Comparative Analysis of Microstrip Patch Antenna With Different Feeding Techniques

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ABSTRACT
A single band microstrip patch antenna for wireless communication is presented. In this paper, direct microstrip line feed and coaxial feed techniques are integrated. This antenna offers low profile, narrow bandwidth, high gain, and compact antenna element. In this paper we compare the feeding techniques and we should proved that the coaxial feeding is better impedance matching technique than microstrip line feeding to improve the gain, return loss and bandwidth. The IE3D software, which is a method of moment (MoM) based software used to find output parameter results.

General Terms
VSWR, Return loss, Elevation Pattern Gain Display.

Keywords
Single Band E-Shaped, Microstrip Line feed, Coaxial Probe feed, Microstrip Patch Antenna, IE3D tool.

1. INTRODUCTION
Due to their many attractive features, microstrip antenna has drawn the attention of researchers over the past work [1-3]. Microstrip antennas are used in an increasing number of applications, ranging from biomedical diagnosis to wireless communications [4]. These wide ranges of applications, coupled with the fact that microstrip patch structures are relatively easy to manufacture, have turned microstrip analysis into an extensive research problem. Research on microstrip antenna in the 21st century aims at size reduction, increasing gain, wide bandwidth, multiple functionality and system-level integration. Significant research work has been reported on increasing the gain and bandwidth of microstrip antennas. Many techniques have been suggested for achieving wide bandwidth [5-6]. In this paper, an attempt has been made to design a single band microstrip antenna without any geometrical complexities.

With the wide spread proliferation of wireless communication technology in recent years, the demand for compact, low profile and broadband antennas has increased significantly. To meet the requirement, the microstrip patch antenna have been proposed because of its low profile, light weight and low cost. However, the microstrip antenna inherently has a low gain and a narrow bandwidth. To overcome its inherent limitation of narrow impedance bandwidth and low gain, many techniques have been suggested e.g., for probe fed stacked antenna, microstrip patch antennas on electrically thick substrate, slotted patch antenna and stacked shorted patches have been proposed and investigated [2].

There are numerous and well-known methods to increase the gain of antennas, including decrease of the substrate thickness, feeding techniques and with the use of different optimization techniques [7-8].

In our research work, antenna feeding is to be classified into two types, first is microstrip line feeding and second is coaxial/probe feeding. There are many other types of feeding used but they are so complex, e.g. aperture coupled feeding, L-probe feeding, non contact feeding, which are used to enhance the bandwidth.

The remaining paper is organised as follows: section 2 gives some information about types of feeding. Section 3 includes design analysis of single band E Shaped microstrip patch geometry. Section 4 gives comparative analysis of coaxial feed over the microstrip line feed antenna with its results. Section 5 and 6 gives conclusion and references respectively.

2. FEEDING TECHNIQUES
There are several techniques available to feed or transmit electromagnetic energy to a microstrip patch antenna. The role of feeding is very important in case of efficient operation of antenna to improve the antenna input impedance matching. The two main commonly used feeding techniques are

2.1 Microstrip line feeding

2.2 Coaxial cable or probe feeding

2.1 Microstrip line feeding

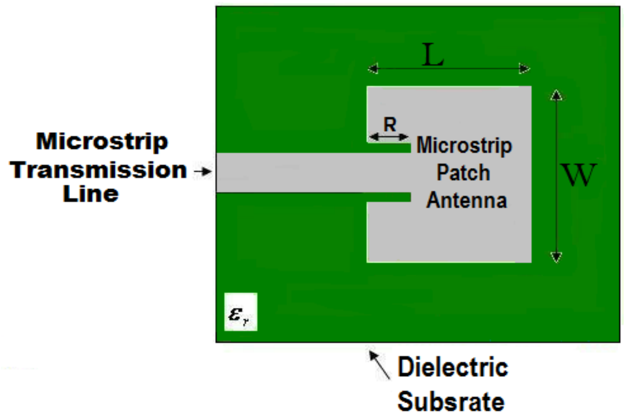

Fig 1: Rectangular Microstrip patch antenna with an Inset Line feeding.

In this type of feeding technique, a conducting strip is connected directly to the edge of the Microstrip patch as shown in Fig 1. The width of conducting strip is small as compared to the patch and this kind of feed arrangement has the advantage that the feed can be etched on the same substrate to provide a planar structure. The purpose of the inset cut in the patch is to match the impedance of the feed line to the patch input impedance without the need for any additional matching element. This can be achieved by properly adjusting the inset cut position and dimensions. Hence this is an easy feeding scheme because it provides ease of fabrication and simplicity in modelling as well as impedance matching. However as the thickness of the dielectric substrate being increases, surface waves and spurious feed radiations are also increases, which hamper the bandwidth of the antenna. The feed radiation also leads to undesired cross polarized radiation.

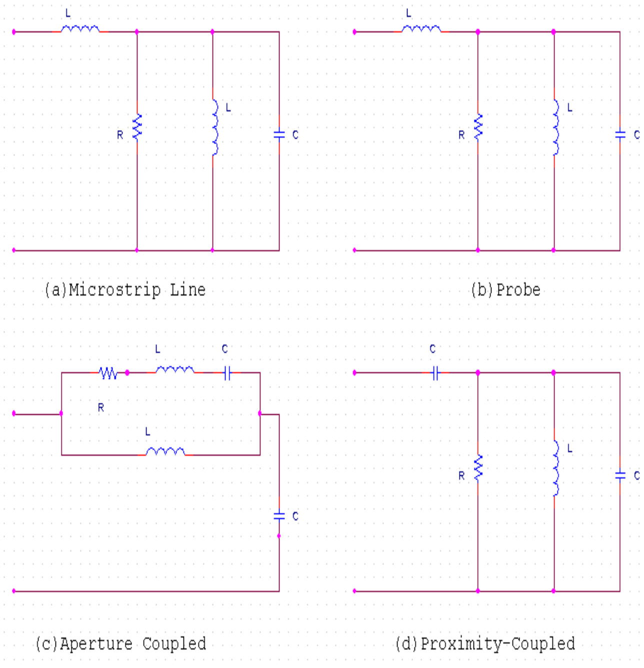

Fig 2: Equivalent circuits of typical feeding methods

2.2 Coaxial cable or Probe feeding

The Coaxial cable or probe feeding is a very common technique used for feeding Microstrip patch antennas. As seen from Fig 3, the inner conductor of the coaxial cable extends through the dielectric and is soldered to the radiating metal patch, while the outer conductor is connected to the ground plane. The main advantage of this feeding scheme is that the feed can be placed at any desired location on the patch in order to match cable impedance with the antenna input impedance. This feeding method has easy to fabricate and has low spurious radiation. However, its major disadvantage is that it provides narrow bandwidth and is difficult to model since a hole has to be drilled in the substrate and the connector protrudes outside the ground plane, thus not making it completely planar for thick substrates ($h > 0.02\lambda o$). Also, for thicker substrates, the increased probe length makes the input impedance more inductive, leads to impedance matching problems. The main aim to use probe feeding is enhancing the gain, narrow bandwidth and impedance matching [15].

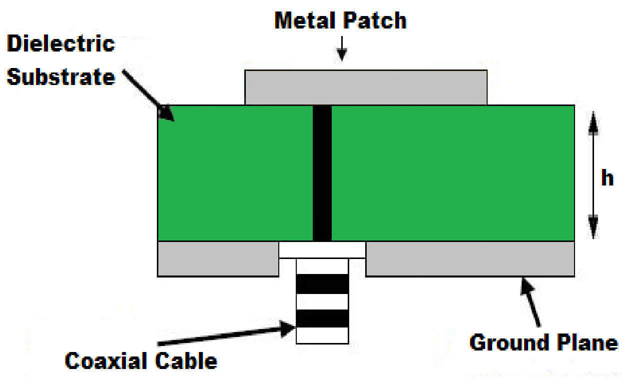

Fig 3: Coaxial cable (Probe) feeding of patch antenna.

3. SINGLE E-SHAPED PATCH ANTENNA DESIGN

In Recent, the coaxially fed E-shaped patch antennas with thick air substrate reported in [7-8], have used in wireless communication applications. The same antenna was optimized in [9] using PSO/FDTD optimizer to design a dual-frequency antenna as well as a broadband antenna. The dual-frequency antenna was operated at 1.8 and 2.4 GHz, while the broadband antenna had a bandwidth from 1.79 to 2.43 GHz (30.5%). In [10], a low-profile microstrip line fed E-shaped patch antenna, shown in Fig 4, has been designed using the Modified CFO/DE optimization techniques. To test the CFO/IE3D and DE/IE3D methods, the optimizers are applied to achieve the simple objective of designing this E-shaped patch antenna to work at the resonance frequency (fr) of 2.4 GHz. Now in this paper, our used approach is to analyze the comparison of parameters of microstrip patch antenna with coaxial and microstrip line feeding techniques. The fitness function to be maximized is formulated as:

$$\text{Fitness} = -S11\ (2.4\ \text{GHz}) \qquad (1)$$

Now in this paper, we design and analysis the affect of coaxial feeding over the microstrip line feeding and compare it. The substrate has a thickness of h = 2 mm, and dielectric constant εr of 2.55. The antenna is fed by a coaxial probe feed at (0, 32.295) mm Coordinates from the origin with a fixed line width ($W_L = 5.6$ mm).

To avoid the overlap problem in IE3D simulations, the following conditions must necessary as additional geometrical restrictions [10]:

$Ps + 2Ws < W$, $Ls < L$, $Lf < L$

$Ps > W_L + 2Wf$ or $Ps + 2Ws < W$,

When $Ls + Lf >= L$

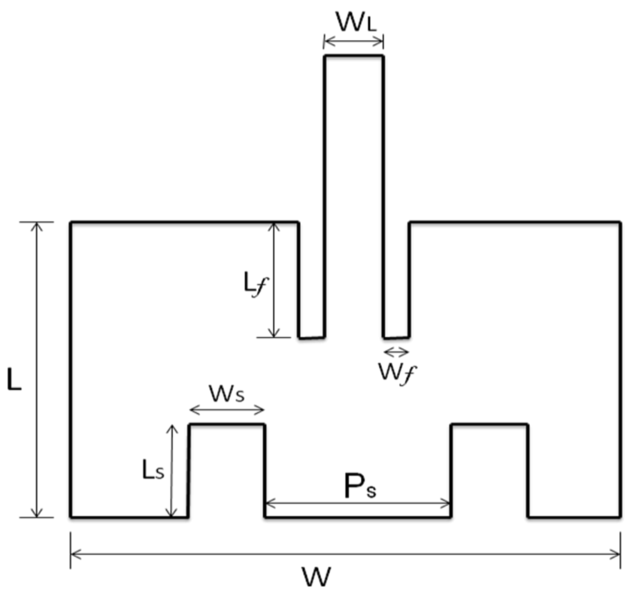

Fig 4: Geometry of low-profile E-shaped microstrip patch antenna [10]

Table 1. Optimized dimensions for the low-profile E-shaped microstrip patch antenna using the fitness function described by Equation (1)

ANTEENA DIMENSIONS:-

Properties	Dimensions
Patch width (W)	64.2 mm
Patch length (L)	39 mm
Feed width (Wƒ)	2.15 mm
Feed line width (WL)	5.6 mm
Feed length (Lƒ)	9.44 mm
Slot width (Ws)	10.95 mm
Slot length (Ls)	14.05 mm
Width b/w slots (Ps)	14.86 mm
Height (h)	2 mm
Dielectric constant (Ɛr)	2.55

4. COMPARATIVE ANAYLSIS OF MICRISTRIP AND COAXIAL PROBE FEEDING

4.1 MICROSTRIP LINE FEED

Fig 5 shows the return loss in dB for rectangular microstrip antenna with line feed without any optimization. The reference dimensions are used, which have calculated by geometrical formulas. Without optimized dimensions, the return loss should decrease to -25 dB at 2.4 GHz reference frequency as shown in Fig 5, which further improves to -73dB (BW=35.5 MHz) and

-66dB (BW=44 MHz) with CFO and DE optimizations respectively as shown in Fig 4.2. [10]

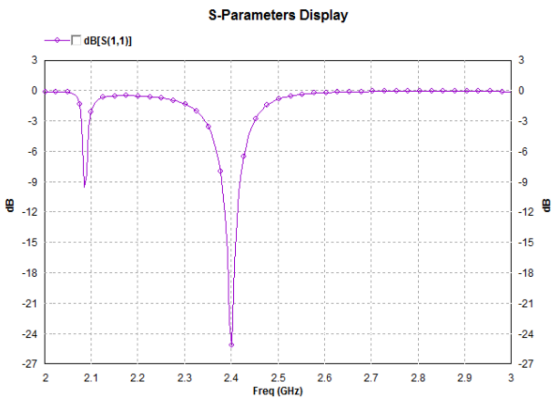

Fig 5: Return Loss (in dB) of the Microstrip line feed Single E-shaped antenna without optimization.

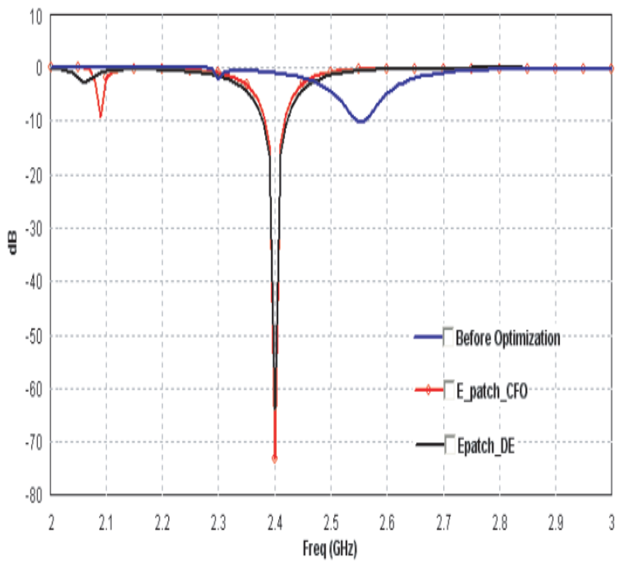

Fig 6: Return Loss (in dB) with CFO/DE optimization of the Microstrip line feed Single E-shaped patch antenna [10].

The optimized dimensions improving the gain and return loss as reported in [10], which is also increased by some other techniques. e.g. the use of coaxial probe instead of microstrip line feeding, because the probe feed can be placed at any desired location inside the patch in order to match line impedance with its antenna input impedance, which is represented in this paper.

4.2 COAXIAL PROBE FEED

4.2.1 Return Loss

In our approach, we uses probe feed instead of line feed, which is also positively affects to improve the gain as well as return loss. The return loss is decreases to -62 dB at 2.397 GHz reference frequency as shown in Fig 7.

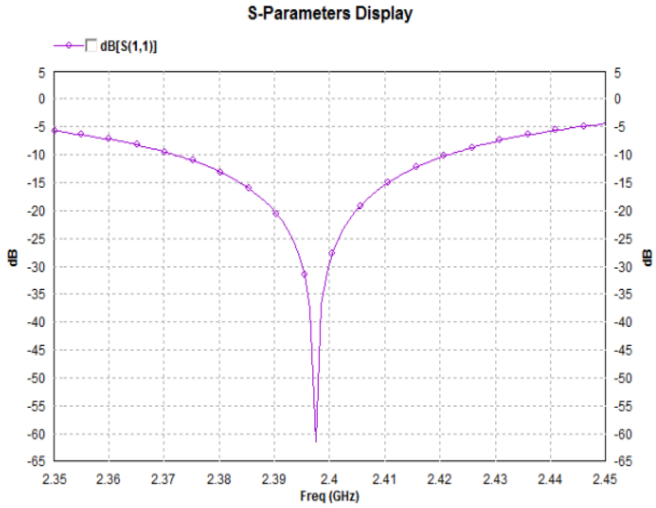

Fig 7: Return Loss (in dB) of the coaxial probe feed Single E-shaped microstrip antenna.

4.2.2 VSWR

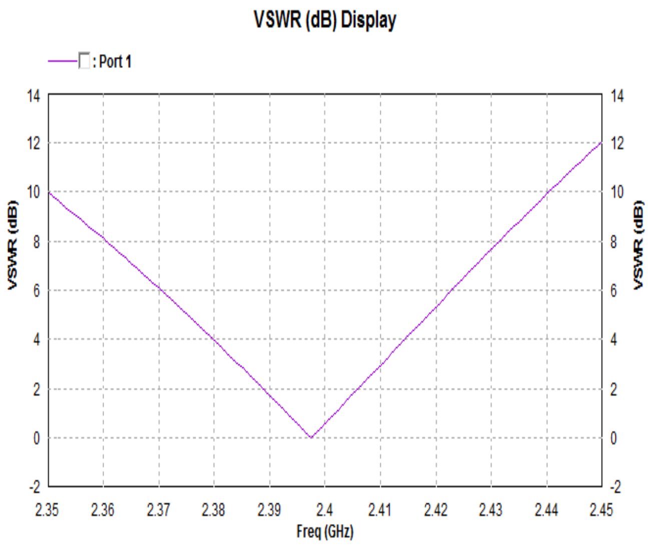

Fig 8: VSWR (in dB) with the coaxial probe feed Single E-shaped microstrip patch antenna.

It is used to describe the performance of an antenna when attached to a transmission line. It is a measure of how well the antenna terminal impedance is matched to the characteristic impedance of the transmission line.

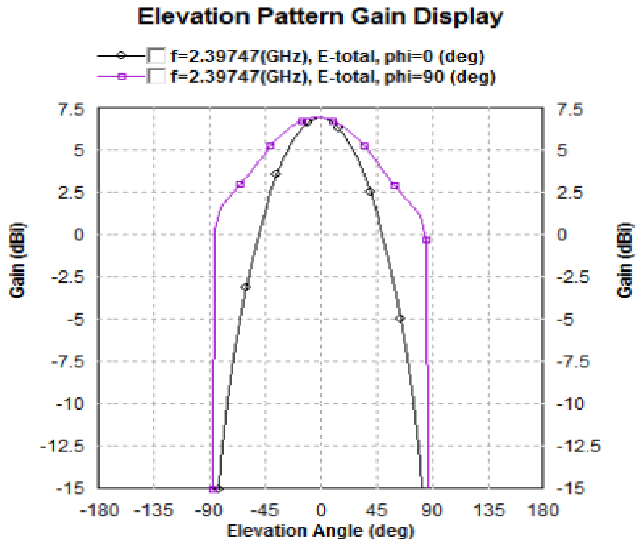

Fig 9: Elevation pattern for Φ=0 and Φ=90 degrees.

If the antenna terminal impedance exhibits no reactive (imaginary) part and the resistive (real) part is equal to the characteristic impedance of the transmission line, then the antenna and transmission line are said to be matched. The value of VSWR <2 is considered good, and values higher than 2.0 may be unacceptable as shown in Figure 8.

4.2.3 Radiation Pattern Plot

Since a microstrip patch antenna radiates normal to its patch surface, the elevation pattern for Φ=0 and Φ=90 degrees.

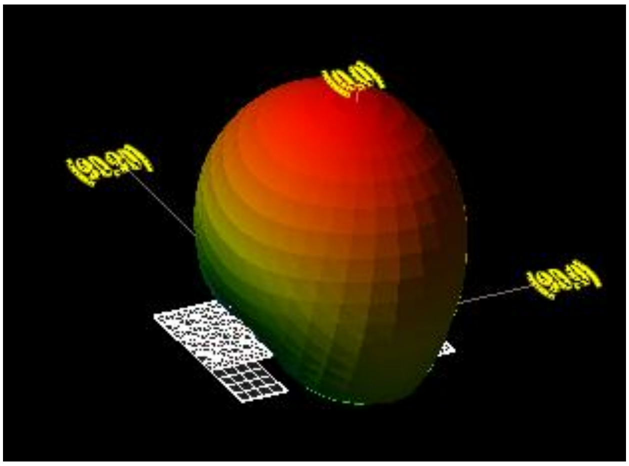

Fig 10: 3D view of radiation pattern looking along Z axis in the XY Plane.

Figure 9 shows the maximum gain of the antenna at 2.397GHz for Φ=0 and Φ=90 degrees and it has not any side lobe as shown in Figure 10.

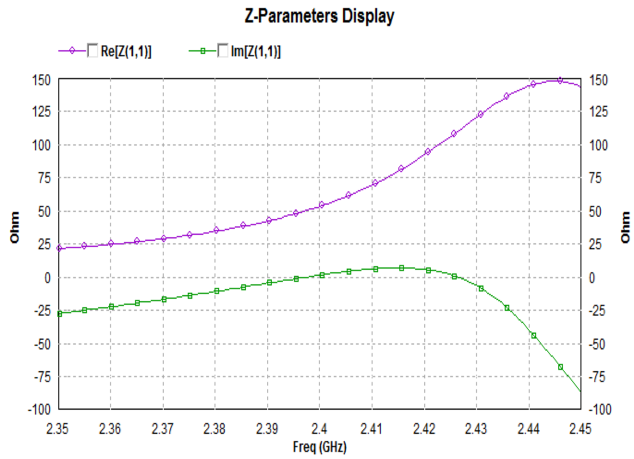

Fig 11: Impedance Plot, which shows R=50Ω at 2.397 GHz

Table 2. COMPARITIVE RESULTS

Parameter	Line feed without opt.	Line feed With CFO/ DE opt.	Probe feed
Resonant Freq	2.4 GHz	2.4 GHz	2.397 GHz
Bandwidth	35 MHz	44 MHz	50 MHz
Return Loss	-25 dB	-72 dB	-62 dB
Max Gain	5.1 dB	6.7 dB	6.88 dB
Minimum VSWR	1.06 dB	Na	0.05 dB
Max axial ratio	80.83 dB	Na	83 dB
Antenna efficiency	56 %	Na	79.45 %
Directivity	7.5 dBi	Na	7.89 dBi

As discussing from the Table 2 results, we proved that probe feeding is better than microstrip line feeding, because in probe feed antenna we are getting a more gain as 6.88 dB, more BW approximate 50 MHz, better return loss as -62 dB, improved VSWR, more antenna directivity and efficiency etc.

5. CONCLUSIONS AND FUTURE SCOPE

In this paper, the coaxial probe feeding is applied to design of microstrip patch antenna. The return loss, gain and radiation pattern of single band E-shaped microstrip antenna is presented in this paper clearly show that the antenna is a narrowband, higher gain and single tuned microstrip patch antenna. The achievement of higher gain with a probe feeding is a focus of attention. The variation of the feed point (feed position) over feed line gives the flexibility to get higher gain and match the impedance, which is a notable feature of this antenna. This paper proved that the coaxial feed is better impedance matching technique than the microstrip line feed, which affects positively to improve the gain, return loss and bandwidth.As comparison to double E-Shaped patch geometry, the design of a Single E-Shaped Patch antenna is simple. The Single E-Shaped Patch antenna is a narrow band antenna (Tuned at reference frequency) while the double E-Shaped is a wideband antenna (with complex geometry) used for various applications.

6. REFERENCES

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