Design of Circularly Polarized Rectangular Patch Antenna with single cut

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Abstract

The focus of this paper is on our contributions towards Single feed circularly polarized antennas. Single feed circularly polarized antennas are currently receiving much attention. Circular polarization is beneficial because current and future commercial and military applications require the additional design freedom of not requiring alignment of the electric field vector at the receiving and transmitting locations. A single feed allows a reduction in the complexity, weight and RF loss of any array feed and is desirable in situations where it is difficult to accommodate dual orthogonal feeds with a power divider network. Circularly polarized micro strip antennas have the additional advantage of small size, weight, suitability in confirm mounting and compatibility with microwave and millimeter wave integrated circuits, and monolithic microwave integrated circuits (MMICS).

Index Terms - Axial ratio, Circular polarization, Micro strip antennas, Single feed.

1. Introduction

If the electric-field vector at a given point in space, traces a circle as a function of time, we are talking about that the time-harmonic wave is circularly polarized. The conditions to accomplish this are if the electric field vector possesses all of

the following:

1. The field must have two orthogonal linear components.

2. The two components must have the same magnitude.

3. The two components must have a time-phase difference of odd multiples of 90^0.

These three characteristics must be met at all times.

Conventional designs of single-feed micro strip antennas for circular polarization (CP) are usually achieved by truncating patch corners of a square patch, using nearly square or nearly circular patches, cutting a diagonal slot in the square or circular patches, protruding or inserting a pair of symmetric perturbation elements at the boundary of a circular patch [1], [2]. Recently, CP operation of single-feed triangular microstrip antennas using a nearly equilateral triangular patch [3], an equilateral triangular patch with an inserted slit [4] or a tip-truncated equilateral triangular patch [5] has also been reported and, due to their physically smaller patch size as compared to the square or circular micro strip antennas, such circularly polarized triangular micro strip antennas are suitable for applications in systems where limited realty space is available.

Also, it is noted that the related CP designs of micro strip antennas are mainly on square, circular, and triangular micro strip patches. Relatively very few CP designs using an annular-ring micro strip patch are available in the open literature. Various perturbation techniques for generating CP have been reported in literature [6], which operate on the same principle of detuning degenerate modes of a symmetrical patch by perturbation segments.

2. Circularly Polarized Rectangular Patch Antenna

2.1 Design Procedure for CP Patch with a Single-Point Feed

- ➢ 1. Determine the unloaded Q_0 of the patch, which depends on dimensions a, substrate thickness t, and the substrate dielectric constant ε_r. For better accuracy Q_0 should be selected to ensure the patch radiation efficiency $\eta > 90\%$.
- ➢ 2. Determine the amount of perturbation ($\Delta S/S$) for the type A.
- ➢ 3. The location of the feed point on the axis can be selected to provide a good match; alternatively a quarter-wavelength transformer can be used for matching purpose.
- ➢ 4. Depending on whether each type of the antenna is type A the sense of CP can be changed by switching the feed axis.
- ➢ Q is the quality factor. Where the four terms, right of the equal mark, represent the quality factor due to Radiation loss, dielectric Loss, Conductor loss, surface wave loss respectively. But Q is equals to Q_r. Because Q_d , Q_c , Q_s are much bigger than Q_r.

3. Antenna Structure

The geometry of rectangular patch antenna is shown in figure 5.1.The centre frequency of antenna designed at 16GHz. The antenna is made up of a 15µm thick copper with width W = 6.19392 and length L = 7.41159 which is located height at 0.254mm above the ground plane. The substrate for the patch is taken as Rogers RT/duroid 5880(tm) with a dielectric constant $\varepsilon_r = 2.2$ and loss tangent is $\tan\delta = 0.0013$.Feeding is done through edge feeding. Theoretical value of corner cutting edge is 2.58mm for 16GHz.

Design steps and specifications:

- Operating Frequency :16 GHz
- Length :6.19392 mm
- Width :7.41159 mm
- Inset Width :1.00 mm
- Inset Length :2.1720 mm
- Transmission Feed line :50 Ohms
- Width :0.78263 mm
- Length :3.42674 mm
- Rogers RT/duroid 5880(tm)

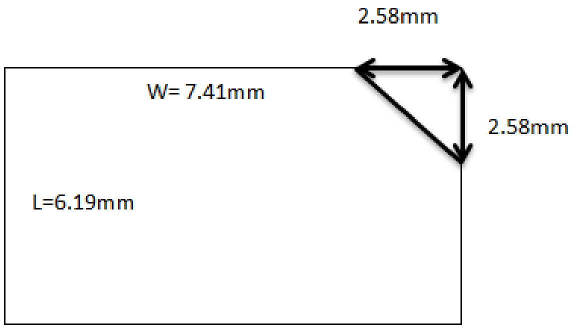

Fig.1: Structure of antenna for CP

4. Simulation Results

4.1 Return Loss:

Return loss variation with frequency for rectangular patch is shown in figure 2.The antenna is resonating 16.25GHz with return loss of -16.5db.

4.2 Axial ratio versus Frequency

The axial ratio is a very important parameter that helps to quantify the polarization of an antenna. The axial ratio of a wave elliptically polarized, is the relationship between major and minor axes of the ellipse, and it can take values among one and infinity.[10] For an antenna that has a purely linear polarization, the axial ratio tends to infinity because one of the components of electric field is zero.

For antennas that have perfect circular polarization, the axial ratio is 1 (or 0 dB), because you have electric field components of the same magnitude, if it is an antenna with elliptical polarization, the axial ratio is greater than 1.Axial ratio versus frequency for rectangular patch is shown in figure 3. The value of axial ratio is 0.15db.The simulated result with different cut for circular polarization is also shown in the table 1.

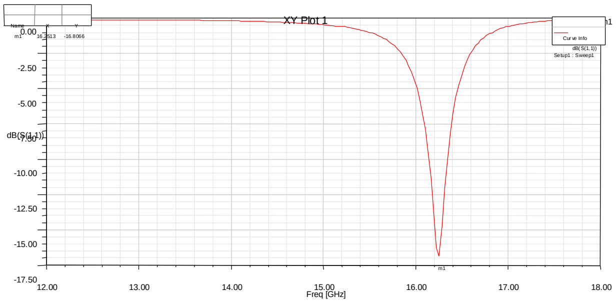

Fig. 2: Simulated result for return loss versus frequency for circular polarized antenna

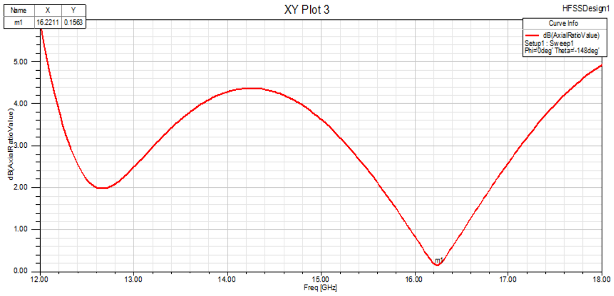

Fig. 3: Axial ratio versus frequency

Table 1 Summary of results for all cutting length for CP

Cutting Length (mm)	Frequency (GHz)	S_{11} (db)	Axial Ratio (db)
0.5	15.91	-32.88	2.2419
1.0	16	-28.89	2.0729
1.5	16.10	-22.90	1.2070
2.0	16.19	-19.24	0.3315
2.4	16.21	-17.47	0.2216
2.5	**16.25**	**-16.80**	**0.1563**
2.6	16.25	-16.12	0.7678
3.0	16.28	-15.03	0.9522

5. Radiation Pattern

The radiation pattern is the spatial distribution of a quantity that characterizes the electromagnetic field generated by an antenna. This distribution can be expressed as a mathematical function or as graphical representation [8]. Most of the time, the radiation pattern, is determined in the far-field region and is usually represented with the spherical coordinate system [9].Gain and directivity of antenna is shown in the figure 4 and 5.

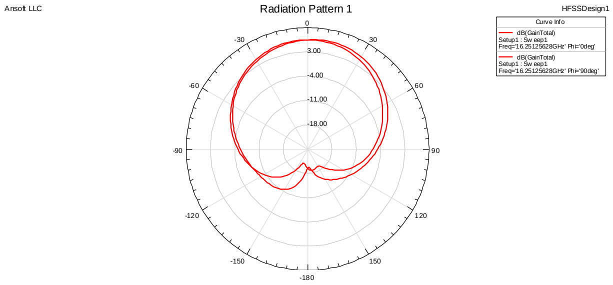

Fig. 4: Gain of the antenna

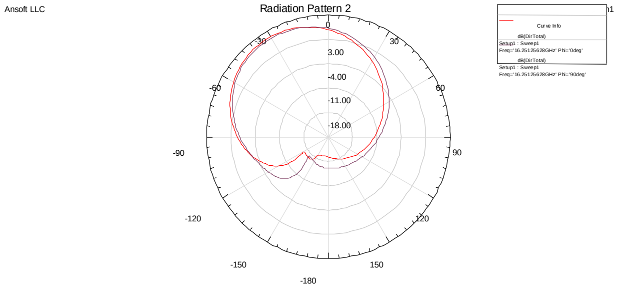

Fig. 5: Directivity of the antenna

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