Quad Band Pentagon Shaped Microstrip Patch Antenna

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Abstract- *In this paper, a typical multiband microstrip patch antenna with pentagonal slot on rectangular microstrip patch forming a simple and efficient technique of design has been introduced for the betterment of bandwidth and impedance matching, also, giving the same performance at the desired resonant frequency. In this the Quad band microstrip patch antenna is proposed for the various wireless applications. This antenna bands is designed for different wireless bands. The multiband microstrip patch antenna can have multiple resonant frequency i.e. we can design a single microstrip patch antenna for multiple bands.*

Keywords- Pentagon, Quad band, HFSS, Return Loss, S-Parameter, VSWR, Smith Chart.

I. INTRODUCTION

Microstrip patch antennas are used in extensive range of applications such as in wireless communication and biomedical diagnosis. There are many feeding techniques used for the Microstrip patch antennas. To keep the structure planar, a microstrip line in the plane of the patch can be etched to feed the antenna. But again, it suffers from the drawbacks that the feed network interferes with the radiating properties of the antenna leading to undesired radiations. For the microstrip feed, an increase in the substrate thickness increases its width, which in turn increases the undesired feed radiations.

In its most basic form, a microstrip patch antenna consists of a patch, Dielectric Substrate, Ground as shown in Figure.1.

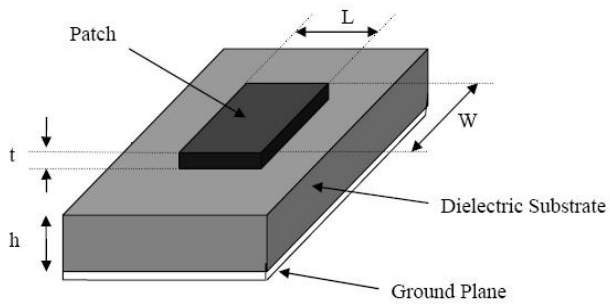

Figure 1. Structure of a microstrip patch antenna

I. Patch: Patch is a very thin, radiating metal strip located on one side of a thin no conducting substrate. The metallic patch is made of thin foil plated with a corrosion resistive metal, such as gold, tin, nickel.[1]

II. Ground: Ground is a metallic surface located on the other side of the substrate. The size of the ground should always be more for practical considerations. It should be greater than patch of six times substrate thickness. [1]

III. Substrate: The substrate is mainly used for providing spacing and mechanical support between the patch and the ground plane. It is many times used with dielectric constant material in order to load the patch and to reduce the size. The substrate material should be low in insertion loss with a loss tangent of less than 0.005.[1]

Wireless Communication is the process of transmitting radio waves or micro waves over a distance between the two points without any physical wire attachment. It encompasses various types of devices such as Bluetooth, remote control, Hand-held walkie-talkies, personal digital assistant, wireless computer mice and so on.

Worldwide Interoperability for Microwave Access is a wireless communications standard designed to provide a high speed data rates. Its capability to deliver high-speed Internet access and telephone services to subscribers enables new operators to compete in a number of different markets. In urban areas already covered by DSL (Digital Subscriber Line) and high-speed wireless Internet access, WiMAX allows new entrants in the telecommunication sector to compete with established fixed-line and wireless operators. The increased competition can result in cheaper broadband Internet access and telephony services for subscribers. In rural areas with limited access to DSL or cable Internet, WiMAX networks can offer cost-effective Internet access and may also encourage the UMTS/HSDPA (Universal Mobile Telecommunications System/ High Speed Downlink Packet Access) operators to extend their networks into these areas. WIMAX is designed to operate in the frequency range 2 - 66GHz; however, most interest is focusing on the 2-6 GHz

range especially in the frequencies 2.3, 2.5, 3.3, 3.5,5 and 5.5GHz. This gives users the ability to move around within a local coverage area and still be connected to the network, and can provide a connection to the wider Internet. WLAN is designed to operate in the frequencies bands 2.4-2.5GHz (802.11b/g/n), 3.6 GHz (802.11y). In various wireless communication applications, microstrip patch antennas are highly preferred due to their light weightiness, small size, low cost, conformability and the ease of integration with active device [7].

It is known that one of the major microstrip antennas limitations is their low gain. Regular substrate geometry is no longer able to provide solutions to more critical and demanding future applications. Satellite-communication applications require structures of low profile, good radiation pattern and high gain. Much research has gone into further increasing the gain; these include using phased array antennas, inevitably, as the number of array elements is increased more antenna volume is required. Another way is to use a thick lower permittivity substrate. Knowing that the patch size is inversely dependent to the substrate permittivity, thus, substrate with higher permittivity is needed to ensure the patch compactness. Fiber Reinforced (FR4) is good in this regard, also its low cost is another benefit. Nevertheless, more permittivity is increased, more the patch suffers from losses inherent the substrate due to the surface waves that propagate along the substrate. These waves, will also lead to increased coupling between adjacent elements and can cause ripples in the radiation pattern[7].

Many applications including aviation (aeronautical radio navigation and radio navigation satellite), satellite communication and maritime aviation (space operation, mobile satellite and earth exploration satellite), wireless communication (mobile except aeronautical mobile and broadcasting satellite), private land mobile (space research), fixed microwave devices, ISM equipment, personal land mobile, personal radio and amateur radio utilize the microstrip patch antennas that have a radiating patch mounted on a dielectric layer (substrate) supported by a ground plane. These microstrip patch antennas provide significant performance with an appreciable bandwidth. Several recent microstrip patch antennas have been studied in this literature review. In yet another work, maximum attained gain is 3.4 dBi. Also both of and slotted rectangular patches in offer a peak gain less than the proposed antenna. Even the triangular slot microstrip patch antenna for wireless communication as in offers a much less gain[8].

International Telecommunication Union's (ITU) Radio Regulations(RR),fixed-satellite service (abbreviated as FSS and alternatively termed as fixed-satellite radio communication service) is defined as a radio communication service between earth stations at given positions, when one or more satellites are used. The given position may be a specified fixed point or any fixed point within specified areas; in some cases this service includes satellite-to-satellite links, which may also be operated in the inter-satellite service; the fixed-satellite service may also include feeder links for other space radio communication services.

III. PROPOSED WORK

A. Problem Definition

Aim of designing of microstrip rectangular patch antenna as a dual band or multiband is to define an antenna for multipurpose for many different wireless applications and to evaluate the all parameters of antenna as like return loss, VSWR, radiation pattern, smith chart, gain and etc. The main challenge in designing of microstrip rectangular patch antenna is to design a single antenna for different-2 wireless application using any feeding technique.

B. Objectives

The objectives associated with presented work are defined here

i). Designing of Pentagon shaped Microstrip Patch Antenna.
ii). Antenna will be designed for different-2 wireless applications using edge Microstrip line and coaxial feeding technique will be used.
iii). Design Parameters of Antenna like Bandwidth, Return loss, Smith Chart, Radiation Pattern, VSWR, Impedance Matching, Gain and resonant Frequency will be optimized.

C. Simulation Parameters

The parameters used for the design of a rectangular Microstrip Patch Antenna are:

- Frequency of operation (*fr*): The resonant frequency for proposed antenna for wireless systems is 5.3 GHz.
- Dielectric constant of the substrate (ϵr): The dielectric material selected for proposed design is FR4_epoxy and Duroid which has a dielectric constant of 4.4.
- Dielectric substrate Height (*h*): Height of the dielectric substrate is selected as 1.6 mm as the microstrip patch antenna to be used in cellular phones, it is essential that the antenna is not bulky.

Design of Rectangular Patch Microstrip Antenna for using HFSS structure Simulator Given some other specifications were,

- Dielectric constant (ε_r) = 4.4
- Frequency (f_r) = 5.3 GHz.
- Height (h) = 1/16 Inch = 1.6 mm.
- Velocity of light (c) = 3×10^8 ms^{-1}
- Thickness of Patch = 0.5 mm

Table 1.1: Simulation parameters

Ground size	27.14 x 34.59mm
Substrate size	27.14 x 34.59mm
Patch size	17.54x 13.02 mm
Feed size	14.89×3 & 8×1mm

IV. RESULT AND ANALYSIS

Design of Proposed Quad-band Antenna:-

The geometry of IEEE base paper Microstrip Patch antenna which is microstrip line fed. In which the antenna parameter are same as above but there is a pentagon slot in microstrip patch Structure. Insertion of slot and the changes in feed technique has a high impact on the behavior and parameter of the patch antenna. To improve the bandwidth of the patch antenna, proper insertion of slot on the planer patch structure has been used. In the design pentagon patch part of size with (centre position in mm = 13.6,6,1.62 & start position in mm= 15.1,3.5,1.62) carved on FR4 substrate is presented.

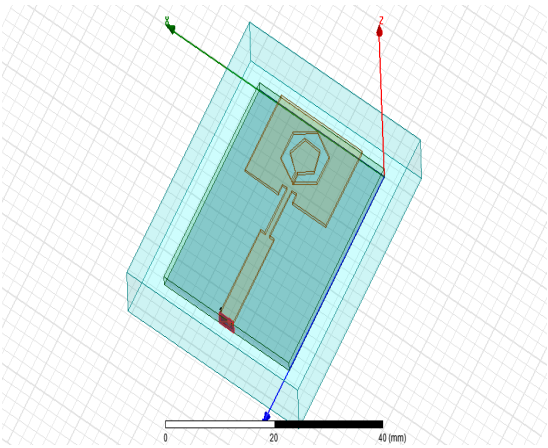

Figure 2 Design of proposed antenna for Quad band.

The return loss plot: Return loss plot for the designed antenna at -10 dB bandwidth with microstrip line feed is shown in figure 3 as below.

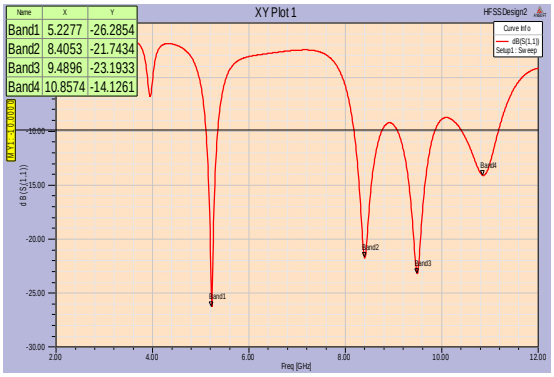

Figure 3 Simulated return loss

Return Loss (S-Parameter) value at Frequency[1] = 5.22 GHz at -26.28 dB
Return Loss (S-Parameter) value at Frequency[2] = 8.40 GHz at -21.74 dB
Return Loss (S-Parameter) value at Frequency[3] = 9.48 GHz at -23.19 dB
Return Loss (S-Parameter) value at Frequency[4] = 10.85 GHz at -14.12 Db

VSWR plot for the proposed antenna:

VSWR at frequency 5.22 GHz=1.10
VSWR at frequency 8.40 GHz=1.17
VSWR at frequency 9.48 GHz=1.14
VSWR at frequency 10.85 GHz=1.48

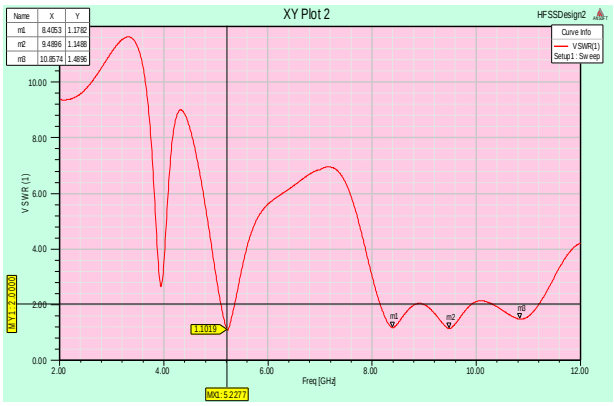

Figure 4 VSWR plot

The Smith Chart Plot

Smith Chart of this antenna shows a very good impedance matching of about value 55.1 ohm which is near about the characteristic impedance 50 ohm.

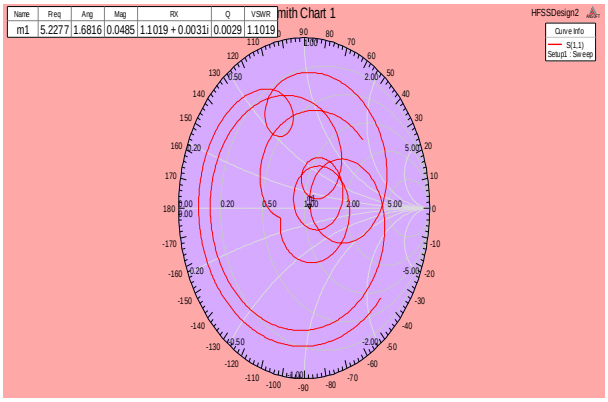

Figure 5 Smith Chart Plot

The Radiation Pattern Plot: As From Fig. 4.13 shows the 3D radiation pattern of the proposed antenna. From the graph, it is observed that at both frequency the radiation pattern is very close to omnidirectional.

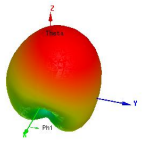

Figure 6 Radiation Pattern Plot

Table 2 Summarized results of the proposed antenna of Quad band.

SR. NO	Frequency (GHz)	RETURN LOSS (dB)	VSWR	IMPEDANCE MATCHING
1	5.22	-26.28	1.10	55.1 ohm
2	8.40	-21.74	1.17	
3	9.48	-23.19	1.14	
4	10.85	-14.12	1.48	

Table 3 Difference result of reference and proposed antenna of Quad band

SR.NO	Frequency (GHz)	RETURN LOSS (dB)	VSWR	IMPEDANCE MATCHING
1. Reference Result	3.5 5.15	-19.12 -25.28	1.25 1.11	40.15 ohm 49.55 ohm
2. Proposed Multiband Antenna Result	5.22 8.40 9.48 10.85	-26.28 -21.74 -23.19 -14.12	1.10 1.17 1.14 1.48	49.63 ohm 55.09 ohm

V. CONCLUSION

In this paper the Quad band microstrip patch antenna is proposed for the various wireless applications. This antenna bands is designed for different wireless bands. The multiband microstrip patch antenna can have multiple resonant frequency i.e. we can design a single microstrip patch antenna for multiple bands. Also, the feeding point selection i.e. proper matching of feed and patch is very important for having desirable features.

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