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Performance Improvement of Circular Micro Strip Patch Antenna for C Band Applications

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Abstract – In this paper we have planned a Circular Micro strip Patch Antenna (CMPA) working at 5GHz utilizing FDTD method EM simulation tool – CST Micro wave studio. It depends on FIT strategy (Finite Integral Technique) which manages basic integral equations rather than differential. CMPA is outlined on a FR4 substrate with dielectric consistent εr = 4.4 and height of the substrate is 1.6mm. Antenna attributes, such as, return loss, VSWR, % Band width, directivity, antenna gain and so forth are examined. The planned CMPA indicates better execution as far as return loss, VSWR, Directivity, Gain, Band Width and % band width. Since CMPA is outlined at C band it is appropriate in various satellite communication applications, for example, transponder and so on.

Index Terms – CMPA, CST, FIT, FDTD, Return Loss, VSWR, Directivity and gain.

I. Introduction

Micro strip patch antennas are widely used at micro wave frequencies (f >1). The patch may be in different shapes, but Rectangular Micro Strip patch Antennas (RMPA) and Circular Micro strip Patch Antennas are prevalent because of its simple fabrication, attractive radiation attributes, particularly low cross polarization. The main drawback of CMPA is narrow band width (<2% for single patch) .In the past many techniques are introduced to improve band width such as, using a thick substrate [2], stacked configuration[3], capacitive feed [4], proximity coupling .These methods have achieved only 15-20% improvement. In order to further enhance the bandwidth, a blend of at least two of these techniques might be utilized which prompts an expansion in bandwidth. CMPA consists of a circular patch of radius (r=8.5mm) on a FR-4 substrate of a thickness (t=1.6) with a dielectric constant (εr=4.4), the lower order modes of this type of micro strip patch are $TM_{11}, TM_{21}, TM_{31}, TM_{01}$.

The CMPA design is based on the derivative of Bessel function, shown in Fig 1, with the orders 0 to 5 each order is indicated by a different color, each intersection of the curve with the x-axis gave a value of this intersection represent a mode, if order 1 was taken as an example, so the first intersection is TM_{11} , and the second intersection is $TM_{12}$and so on. The resonance frequency and radius of a circular antenna are calculated as discussed in [1], [5].

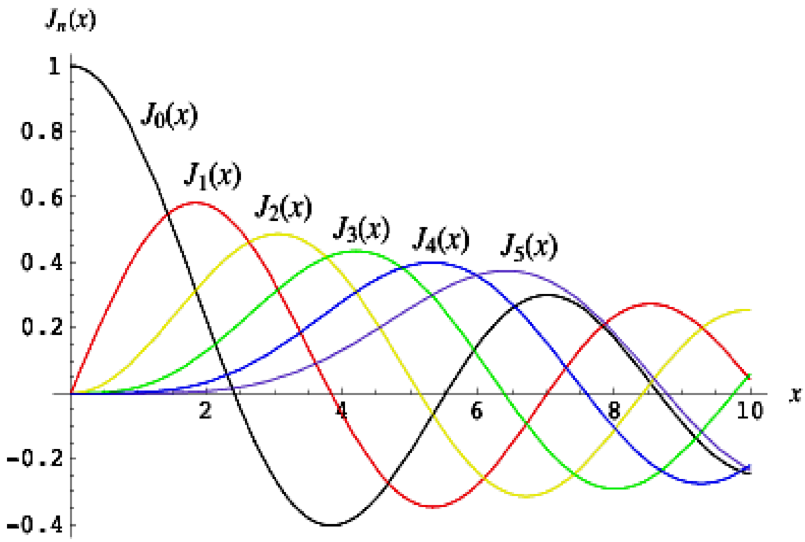

Fig 1. Derivative of Bessel function

II. ELECTROMAGNETIC SIMULATION

The CMPA is designed on a FR4 substrate with a dielectric constant, εr = 4.4 and height of the substrate h = 1.6mm at an operating frequency of 5GHz. For designing patch and ground Perfect Electric Conductor (PEC) is used with bulk conductivity equal to 5.8×107siemens/m. The CMPA is designed and simulated using CST microwave studio, which works on the principle of FTDT .The radius of CMPA, a = 8.56mm. A FR4 substrate of dimensions 30mm×30mm is taken. The depth (L) and width (W) of the inset are taken as 7.4mm and 3.6mm respectively. A 50Ω impedance micro strip line is used to feed the circular patch. The length of the feed line is 15.53mm and the width of the line taken is 3mm. For exciting the circular patch a wave guide port is used. The parameters of the antenna are calculated according to [1], [5]. The CMPA model designed in CST tool is shown in Fig 2.

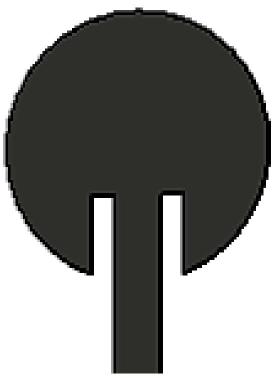

Fig 2. CMPA model designed in CST (design 1)

Design parameters:

radius (a) : 8.5mm
frequency f: 5 GHz

Substrate dimension(W, L, h) : $30mm * 30mm * 1.6mm$
ground plane dimension (W, L, h): $30mm * 30mm * 0.02mm$
Inset length (L) and Width (W): $7.4mm * 3.6mm$:
Length and width of feed line ($L * W$): $15.53mm * 3mm$

In this work we have taken [1] as reference and its performance is compared with designed antennas .To improve the performance of CMPA we have designed two more antennas as follows

Design 1:

In order to increase the bandwidth , micro strip feeding is provided in different locations on an error and correction based method .optimal result is obtained by optimizing feed position .Optimized micro strip feed location is provided in between -1.5 and 1.5 (3mm width)and length is 12mm (from -3 mm to -15mm)

Design 2:

In second case a circular 2×1 patch array is designed with corporate feed as shown in Fig 3.

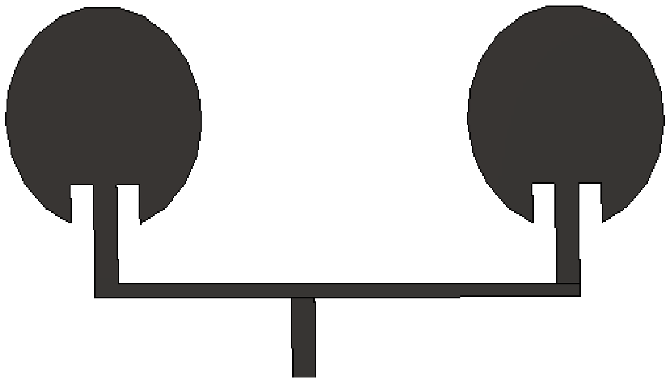

Fig 3. Circular 2×1 patch array wit corporate feed

III. RESULTS

Fig 4. Shows the return loss of the single CMPA (method-1), .i.e. -13.01dB and bandwidth is 204 MHz (which is 4.10% with respect to the resonance frequency). Fig 5 indicates the VSWR of method 1 i.e. 1.57. Fig 6, Fig 7 and Fig 8 represents gain, directivity and radiation pattern (at phi-90) for method-1.In method 1 3.92dB gain and 6.51dBi directivity is achieved. In this method we have improved gain by 1.26 dB, directivity by 2.01 and band width by 0.31%

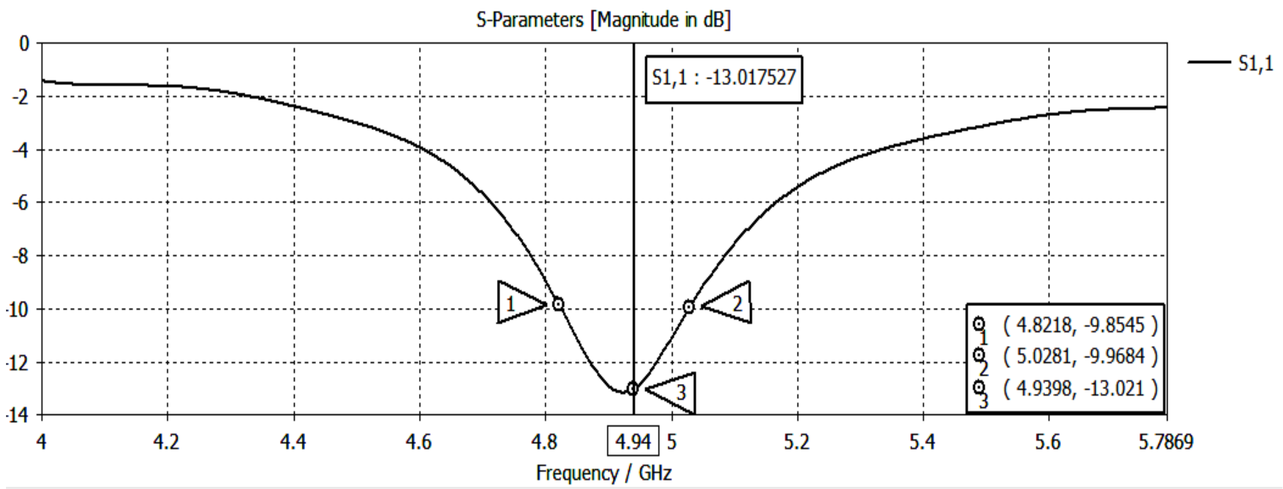

Fig 4. Return loss of method -1

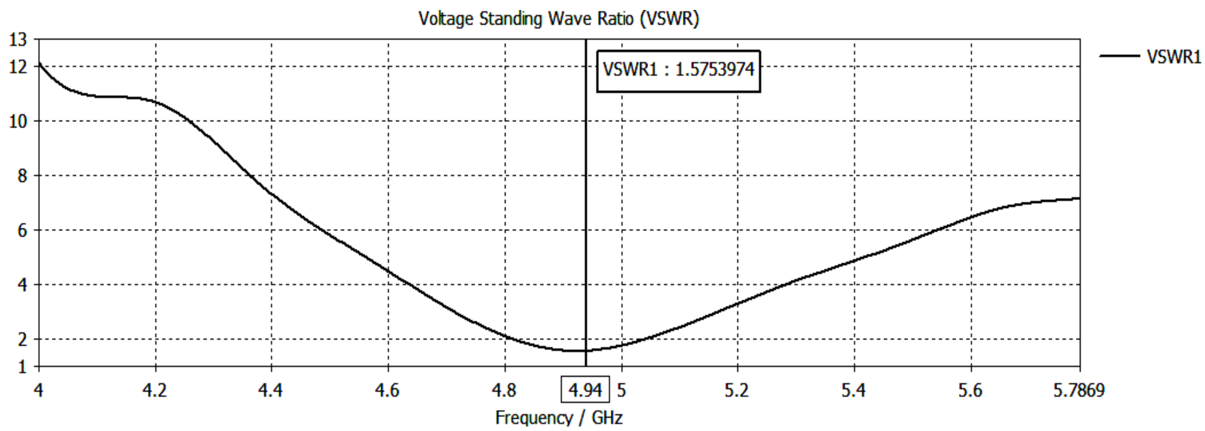

Fig 5. VSWR of method 1

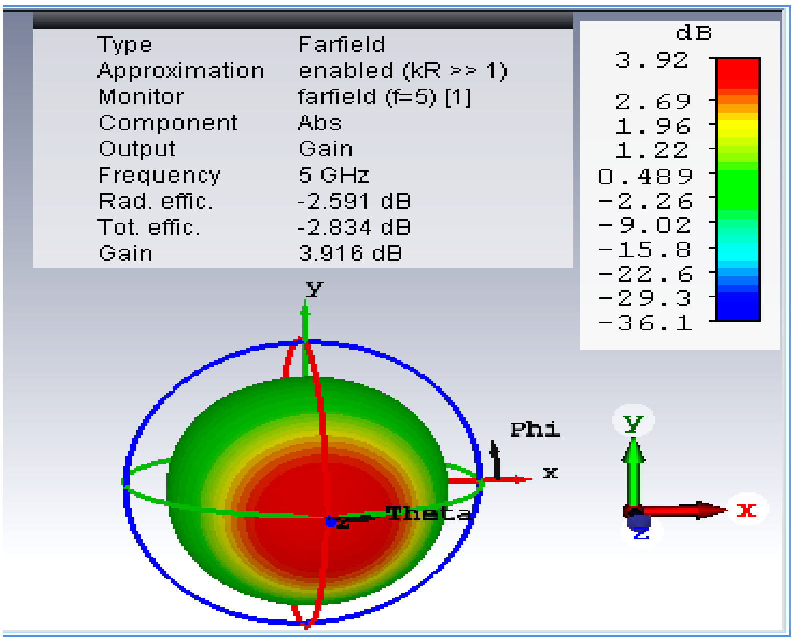

Fig 6. Gain of method 1

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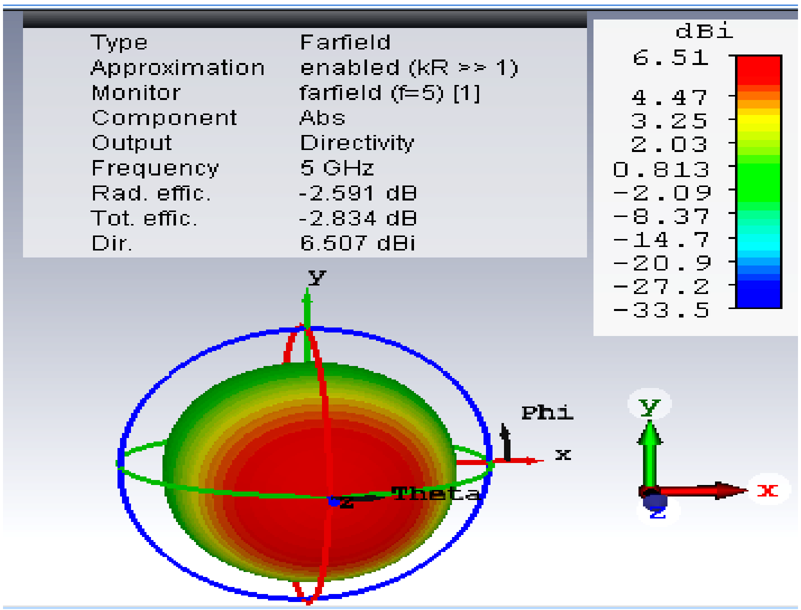

Fig 7. Directivity of method 1

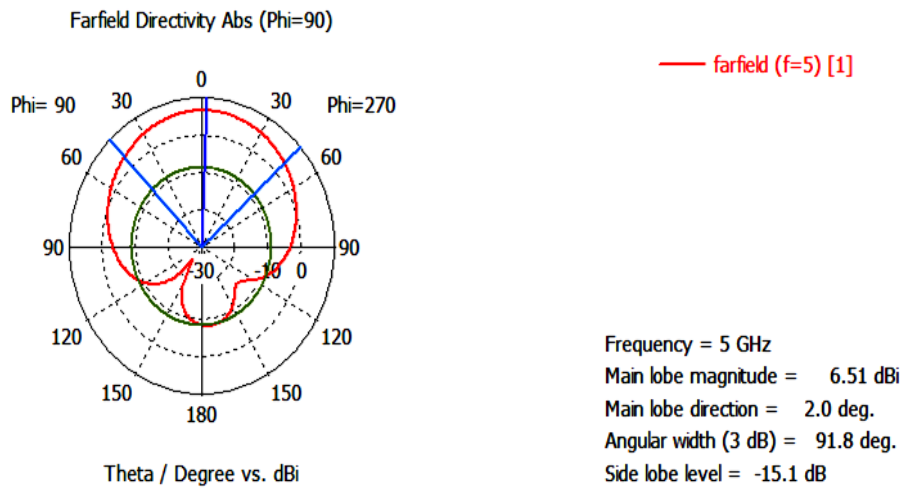

Fig 8. Antenna radiation pattern at phi-90 (method -1)

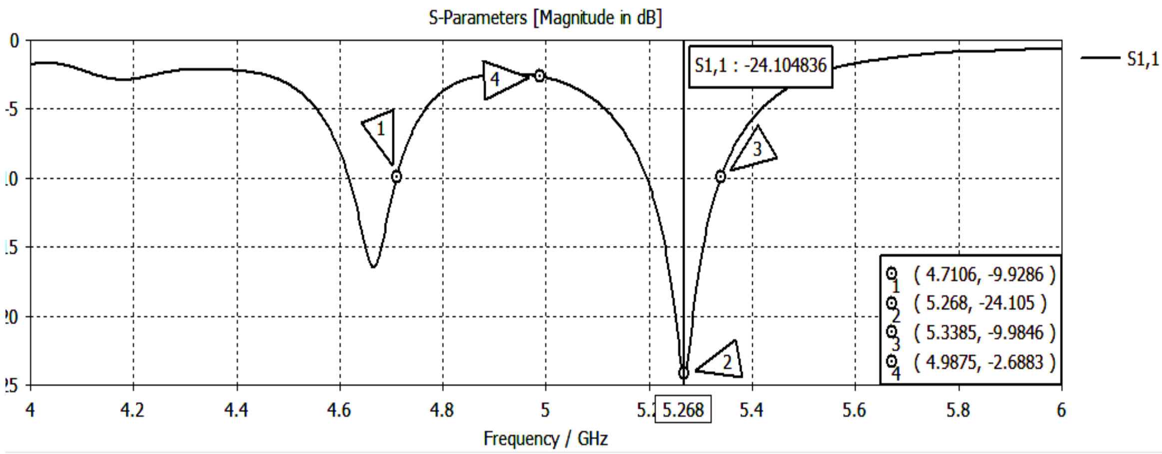

Fig 9. Return loss of method-2

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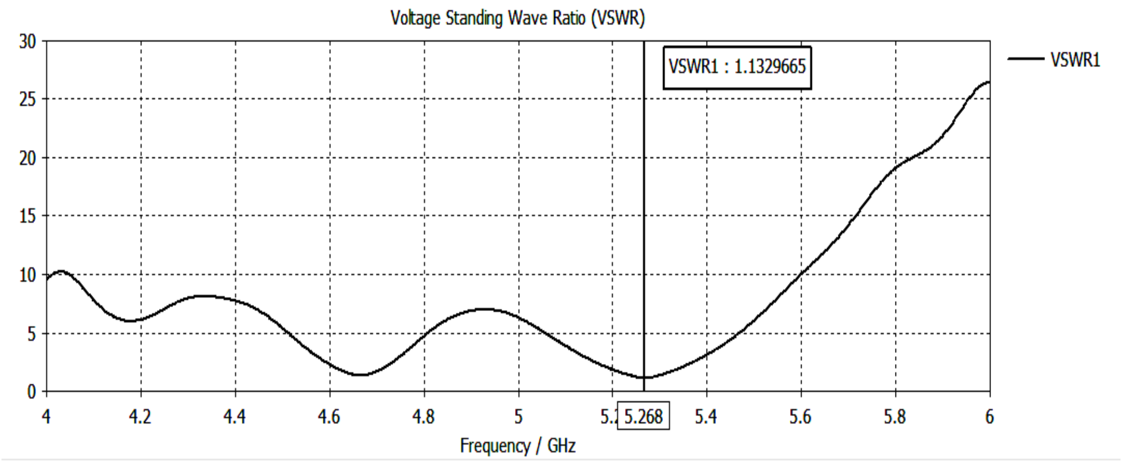

Fig 10. VSWR of method-2

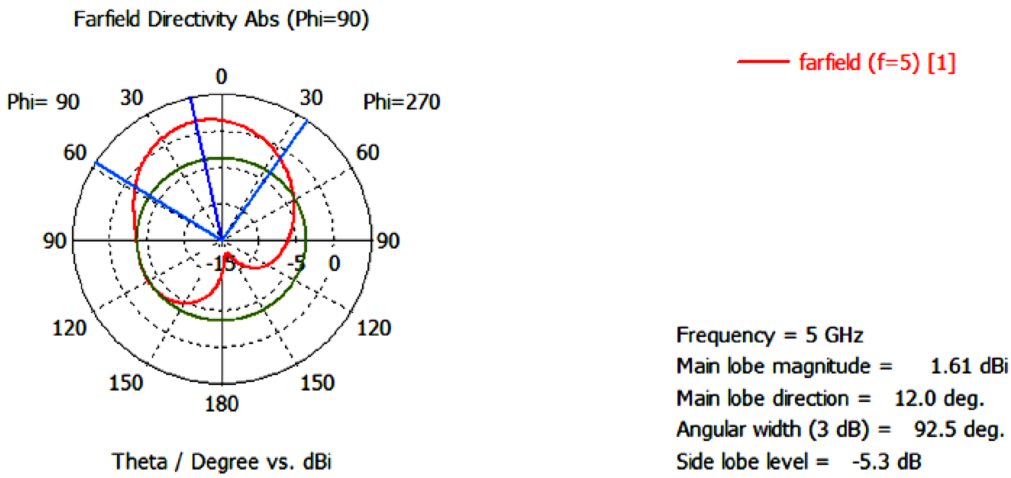

Fig 11. Antenna radiation pattern at phi-90 (method -2)

Fig 9 shows the return loss of the single CMPA (method-2), i.e. -24.01dB and bandwidth is 628 MHz (which is 12.49% with respect to reference antenna). Fig 10. indicates the VSWR of method 2 .i.e. 1.13. Fig 11 shows the radiation pattern (at phi-90) for method-2.In this method 7.8 dB gain and 7.6 dBi directivity is achieved.

TABLE 1. PERFORMANCE COMPARISON OF REFERENCE ANTENNA, METHOD-1 AND METHOD

	RL (dB)	VSWR	Gain (dB)	Directivity (dBi)	Band width(MHz)	% B.W
Reference paper	-30	1.6	2.66	4.5	190.5	3.79
Design 1	-13	1.5	3.92	6.51	204	4.10
Design 2	-24.10	1.13	7.8	7.6	628	12.49

In reference antenna return loss is -30dB, it is for better than method 1 and method 2, but it is still less than -10dB.VSWR is improved in designed antennas in comparison to reference antenna. In design 2 VSWR is close to 1.The improvement of gain in design 1 and design 2 is

1.5 times and 2.93 times to reference antenna. The improvement of directivity in design 1 and design 2 is 1.44 times and 1.68 times in comparison to reference antenna .Band width is 1.07 times (design 1) and 3.29 times (design 2) with respect to reference antenna. Percentage band width is 1.08 times (design 1) and 3.29 times (design2) with respect to reference antenna .The gain of design 2 is 1.98 times and directivity is 1.16 times to design 1.band width of design 2 is 3.07 times to design 1 .

IV. CONCLUSION

In this paper, we have design CMPA at c band frequency region. The simulated results of CMPA shows good directivity and gain value. The directivity and gain for the Circular 2 × 1 patch array with corporate feed is47.6 dBi and 7.8dBi respectively and a % band width is 12.49 %. The high return loss value gives perfect impedance matching between patch and feed. Although, this circular patch antenna may find applications in C-band satellite communication applications such as transponders. Applying different circular patch arrays we may further improve gain, directivity and percentage of band width

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