Design Of Hexagonal Microstrip Antenna

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Abstract— **In this paper, the Hexagonal shaped Antenna concept has been used in antenna designed to reduce antenna size. There is a reduction of resonance frequency from 2.44GHz to 2.10GHz i.e. around 15 % with the proposed antenna compared to the square patch of the same size. The antenna operating frequency range is 2.43GHz - 2.47GHz with VSWR less than 2. It exhibits remarkable gain which corresponds to the gain of 4.5dB. It has wireless applications which require more bandwidth such as for covering wireless applications of WLAN. The radiation pattern, beamwidth, directivity, return loss, VSWR and Bandwidth of the proposed antenna are described and also simulated using HFSS software package.**

Keywords—Hexagonal micro strip, WLAN, VSWR

I. Introduction

The antenna works as an interface between transmission lines and free space (wireless communication). Antenna can be designed for different frequency bands. Beyond the operating band, the antenna rejects the signal. Therefore antenna can work as a band pass filter and a transducer.

Conventional microstrip antennas in general have a conducting patch printed on the grounded microwave substrate, and have the attractive features like low profile, light weight, easy fabrication, and conformability to mounting hosts. Due to the emerging need of wireless communication systems, broadband high gain antennas are of great demand. The low bandwidth of microstrip antennas limits their application in modern wideband imaging and wireless communication systems. For this reason, studies to achieve broadband operations of microstrip antennas havegreatly increased. Microstrip antenna having wide range of operating bandwidth, simple fabrication techniques, and good performance characteristics, low cost, all of these advantages attracted towards the more work on the MSA.

This report deals with design & development of hexagonal microstrip antenna for Wireless Application. Compact double band and multiband antennas got their popularity due to the growing demand of small and broadband antennas for the communication devices. The continuous growth of the short distance wireless communications, for example wireless local area networks (WLAN) operates at the 2.4 GHz (2.4_2.48 GHz) and 5 GHz bands (5.15_5.35 and 5.725_5.825 GHz in the US and 5.15_5.35 and 5.47_5.725 GHz in Europe), broadband wireless access or WiMAX (worldwide interoperability for microwave access) operates at 2.5_2.69/ 3.4_3.69/5.25_5.85 GHz and X-band operates in 8_12 GHz (satellite communication, terrestrial communications, radar etc.) needs a very compact and the single antenna that could fulfill these requirements [1].

Due to higher efficiency, broadband behavior, and compact size, the printed monopole antennas find their suitability for such applications. In literature, a number of the wideband antennas have been proposed and investigated. A printed wide-slot antenna of 110 X 110 X 0.8 mm3 size with a fork-like tuning stub [2] and a semicircular slot antenna of 120 X 120 X 1.6 mm3 size [3] have been investigated for bandwidth enhancement. Two different antennas of 110 X 110 X 0.8 mm3 size with arc-shaped and triangular-shaped slots fed by microstrip lines and similar patch shapes are reported in the [4]. The broadband behavior of these antennas depends upon the slot and patch shape. In [5], a compact wide-slot monopole antenna with microstrip feed for the ultra-wideband (UWB) application is presented and having the size of 30 X 30 mm2.

Besides a number of research article has been published on miniaturization of UWB monopole antennas using the half-cutting method [6_11]. In [12], a symmetric zeroth-order resonator (ZOR) antenna is miniaturized by bisection of the antenna with a shorted end. In this report, a miniaturized hexagonal slot monopole antenna with dual broadband characteristic is proposed and investigated for improving performance. The present antenna is design on a lower cost FR4 substrate finds benefits over the conventional related antennas in the literature [1_5] with its compact size and dual broadband behavior. Unlike those in literature [6_12], a dual broadband characteristic with a bisected miniaturized antenna structure is also reported here. First, a broadband reference antenna with a hexagonal slot is designed and optimized.

The miniaturization is achieved by bisection of the reference antenna from its symmetry plane. Because of bisection of antenna, its lower frequency of operation is downshifted and upper frequency of operation is upshifted. Another phenomenon observed in bisecting the reference antenna is mode splitting in its [S11] curve. Further miniaturization and dual broadband behavior is achieved by scaling down the bisected antenna. The reference and the proposed antennas are fabricated and measured, they are found suitable for broadband communication systems. HFSS software has been used for the simulation.

II. MICRO STRIP ANTENNA AND HEXAGONAL MICROSTRIP PATCH ANTENNA DESIGN

Structure of single patch antenna with inset feed is shown in figure 1. The Antenna is composed of patch, substrate, ground and feeding network. The performance of antenna generally depends on dimensions of above components and the operating frequency.

A simple rectangular linear polarized microstrip patch antenna is designed to operate at 2.42GHz. To develop light weight antenna, FR4_epoxy is used as the substrate material as it is light in weight and also have good mechanical strength, which is having the thickness of 1.6mm and permittivity εr=4.4. These properties make FR4_epoxy very attractive to be used as substrates for the fabrication of antennas in applications requiring the light weight, low loss, reduced bill of materials, preserving the electromagnetic performance. The length and width of the patch are 39mmand 28.2mm respectively. The feed point is 7.5mm from the centre of the patch.

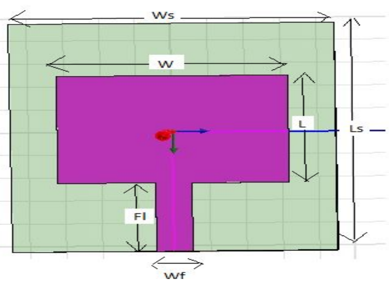


Figure 1: Rectangular micro strip antenna

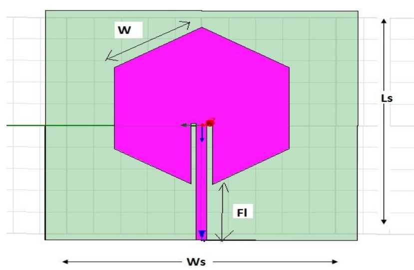


Figure 8: Hexagonal micro strip antenna

Hexagonal microstrip antenna is designed to operate at 2.42GHz. To reduce size of a antenna, FR4_epoxy is used as the substrate material as it is light in weight and also have good mechanical strength, which is having the thickness of 1.6mm and permittivity εr=4.4. These properties make FR4_epoxy very attractive to be used as substrates for the fabrication of antennas in applications requiring light weight, low loss, reduced bill of materials, preserving the electromagnetic performance. The length and width of the patch are same 39mm. The feed point is 7.5mm from the centre of the patch.

III. METHODOLOGY

The formulas for calculating the length, width and value of air gap are taken from [8]. The value of resonant frequency (Fr) is 2.44 GHz and dielectric constant of the substrate (εr) is 4.4 and Height of dielectric substrate (h) is 1.6mm.

Next step is to calculate the other parameters like length and width of micro strip patch is given as follows:

Step 1:

Width of micro strip patch is given below:

$$w = \frac{c}{2f_0\sqrt{\frac{\varepsilon_r+1}{2}}} \quad (1)$$

Step 2:

Length of micro strip patch is given below:

$$\Delta L = (0.412 * h)\frac{(\varepsilon_{reff}+0.3)\left(\frac{w}{h}+0.264\right)}{(\varepsilon_{reff}-0.258)\left(\frac{w}{h}+0.813\right)} \quad (2)$$

Step 3:

The resonant frequency for any mode is given by:

$$f_0 = \frac{c}{2\sqrt{\varepsilon_{reff}}}\left[\left(\frac{m}{l}\right)^2+\left(\frac{n}{m}\right)^2\right]^{1/2} \quad (3)$$

Steps for calculations of hexagonal microstrip antenna are as follows

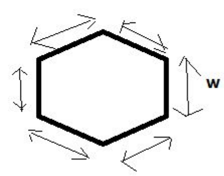
The fundamental mode resonant frequency of such antenna is given by

$$fr = \frac{2c}{6W\sqrt{\varepsilon_r}} \quad (1)$$

where: c is the speed of light, and ε_r - relative permittivity of substrate.

From Eqn. 1 we estimated the patch side length W, for ISM band, f= 2.4GHz and ε_r=4.4, which is

$$W_{[mm]} = \frac{2c_{[m/s]}}{f_{1[Hz]}\sqrt{\varepsilon_r}} = \frac{2\cdot 3\cdot 10^8}{6\cdot\ 2.4\ \cdot 10^9\sqrt{4.4}} = \mathbf{20.5mm}$$



IV. SIMULATION RESULTS

Simulation of this antenna has been carried out in HFSS. The simulation results for rectangular microsrtip antenna are given in the following section:

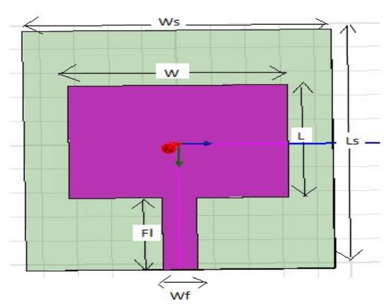


Figure 3: Rectangular micro strip antenna

VSWR: The ratio between the maximum voltage and the minimum voltage along the transmission line is defined as the Voltage Standing Wave Ratio or VSWR. The VSWR, which can be derived from the level of reflected and forward waves, is also an indication of how closely or efficiently an antenna's terminal input impedance is matched to the characteristic impedance of the transmission line. An increase in VSWR indicates an increase in the mismatch between the antenna and the transmission line.

Return loss: Return loss indicates the amount of power that is lost to load and does not return as reflection. Return loss is a parameter similar to VSWR to indicate how well the matching between transmitter and antenna has taken place. Ideal value of return loss is around -13dB which corresponds to VSWR of less than 2.

Impedance: The VSWR provides an indication of how closely the impedance of an antenna matches the impedance of the connecting transmission line. If an impedance mismatch exists, a reflected wave will be created towards the energy source. This reflected wave reduces the level of forward energy transferred from the transmission line to the antenna. This effectively reduces the total level of energy available for radiation thus reducing the effective gain of the antenna.

Radiation patterns: The radiation patterns of an antenna provide the information that describes how the antenna directs the energy it radiates. As stated earlier, an antenna cannot radiate more total energy than is delivered to its input terminals. All antennas, if 100% efficient will radiate the same total energy, for equal input power, regardless of pattern shape. Antenna radiation patterns are typically presented in the form of a polar plot for a 360 degree angular pattern in one of two sweep planes. The most common angular sweep planes used to describe antenna patterns are a horizontal or azimuth sweep plane and a vertical or elevation (zenith) sweep plane.

As shown in figure: 4 the value of VSWR is 1.61

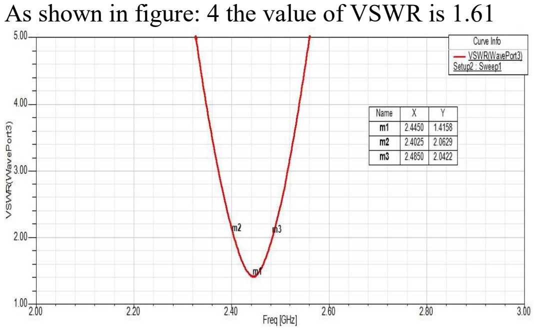


Figure 4: VSWR

As shown in figure: 5 the value of Return loss is -12.77dB.

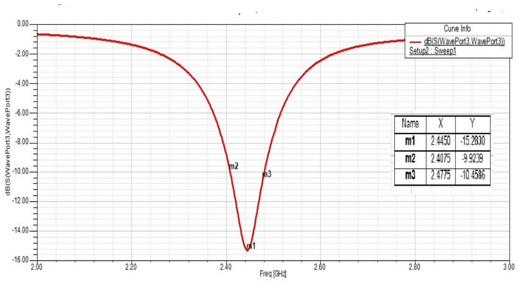


Figure 5: Return loss

As shown in figure: 6 the value of Impedance is 50.81.

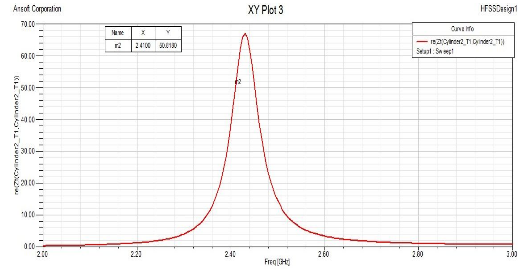


Figure 6: Impedence

Figure: 7 shows the radiation pattern of rectangular microstrip antenna

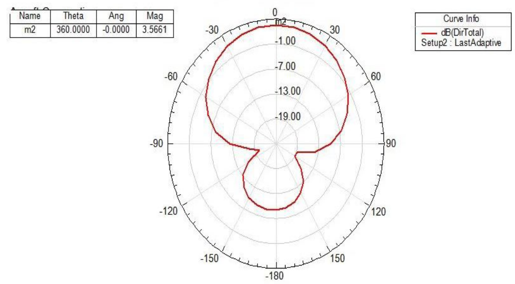


Figure7: Radiation Pattern

Similarly The simulation results for hexagonal microsrtip antenna are given in the following section:

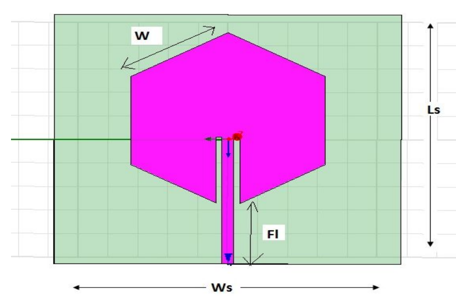


Figure 8: Hexagonal micro strip antenna

As shown in figure: 9 the value of VSWR is 1.44.

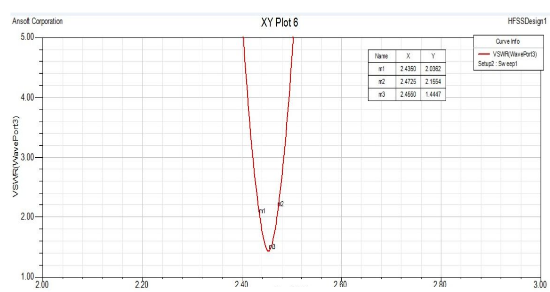


Figure 9: VSWR

As shown in figure: 10 the value of Return loss is -14.98dB.

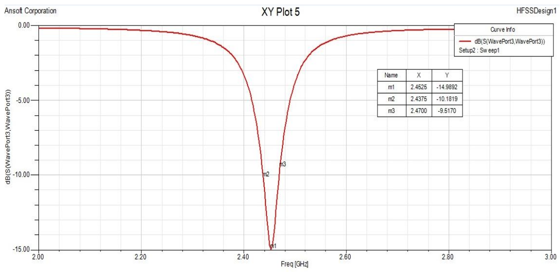


Figure 10: Return loss

As shown in figure: 11 the value of Impedance is 50.81.

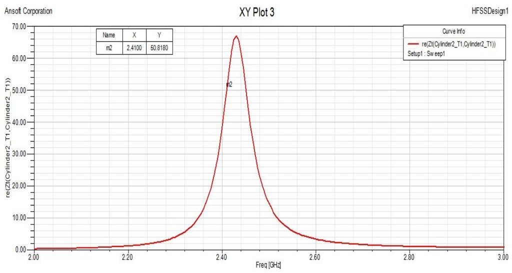


Figure 11: Impedence

Figure: 12 shows the radiation pattern of Hexagonal microstrip antenna

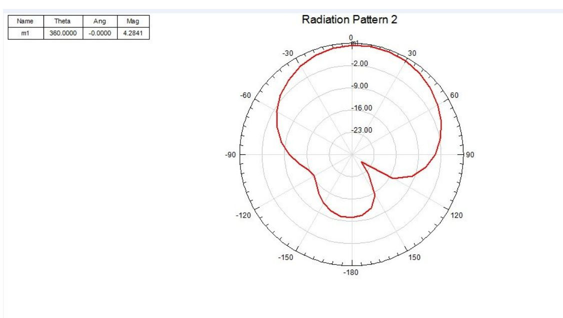


Figure 12: Radiation Pattern

V. COMPARISON TABLE

The work started with basic rectangle antenna with resonant frequency 2.43GHz and bandwidth of 60MHZ. the same antenna was converted to hexagonal antenna which resulted into lower shift in frequency of operation at 2.10GHz.This result shows an area reduction of antenna. The size of this slot antenna is lower than that of rectangular antenna .To improve the compact size of this antenna, modified u slot technique are introduced. As seen from the table, u slot antenna, with size of 0nly 46mm*56mm.

VI. CONCLUSION

In this paper, to improve performance of microstrip patch antenna in term of bandwidth. In this project a microstrip patch antenna with Hexagonal microstrip antenna is designed and simulated at operating frequency 2.4 GHz using HFSS software.

Simulation results shows that, a microstrip patch antenna with Hexagonal microstrip antenna have bandwidth of 60MHz, 40MHz, VSWR as 1.61, 1.44 Return loss as -12.77dB, -14.98dB, and gain value as 3.5dB, 4.5dB, respectively. The proposed Hexagonal microstrip antenna has measured Bandwidth of 40MHz, VSWR of 1.14, Return loss of -22.87dB and Gain of 7dB.

Thus Hexagonal microstrip antenna has improved performance in terms of Bandwidth, VSWR and Return loss.

Sr. No.	Shape of MSA	Freq range (GHz)	Return Loss(dB)	VSWR	Band width (MHZ)	Gain (dB)
1.	Rectangular patch	2.41-2.47	-12.77	1.61	60	3.5
2.	Hexagonal Patch	2.43-2.47	-14.98	1.44	40	4.5

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