Estimation Error of a Mono-Pulse DOA Estimation Antenna for Two Incident Waves

Ryo Tanaka, Eisuke Nishiyama, and Ichihiko Toyoda
Graduate School of Science and Engineering, Saga University
1, Honjo-machi, Saga-shi, Saga, 840-8502, Japan
{tanakar, nisiyama}@ceng.ec.saga-u.ac.jp, toyoda@cc.saga-u.ac.jp

***Abstract*—We have proposed a novel direction-of-arrival (DOA) estimation antenna based on the mono-pulse mechanism. The proposed DOA estimation antenna consists of microstrip antennas and Magic-Ts which generate Σ and Δ signals from received RF waves. As the Both-sided MIC technology is used for the Magic-T and feed circuits, the proposed antenna has a good performance with a simple structure. In this paper, the estimation errors of the proposed antenna are examined when an undesired wave is simultaneously received with the desired wave.**

***Index Terms* — mono-pulse, DOA, Mgic-T**

I. Introduction

Recently, a wide variety of radar and sensor systems have been developed. In these systems, high functionality and compactness are required [1], [2].

We have proposed a novel antenna for the direction-of-arrival (DOA) estimation systems based on the phase mono-pulse mechanism in order to meet these requirements. In the DOA estimation process, the arrival angle is determined by the sum and difference of the signals received by two antenna elements [3]. The proposed DOA estimation antenna employs Magic-T circuits to obtain the sum and difference of the received signals [4], [5]. The proposed antenna has a good performance with a simple structure. However, undesired waves simultaneously received with the target wave may cause estimation errors. In this paper, the estimation errors caused by an undesired wave are examined based on the measured radiation patterns of the proposed antenna.

II. DOA Estimation Antenna

Fig. 1 shows the block diagram of the proposed DOA estimation antenna. A Magic-T is used to obtain the sum and difference of the received signals. The arrival angle θ can be obtained by the following equation:

$$\theta = \sin^{-1}\left(\frac{\lambda}{\pi d}\tan^{-1}\frac{\Delta}{\Sigma}\right) , \qquad (1)$$

where Σ and Δ are the summed and subtracted amplitude of the RF signals received by two antenna elements [1].

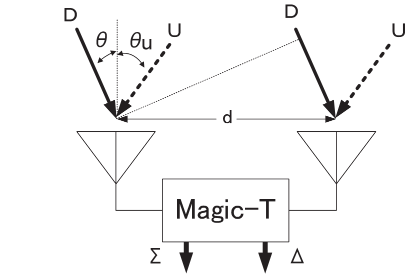

Figure 1: Brock diagram of the antenna and Magic-T of DOA estimating system.

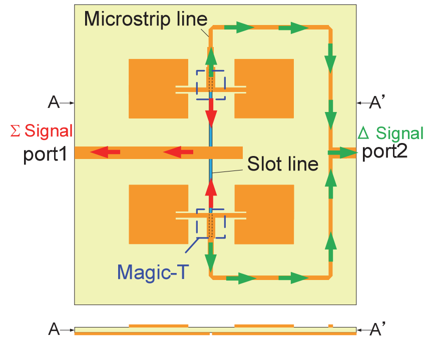

Figure 2: Structure of the DOA estimation antenna. A 4-element array antenna is integrated with Magic-Ts.

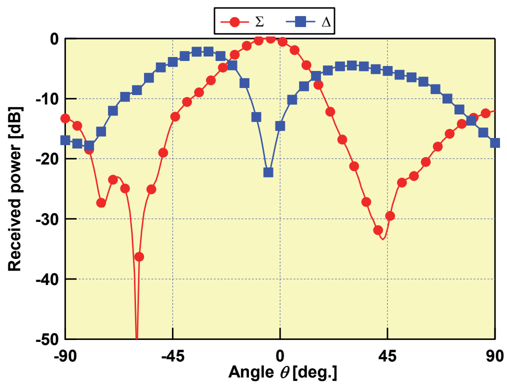

Figure 3: Measured radiation pattern of the array antenna. (f = 10 GHz).

Fig. 2 shows the structure of the proposed DOA estimation antenna. This antenna is composed of a 4-element microstrip array antenna, two magic-Ts, and two orthogonal feeding circuits employing microstrip lines and a slot line. When an RF signal is received by the antenna elements, summation (Σ) and difference (Δ) of the RF signal are obtained at Port 1 and Port 2 thanks to the function of the Magic-T, respectively.

III. Estimation Error

In this paper, it is assumed that one undesired wave is simultaneously received with the target wave. The incident angle of the undesired wave is θ_u and the phase difference between the waves is φ_u.

As expressed in (1), the arrival angle of the target wave is determined by Σ and Δ. When the undesired wave is received with the target wave, Σ and Δ include the power of the undesired wave as well as the target wave. This power causes the estimation error. However, the impact of the undesired wave depends on the direction of the undesired wave because each microstrip antenna has directivity. Then the Σ and Δ including both waves are calculated using the measured radiation patterns of the array antenna shown in Fig. 3.

Fig. 4 shows the estimation errors vs. arrival angle of the target wave when the undesired wave received from the angle of θ_u = 0 deg. with the phase difference φ_u = 0 deg.. The error is defined by the difference from the estimated angle when only the target wave is received. The estimation error is better than 7 deg. for the D/U of 20 dB.

Fig. 5 shows the estimation errors in the case of the undesired wave with the phase difference φ_u = 0 deg., and the D/U of 20 dB. The incident angles of the undesired wave are θ_u = 0, 10, 20 and 30 deg.. It can be seen that the estimation error is decreased in accordance with the incidence angle of the undesired wave.

IV. Conclusion

In this paper, estimation errors of the DOA estimation antenna integrating microstrip array antenna and Magic-Ts are examined based on the measured radiation patterns. The proposed DOA estimation antenna employs mono-pulse DOA estimation mechanism which needs sum and difference of the signals received by two antenna elements. The proposed antenna is effectively using Magic-Ts which generate Σ and Δ signals with a simple structure. The estimation error is better than 7 deg. for the undesired wave incident from normal direction of the antenna (θ_u = 0 deg.) with D/U of 20 dB and phase difference φ_u = 0 deg..

Acknowledgement

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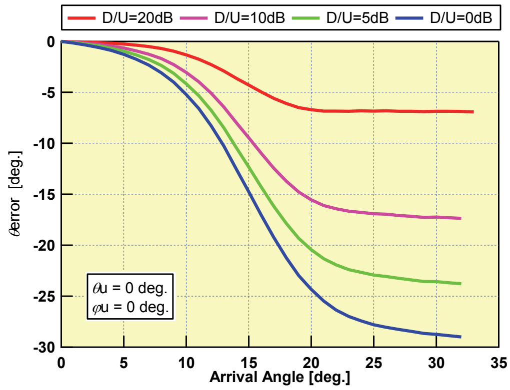

Figure 4: Estimation errors (θ_u = 0 deg., φ_u = 0 deg.).

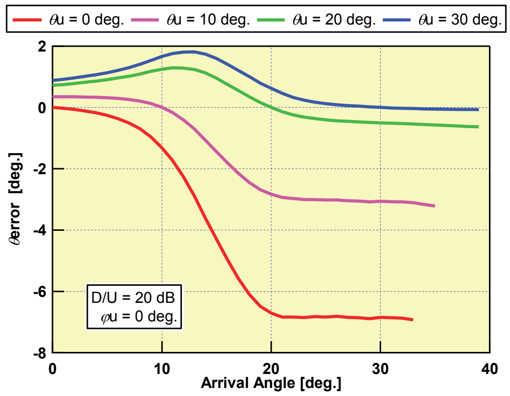

Figure 5: Estimation errors (D/U = 20dB, φ_u = 0 deg.).

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