed position is shown in Fig. 6.

The material of the car is selected as steel_stainless (relative permittivity = 1, relative permeability = 1, bulk conductivity = 1100000s/m, and Lande G factor = 2). No window glass is considered yet.

The radiation boundary is set on the outer box with dimensions 4600mm * 1000mm *1300mm.

The HFSS solution type and analysis setup are same as in Part 1. The excitation of the antenna is also moved together with the antenna.

For the mesh on the dipole, the maximum length is set to 2mm, maximum elements is set to 20000. For the mesh on the radiation box, the maximum length is set to 120mm, maximum elements is set to 30000. For the mesh on the car body and steer, the maximum length is set to 50mm, maximum elements is set to 50000.

The iteration passes is set to 6, maximum Delta S requirement is set to 0.02. The minimum number of passes and minimum converged passes are both set to 2.

The simulation finished for Adaptive passes = 5, run 17 hours and 58 minutes on Maxwell.uwaterloo.ca. Converged for Target Maximum Delta S = 0.02 (Currently 0.0050118 for 250743 tetrahedral).

The far field pattern of the half-wavelength antenna in free space is shown in Fig. 7. The S parameter and impedance are **S11=0.25105-j*0.11578, Z11=80.405-j*20.159 ohm**.

The mesh is shown in Fig. 8.

Part 3. Dipole antenna in a part of the car

The only difference between this case and the above case (Part 2) is that only a part of the car near the dipole antenna is taken into account for the simulation, as shown in Fig. 9. This part of the car is obtained by intersecting with a box (location (100, -550, -1250)mm, dimensions 1800mm * 1000mm * 1300mm). The two cut-planes at the front and back of the car are set as perfectly electric conductor (PEC) boundary condition in the calculation.

The simulation finished for Adaptive passes = 4, run 17 hours and 14 minutes on Maxwell.uwaterloo.ca. Converged for Target Maximum Delta S = 0.02 (Currently 0.0044969 for 172928 tetrahedral).

The far field pattern of the half-wavelength antenna in free space is shown in Fig. 10. The S parameter and impedance are **S11=0.14489-j*0.11723, Z11=64.787-j*15.737 ohm**.

The mesh is shown in Fig. 11.

Summary and Conclusion

Now we summarize the results of the above three cases in the Table I. Note that as a compassion, in [Balanis, 1997, Antenna Theory, pp. 162], the impedance of the half-wavelength dipole is: Z11=73+j*42.5 Ohm (real part agrees well with Case 1 of Table I).

The far field patterns are compared by Fig. 1, Fig. 7, Fig. 10, and Fig. 13 for these four cases. It is observed that the existence of the car introduces several sidelobes. By comparing case 2 and case 3, we find that the shape of the car also have a significant influence on the far field pattern, and some variations on the impedance.

Table I. Comparison of the three dipole cases

	Total Tetrahedral	Passes	Time	Max Delta S	Converged	S11	Z11 (Ohm)
Case 1: Dipole in Vacuum	41064	4	40.39m	0.0021504	Yes	S11=0.19824-j*0.031265	Z11=74.537-j*4.8564
Case 2: Dipole in Whole Car	250743	5	17h58m	0.0050118	Yes	S11=0.25105-j*0.11578	Z11=80.405-j*20.159
Case 3: Dipole in Part of Car	172928	4	17h14m	0.0044969	Yes	S11=0.14489-j*0.11723,	Z11=64.787-j*15.737
Case 4: Dipole in Car with ground	177495	2	37h34m	0.045996	No	S11=0.24125-j*0.13434,	Z11=77.79-j*22.626

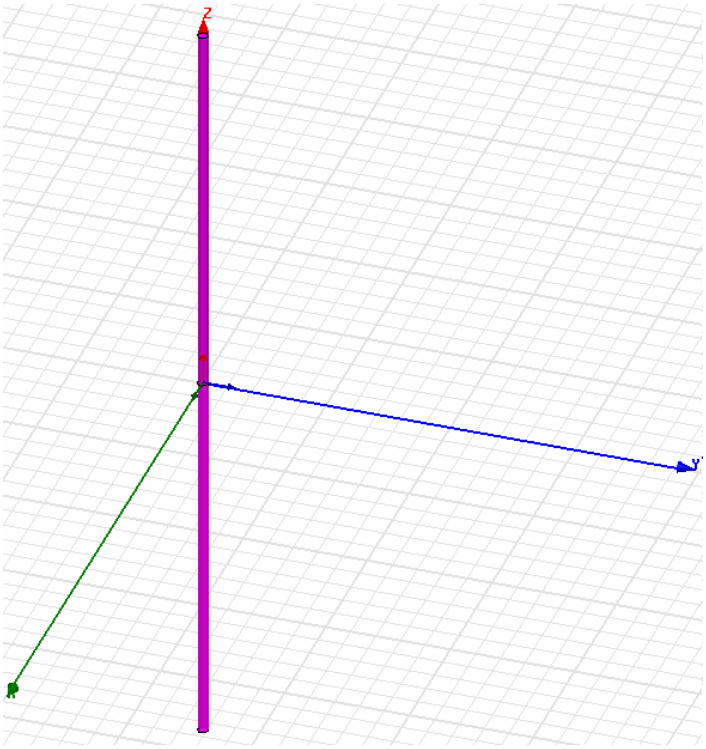


Fig. 1. the dipole antenna (for each arm, radius 1mm, length 78.279mm, gap between the two arms is 0.1mm)

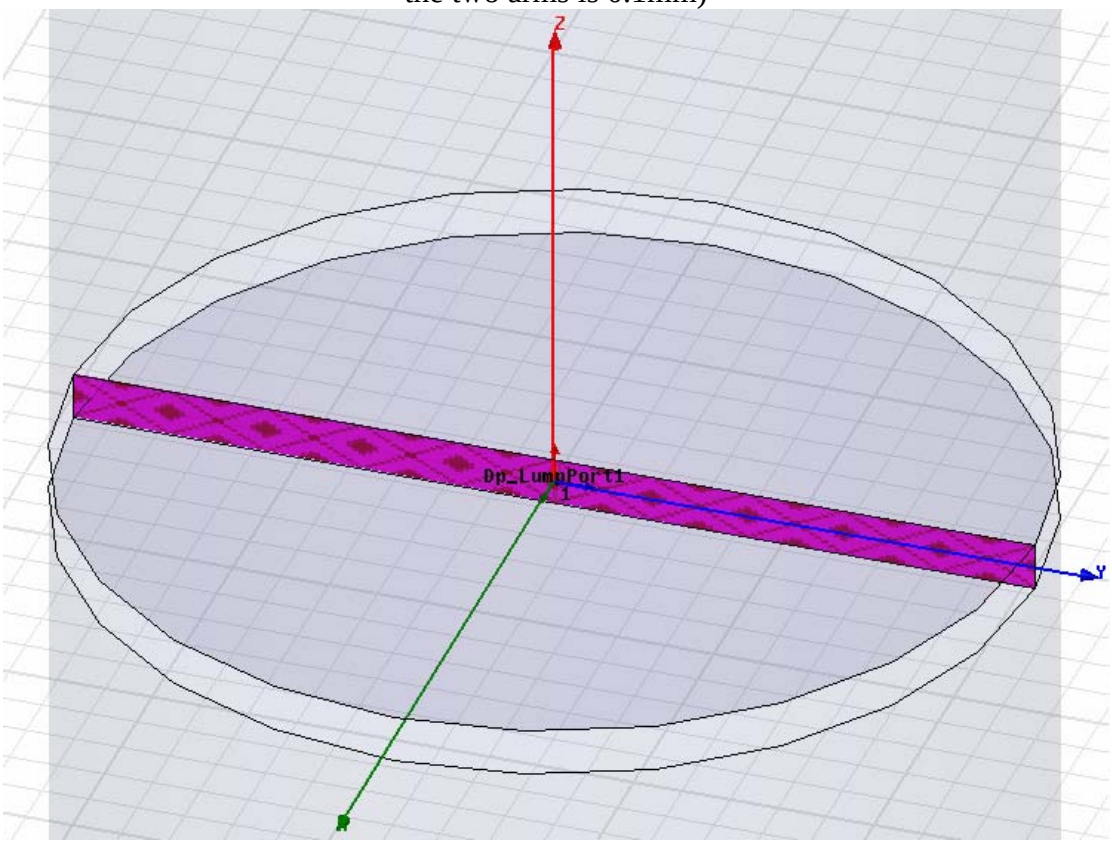


Fig. 2. The lumped port feed of the dipole antenna

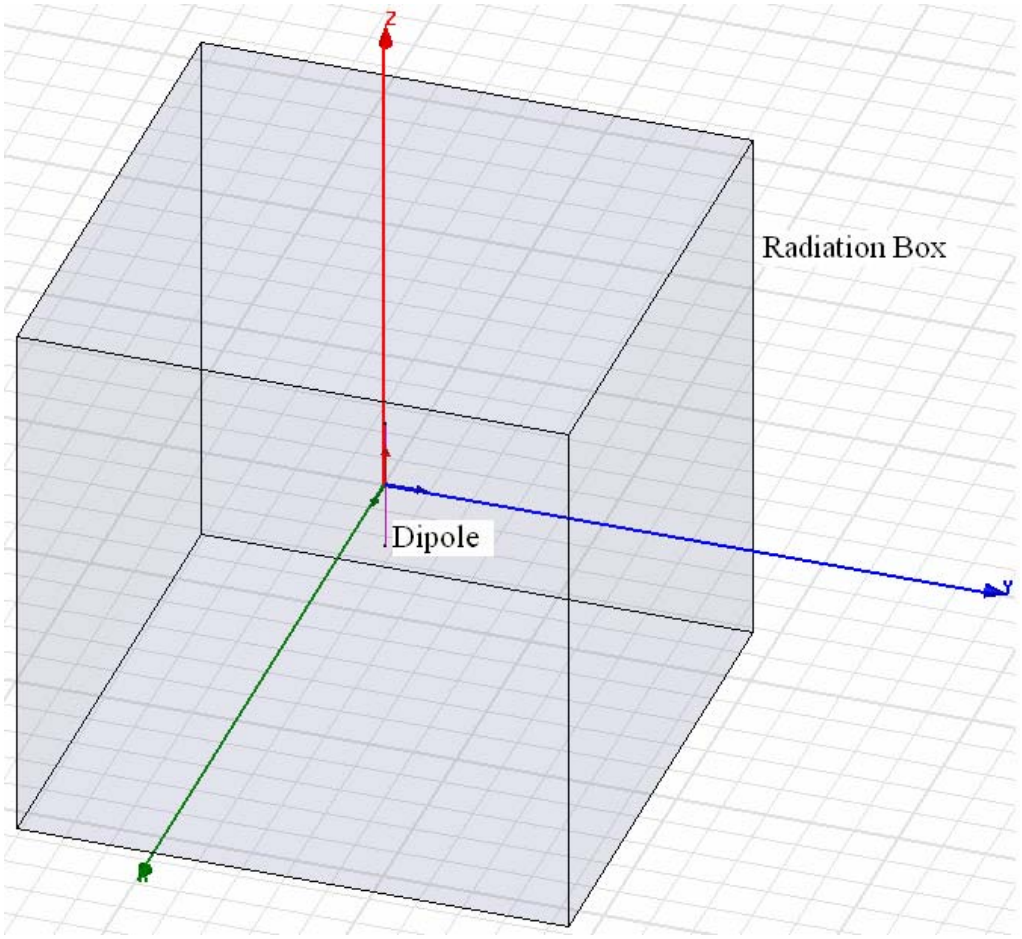


Fig. 3. The radiation boundary (Box: 626.23mm * 626.23mm * 626.23mm)

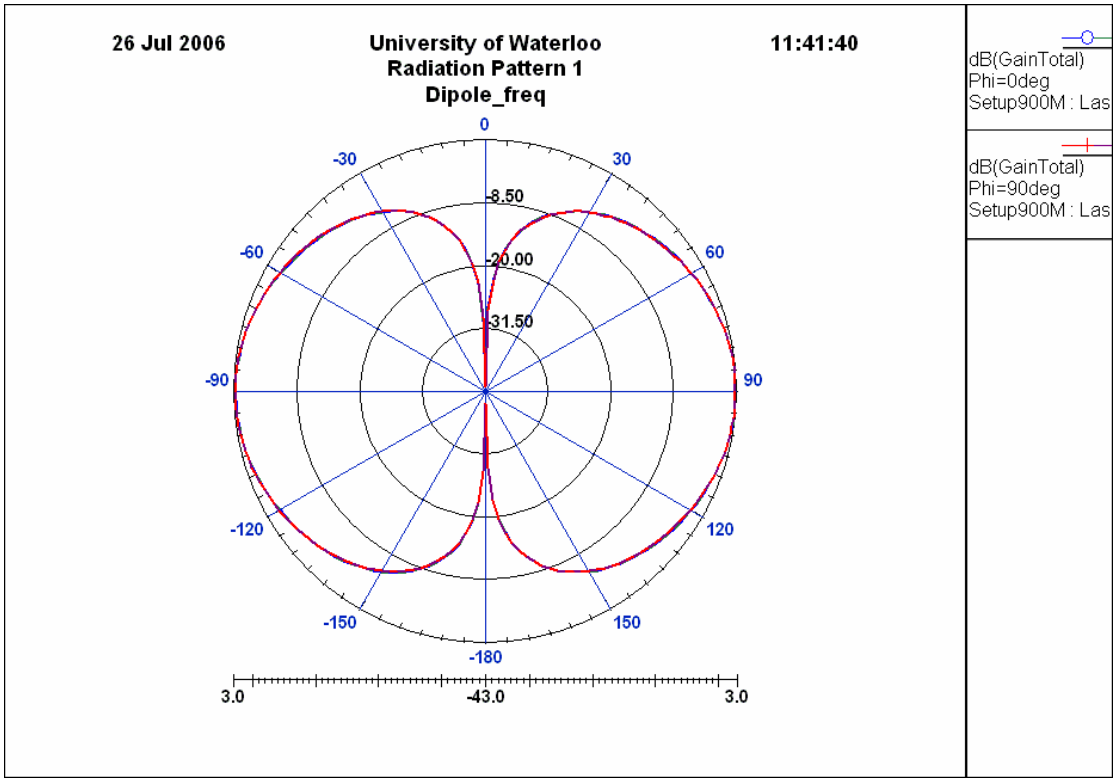


Fig. 4. The far field pattern for the half-wavelength dipole in free space. The S parameter and impedance are **S11=0.19824-j*0.031265, Z11=74.537-j*4.8564 ohm**.

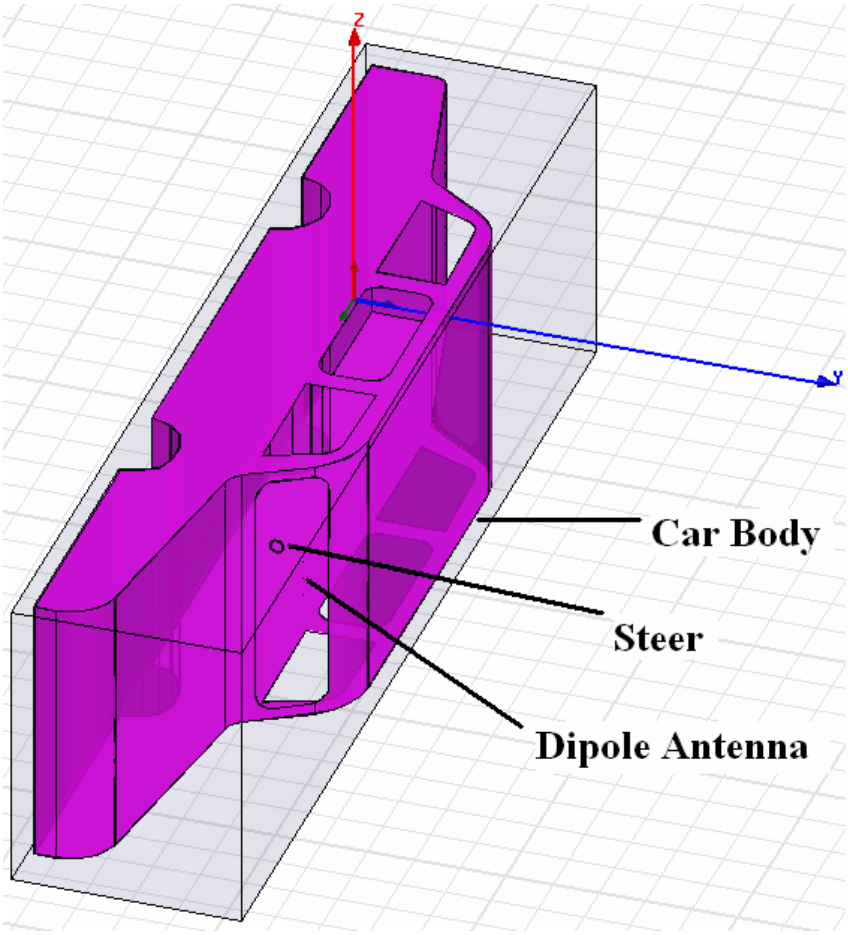


Fig. 5. The dipole antenna in the car.

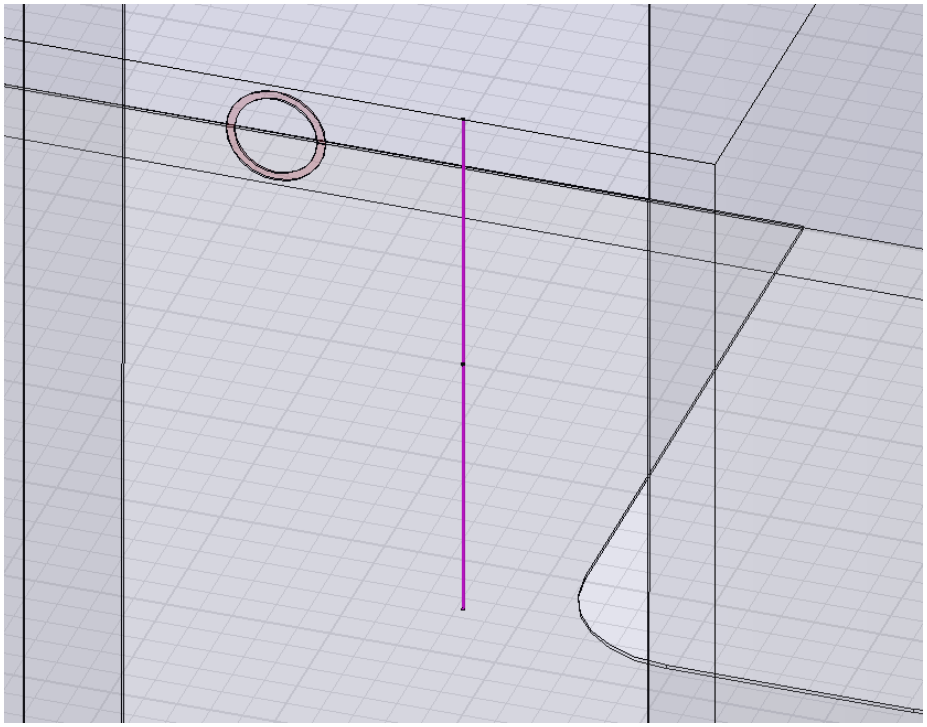


Fig. 6. The position of the dipole antenna

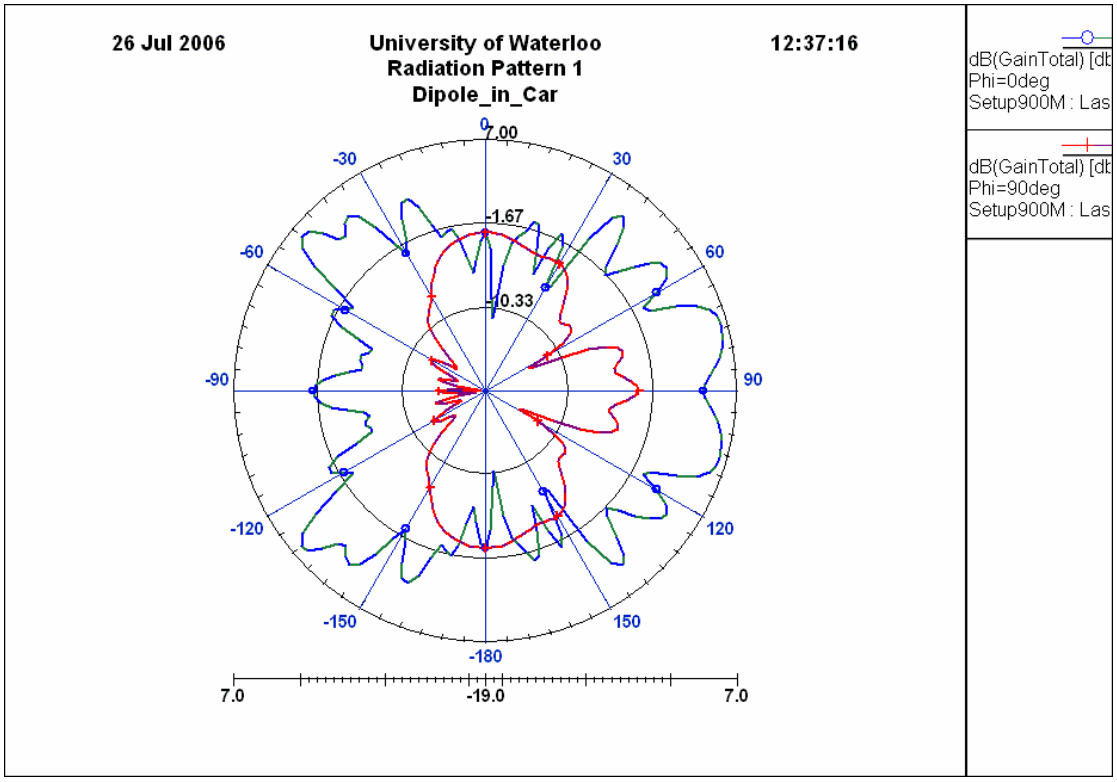


Fig. 7. The far field pattern for the half-wavelength dipole with the whole car (Fig. 5). The S parameter and impedance are **S11=0.25105-j*0.11578, Z11=80.405-j*20.159 ohm**.

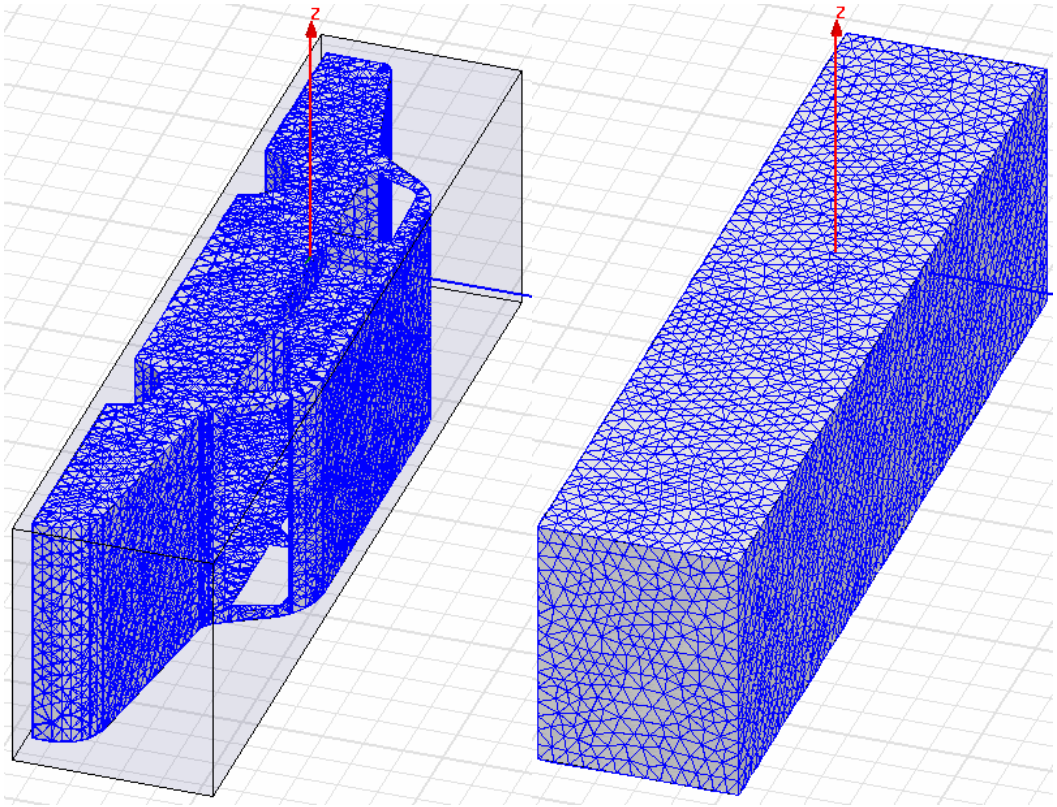


Fig. 8. The final mesh of the car and the outer-box.

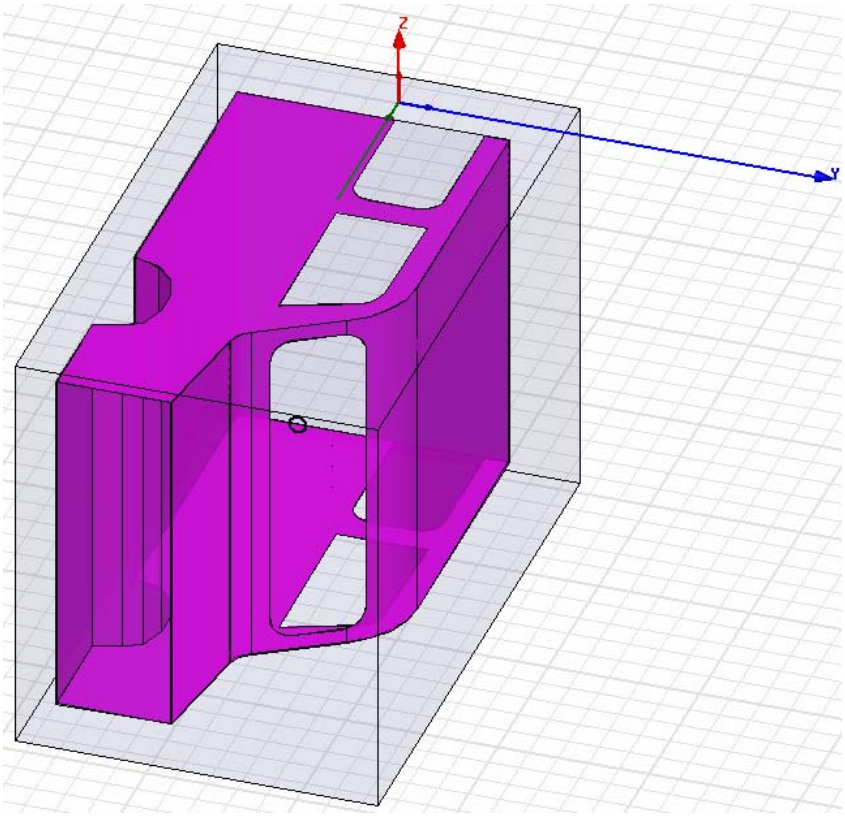


Fig. 9. The antenna in the car, only a part of the car is used in simulation. The two cut-planes at the front and back sides are set to perfectly electric conductor (PEC) boundary condition.

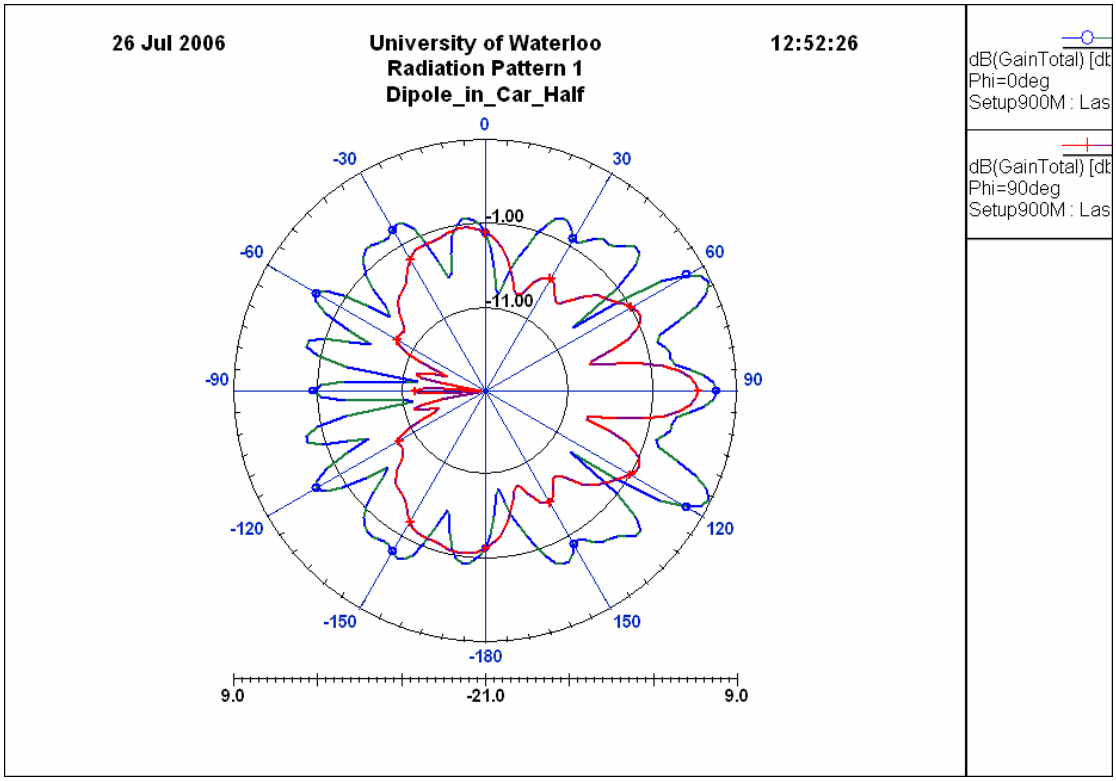


Fig. 10. The far field pattern of the dipole in the car (Fig. 9). The S parameter and impedance are **S11=0.14489-j*0.11723, Z11=64.787-j*15.737 ohm**.

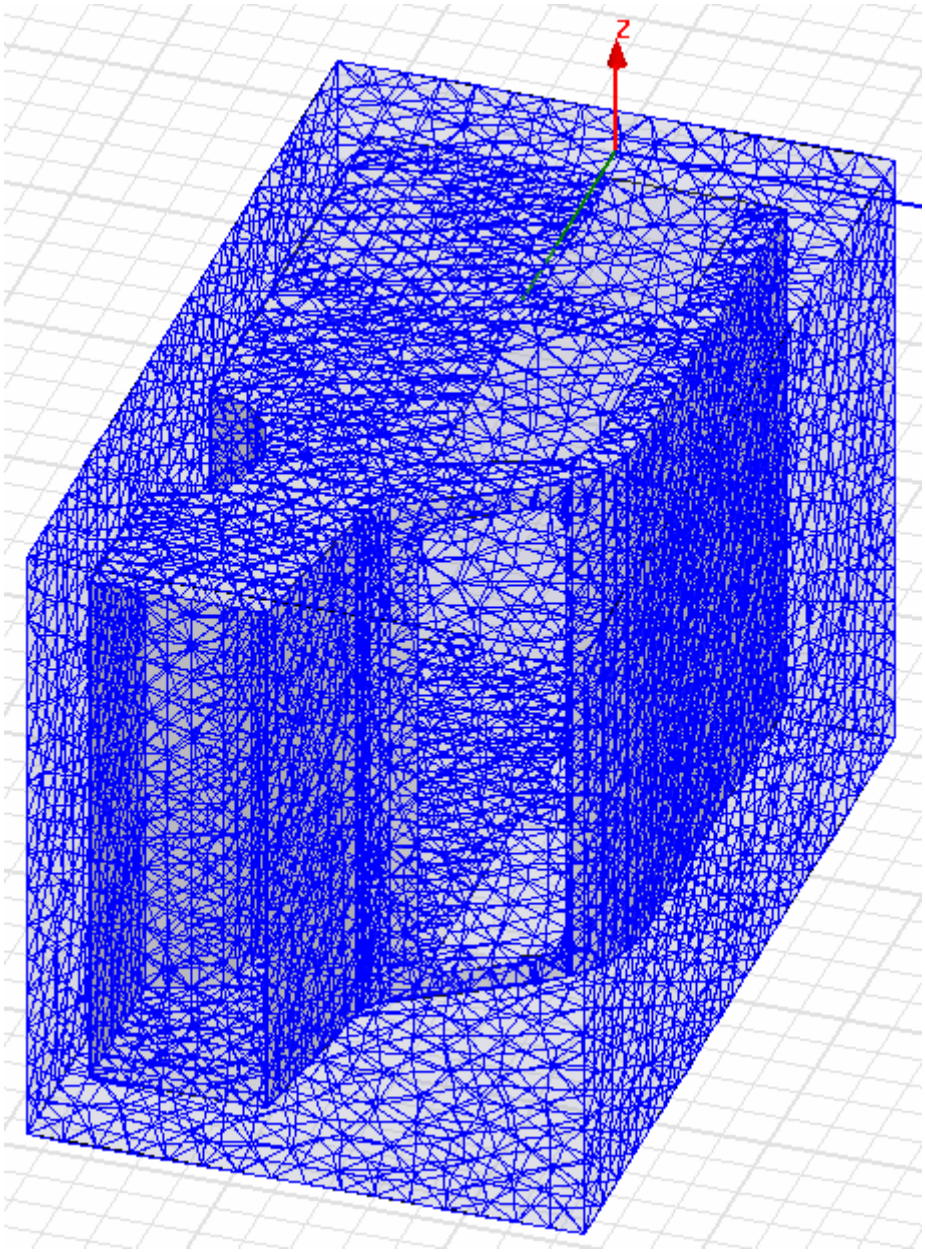


Fig. 11. The final mesh of the car and the outer-box.

Part 4. Dipole antenna in the whole car with ground underneath

2006-07-31. The simulation with a ground under the car. (Record on Aug 5, 2006) The only difference with Part 2 is the boundary setup as Fig. 12.

The simulation finished for Adaptive passes = 2, run 37 hours and 34 minutes on Sina9.uwaterloo.ca. Not converged for Target Maximum Delta S = 0.02 (Currently 0.045996 for 177495 tetrahedral).

The far field pattern of the car with gound (asphalt) is shown in Fig. 13. The S parameter and impedance are **S11 = 0.24125 - j* 0.13434; Z11 = 77.79 - j* 22.626 ohm**.

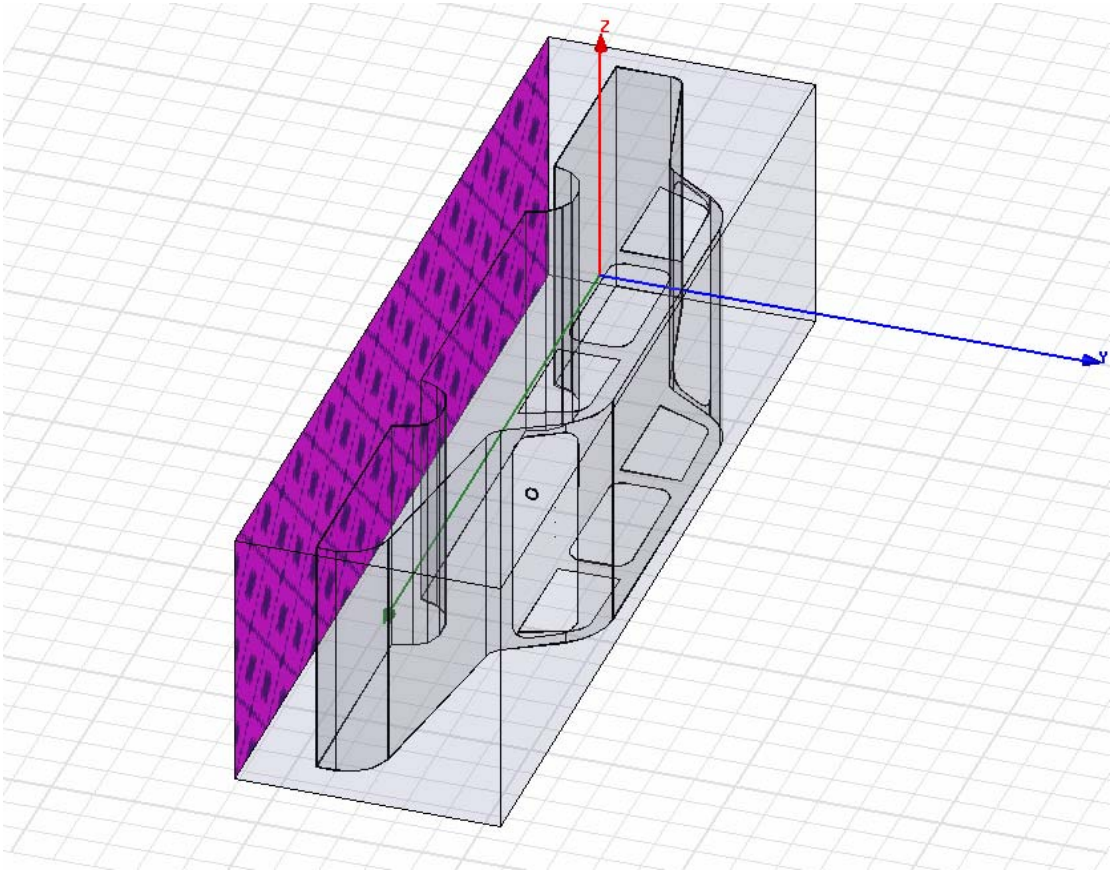


Fig. 12. The asphalt is taken into account by setting the bottom of the box as a finite-conductivity boundary condition (Use material Asphalt 900M (user defined: relative permittivity = 6, relative permeability = 1, bulk conductivity = 0.014s/m, Dielectric Loss Tangent = 0.02, and Lande G factor = 2), Surface Roughness 5mm, Layer Thickness 100mm.) The values of the material Asphalt is based on the reference [1].

Reference:

[1]. Edward J. Jaselskis, A.M.ASCE, Jonas Grigas; and Algirdas Brilingas, Dielectric Properties of Asphalt Pavement, JOURNAL OF MATERIALS IN CIVIL ENGINEERING, SEPTEMBER/OCTOBER 2003, pp. 427-434.

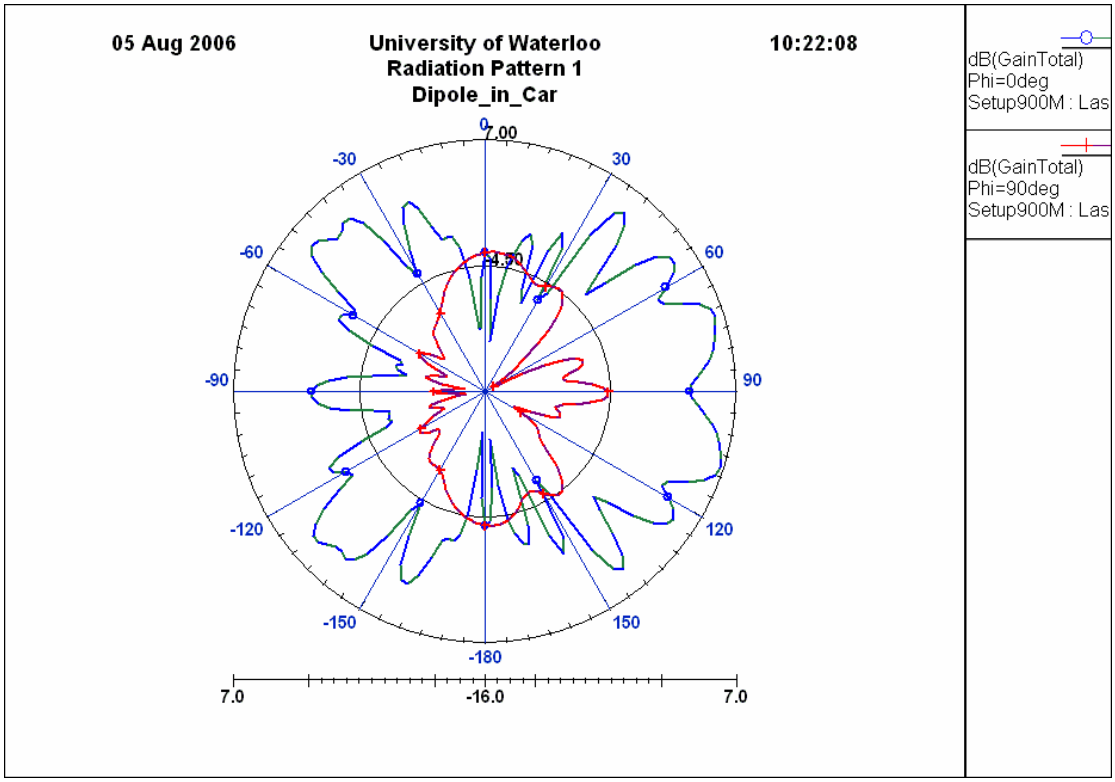


Fig. 13. The far field pattern for the half-wavelength dipole with the whole car with the ground (Asphalt). The S parameter and impedance are **S11=0.24125-j*0.13434, Z11=77.79-j*22.626 ohm**.