DESIGN OF DUAL BAND DISSIMILAR PATCH SIZE ARRAY ANTENNA FOR WIRELESS APPLICATIONS

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Abstract-

This paper deals with the design of a dual band array antenna for wireless applications such as LTE (Long Term Evolution), WiMAX etc…that resonates at 3.5 GHz and 5 GHz respectively. The substrate used for design is FR4 ($\in_r$ =4.6) and the software used for simulation is Agilent ADS Momentum. The concept of dissimilar patch size array antenna has been introduced. So patches of different dimensions have been used in the array and their corresponding results are validated based on various antenna parameters like VSWR, gain, directivity and power radiated.

Keywords-

Patch antenna; dual-band; LTE; WiMAX; MIMO

1. INTRODUCTION

The rapid growth of wireless communication systems has increased the demand for compact antennas with multiband operating frequencies. In some cases, the bandwidth of the entire frequency range could be covered with the antenna. Owing to their low-profile, low-cost, and low-mass features, microstrip antennas can be easily placed inside packages, making them a suitable choice for numerous consumer applications. There is huge demand for new kind of antennas such as small antennas, multi-frequency antennas, broadband antennas for mobile and satellite communication systems. A dual band antenna is an antenna designed for use on two different bands which provides various applications such as Wireless Communications, satellite communications, Area monitoring, Forest fire detection, Disaster prevention. A patch antenna (also known as a rectangular Microstrip antenna) is a type of radio antenna with a low profile, which can be mounted on a flat surface. It consists of a flat rectangular sheet or "patch" of metal, mounted over a larger sheet of metal called a ground plane.

Planar antennas [1] are preferred because of their small size and simple structure. One of the main types of planar antennas is microstrip patch antenna. They are preferred over other planar antennas because of their thin profile. A patch antenna is a piece of metal mounted on a substrate of thickness h and dielectric constant $\in_r$. It is an easy to fabricate, low cost, small-sized and low weight antenna [1].These properties of microstrip patch antennas make them most suitable for mobile devices. A simple rectangular patch antenna typically resonates at a single resonance frequency F_r [2]. Multiple Input Multiple Output (MIMO) is considered as a key smart antenna technology, to improve the capacity of a communication channel at a greater extent [3], because it makes it possible to transmit multiple data streams over a same frequency channel without increasing the physical bandwidth of that channel [4].MIMO utilizes multiple antenna elements both at transmitter and receiver ends to increase the data transmission rate by providing higher spectral efficiency [3].The 4G cellular mobile communication standards, Long Term Evolution(LTE) and WiMAX[4], utilizes MIMO to provide improved data rate of up to 1Gbps

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II ANTENNA DESIGN

Our goal is to design a dual band microstrip patch antenna array at 3.5 GHz and 5.0 GHz using ADS simulation software. We used microstrip line (edge feed) technique to feed the microstrip patch antenna covering both the frequencies.

A. Two element antenna design

Substrate selection is the first practical step in designing a patch antenna. FR4 (ϵ_r=4.6) is used as substrate to design the patch antenna. These values are carefully chosen to meet our performance and bandwidth requirement because dielectric material is crucial for determining the performance of antenna. To achieve compactness, thin substrates are required but the bandwidth of antenna decreases as height is reduced. Also with higher values of ϵ_r the patch size can be reduced but it would also reduce the antenna bandwidth. So, a trade-off must be done between antenna performance and its size [1, 5]. The empirical formulas in [6] are used here to obtain the initial parameters of dual band patch antenna. The dimensions for different patch size are calculated. The length of the large patch radiator is 22.2 mm and width is 28.1 mm whereas the length of the small patch radiator is 14.565 mm and width is 19.7 mm. Length of the feedline is 12 mm and width is 0.7 mm. Distance between the centers of both the feedline is 59.3 mm. (fig.1)

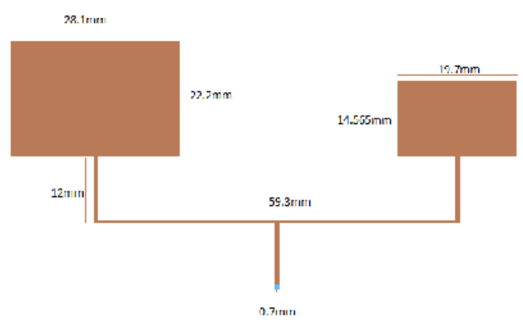

Figure 1(a) : Array of 2 elements with ideal ground plane covering both the frequencies of 3.5 GHz and 5.0 GHz.

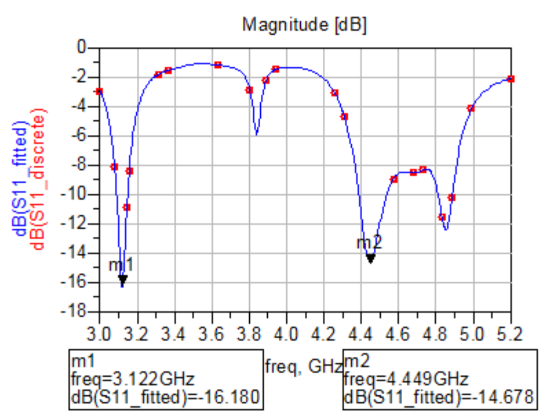

Figure 1(b): Radiation pattern of two element array antenna.

B.Four element antenna design

The length of the large patch radiator is 21.7 mm and width is 28.1 mm whereas the length of the small patch radiator is 14.84 mm and width is 19.7 mm. Length of the feedline is 12 mm and width is 0.7 mm. Distance between the centre of both the 2 element feedline is 59.3 mm. Distance between the edges of above and below radiator is 61.4 mm. The efficiency of the antenna is found to be 70.096%.

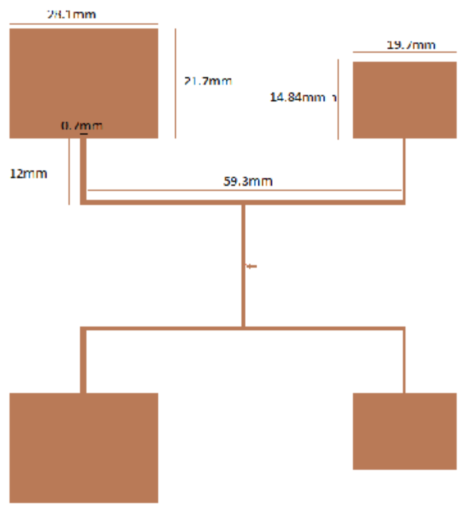

Figure 2(a): Array of 4 elements with ideal ground plane covering both the frequencies of 3.5 GHz and 5.0 GHz.

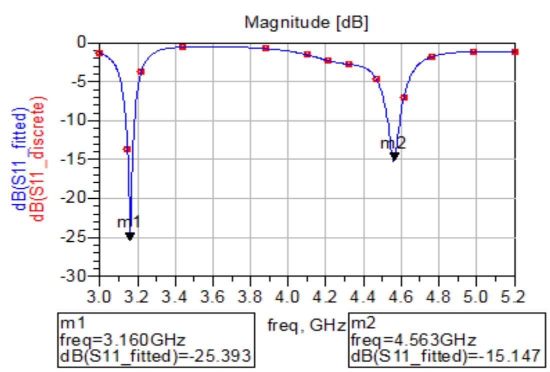

Figure: 2(b)

Figure 2(b): Radiation pattern for four element array antenna.

C.Eight element antenna design

The length of the large patch radiator is 21.3 mm and width is 28.1 mm whereas the length of the small patch radiator is 14.7 mm and width is 19.7 mm. Length of the feedline is 12 mm and width is 0.7 mm. Distance between the centre of both the 2 element feedline is 59.3 mm. Distance between the edges of above and below radiator is 61.4 mm. Distance between the centre of both the 4 element array feedline is 121.7 mm. The efficiency of the antenna is found to be 73.05%.

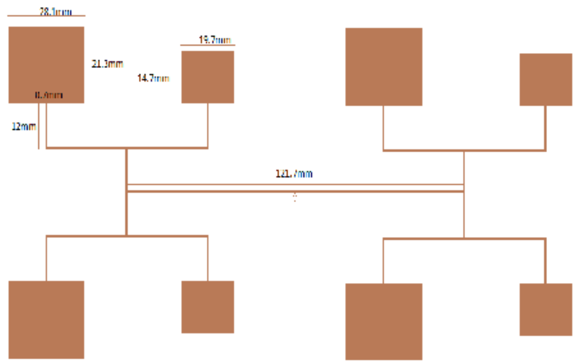

Figure 3(a): Array of 8 elements with ideal ground plane covering both the frequencies of 3.5 GHz and 5.0 GHz.

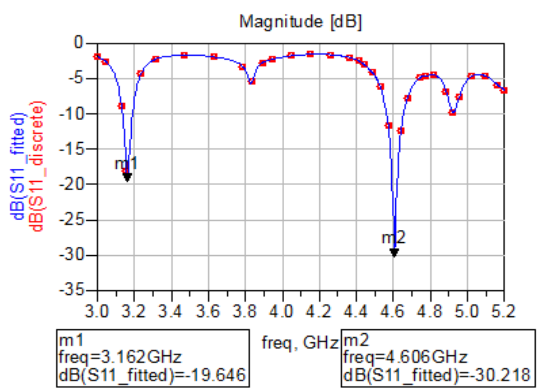

Figure: 3(b)

Figure 3(b): Radiation pattern of eight element array antenna.

D. Sixteen element antenna design

The length of the large patch radiator is 21.3mm and width is 28.1 mm whereas the length of the small patch radiator is 14.7 mm and width is 19.7 mm. Length of the feedline is 12 mm and width is 0.7 mm. Distance between the centre of both the 2 element feedline is 59.3 mm. Distance between the edges of above and below radiator in 4 element is 61.4 mm. Distance between the centre of both the 4 element array feedline is 217.4 mm. Distance between the centre of both the 8 element array feedline is 190 mm.

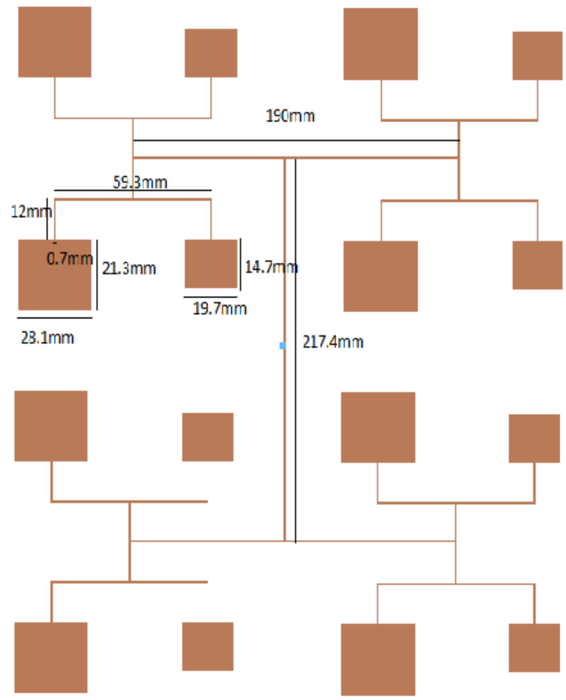

Figure 4(a): Array of 16 elements with ideal ground plane covering both the frequencies of 3.1 GHz and 4.5 GHz.

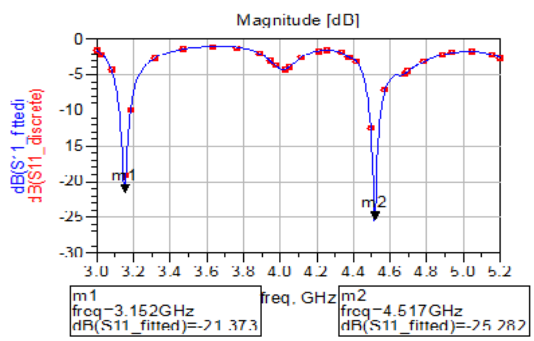

Figure 4(b): Plot of return loss vs. frequency of sixteen element array antenna.

III RESULTS AND DISCUSSIONS

The return loss is determined for the two, four, eight element antenna respectively and a better return loss was observed in eight element antenna and the results are tabulated in table I.

Array element	Freq (GHz)	Return loss,S(1,1), (dB)
2	3.1	-16.18
	4.5	-14.67
4	3.1	-25.39
	4.5	-15.14
8	3.1	-19.64
	4.5	-30.21
16	3.1	-21.37
	4.5	-25.28

Table I: Comparison of return loss for different array element

The VSWR is determined for the two, four, eight element antenna respectively. The optimum VSWR is in the range of 1.6 and we have achieved it in our antenna design and the results are tabulated in table II.

Array element	Freq (GHz)	VSWR
2	3.1	1.36
	4.5	1.46
4	3.1	1.28
	4.5	1.52
8	3.1	1.39
	4.5	1.32
16	3.1	1.19
	4.5	1.11

Table II: Comparison of VSWR for different array element

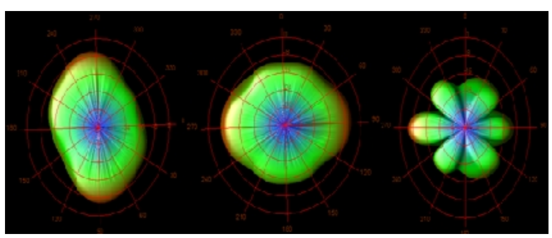

Figure 4: Comparative study of radiation pattern of two, four, eight element respectively

The gain is determined for the two, four, eight element antenna respectively and a better gain of 9.250 dB was observed in eight element antenna and the results are tabulated in table III

Array element	Gain (dB)
2	5.006
4	6.91
8	9.72
16	9.95

Table III: Comparison of Gain for different array element

The bandwidth is determined for the two, four, eight element antenna respectively. F_L denotes lower frequency and F_H denotes higher frequency and the bandwidth is obtained in the range of mega hertz and the corresponding the results are tabulated in table IV.

Antenna array elements	Freq (GHz)	F_L (GHz)	F_H (GHz)	Bandwidth (MHz)
2	3.1	3.10	3.15	50
	4.5	4.24	4.32	80
4	3.1	3.12	3.19	70
	4.5	4.50	4.61	110
8	3.1	3.12	3.21	90
	4.5	4.54	4.67	130
16	3.1	3.10	3.20	100
	4.5	4.46	4.57	150

Table IV: Comparison of bandwidth for different array element for two frequency 3.1 GHz and 4.5 GHz

IV CONCLUSION

A dual-band microstrip patch antenna array for LTE, WiMAX and other wireless applications is presented. The antenna covers 3.1 GHz and 4.5GHz frequency bands .Good results are obtained in terms of return loss, VSWR and array gain. The use of Agilent ADS software ensures that there would not be large differences between the results of simulated and measurements of fabricated antenna. The fabrication will be performed using the same FR4 substrate to compare antenna results.

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