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Design of Probe Feed Microstrip Patch Antenna in S-Band

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Abstract

The microstrip patch antennas as radiating device have advantages like, low profile, conformal and low-cost. They are suitable for vehicle based satellite link antennas, global positioning systems, radar for missiles and mobile handheld radios. The microstrip antennas can be excited either by coaxial probe or by a microstrip line. It can also be excited indirectly using electromagnetic coupling or by aperture coupling method, in which there are no direct metallic contact between the feed line and the patch. Since feeding technique influences the input impedance, it is often exploited for matching purposes. Also as the antenna efficiency depends on the transfer of power to the radiating element, feeding technique plays a vital role in the design process. We have designed a probe feed rectangular patch antenna at 2.21GHz frequency using IE3D simulator and studied the radiation characteristics.

Introduction
In this 21st century, it has been a major field of research regarding the transmission and reception of data. Today, every people are thinking regarding the maximum efficiency and minimum loss while transmitting or receiving the signal. Communication has become a part and parcel of our daily life. Either it is your Wi-Fi connection or your cell-phone, transmission and reception of data is a vital part, and antenna is responsible for these transmissions. Hence, while designing the antenna, its usability, its upgradability, its feasibility and efficiency are to be taken into account. The microstrip patch antennas are associated with several advantages of being low

profile, versatile, conformal and low-cost devices. These features of microstrip antennas make them suitable for various applications like, vehicle based satellite link antennas, global positioning systems (GPS), radar for missiles and telemetry and mobile handheld radios or communication devices. These technologies are having a wide scope in near future, as these are low cost and reliable devices, which can be easily made, and their implementation is also simpler as compared to other antennas.

Microstrip antennas are similar to parallel plate capacitors. Both have parallel plates of metal layer and a sandwiched dielectric substrate between them. But in microstrip antenna, one of these metal plates is infinitely extended than the other, to form the ground plane; whereas the smaller metal plate is described as radiating patch, shown in fig.1.Since the size of the patch is often proportional to frequency of the propagating signal, this class of antenna is classified as resonant antennas. This contributes to the basic shortcoming of the microstrip antennas related with its narrow bandwidth, usually only a few percent of the resonance frequency. The patch is excited by a feed line. Assuming no variations of the electric field along the width (W) and the thickness (t) of the microstrip structure, the electric field excited by the patch is shown in Fig.2.

Radiation is ascribed mostly to the fringing fields at the open circuited edges of the patch length. The fields at the end can be resolved into normal and tangential components with respect to the ground plane. The normal components are 180^0 out of phase because the patch line is λ/2 long; therefore the far field radiation produced by them cancels in the broadside direction. The tangential components (those parallel to the ground plane) are in phase, and the resulting fields combine to give maximum radiated field normal to the surface of the structure i.e., broadside direction. Therefore, the patch may be represented by two slots λ/2 apart as shown in figure below, excited in phase and radiating in the half space above the ground plane. The patch may be represented by two slots λ/2 apart as shown in fig.3, excited in phase and radiating in the half space above the ground plane. The effective length of the patch increases due to fringing field.

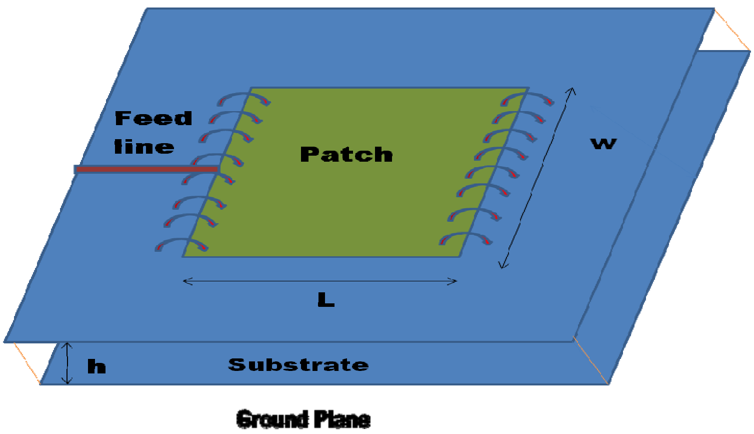

Figure 1: Radiation mechanism of microstrip patch

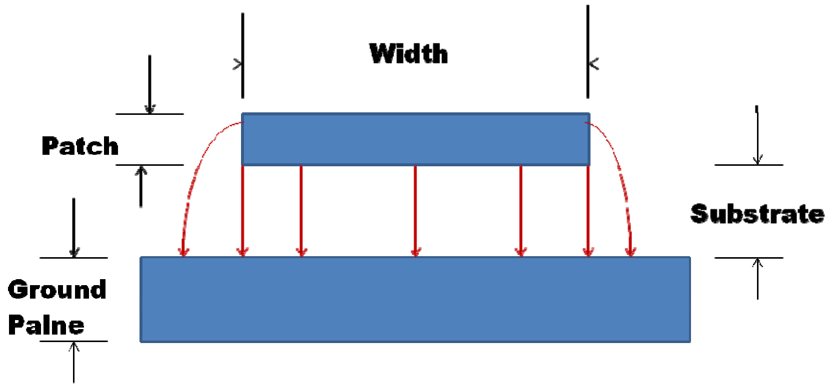

Figure 2: Electric field from a microstrip patch antenna

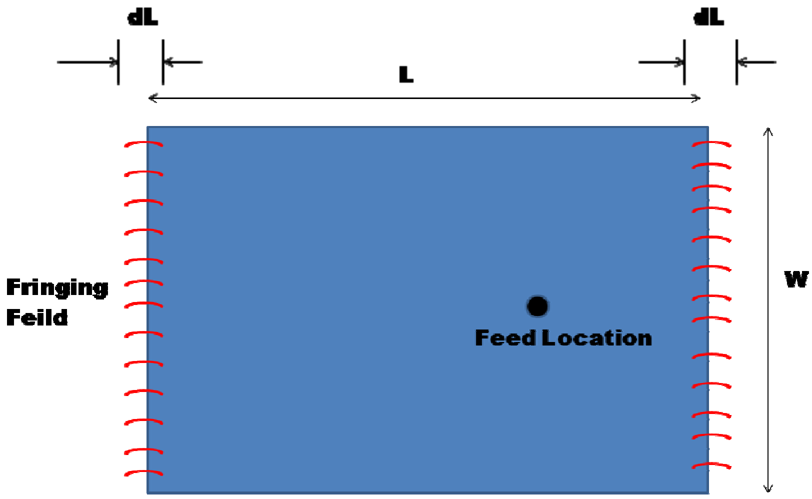

Figure 3: Increase in length of the microstrip patch

Probe Feed Microstrip Antenna

Typically, to excite the fundamental TEM mode, the length L of the rectangular patch remains slightly smaller than λ/2, where λ is the wavelength in the effective dielectric medium. In terms of free space wavelength (λ_0), λ is expressed by;

$$\lambda = \frac{\lambda 0}{\sqrt{\epsilon eff}} \quad (1)$$

The essential parameters for the design are-

F_0 =2.25 GHz , εr =2.2 , h =1.6mm

Calculation of Patch width

$$(W) = \frac{c}{2f0\sqrt{\varepsilon r}} \quad (2)$$

ε_{eff} is the effective dielectric constant of a microstrip line and is given as

$$\epsilon eff = \frac{\varepsilon r + 1}{2} + \frac{\left(\varepsilon r - 1\left[1 + \frac{12h}{W}\right]^{-1/2}\right)}{2} \ldots\ldots\ldots\ldots\ldots\ldots \quad (3)$$

The value of ε_{eff} stays between 1 (dielectric constant of air) and the dielectric constant of the substrate, ε_r, because the electromagnetic fields excited by the microstrip resides partially in the air and partially in the substrate. However, to enhance the electromagnetic (EM) fields in the air, which account for radiation, the width (*W*) of the patch needs to be increased. Radiating EM fields can also be enhanced by decreasing the ε_r or by increasing the substrate thickness (*h*). It is of note that, since '*W*' and '*h*' are constrained by the input-impedance and unwanted-surface-waves respectively, a compromise is required while selecting antenna dimensions. Since microstrip patches are often feed or integrated with microstrip transmission-lines or circuits, the design requirement of these are also important.

Calculation of effective length

$$(L_{eff}) = \frac{c}{2f0\sqrt{\epsilon eff}} \ldots\ldots\ldots\ldots\ldots\ldots \quad (4)$$

Calculation of the length extension

$$\Delta l = 0.412h\left[\frac{\epsilon eff + 0.3}{\epsilon eff - 0.258} \times \frac{(W/h) + 0.264}{(W/h) + 0.8}\right] \ldots\ldots\ldots\ldots\ldots\ldots \quad (5)$$

Calculation of actual length of patch

$$L = L_{eff} - 2\Delta l \ldots\ldots\ldots\ldots\ldots\ldots \quad (6)$$

From equation (4) & (6) we get,W= 45mm ,L= 44.31mm

The feed point must be located within the patch, where the input impedance is 50 ohms for the resonance frequency. Here we have taken Feed location at (x,y)=(6,0) & (7,0)

Performance Evaluation

The parameters would be:

1. Solution Frequency: 2.25 GHz
2. Maximum Number of Passes: 20

The start frequency should be 1.0GHz and stop frequency should 5.0GHz.

- Feed at(7,0), freq=2.21442GHz at -28.9856dB, shown in fig.5
- Feed at(6,0), freq=2.21437GHz at -17.1301dB,shown in fig.4

we change the frequency to 2.25253GHz , as obtained by the trace report at feed point(7,0)

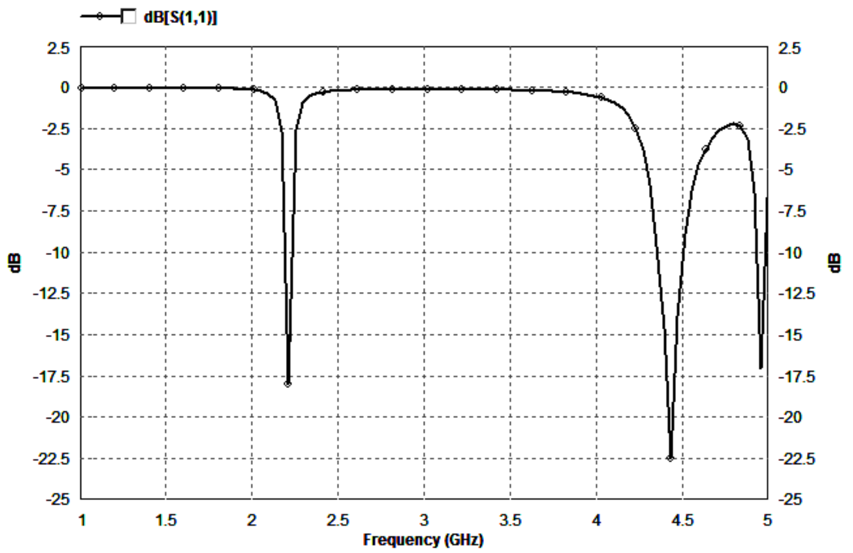

Figure 4: Return loss characteristics at feed point(6,0)

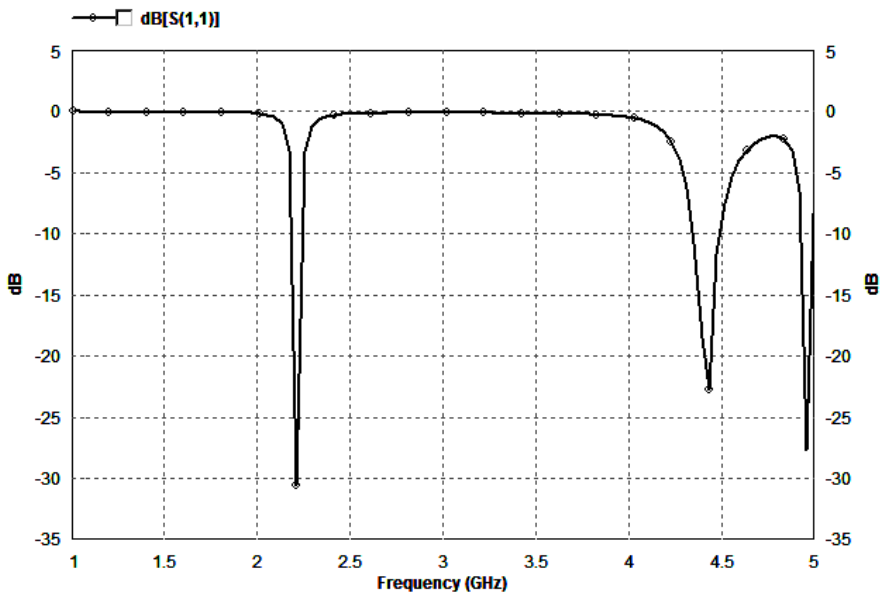

Figure 5: Return loss characteristics at feed point(7,0)

Radiation Characteristics

- Phi and Theta will have following configuration:
- Phi: (Start: 0, Stop: 90, Step Size: 90), and
- Theta: (Start: -180, Stop: 180, Step Size: 2)

Since a microstrip patch antenna radiates normal to its patch surface, the elevation pattern for $\phi = 0$ and $\phi = 90$ degrees would be important. Which is shown in fig.6.

- F=2.25253GHz,phi=0(deg),PG=4.17955dB,AG=1.37338dB
- F=2.25253GHz,phi=90(deg),PG=4.17955dB,AG=2.24811dB
- Field property,
- Radiation efficiency=86.0457%
- Antenna efficiency=45.8516%
- 3dB Beam width (79.5937,93.4331)deg

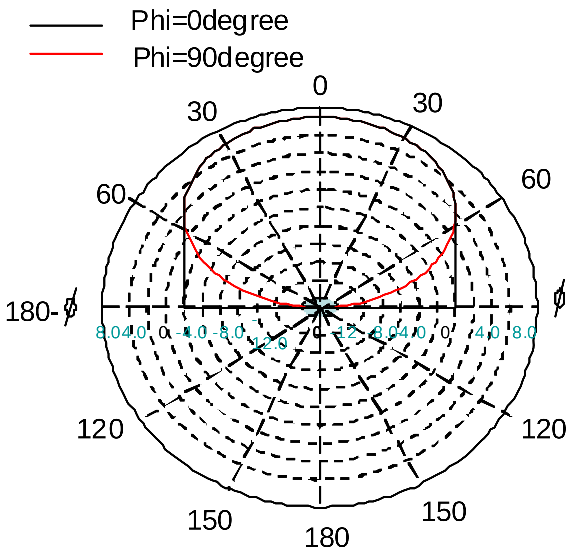

Figure 6: Evalution pattern gain display(dBi)

Conclusion

Their ease of mass production using printed circuit technology leads to a low fabrication cost and easier to integrate with other microstrip circuits. They support both linear polarization and circular polarization, and can be realized in a very compact form, desirable for personal and mobile communication hand held devices. They allow for dual and triple band operations. From that type of design we get Narrow bandwidth and lower power gain, so in future days it will be challenged to us to design a high gain & high band width microstrip probe feed patch antenna for better performance.

The microstrip patch antennas are associated with several advantages of being low profile, versatile, conformal and low-cost devices. These features of microstrip antennas make them suitable for various applications like, vehicle based satellite link antennas, global positioning systems (GPS), radar for missiles and telemetry and mobile handheld radios or communication devices. These technologies are having a wide scope in near future, as these are low cost and reliable devices which can be easily made and their implementation is also simpler as compared to other antennas.

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