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Design and Implementation of Multiband Microstrip Patch Array Antenna Using DGS for Wireless Applications

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ABSTRACT
In this paper, a multiband microstrip patch antenna using defected ground structure is presented. The proposed antenna is designed by applying FR-4 epoxy (Fire-Retardant-4)substrate. By inserting Defected ground structure in the proposed antenna the various parameter have been improved such as return loss, bandwidth, and gain.Design and simulation of this proposed antenna has been done by using HFSS (High frequency simulation software) . The application of this antenna is to make it compatible with bluetooth, Wi-max and WLAN etc.The proposed antenna has been fabricated and tested. And it has been found that there is a good agreement between the simulated and measured result.
Keywords - DGS, FR-4, Microstrip, Wi-max , wireless

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I. INTRODUCTION

Now a days,With increasing requirements for personal and mobile communications, the demand for smaller and low-profile antennas has brought the MSA to the forefront[1]. Compared with single element antenna arrays are in huge demand due to their higher gain and directivity. The growing demand of light weight and low cost and easy to fabricate antenna array .There are various techniques to enhancement antenna parameter like bandwidth and gain, one of them is defected ground structure [2].A Novel microstrip Patch antenna with double U-shape slot is applicable in 2Ghz-5Ghz frequency range and with reasonable gain and bandwidth [3]. For improvement of impedance bandwidth , the array element fed by only feed network, shape of radiating element depends on different antenna factor such as radiated power, the multiband operation and polarization type[4]. Compact size of multiband antenna array in the form of a dollar symbol almost achieve a good gain values for Ku,K and Ka frequency bands [5]. Parasitic coupling feeding phenomenon is used for reduction of the antenna size [6]. Configuration of corner fed rectangular antenna are miniature and compact , Their integration in the satellite communication system will be easier and more important [7].

In this paper, a microstrip patch antenna array for multiband operation is proposed . The proposed antenna resonate at four frequency bands applicable for the WiMAX and WLAN applications. The proposed antenna uses a single substrate and dumbbell shape Defect is incorporated in the ground plane.The proposed antenna is prototype d and tested

for verification. The methodology as well as discussion on both simulation and measurement is presented in the subsequent sections.

II. ANTENNA DESIGN

Initially, a single element which include a square shape fractal structure are added in the double I-shape slot microstrip patch antenna as shown in fig 1.In this design, the substrate FR-4 epoxy (Fire Retardant) which has a relative dielectric constant of 4.4 with tangent loss 0.019 and substrate thickness 1.6mm is used. This antenna resonated at three different frequencies i.e. 2.40 GHz, 3.58 GHz and 5.50 GHz respectively as shown in fig 2.

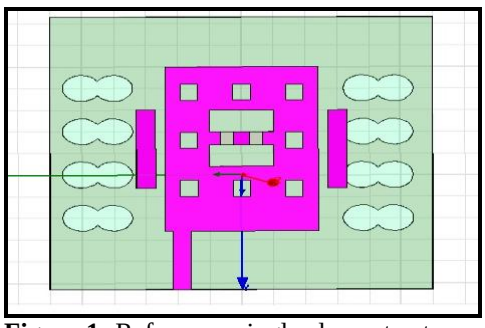

Figure 1: Reference single element antenna

Figure 2 shows the simulated result of reference antenna, S_{11} versus frequency indicating fundamental resonance frequencies. The polar polar plot is shown in figure 3.

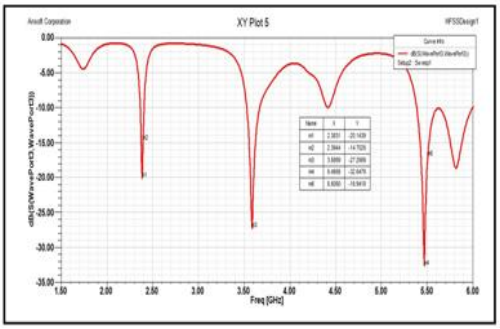

Figure 2:simulated s11 of the reference single element antenna

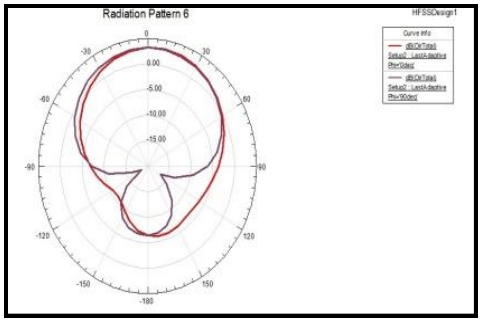

Figure 3:E and H plane Radiation pattern of the reference antenna

The design and simulation of the single element antenna has been carried out. Fig 2 shows the [S11] dB of the antenna resonated at three different frequencies i.e.2.40 GHz, 3.58 GHz and 5.50 GHz respectively with bandwidth 60Mhz, 130Mhz and 70 MHz with gain of 3.3 dB.The main objective of this work is to enhance the gain and bandwidth of the antenna using array method. Therefore , the single element reference antenna is transformed to a 2x1 linear array to increase bandwidth, directivity , gain and efficiency and have better radiation pattern.

III. DESIGN OF 2x1 MICROSTRIP PATCH ANTENNA ARRAY

A modified 2x1 element array microstrip patch antenna is shown in figure 4. The design of 2x1 element microstrip antenna in order to enhance performance of the antenna system and other function which are difficult to do with single element.

The proposed antenna is designed on FR-4 substrate with dielectric constant of 4.4 and thickness is 1.6mm. A metal patch of length 26mm and width 38 mm is connected to 50 ohm feed line. The microstrip line 1:2 power divider is used to feed the two antennas and hence the line width are adjusted according to power division.

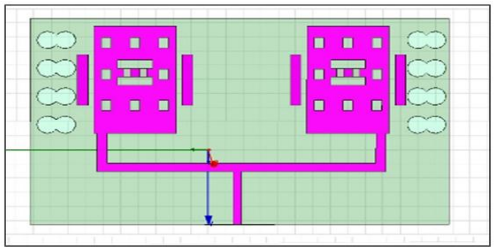

Fig 4: 2x1 micrstrip patch antenna array

The rectangular slots are incorporated on the patch to avoid leaky which results in leaky radiation which results in undesired radiation. Also with the help of parasitic element which are parallel to the patch is included in the proposed antenna design for improvement in the return loss.

For enchantment of bandwidth a dumbbell shape defect is employed in ground structure. By introducing DGS in microstrip patch antenna, there is an increase in capacitance and inductance which influence the input impedance and current flow of antenna and thus result in improvement of gain of antenna with respect to given resonance frequency.

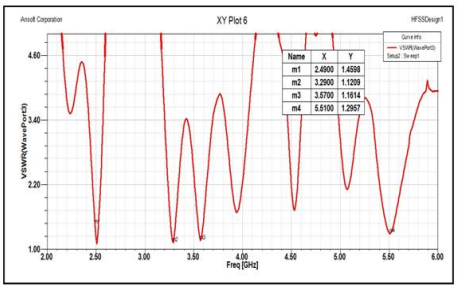

Fig 5: simulated s11 of the proposed antenna array

Figure 5 shows the s11 versus frequency plot of the 2*1 fractal double I-shape slot with DGS rectangular microstrip patch antenna array. From figure, the antenna resonated at the four frequencies i.e. 2.48 GHz, 3.29 GHz, 3.57 GHz and 5.51 GHz with return loss -14.56 dB, -24.88dB, -22.53dB and -17.80
dB respectively.

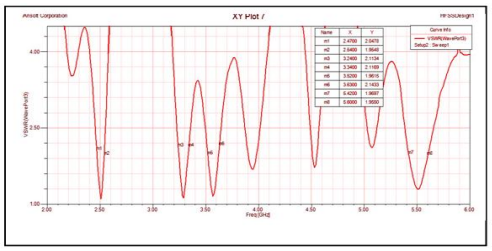

Fig 6: bandwidth plot of the proposed antenna array

Fig 6 shows the bandwidth plot of the proposed antenna array from figure the bandwidth for the four resonant frequencies are 80 MHz, 90Mhz, 110Mhz and 180 MHz respectively.

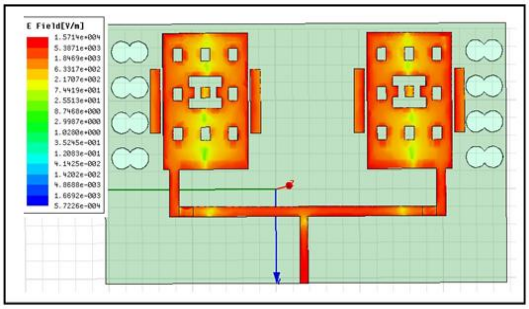

Fig 7: E-field for the proposed antenna array

Figure 7 shows the electric field distribution of the proposed microtrip patch antenna array.

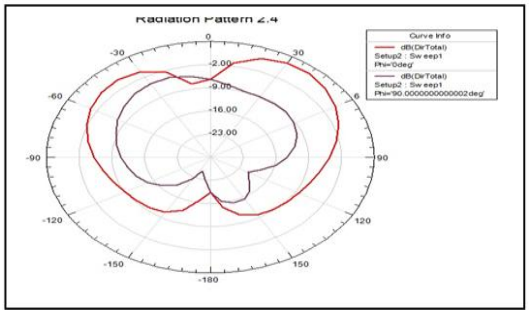

Fig 8 : E and H-plane of the proposed antenna array for frequency 2.48 Ghz

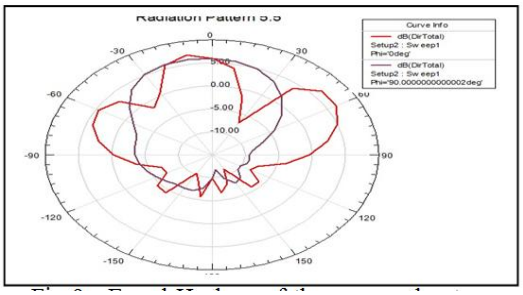

Fig 9 : E and H-plane of the proposed antenna array for frequency 5.51 GHz

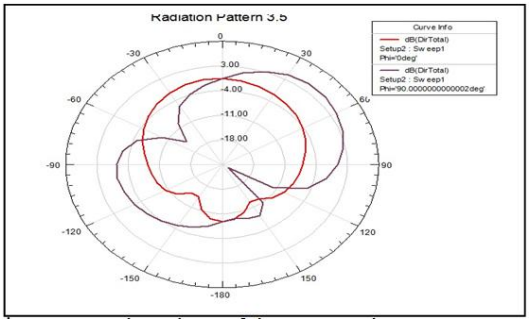

Fig 10 : E and H-plane of the proposed antenna array for frequency 3.57 GHz

Figure 8, figure9 and 10 shows the E-field and H-field radiation pattern for three resonance frequency i.e.2.48 GHz, 3.57 GHz and 5.51 GHz.

IV. FABRICATION AND MEASUREMENT

A 2x1 proposed multiband microstrip patch antenna array with dumbbell shape DGS and two parallel parasitic elements has been fabricated as shown in figure 11. Figure 12 shows the bottom view of the proposed antenna array.After fabrication , the various antenna parameters of antenna has been measured by using vector analyzer with a frequency range up-to 8 GHz.

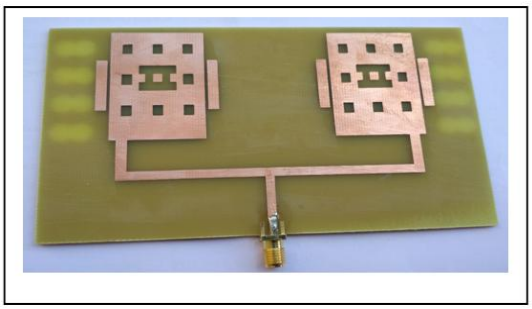

Fig 11: Top view of the prototype proposed antenna array

Fig 12: bottom view of the prototype proposed antenna array

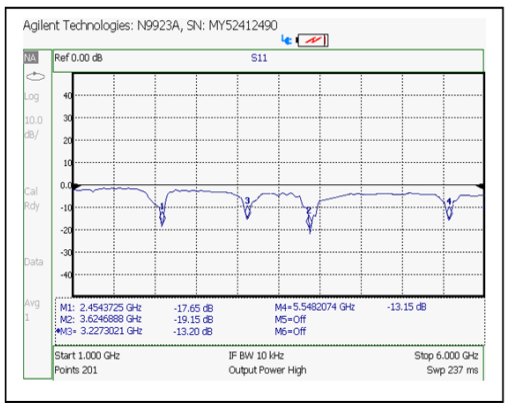

Fig 13: measured impedance plot of the proposed prototype

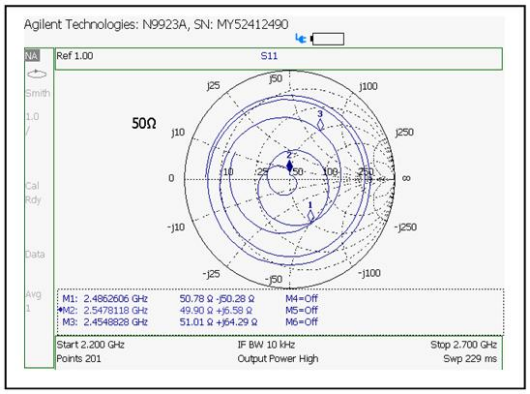

Fig 14 : measured impedance of proposed prototype

Comparison table Simulated Vs Measured Results Fractal 2x1 Array

S N.	Results	Freq (GHz)	Return loss (dB)	VSWR	Band width (MHz)	Impedance (ohm)
1.	Simulated results	2.48	-14.56	1.45	80	51.4
		3.29	-24.88	1.12	90	
		3.57	-22.53	1.16	110	
		5.51	-17.80	1.29	180	
2.	Measured Results	2.45	-17.65	1.47	75	51.0
		3.22	-13.20	1.56	96	
		3.62	-19.15	1.31	160	
		5.54	-13.15	1.74	170	

Above table shows the comparison between simulated and measured result of fractal double I-shape slot RMSA Array with two parallel parasitic element and DGS. From table, it is observed that there is good agreement between the simulated and measured results.

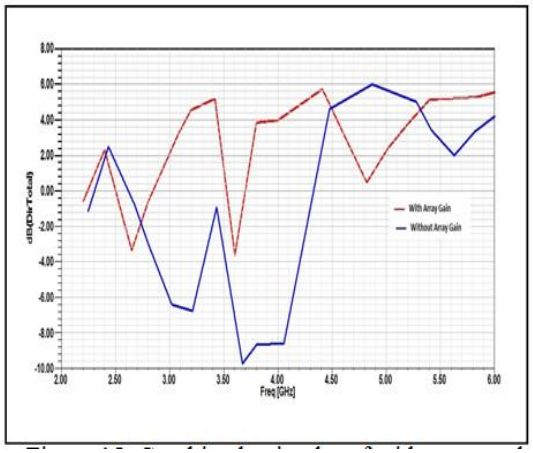

Figure 15: Combined gain plot of with array and without array

For enhancement in gain , the antenna is modified by designing 2*1 fractal double I-shape slot RMSA array with two parasitic elements parallel to the radiating and defect of dumbbell shape in ground plane and after simulation frequency bands obtained at 2.48 GHz, 3.29 GHz, 3.57Ghzand 5.51 GHz with return loss -14.56dB, -24.88dB,-22.53 and -17.80 dB and bandwidth 80 MHz ,90 MHz,110 MHz and 180 MHz respectively. And after fabrication, the measured results are 2.45Ghz, 3.22Ghz, 3.62nGhz and 5.54 GHz with return loss -17.65dB, -13.20dB, -19.15dB and -13.15 dB and bandwidth 75Mhz, 96Mhz,160Mhz and 170 MHz respectively. Also gain for single fractal antenna is 3.3 dB which is improved in 2*1 fractal array i.e.5.4 GHz. Hence with the proposed antenna system, it is concluded that, with multiband frequency , enhancement in bandwidth and return loss has been achieved

V. CONCLUSION

In this paper a multib and microstrip patch antenna array is presented to enhancement to gain parameter.The proposed antenna resonated at four frequency band with higher gain. And it is also applicable for high power consumption applications such as satellite applications. The proposed antenna has been fabricated and tested and it showed good agreement between simulated and measured results.By inserting switches or PIN diodes, the proposed antenna further can be modify into re-configurable microstrip patch antenna array

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