# Design of the 77GHz Antenna for Automotive Radar Using Two Type Coupling Methods

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***Abstract*-An antenna for automotive radar is investigated using Taylor pattern synthesis. The proposed antenna consists of 4 gap coupled antenna for low coupling coefficient and 14 direct coupled antenna for high coupling coefficient in single column. The proposed antenna has 21.35dBi gain with low sidelobe level.**

## I. INTRODUCTION

Making driving safer and more convenient has been one of the key promises for every new car generation during the last three decades[1]. Automotive radar systems are used in adaptive cruise-control systems that detect objects hundreds of meters ahead of a vehicle[2]. The antennas for automotive radar are required high gain with low sidelobe level to reducing the undesired reflection. In spite of the loss caused by dielectric loss and conductor loss, the microstrip antennas are good candidates for automotive radar due to their low cost, low profile, simple integration with systems and easy implementation in array structures[3].

This paper presents straightforward design procedure to synthesize radiation patterns of series fed microstrip array antenna. The Taylor pattern synthesis is used to suppress sidelobe level.

## II. ANTENNA DESIGN

The Taylor pattern synthesis is one of widely used technique in array antenna for reducing sidelobe level[4]. It is more suitable for series fed antennas due to the array weights for the end element usually are not increased in comparison to those of the Chebyshev array pattern synthesis, although this technique is not optimum. The weight factor of each antenna element and the coupling coefficient for -20dB sidelobe level are shown in Figure 1.

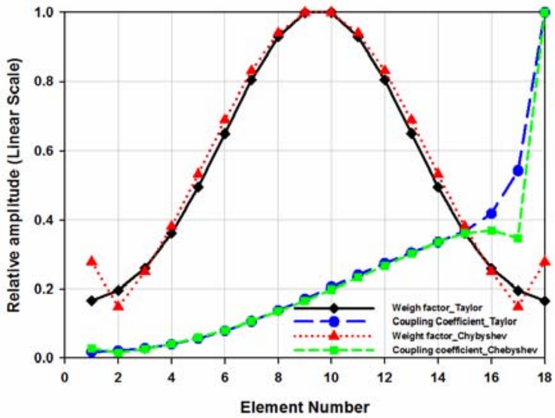


Figure 1. Desired weight factor and coupling coefficient for the Taylor and the Chevyshev array pattern synthesis

The proposed antenna is designed using the series fed to synthesize the radiation patterns in the elevation plane. The incident power has loss (dielectric loss and conductor loss), radiation and reflection. The remaining power is delivered to the next antenna. The radiated power and delivered power of each antenna with a feed line are calculated by an electromagnetic simulation CST to obtain the optimum parameters when the antennas are connected in an array. The Taylor pattern array synthesis requires a coupling coefficient that ranges from very low to very high as shown in Figure 1. The direct coupling method is widely used in microstrip array antennas, but it is not suitable for a low coupling coefficient due to the limits of the line width in the fabrication process. A gap coupling method is therefore proposed to provide a low coupling coefficient. The structures of the antenna using two types of coupling methods are shown in Figure.2. The width of feed line is 150um. The radiating elements are inclined 45 degrees from the feed line for the polarization characteristic[5].

Figure. 3 shows the coupling coefficient of a gap coupling method with a 150um coupling gap and a direct coupling method with varying coupling width. The gap coupling method with a 150um coupling gap has much smaller coupling coefficient than the direct coupling method with a 150um coupling width. The coupling coefficient is mainly varied by the coupling width. It is inversely proportional to the coupling width.

The one column of the proposed antenna is consists of 4 gap coupled antenna elements and 14 direct coupled antenna elements. The first 8 elements are arranged in left side of feed line and the last 8 elements are arranged in right side of feed

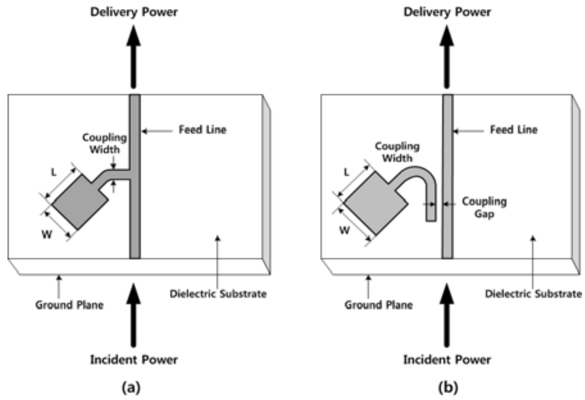


Figure 2. The two types of coupling method; (a) direct coupled; (b) gap coupled

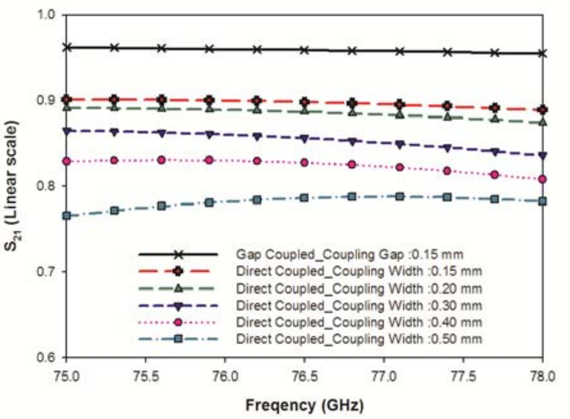


Figure 3. The transmission power of each antenna with varying coupling width

line. The parameters W, L and coupling width of each element are optimized to achieve the sidelobe suppression.

The feeding circuit is designed to synthesize the pattern in azimuth plane. The branch line power divider is not suitable for millimeter wave band due to the loss is increased depending on the length of feed line. So, the series line power divider is used in proposed antenna to reduce the total length of feed line.

## III. Measurement

The fabricated antenna is shown in Figure 4. It is fabricated on a substrate with a dielectric constant of 2.2 (loss tangent = 0.0009) and a thickness of 0.127 mm. The size of proposed antenna is 23mm x 58mm. The scattering parameter of $S_{11}$ is shown in Figure 5. The simulated and measured results are good agreement with each other. The simulated and measured radiation patterns are plotted in Figure 6, respectively. The measured gain of the proposed antenna is 21.35dBi with -19.9dB sidelobe level in the elevation plane and -24.36dB sidelobe level in the azimuth plane. The measured result of the radiation patterns is similar to those of the simulation results.

## IV. Conclusion

The antenna for automotive radar is designed in this paper. Taylor pattern synthesis is used for suppressing the sidelobe level. Two types of coupling technique are used to pattern synthesis. These antenna elements are modeled taken into

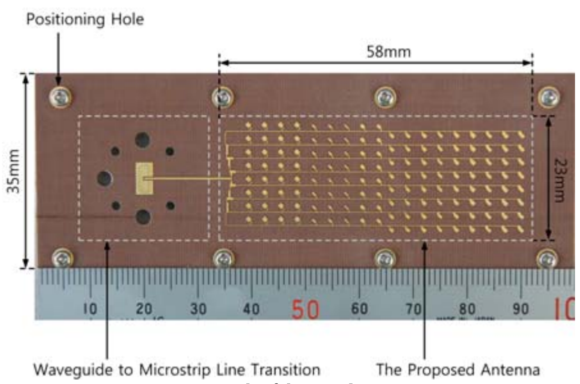


Figure 4. The fabricated antenna

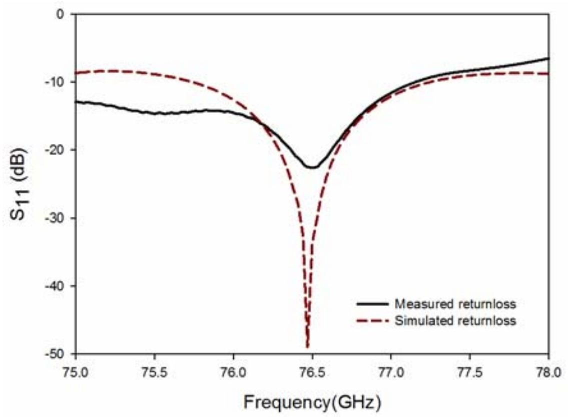


Figure 5. The scattering parameters of proposed antenna

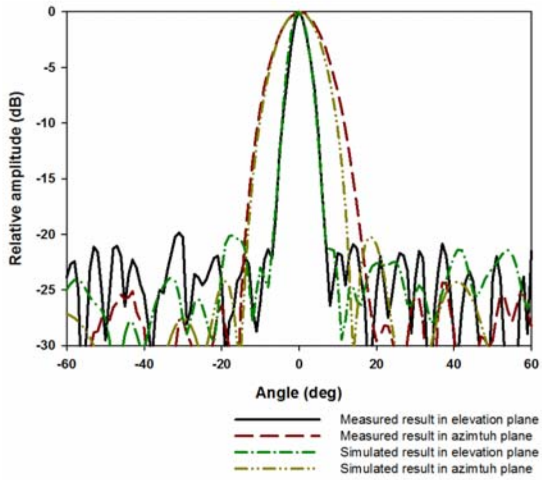


Figure 6. The radiation patterns of proposed antenna

optimized for the operating frequency as well as for a given coupling coefficient. As a result of the design, the antenna has a high gain of 21.35dBi with low sidelobe level. The array antenna designed here will be utilized as no only a fixed beam antenna but also beam forming antenna for automotive radar.

## Acknowledgment

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## References

[1] J. Harsch, et al., "Millimeter-Wave Technology for Automotive Radar Sensors in the 77GHz Frequency Band.", *IEEE Trans on Microwave Theroy an Technique*, vol. 60, NO3, March 2012.

[2] J. Wenger "Automotive radar – Status and perspectives," in *Proc. IEEE Compound Semiconductor Interg. Circuit Sym*., Oct. 2005, pp. 21-25

[3] Y. Hayashi, et al., "Millimeter wave Microstrip Comb-Line Antenna Using Reflection-Canceling Slit Structure." *IEEE Trans on Antennas and Propagation*, Vol. 59, No.2, Feb., 2011.

[4] T.T Taylor, "Design of line source antennas for narrow beamwidth and low side lobes", *IRE AP Trans.* vol4 pp 16-28 Jan 1955.

[5] Schneider, R.; Wenger, J, "System aspects for future automotive radar ", *IEEE MTT-S Int,Microwave Symposium 1999*, pp.293-296, June 1999