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Effect of a Surface Wave in Mutual Coupling for Printed Bow-Tie Antenna Array

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Abstract - **In this paper, we analyze an effect of surface wave on the mutual coupling for H-plane bow-tie array antenna. To check the coupling mechanism, the E-field distribution of a bare bow-tie antenna and the antenna on a substrate is compared. In the case of the antenna without substrate, only a field radiated from the antenna is confirmed. But a surface wave guided along the substrate is observed in the antenna having a substrate. The diffracted field at the edge of the substrate can be used to improve the mutual coupling characteristic. An 11 by 1 bow-tie array is designed and simulation shows that the coupling between two adjacent antennas is less than -20 dB in the 13.6 ~ 17.8 GHz band.**

Index Terms — **Bow-tie antenna array, Mutual coupling, Surface wave, Wave cancellation**

1. Introduction

In an antenna array, mutual coupling between antenna elements degrades the performance of the array signal processing algorithm [1]. There are various way of reducing the mutual coupling. Electromagnetic band-gap (EBG) structures is an attractive way to suppress the mutual coupling. However it occupies a large area and has the complex structure. So it is usually difficult to implement. Parasitic elements in an antenna is another way to reduce mutual coupling. Parasitic elements make a double-coupling path. So it can be used to cancel out direct coupling depending on the position of the antenna and the parasitic elements [2], [3].

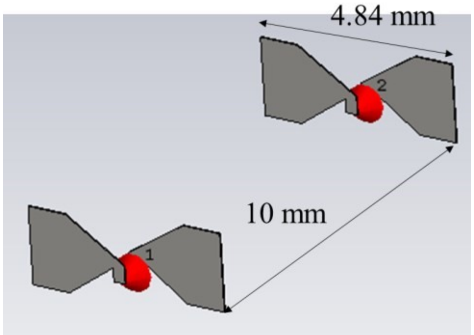
In this paper, we analyze an effect of surface wave on the mutual coupling for H-plane bow-tie array. For the wideband implementation, the antenna is designed as bow-tie type [4]. The array is in the H-plane direction and the spacing between elements is 10 mm to be 0.5 λ_o at 15 GHz. In section 2, in order to understand the coupling mechanism, E-field distribution of a bare bow-tie antenna and the antenna on a substrate is compared. Then, in section 3, the 11 by 1 1D bow-tie array with ground is designed using a substrate with a high dielectric constant so that the surface wave can be sufficiently guided. The proposed model doesn't need any other structure such as EBG or parasitic elements. So it is very easy to implement compared with the conventional array antenna.

2. Principle of Mutual Coupling Reduction

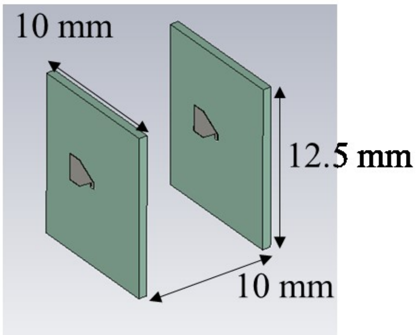
Fig. 1 shows two elements array configuration of a printed bow-tie antenna without/with substrate. The dielectric constant of the substrate is set to 10.2 for antenna impedance matching and guiding a surface wave sufficiently. In the case of the antenna without substrate, there is only a direct path that radiates from the antenna. However, in the case of the antenna with substrate, the diffracted field occurs at the edge of the substrate due to surface waves. At this time, the substrate is operated as a dielectric slab waveguide [5]. Fig 2 shows the coupling between two antennas when the antenna is perfectly matched. Using the effective length of the antenna is 4.84 mm in Fig 1(a), the Fraunhofer distance can be calculated as 2.34 mm at 15 GHz. Since the space between two antennas is much larger than Fraunhofer distance, it can be assumed to be a far field region. Thus, for a bow-tie array without a substrate, the mutual coupling agrees with the tendency of free space loss. In the case of the antenna with a substrate, mutual coupling is reduced by wave cancellation of direct path induced from antenna and diffraction from edge of the substrate as shown in Fig 2. It can be shown by field configuration.

3. Antenna Design and Simulation Results

The proposed printed bow-tie element is designed on the substrate with εr = 10.2, loss tangent = 0.0023 and thickness = 0.635 mm (Roger RT/ Duroid 6010) and the antenna structure is mounted on a ground plane. In order to effectively reduce the mutual coupling in the desired band, the size of the substrate must be adjusted. Fig. 3 presents the geometry of the 11 by 1 H-plane antenna array with 0.5 λ_o element spacing at 15 GHz. The result of simulation in Fig 4 shows the S–parameter. Mutual coupling between two adjacent antennas is less than -20 dB in the 13.6 ~ 17.8 GHz band.



(a) Bow-Tie



(b) Bow-tie with substrate

Fig. 1. Two element array configurations.

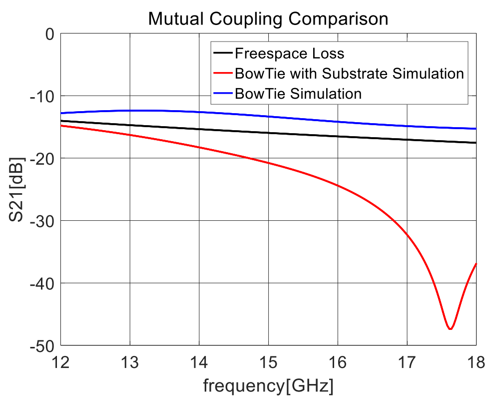


Fig. 2. Mutual coupling with and without substrate of two array.

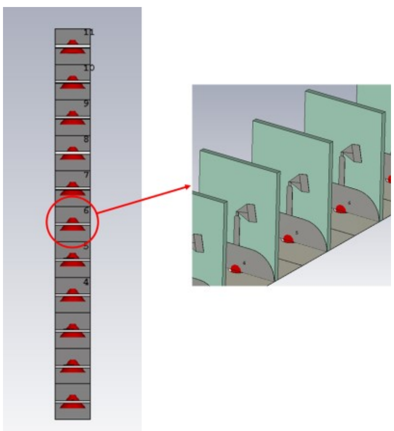


Fig. 3. Geometry of an 11 by 1 bow-tie array in H-plane.

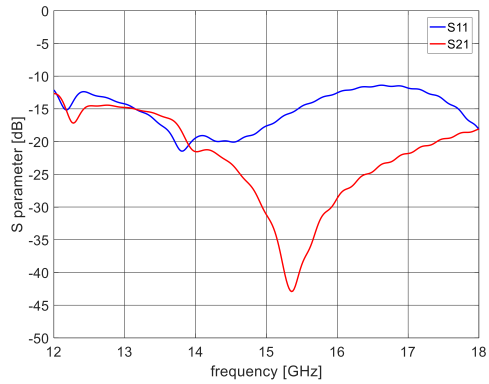


Fig. 4 Simulated S parameter of proposed 11 by 1 array.

4. Conclusion

The printed bow-tie array for 1D H-plane is proposed and simulated. Simulation of two elements array shows that mutual coupling is reduced by wave cancellation of direct path induced from antenna and diffraction from edge of the substrate. Based on the principle, we design an 11 by 1 antenna array in H-plane direction with 0.5 λ_o element spacing at 15 GHz. The simulated results show that the mutual coupling is less than -20 dB in the 13.6 ~ 17.8 GHz band.

Acknowledgements

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