Dual-polarized Wideband Tapered Slot Antenna

#Takuto Izumi, Hiroyuki Arai
Graduate school of Engineering , Yokohama National University
79-5 Tokiwadai Hodogaya Yokohama, trigger.onrop@gmail.com

Abstract

A dual-polarized tapered slot antenna (TSA) is designed for covering 0.65-9 GHz. Simulated and measured results of optimized single TSA are shown, and two TSAs are crossed for dual-polarization antenna. To make isolation between two TSAs less than -25 dB and to obtain the same gain for each TSA, the configuration is optimized.

Keywords : Dual-polarization, , High gain, Taper slot antenna, UWB applications, Wide-band

1. Introduction

The strip line-fed tapered slot line antenna(TSA) has characteristics of wide-band, high gain, light weight, and relatively simple structure, then it is widely used for UWB applications, as see-through-wall imaging system, snow radar, and mobile telecommunications [1]. In other researches [2],[3], parameter study of TSA characteristics are found, and TSA is intended to be used as an array configuration with the power divider. However, the divider has a complex feeding network and the insertion loss especially in higher frequency, and the theoretical power split depends on the number of splits (the power split of N-way divider would be 10 log(N) dB). There is need for designing a dual-polarized TSA using simple feeding network and small number of the power dividers.

This paper proposes a dual-polarized tapered slot antenna using two TSAs for orthogonal polarizations without the power divider. This antenna operates at 0.65-9GHz. The feeding structure of two TSAs is optimized to have S_{21} less than -25 dB and have the same gain in each polarization. Measured results of optimized single TSA are shown and details of configuration for dual-polarization with two TSAs are also presented.

2. Configuration of Tapered Slot Antenna

The single TSA structure is shown in Fig. 1 and the fabricated one is in Fig. 2. The top view of this antenna (Fig. 1a) is the microstrip line terminated by radial stub which is used for feeding the slot line on the bottom layer. This strip line is defined to give the characteristic impedance of 50 Ω. The slot line at the bottom of TSA (Fig. 1b) is terminated by circular slot cavity, and it has the exponential curve for radiation. This curve is defined by opening rate R, $P_1(z_1, x_1)$ and $P_2(z_2, x_2)$ using the following exponential relation [2].

$$x = c_1 e^{Rz} + c_2 \tag{1}$$

where

$$c_1 = \frac{x_2 - x_1}{e^{Rz_2} - e^{Rz_1}}, \quad c_2 = \frac{x_1 e^{Rz_2} - x_2 e^{Rz_1}}{e^{Rz_2} - e^{Rz_1}}, \; R = 0.065. \tag{2}$$

TSA is a type of a traveling-wave antenna. On this antenna, the waves travel the curved path and radiate at the end of the flare. The strip line and slot line patterns are fabricated on FR-4 substrate with a relative permittivity of 2.6, thickness of 0.8 mm. Compared to the other TSA designs in other papers, this antenna is large. This is because this antenna operates at low frequency.

The simulated and measured results of single TSA are shown. The radiation patterns are in Figs. 3, 4, and Fig. 5 is VSWR results. Measured results are in good agreement with simulated one. In designing TSA, we use CST's simulation soft; CST MWS. The next section shows the dual-polarized configuration using two TSAs.

3. Dual-polarized Configuration

For using TSA as the dual-polarization, two TSAs are crossed at the center of the slot line. Fig. 7 shows this crossed configuration (type-1). This configuration is achieved by additional cuts on the substrate. TSA-A has the hole which the feeing strip line of TSA-B passes through (Fig. 8a). On the other hand, TSA-B has a large slot line to inject TSA-A (Fig. 8b). Two TSAs are crossed with this hole and slot line as shown in Fig. 7. In fabrication, feeing line of TSA-B is cut when we make the slot line, and reconnected through the hole on TSA-A after injection. However with this configuration, two feeding lines get closer and coupling between these two is strong. S_{21}, and S_{12} between TSA-A and TSA-B should be less than -25 dB in dual-polarization. To solve this problem, we place TSAs with an offset arrangement in the same direction of z-axis shown as Figs. 7 and 8. From Fig. 6 showing transmission coefficients S_{21}, it is apparent that if the offset is small, feeding line of TSA-A and TSA-B are coupled at low and high frequency. It is better to have the offset larger for isolation especially at these frequencies. The directions of feed lines have the effect to the each gain of the two TSAs. To use these two as dual-polarization, gains in both planes should be equal, so the difference of the gain in the direction of 0 degree between TSA-A and TSA-B is important. However type-1 in Fig. 9, the difference of the gain between two TSAs is large. It is up to 2.9 dB at 7 GHz. To obtain the same gains, we propose the type-2 shown in Fig. 10. The difference between type-1 and type-2 is the direction of TSA-A. TSA-A is rotated 180 degree compared to type-1. This configuration achieves a little difference of the gains shown in Fig. 9. Finally, the optimized results of VSWR and S_{21} are shown in Figs. 11 and 12. It covers 0.65-9GHz.

4. Conclusion

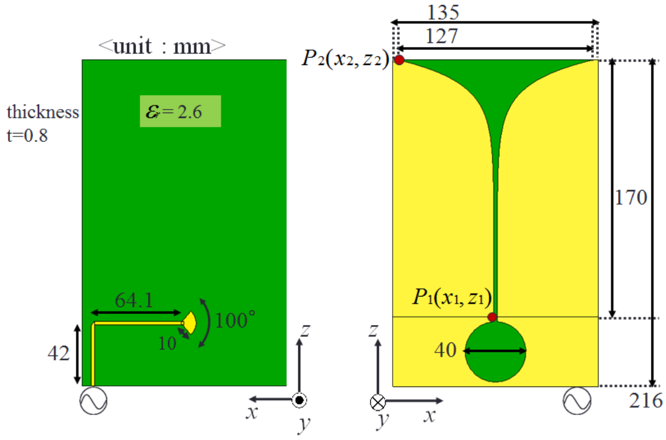
We developed wideband dual-polarized Tapered Slot Antenna operating at 0.65-9GHz. Single element of TSA is larger than the previously designed one in other researches, but developed antenna covers low frequency. It needs simple feeding network, and the number of divider can be small and insertion loss is a little. Geometry of single TSA was optimized, and measured results of VSWR and the radiation patterns were in good agreement with simulated one. Using this as the dual-polarization, we crossed two TSAs with hole and slot line, and made the offset arrangement between two for isolation. It has been found that larger offset had better results. To obtain the same gains of two TSAs, we optimized the configuration of positional relation and the direction of feeding strip lines.

References

[1] Y. Yang, Y. Wang, A. E. Fathy "Design of compact Vivaldi antenna arrays for UWB see through wall applications" Progress in Electromagnetics research, PIER 82, 401-418, 2008.

[2] Tan-Huat Chio, Schaubert D.H., "Parameter study and design of wide-band widescan dual-polarized tapered slot antenna arrays", IEEE trans. on antenna and propagation, vol.48 issue:6, pp. 879-886, 2000.

[3] J. H. Shafieha, J. Noorinia, Ch. Ghobadi, "Probing the feed line parameters in Vivaldi notch antennas", Progress in Electromagnetics research B, Vol. 1, 237-252, 2008.



(a) top view (b) bottom view

Fig. 1: Simulated geometry of TSA.

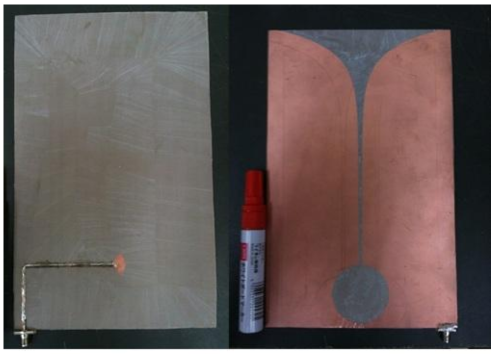


Fig. 2: Top, bottom view of fabricated TSA.

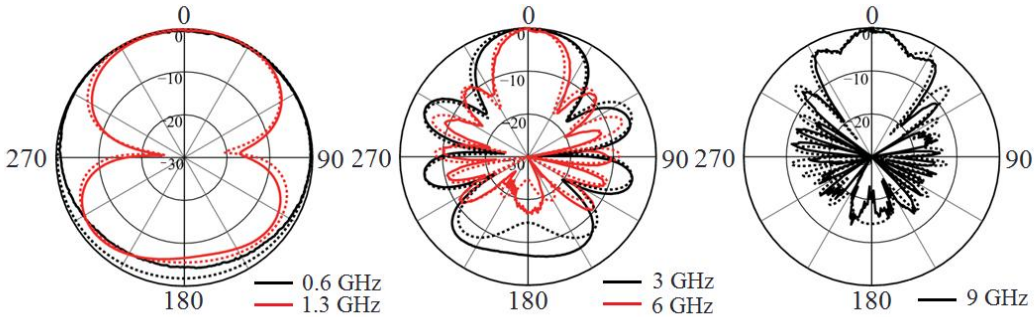


Fig. 3: Radiation pattern of single TSA in yz-plane (measured: solid, cal.: dot).

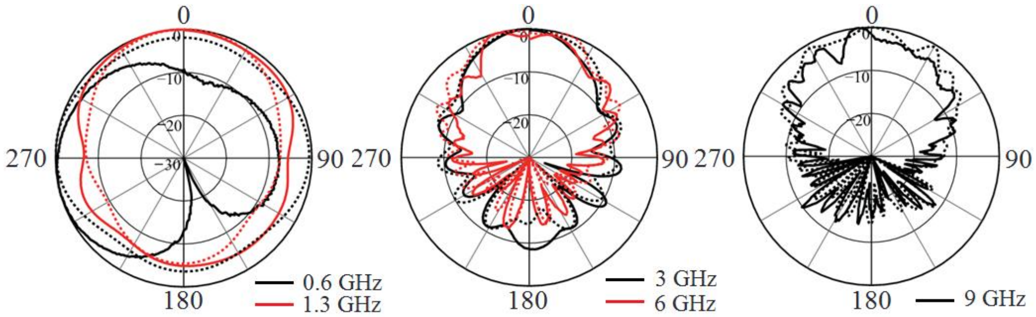


Fig. 4: Radiation pattern of single TSA in zx-plane (measured: solid, cal.: dot).

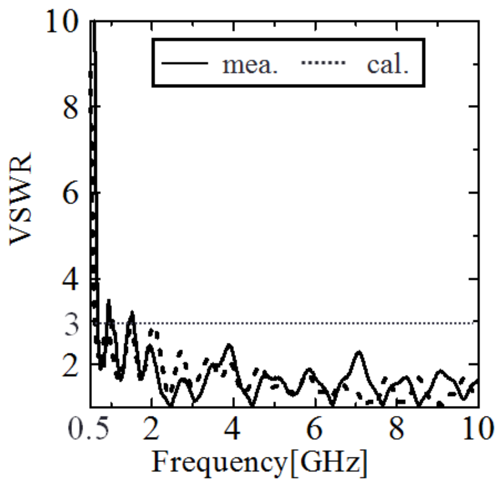


Fig. 5: Simulated and measured VSWR of single TSA.

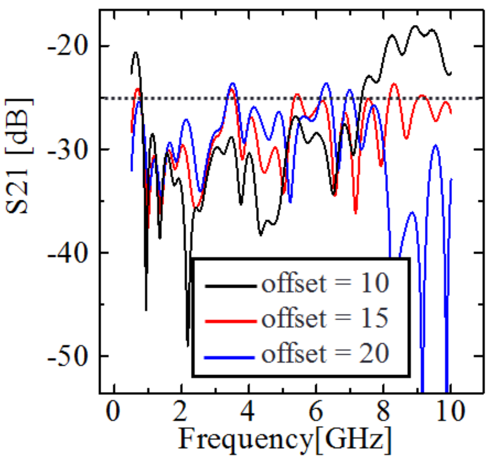


Fig. 6: Difference of S_{21} results with the offset in dual-polarization.

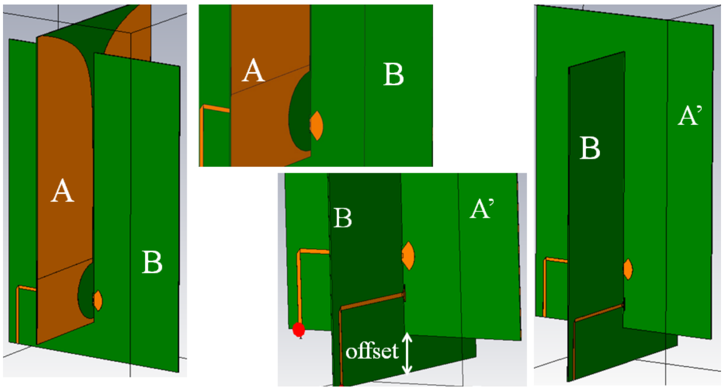
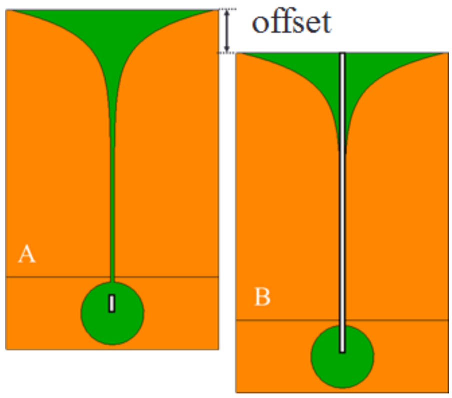


Fig. 7: Crossed configuration with two TSA, picked up the crossed point (type-1).



(a)TSA-A (b) TSA-B

Fig. 8: Hole and slot line for crossing two TSAs.

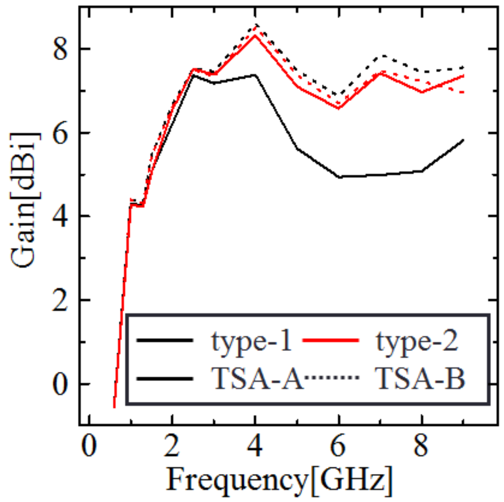
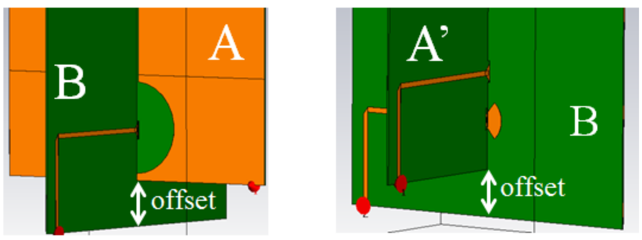


Fig. 9: Difference of the Gain in two types of TSA.



(a) Bottom of TSA-A (b) Top of TSA-A

Fig. 10: Optimized configuration of feeding strip lines(type-2).

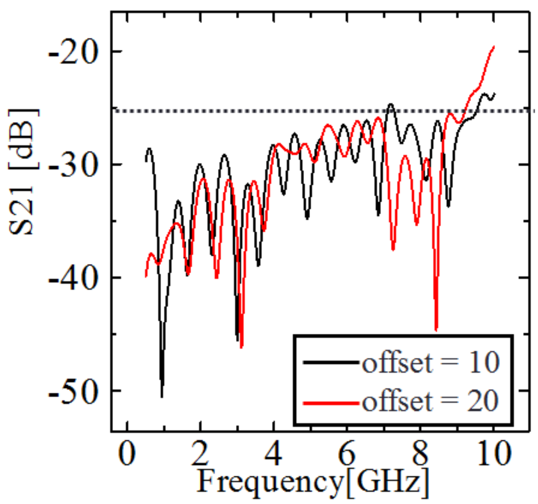


Fig. 11: Simulated result of S_{21} of crossed configuration.

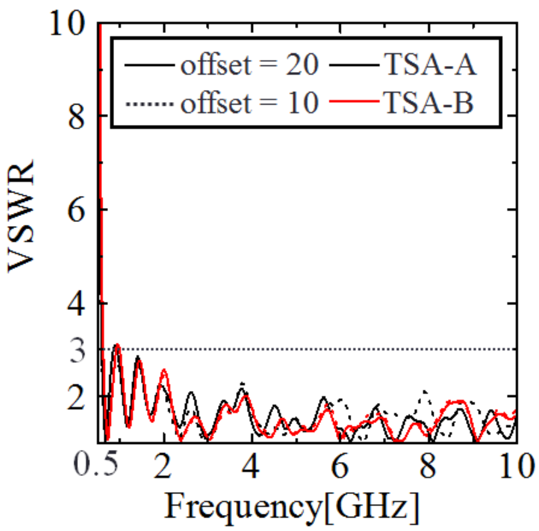


Fig.12: Simulated VSWR of crossed configuration.