Design and Investigation of Circular Polarized Rectangular Patch Antenna

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ABSTRACT: ***Microstrip patch antennas represent one family of compact antennas that offer a conformal nature and the capability of ready integration with communication system's printed circuitry. In this project, a 2.4 GHz circular polarization microstrip antenna is designed, constructed and measured. The microstrip antenna chose is a dual –fed circular polarized microstrip antenna. The antenna consists of rectangular patch and 3 dB hybrid. The dual – fed circular polarized microstrip antenna is etched on a FR4 with dielectric substrate of 4.5 with the height of 1.6 mm. Circular polarization is obtained when two orthogonal modes are equally excited with 90° phase difference between them. Circular polarization is important because regardless of the receiver orientation, it will always able receiving a component of the signal. This is due to the resulting wave having an angular variation.***

Index Terms—**Microstrip Patch Antenna, Orthogonal Modes, and Circular Polarization.**

I. INTRODUCTION

At present wireless and microwave communication is dominating day by day.In microwave communication microstrip patch antenna technology is one of the rapid progressing communication field and which was started in mid 1970-80s. Basic microstrip antenna elements, arrays and polarization concept was well developed in form of design and modeling in the early 1980s [1]. In the last 10 years printed antennas/software based antenna have been largely researched/studied due to reduced size, their advantages over other radiating systems, such as very light weight, less expensive, both conformability and possibility of integration with both active and passive devices.

Therefore, this project work is aimed to design a circularly polarized antenna at 2.4 GHz. The best thing of circular polarization is no particular orientation i.e. in any orientation it will always receive a component of the signal. This is due to the producing or resulting wave having an circular variation [2].

This microstrip patch antenna has a radiating patch on the dielectric substrate. There are many shapes that can be used for radiating patch. However, for this project, we will select square patch with 3 dB hybrid With two orthogonal modes and dual feeding methods are equally excited with 90° phase difference between them, as a result antenna will act as polarize circularly.

The microstrip antenna is tested and simulated using Microwave Office v15, where different tools will be used e.g elecromagnetic analysis tools.

This microwave patch antenna will be fabricated and tested with network analyzer also. Both results will be compared i.e simulated and measured results.

II. DESIGNED ANTENNA

In order to ease the processes of designing the microstrip antenna, the project is split into subtask, which allowed for achievable short term goals. The flow chart as in Figure 1, explains the process.

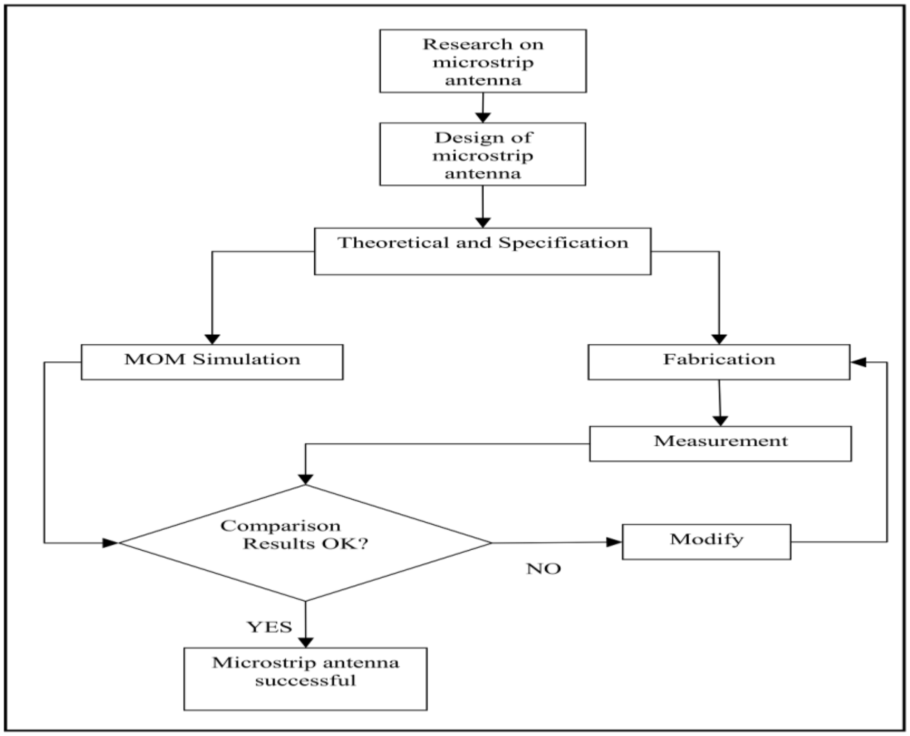

Figure 1: Design Flow Chart

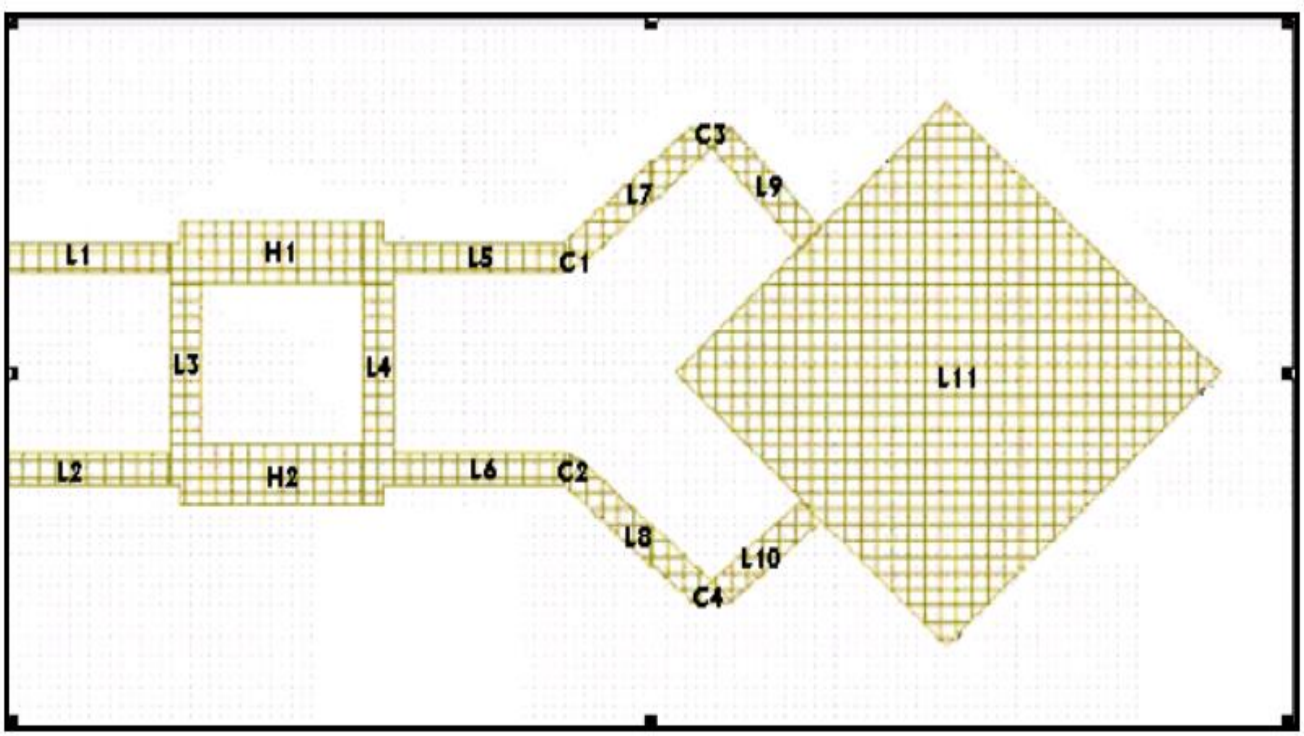

Figure 2: Layout of the Microstrip Patch Antenna

The microstrip antenna is designed by referring to the specifications as shown in the Table 1 below.

Table 1: Performance of microstrip antenna

Performance	
Frequency	2.4 GHz
VSWR	1.5:1
Beamwidt h Azimuth Zenith	 <100 <100
Gain	6 – 20 dBi
Polarization	Circular

For FR4 (εr = 4.5) and height (h) of 1.6mm, the overall value for the design antenna is as shown in Figure 2 and Table 1.

Then, the schematic diagram of the antenna is drawn by using the Microwave Office software. Figure 3 shows the schematic diagram for the designed microstrip patch antenna.

III. SIMULATION RESULTS

The return loss of the antenna can be obtained from the simulation process.Figure 5.5 shows that the return loss obtained is -23.25 dB at 2.474 GHz.The return loss also shows that only 0.47% power is reflected and 99.53% power is transmitted. The bandwidth can also be obtained from Figure 5.5. Formula for finding a bandwidth is as shown below:

$$\text{Bandwidrh} = \{(f_1 - f_2)/(f_1 f_2)^{1/2}\}\text{x}100\ \% \qquad (1)$$

The value of *f2* and *f1* are taken 10% of power transmitted, or at 10 dB as shown in Figure 5.5.
The value of *f2* and *f1* are taken 10% of power transmitted, or at 10 dB as shown in Figure 4.

VSWR or Voltage Wave Standing Ratio occurs when there is mismatched impedance (resistance to current flow, measured in Ohms) between devices in a RF system. Figure 5 show that VSWR for the antenna is 1.184 dB. Thus, VSWR value for this antenna is 1.2:1. This considers a good value as the level of mismatched is not very high. High VSWR means that the port is not properly matched.

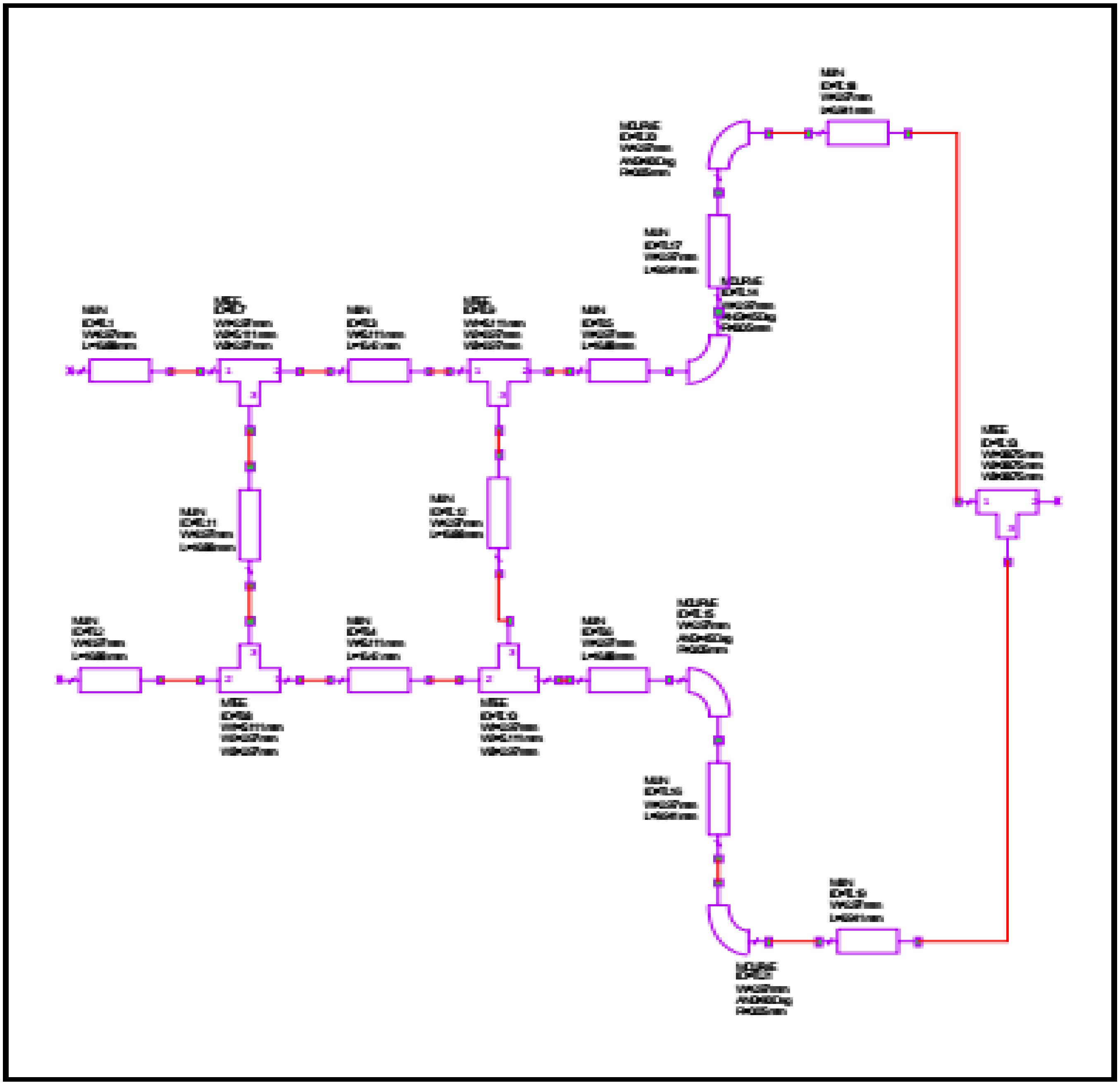

Figure 3: Schematic Diagram of the Antenna

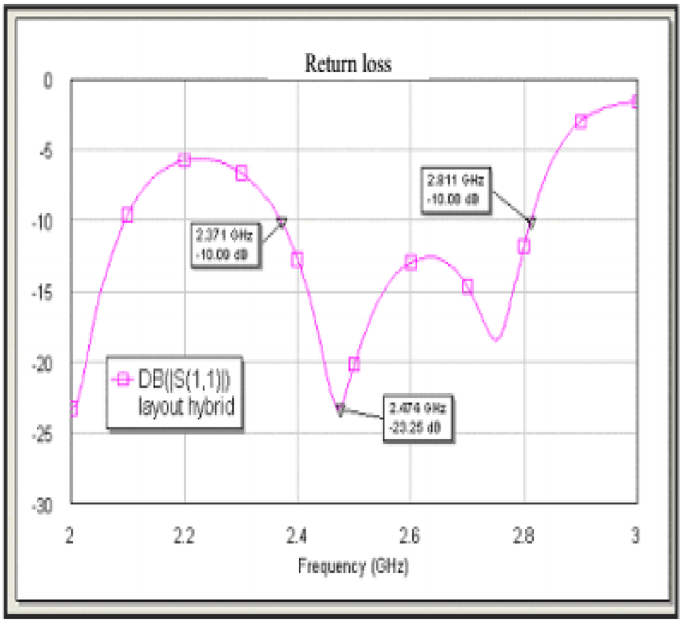

Figure 4: Return loss of the microstrip patch antenna

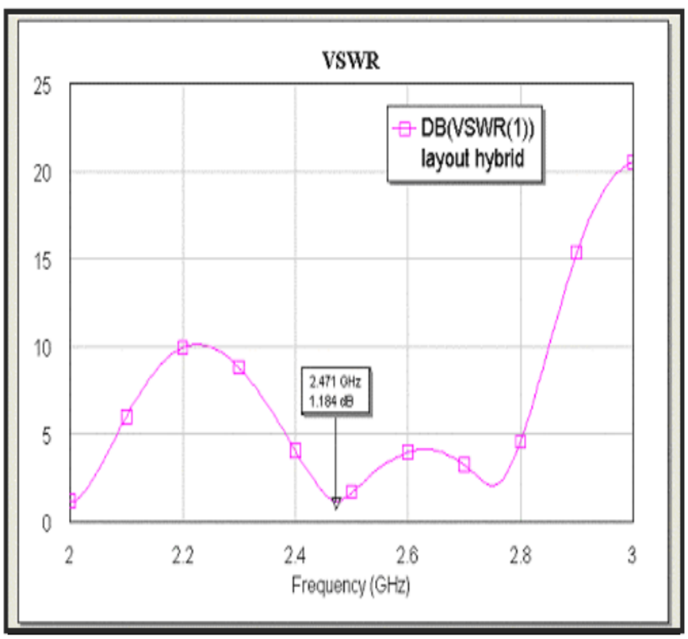

Figure 5: VSWR for the antenna

Radiation pattern of the microstrip antenna is as shown in Figure 6. From the graph, the maximum radiation occurs at -40° with gain of 4.28 dB.

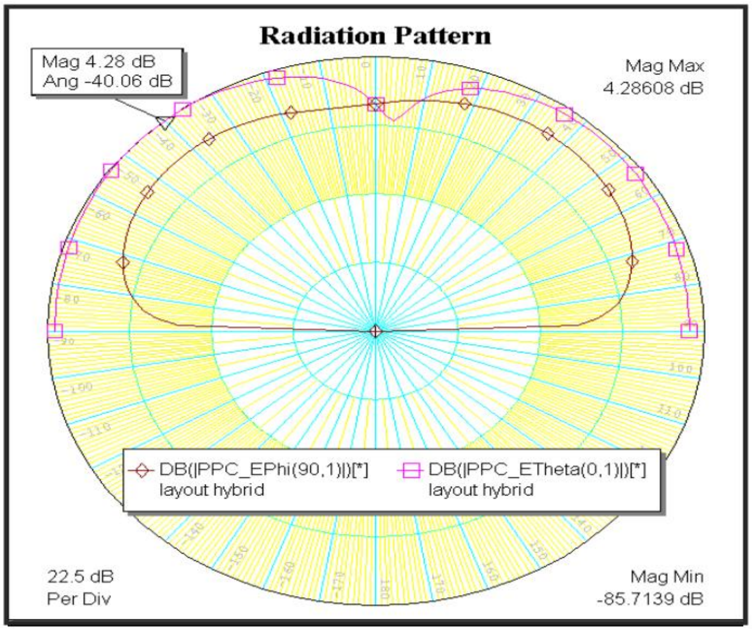

Figure 6: Radiation pattern

From the radiation pattern, the normalized value of the radiation pattern will give half power beamwidth value. Half power beamwidth is a measurement of angular spread of the radiated energy. By adding the values at 3 dB, the half power beamwidth of the antenna can be obtained. From Figure 7, the values at 3dB are 16.99° and 28.91°. Thus, the half power beamwidth of this microstrip patch antenna is 45.9°.

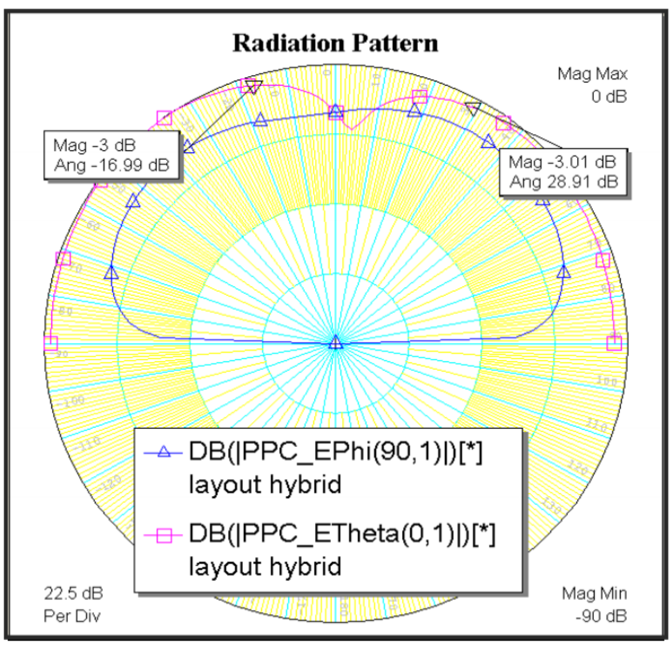

Figure 7: Half power beamwidth

A circular polarized wave radiates energy in both the horizontal and vertical planes and all planes in between. The difference between the maximum and minimum peaks as the antenna is rotated through all angles is called the axial ratio or ellipticity and usually specified in decibels (dB). If the axial ratio is near 0 dB, the antenna is said to be circular polarized. If the axial ratio is greater than 1 – 2 dB, the polarization is often referred to as elliptical [10].

To be able to obtain the axial ratio, the values of Left hand circular polarized (as shown in Figure 8) and values of Right hand circular polarized (as shown in Figure 9) are tabulated. By using Microsoft Excel software, the axial ratio is calculated. The formula of axial ratio is given as:

$$Axial\ Ratio = \left| \frac{E_{RHCP} + E_{LHCP}}{E_{RHCP} - E_{LHCP}} \right| \quad (2)$$

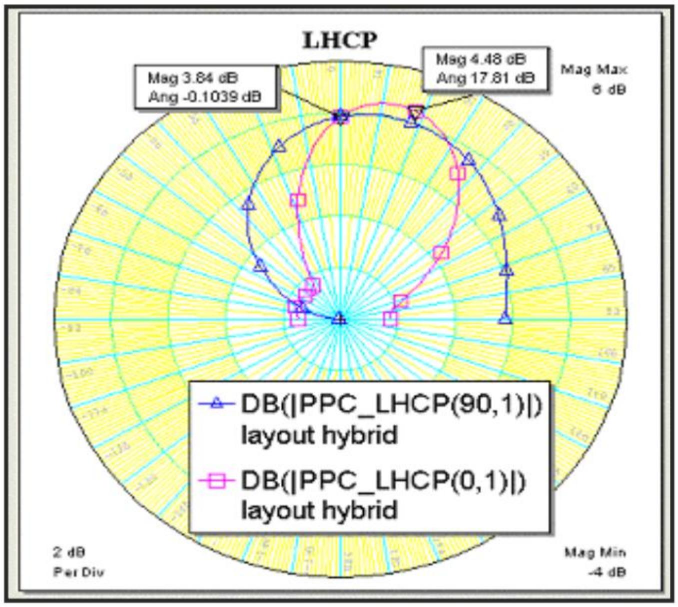

Figure 8: Left hand circular polarization

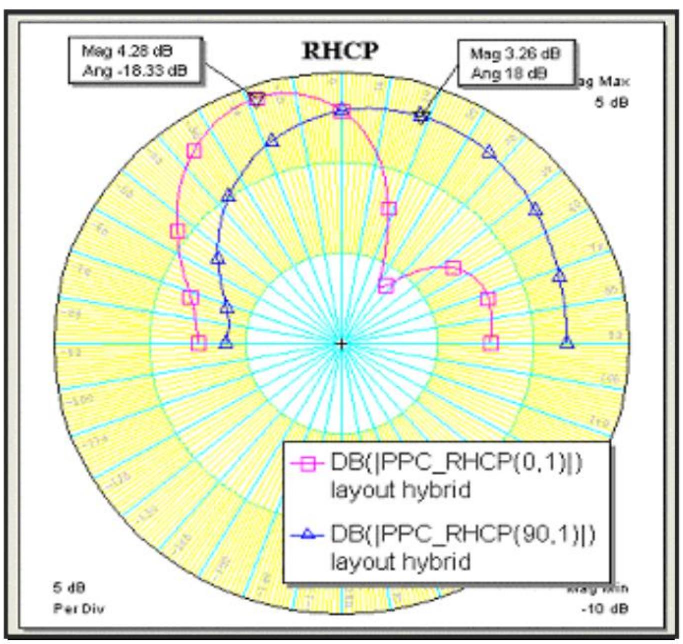

Figure 9: Right hand circular polarization

As can be seen in Figure 10, at most of the angles, the axial ratio is 0 dB. 0 dB means that the polarization is said to be circular. Please refer to Appendix A for the calculated values of axial ratio.

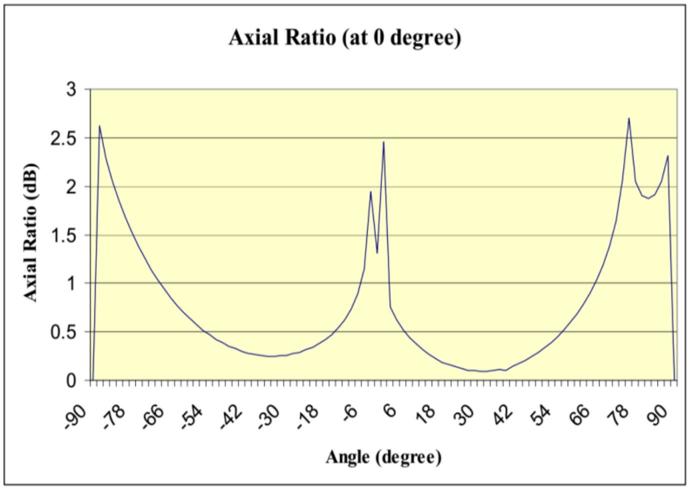

Figure 10: Axial ratio for the microstrip antenna

IV. CONCLUSION

There is various type of microstrip antenna that is able to excite a circular polarization. For this project, dual –fed circular polarization microstrip antenna is chosen. The microstrip antenna is design to operate at 2.4 GHz frequency. The dual –fed circular polarization microstrip antenna is successfully implemented and fabricated. The microstrip antenna resonates at 2.47 GHz and gives a good return loss, which is -23.25 dB. This is a good value because only 0.47 % power is reflected and 99.53 % power is transmitted. The VSWR of the microstrip antenna is 1.2:1, which shows that the level of mismatched for the microstrip antenna is not very high. High VSWR means that the port is not properly matched. The bandwidth of this microstrip antenna is also good, which is 17.04 % and the maximum radiation occurs at -40° with gain of 4.28 dB. The microstrip antenna is said to be circular if the axial ratio is 0 dB. From the calculation of axial ratio, most of the angles give 0 dB value, thus prove that the microstrip antenna polarize circularly.

The results are obtained from simulation and measurement. Firstly all the vakues that obtained from the calculations for the width and length of dual fed cicularly polarization is tabulated.

Then from the simulation by Microwave Office software, the schematic diagram, as well as the 2D and 3D view of the dual –fed circular polarization microstrip antenna are shown. The values for return loss, bandwidths, VSWR are obtained and shown in this chapter, as well as the radiation pattern and axial ratio for this dual –fed circular polarization microstrip antenna. Finally, measurement is done and comparison between simulated and measured value is compared and contrasted.

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