Improved Design of Tapering and Through Element Series Antenna

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Abstract— **In this paper, an array of series fed antenna based on tapering patch width and through element is presented. The antenna has wide impedance bandwidth of 16.18% covering from 5.34 GHz to 6.28 GHz with a gain of 6.53 dBi. The use of through element technique reduces the overall length of array structure by 25.47%. It also has lower side lobe level, and wider impedance bandwidth compared to the past research.**

Keywords-Tapering, Side Lobe Level, Series Fed, Impedance Bandwidth

I. Introduction

Most of the studies of input feeding in array antenna are primarily based on either series or parallel feeding network. Parallel feeding is also referred as corporate feeding. Series feeding network has several advantages over the latter. Series feeding network is simpler structure, more compact networks and lower feed line losses compare to the corporate feeding network [1]. In this paper, the comparison study is made for three different methods of designing array antenna that use series feeding network namely variable patch width, variable patch width with feeding at the tap point of patch and centre feed network. The series feed network also possess minimum line length feeding network and more compact compared to parallel feeding network [2]. Also, it has been shown that side lobe suppression is improved by using series feeding network [3-4].

The array structure used in this paper is feed via 'through element' feeding technique as shown in [2] but with less complexity due to constant tapering of line feeding network. The implementation of through element technique reduces the overall length of array structure by 25.47%, taken that $\frac{\lambda_{\mathrm{eff}}}{2} = 13.05\ \mathrm{mm}$. Conventional array structure of series fed array antenna without the use of through element technique would required total length of $\frac{5\lambda_{eff}}{2}$. The side-lobe level of the proposed array antenna is 19.5dB which is much less than [4-5] and wider impedance bandwidth [4]. It is suitable to be used for wireless application such as WiMAX and WLAN.

II. Antenna Design

The design is simulated using transient solver in CST Microwave Studio 2010 software. The substrate used is inexpensive FR-4 substrate with thickness of h= 1.6mm, copper thickness 0.035mm, dielectric permittivity of 4.5, and loss tangent of 0.0195. Equation (1) to (6) in [6] is used in designing the initial dimension of patches and the feeding network. A portion of the feeding network is inserted at either the bottom or the upper patch element resulting in reduction of overall length of array structure. Fig. 1 shows the geometry of the 3 element series fed antenna array. The first element from the input feeding has a width and length of W_{b0} and L_{b0} respectively. While the second and third element has the width of W_{b1} and W_{b2} and length of L_{b1} and L_{b2} respectively. The dimension of the array structure is shown in Table I.

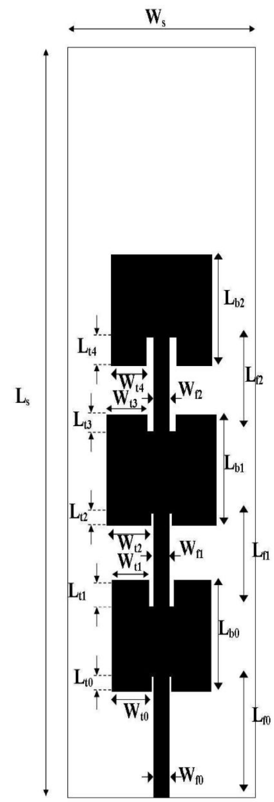

Fig. 1. Geometry of Tapering and Through Element Series Antenna

TABLE I. ANTENNA DIMENSION

Parameter	Length (mm)	Parameter	Length (mm)
L_{b0}	11.85	W_{b0}	18.07
L_{b1}	11.83	W_{b1}	20.00

L_{b2}	11.83	W_{b2}	18.38
L_{f0}	12.93	W_{f0}	2.92
L_{f1}	10.00	W_{f1}	2.92
L_{f2}	10.00	W_{f2}	2.92
L_s	80.00	W_{t0}	7.36
L_{t0}	1.59	W_{t1}	6.75
L_{t1}	2.81	W_{t2}	8.13
L_{t2}	1.36	W_{t3}	7.36
L_{t3}	1.81	W_{t4}	6.16
L_{t4}	3.03		

III. RESULT AND DISCUSSION

Parametric studies were conducted on W_{t0}, W_{t1}, W_{t2}, W_{t3} and W_{t4} as shown in fig. 2, 3, 4, 5 and 6 respectively with other parameter set to be constant. Increase in W_{t0}, W_{t1}, W_{t2}, W_{t3} and W_{t4} would result in the decrease of width of inset feed and vice versa. From fig. 2 to fig. 6, it is observed that the increase of W_{t0}, W_{t1}, W_{t2}, W_{t3} and W_{t4} generally shifted the return loss curve to the left and vice versa. It is also alternatively implied that the decrease in width of inset feed result in the return loss curve to be shifted to the left.

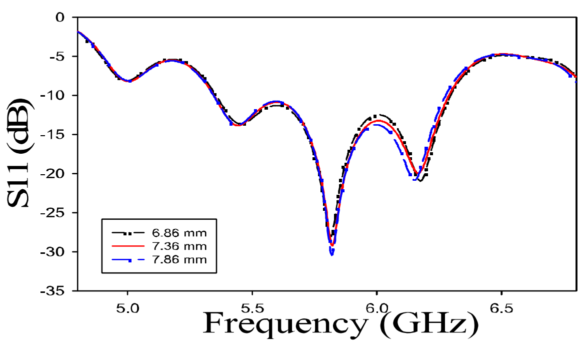

Fig. 2. Variation of return loss with respect of W_{t0} of the proposed antenna

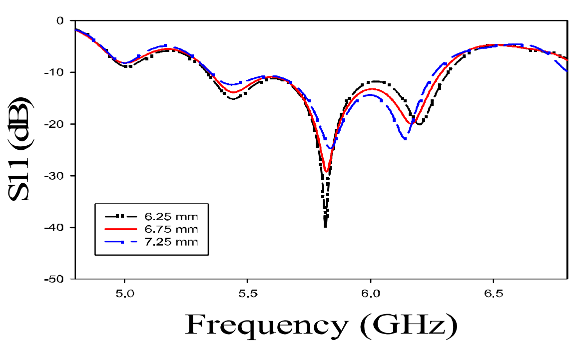

Fig. 3. Variation of return loss with respect of W_{t1} of the proposed antenna

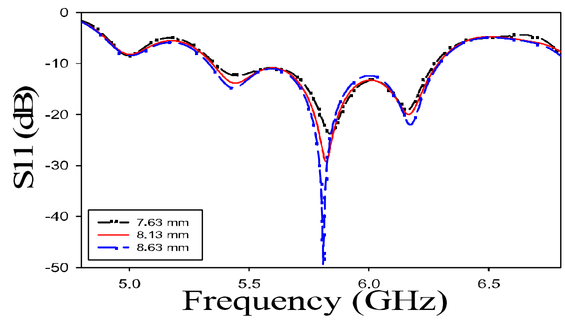

Fig. 4. Variation of return loss with respect of W_{t2}

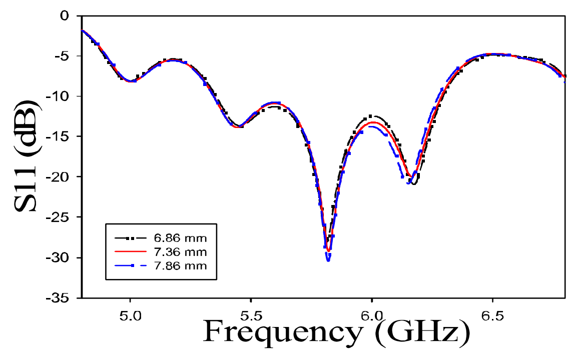

Fig. 5 Variation of return loss with respect of W_{t3} of the proposed antenna

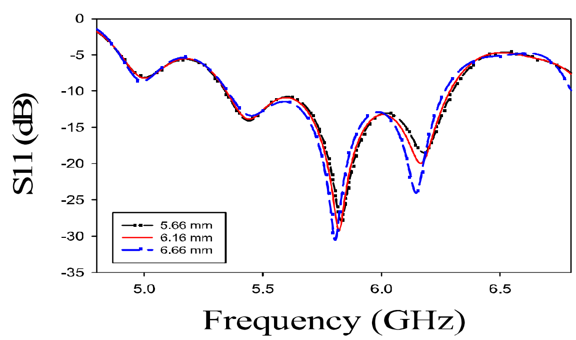

Fig. 6 Variation of return loss with respect of W_{t4} of the proposed antenna

Parametric studies were conducted on W_{b0}, W_{b1}, W_{b2}, as shown in fig. 7, 8 and 9 respectively with other parameter set to be constant. From fig. 7 to fig. 9, it is observed that the increase of W_{b0}, W_{b1} and W_{b2} generally shifted the return loss curve to the left and vice versa. Based fig. 8 and fig 9, it is also observed that resonance at higher frequency become more significant.

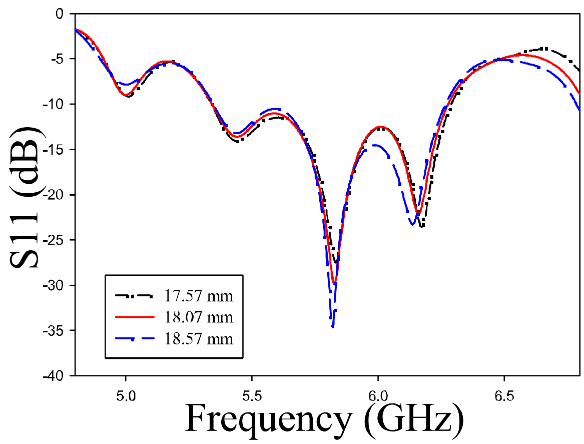

Fig. 7. Variation of return loss with respect of W_{b0} of the proposed antenna

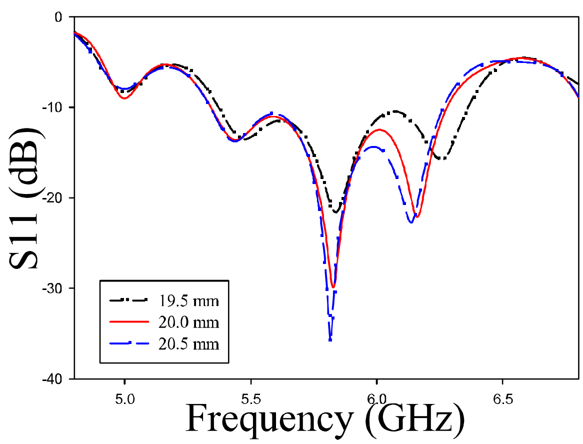

Fig. 8. Variation of return loss with respect of W_{b1} of the proposed antenna

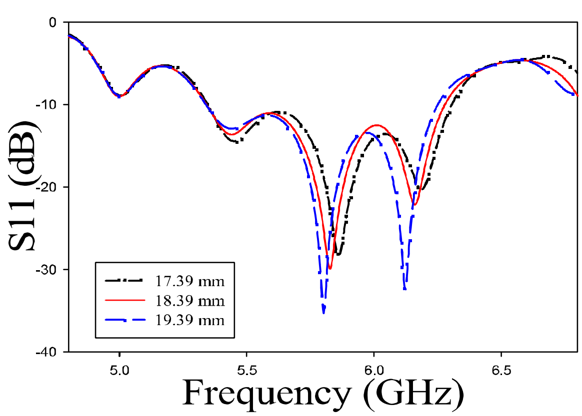

Fig. 9. Variation of return loss with respect of W_{b2} of the proposed antenna

Fig. 10 shows the return loss of simulation and measurement result. It is observed that the measured result is shifted to the right from the simulated result. This is due to imperfection in fabrication. However, the measured result satisfactorily agreed with simulated result. The impedance bandwidth of simulated result is 16.18%. Fig. 11 shows the radiation pattern of both simulated and measured results. The monopole radiation pattern of simulated result is in good agreement with measured result. The simulated result shows a side lobe level of 19.5 dB which much less than [4-5]. The uses of through element feeding technique at both lower and upper part of patch have successfully reduced the overall array structure by 25.47%. Conventional series feeding network required each of the feeding network and patches to have length of $\frac{\lambda_{eff}}{2}$. All feeding network has constant width while tapering is done on the patch width. Fig. 12 shows the fabricated antenna.

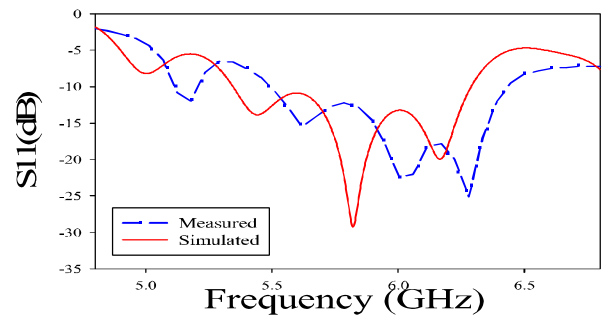

Fig. 10. Simulated and measured return Loss of the proposed antenna

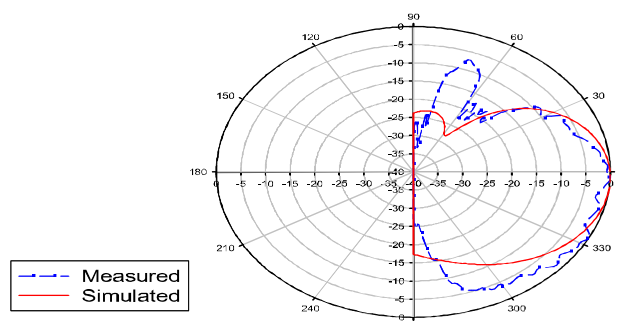

Fig. 11. Simulated and measured radiation pattern of the proposed antenna

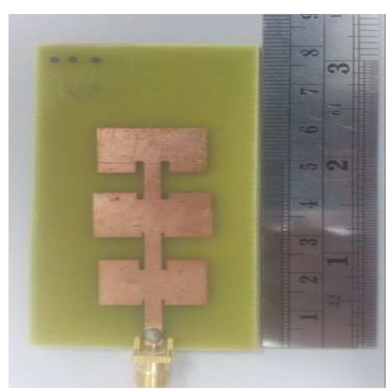

Fig. 12. Fabricated Antenna

IV. Conclusion

In this paper, improved design of tapering and through element series antenna have been designed. The array antenna has gain of 6.53 dBi, impedance bandwidth of 16.18%, and lower side-lobe level of 19.5 dB.

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