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Design and Analysis of Rectangular Microstrip Patch Antenna

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Abstract--- *In this paper rectangular microstrip patch antenna is designed and analysed for several wireless and broadband communication applications. This rectangular microstrip patch antenna has ground plane on one side and on the other side of its substrate having radiating patch which will radiate the power. The microstrip patch has dielectric material such as gold or copper with any desired shape. The rectangular patch is act like a radiator. Several advantages of this type of broadband antenna like it is a planar, flexible construction, compact size and easily fabricated thus it is useful for several practical applications. This rectangular microstrip patch antenna is designed, constructed and analysed for several wireless communication applications that operate at 5.2 GHz for different environment. It also has a broad angle of beam in its radiation pattern. Several results are obtained in rectangular microstrip patch antenna that is used as reference antenna in computer and which antenna is used for wireless fidelity. Simulated results are taken using HFSS software tool in this work.*

Keywords--- *Microstrip Patch Antenna, Substrate, HFSS.*

I. INTRODUCTION

Several wireless communication applications are operating at 5.2 GHz such as a video game application, computer, digital audio and video player or smartphone are connected within a range of wireless network through internet [2]. The coverage of many interconnected access points should be placed up from few meters to several square miles. With the development of high frequency solid state devices and integrated circuits, rectangular microstrip antenna provides the significant properties of the antenna area in current years[1]. In spite of its features likeless cost, small weight, conformability on curved surface, flexible fabrication and so on, the rectangular microstrip patch element suffers from an inherent disadvantages of small bandwidth in wireless communications[6]

Patch antenna is the most common and popular type of rectangular microstrip antenna [7]. Antennas which uses patches in the arrangement of an array are also possible. A patch antenna is a wide-beam and narrow band antenna which is fabricated by etching the element in metal trace combined to an dielectric substrate like printed board with a metal layer combined substrate opposite side that will give a ground plane. The popular shapes of the microstrip antenna are rectangular, square, elliptical and circular but any required shape is possible to construct. Few patch antennas which do not utilize the dielectric substrate and it is constructed by metal patch mounted above the ground plane with a help of dielectric spacers and the final construction is less rugged but it is having a large bandwidth. Because such antennas have a property of mechanically rugged but it has very less profile and they are rarely placed on the aircraft, spacecraft or it should be constructed to conform to a vehicle are incorporated into wireless radio communications devices.

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One more kind of patch antenna is the planar inverted-F patch antenna [8] The PIFA antenna is used in mobile phones with built-in antennas. This kind of antenna is resonant at a quarter-wavelength so that it will reduce the space required on the phone and also which has a SAR characteristics. This particular antenna resembles an inverted Fantenna structure, which represents the PIFA. The PIFA[9] is most popular one because it has unidirectional pattern and a very low profile. These antennas are constructed using quarter-wave half-patch antenna. The plane of the half-patch is decreased in length which will reduce the resonance frequency. Moreover, PIFA antennas are resonate at the several frequency bands. On some mobile phones are grounded parasitic elements and which are used to improve the radiation bandwidth properties. The inverted antenna [10] has some advantages with respect to the planar inverted F patch antenna due to its better volume reuse.

II. METHODOLOGY ADAPTED

2.1. Antenna Design

In its common form, a rectangular microstrip patch antenna having a ground plane on one side and on the other side it has radiating patch of a substrate shown in Figure 1. This patch is commonly made of conducting material like gold or copper and can take any required shapes. The feed lines and its radiating patch are generally photo etched on its substrate. Rectangular microstrip patch antenna radiates more because of the fringing fields lie between the ground plane and patch edge. For very good antenna performance, a thick dielectric substrate having a very low dielectric constant is required since this gives best efficiency, good radiation and larger bandwidth [3]

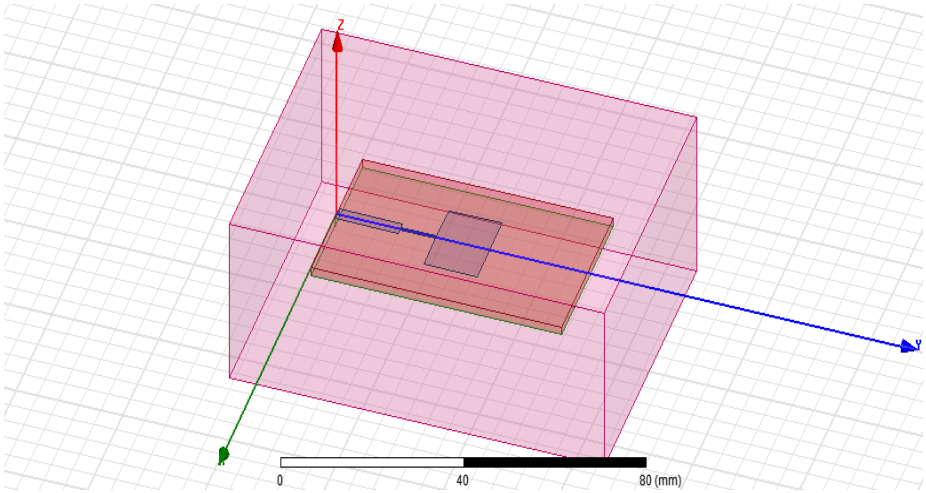

Fig 1: Structure of Rectangular Microstrip Patch Antenna

Consider Figure 1 above which shows a rectangular microstrip patch antenna of length L = 13.203mm, width W = 17.56mm, dielectric constant = 4.4 and dielectric height = 1.6mm and microstrip feed line length L = 7.9035mm, width W = 0.7091mm and length of the substrate = 58.94mm and width = 35.9 mm is designed at a frequency of 5.2GHz. The material FR4 is usually used for substrate to construct the antenna. The co-ordinate axis is chosen such that the length of the patch is along the x direction, width of the patch is along the y direction and the height of the patch is along the z direction.

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2.2. Feed Techniques

Microstrip patch antennas can be constructed by a variety of different variety of methods. These methods have two categories- contacting and non-contacting. In the contacting method, the radio wave frequency power is passed directly to the radiating patch using a element like microstrip feed line. In the non-contacting scheme, electromagnetic field coupling is provided to transfer power between the radiating patch antenna and microstrip feed line.

The four most common and popular feed techniques which is used are the microstrip line, coaxial probe and both contacting schemes, aperture coupling and proximity coupling both non-contacting schemes.

2.2.1. Microstrip Line Feed

In this microstrip feed line technique, a conducting strip line is connected directly with the corner of the microstrip patch antenna. The conducting strip line width is smaller as compared to the patch width and this kind of feed arrangement has an advantage that the feed will be etched on the same substrate to give a structure of planar.

2.2.2. Coaxial Feed

The probe feed or coaxial feed is a very common method which is used for feeding microstrip line patch antennas. The inner conductor of the coaxial connector is combined through the dielectric and it is soldered to the patch itself, while the outer conductor is combined with the ground plane.

2.2.3. Aperture Coupled Feed

In this type of feed technique, the microstrip feed line and radiating patch are splited by the ground plane coupling between patch and feed line is made by through a slot or an aperture.

2.2.4. Proximity Coupling Feed

The Proximity coupling feed method in microstrip patch antenna which contains with two layer substrate and patch antenna on the upper layer and microstrip feed line on the lower layer.

2.3. Antenna parameters

Antenna is one of the electrical conductor in which transmitter radiates electromagnetic energy into space and its receiver collects electromagnetic energy from the space. The important parameters associated with an antenna are discussed in the following sections.

2.3.1. Antenna Gain

Gain is a measurable parameter of an antenna from the input power into radiation in a particular direction and is calculated at the peak radiation intensity. Consider the power density radiated by an isotropic antenna with input power P with a distance R which is defined by $S = P /4\pi R^2$. An isotropic patch antenna radiates equally in all the directions, and it's radiated power density S is calculated by dividing the radiated input power P by the area of the sphere $4\pi R^2$. An isotropic radiator provides 100% efficiency. The gain of an actual isotropic antenna increases with the power density in the direction of the peak radiation of antenna.

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2.3.2. Antenna Efficiency

Antenna efficiency is mostly used to calculate average radiation efficiency. It is measured in radio antenna which converts the radio wave frequency power at its ports into a radiated power.

2.3.3. Directivity

Directivity is a measure of concentration of the maximum radiation in the desired and required direction.

2.3.4. Path Loss

Path loss is the reduced power density or electromagnetic wave attenuation and it propagates through space. This is commonly used in signal propagation area and wireless communication applications.

2.3.5. Return Loss

It is a parameter which represents the amount of power which is lost in to the load and does not return back as a reflection.

Hence RL is a parameter which indicates how well it is matched between the transmitter and receiver has taken place. It is the S_{11}parameter of an antenna. A graph of S_{11} parameter of an antenna with respect to frequency is known as its return loss curve. For optimum working such a plot must indicate a dip at the operating resonant frequency and have a minimum return loss in decibels value at this particular resonant frequency. This parameter was determined to be very important one as the antenna dimensions length and width has to be adjusted for a particular fixed operating frequency at 5.2GHz.

2.3.6. Radiation Pattern

The radiation pattern of an antenna is a graphical representation of the far-field radiation characteristics of an antenna as a function of the spatial co-ordinates which is specified by the elevation angle θ and the azimuth angle φ. More specifically it is a graphical representation of the power dissipated from an antenna element per unit solid angle which is the radiation intensity. It should be plotted as a Cartesian slice of the three dimensional graph or as two dimensional graph. It is a parameter as it shows the antenna's directivity and gain at various points in space.

2.4. Applications of Microstrip Patch Antennas

Microstrip patch antennas are popular and common one in wireless communication applications due to their very low profile construction. Therefore they are flexible for embedded antennas in handheld wireless component devices like pagers and cellular phones etc. The communication and telemetry antennas are to be thin and conformal. In satellite communication area they have been utilized successfully.

III. SIMULATED RESULTS

Simulated results are shown in below figures. Antenna parameters such as S parameter, VSWR, Gain, Directivity, Radiation Pattern and Input Impedance values are plotted in the graphs shown in below figures.

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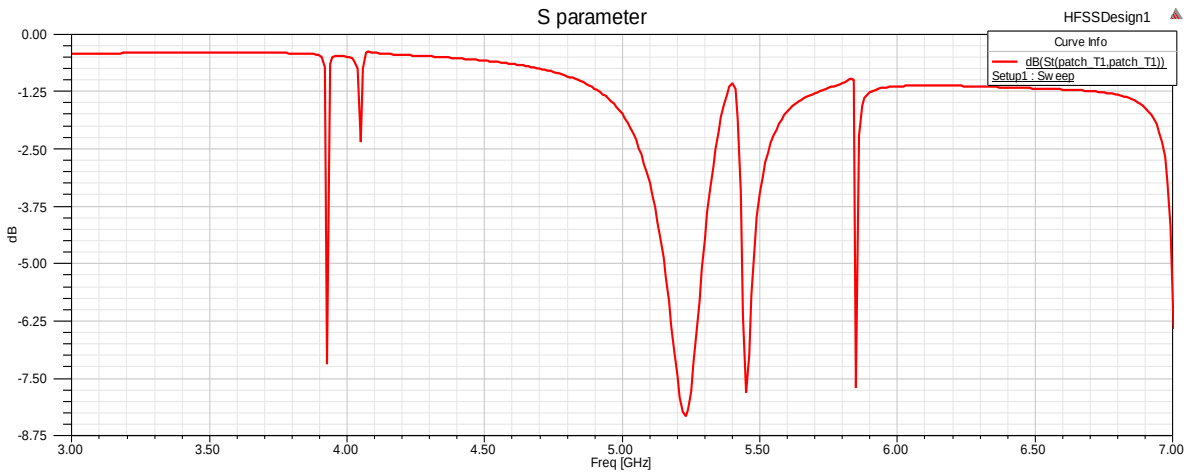

Fig 2: S Return Loss

Figure 2 shows that return loss value of patch antenna. It is obtained at a frequency of nearly 5.2 GHz.

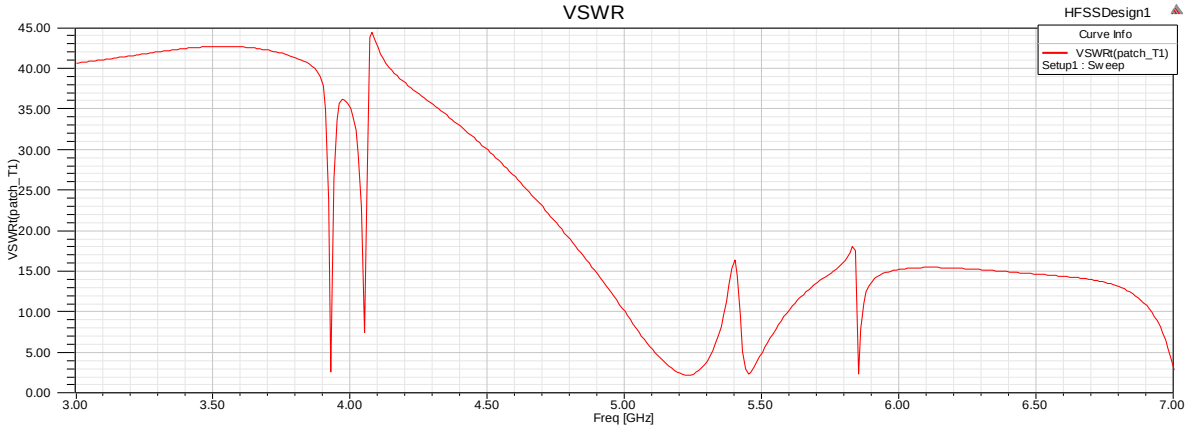

Fig 3: VSWR

Figure 3 shows that VSWR value of patch antenna. It's value is 1.1 obtained at a frequency of 5.2 GHz.

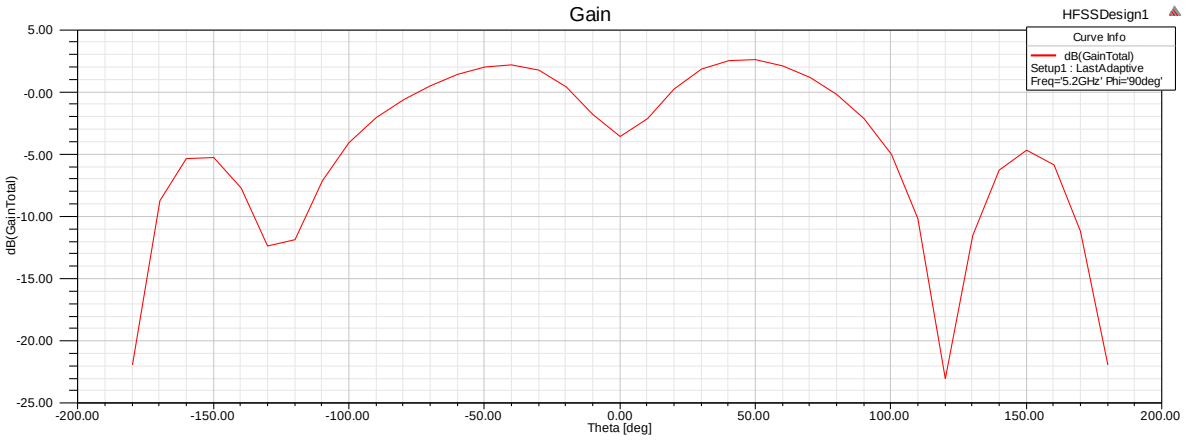

Fig 4: Gain Vs Theta

Figure 4 shows that gain of patch antenna. It is measured with respect to angle from -180º to 180º

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Fig 5: Gain Vs Frequency

Figure 5 shows that gain of patch antenna. It is measured with respect to frequency. Max gain obtained here is closer to 2.83

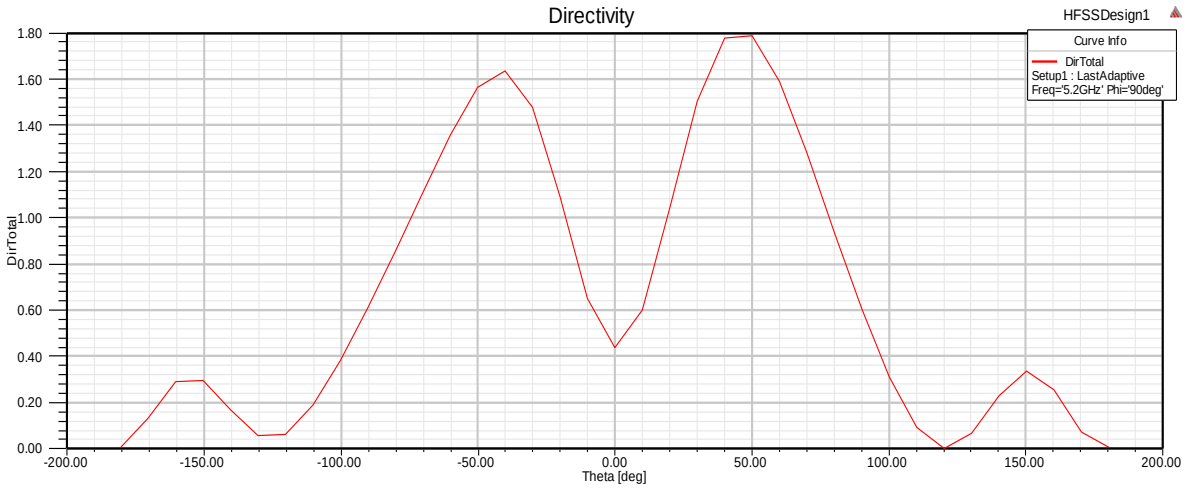
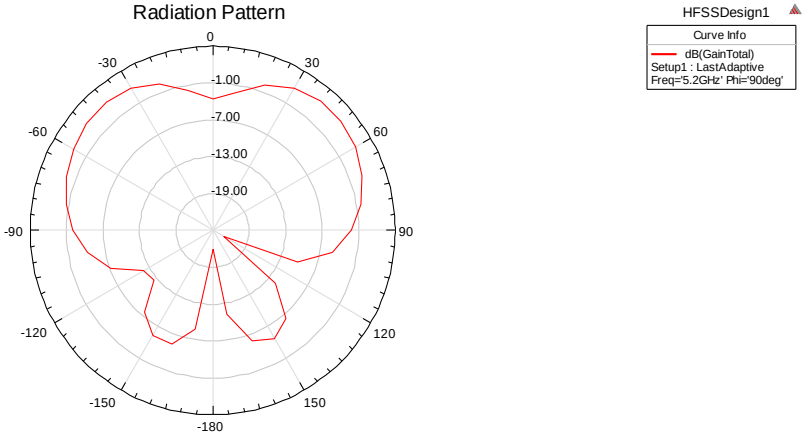


Fig 6: Directivity

Figure 6 shows that the directivity of patch antenna. It is measured with respect to angle from -180º to 180º



z

Fig 7: Radiation Pattern

Figure 7 shows the radiation pattern of an antenna which indicates the gain with respect to different angles.

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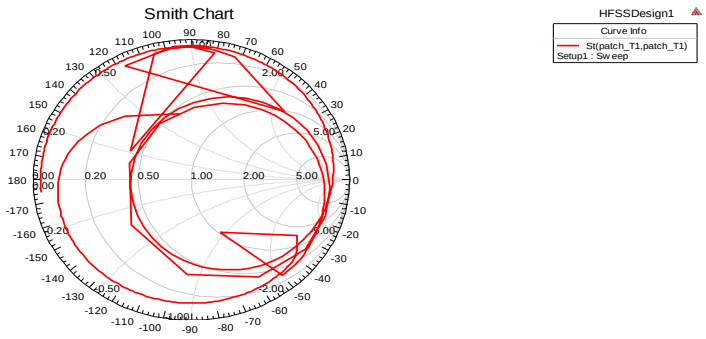

Fig 8: Input Impedance

Input impedance 50Ω and VSWR values are measured by using smith chart as shown in figure 8.

IV. CONCLUSION

Design and analysis of rectangular microstrip patch antenna is presented in this paper. The method to design an antenna, some characteristics of feeding technique and various antenna parameters are discussed in this paper. This rectangular microstrip patch antenna is designed and various antenna parameters such as S parameter, VSWR, Gain, Directivity, Input impedance and Radiation pattern results are taken at a frequency of 5.2 GHz using HFSS software tool. Particular microstrip patch antenna can be designed for each application and different merits are compared with wireless communication and conventional microwave antenna.

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