PROPAGATION LOSS BETWEEN DIPOLE ANTENNAS OVER THE GROUND PLANE WITH AN OPENING

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1. Introduction

In the calculations of antenna characteristics an infinite ground plane is often assumed. In the actual problem such an ideal ground plane is impossible to construct. A research on the antenna test site with various ground conditions has been already done [1]. As the characteristics of the soil ground are hard to predict, high accurate measurements supported by the numerical analysis cannot be achieved. Then large conducting plates are usually laid on the ground for the perfect electromagnetic reflection. When a finite ground plane is used, the diffracted fields from the edges of the ground plane degrade accuracy of the antenna measurement. To avoid influences by the diffracted fields from the edges of the ground plane a large ground planes is used to measure antenna characteristics. In the literature [2] the diffracted fields from the edges of the ground plane are taken into account by the hybrid method of the moment method and the geometrical theory of diffraction. Many ground planes have openings to connect measurement cables and supply electric power to the antenna positioner. Such openings are usually covered with a conducting plate to achieve ideal ground conditions. Although the importance of the surface of the ground plane is widely accepted, little research on the effect of an opening on the propagation loss has been done.

In this paper propagation loss between two half-wave tuned dipole antennas over the ground plane with an opening is focused on. The measurement frequency is from 300MHz to 1000MHz. The propagation losses between two antennas are calculated by using moment method. Measurements over a sufficiently large ground plane with and without an opening were done and the measured results are compared with the calculated results.

2. Focused Model

The focused model in this paper is shown in fig. 1. A rectangular opening on the ground plane is located between transmitting and receiving antennas. The size of the opening is 0.6m (parallel to the y-axis)× 0.85m. This opening is usually covered with a conducting plate to keep electrical touch with the ground plane around the opening. Both of the transmitting and receiving antenna heights $h_{t,r}$ are 0.6m. The horizontal distance d between transmitting and receiving antennas is fixed to 3.0m. Propagation losses with and without an opening are named as PL_{on} and PL_{xs}, respectively. The offset

distance d_o is defined as the distance from the center of the opening to the geometrical reflection point on the surface of the ground plane. As one side length of the opening parallel to the x-axis is 0.85m, the geometrical reflection point does not exist when $ABS(d_o)$<0.425m for the measurements with an opening.
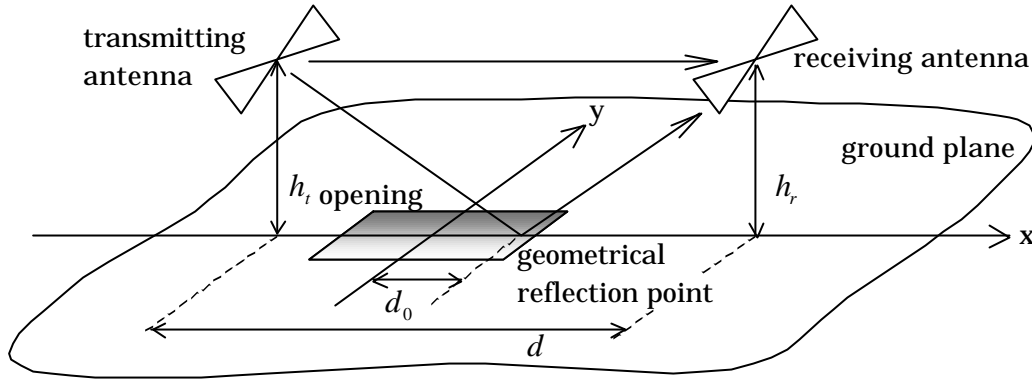

fig. 1 Focused model.

3. Measured and Calculated Results
3.1 Measurement Method

Transmitting and receiving antennas are located with the separation of 3.0 m over the ground plane and the heights of the antennas are fixed at 0.6 m. The centers of dipole element are located over the x-axis and the axis of the element is parallel to the y-axis. Propagation loss without an opening PL_{xs} is measured at each frequency. Then the conducting plate that covers the opening is removed to measure the propagation loss with an opening PL_{on}. PL_{xs} and PL_{on} include undesired effects within them, for example, the effects of the scattered fields by the antenna supports and feeder cables. By subtracting PL_{xs} from PL_{on} the effects of an opening on the propagation loss between antennas can be estimated. PL_{xs} and PL_{on} are measured at each 0.1 m of d_o.

3.2 Calculation Model

To calculate propagation loss between antennas the moment method is applied [3]. In the calculation of antenna characteristics near the conducting structure a wire-grid model is often used [4]. Although the wire-grid model can easily represent the conducting structure, it requires large size of computational memory and takes much time to calculate a model of the large structure. To reduce calculation time and computational memory the equivalence theorem is applied to the problem. By assuming proper magnetic and electric current sheets on the surface of the opening the boundary condition is satisfied and the electromagnetic fields inside of the opening becomes zero. Then the opening can be covered with the conductor and the image theory is used. Consequently the calculation model becomes a combination of two transmitting antennas, two receiving antennas and a magnetic current sheet in free space. The calculation model with transmitting, receiving antennas and the magnetic current mesh is shown in fig. 2. By replacing the magnetic current sheet with the wire-grid model the computational time is reduced in comparison with the one to calculate the wire-grid

model representing the ground plane. In this paper the grid separations parallel to the x- and y-axis are set to be less than 0.1 and 0.2 wavelength of the operating frequency, respectively. The load Z_L at the port of the receiving antennas is 100   [5].
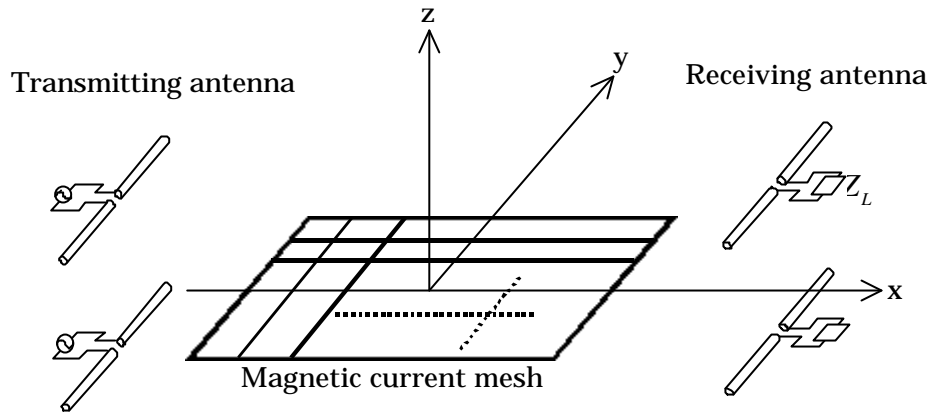

fig. 2 Calculation model

3.3 Results

The measured and calculated PL_{on}'s at 1000MHz with respect to the offset distance d_o are shown in fig. 3. The degree of the agreement of measured and calculated propagation losses with an opening is shown by this figure. The geometrical reflection point on the ground plane is inside the opening area when the offset distance d_o is from -0.4 to 0.4 m. Measured and calculated PL_{on}'s are in good agreement when d_o is larger than 0.5m as the geometrical reflection point is located outside of the opening. When the reflection point is inside the opening area, calculated PL_{on}'s are about 2 dB smaller than the measured ones. A conducting structure exists inside the opening that is supposed to affect on the measured results. By taking the conducting structure into account in the calculation calculated results will be in good agreement with measured results in the region $-0.4 < d_o < 0.4$.
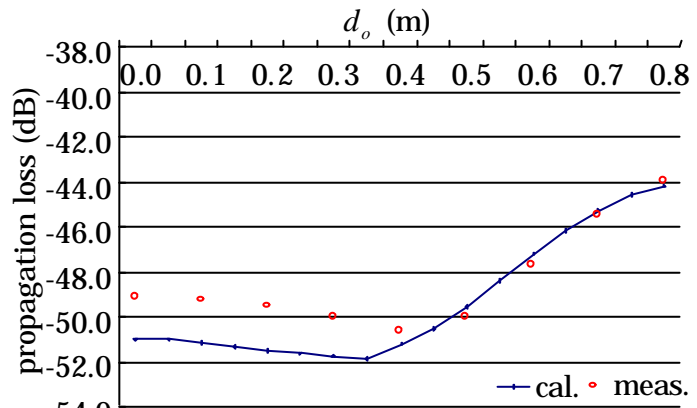

fig. 3 PL_{on} at 1000 MHz with respect to the offset distance d_o .

Typical two cases of the configuration of antennas and an opening are considered for the evaluation of the effect of an opening. One is the symmetrical case (d_o = 0.0 m) and the other is the offset case (d_o = 0.5 m). Figure 4 shows the frequency characteristics of $PL_{on} - PL_{xs}$ for the two offset distances. As PL_{xs} is the propagation loss with perfect reflection, it is used as a reference to evaluate the influence of the opening. For d_o = 0.5m frequency characteristics of the measured and calculated propagation losses are similar. On the other hand, for d_o = 0.0 m the differences between

calculated and measured results become larger as the frequency goes higher. It is supposed to be the same reason as mentioned above for this tendency. Because tendencies of the difference between measured and calculated results are similar, results with different d_o are comparable with each other.

For the antenna configurations in this paper the reflected fields and direct fields are not out of phase and do not cancel completely in all bandwidth of measurement. We can see that the propagation loss PL_{on} with d_o = 0.0 m is smaller than the one when the geometrical reflection point exists (d_o = 0.5 m). This means the received power at the receiving antenna with d_o = 0.0 m is larger than the one with d_o = 0.5 m when frequency is lower than 900 MHz. For this reason the electric current distribution is disturbed by the opening and the receiving antenna must be supposed to receive the more reradiated power from the disturbed current than the one without an opening.
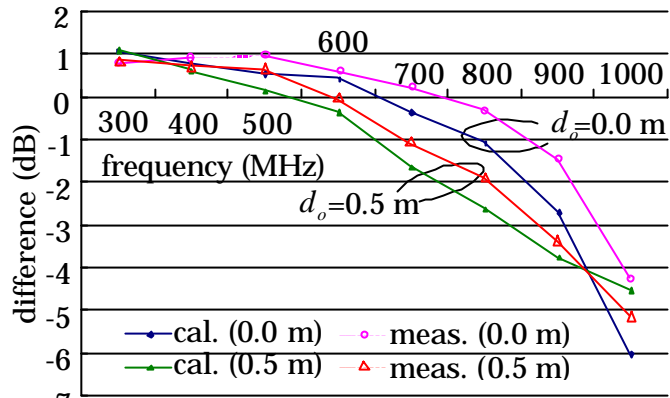

fig. 4 Frequency characteristics of $PL_{on} - PL_{xs}$ for offset distance d_o is 0.0 and 0.5 m.

4. Conclusions

In this paper propagation losses between dipole antennas over the ground plane with and without an opening are studied. For the measurement pairs of resonant dipole antennas at each frequency are used. Transmitting and receiving antennas are located parallel to the ground plane. The method of moment is applied to the problem and measured results are compared with calculated results. Even when the geometrical reflection point exists in the opening area, the propagation loss is not always larger than the one without an opening. It is supposed that the receiving antenna receives the more power reradiated from the disturbed electric current by the opening as the interpretation.

References

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