Design of Linear Printed Phased Array Antenna for C-Band Applications - A Review

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***Abstract*—This paper presents printed antenna (also known as micro strip antenna) is used because of their geometrical shapes and implementation but characteristics of single printed antenna is low gain, directivity, efficiency. Here proposed antenna consists of two parts, one is array design and another is beam scanning mechanism. Thus array arrangement is used to overcome the disadvantage of single microstrip antenna and beam scanning used to detect the target. Here different feeding techniques are used to achieve beam scanning. This type of antenna is useful for various applications such as radar communication, satellite communication etc.**

Index Terms— **Printed antenna; Phase array antenna; Feeding techniques**

I. INTRODUCTION

Printed Antenna was first proposed by Deschamps in 1953. However, the first practical antennas were developed by Howell and Munson in the 1970s [1]. Desire characteristics may be achieved with single microstrip antenna but in conventional microwave antenna, characteristics such as high gain, beam scanning capability are possible only when number of elements to form array. Here linear Array Antenna is described which is consists of elements located finite distances apart along a straight line. Array arrangement of microstrip antenna is used to improve gain, directivity, efficiency of the antenna.

The first use of the phased-array antenna in commercial broadcasting transmission was in the early thirties and the first large steered directive array for the reception of transatlantic short-wave communication was developed and installed by the Bell Telephone Laboratories in the late thirties. Normally phase shifters are devices in a phased array antenna that allow the radiated beam to be steered in the direction. One of the more popular forms of phase shifters is one that varies the physical length of line to obtain change in phase [2].

II. FEEDING TECHNIQUES

Feeding Techniques plays important role in design process. Due to feeding technique, efficient power is transferred between radiating structure and feed structure that is impedance matching between radiating and feed structure. The microstrip antennas can be fed through different techniques which are microstrip line, probe feed, aperture coupling and proximity coupling [1]. Another feeding techniques are corporate and series feeding.

II (a) Series feeding- In this feeding, patches are connected in series through conducting line. Thus power available for the first element is maximum and power is available to the last element is minimum. The main limitation of this feed technique is the large variation of the impedance and beam pointing direction over a band of frequencies [2].

II (b) Corporate feeding- In this feeding, the energy to be radiated is divided between the elements by power splitter. When a series of power splitters are used to create a tree like structure, it is called a corporate feed. Equal lengths of line transmit the energy to each element so that no unwanted phase differences are introduced by the lines themselves. If the lines are not of equal length, a compensation in the phase shift must be made. Thus this feeding technique is widely used in scanning phased array antenna [2].

III. LITERATURE REVIEW

A. Microstrip antenna design & analysis of its parameters[3]

In this paper authors presented [3] that microstrip patch antennas consists of very thin metallic strip (patch) placed on ground plane where the thickness is restricted by t $<< \lambda_0$.
The height is restricted by $0.0003\,\lambda_0 \leq h \leq 0.05\,\lambda_0$ [3]. There are numerous substrates that can be used for the design of microstrip antenna and their dielectric constants are in the range of $2.2 \leq \epsilon_r \leq 12$. Then performance of microstrip antenna depends on its dimension. Here transmission line model is used to design patch dimensions.

Performance of microstrip antenna depends on the used dielectric material, operating frequency and height of substrate. Thus we need to maintain the value of all these parameters within a desired threshold level. So we get better performance of a microstrip antenna [3].

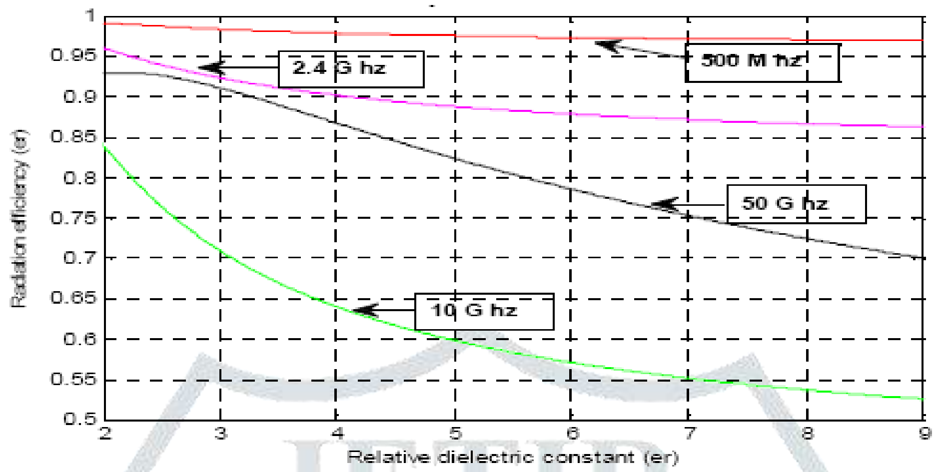

Fig.1: Effect of the dielectric material on radiation efficiency at different operating frequency [3]

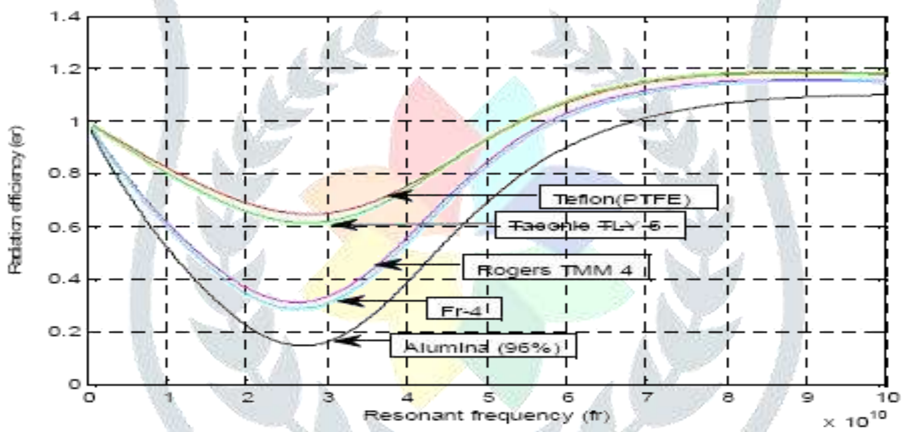

Fig.2: Effect of the operating frequency on radiation efficiency for different dielectric material [3]

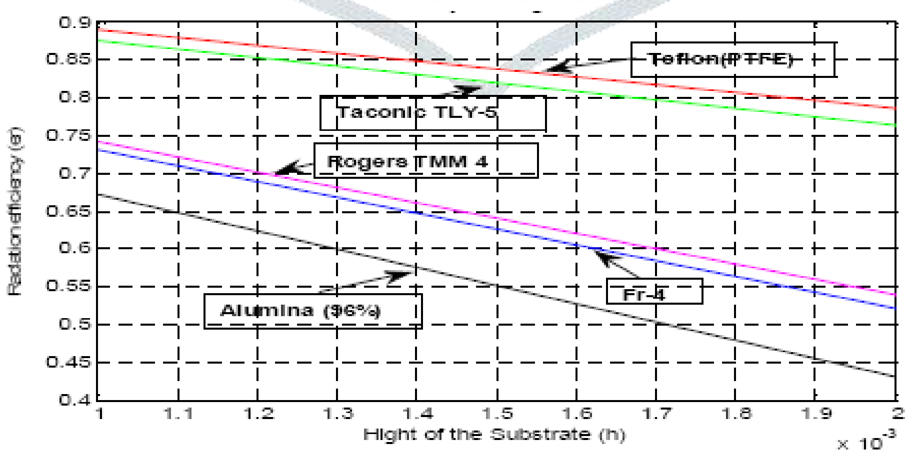

Fig.3: Effect of the radiation efficiency on the height of the dielectric material considering the relative dielectric constant [3]

Thus after observing the above fig. 1, 2, 3 it can be concluded that to get a microstrip antenna having higher radiation efficiency following considerations are required.

The relative dielectric constant ϵ_r of the dielectric material should be less than 3 in order to get higher radiation efficiency and directivity. The operating frequency f_0 of the microstrip antenna should be less than 10GHz or higher than 50GHz in order to get improved radiation efficiency and height h of the substrate should be near to 1mm to get the higher radiation radiation efficiency [3].

B. Microstrip array antenna effect on output parameters [4, 5 and 6]

Preeti Sharma and Shubham Gupta presented bandwidth and gain enhancement in microstrip antenna array for 8 GHz frequency applications [4]. They presented proximity feed technique to improve bandwidth and gain of antenna. Here input parameters as operating frequency 8 GHz, dielectric substrate material FR4 with constant 4.4 and height of substrate 1.58 mm is selected. After simulation, the output parameters gain, directivity, efficiency and bandwidth of array antenna are compared with single patch antenna. The simulated result of single and 2×1, 4×1, 4×2 array antenna shown in Table 1 [4].

TABLE 1: Simulated Result [4]

Parameters	Microstrip Antenna	2×1 Antenna Array	4×1 Antenna Array	4×2 Antenna Array
Gain(dBi)	6.94	10.05	11.16	11.73
Directivity(dBi)	8.26	10.9	11.66	12.59
Efficiency (%)	84%	92.2%	95.69%	93.65%
10dB Bandwidth	172 MHz	191 MHz	232 MHz	289 MHz

K. Thenmozhi, K.Jagadeeshvelan, M. GaneshMadhan, S.Piramasubramanian presented simulation of microstrip array antenna for Ka band application [5]. They demonstrated a microstrip rectangular patch antenna for 35 GHz which has thickness of substrate 0.254 mm and duroid substrate material with constant 2.2. Here microstrip patch fed by inset feed line. Then 4×1 and 4×2 array antenna simulated using ADS software and compared both array antenna. From simulation result, return loss of 4×1 arrays is found to be −19.206dB at 35.3 GHz and 4×2 array is found at −40.0911dB at 34.93 GHz [5]. The gain and directivity of 4×1 and 4×2 array antenna shown in fig. 4 and 5. Gain and directivity of 4×1 array is 12.438dB and 13.325dB respectively while gain and directivity of 4×2 array is 13.728dB and 15.301dB respectively.

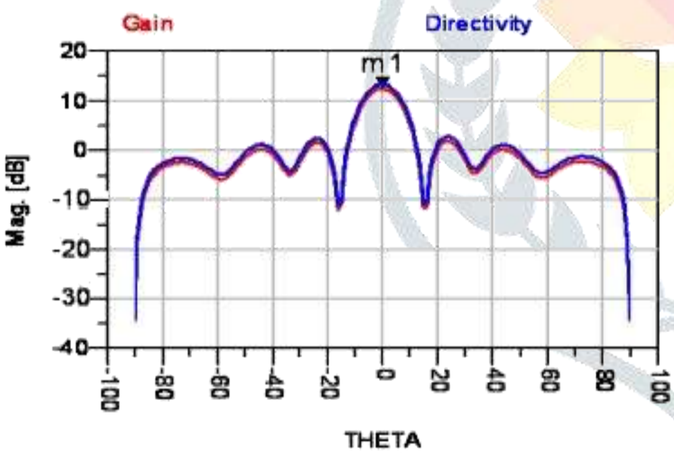

Fig. 4: Radiation pattern 4×1 array [5]

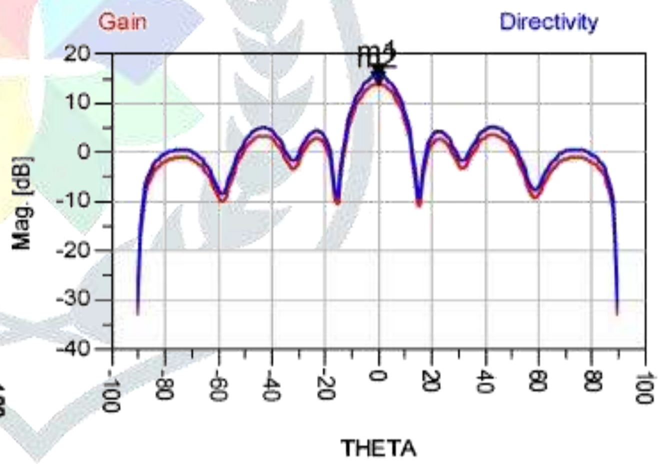

Fig. 5: Radiation pattern 4×2 array [5]

Norfishah Ab Wahab, Zulkifli Bin Maslan, Wan Norsyanfizan W. Muhamad, Norhayati Hamzah presented microstrip 4×1 patch array antenna at 2.5GHz for WiMAX application [6]. Here array antenna used with substrate material FR4 with constant 4.9 and thickness of substrate is 1.6 mm. In this paper, the design of single and four by one patch array microstrip rectangular antennas with microstrip line as feeding method is presented. From CST simulation, the result of gain, directivity, VSWR, return loss is 0.837dB, 5.989dB, 1.414, -15.315dB for single patch antenna respectively while the result of gain, directivity, VSWR, return loss for 4 patch
Array antenna is 5.732dB, 10.25dB, 1.2155, -20.24dB respectively [6].

C. Phased array antenna [7 and 8]

Md. Baskhar, Vani R.M & P.V. Hunagund presented microstrip linear phased array for smart antenna applications [7]. Here 4 patch array antenna is used at 2.7 GHz operating frequency. In this paper beam scanning is achieved by changing the length of transmission line. They found practically that there is an increase in gain by factor 2 with increase in array elements and also demonstrated 5° beam steering of a main beam towards right with L/6 length of transmission line from the first element (5L/6 from second element) [7].

M. U. Afzal, A. A. Qureshi, M. A. Tarar, T. Taqueer modeling and simulation of an X-band planar phased array antenna [8]. In this paper, they proposed beam scanning mechanism which can be achieved by relative phase difference of radiating element. Here 4 array elements at 9 GHz operating frequency are used. If a phase delay of Φ, 2Φ and 3Φ is introduced in second, third and four element, respectively with zero delay in the first element, then the beam will be tilted by an angle θ_s [8]. Beam steering is achieved by sending signals to each antenna element with relative phase difference generated in ADS. When there is no phase difference between the antenna elements, radiation pattern is shown in fig. 6, zero degree tilt. In order to tilt the beam angle 10 degrees to the right, phase difference of 31.26 degree, using this equation (1) which is given below, needs to be added in each consecutive element [8].

$$\Phi = \frac{2\pi d \sin\theta}{\lambda} \qquad (1)$$

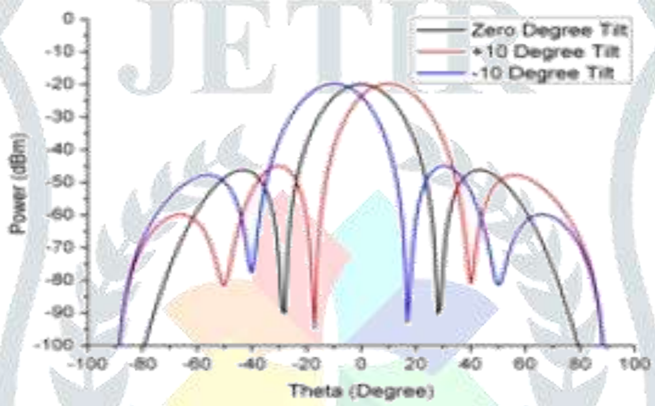

Fig.6: Simulation of beam steering [8]

IV. Conclusion And Future Scope

The research has been motivated by their potential use in future applications in radar communication, satellite communication etc. Conclusion from this study is that desired antenna characteristics may be achieved with single microstrip antenna but in case of conventional microwave antennas, characteristics such as high gain, beam scanning capability are not possible with single microstrip antenna. Thus array antenna is used to overcome the disadvantages of single microstrip antenna.

V. Acknowledgment

I would like to say heartily thanks to Mr. R. K. Malaviya, Ex-Head Antenna division at ISRO, Ahmedabad, India. I would also like to say thanks to Prof. B. G. Upadhyay, professor, S.V.B.I.T. College, E.C. department, Gandhinagar, India. I thank my family and friends who motivated me to complete this work.

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