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EFFICIENT DESIGN OF FLOWER BASED MICROSTRIP ANTENNA FOR HIGH FREQUENCY APPLICATIONS

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Abstract – In today's modern communication industry, antennas are the most important components required to create a communication link. Microstrip Patch antennas are the most suited for aerospace and UWB applications because of their low profile, light weight and low power handling capacity. They can be designed in a variety of shapes in order to obtain enhanced gain and bandwidth, dual band and circular polarization to even ultra-wideband operation. The proposed work is based on the design of a Microstrip Patch antenna. For the simulation process ANSOFT HFSS (high frequency structure simulator) has been used. The effect of antenna dimensions and substrate parameters on the performance of antenna have been discussed. The antenna has been designed using the FR4 epoxy substrate with relative permittivity of 4.3 and a substrate of Flower shaped Microstrip patch placed on it. Feed used is the coaxial feed. The designed antenna is a low profile, small size and multiband antenna since it can be operated at different frequencies within the frequency range of 2.32GHz to 2.54GHz and 5.11GHz to 5.4GHz. It includes the frequencies used for wireless WLAN application, mobile applications and used in Bluetooth applications.

I. INTRODUCTION

The idea of antenna was first considered in 1886, by Heinrich Rudolph Hertz, the father of Electromagnetics, in his Laboratory at the Technical Institute of Kalsruhe. Hertz proved experimentally that the electrical turbulences could be noticed with a secondary circuit of correct dimensions for resonance and comprising an air gap for sparks to happen. Antennas are like Electronic eyes and ears [2]. Their performance is as boundary between free space and circuitry. IEEE standards describe an antenna as "a means for burning or receiving electromagnetic breakers". An antenna is an integral part of any communication device.

A microstrip antenna consists of conducting patch on a ground plane separated by dielectric substrate [7]. This concept was undeveloped until the revolution in electronic circuit miniaturization and large-scale integration in 1970. Low dielectric constant substrates are generally preferred for maximum radiation. The conducting patch can take any shape but rectangular and circular configurations are the most commonly used configuration. Other configurations are complex to analyze and require heavy numerical computations. A microstrip antenna is characterized by its Length, Width, Input impedance, and Gain and radiation patterns. The length of the antenna is nearly half wavelength in the dielectric; it is a very critical parameter, which governs the resonant frequency of the antenna. There are no hard and fast rules to find the width of the patch.

Microstrip antennas also known as printed antennas, as shown in figures 1 and 2, consist of a radiating patch on one side and on the other side of the substrate a ground plane. The size of a microstrip antenna is inversely desired to the pretended resonant frequency. Microstrip antennas only make sense when talking about UHF and above due to the fact that antennas for these frequencies are centimetre antennas.

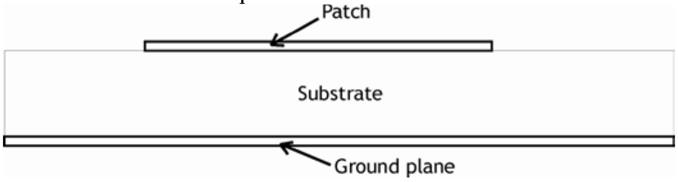

Figure 1: Side view of microstrip patch

The patch and ground plane are usually made of copper and can take any shape. This helps to face the high complex geometry microstrip antennas use. Microstrip patch antennas are good radiators due to the fact that they have a fringing field between the patch edge and the ground plane. The best performance of an antenna is achieved with a thick dielectric substrate with a low dielectric constant. This kind of substrate will provide better efficiency, larger bandwidth and better radiation. Unfortunately this leads to a larger antenna, therefore, a substrate with higher dielectric constant must be used

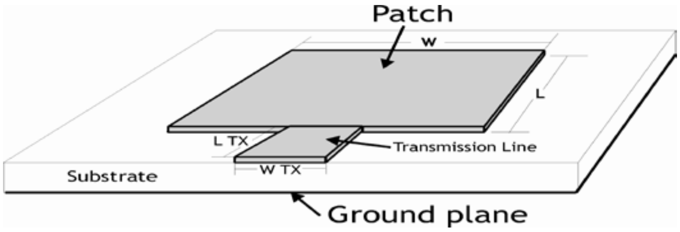

Figure 2: Top view of microstrip patch

A. 1.3 Feeding methods

1) 1.3.1 Microstrip feed

It is easy to fabricate and simple to match by controlling the inset position thus making it relatively simple to model.

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However, as the substrate thickness increases, surface waves and spurious feed radiation increase [9].

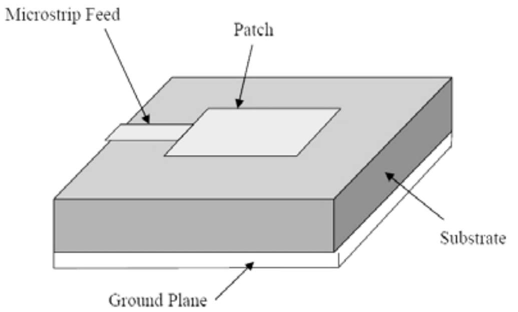

Figure 3: Microstrip feed

2) 1.3.2 Coaxial probe feed

It has many advantages like easy to fabricate, low spurious radiation; difficult model accurately; narrow bandwidth of impedance matching [10].

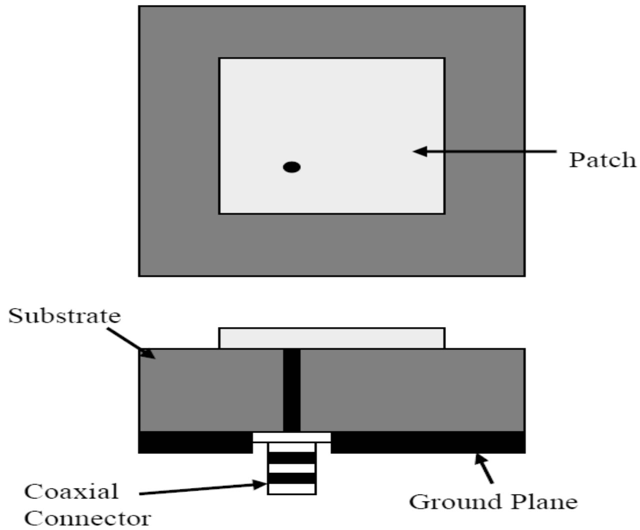

Figure 4: Coaxial probe feed

3) 1.3.3 Aperture coupling (no contact)

Microstrip feed line and radiating patch is on both sides of the ground plane,

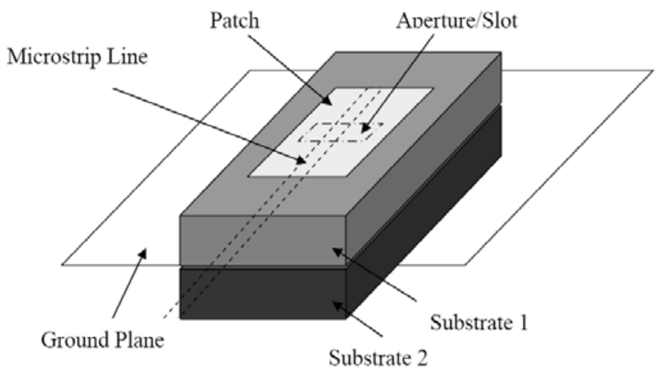

Figure 5: Aperture coupling (no contact)

The coupling aperture is in the ground plane– low spurious radiation, easy to model; difficult to match, narrow bandwidth [11].

4) 1.3.4 Proximity coupling (no contact)

Microstrip feed line and radiating patch are [12] on the same side of the ground plane – largest bandwidth (upto 13%), relatively simple to model, has low spurious radiation.

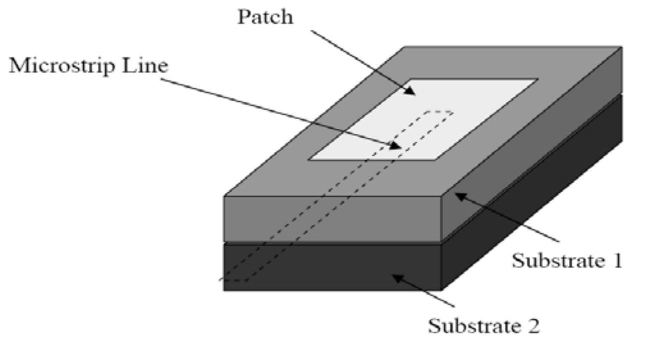

Figure 6 Proximity coupling (no contact)

B. 1.6 Basic antenna parameters:

1) 1.6.1 Scattering Parameters

Scattering Parameters also known [13] as S-Parameters, are the reflection and transmission descriptor between the incident and reflection waves, which for a two port system is given by

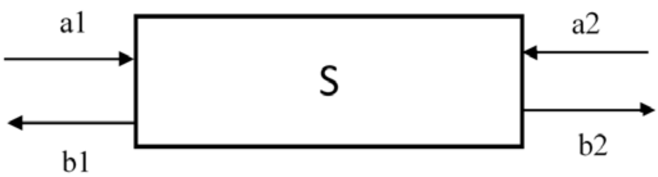

Figure 7: Generalized two port network, [S] represents the scattering matrix.

$$\begin{bmatrix} b_1 \\ b_2 \end{bmatrix} = \begin{bmatrix} S_{11} & S_{12} \\ S_{21} & S_{22} \end{bmatrix} \begin{bmatrix} a_1 \\ a_2 \end{bmatrix} \qquad (1.1)$$

To measure S_{11} we inject a signal at port 1 with port two terminated with impedance matched to the characteristic impedance of the transmission line ($a_2 = 0$).

2) VSWR

Voltage Standing Wave Ratio is the ratio [13] of maximum radio-frequency voltage to minimum radio-frequency voltage on a transmission line. It is given by:

$$\mathrm{VSWR} = \frac{V_{max}}{V_{min}} \qquad (1.2)$$

The VSWR can also be calculated from the return loss (S_{11}) which means that it is also an indicator of an antennas efficiency. With the return loss we can determine the mismatch between the characteristic impedance of the transmission line and the antennas terminal input impedance. If the magnitude of the reflection coefficient is known the VSWR can be determined by.

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$$\mathbf{VSWR} = \frac{1+|S_{11}|}{1-|S_{11}|} \qquad (1.7)$$

The VSWR increases with the mismatch between the antenna and the transmission line and decreases with a good matching. The minimum value of VSWR is 1:1 and most equipment's can handle a VSWR of 2:1, the bandwidth of an antenna can be determined by the VSWR or the return loss. The best performance of an antenna is achieved when the VSWR under 2:1 or the return loss is -10 dB or lower.

3) Bandwidth

Bandwidth can be defined as "the range of frequencies within which the performance of the antenna, with respect to some characteristics, [13] conform to a specified standard". Bandwidth is a measure of frequency range and is typically measured in hertz. For an antenna that has a frequency range, the bandwidth is usually expressed in ratio of the upper frequency to the lower frequency where they coincide with the -10 dB return loss value. The formula for calculating bandwidth is given in Equation.

$$\%BW = \frac{f_h - f_l}{\sqrt{f_h f_l}} \times 100\% \qquad (1.3)$$

Where,

$f_h \rightarrow$ Upper frequency that coincide with the -10 dB return loss value

$f_l \rightarrow$ Lower frequency that coincide with the -10 dB return loss value

4) Radiation Pattern

The Radiation pattern of an antenna can be defined as the variation in field intensity as a function of position or angle. Let us consider an anisotropic radiator, which has stronger radiation in one direction than in another.

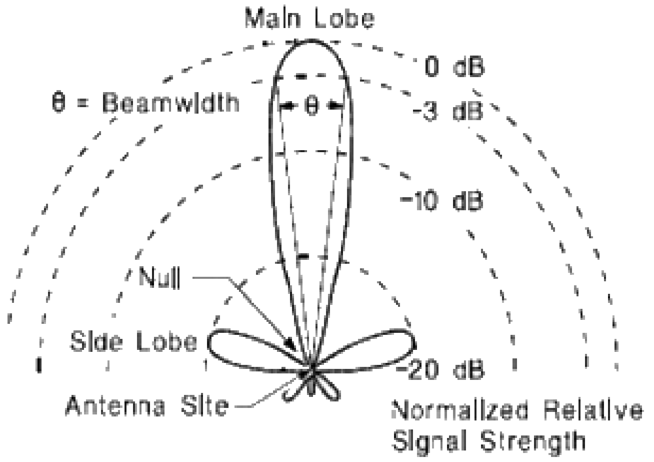

Figure 8: Radiation Pattern.

The radiation pattern of an anisotropic radiator shown below in figure 8 consists of several lobes. One of the lobes has the strongest radiation intensity compared to other lobes. It is referred to as the Major lobe. All the other lobes with weaker intensity are called Minor Lobes. The width of the main beam is quantified by the Half Power Beam width (HPBW), which is the angular separation of the beam between half-power points.

5) Total Gain

The efficiency of an antenna relates the power delivered to the antenna and the power radiated or dissipated within the antenna. A high efficiency antenna has most of the power present at the antenna's input radiated away. A low efficiency antenna has most of the power absorbed as losses within the antenna, or reflected away due to impedance mismatch.

The antenna efficiency (or radiation efficiency) can be written as the ratio of the radiated power to the input power of the antenna:

$$\varepsilon_r = \frac{P_{radiated}}{P_{input}} \qquad (1.4)$$

II. PROPOSED WORK:

We proposed a new method to design a Microstrip Patch Antenna of Flower shaped. We use the flower shape by using curved lines for the best results. The designed Microstrip antenna is used in wireless WLAN application, mobile applications and used in Bluetooth applications etc.

In the proposed geometry the concept of Microstrip has been applied to the geometry of a Microstrip Patch Antenna of Flower shaped to obtain multi band frequency operation. It is similar to the Microstrip Patch Antenna construction except the basic shape used in it that is curved shaped flower shaped microstrip antenna.

A schematic diagram of flower shaped microstrip patch antenna is shown in figure 4.1 below:

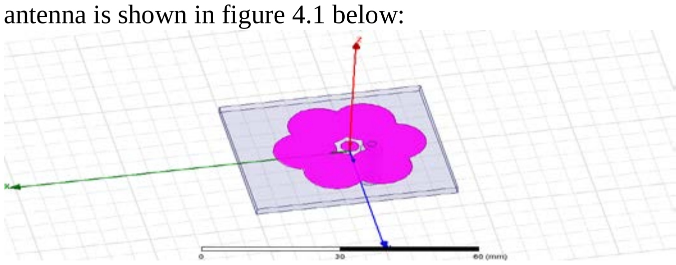

Figure 9: Geometry of the patch antenna

A scaling factor of 1/3 was chosen so as to maintain the perfect geometry symmetry of microstrip structure. To establish the multi band frequency operation, initially the order n of the antenna was limited to three (n=3), which enabled the antenna to operate in three different frequency bands.

Substrate Dimension		
Width of the dielectric substrate	W	40 mm
Thickness of the dielectric substrate	T	2.5 mm
Length of the dielectric substrate	L	45 mm
Patch Dimension		
Width	P_w	33.6 mm
Port Dimension		
Radius	W_p	4 mm
Feed Dimension		
Pin Height	Cpi	15
Probe Height	Cp	2.5
Pin Radius (inner)	r_1	1
Pin Radius (Outer)	r_2	2.5

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III. RESULTS

Figure 10 shows the results from HFSS simulations, as may be noted that the antenna has a magnitude of return loss below-15 dB at the frequencies approximately 2.32 GHz to 2.54 GHz, 5.11 GHZ to 5.4 GHz, thus it is displaying multiband behavior, but there is also a shift from the initial design frequency.

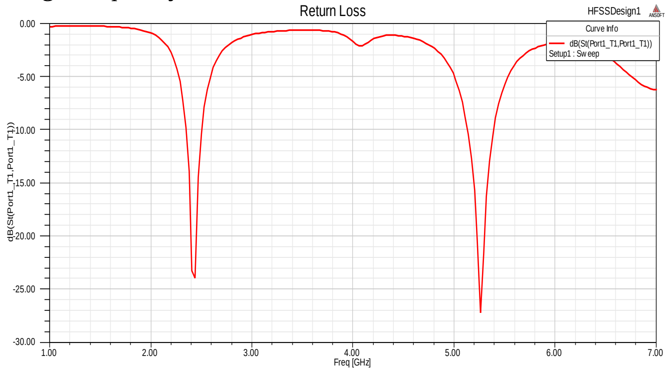

Figure 10: Return Loss parameter graph

Voltage Standing Wave Ratio is the ratio of maximum radio-frequency voltage to minimum radio-frequency voltage on a transmission line.

The best performance of an antenna is achieved when the VSWR under 2:1 or the return loss is -1.09 dB or lower.

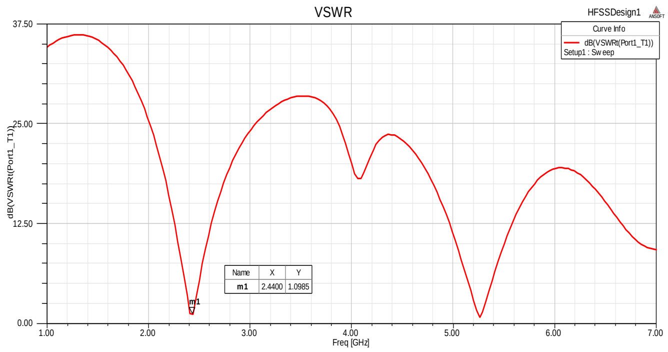

Figure 11: VSWR graph

The Radiation pattern of an antenna can be defined as the variation in field intensity as a function of position or angle. Let us consider an anisotropic radiator, which has stronger radiation in one direction than in another. The radiation pattern of an anisotropic radiator shown below in figure 12

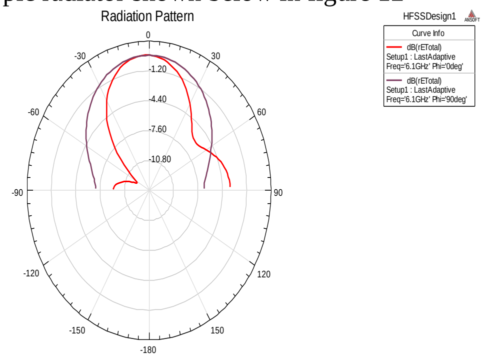

Figure 12: Radiation pattern in 2D

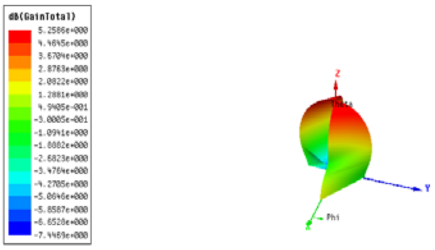

Figure 13: Radiation pattern in 3D

The efficiency of an antenna relates the power delivered to the antenna and the power radiated or dissipated within the antenna. The antenna efficiency (or radiation efficiency) can be written as the ratio of the radiated power to the input power of the antenna:

$$\varepsilon_r = \frac{P_{radiated}}{P_{input}} \qquad (1.5)$$

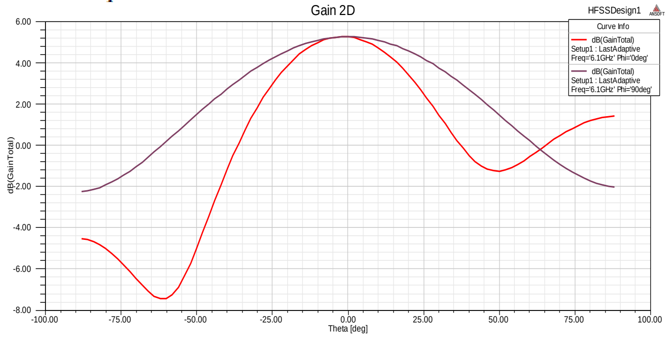

Figure 14: Total gain

IV. CONCLUSION

The main goal behind this thesis work was to design a Microstrip Patch antenna capable of working at different frequencies which categorized it under multiband antennas. The range of the operating frequencies is between 2.32GHz to 2.54GHz and 5.11GHz to 5.4GHz range, therefore it can be used for wireless WLAN application, mobile applications and used in Bluetooth applications. Return loss is bellow -10dB which is our margin, consequently the VSWR is always under 1.3, the radiation patterns show that these antennas have good gain. From the results we can conclude that with the increase in iteration there is an increase in bandwidth and decrease in the return loss. Hence the goals of this assignment were successfully accomplished.

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