S-PARAMTER BETWEEN DIPOLE ANTENNA ELEMENTS ON A FINITE GROUND PLANE

Katsumi FUJII and Takashi IWASAKI
Department of Electronic Engineering, The University of Electro-Communications
1-5-1 Chofugaoka, Chofu-shi Tokyo, 182-8585, Japan
E-mail: katsumi@snow.ee.uec.ac.jp

1. Introduction

In order to evaluate test sites for measuring complex antenna factors (CAF) [1], the transmission S-parameter, S_{21}, between two dipole antenna elements on a rectangular finite ground plane is calculated in horizontally and vertically polarized configurations using two analysis methods. One is the hybrid method combined with the Moment method (MoM) and the geometrical theory of diffraction (GTD) [2]. The other is the MoM in which the finite ground plane is divided to planar-segments [3]. The S_{21} is also measured using a network analyzer with TRL (Thru-Reflect-Line) calibration technique [4]. The calculated results are compared with the measured results.

2. Calculation

2.1 Hybrid method

In the MoM-GTD hybrid method, the diffracted wave from edges is considered. As shown in Fig.1, electromagnetic wave is radiated from transmitting antenna. The electric field at the receiving antenna, E, is express as,

$$E = E^i + E^r + E^d \quad , \qquad (1)$$

where E^i is a direct wave, E^r is a reflected wave in which the infinite ground plane is assumed and E^d is a diffracted wave from the four edges of the finite ground plane. To obtain E^d, Keller's diffraction coefficient is used [5]. The second diffracted waves between parallel edges are considered. The field of (1) is used in the MoM calculation.

2.2 MoM with planar-segments

Here, a planar-segments model of the finite ground plane is adopted. The ground plane is divided into 8 x 20 planar-segments as shown in Fig.2. The current on the ground plane is decomposed into the z- and y- components. The upper and lower segments are corresponding to the z- and y- components, respectively. The mutual impedance between two planar-segments is as follows [3],

$$Z_{mn} = \frac{1}{w_m}\frac{1}{w_n}\int_0^{w_m}\int_0^{w_n} Z^0(\zeta_m, \zeta_n)\, d\zeta_n\, d\zeta_m \quad , \qquad (2)$$

where Z^0 is the mutual impedance between linear-segments shown as the thick lines in Fig.3. The double integration (2) is calculated with the Gauss-Legendre's numerical method. The gap of the two current planes is 1 mm in order to avoid singularity.

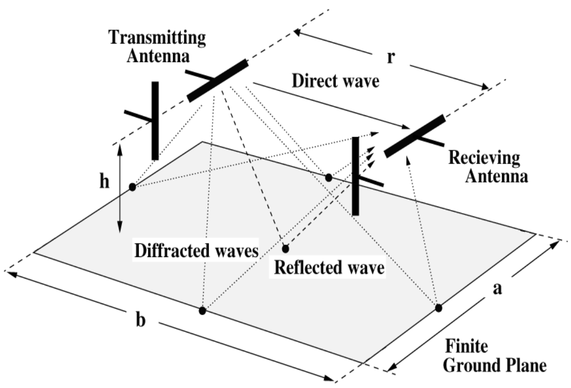


Figure1. Electric field radiated by the transmitting antenna

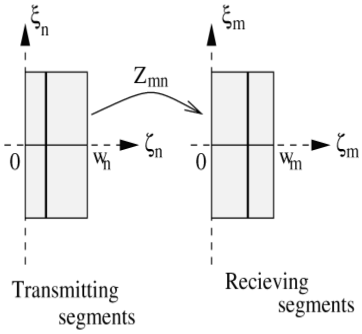


Figure3. Mutual impedance between planar-segments

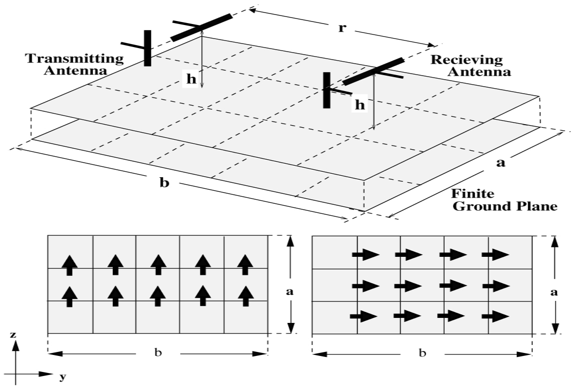


Figure2. Divided finite ground plane for the MoM calculation

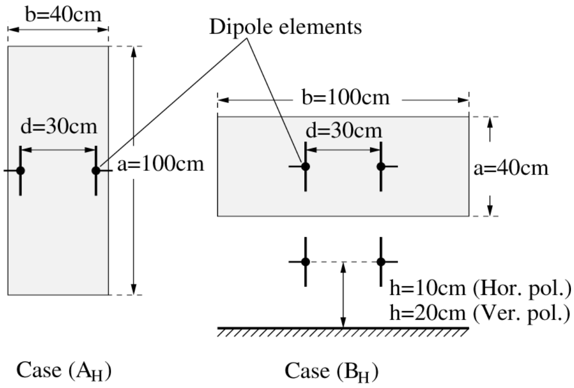


Figure4. Geometries in horizontal and vertical polarizations

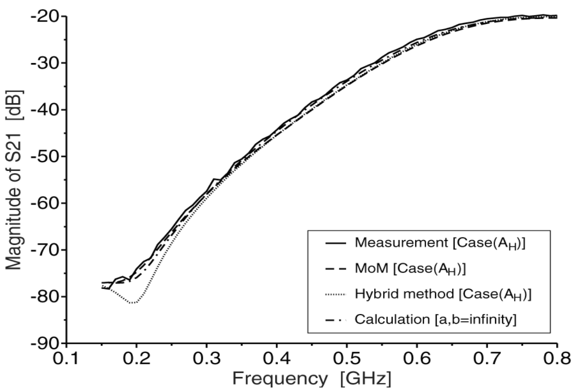
2.3 Configuration

Considering a 1/10 scaling experiment, the calculations are carried out under the following conditions. The dipole-element length is 18.76 cm (half-wavelength at 0.8 GHz). The diameter of antenna element is 2 mm. Two dipole antennas with a 1:4 balun (50 ohms to 200 ohms) are used [4]. The frequency range is from 0.15 GHz to 0.8 GHz. A metal plane whose size is 40 cm x 100 cm is used as shown in Fig.4. The distance between dipole elements is 30 cm. The antenna height is 10 cm in the case of horizontal polarization and 20 cm in the case of vertical polarization, respectively.

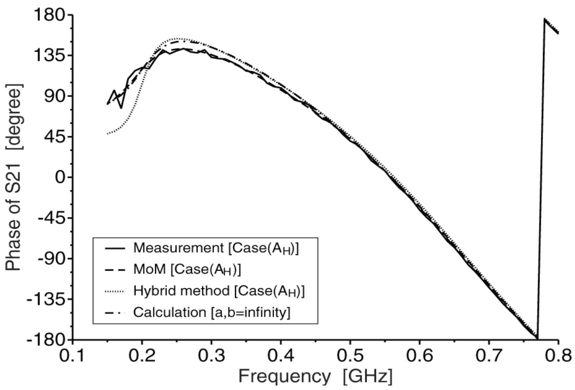
In the both analyses, the antenna element is divided into 20 segments. The current distribution of each segment is assumed to be a partial sinusoidal function. The usual Galarkin's method and the delta gap excitation are used.

3. Measurement

A measurement is carried out in an anechoic chamber (3.9 m x 8 m floor and 6 m height). A network analyzer (Anritsu 37225A) is used with its TRL calibration of the two-wire line in order to exclude the effect of the baluns of the dipole antennas [4]. In the TRL calibration, the baluns are considered as error circuits in the network analyzer. After the TRL calibration, the measurement is made at the reference planes in the two-wire lines between the antenna elements and the baluns.

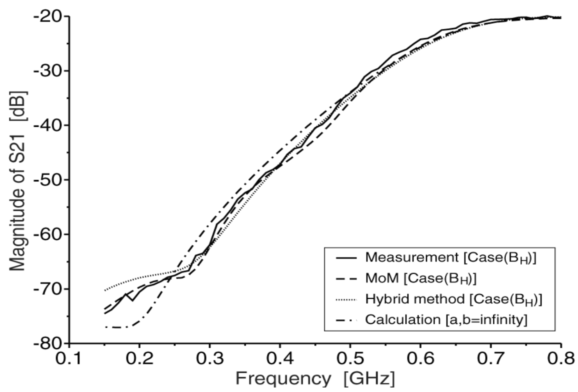


(a) Magnitude

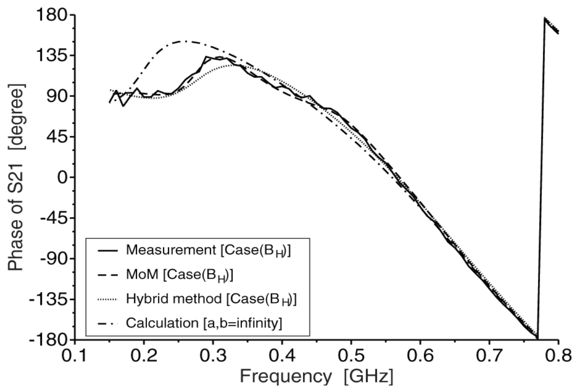


(b) Phase

Figure5. S_{21} in the case (A_H)



(a) Magnitude



(b) Phase

Figure6. S_{21} in the case (B_H)

4. Results and conclusions

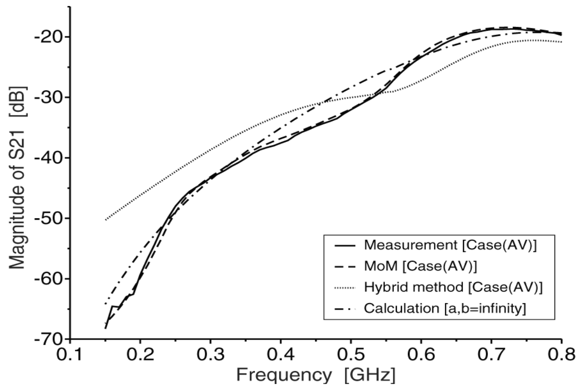
The measured and calculated results in horizontal polarization are shown in Fig.5 for the case (A_H) and in Fig.6 for the case (B_H). In vertical polarization, the results are shown in Fig.7 for the case (A_V) and in Fig.8 for case (B_V).

The magnitude and phase of S_{21} are shown in (a) and (b) in the both figures, respectively. The solid lines show the measurement results. The dashed lines show the corresponding results calculated by the MoM with planar-segments. The dotted lines show the results calculated by the MoM-GTD method. The calculated results for the infinite ground plane are also shown as dotted-dashed lines.

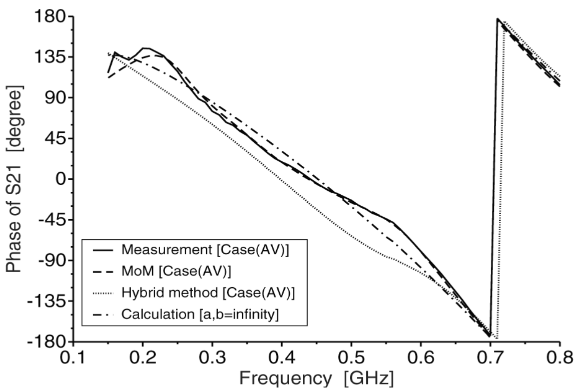
Not all the results using the MoM-GTD agree with the corresponding measurement results. On the other hand, the results by the MoM with the planar-segments agree well. In horizontal polarization, the dipole element direction of a rectangular finite ground plane should be wider. In vertical polarization, the effects of the finite ground plane are much larger than in horizontal polarization.

Acknowledgement

The authors would like to thank Prof. K. Sawaya and Dr. Q. Chen, Tohoku University for helpful advises. This work is supported by the Research for the Future Program (Reduction of Electromagnetic Noise Levels), Japan Society for the Promotion Science.

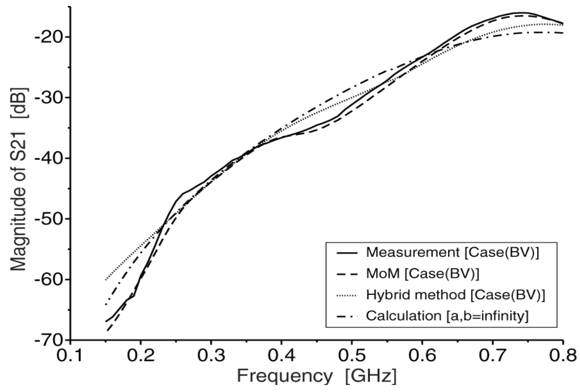


(a) Magnitude

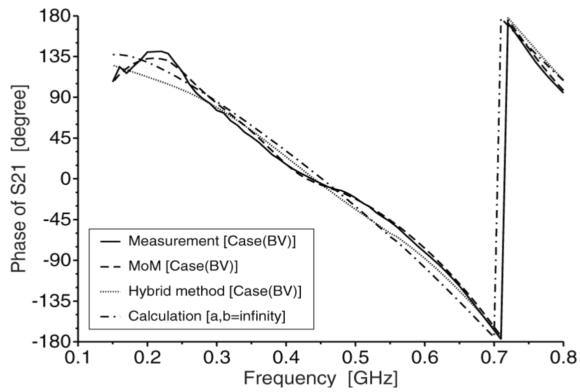


(b) Phase

Figure7. S_{21} in the case (A_V)



(a) Magnitude



(b) Phase

Figure8. S_{21} in the case (B_V)

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