DESIGN OF SINGLE-LAYER POWER DIVIDER COMPOSED OF E-PLANE T-JUNCTIONS FEEDING WAVEGUIDE ANTENNA

Akiyoshi MIZUTANI, Yuta YAMAMOTO, Kunio SAKAKIBARA
Nobuyoshi KIKUMA and Hiroshi HIRAYAMA
Nagoya Institute of Technology
Gokiso-cho, Showa-ku, Nagoya, 466-8555, Japan
E-mail sakaki@nitech.ac.jp

1 Introduction

High speed wireless communication systems and high angular resolution automotive radars have been developed in the millimeter-wave band. Waveguide antennas are one of the attractive candidates for these systems because of the negligible feeding loss even at such high frequency. Since slotted waveguide array antennas[1] have advantages of low loss and low profile, they are expected for the systems which require both high sensitivity and compact size. Narrow wall slotted waveguide linear array antennas have already reported for the low loss configuration of the waveguide[2], [3]. Here, we propose a single-layer power divider composed of E-plane T-junctions feeding high-gain two-dimensional waveguide planar array as is shown in Fig.1(a). The design concept and the configuration of the proposed feeding circuit are summarized and performance is indicated in this paper.

2 Configuration of the Feeding Circuit

A two-dimensional waveguide planar array is composed of one feeding waveguide and 24 radiating waveguides slotted on the narrow walls. The input port of the feeding waveguide is at the center and all the radiating waveguides are fed from the feeding waveguide in the cascade connection. Since adjacent waveguides are spaced in a half guide wavelength of the feeding waveguide, the radiating waveguides are fed in an alternating 180-degree out of phase. The radiating waveguides are connected on the broad wall of the feeding waveguide, which forms a series of E-plane T-junctions indicated in Fig.1(b). A coupling window is opened at the junction and coupling power to the radiating waveguide is controlled by the width W in the H-plane of the window. A post is set at the opposite side of the window for matching where the reflection from the window is canceled with that from the post out of phase. Reflection level and phase of the post are adjusted by the length L and the offset D from the center of the radiating waveguide, respectively. The feeding waveguide is fed through the H-plane T-junction at the input port. Since two adjacent radiating waveguides are very close to the input port, the H-plane T-junction is designed with taking the two waveguides into consideration as the simulated model is shown in Fig.1(c). The terminated E-bends feeding two edge radiating waveguides are shown in Fig.1(d). The size of the post is designed for matching and the width P of the waveguide is the parameter for phase adjustment of the divided power.

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3 Design

Key features of the array design are summarized as follows. Required coupling of each radiating waveguide is assigned for Taylor distribution on the aperture to be a sidelobe level lower than -20 dB as is shown in Fig.2. A required variety of coupling is 13.8 % - 100 %. The previously mentioned parameters W, L and D are optimized in each T-junction by using the electromagnetic simulator of the finite element method. The width W of the window gradually increases with port number because large coupling is required. Relatively large windows are used at the port number 12 and 13 to compensate the effect of the mutual coupling from the adjacent input port. The length L of the post also increases with port number because the reflection from the window is large for large window. The broad wall width of the feeding waveguide is determined so that the guide wavelength of feeding waveguide is just twice the narrow wall width of the radiating waveguide including the wall thickness. Phase perturbation of each T-junction is evaluated by simulation. The effect is compensated by adjustment of the spacing between the radiating waveguides.

4 Performance

A 24-way power divider is designed at 76.5 GHz. Field amplitude and phase of the twenty four output ports are shown in Fig.3. The simulated and experimental results almost agree well with the design in the error smaller than 1 dB of amplitude and 5 degrees of phase. Figure 4 shows array factors calculated from the field amplitude and phase indicated in Fig.3. Both of the simulated and designed sidelobe level is lower than -20 dB. The simulated results almost agree well with the design. Next, frequency dependency of reflection is shown in Fig.5. Resonant frequency is at 76.5 GHz of the design frequency. Bandwidth of the reflection below -20 dB is 8 GHz.

5 Conclusion

We propose the single-layer power divider composed of E-plane T-junctions and the performance is confirmed in this paper. Future study is to test the performance of a fabricated planar array antenna and to confirm the applicability of the proposed feeding circuit.

Acknowledgments

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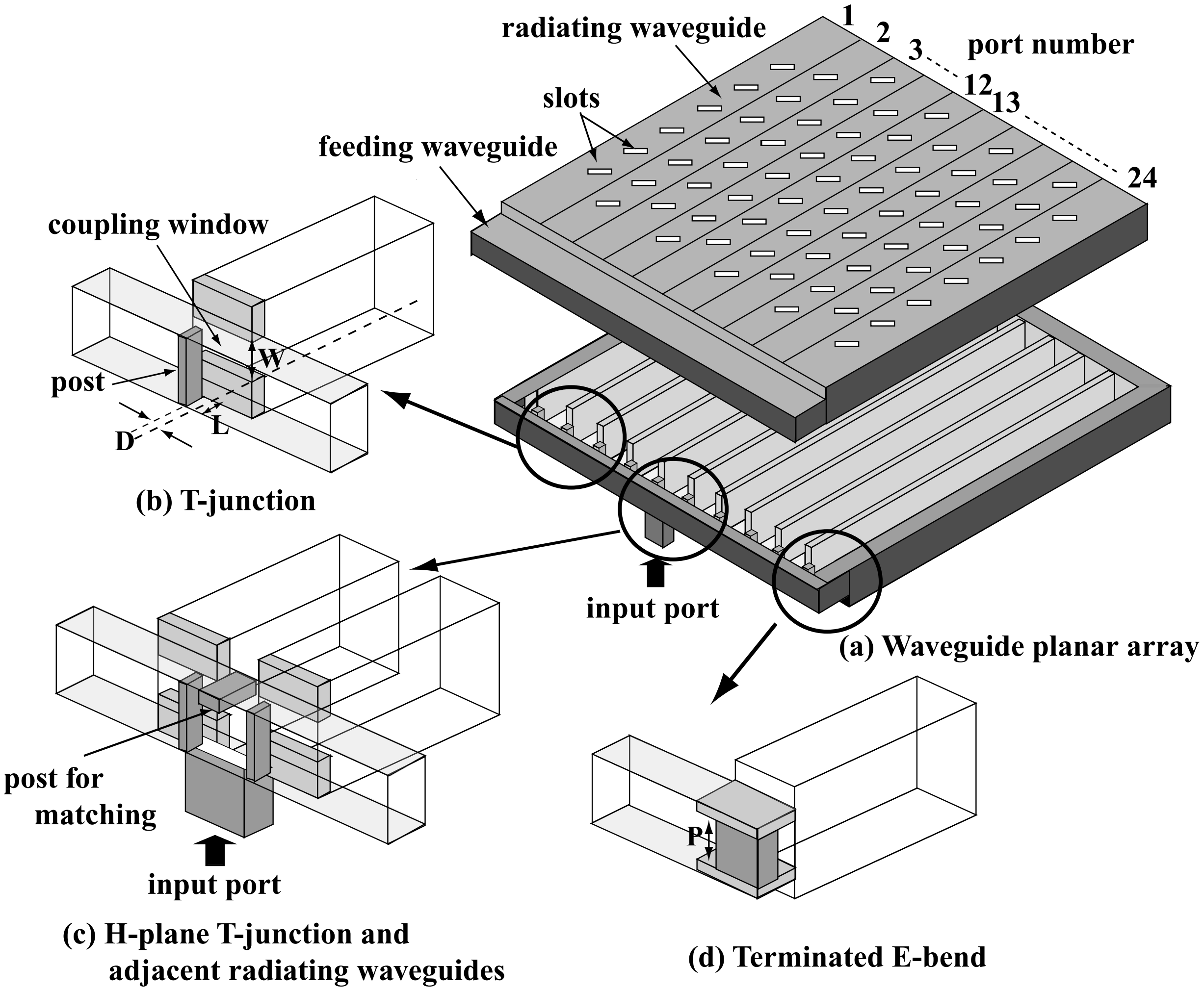

(a) Waveguide planar array

(b) T-junction

(c) H-plane T-junction and adjacent radiating waveguides

(d) Terminated E-bend

Fig.1 Configuration of the feeding circuit

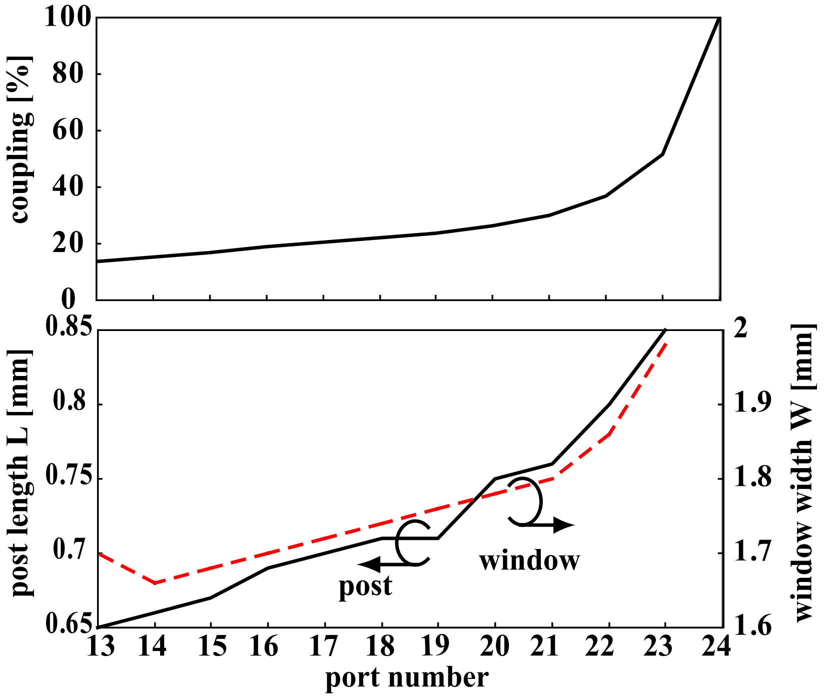

Fig.2 Design parameters of the 24-way power divider

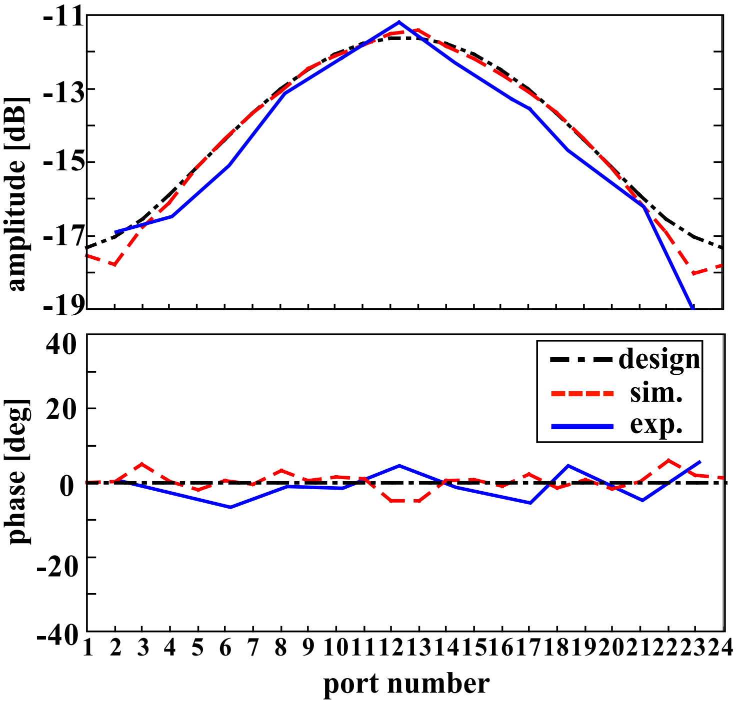

Fig. 3 Field amplitude and phase of output ports

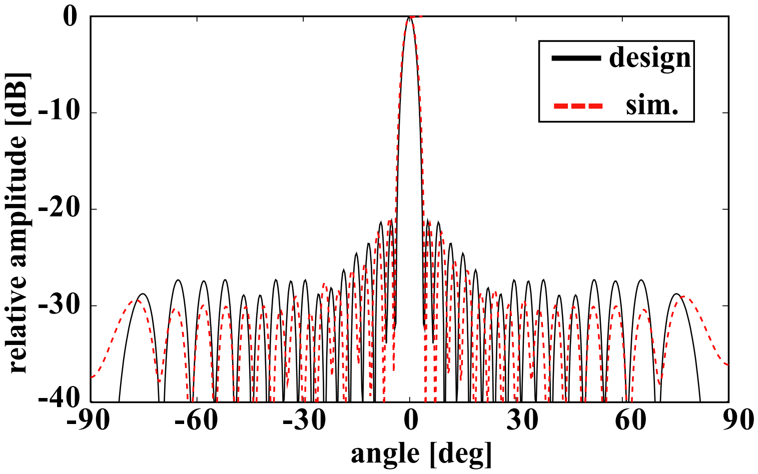

Fig. 4 Array factor

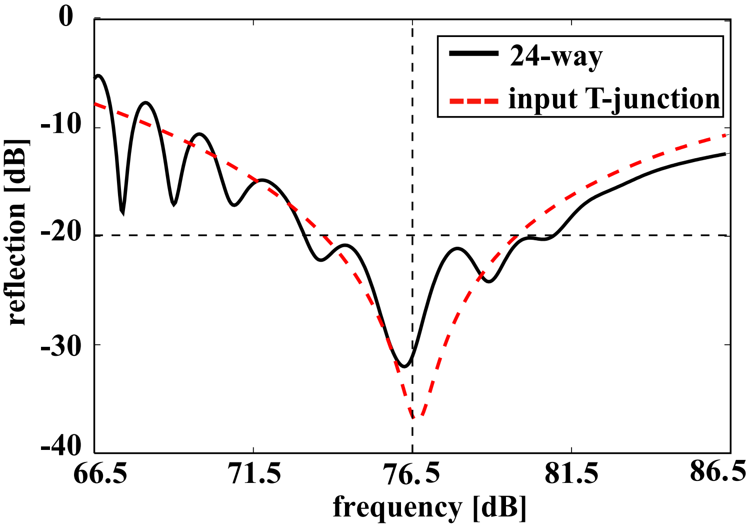

Fig. 5 Simulated frequency dependency of reflection