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Antenna Array Designed using Wilkinson Power Divider

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Abstract: These day microstrip patch antenna is preferred in many applications due to its compact, conformal and ease of designing structure. However the achieved gain of single microstrip patch antenna is very low which makes it insignificant for various applications. In this work a microstrip patch antenna array is designed to achieve a significant again for various applications. Gain is improved by using feeding microstrip patch antenna array in corporate fashion. Wilkinson power divider is used to feed patch antenna array in corporate fashion. Designed Wilkinson power divider divides power equally between output ports and provide an isolation of 12.1 dB between output ports. Achieved gain of single patch antenna is 6.9 dB which had improved by 15 dB by using corporate fed patch antenna array using Wilkinson power divider.

Index Terms: Microstrip Patch antenna, Wilkinson power divider, Microstrip Patch antenna array.

I. INTRODUCTION

A rectangular microstrip patch antenna design consist of a radiating patch of rectangular conducting material on one side of substrate. A slab of conducting material on other side of dielectric acts as ground. A microstrip line is used to feed the patch element as shown in Fig (1).

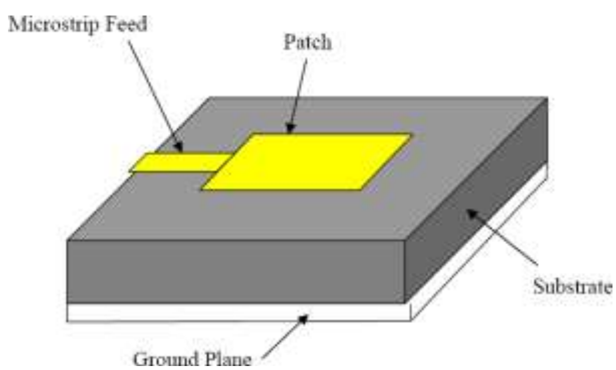

Fig (1). Microstrip patch antenna

Parameters like the resonant frequency, input impedance of the antenna is dependent on the dimensions of patch, Dimensions of dielectric material and dielectric constant of the dielectric [1- 6]. The required width of patch W for operative frequency f and dielectric having dielectric constant ϵ is given by

$$w = \frac{C}{2f\sqrt{\frac{\varepsilon(r)+1}{2}}} \quad \text{-------------(1)}$$

Here C is light velocity.

Due to interaction with air the effective dielectric constant of dielectrics is given as

$$\varepsilon(eff) = \frac{\varepsilon(r)+1}{2} + \frac{\varepsilon(r)-1}{2}\sqrt{1+12\,\frac{h}{w}} \quad \text{------------(2)}$$

where is the width of the substrate and h indicates the height of the substrate. The length of the patch antenna required is

$$L = \frac{c}{2f\sqrt{\varepsilon\,(\text{eff})}} - 2\Delta\text{l} \quad \text{------------- (3)}$$

Here Δl is the change in length of patch antenna due to fringing field. The expression of Δl is given by

$$\frac{\Delta \text{l}}{h} = .412\,\frac{[\varepsilon\,(\text{eff}) + .3]\left[\frac{w}{h} + .264\right]}{[\varepsilon\,(\text{eff}) - .258]\left[\frac{w}{h} + .8\right]} \quad \text{-----------(4)}$$

As single microstrip patch antenna is insignificant to provide the required gain so we need to use array of antenna to improve the gain of radiating or receiving system. Microstrip patch antenna arrays can be designed either by connecting patch antenna elements in series or in parallel. In series fed patch antenna array elements are fed from the preceding elements as shown in Fig(2). In corporate fed antenna array system as shown in Fig(3) each element is directly feed from the feeding source. Due to direct feeding the mutual coupling between the elements is reduced. Further by using suitable circuitry the patch antenna elements can be matched with the source impedance. So as to transfer maximum power from source to patch element.

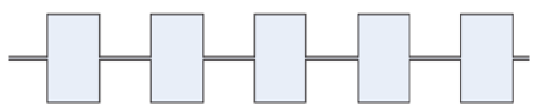

Fig (2) Series fed patch array

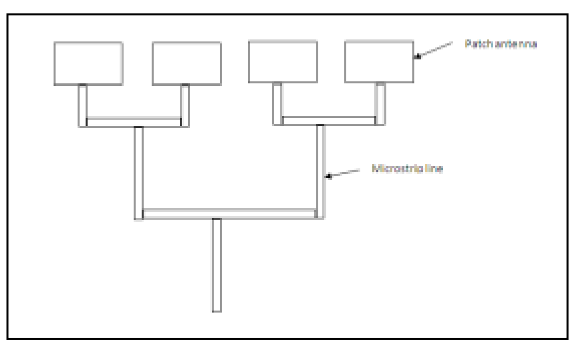

Fig (3) Corporate fed patch array

In this work Wilkinson power divider is used to feed patch elements. Wilkinson power divider is a three port device with one input and two output ports [7]. A good power divider circuit requires that input power supplied at input port should be distributed equally between output ports and the two outputs ports should be isolated from one another. The requirement of good power divider are observed by Wilkinson power divider. Circuit diagram of Wilkinson power divider is as shown in Fig(4). All sections of

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Wilkinson power divider are designed using microstrip lines. Section A having characteristics impedance of 50 Ω having length of
.25λ. Section B & section C having characteristics impedance of 70.7 Ω having length of .25λ. Section D is having Resistance of 100 Ω and Section B & section C having characteristics impedance of 70.7 Ω having length of .25λ.

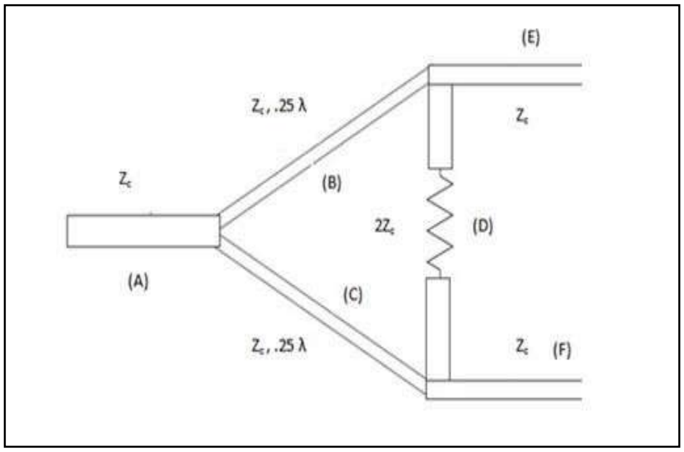

Fig (4) Wilkinson Power Divider

Wilkinson power divider is fed at section A, Section E and section F of Wilkinson power divider are used to feed the patch antenna. Wilkinson power dividers can be cascaded to obtain patch antenna array of any elements. Obtained structure of patch antenna array using Wilkinson power divider is shown in Fig (5)

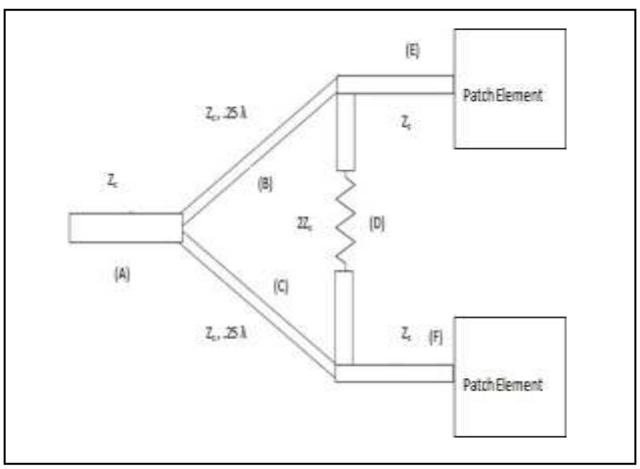

Fig (5) Patch antenna array using Wilkinson Power Divider

II. Results and Discussion

By using above mentioned equations the dimensions of patch antenna for 2.4 GHz operative frequency and for substrate with dielectric constant
2.2 , substrate height .787 mm are given as

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Length of patch element = 41.7 mm Width of patch element = 47.93 mm

The structure of Microstrip patch antenna obtained using HFSS is represented in Fig (6).

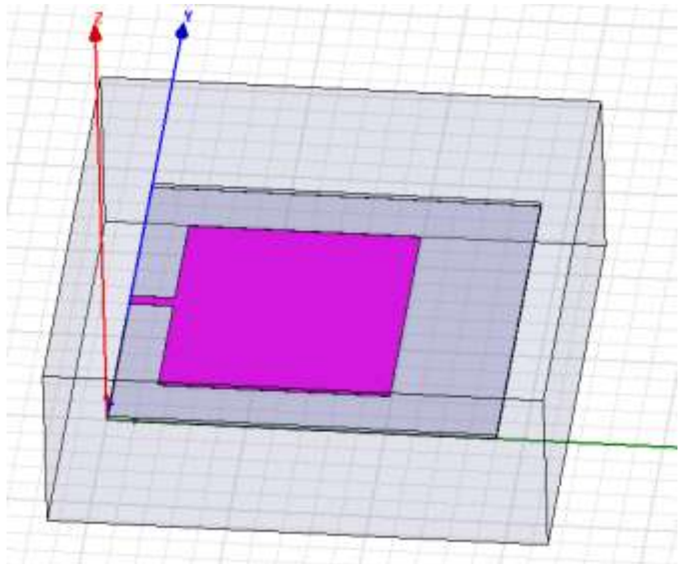
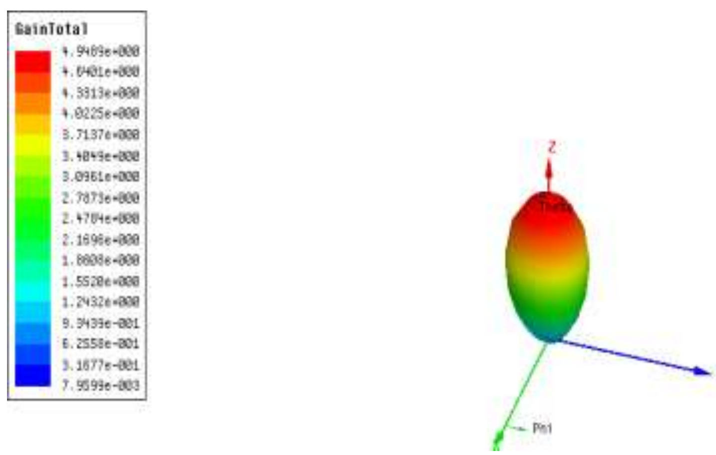


Fig (6) Microstrip patch antenna using HFSS

The polar radiation pattern of gain for this structure is as shown in fig (7)

Fig (7) Polar radiation pattern



The radiation pattern for this antenna is plotted in fig(8)

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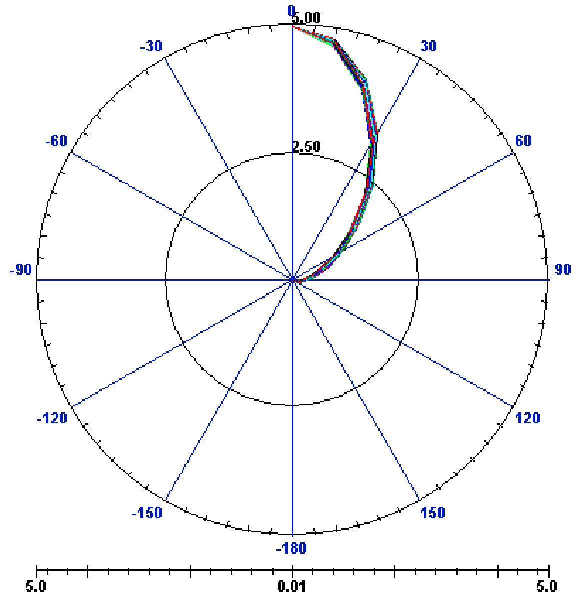

Fig (8) Radiation pattern of patch antenna

The maximum directive gain for this structure comes out to be 6.9 dB. The structure of Wilkinson power divider obtained using HFSS is as shown in Fig(9).

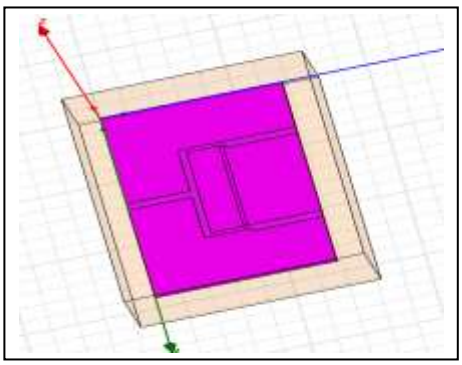
Fig (9) Wilkinson power divider using HFSS

The scattering parameters of patch antenna are plotted in Fig (10).

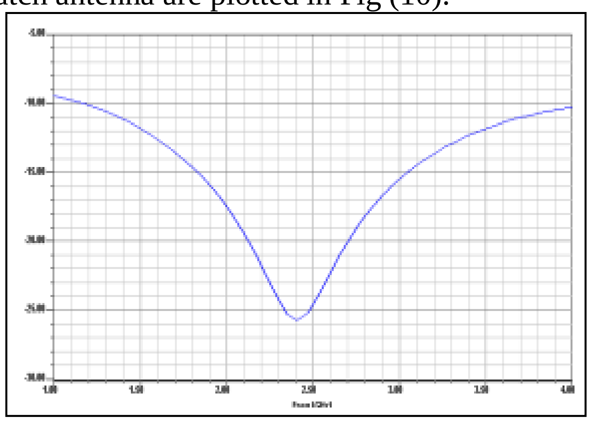
Fig (10) Scattering parameters of WPD

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Transmission parameters of WPD between output and input obtained using HFSS are plotted in Fig.(11)

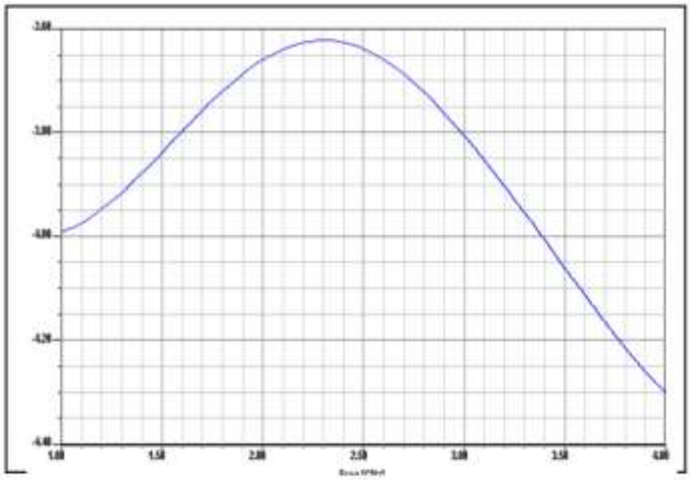

Fig (11) Scattering parameters of WPD

Transmission parameters indicate that input power is equally divided between output ports. The structure of patch antenna array obtained using HFSS is shown in Fig.(12). Polar plots of radiation pattern of designed antenna array are shown in Fig.(13).

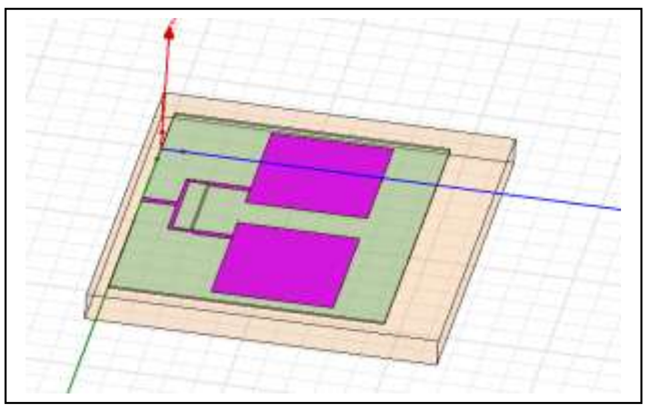

Fig (12) Patch antenna array using WPD

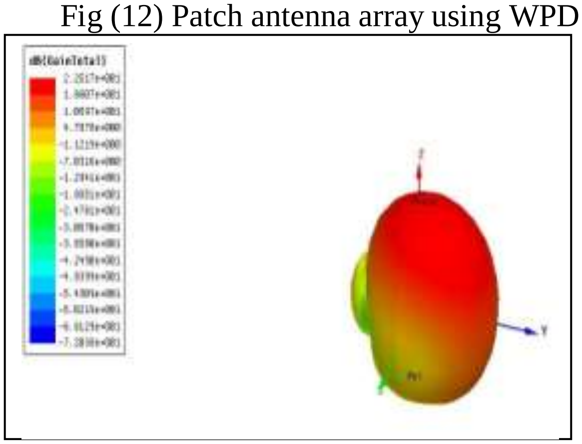

Fig (13) Polar plots of gain of Patch antenna array using HFSS

The maximum gain of this antenna array comes out to be 22.5 dB.

III. CONCLUSION

A two element microstrip patch antenna array is designed using Wilkinson power divider. The gain of array had been improved by a factor of 15 dB as compared to gain of single patch antenna.

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