A Flexible Mono Pole Multi layer Wearable Tuning Patch For Wireless Communication

Vikash Kumar*, Prof. Sadbhawana Jain, Prof. Jitendra Kumar Mishra****
M.Tech Scholar Digital Communication,Assistant Professor, Head of Department,
Department of Electronics and Communication
PCST, RGPV, Bhopal [M.P.]

Abstract : The current generation of wireless communication is based on Wi-Fi and Wi-Max devices. Most of the communication devices are worked on non flexible tuning element. This presented work shows the design of multi-layer mono pole patch antenna with rectangular slots. The proposed design shows good result as compared to other previous method's results on the basis of basic antenna parameters such as VSWR, gain, Return Loss and bandwidth. The proposed antenna shows a wide band and cover Wi-Fi and Wi-Max ranges whose frequencies is between 1 to 6 GHz. The range of proposed design cover the wireless fidelity and Wi-Max range. The overall gain of proposed antenna is above 4db. Also shows the good result in terms of return loss that is (S-11) -37.11 dB as well as VSWR that is 1.02 and important parameter is percentage bandwidth is 77.01%. The proposed designs very easily manufactured and it's fabrication from flexible Rogers RO4003C substrate for commercial use is convenient. Achieved gain over the range of bands is attractive feature for antenna. .In the paper also shows the comparative analysis of different research work on the basis of shape and method adopted for designing.

Index Terms* - *Dipole Antenna, CST, VSWR, Gain, Wi-Fi, Printed Dipole Antenna, and Wi-Max.

I. INTRODUCTION

Flexible and wearable antennas have attracted considerable attention recently due to their potential advantages of lowcost, lightweight, reduced fabrication complexity, convenient integration, and conformability. The utilization of the inexpensive flexible substrates (i.e., polyimide, research works, plastics, and polyethylene) is used instead of using rigid and brittle one.The microstrip patch antennas have got a good attention due to its planar configuration, lower profile, and effortlessness integration with connected electronics. Since the inception of microstrip antenna tremendous research effort has been made to meet the impedance and radiation pattern requirement of the modern compact wireless communication devices. However, due to their lower profile and compact size benefit, micro-strip antennas have to face the narrow impedance bandwidth challenge.A **s**ubstrate (also called a wafer) is a solid (usually planar) substance onto which a layer of another substance is applied, and to which that second substance adheres. In solid-state electronics, this term refers to a thin slice of material such as silicon, silicon dioxide, aluminum oxide, sapphire, germanium, gallium arsenide (GaAs), an alloy of silicon and germanium, or indium phosphide(InP). These serve as the foundation upon which electronic devicessuch as transistors, diodes, and especially integrated circuits (ICs) are deposited. Flexible substrate can be defined as a technology for assembling electronic circuits by mounting electronic. deviceson flexible plastic substrates, such as polyimide, PEEK or transparent conductive polyester film. Additionally, flex circuits can be screen printed silver circuits on polyester. Flexible substrates may be manufactured using identical components used for rigid printed circuit boards, allowing the board to conform to a desired shape, or to flex during its use.The Many studies have significantly contributed to improve the performance of printed antennas using metals like silver, copper, or gold because of their high electrical conductivity. However, noticeably less research has been dedicated to the development of printed antennas using conductive polymers[01].

1.2 Flexible Antenna

Flexible antennas operating in wireless local area network (WLAN) can provide a route to creating high speed wireless data transmission systems that can be combined with other flexible devices to transmit and receive signals in a myriad of applications. Antenna designs utilizing novel materials and techniques have been demonstrated in flexible forms. However, many of the antennas were incompatible with existing flexible electronic devices, or limited by rigid substrates that were too thick to be integrated in the body. Moreover, most of the reports use tissue mimicking gels as their design parameters, but such approach does not prove that the antennas may be used in practical applications[02].

INKJET printing technology is investigated and wide utilized as another fabrication methodology to the conventional subtractive fabrication ways, like milling and etching. Inkjet printing could be a kind of computer printing that recreates a digital image by propellant droplets of ink onto paper, plastic, or different substrates. Inkjet printers are the most commonly used type of printer, and range from small inexpensive consumer models to expensive professional machines. The importance of "green", scalable and cost-efficient technology is ever increasing for numerous applications like the Internet of Things (IoT), the radio frequency identification tags (RFIDs), and the wireless sensor networks (WSNs). The inkjet printing technology does not produce any byproducts because it only deposits the controlled amount of functionalized inks such as silver nano particles on desired position[03].

(a) (b)

Fig 1 Inkjet-Printed Wide band Circularly Polarized Micro-strip Patch Array Antenna on a PET Film Flexible Substrate Material

II LITERATURE SURVEY

Amal Afyf et.al. [2020], In this research work author represent a flexible and body centrist trans-receiver device for S band. The new structure improves on previous passive microwave imaging systems in that it is highly flexible, cost-effective to fabricate, and light-weight. Simulations were carried out with CST, exploiting a layered (in homogeneous) model with different dielectric constants and loss tangents to capture the effect of surrounding tissues[**01].** ***Wang, Chao, et.al.[2019]***, This work present a low cost and highly flexible patch antenna for Io-T applications in the 2.4 GHz ISM band was fabricated using a commercial of the shelf (COTS) flexible silicone sponge rubber substrate backed by a flexible copper wire mesh in order to demonstrate feasibility of the materials as a substrate for flexible and conformal RF devices. The presented antenna can be significantly deformed mechanically without deterioration in RF performances when conformed to a surface with high curvature radius, except for the maximum gain which steadily decreases from the flat case to the case of R = 35 mm, for a total reduction in maximum gain of 1.96 d Bi due to the decrease of the antenna equivalent aperture. The antenna can be flexed repeatedly without any permanent damage, which enables application such as flexible conformal patch array and mechanical beam steering for example **[02]. Li et.al. [*2018],*** A patch antenna having the inkjet printing of bandwidth-enhanced is presented with detailed simulation and measured results. The designs which are used are multi-layer and fractal designs for getting a compact size of the antenna. The measured impedance bandwidth for |S11|< －10 dB covers 4.79－5.04 The antennas which are inkjet printed show steadiness and tolerance under different bending radii of curvature. A 2- bit, 4-element PAA is been made and proved to work well through the beam steering experiments. These fabrication method of the antenna used in this paper shows the potential applications in on-package and on-chip printed antennas **[03]. Kumari et.al. [*2016],*** In this the study of multi band Bow Tie antenna with circular arm and fractal geometry is given. The multi band operation is achieved by Apollonian Gasket of Fractals which is the combination of mutually tangent circles. 3 iterations have been designed in this In this the study of multi band Bow Tie antenna with circular arm and fractal geometry is given. The multi band operation is achieved by Apollonian Gasket of Fractals which is the combination of mutually tangent circles. 3 iterations have been designed in this **[04]. Shao et.al [*2015],*** An elastic RFID tag antenna is been made here which is a textile-based broadband, fabricated and tested. The antenna which was designed here gets a bandwidth of 263MHz in free space. It also upholds its tuned behaviour when placed on dielectrics with unstable permittivity. Many versions were also made and tested. The outcome was that the designed tags give better performances when judged against an existing commercial tag. The work done by the tag antenna then does n' t decrease its efficiency under mechanical deformation up to 10%, which makes it a good candidate for elastic and hostile environments **[05].**

III. PROPOSED DESIGN

In this presented work shows the flexible antennas. These antennas have attracted considerable attention recently due to their potential advantage of low-cost, lightweight, reduced fabrication complexity, convenient integration, and conformability. The utilization of the inexpensive flexible substrates (i.e., polyimide, papers, plastics, and polyethylene), instead of using rigid and brittle substrates, makes flexible electronics an appealing alternative for the current electronics technology . In this antenna apply defected ground structure (DGS) technique to enhance bandwidth (B.W.) and gain (G) of the antenna. Flexible and wearable antennas patch antenna has become popular day by day the reason behind this is ease of flexibility and fabrications in cloths. Flexible patch antenna is designed for Giga hertz frequency range 1 to 6GHz where this frequency range accommodate in the various band in the wireless fidelity range 3.4 GHz and wireless local LAN all are in GHz range frequency. Flexible patch antennas have Gaining importance in the applications of Wireless Local Area networks (WLAN). The simulated results such as Return Loss S_{11}, VSWR, Gain, and Radiation Pattern, Vector diagram of electric field and Mesh field is made[04].

A. Proposed Wide Multi Layer Micro-strip Patch Antenna

In the research work present a multilayer micro-strip monopole fractal patch antenna for integration into flexible and conformal devices, it is good step for flexible technology. During this evolution two vital standards are Wi-MAX and Wireless local area network antennas are standard for its well-known engaging options, like a small size, easy to fabricate and easy to use. The demand of flexible antenna is increasing rapidly due to its good properties such an easy to fabricate, easy to fit any communication device and also use in different places where require flexible technology structure. For the flexible technology in antenna use different type of substrates such as Graphene, copper indium gallium.The next generation of technology is based on flexible electronics, for the growth of this technology, proposed flexible antenna shows a vital role. In the below figures 2 shows the design specification of the proposed design. The proposed design contain five different layer or parts. There are ground, substrate, patch1, patch 2 ,fractal design. In the below figure 2 (a) and (b) shows the patch and ground of the proposed design , (c) shows the substrate, d shows patch 1 and e shows patch 2 of proposed design[05].

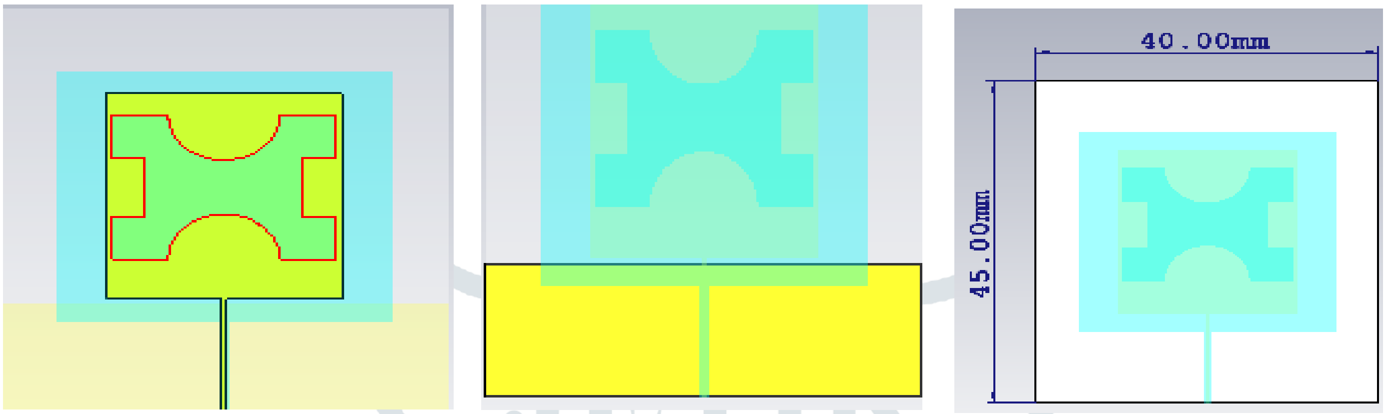
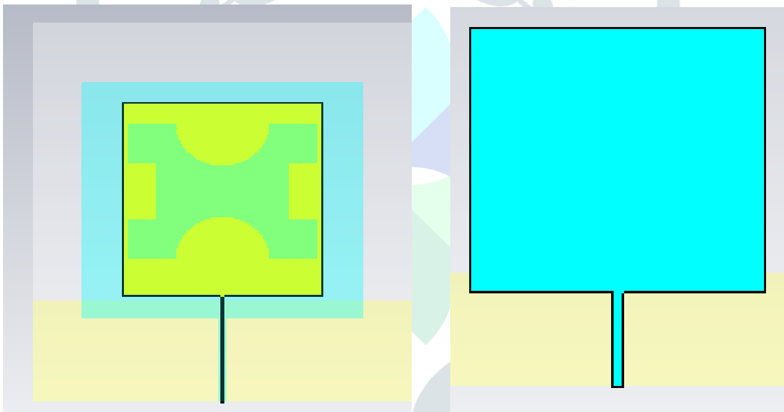


Fig. 1 (a) Design of front view of multilayer microstrip monopole fractal patch antenna (b) Design of back end view (c) Shows the dimension of substrate



(d) Shows the patch 1 (Copper based) (e)Shows Patch 2 SU 8 based

B. **Design of basis Micro-strip Patch Antenna**

For the design of multi-layer monopole antenna first design simple micro-strip patch antenna. For design of simple micro-strip patch antenna require some mathematical calculation. The square patch is easily designed widely used simple to analyze and easy to manufacture. To design square patch following method are used. In the conventional procedure design of rectangular micro-strip patch antenna, three essential parameters are:

Frequency of operation (f_0): The antenna resonance frequency must be chosen appropriately. Communication systems using the frequency range of 1 to 6 GHz at different wireless frequency range. The selected resonance frequency for proposed design is 1 to 6 GHz [06].

Di-electric constant of the substrate (εr): The di- electric constant of the substrate material plays an important role in the design of the patch antenna. So there is a compromise between size and performance of the patch antenna. In this thesis, use flexible Rogers RO4003Csubstrate with di-electric constant 3.38.

Height of di- electric substrate (*h*): The height of the di- electric substrate must be less. In this thesis substrate height is taken 1.6 mm. To design a rectangular micro-strip patch antenna according to parameters such as di- electric constant (εr), the resonance frequency (f_o) and the height (h) are taken into consideration for the calculation of the length and width of the room[07].

Step 1: Calculation of Width (W)

For efficient radiator, the practical width which leads to a good radiation efficiency is:

$$W = \frac{c}{2fo\sqrt{\frac{\varepsilon r+1}{2}}} \qquad 1$$

Where c is the speed of the free area of the light.

Step 2: Di-electric Coefficient value calculation (ε reff)

The effectiveness of the DI-electric constant (ε reff), using the same geometry (W h), but is surrounded by a homogeneous DI-electric ε reff the effective permittivity whose value is determined by assessing the ability of the fringe field.

$$\varepsilon reff = \frac{\varepsilon r + 1}{2} + \frac{\varepsilon r - 1}{2}\left[1 + 12\frac{h}{w}\right]^{-1/2} \quad 2$$

Step 3: Effective Length Design Equation (L eff)

$$Leff = \frac{c}{2fo\sqrt{\varepsilon reff}} \quad 3$$

Step 4: Length Extension (ΔL) Design Equation

$$\frac{\Delta L}{h} = \frac{0.412(\varepsilon reff + 0.3)(\frac{w}{h} + 0.264)}{(\varepsilon reff - 0.258)(\frac{w}{h} + 0.8)} \quad 4$$

Step 5: Actual Length of Patch (L) Equation

The length of patch calculated by given below equation

$$L = Leff - 2\Delta L \quad 5$$

Step 6: Ground Dimensions (Lg, Wg) Equation

The broadcast line model is applicable to infinite base surfaces solely. However, for sensible issues, it's essential to own a finite base surface. it's been shown by [6] that similar results to the finite base surface and eternity is also obtained if the scale of the bottom surface is bigger than the patch dimensions of regarding sixfold the thickness of the substrate all round the edge[08]. Therefore, for this reason, the size of the bottom surface is given by:

$$L_g = 6h + W \quad 6$$
$$W_g = 6h + L \quad 7$$

Step 7: Calculation of width of the micro-strip feed line

Width of the micro-strip line is calculated by below equations

$$\frac{w}{h} = \left(\frac{exp(H')}{8} - \frac{1}{4\exp(H')}\right)^{-1} \quad 8$$

$$H' = \frac{Z_0\sqrt{2(\varepsilon_r+1)}}{119.9} + \frac{1}{2}\left(\frac{\varepsilon_r - 1}{\varepsilon_r + 1}\right)\left(l_n\frac{\pi}{2} + \frac{1}{\varepsilon_r}l_n\frac{4}{\pi}\right) \quad 9$$

$$\varepsilon_{eff} = \frac{\varepsilon_r+1}{2}\left[1 - \frac{1}{2H'}\left(\frac{\varepsilon_r - 1}{\varepsilon_r + 1}\right)\left(l_n\frac{\pi}{2} + \frac{1}{\varepsilon_r}l_n\frac{4}{\pi}\right)\right]^{-2} \quad 10$$

Where er is DI- electric constant, Zo is 50 ohm and h is 1.6mm.

Step 8 : Calculation of length of the micro-strip feed line

Free-space wavelength

$$(\lambda o):\lambda o = c / f \quad 11$$

For the designing the bow tie antenna first require to design a simple patch antenna. After that apply different Boolean function of give the shape of bow Tie. In the below section discuss the evolution of proposed flexible bow tie antenna[09]

IV SIMULATION AND RESULT

In this section discuss the simulation and result of the proposed antenna. In this proposed antenna different substrate technique as well as multi layer substrate are used for enhance the bandwidth , return loss (S-11) and other properties of antenna. The proposed multi lay-per mono pole patch antenna is design for Giga hertz (GHz)frequency range up to 6 GHz. The proposed frequency where this frequency range accommodate in the various band in between 1 GHz to 6 GHz in between the Wi- Fi and Wi-Max range. The multi layer flexible patch based micro-strip patch antennas have gaining importance in the applications of Wireless Local Area networks (WLAN), Wireless Fidelity. The simulated results such as Return Loss (S_{11}), VSWR and Radiation Pattern, Bandwidth and Mesh field. The details of the result antenna designs and simulated results are presented in this chapter. New micro strip antennas have enhanced gain and bandwidth is presented . The optimized dimensions of the geometric parameters are shown in the previous chapter 4 table 4.1. There is good agreement by the simulated results of software CST. Design has been simulated. All the comparable results of the software's are achieved by simulation and approximation for proposed design[10].

Design environment

Below the figure 3 shows the basic view of CST software. The proposed design in the CST 2016 version. The system for designing used is core i-5 4^{th}G processor. The main part of proposed design is substrate (S), patch (P), ground (G) and feeding system (Wave guide feed). In this design using a wave guide wave port for feeding system. In general there are two type of feeding systems first one is wave guide port and second one is the wave guide port. Figure. 3 and 4 shows the CST Design environment. In the below figure shows the design environment of proposed antenna. CST contain different window for different task. Navigation tree shows the different design parts and different result parameters of the antenna. The complete design simulated on Time domain analysis. CST is based on Finite element based method [11].

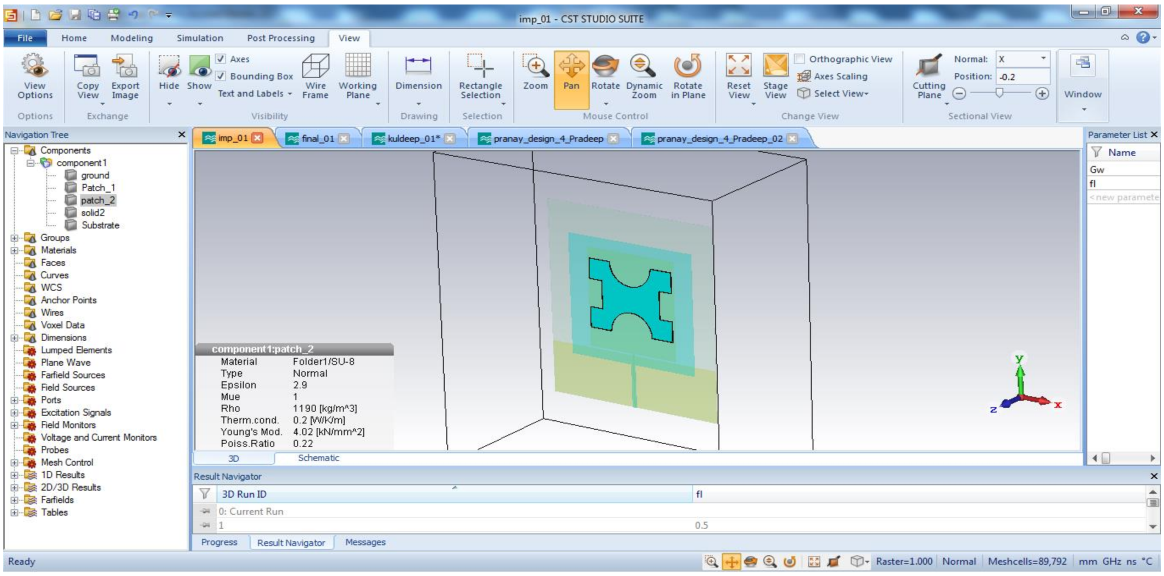


Fig. 3 (a) Shows the front view of proposed design

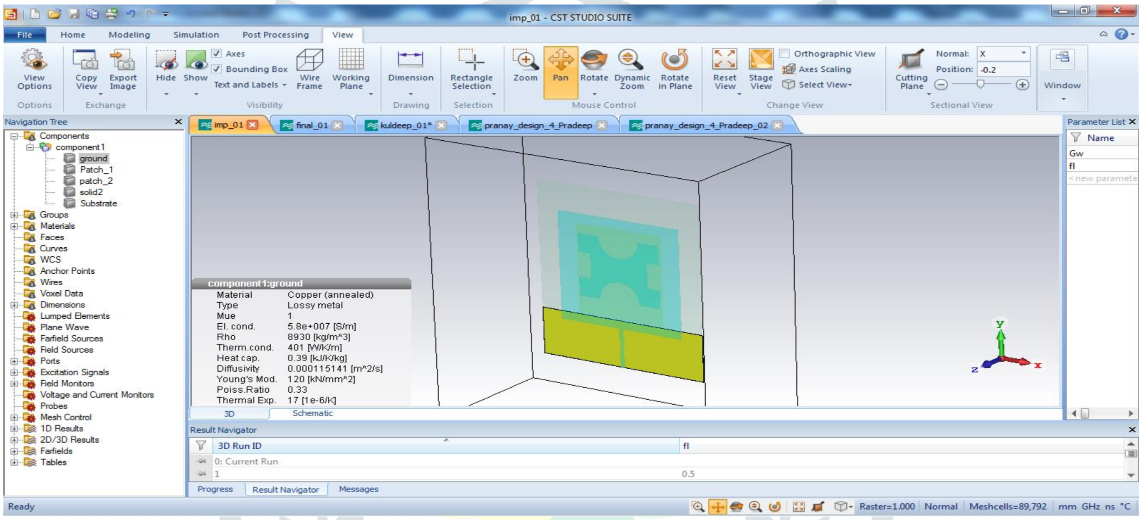


Fig .4 (b) Shows the Back view of proposed design (Ground)

Result Parameters

There are different parameters of antenna which are utilized to examine the efficient functioning of the antenna.

Return Loss (S -11)

Return loss (S-11) is an important parameter for performance measurement of antenna that is measure is DB. It is the Return loss measure in Db. It is defined as the ratio of output verse input power received by transmitter It is the power loss in the signal that is reflected due to discontinuity in the transmission line.

$$S11(\mathrm{dB}) = 10\log\frac{P_r}{P_i} \qquad 12$$

$P_r -$ *Received Power of the antenna*

$P_i -$ *Input Power of the antenna*

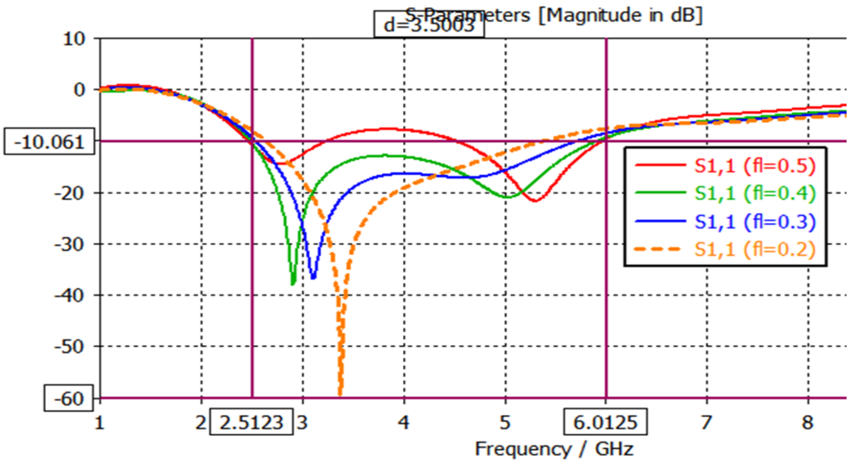


Fig. 5 Return loss (S-11) of proposed antenna 3 (Single Wide Band

Voltage Standing Wave Ratio (VSWR):

The VSWR is also an important parameter for analysis of antenna design. Ideal value of VSWR 1 to 2. For particle system is near to 2. In ideal case VSWR is 1.

$$\text{VSWR} = \frac{1+7}{1-7} \qquad 13$$

Where Γ is the reflection coefficient of the antenna.

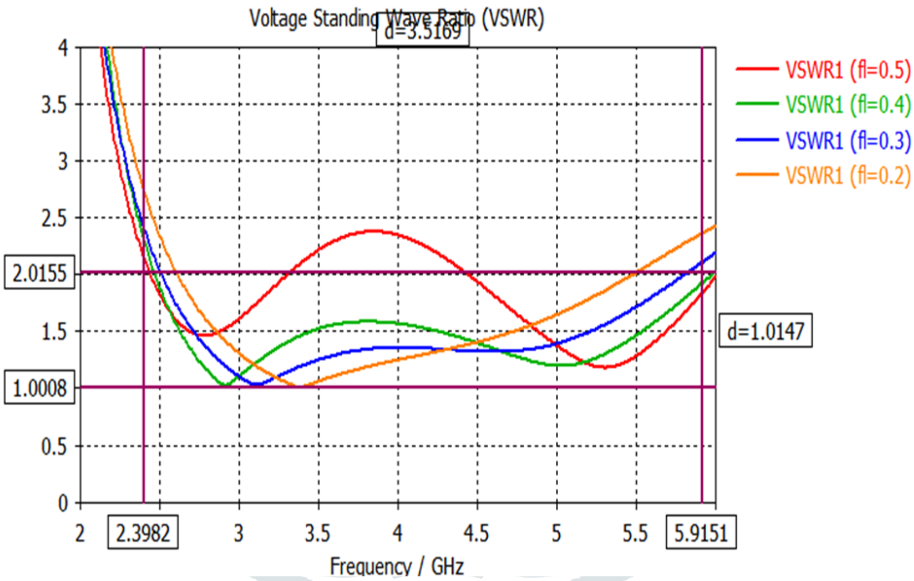


Fig. 6 shows the VSWR of proposed antenna at different feed line widths

Result Comparison

In the above section discuss the result compression of proposed design 1, proposed 2 and proposed design 3 In the below result table 1 shows the Our proposed design shows better result as compare to other antenna.

Table.1 Result Comparison of proposed design 1, proposed 2 and proposed design 3

Shape	Feed Technique	Range	S – Parameter (dB)	VSWR	Band Width	No. of Band
Multi-layer proposed -1	Microstrip feed	1 to 6	2.7 GHz = -20.37dB 4.5 GHz = -15.58dB	1.2 1.4	**69.61%**	Single Wide Band
Multi-layer Proposed design -2	Microstrip feed line	1 to 6	**3.3 GHz = -59.57dB**	.1.1	67.8%	Single Wide Band
Multi-layer Proposed design -2	Microstrip feed line	1 to 6	**3.1 GHz = -37.11**	**1.02**	**77.1%**	Single Wide band

In the above table. 1 shows the comparison of all three design having different advantages, in case of design one contain 2 separate bands, design 2 contain single band with 69.61% band with two resonant frequencies. But the design 3 is better as compare to all three design 3.

V. CONCLUSION

This presented work shows the design of multi-layer mono pole patch antenna with rectangular slots. The proposed design shows good result as compared to other previous method's results on the basis of basic antenna parameters such as VSWR, gain, Return Loss and bandwidth. The proposed antenna shows a wide band and cover Wi-Fi and Wi-Max ranges whose frequencies is between 1 to 6 GHz. The range of proposed design cover the wireless fidelity and Wi-Max range. The overall gain of proposed antenna is above 4db. Also shows the good result in terms of return loss that is (S-11) -37.11 dB as well as VSWR that is 1.02 and important parameter is percentage bandwidth is 77.01%. The proposed designs very easily manufactured and it's fabrication from flexible Rogers RO4003C substrate for commercial use is convenient. Achieved gain over the range of bands is attractive feature for antenna. This designed radio is for high power, RF efficient radio equipped to transmit over band also compatible for OFDM & military purposes. These results shows antennas could be developed for possible applications in several wireless systems like WLAN, Wi-MAX if properly scale to the allowed frequency bands. As the Micro-strip antenna is small in size so due to its compact size and compatibility with microwave devices more deserves to be a part of future modern communication system with much more accuracy, reliability and high performance. In future try to improve the gain as well as directivity of the design. In future apply soft computing to enhance the present result with the help of neural network and other machine learning techniques. Proposed bow tie antenna has opened the door of the wireless communication for the long distance. Based on antenna designs, the following points were identified which would be helpful for further investigation Fabrication and measurements of four elements MSA array and the MDA array will be carried out in future. Besides, the experience of designing MS As with Micro-strip line feeding with conformal patch, MDA array with dielectric image guide feeding can further be designed to minimize the metallic losses.

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