A New Model of Wire/Surface Junction for Picewise Sinusoidal Reaction Formulation

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1 Introduction

In designing antennas for the portable telephones numerically, it is necessary to consider both the antenna and the conducting body of the portable telephone, since the conducting box yields great effects on the characteristics of the antenna. For this reason, numerical analysis for a conducting structure consisting of surfaces, wires and wire/surface junctions is required. When the Galerkin's moment method is applied, the wire is usually devided into wire dipole segments and the surface is devided into the patch dipole segments . If the wire is attached to the surface, a special attachment segment have to be introduced to ensure a continuity of the current between the wire segments and the patch segments. Newman and Pozar [1] has proposed a attachment segment which contains two parts: a wire monopole and a disk monopole. They also pointed out that the attachment segment is only effective when the radius of the monopole disk of the attachment segment is larger than about 0.1 λ, which means that the wire structure should be located 0.1 λ away from the edge of the surface. This limitation makes the analysis for the portable telephone antennas impossible because most of the antennas are located in the vicinity of the edge of the conducting box.

In this report, a new attachment segment is introduced to the wire/surface junction, which is called joint patch segment [2]. The limitation described above is eliminated by introducing this segment. Furthermore, the segment is divided into several segments in the azimuth direction to incorporate the inhomogeneous current distribution with respect to the azimuth angle. To confirm the validity of the method, an analysis of a monopole antenna mounted in the vicinity of the edge of a rectangular conducting plane is performed, and the results of the analysis are compared with those of the measurements.

2 Theory

The geometry of the wire monopole antenna mounted on a rectangular conducting plane is shown in Figure 1. The size of the conducting plane is $a \times b$. The height of the monopole is h and the radius is r. The distance between the driving point and the edge of the plane is d. The conducting plane is divided into rectangular patch segments in the two orthogonal

directions. The current on each patch segment in the x-axis direction shown in Figure 3 is given by

$$J_x^n = \begin{cases} \dfrac{1}{w}\dfrac{\sin k_0(x - x_1)}{\sin k_0(x_2 - x_1)}\hat{x} , & x_1 \le x \le x_2 \\ \dfrac{1}{w}\dfrac{\sin k_0(x_3 - x)}{\sin k_0(x_3 - x_2)}\hat{x} , & x_2 < x \le x_3 \end{cases} \tag{1}$$

where w is the width of the patch segment.

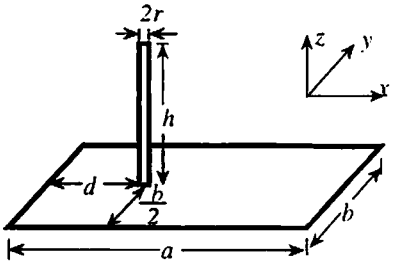

Figure 1 The geometry of a wire monopole antena mounted on a rectangular conducting plane.

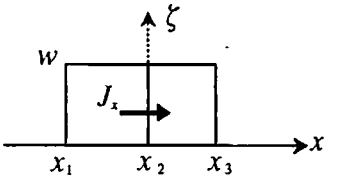

Figure 2 A patch dipole mode for expanding the current on the rectangular plane.

The wire monopole is divided into the wire segments. The attachment segment [1] is used to connect the wire segment and the patch segment on the surface as shown in Figure 4. The attachment segment is divided into 8 segments to incorporate the inhomogeneous current distribution with respect to the azimuth angle as shown in Figure 5. The basis and test functions on the attachment segment shown in Figure 5 are given by

$$J_z^n = -\frac{1}{(\phi_2 - \phi_1)r}\frac{\sin k_0(z_1 - z)}{\sin k_0 z_1}\hat{z} \quad \text{on monopole} \tag{2}$$

$$J_\rho^n = \frac{1}{w(\rho)}\frac{\sin k_0(L(\phi) - \rho)}{\sin k_0(L(\phi) - r)}\hat{\rho} \quad \text{on plane} \tag{3}$$

In order to remove the limitation of the size of the attachment segment pointed out by [1], additional segment called "joint patch segment" is introduced to connect half of the patch segment and the disk portion of the attachment segment as shown in Figure 5.

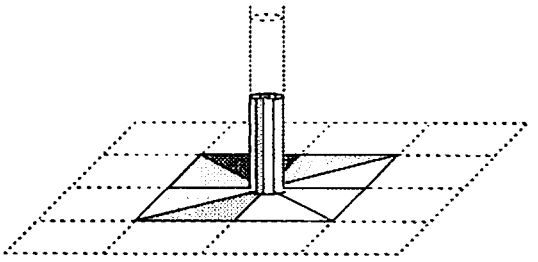

Figure 3 Attachment segment divided into 8 segments.

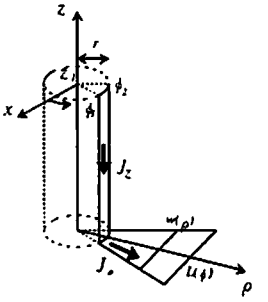

Figure 4 Detail of attachment segment.

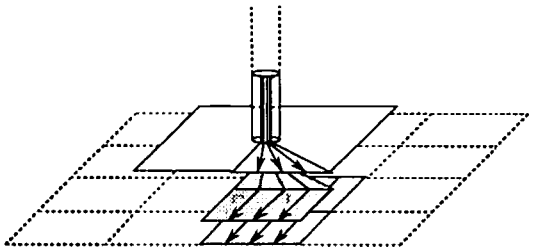

Figure 5 Joint patch segment added to the attachment segment (shaded part).

3 Numerical Results

The parameters used in the calculation are summarized in Table 1. The number of the division of the plane in x direction is 10 – 16 and that in y-axis direction is 10. The monopole antenna is divided into 5 segments. The number of all segments is about 350. Figure 6 shows the input impedance at d=5mm. Although the radius of the disk monopole segment is 0.0125λ at 1.5GHz, a good agreement between the calculation and the experiment is observed. The input impedance versus the distance d between the monopole and the edge at 1.5GHz is shown in Figure 7. This figure shows the accuracy of the present analysis and the advantage of the introduction of the joint patch segment are confirmed.

Table1 Parameters used for calculations.

Dimension of plate	a	100mm
	b	100mm
Height of monopole	h	50mm
Radius of monopole	r	0.25mm
Distance from the attachment point to the edge	d	5mm

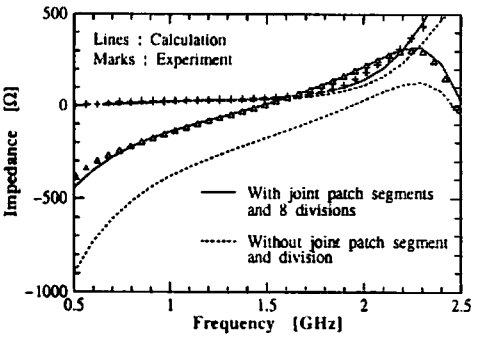

Figure6 Input impedance of the monopole antenna mounted on the rectangular conducting plane.

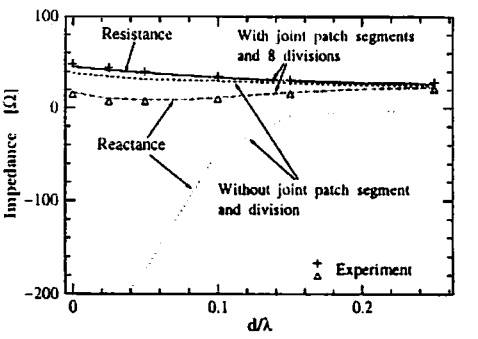

Figure7 The input impedance versus d.(Frequency:1.5GHz)

4 Conclusion

A monopole antenna mounted in the vicinity of the edge of a rectangular conducting plane has been analyzed by using the moment method. The joint patch segment overlapping half of the patch segment and the disk of the attachment segment. Furthermore, the disk monopole segment has been divided into 8 segments with respect to the azimuth angle. Good agreement between the calculation and the experiment has been observed confirming the validity and the high accuracy of this method.

References

[1] E.H.Newman and D.M.Pozar, "Electromagnetic Modeling of Composite Wire and Surface Geometries", *IEEE Trans. Antennas and Propagat.*, vol.AP-26, pp.784-789, Nov.1978.

[2] H.Ochi, E.Yamamoto, Q.Chen and K.Sawaya. "Moment Method Analysis of Antennas Composed of Conducting Wires and Plates – Introduction of a Joint Patch Segment –", *Technical Report of IEICE*, A·P95-73, pp.61-66. 1995.

[3] J.H.Richmond and N.H.Greay, "Mutual impedance of non-planar-skew sinusoidal dipoles", *IEEE Trans. Antennas and Propagat.*. vol.AP-23, pp.412-414. May 1975.