Analysis of Coaxial Fed U-Shaped Slot Multiband Antenna

Nidhi[1] Ravinder S. Bisht[2]
[1]M. Tech Scholar [2]Assistant Professor
[1,2]Department of Electronics and Communication Engineering
[1,2]RPIIT Technical Campus, Bastara, Karnal

Abstract— In this Paper, the designing and result analysis of single band and multiband microstrip antenna have been studied. A multiband microstrip patch antenna with DMPS (Defected Microstrip Patch Structure) in which using three rectangular slots making U-Shape slot in patch forming a simple and efficient technique of design has been introduced for the betterment of more bands, VSWR, Radiation Pattern and impedance matching, also, giving the good performance at the desired resonant frequency. A U-slot loaded microstrip line fed antenna providing multiband of 5 bands (at five frequencies 3.8 GHz, 7.3 GHz, 9.5 GHz, 10.75 GHz, 14 GHz) for many microwave bands application is designed in HFSS 13.0. Loading slots at the non-resonating sides of the patch of single band antenna make its multiband for S-Band Applications (2-4 GHz), C-Band Applications (4-8 GHz), X-Band Applications (8-12 GHz), Ku-Band Applications (12-18 GHz).

Key words: U-Shape, Multi-band, HFSS, Return Loss, S-Parameter, VSWR, Smith Chart

I. INTRODUCTION

Wireless communication systems have been growing as the application of mobile phones and systems are booming in use. For such wireless systems the crucial component to emit and collect signals is the antenna. Antenna is not active device; they are passive that only guides the signal energy in a peculiar direction in connection with isotropic antenna. They act as bridging links between transmitter, free space and the receiver. Some of the alluring characteristics of antenna include low profile, radiation emitted from the antenna should be less, less bulkier, high gain, fabrication should be done in an uncomplicated manner and its overall cost be less and it need to have certain amount of compatibility with looped surfaces. But, stability is still one of the important properties of coming up application.

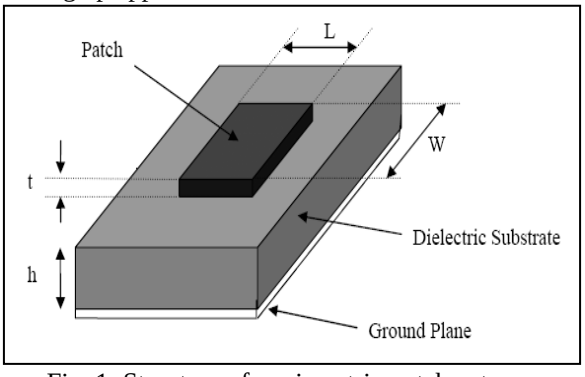

Fig. 1: Structure of a microstrip patch antenna

A. 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]

B. 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]

C. 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]

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.

II. PROPOSED WORK

A. Problem Definition

Aim of designing of microstrip rectangular patch antenna as a 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

1) Designing of U-Shaped Slotted Microstrip Patch Antenna.
2) Antenna will be designed for different-2 wireless applications using coaxial feeding technique will be used.
3) 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 2.4 GHz.
– Dielectric constant of the substrate (Cr): 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.

III. RESULT AND ANALYSIS

A. Design of Proposed Multi-band Antenna:

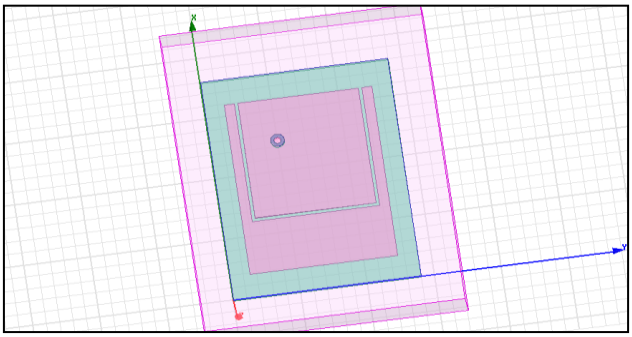

Fig. 2: Design of proposed antenna for Multi-band.

B. The Return Loss Plot:

Return loss plot for the designed antenna at -10 dB bandwidth with coaxial probe feed is shown in figure 3 as below.

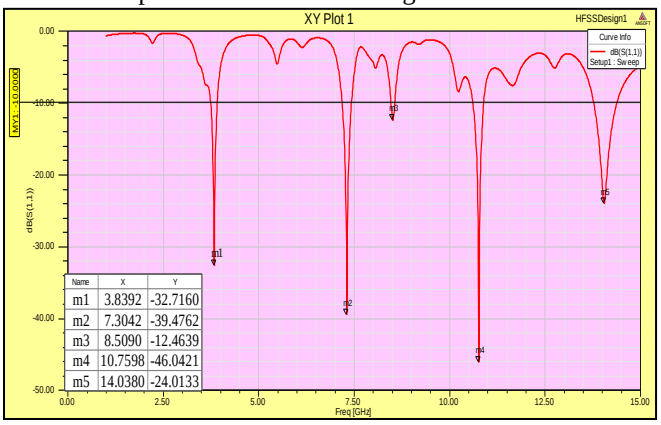

Fig. 3: Simulated return loss

The Proposed antenna is resonating at Five frequencies means provide five band as described below:

1) Resonant frequency = 3.8 GHz at -32.71 dB(S-parameter)
2) Resonant frequency = 7.3 GHz at -39.47 dB(S-parameter)
3) Resonant frequency = 8.5 GHz at -12.46 dB(S-parameter)
4) Resonant frequency = 10.7 GHz at -46.04 dB(S-parameter)
5) Resonant frequency = 14 GHz at -24.13 dB(S-parameter)

C. VSWR plot for the Proposed Antenna:

The proposed antenna give the value of VSWR less than 2 at each resonating frequency which is practically very good.

VSWR at Resonant frequency 3.8 GHz is 1.04
VSWR at Resonant frequency 7.3 GHz is 1.02
VSWR at Resonant frequency 8.5 GHz is 1.62
VSWR at Resonant frequency 10.75 GHz is 1.01
VSWR at Resonant frequency 14 GHz at 1.13

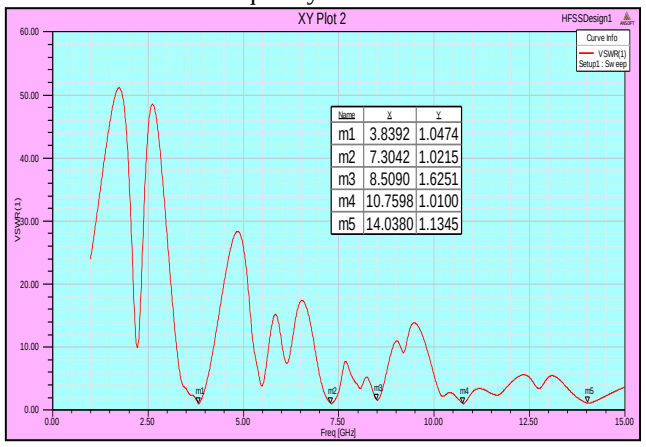

Fig. 4: VSWR plot

D. The Smith Chart Plot

Smith Chart of this antenna shows a very good impedance matching at initial resonant frequency (7.30 GHz) = 1.0114 ×50= 50.55 ohm

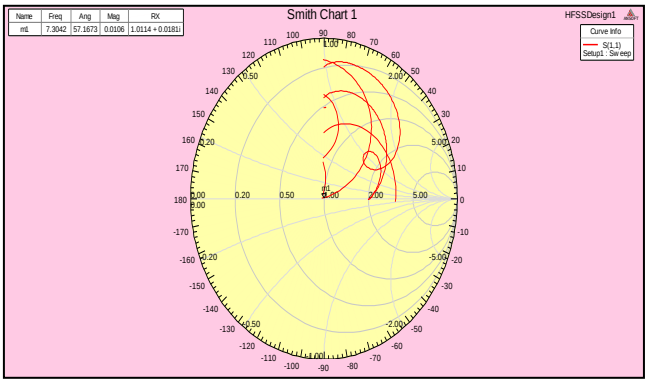

Fig. 5: Smith Chart Plot

E. The Radiation Pattern Plot:

As From Fig. 6 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.

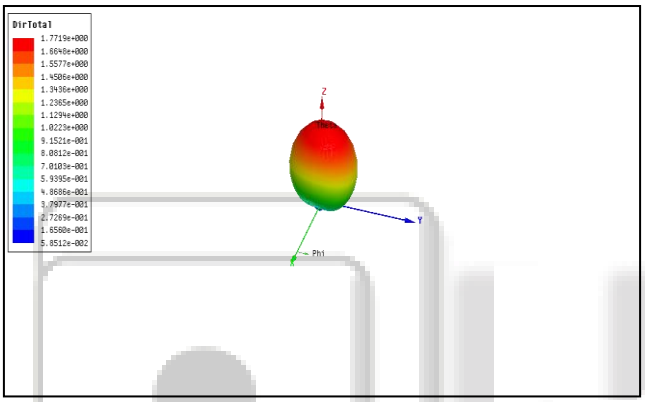

Fig. 6: Radiation Pattern Plot

F. Conclusion with Difference Table

Antenna	Difference in Design	Resonant Frequency	VSWR
Reference Multiband Antenna	40×30×3.22 mm^3 Using U-slot in patch and coaxial feeding technique	3.3 GHz 5.0 GHz 6.2 GHz 8.8 GHz	1.52 1.31 1.68 1.51
Proposed Multi Band Antenna	36×28×1.6 mm^3 Less in size with same U-Slot and coaxial feeding technique	3.8 GHz 7.3 GHz 8.5 GHz 10.7 GHz 14 GHz	1.04 1.02 1.62 1.01 1.13

Table 1: Difference result of reference and proposed antenna of Multi-band

IV. CONCLUSION

The conclusion from the proposed antenna is that it gives the best result of multiband that more bands (5 as compare to reference antenna has 4), better S-Parameters, better VSWR and impedance matching. Hence, it has been shown that microstrip antenna can be analyzed both theoretically and experimentally through simulations and fed by microstrip line feeding techniques. The multiband microstrip patch antenna can have multiple resonant frequency i.e. we can design a single microstrip patch antenna for multiple bands.

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