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# Microstrip Patch Array Antenna Pattern Design With Active Element

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## Abstract

**This paper proposed design of microstrip phased patch array antenna . The proposed design array is combination of linear and colinear feed with active element . The Active element pattern technique is applied for analyzing microstrip array, which reduces analysis problem and computation . The mutual coupling effect is added in the results of the proposed design . The FR-4 substrate with Dielectric constant 4.3 and loss tangent 0.019 is used for proposed design at resonant frequency of 3 GHz. Radiation characteristics, gain and return loss of the planar array antenna is simulated using Zeland IE3D simulation software . Operating frequency of these antennas are 3 GHz, 3.5 GHz and 5.4 GHz , so these design is suitable for S-band and C-band application.**

**Kyewords :-** Microstrip patch , array antenna , Mutual Coupling, IE3D .

## I . INTRODUCTION

The Microstrip patch array antenna are perfect choice for S-band and L-band various application due to following features, low profile, small size and conformability. But microstrip antennas suffer from bandwidth limitations. The bandwidth can be increased by adding lossy elements but it affects efficiency of the antenna. So the better method is to use array antenna. This design of microstrip array antenna is for Wimax and WLAN applications. The microstrip patch antenna is design at resonant frequency of 3GHz ,This designed added mutual coupling into account of simulated results . With this active array pattern the simulation time will be reduced and calculation will be easier . The spacing difference between two element is $\lambda/4$ for introducing mutual coupling between the elements .The common probe feeding is given to the centered active patch in my design based on slot coupling . Ring shaped slot is on the radiating patch and two rectangular slots on groung plane . Due to many advantages such as low profile , light weight , low cost ,ease of fabrication microstrip are widely applied in communication system . The simulated results of the proposed design achives a triple band 2.9 GHz to 3.2 GHz , 3.3 GHz to 3.6 GHz and 5 GHz – 5.6 Ghz (return loss less than -10dB). At this frequency band it is also useful in WiMAX[1] aplications and third band provide applications for wilreless local area network ( WLAN )[1] services such as IEEE 802.11a in the USA (5.15 to 5.35 GHZ,5.7 to 5.825GHz ) and HIPERLAN/2 in Europe (5.15 to 5.35 GHZ , 5.47 to 5.725GHz) .

## II.DESIGN METHODOLOGY AND PARAMETERS

Theoretical analysis and calculation of a single microstrip patch is calculated with following equations [2] :

The first step is to find the width , W of the patch at the resonant frequency using Equation 1 ;

$$W=\frac{c}{2f_o}\sqrt{\frac{2}{\varepsilon_r+1}} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (1)$$

Where $\varepsilon_r$ is the relative permittivity of the substrate, c is the speed of the light in free space and $f_o$ is the resonant frequency .

Length of the patch is calculated by Equation 2;

$$L=\frac{c}{2f_o\sqrt{\varepsilon_{eff}}} \quad \ldots\ldots\ldots\ldots\ldots\ldots(2)$$

Where , $\varepsilon_{eff}$ is the effective dielectric constant of the substrate . To measure for the fringing effects , the actual length of the patch also includes the correction factor due to fringing effect . Actual length is given by Equation 3 ;

$$L=\frac{c}{2f_r\sqrt{\varepsilon_{eff}}}-2\Delta L \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots(3)$$

Correction factor can be found using the equation 4;

$$\Delta L=0.412h\frac{(\varepsilon_{eff}+0.3)(\frac{W}{h}+0.264)}{(\varepsilon_{eff}-0.258)(\frac{W}{h}+0.8)} \quad \ldots\ldots\ldots(4)$$

Where , h is the height of the substrate .

$\varepsilon_{eff,}$ effective dielectric constant used in equation 4 is given by Equation 5.

$$\varepsilon_{eff}=\frac{\varepsilon_r+1}{2}+\frac{\varepsilon_r-1}{2}\left(1+12\frac{h}{w}\right)^{-1/2} \quad \ldots\ldots\ldots\ldots(5)$$

Ground patch of the geometry is design with the following equation 6 ;

Length of ground patch, $L_g = 6h+L$ ………. (6.a)
Width of ground patch, $W_g = 6h+w$ ……… (6.b)

The dimensions for designing a single microstrip patch are tabled below :

**Table 1. Antenna Design parameters**

| Antenna parameters | Dimensions |
|---|---|
| Resonant frequency $f_o$ | 3GHz |
| Dielectric constant $\varepsilon_r$ | 4.3 |
| Height of Substrate (h) | 1.5mm |
| Width (W) | 30.72mm |
| Length (L) | 23.74mm |
| Effective dielectric substrate $\varepsilon_{eff}$ | 3.96 |
| Widht of ground patch $W_g$ | 32.74mm |
| Length of ground patch $L_g$ | 39.72mm |

The antenna array geometry is designed with spacing between center element and rest four elements is λ /4 . The proposed geometry is with single patch and with four patches shown in fig. 1

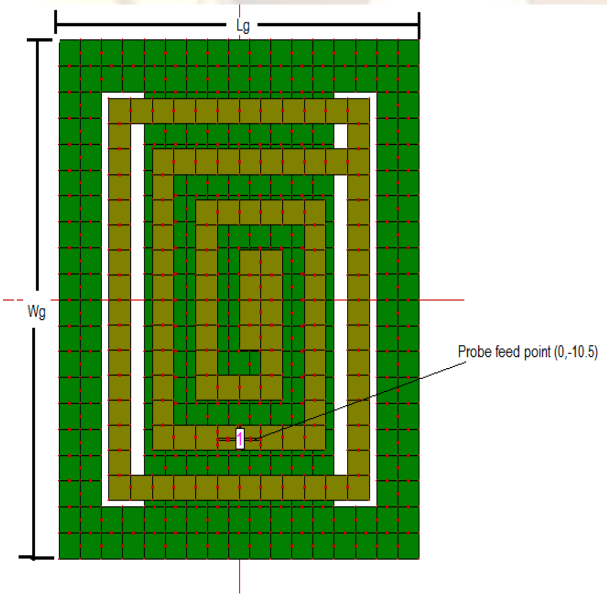


**Fig.1. Geometry of proposed single patch array**

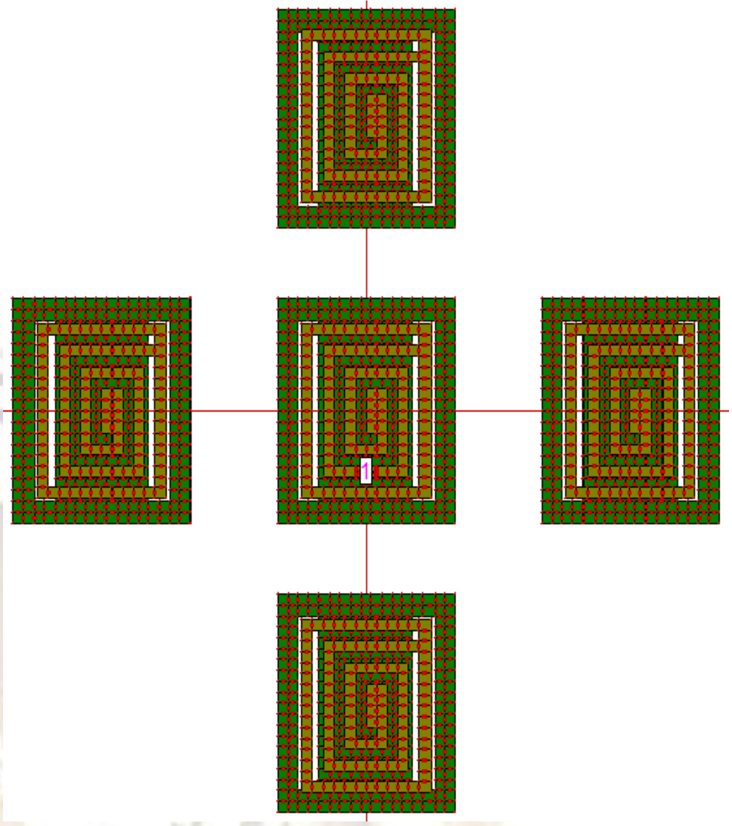


**Fig.2.Geometry of proposed phased array antenna**

## III.SIMULATION AND RESULTS

The proposed geometry of microstrip phased array antenna designed with IE3D and simulation is perfomed . At the resonant frequency of 3GHz the design is simulated in the frequency range of 1 to 6GHz. The proposed phased array antenna has scanned at angle of $80^o$ and $90^o$ in the array .The radiation pattern is bidirectional[3].The simulated return losses versus frequency for the array exhibits in fig.3.The returnlosses at three frequency bands are -17.56dB at 3 GHz , -26.98dB at 3.5 GHz, and -23.9dB at 5.4GHz. The impedance bandwidth for these with returnlosses of the proposed array is about to 9.83% ,9.45% and 14.9% in three frequency bands which cover LTE(long term evalution ) in 4G , WiMAX and WLAN applications . The total radiation efficiency is about 100% in all three bands shown in fig.4 .The axial ratio below 3db shwn in fig.5, and VSWR is near about 1 as shown on fig.6. The gain is achived 17.56dBi at 3.5GHz and it is over 22dBi at 5.4 GHz .The gain versus frequency graph is shown in fig.7.The directivity of the proposed phased array antenna is shown in figure 8 .The Impedance matching is shown in smith chart is shown in fig.9, its shows proper impedance matching at freque 3.5GHz and 5.4GHz. Figur.10 shows 3-D radiation pattern .Cartesian ploting of elevation angle versus gain of three frequencies is shown in figure11.Azimuth Cartesian graph is shown in figure.12. The returnloss , bandwidth , and antenna efficiency gain and directivity are compared with prior works shown in [4-7]

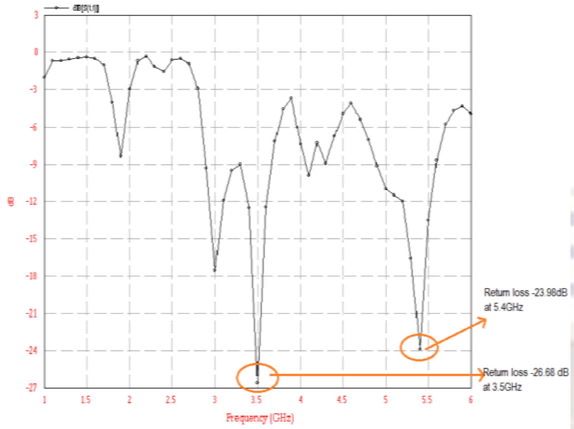


Fig.3 Return loss Vs Frequency graph

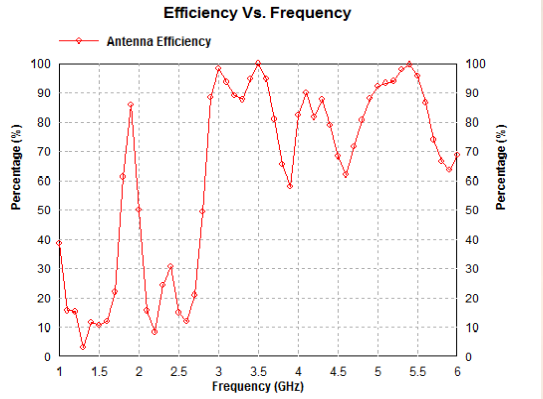


**Fig.4 Antenna Efficiency of the proposed design**

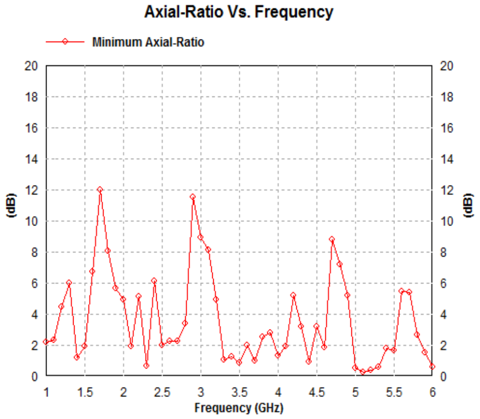


**Fig.5. Axial Ratio of proposed array antenna**

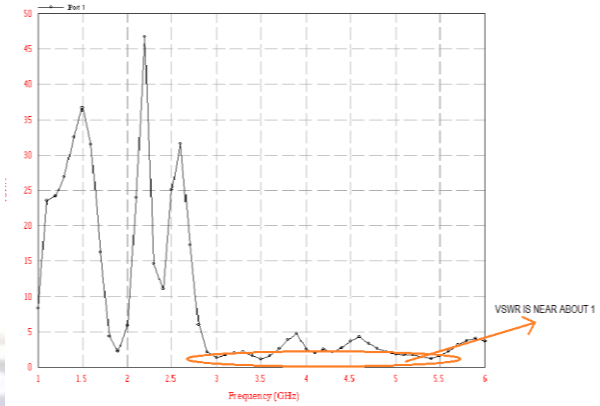


Fig.6 VSWR of proposed array antenna

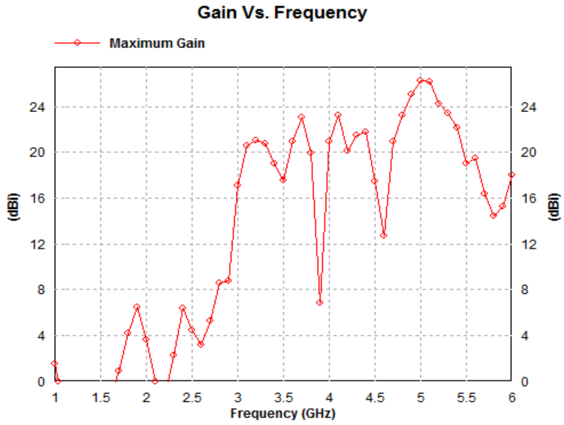


**Fig.7 Gain Vs frequency of proposed array antenna**

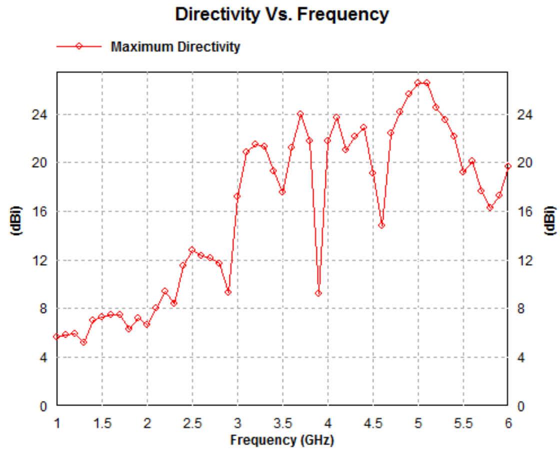


**Fig.8 Directivity Vs frequency of proposed array antenna**

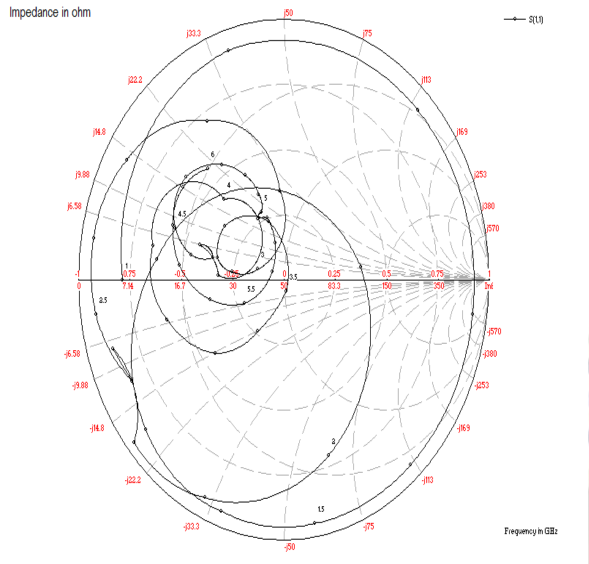


Fig.9 Smith Chart of proposed array antenna

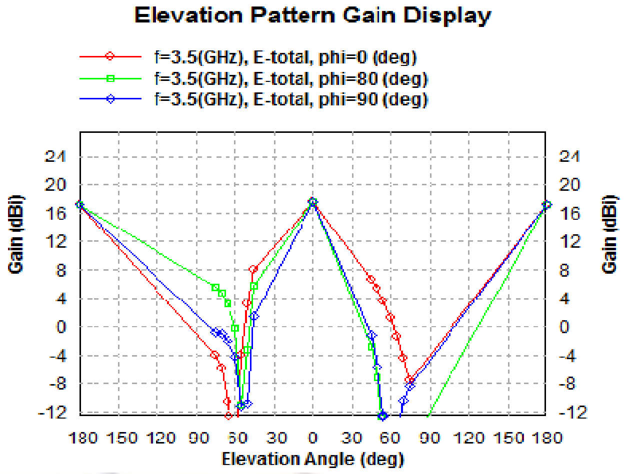


Fig11.b. Elevation Pattern Gain at 3.5GHz

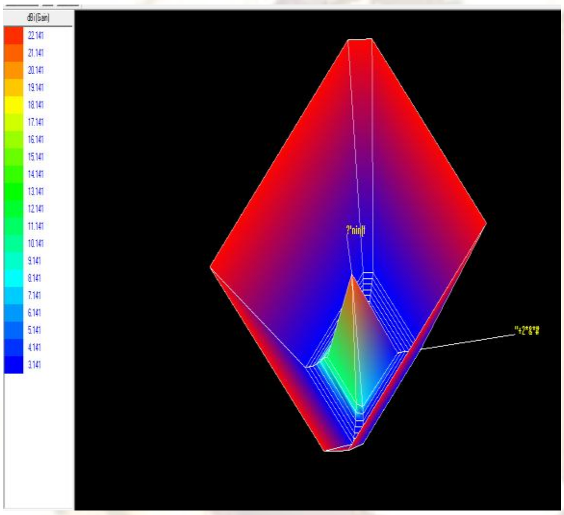


Fig.10. 3-D Ration Pattern at 5.4GHz

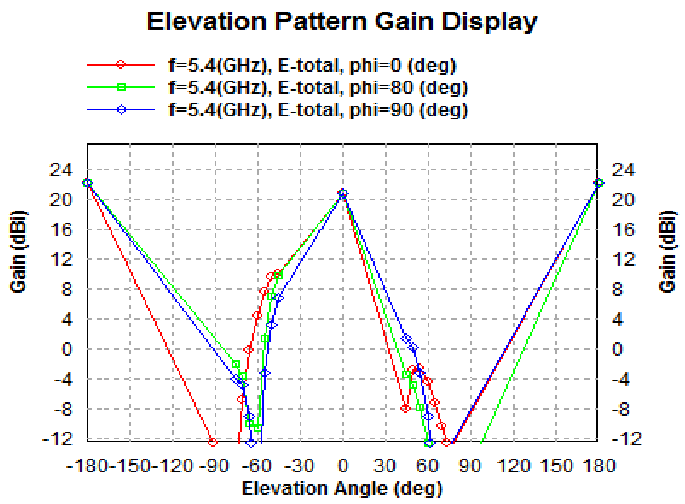
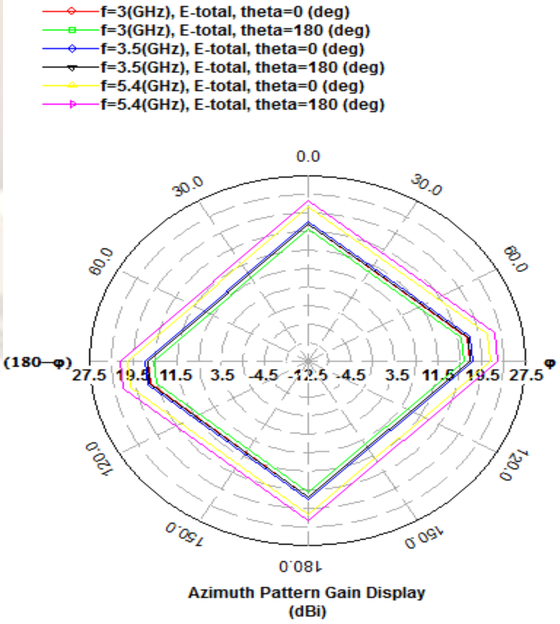


Fig11.c. Elevation Pattern Gain at 5.4GHz



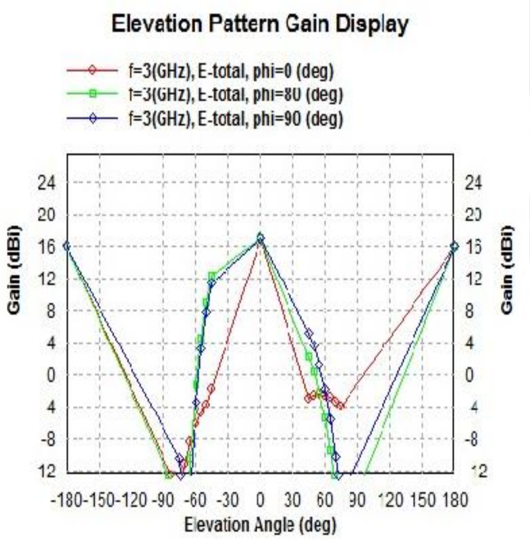


Fig11.a. Elevation Pattern Gain at 3GHz

Fig.12 Azimuth Pattern Gain at 3GHz, 3.5GHz and 5.4GHz

## CONCLUSION

The novel design method is proposed in this paper. This design can be implement for LTE (4G),WiMAX and WLAN application with mutual coupling . Consequently the feeding network can be greatly simplified and it can also be implemented in large array with active arrays and by using the mutual coupling effect of the active array.

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