

Beamsteering of 8x1 Circular Patch Phased Array Antenna at L Band for Airborne Applications

U.Srinivasa Rao

Abstract— This paper presents modelling and simulation of a Microstrip Line Quarter Wave Transformer-fed 8x1 Circular Patch Antenna is presented. The maximum size of proposed array antenna is 900mm x 300mm x 24mm. The substrate material used for this antenna has thickness of 1.588mm and relative permittivity (ϵ_r) is 2.2. The design frequency of the antenna is 2GHz and $VSWR \leq 2$. The proposed antenna is modelled and simulated using ANSOFT HFSS 15.0 version. The gain of this array antenna is 14.11 dB and return loss of -13.5dB. The phased array antenna is steered for 100 , 200 and 300 with the beam width of 13.6 and bandwidth of 57 MHz. These type of antennas are very useful for airborne applications.

Index Terms— Quarter wave Transformer, Circular Patch Antenna, Beamsteering, Gain, Return loss, Beamwidth.

I. INTRODUCTION

Microstrip patch antennas are popular, because they have some advantages due to their conformal and simple planar structure. They allow all the advantages of printed-circuit technology. A vast number of papers are available in the literature, investigating various aspects of microstrip antennas. Development of microstrip antennas was initiated in 1981, where a space-borne, light-weight, and low-profile planar array was needed for a satellite communication system. Since then, the development of the microstrip antenna has been expanded into three major program areas: mobile satellite (MSAT) communication, earth remote sensing, and deep-space exploration.

The term “Microstrip” comes because the thickness of this metallic strip is in micro-meter range. Microstrip patch antennas are popular, because they have some advantages due to their conformal and simple planar structure. They allow all the advantages of printed-circuit technology. Next we describe the procedure for increasing the antenna bandwidth. Finally, the simulated results are described, and it can be used for communication and other applications.

II. DESIGN AND ANALYSIS OF 8X1 CIRCULAR PATCH ARRAY ANTENNA

The array factor for N elements in general is

$$AF = \left[\frac{\sin\left(\frac{N}{2}\psi\right)}{\sin\left(\frac{1}{2}\psi\right)} \right]$$

Where

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$$\psi = kd \cos \theta + \beta |_{\theta=\theta_0} = kd \cos \theta_0 + \beta = 0 \Rightarrow \beta = -kd \cos \theta_0$$

The direction of the major radiation from an array can be controlled by changing the phase excitation between the elements. It is then logical to assume that the maximum radiation can be oriented in any direction to form a scanning array.

To accomplish this, the phase excitation β between the elements must be adjusted. Thus by controlling the progressive phase difference between the elements, the maximum radiation can be squinted in any desired direction to form a scanning array. This is the basic principle of electronic scanning phased array operation. Since in phased array technology the scanning must be continuous, the system should be capable of continuously varying the progressive phase between the elements.

The elements are placed such that the spacing between them is $\lambda/2$. All the elements are fed with the same amplitude and difference in phase. The phased array antenna is steered for 10° , 20° and 30° by changing the progressive phase between the elements .

The structure of modeled and simulated 8X1 circular patch phased array antenna is shown in Fig.1.

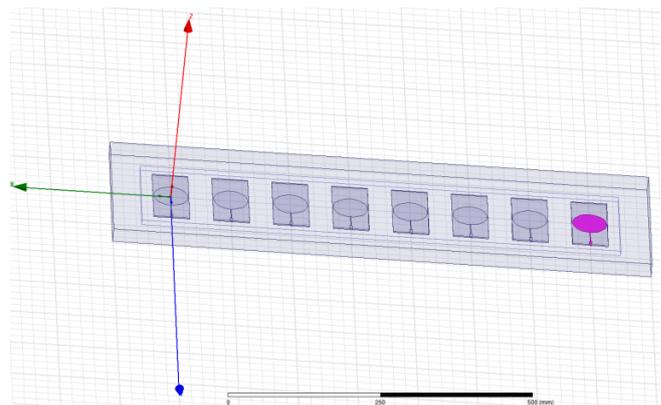


Fig.1. 8X1 circular patch phased array antenna

Return Loss

The amount of power reflected from the antenna input terminal is termed as return loss. The return loss of the proposed antenna at 2GHz is -13.5682dB is shown in Fig.2. The VSWR is referred as Voltage standing wave ratio, is a measure of how effectively antenna impedance is matched to the source impedance. The VSWR of the proposed antenna is 1.5307 as shown in Fig. 3.

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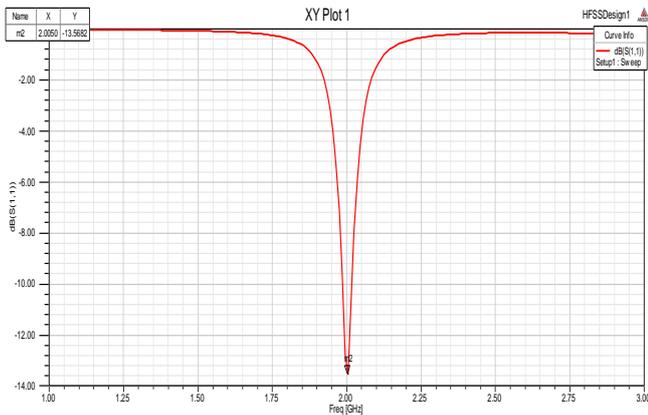


Fig.2. Return loss of the proposed antenna.

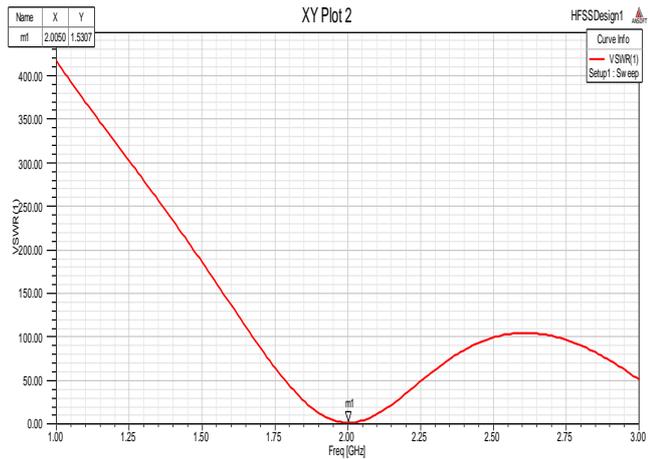


Fig.3. VSWR of the proposed antenna

Bandwidth is the range of frequencies over which antenna works satisfactorily. The Bandwidth of the proposed antenna at 2GHz is 57MHz is shown in Fig. 4.

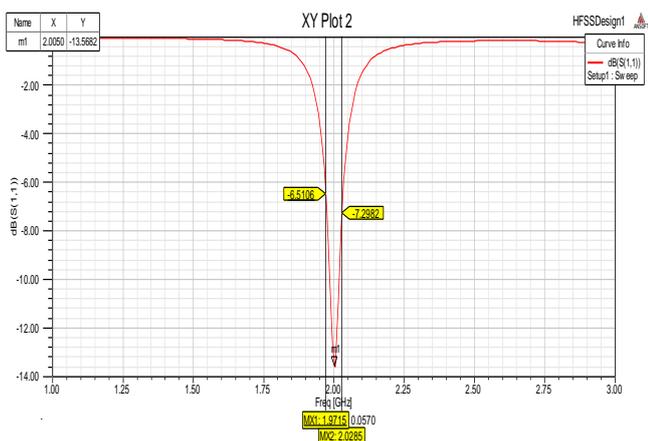


Fig 4. Bandwidth of the proposed antenna

The gain of the antenna is nothing but that is excess power transmitted by the practical antenna compared to the reference antenna that is isotropic antenna. The gain of the array antenna is 14.11 dB is shown in fig 5.

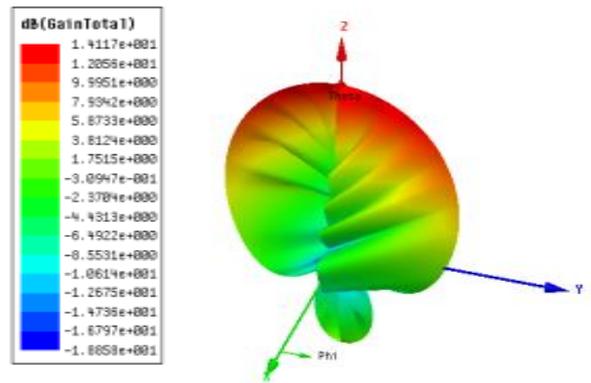


Fig 5. The gain of the array antenna.

The beam width is in general is the HPBW (Half Power Beam Width) & it is angle separation between half power points on the main lobe. The beam widths in elevation and azimuth direction of the proposed array antennas are 13.6° and 70.3° is shown in Fig. 6.

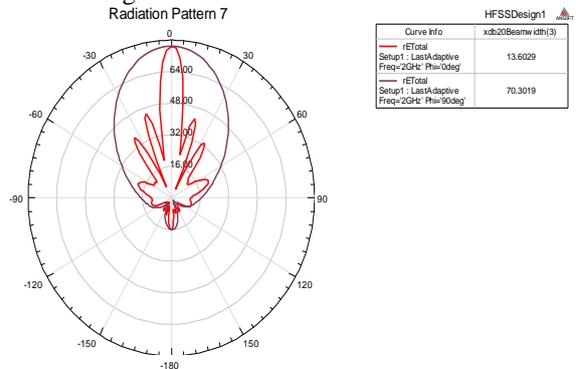


Fig.6. The beamwidths of array antenna.

The gain depends on the radiation efficiency of the antenna. The Radiation efficiency of the proposed antenna is 97.6% as shown in Fig.7.

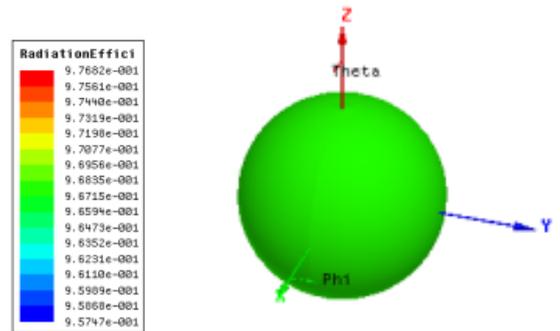


Fig. 7. Radiation efficiency of array antenna

The input impedance should match with the source impedance to minimize return loss and improve efficiency and gain. The input impedance of the proposed array antenna is shown in Fig. 8.

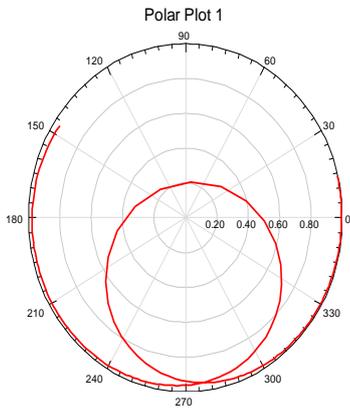


Fig. 8. Input impedance of the array antenna

III. 8X1 CIRCULAR PATCH ARRAY ANTENNA BEAM STEERING

Beam steering is nothing but changing the directions of main lobe of a radiation pattern to achieve better coverage. The direction of the main lobe can be changed simply by varying the phase difference between elements in the array.

The direction of the maximum radiation is steered in polar form at 0° , 10° , 20° and 30° respectively in Fig. 9(a), 9(b), 9(c), 9(d).

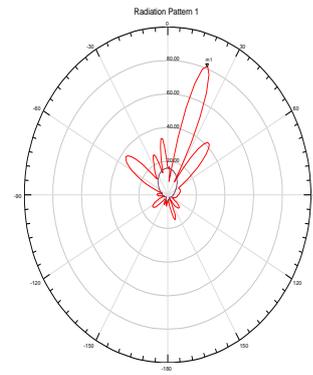


Fig.9(c). Main beam at 20°

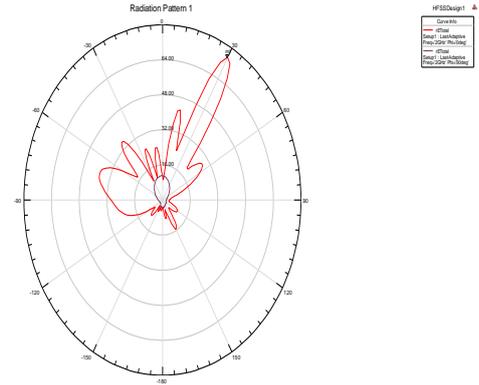


Fig.9(d). Main beam at 30°

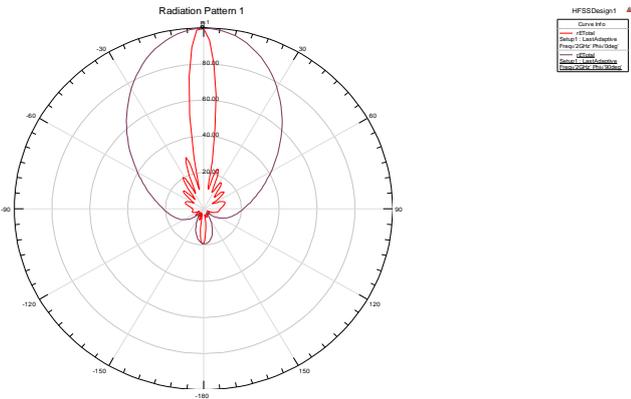


Fig.9(a). Main beam at 0°

Name	Theta	Ang	Mag
m.1	10.0000	10.0000	70.9329

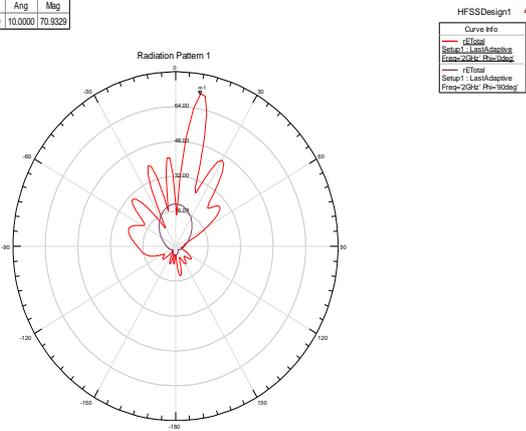


Fig.9(b). Main beam at 10°

The direction of the maximum radiation is steered in rectangular form at 0° , 10° , 20° and 30° respectively in Fig. 10(a), 10(b), 10(c), 10(d).

Rectangular

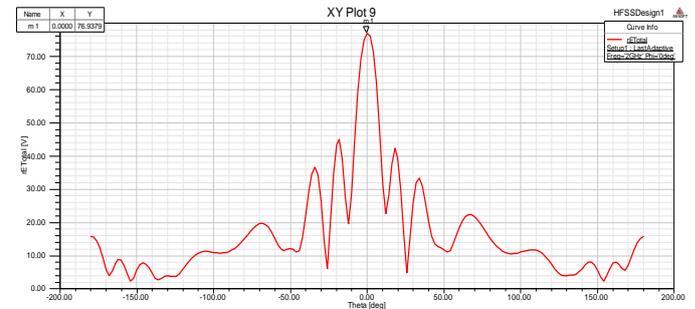


Fig.10(a). Main beam at 0°

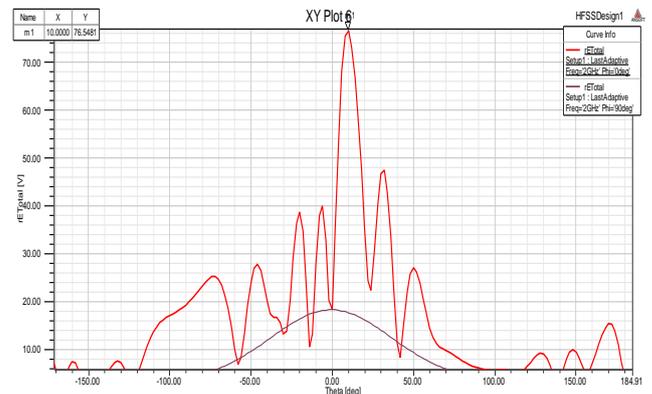


Fig.10(b). Main beam at 10°

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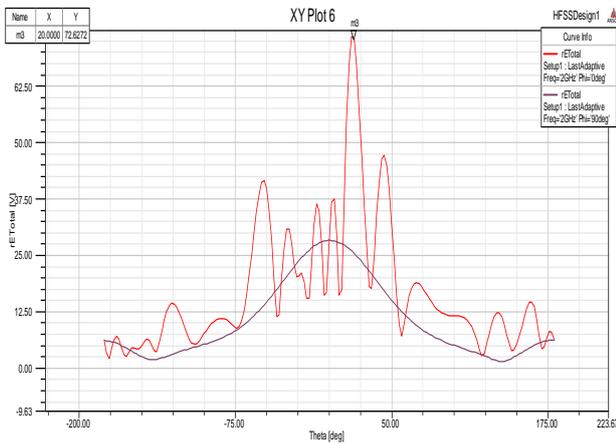


Fig.10(c). Main beam at 20°

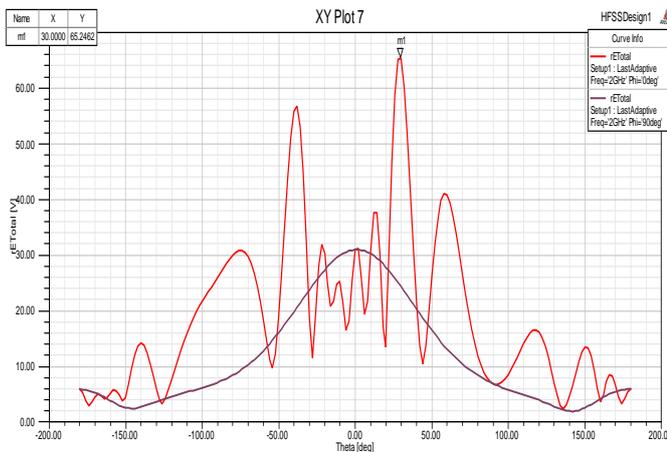


Fig.10 (d). Main beam at 30°

IV. DISCUSSION

The proposed array antenna is successfully modeled and simulated using ANSOFT HFSS 15.0 and the radiation characteristics of the proposed 8X1 circular patch phased array antenna are summarized in the table 1.

Table 1. Radiation characteristics of the proposed antenna

S.No.	Parameter	Value
1	Frequency	2 GHz
2	VSWR	1.5307
3	Return loss	-13.5682 dB
4	Gain	14.11 dB
5	E Theta	13.6°
6	E Pi	70.3°
7	Efficiency	97.68%
8	Bandwidth	57 MHZ

V. CONCLUSION

The proposed 8x1 Circular Patch Phased Array Antenna at L Band is successfully modeled and simulated. The main lobe of the array antenna beam is steered at 0°, 10°, 20° and 30° in both polar and rectangular forms. The radiation characteristics obtained by this proposed 8x1 Circular Patch Phased Array Antenna at L Band is very much useful for air borne applications.



U.Srinivasa Rao obtained his B.Tech degree in Electronics and Communication Engineering from RVR&JC College of Engineering in the year 1997. He received his M.E degree from Osmania University, Hyderabad in 2005. At present, he is pursuing his Ph.D in Acharya Nagarjuna University, Guntur, Andhra Pradesh, India. He is currently working as Associate Professor and Head, Department of ECE in Vignana's Lara institute of Technology and Science, Vadlamudi, Andhra Pradesh, India. He has taught a wide variety of courses for UG students and guided several projects. He is the life member of MISTE. His interested research areas are Microwave antennas, radar and optical communications.