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Design and Simulation Analysis of Microstrip Patch Antenna For Wireless Applications

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Abstract - The proposed microstrip antenna has been designed and simulated using the Ansoft's HFSSv13 and fabricated with FR4-Epoxy (ε=4.4) as substrate. The proposed microstrip antenna has been designed for wireless communication applications. The antenna is designed, simulated and fabricated for the radiation characteristics atthe central frequency of 10GHz. The return loss is less than -18.75 dB for a frequency of 10 GHz.The antenna exhibits good matching impedance and radiation efficiencies around. However, an optimum selection of position of the feed is important for better results. Microstrip patch antenna is mostly used in modern communication devices over conventional antennas mainly because of their size. The properties of antenna such as, return loss, VSWR has been investigated for the improvement in the design.

Keywords- Microstrip antenna, HFSS, return loss,impedance, VSWR.

I. INTRODUCTION

The Microstrip Patch Antenna is a single-layer design which consists generally of four parts namely patch, ground plane, substrate and the feed. Patch antenna can be classified as single element resonant antenna. Once the frequency is given then antenna parameters radiation pattern input impedance, etc. are fixed. In the microstrip antenna the upper surface of the dielectric substrate supports the printed conducting strip which is suitably contoured while the lower surface of the substrate is backed by a conducting ground plane. Such antenna sometimes called a printed antenna because the fabrication procedure is similar to that of a printed circuit board. Many types of microstrip antennas have been evolved which are variations of the basic structure. Microstrip antennas can be designed as very thin planar printed antennas and they are very useful elements for communication applications.

Figure 1: Microstrip line fed patch antenna

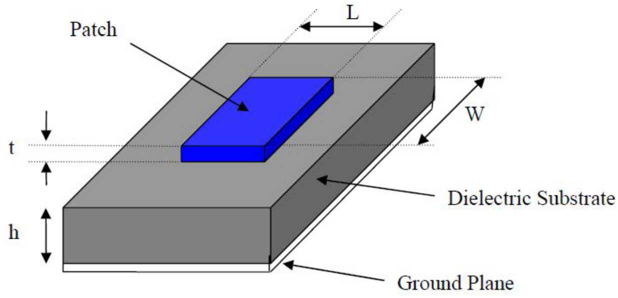

Figure 2: Microstrip patch antenna

Antennas transfer information between locations by altering electromagnetic fields in one location and detecting changes in electromagnetic fields in another location. One must first understand the working physics that govern their operation to understand how antennas can transfer information to increasingly remote locations.

II. ANTENNA PARAMETERS

Return loss:

The return loss measurement describes the ratio of the power in the reflected wave to the power in the incident wave in units of decibels. The standard output for the return loss is a positive value, so a large return loss value actually means that the power in the reflected wave is small compared to the power in the incident wave and indicates a better impedance match. Return Loss is the portion of a signal that is lost due to a reflection of power at a line discontinuity. Return Loss is similar to VSWR and is generally preferred in the cable industry to a VSWR specification. Since it is a logarithmic measurement, it is very useful when displaying very small reflections. The return loss can be calculated from the reflection coefficient with the equation:

$$\text{Return Loss} = -20*\text{Log}(\Gamma)$$

VSWR:

The VSWR (Voltage Standing Wave Ratio) measurement describes the voltage standing wave pattern that is present in the transmission line due to the phase addition and subtraction of the incident and reflected waves. The ratio is defined by the maximum standing wave amplitude versus the minimum standing wave amplitude. VSWR is the ratio of voltage applied to voltage reflected. VSWR is similar to Return Loss and is generally preferred in the connector industry to a Return Loss specification. Since it is a linear measurement, it can be useful when displaying larger reflections due to the fact that small differences are not compressed as they are in a logarithmic measurement.The VSWR can be calculated from the reflection coefficient with the equation:

$$VSWR = (1 + \Gamma)/(1 - \Gamma)$$

Gain:

Gain of an antenna is a measurement of overall efficiency of an antenna. Antenna gain incorporates directivity as well as the efficiency of the antenna.

Gain=Efficiency×Directivity

$$G = \frac{(dP/d\Omega)_{\max}}{P/4\pi}.$$

Efficiency accounts for the actual losses of a particular antenna design due to manufacturing faults, surface coating losses, imperfections, impedance mismatch, or any other factor.

Directivity:

Directivity is expressed as an ordinary number representing the ratio or in dB, with larger numbers representing more focused beams. An antenna that radiated equally well in all directions would have a directivity of 1.Antennas can be used in different applications based on their directivity. Low-directivity antennas transmit and receive information from all directions more or less equally. These are useful in mobile applications where the direction between transmitter and receiver can change. High-directivity antennas are able to transmit and receive information over greater distances but must be aimed towards another antenna. They are used in permanent installations such as satellite television.

Radiation Pattern:

The radiation pattern of an antenna gives us information about its receiving and transmitting properties in different directions. The radiation pattern can be shaped by adding directing elements in front and reflecting elements behind.Reflectors redirect the energy that would radiate behind an antenna such that it propagates in the forward direction. While receiving, it captures energy from a large area and reflects it toward a receiving element. When transmitting, it concentrates electromagnetic radiation along a central axis. The gain provided by antennas such as this one greatly aids in successful transmission of information over very long distances.UHF television antennas, on the other hand, have reflecting elements on the far side of a folded-dipole receiving element; they collect and reflect (toward the receiving element) radio waves that would otherwise pass by.Different antenna designs produce different radiation patterns. The complexity of the pattern depends on the antenna's design and construction.

Polarization:

An antenna is a transducer that converts radio frequency electric current to electromagnetic waves that are then radiated into space. The electric field or "E" plane determines the polarization or orientation of the radio wave. In general, most antennas radiate either linear or circular polarization.Polarization is one of the fundamental characteristics of any antenna. Polarization of an antenna is the polarization of the radiated fields produced by an antenna, evaluated in the far field. Hence, antennas are often classified as Linearly Polarized or a Right Hand Circularly PolarizedAntenna. This simple concept is important for antenna to antenna communication. First, a horizontally polarized antenna will not communicate with a vertically polarized antenna. Due to the reciprocity theorem, antennas transmit and receive in exactly the same manner. Hence, a vertically polarized antenna transmits and receives vertically polarized fields. Consequently, if a horizontally polarized antenna is trying to communicate with a vertically polarized antenna, there will be no reception

The microstrip patch antenna can be designed using substrate with dielectric constant of ε=4.4 considering the following dimensions:

Substrate =40, 40, 31mm

Patch =4.6mm, 1.75 mm

III. ANTENNA SYSTEM DESIGN

There are many advantages and applications of microstrip patch antennas over conventional antennas. There are several undesirable features we encountered with conventional antennas like they are size, conformability problems and difficult to perform multiband operations and so on. The advantages include planar surface, possible integration with circuit elements, small surface, generate with printed circuit technology and can be designed for dual and multiband frequencies as well. There are a few disadvantages also which are narrow bandwidth, low RF power handling capability, large losses and low efficiency because of surface waves etc. For the last two decades, researchers have been struggling to overcome these problems and they succeeded many times with their novel designs and new findings.

There are many configurations that can be used to feed microstrip antennas. The four most popular are themicrostrip line, coaxial probe, aperture coupling and proximity coupling. This paper uses microstrip line feeding technique. In this type of feed technique, a conducting strip is connected directly to the edge of the

Microstrip patch. The conducting strip is smaller in width 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. There are many methods of analysis for Microstrip antennas. The most popular models are the transmission line model, cavity model, and full wave model.The transmission-line model is the easiest of all, it gives good physical insight, but is less accurate and it is more difficult to model coupling. Compared to the transmission-line model, the cavity model is more accurate but at the same time more complex. However, it also gives good physical insight and is rather difficult to model coupling, although it has been used successfully. In general when applied properly, the full-wavemodels are very accurate, very versatile, and can treat single elements, finite and infinite arrays, stacked elements, arbitrary shaped elements, and coupling. However they are the most complex models and usually give less physical insight.

Effective dielectric constant (Ɛeff): (Ɛr + 1)/2 + (Ɛr – 1)/2 [1+ 12 h/W]1/2

The resonant length of patch (L):L = Leff – 2 ΔL

The Effective length (Leff): Leff = c / 2 f0 √Ɛeff

IV. EXPERIMENTAL RESULTS & ANALYSIS

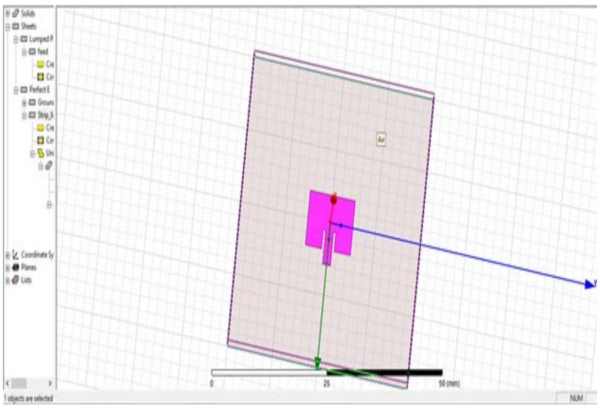

Figure 3: Diagram of the microstrip patch antenna

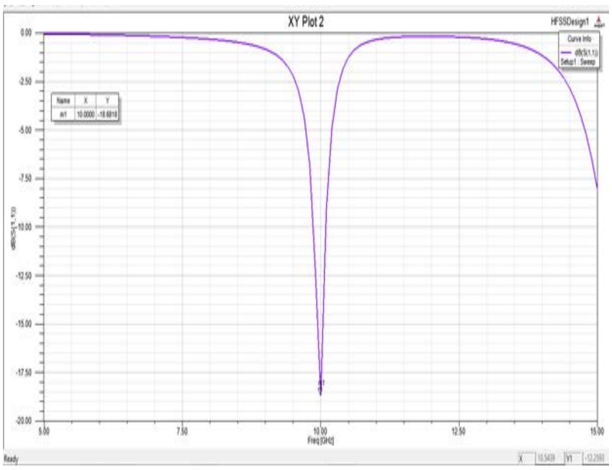

Figure 4: Plot between S (11) Vs Frequency

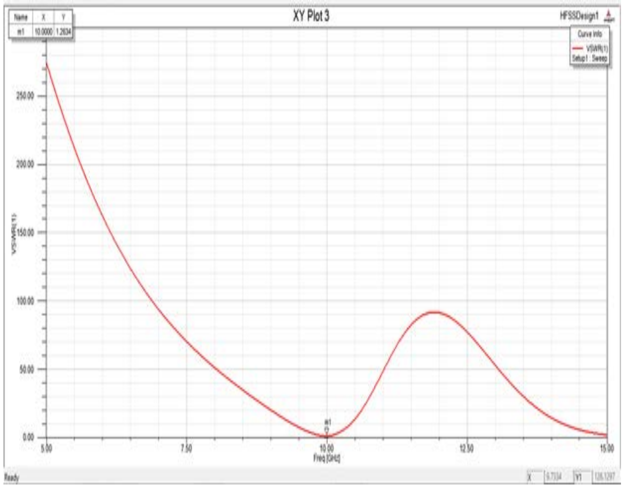

Figure 5: Plot between VSWRVs Frequency

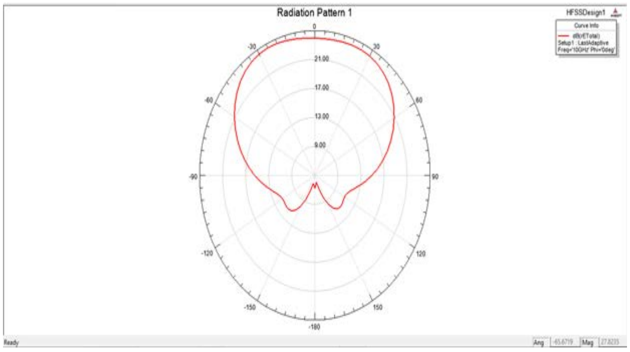

Figure 6: Radiation pattern of themicrostip patch antenna

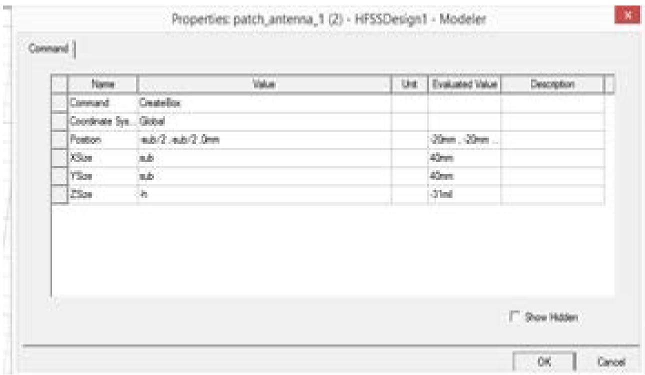

Figure 7: Table of themicrostrip patch antenna modeler

TABLE 1: PARAMETERS OF MICROSTRIP PATCH ANTENNA

S. No.	PARAMETERS	MICROSTRIP PATCH ANTENNA
1.	Resonant Frequency	10 GHz
2.	Return loss	-18.75 dB
3.	VSWR	1.204
4.	Gain	5.5 dB

V. FUTURE WORK

Microstrip antennas of different patch shapes and sizes can be explored and discussed in great details in future. Design of the same can further be improved with in terms of basic parameters such as type of substrate,the thickness of the substrate and dielectric constant. Microstrip patch antennas can be used in a very broad frequency range, extending roughly from about 1 GHz to 10 GHz. Of course, microstrip antennas also have some drawbacks, the most important being inherent narrow (impedance) bandwidth and low efficiency.

VI. CONCLUSION

The proposed antenna has been designed and simulated using high frequency structure simulator (HFSS) at the central frequency of 10 GHz using the Ansoft'sHFSSv13 and fabricated with FR4-Epoxy (ε=4.4) as substrate. The main issue is to study thebandwidth improvement of the microstrip antenna. In today world of wireless communication, recent developments in wireless communication industry continue to derive requirement of small, compatible and affordable microstrip patch antennas. The proposed antenna is a low profile antenna thus it is very compact, easy to fabricate and is fed by a microstrip feed line which makes it an attractive structure for current as well as future wireless applications. The fabrication process is easy and cost effective.Microstrip patch antennas are increasing in popularity for use in wireless applications due to their low-profile structure. Therefore they are extremely compatible for antennas embedded in hand-held wireless devices such as cellular phones, PDA, Tablets etc.

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