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2 X 1 Array Using Photographic Paper as Substrate

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ABSTRACT
In the field of wireless communication many advances have took place, which made us possible to use photographic paper as substrate for a microstrip patch antenna. In this paper a 2x1 array using photographic paper as substrate is designed using HFSS software. Due to use of Photographic paper as substrate the antenna becomes flexible and also the manufacturing cost is reduced. To design an array single element was designed using photographic paper substrate. Using that single element 2x1 array was designed. The designed antenna gives four frequencies, and the values of bandwidth and gain makes this antenna suitable for WLAN & WiMAX applications.
Keywords - Microstrip Antenna, Photographic Paper, Array, Flexible antenna, WLAN

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I. INTRODUCTION

The smart antennas play an important role in today's wireless communication, such as Mobile and satellite communication, Global Positioning System (GPS), WiMAX, Radio Frequency Identification (RFlD), Wireless Local Area Networking (WLAN) and medicinal applications. The requirements of antenna for Wireless communication applications are small, low cost, and low profile. Microstrip patch antenna meets all this requirements .So most antenna designers preferred microstrip patch antenna for various wireless communication applications according to C.A.Balanis [1]. Today Microstrip patch antennas are probably the most widely used type of antennas due to their advantages such as low volume, low cost, light weight, and compatibility with integrated circuits and easy to install on the rigid surface. [2]

Recent developments in conformal wireless devices have sparked a lot of interest in designing antennas that can be bent and mounted on non-planar objects [3]. Mobile phones or other wireless devices may be developed to be foldable and small in size. Lower cost is another critical aspect for these types of upcoming wireless devices. Recently, paper has emerged as a material that can reduce the cost to approximately one-tenth of the cost of plastic films or polymers [4]. It has been shown that electronics can be realized on paper substrates through simple processes such as inkjet printing. This could result in further cost savings through roll-to-roll mass manufacturing options [5]. Paper is light weight, environmentally friendly (biodegradable) and comes from a renewable source, making it a very attractive option for such designs. Practical antennas for mobile and wireless applications have typically been designed using flat and rigid substrates such as FR4 [6, 7] with such rigid substrates, the antennas cannot be conformal. However, antennas placed on curved substrates, such as, Polyethylene [12]

In the field of communication, Various Conductive and nonconductive dielectrics are used to design antennas. Fabrication of Planar antennas on a dielectric substrate is done mostly by photolithography process or etching process. In both the Process, large amount of material is wasted which is major disadvantage of both the techniques. Due to this, both processes are called as subtractive techniques. In past few years, additive printing and direct write inkjet printers gave a significant position and enabled a technology called as additive manufacturing. In this manufacturing technique, minimal waste is generated proving additive manufacturing as an ecofriendly technology. Paper as a substrate, it is compatible with additive direct-write, ink-jet, and copper lamination technologies [8, 9]. It is also suitable for wearable devices and sensors due to its low profile (small thickness and light weight) that makes it an attractive substrate for modern RF applications including mass-produced RFID tags, antennas, microwave filters, and modules [10,11] for RF scavenging, smart devices, smart skins, wireless sensor networks, and anti-counterfeiting.

Microstrip antenna used as a single element or can be used in arrays. To achieve the requirement of High directivity a number of elements can be set in an array configuration. By using array antenna performance like increasing gain, scanning the beam of the system, and directivity is enhanced. This is tricky to do with single radiating element. To achieve low side lobe level, narrow beam width, high directivity, group of radiating elements called as antenna array is used.as it is difficult to achieve above parameters with a single element, the Array is essential. Array geometry and selection of an element is important to achieve the performance of antenna system. Input impedance, mutual impedance between two elements in given array should be proper.

II. DESIGN AND SIMULATION

Dimensions of the rectangular Microstrip patch antenna with double U slot and two parasitic elements of rectangular shape which are gap coupled are shown in fig 2.1. Gap coupled has been used to obtain broad bandwidth and increase the value of directivity. In this the ground is made partial. Partial ground is a simple and effective method for increasing the bandwidth of a Microstrip Patch antenna and also makes antenna omnidirectional.

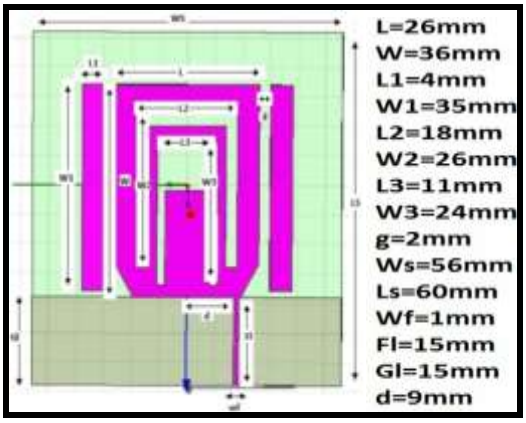

Fig 2.1 Dimensions of Patch with double U slot and parasitic Element

A metal Patch (Lp= 35mm and Wp=32mm) was connected with a Microstrip line of 50-Ω. Feed-line, ground plane are printed on the photographic paper substrate. The thickness of photographic paper substrate is 0.23mm and a dielectric constant of 3.0. The rectangular Microstrip patch antenna with double U slot and two parasitic elements of rectangular shape which are gap coupled are element of an array. 2X 1 array is designed. Gap coupled has been used to obtain broad Bandwidth and array is used to increase the value of Directivity. The distance between the two elements is 65mm.

The distance between the patches is varied to find the best possible distance. The distance d varies for 60mm, 65mm and 70 mm. The results of the antenna is best when the distance d is 65mm amongst all the result tabulated. Table 2.1 shows the values of antenna parameters for different value of distance d. 2x1 Element Microstrip Patch Antenna Array with dimensions is shown in fig 2.2. The 2x1 Element Microstrip Patch Antenna is designed in order to enhance the performance of the antenna like increasing gain , bandwidth and other parameters which are difficult to do with single element.

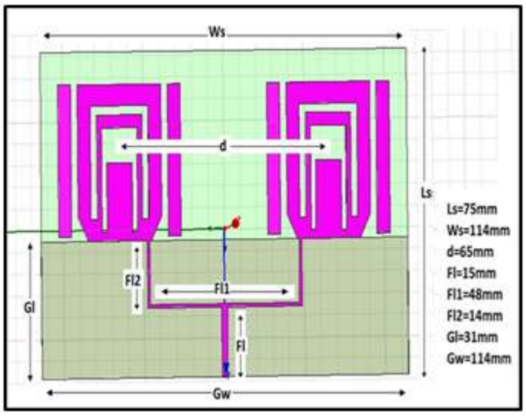

Fig 2.2 Dimensions of 2x1 Element Microstrip Patch Antenna Array

Table 2.1 Comparisons table of effect of d

Distance d between two patches	**Freq (GHz)**	**Return loss (dB)**	**VSWR**	**BW (MHz)**	**Gain (dB)**
60mm	2.48	-34.73	1.03	240	4.2
	3.26	-11.08	1.77	80	
	3.86	-25.23	1.11	300	
65mm	2.42	-20.77	1.20	240	5.2
	3.20	-11.83	1.68	100	
	3.68	-24.32	1.12	320	
	5.00	-11.38	1.73	200	
70mm	2.48	-25.43	1.11	200	5.2
	3.22	-19.79	1.22	100	
	3.64	-17.73	1.30	220	
	4.86	-11.86	1.65	220	

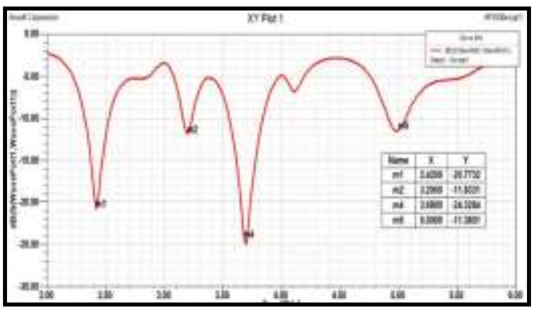

Fig 2.3 Return loss of 2x1 Element Microstrip Patch Antenna Array

Fig 2.3 shows the Return loss of 2x1 Element Microstrip patch Antenna Array. Four frequencies are obtained 2.42 GHz, 3.20 Ghz,3.68 Ghz and 5.0 GHz .The return loss for 2.42 GHz is -20.77, return loss for 3.20 GHz is -11.83 ,return loss for 3.68 Ghz is -24.32 and the return loss for 5.0 GHz is -11.38. The bandwidth obtained for 2.42 GHz is 240 MHz, for 3.20 GHz is 100 MHz, for 3.68 GHz is 320 MHz and the bandwidth obtained for 5.0 GHz is 200 MHz.

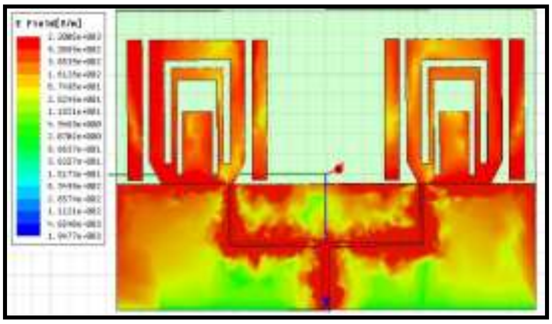

Fig 2.4 Current Distribution of 2x1 Element Microstrip Patch Antenna Array.

Fig 2.4 shows Current Distribution of 2x1 Element Microstrip patch Antenna Array. Here it is observed that there is equal current distribution in both the elements of an array

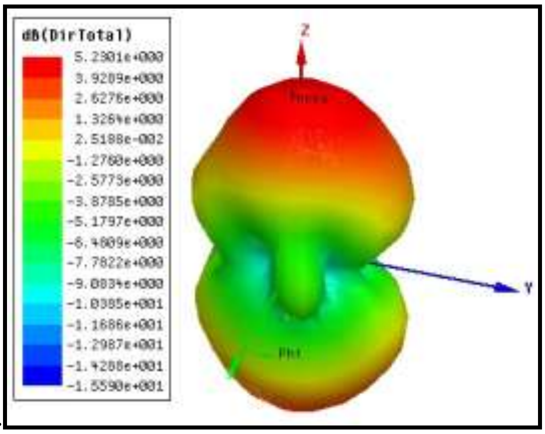

Fig 2.5 Directivity of 2x1 Element Microstrip patch Antenna Array

Fig 2.5 shows the directivity of 2x1 Element Microstrip patch Antenna Array, as 5.2 dB for four different frequencies.

Table 2.2 shows the comparison of various antenna parameters of single element patch and antenna array. Here it is observed that antenna with array after simulation is giving four different frequencies, and the bandwidth and gain requirement is fulfilled for WLAN/WIMAX and Bluetooth applications.so, we can say that antenna with array element is good to be used.

Table 2.2 Comparisons table of Single element patch and Antenna Array

Sr. no.	**Type of MSA**	**Freq (GHz)**	**Return loss (dB)**	**VSWR**	**Bandwidth (MHz)**	**Gain (dB)**
1.	Single Element Patch	2.65	-22.45	1.20	800	3.2
		3.42	-22.86	1.15	200	
		5.50	-13.78	1.51	1200	
2.	With Array double U slot design with parasitic	2.42	-20.77	1.20	240	5.2
		3.20	-11.83	1.68	100	
		3.68	-24.32	1.12	320	
		5.00	-11.38	1.73	200	

III. CONCLUSION

A 2x1 Element Microstrip patch Antenna Array using photographic paper substrate was designed. This antenna gave four different frequencies which covers all the WiMAX and WLAN applications and also gives the sufficient gain for the applications to operate. Due to use of photographic paper as substrate the antenna became light weight and flexible. In Future this antenna can be fabricated to get the comparison of results for simulated and fabricated antenna.

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