MILLIMETER-WAVE MICROSTRIP ARRAY ANTENNA FOR AUTOMOTIVE RADAR SYSTEMS

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1. INTRODUCTION

A microstrip array antenna is one of the promising antennas for automotive radar systems since it has several advantages such as low cost, low profile and ease of manufacture. However, there is a problem that aperture efficiency of a microstrip array antenna with a large aperture is degraded due to feeding line losses [1]. 45degree-inclined linear polarization is utilized in automotive radar systems to avoid mutual radio interference between the automotive radars [2], but there have been few studies on microstrip array antennas with 45degree-inclined linear polarization. We propose a microstrip array antenna with high aperture efficiency for automotive radar systems. The proposed antenna consists of a straight feeding microstrip line and rectangular radiating elements connected directly to the microstrip line at their corners to realize lower feeding line losses and 45degree-inclined linear polarization. The configuration and performance of the developed antenna in the 76 GHz band are described in this paper.

2. CONFIGURATION OF ANTENNA

The basic configuration of the proposed microstrip array antenna is shown in Fig. 1. A straight microstrip line and rectangular radiating elements are printed on one side of a dielectric substrate (t = 0.127mm, εr = 2.2) and a ground plane is printed on the other side of it. The rectangular radiating elements inclined 45 degrees from the straight microstrip line (*y*-axis) are arranged on both sides of the microstrip line and connected directly to the microstrip line at their corners. The element spacing in the y-direction is set as approximately a half guide wavelength so that all of the rectangular radiating elements are excited in phase. The radiating coefficient of each rectangular radiating element can be controlled widely by changing the width W of each rectangular radiating element. The length L of each rectangular radiating element is chosen to be the resonant length. The microstrip line is terminated by a matching element to suppress the reflection of the residual power and radiate it at the end of the microstrip line. The antenna is fed by a waveguide

(WR-12) through the transition [3] at the opposite end of the microstrip line. The transition has a feature of low loss and is made by the same manufacturing process as the antenna.

The photograph of the developed antenna which has 2×37 radiating elements including matching elements is shown in Fig. 2. The dimensions of the antenna are $1.78\lambda_0 \times 14.91\lambda_0$ (λ_0 : wavelength in free space).

3. EXPERIMENTAL RESULTS

Fig. 3 shows the measured reflection characteristic of the developed antenna at the input port. The reflection is –18.7 dB at the design frequency of 76.5 GHz, which is small enough to ignore the antenna gain reduction. The bandwidth of the reflection below –10 dB is 2.98 GHz and sufficient for automotive radar systems allowing for a margin of errors in manufacturing. Fig. 4 shows the measured gain subtracting the transition loss and the aperture efficiency of the developed antenna represented by a solid line and a dotted line, respectively. It can be seen that a high gain of 22.5 dBi with a high aperture efficiency of 53 % is obtained at the design frequency of 76.5 GHz. The gain and the aperture efficiency are higher than 22.4 dBi and 53 %, respectively from 75.5 GHz to 77.5 GHz. When the transition loss of 0.4dB is included, the gain and the aperture efficiency are corresponded to 22.1dBi and 49%, respectively at the design frequency of 76.5 GHz. Fig. 5 (a) shows the measured radiation pattern in yz-plane of the developed antenna at the design frequency of 76.5 GHz. The half-power beam width is 4.0 degrees. The main beam is tilted to 2.8 degrees in the y-direction to suppress the overall reflection at the input port. The sidelobe level is reduced to lower than –15.4 dB. Fig. 5 (b) shows the measured radiation pattern in zx-plane at the design frequency of 76.5 GHz. The radiation pattern is almost symmetrical. The half-power beam width is 26.3 degrees and the sidelobe level is –10.7 dB.

4. CONCLUSION

We have proposed the microstrip array antenna for the automotive radar systems. As a result of the experiments, a high gain of 22.5 dBi with a high aperture efficiency of 53 % was realized in the 76 GHz band. The array antenna developed here will be utilized as not only a fix beam antenna but also a beam scanning antenna for the automotive radar systems.

REFERENCES

[1] J. R. James, P. S. Hall and C. Wood, “Microstrip antenna theory and design”, *Peter peregrinus*, 1981.

[2] K. Fujimoto,“Current status and trend of millimeter-wave automotive radar”, *1995 Microwave workshops and exhibion digest*, Yokohama, Japan, Dec. 1995, pp.225-230.

[3] H. Iizuka, T. Watanabe, K. Sato and K. Nishikawa, “Microstrip line to waveguide transition in millimeter-wave band”, *IEICE Natl. conv. rec.*, B-1-136, Mar. 2000.

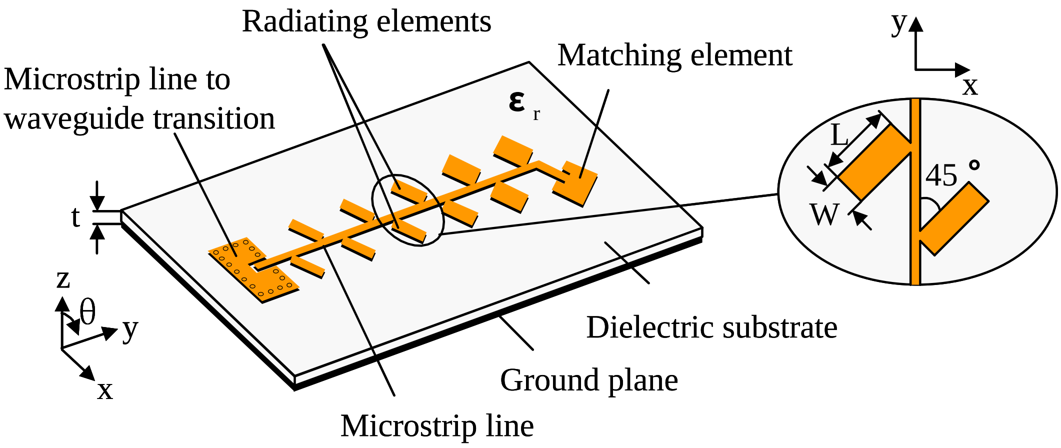


Fig.1 Basic configuration of microstrip array antenna

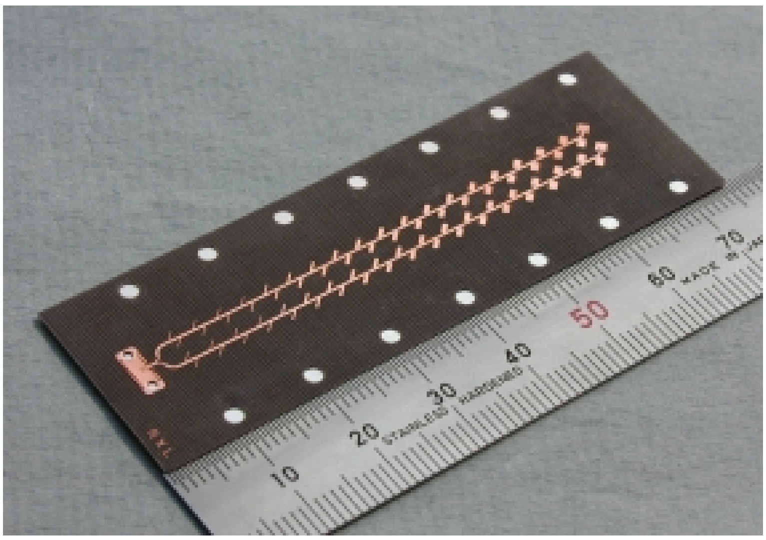


Fig.2 Photograph of developed antenna

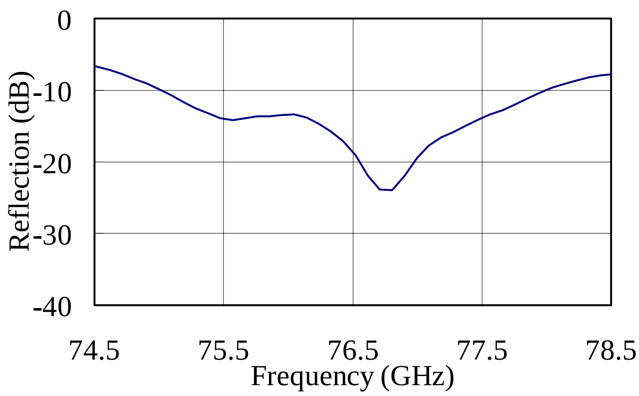
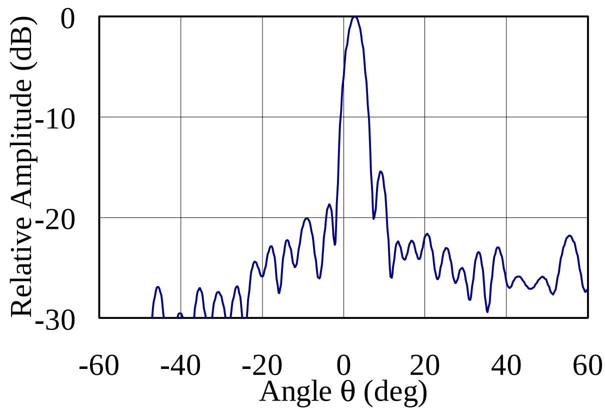


Fig.3 Measured reflection



(a) yz-plane

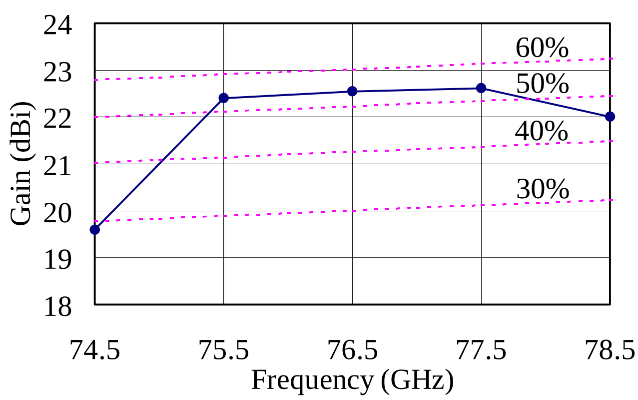
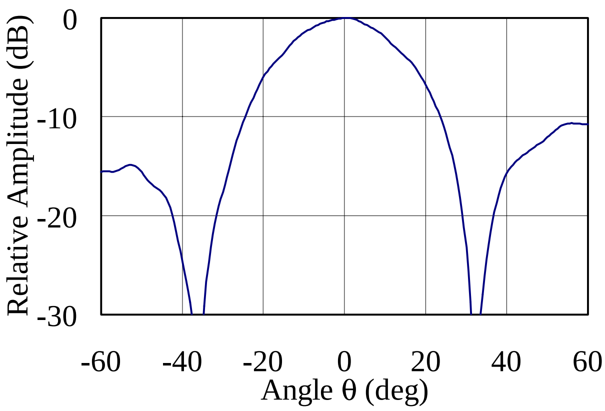


Fig.4 Measured gain subtracting transition loss and aperture efficiency



(b) zx-plane

Fig.5 Measured radiation patterns at 76.5GHz