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Designing of a Coaxial fed antenna for S-band Applications

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Abstract- A Microstrip patch antenna is designed for coaxial feeding technique for wireless microstrip patch antenna i.e S-Band applications. In this paper the antenna is resonating at 2.8 GHz frequency range which is desired frequency for S-Band range. The frequency range for S-Band is vary from 2700 MHz to 2900 MHz. The proposed antenna is designed by using rectangular type patch for particular feeding technique (coaxial probe feed) is used. From the four feeding techniques, microstrip line and coaxial probe feeds are contacting schemes whereas proximity and aperture coupled feed are non-contacting schemes. The Paper gives a better understanding of design parameters of an antenna and their effect on return loss, S-Parameters, smith chart, radiation pattern, bandwidth, VSWR and resonant frequency. Finally simulation is done using design software HFSS13.0.
Keywords- Rectangular microstrip patch antenna, S-Parameters, smith chart, radiation pattern, bandwidth, VSWR, resonant frequency, coaxial probe feed, HFSS.

I. INTRODUCTION

During the past two decades we can see that the wireless communication has brought in an unimaginable revolution in the field of communication. The mobile communication industry has exceeded the growth of all other communication fields. The amount of mobile data traffic is doubling each year due to the increase in communication traffic and increase in the usage of smart phones. Transferring data over a distance without using any physical mediums like wires etc. can be referred to as wireless technologies. The coverage distance may be short or long. The term wireless means having no wires. In networking terminology, wireless is a term used to describe any computer network where there is no physical wired connection between the sender and receiver, whereas the network is connected by radio waves or micro waves to maintain communication. They use NICs at routers in place of wires. Wireless technologies have made tremendous growth in the last two decades.

Due to fast development of technology, future communication and transmission are totally depends upon wireless network. Now technology demands antennas which can operate on different wireless bands and should have different features like low cost, minimal weight, low profile antennas that are capable of maintaining high performance over a large spectrum of frequencies. This technological trend has focused much effort into the design of Microstrip patch antennas. The vision of the wireless communication supporting information exchange between people and devices is the communication frontier of the next few decades. This vision will allow multimedia communication from anywhere in the world. Presently wireless communication, by measure is the fastest growing segment of the communication field. There are many government and commercial applications such as mobile radio, Satellite communication and Wireless communication where weight, size, cost, performance, ease of installation, aerodynamics profile are major constraints.

A microstrip patch antenna is a type of antenna that offers a low profile, i.e. thin and easy manufacturability, which provides a great advantage over traditional antennas [1,2]. Patch antennas are planar antennas used in wireless links and other microwave applications. Microstrip antennas have many attractive features that are draws the attention of researchers over the past work [1- 2]. Microstrip antennas are used in number of applications like biomedical diagnosis and wireless communication [3]. With the rapid growth of the wireless communication system the future technologies need very small, compact and multiband antennas. Nowadays, people demand multiband wireless phone supporting more than one network, having different frequencies and simultaneous transmission of video, audio and data. These services are possible with the help of microstrip patch antenna having multiband characteristics. Modern wireless communication system also requires low profile, light weight, high gain, ease of installation, high efficiency, simple in structure to assure reliability and mobility characteristics. Microstrip antennas satisfy such requirements.

In this paper the antenna is resonating at 2.8 GHz frequency range which is desired frequency for S-Band range. The frequency range for S-Band is vary from 2700 MHz to 2900 MHz. The proposed antenna is designed by using rectangular type patch for particular feeding technique (coaxial probe feed) is used.

II. FEEDING TECHNIQUES

Feeding Techniques are classified into two categories, one is contacting (microstrip line feed, coaxial probe feed) and second type is non-contacting (proximity coupled feed and aperture coupled feed). As we are using coaxial probe feed that is a type of contacting so first of all we will discuss all feeding techniques as follows.

A. Microstrip Line Feed

Microstrip line feeding is a technique in which a conducting strip is connected directly to the edge of the microstrip patch as shown in figure 1. The width of conducting strip is smaller as compared to the patch. This type of feeding arrangement has the advantage that the feed and patch can be etched on the same substrate to provide a planar structure.

However as the thickness of the dielectric substrate being used increases, surface waves and spurious feed radiation also increases, which hampers the bandwidth of the antenna. The feed radiation also leads to undesired cross polarized radiation. This method is advantageous due to its simple planar structure.

B. Coaxial Probe Feed

The Coaxial feed or probe feed is a very common technique used for feeding Microstrip patch antennas. The inner conductor of the coaxial connector extends through the dielectric and is soldered to the radiating patch, while the outer conductor is connected to the ground plane. The main advantage of this type of feeding scheme is that the feed can be placed at any desired location inside the patch in order to match with its input impedance.

However, its major drawback 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.

Also, for thicker substrates, the increased probe length makes the input impedance more inductive, leading to matching problems. It is seen above that for a thick dielectric substrate, which provides broad bandwidth, the microstrip line feed and the coaxial feed suffer from numerous disadvantages. So to reduce these types of disadvantages, we will study non-contacting schemes.

C. Proximity coupled Feed

This method uses electromagnetic coupling between the feed line and the radiating patches, printed on separate substrates [7]. Two dielectric substrates are used such that the radiating patch is on top of the upper substrate and feed line is between the two substrates. The advantage of this coupling is that it yields the largest bandwidth compared to other coupling methods, it is somewhat easy to model and has low spurious radiation. This feeding method also provides choices between two different dielectric media, one for the feed line and one for the patch to optimize the individual performances. Matching can be achieved by controlling the width-to-line ratio of the patch and length of the feed line. The major disadvantage of this feeding scheme is that it is difficult to fabricate because of the two dielectric layers which need proper alignment. Also, the overall thickness of the antenna also increases [7].

D. Aperture coupled feed

In this type of feed technique, the radiating patch and the microstrip feed line are separated by the ground plane. Coupling between the patch and the feed line is made through a slot or an aperture in the ground plane and variations in the coupling will depend upon the size i.e. length and width of the aperture to optimize the result for wider bandwidths and better return losses. The coupling aperture is usually centered under the patch, leading to lower cross-polarization due to symmetry of the configuration. Since the ground plane separates the patch and the feed line, spurious radiation is minimized.

Aperture coupled feeding is attractive because of advantages such as no physical contact between the feed and radiator, wider bandwidths, and better isolation between antennas and the feed network. Furthermore, aperture-coupled feeding allows independent optimization of antennas and feed networks by using substrates of different thickness or permittivity.

III. DESIGNING FORMULAS

The length of the patch is denoted by L and width of the patch is denoted by W. Because the dimensions of the patch are finite along the length and width, the fields at the edges of the patch undergo fringing. Since some of the waves travel in the substrate and some in air, an effective dielectric constant $\varepsilon reff$ is introduced to account for fringing and the wave propagation in the line. The dimension the patch along its length has been extended by a distance ΔL due to the fringing field which is a function of effective dielectric constant. Hence the effective length is increased by 2ΔL as shown. Various formulas for designing a microstrip patch antenna are written below.

Calculation of effective dielectric constant, εreff, which is given by: $\varepsilon_{reff} = \frac{(\varepsilon_r+1)}{2} + \frac{(\varepsilon_r-1)}{2}\left[1 + 12\frac{h}{W}\right]^{-\frac{1}{2}}$

Calculation of the length extension ΔL, which is given by:

$$\frac{\Delta L}{h} = 0.412\frac{(\varepsilon_{reff} + 0.3)\left(\frac{W}{h} + 0.264\right)}{(\varepsilon_{reff} - 0.258)\left(\frac{W}{h} + 0.8\right)}$$

For efficient radiation, the width W is

$$W = \frac{\lambda_0}{2\sqrt{(\epsilon_r + 1)/2}}$$

Now to calculate the length of patch becomes:

$$L = \frac{\lambda_0}{2\sqrt{\epsilon_{reff}}} - 2\Delta L$$

Length and width of the ground is:

$$L_{g=}6h + L$$
$$W_g = 6h + W$$

Microstrip antenna suffers some disadvantages like spurious feed radiation, surface wave excitation and narrow bandwidth etc.
For a typical substrate thickness and a typical substrate permittivity (ε_r = 2.2) the bandwidth is about 3%.
By using a thick foam substrate, bandwidth of about 10% can be achieved.
By using special feeding techniques (proximity or aperture coupling) and stacked patches, bandwidth of over 50% has been achieved. However, such configurations lead to a larger antenna size. In order to design a compact Microstrip patch antenna, various efforts have been made by researchers all over the world to improve the bandwidth of a patch antenna.

IV. DESIGNING

A. Coaxial Probe Feed

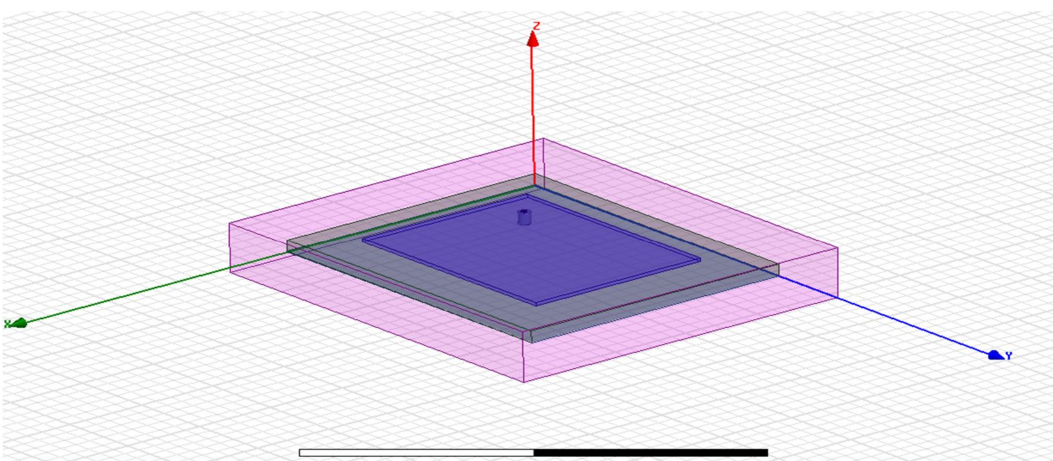

Figure 1 Design using Coaxial Probe Feed

Observation from return loss at or below -10dB as shown in figure 2-5.
1) Resonant frequency=2.8 GHz at -16.84 dB
2) Band width= f2-f1= 2.93-2.68=0.25GHz=250MHz
3) VSWR= 1.47
4) Impedance Matching = 67.75 ohm.

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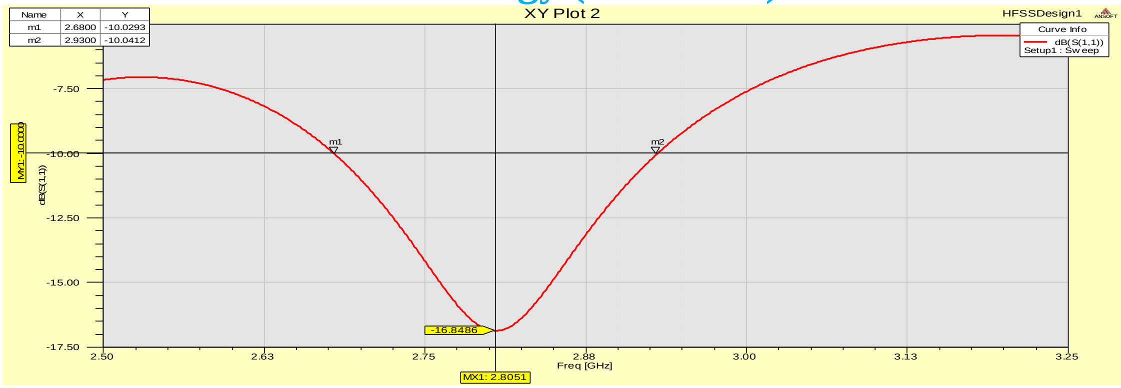

Figure 2 Return loss

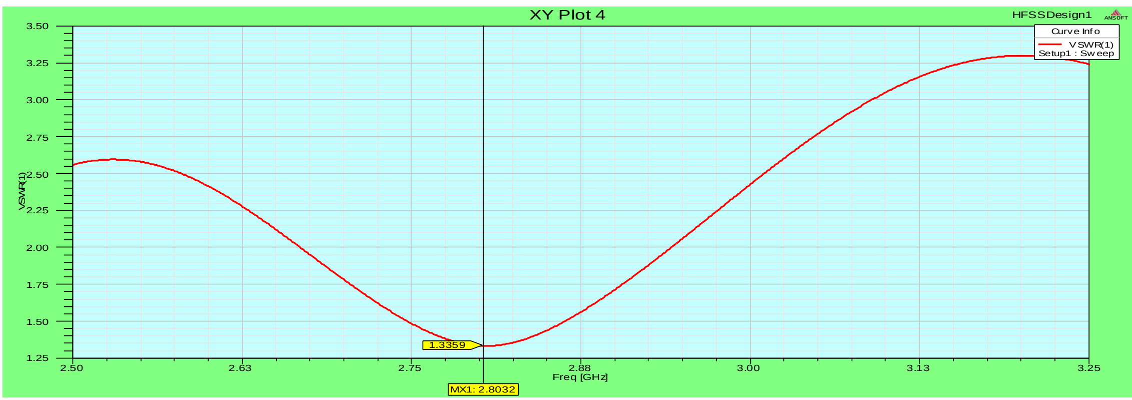

Figure 3 VSWR Plot

Figure 4 Radiation Pattern

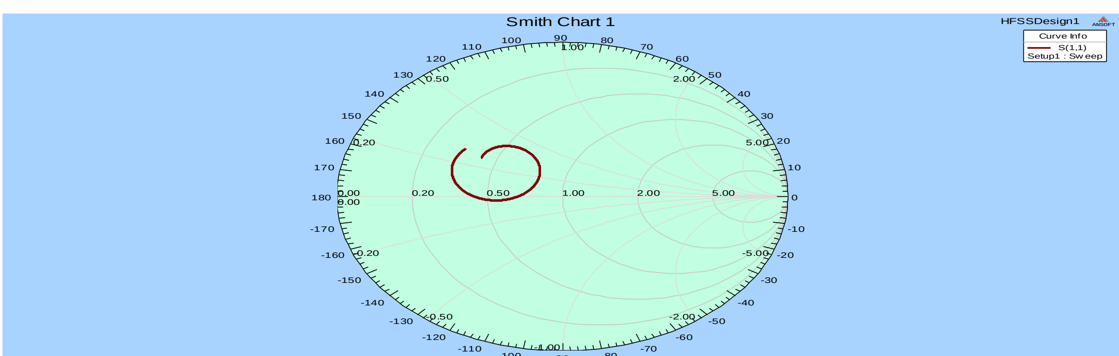

Figure 5 Smith Chart Plot

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V. CONCLUSION

A Micro strip patch antenna for S-Band application dimensions using coaxial probe feed has been designed and simulated using HFSS V13 software. A simulation is made in terms of bandwidth, return loss, VSWR and patch size and smith chart. So, we can see that selection of the feeding technique for a micro strip patch antenna is an important decision because it affects the bandwidth and other parameters also. A micro strip patch antenna excited by different excitation techniques gives different bandwidth, different gain, different efficiency etc. The performance properties are analyzed for the optimized dimensions and the proposed antenna works well at the required (2700-2900) MHz S-Band frequency band.

We can also conclude that by changing the feed point where matching is perfect, the high return loss can be achieved at the resonant frequency. Various microstrip patch antennas with proximity coupled feeding technique are presented. The various parameters like return loss, radiation pattern, smith chart, electric field and VSWR are plotted for each antenna. We can easily match the impedance by locating feed point at desired position in coaxial fed method.

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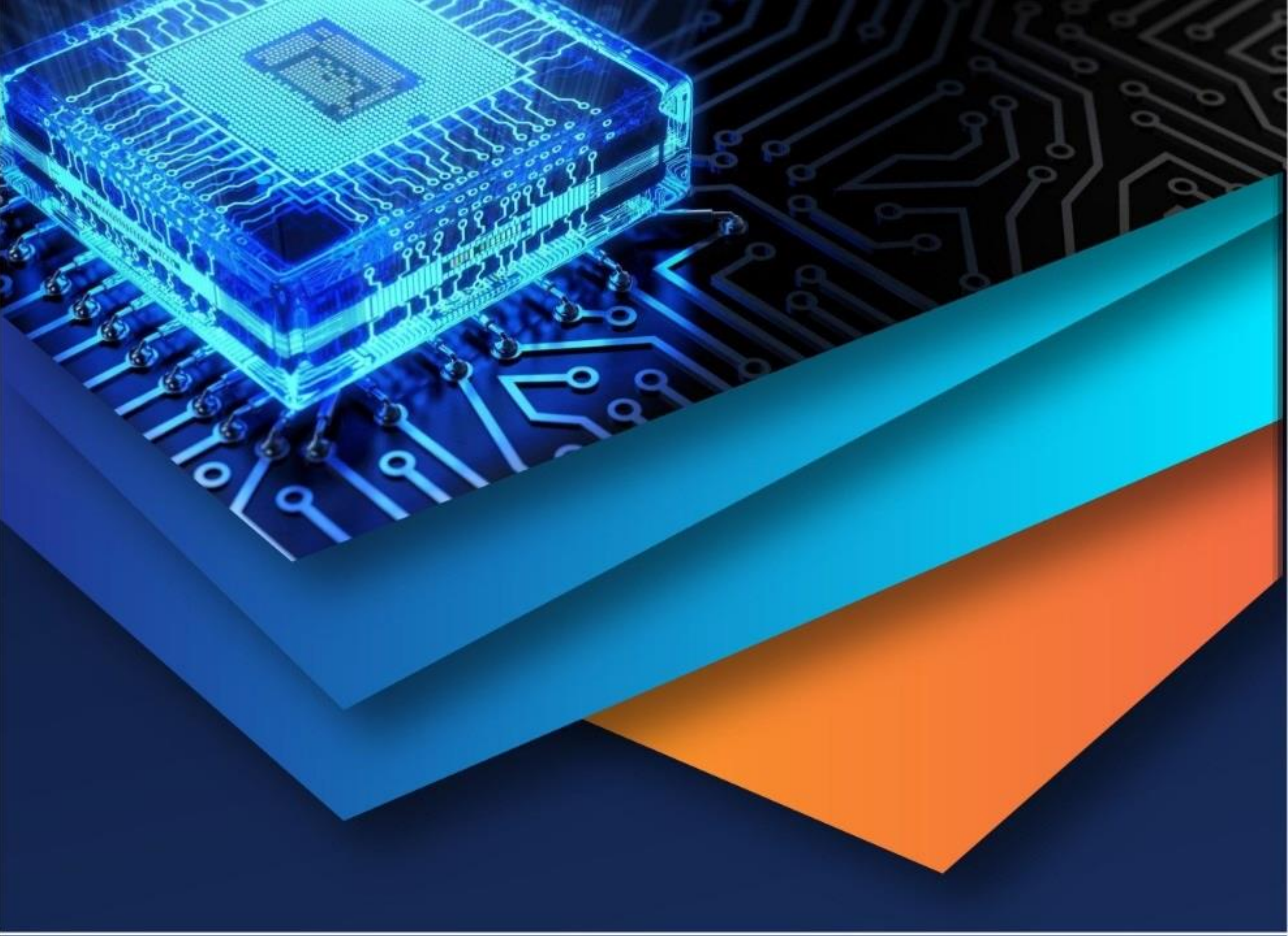

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