ISSN 2250-3153

Design of Triband Miniature Microstrip Antenna with Modified Resonating Structure using CADFEKO

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***Abstract*-**In this paper, a Tri band linearly-polarized microstrip patch antenna is designed and simulated with Modified Resonating Structures using CADFEKO antenna simulation software from a dual band antenna. Antenna parameters are examined in this which includes resonating frequency, VSWR, impedances and bandwidth of the designed and proposed resonating structure with microstrip feed. The antenna is proposed for GPS/GSM, UMTS and Wi-Fi/WLAN wireless communication applications provided with greater bandwidth. This paper focuses on the designing of miniature microstrip antenna with microstrip feed and analyzes the results like return loss S_{11}, VSWR, impedance and Bandwidth.

***Index Terms*-** Resonating Structure, Tri band, Microstrip Antenna, CADFEKO, Modified Structure Resonator.

I. INTRODUCTION

In the last few years, the development of GPS/GSM and Wi-Fi/WLAN represented one of the principal techniques in the information and wireless communication. As per the present situation in communication systems has been to develop low cost, low profile antennas, minimum weight commonly used dielectric materials that are capable of maintaining high performance over a wide spectrum of frequencies [1]. With a simple geometry, patch antennas offer many advantages not commonly exhibited in other antenna geometry. Advantages are low profile, inexpensive, lightweight and simple to manufacture using modern day printed circuit board technique, compatible with microwave and millimeter-wave integrated circuits (MMIC), and have the ability to conform to resonating structures[1]. In addition, once the shape or geometry and operating mode of the patch are confirmed, designs become very selective in terms of resonating frequency, return losses, polarization, radiation pattern, voltage standing wave ratio and impedance. That is possible with Microstrip antenna probably exceeds that of any other type of antenna element [1]. Using the Multi Band Resonator concept in this paper on Tri band modified Resonating Structure Microstrip antenna is designed and simulated. There are few software available which allow the optimization of the antenna. CADFEKO is one of the imperial electromagnetic software which allows to designing and solving for radio and microwave application. It works based on methods of moments (MOM).The CADFEKO simulator tool computes most of the useful parameters of interest such as radiation pattern, input impedance, return loss, VSWR,gain, directivity etc.

However, the difficulty in designing antenna challenges engineers when the size of the antenna reduces and the number of operating frequency bands increases. So far, for size reduction, bandwidth enhancement, and resonance-mode increment, numerous antennas have been proposed by employing various feed structures such as the probe, the microstrip, and the coplanar waveguide (CPW). In these monopole antennas, a large solid ground plane having the shape of a rectangle,square, circle, or ellipse is usually adopted[3,4]. Different from this, a notable ground structure named defected ground structure (DGS) has recently been investigated and found to be a simple and effective method to reduce the antenna size as well as excite additional resonance modes[1].Designing of antenna in this paper is done by FEKO antenna software simulation, with the standard parameters and consideration like permittivity of ε_r=4.4, microstrip feed, tangent loss of 0.01 and infinite ground plane.

II. DUALBAND RESONATING STRUCTURE MICROSTRIP ANTENNA

In order to realize multiband operation, there is a wide variety of antenna types, which uses different multiband techniques, is used. The most popular technique for obtaining multiband antenna system is the usage of multiple resonant structures. The multiple resonant structure technique is also frequently used in mobile communication systems to achieve multiband mobile antennas.The proposed antenna is miniature in size the overall dimension of the 16 mm X 3.2 mm in length and width with the thickness of 0.1 mm provides the one of the objective of this paper of compact size [2]. The resonating structure is at distance of 0.1 mm from the feed line which has modified structure of rectangular curl. Further in this paper, these curls are increased to one to two in number to achieve triband operations.

The design of a dual band single resonating structure microstrip antenna using microstrip feeding technique satisfying the given specifications:

Frequency(fr)	1.65 GHz and 3.64 GHz
Dielectric constant(εr)	4.4
Substrate Height(h)	1.5 mm
Line Impedance	50Ω
Ground Plane	Infinite
Tangent Loss	0.01

As for the substrate selection, the major consideration will be the dielectric constant. A high dielectric constant will result in a smaller patch size but this will generally reduce bandwidth efficiency and might have difficulty in fabricating a very small patch size antenna [1,4].

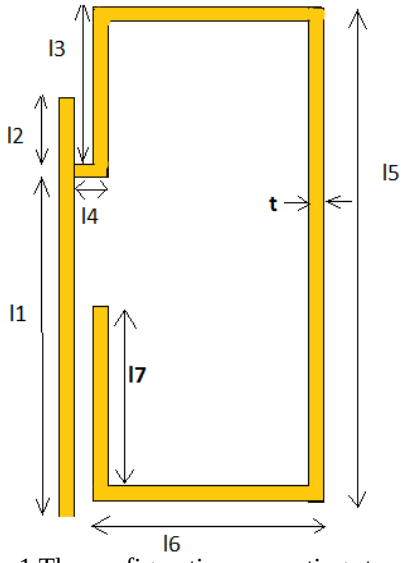

Figure 1 The configuration resonating structure

As shown in Figure.1, the proposed dimension of dual bandresonating structure.

- **Patch Dimensions:**

  Length (L1) = 4.2 mm Length (L2) = 1.1 mm
  Length (L3) = 2.2 mm Length(L4)= 0.3 mm
  Length (L5) = 6 mm Length (L6) = 2.6 mm
  Length (L7) = 2.8 mm Thickness (t) = 0.1 mm
  ε_r =4.4 Tangent Loss= 0.01

- **Feed Line Dimensions**:

  Length = 11.575 mm
  Width = 0.45 mm
  Ground Plane: Infinite
  Feed: Microstrip port

With the above parameters, a microstrip patch antenna is designed and simulated for the range of 1 GHz to 5 GHz, which is commonly used for wireless communication systems [2].

III. TRIBAND RESONATING STRUCTURE MICROSTRIP ANTENNA

The configuration of proposed tri band antenna is the outer geometry specification kept same as for dual band but inner geometry is designed by keeping distance between outer and inner geometry as shown in Figure 2.

Frequency(fr)	1.57, 2.95 and 4.05 GHz
Dielectric constant(εr)	4.4
Substrate Height(h)	1.5 mm
Line Impedance	50Ω
Ground Plane	Infinite
Tangent Loss	0.01

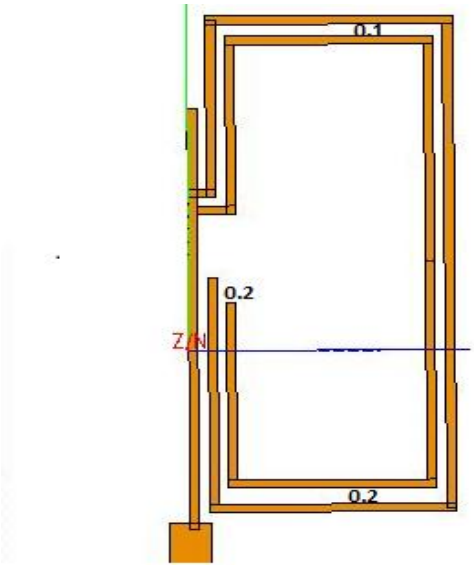

Figure 2The configuration Tri band resonating structure

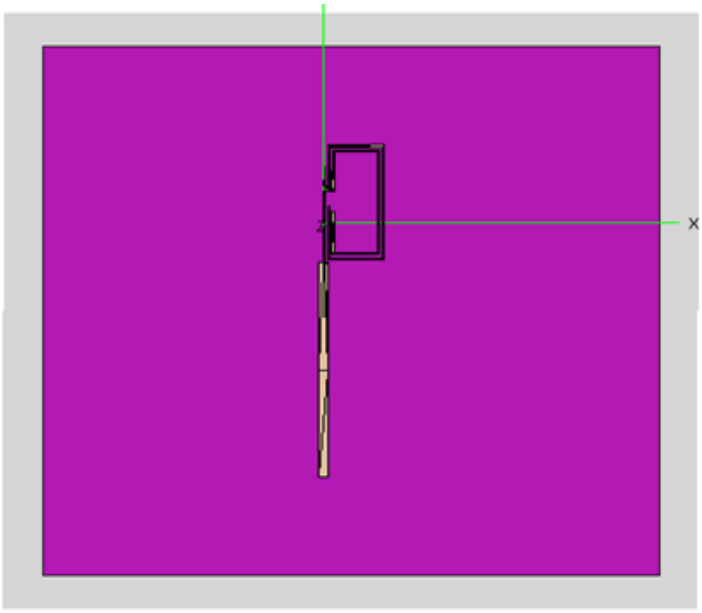

Figure 3Triband resonating structure on CADFEKO Simulation Software

IV. SIMULATED RESULT AND DISCUSSION

The microstrip feed used is designed to have an inset depth of 11.575mm, feed-line width of 0.45 mm. A frequency range of 0.1-6.0 GHz is selected. CADFEKO simulated for approx 26 frequency points over this range to obtain approximate results. The center frequency is one at which the return loss is minimum. The bandwidth can be calculated from the return loss plot as shown in figures. The bandwidth of the antenna can be said to be those range of frequencies over which the return loss is greater than -10 dB (-9.5 dB corresponds to a VSWR of 2 which is an acceptable figure) [1,5]]. The designed antenna resonates at 1.65 GHz and 3.64 GHz. The return loss at 1.65 GHz frequency is -37 dB and at 3.64 GHz is -31 dB as shown in Figure 4.

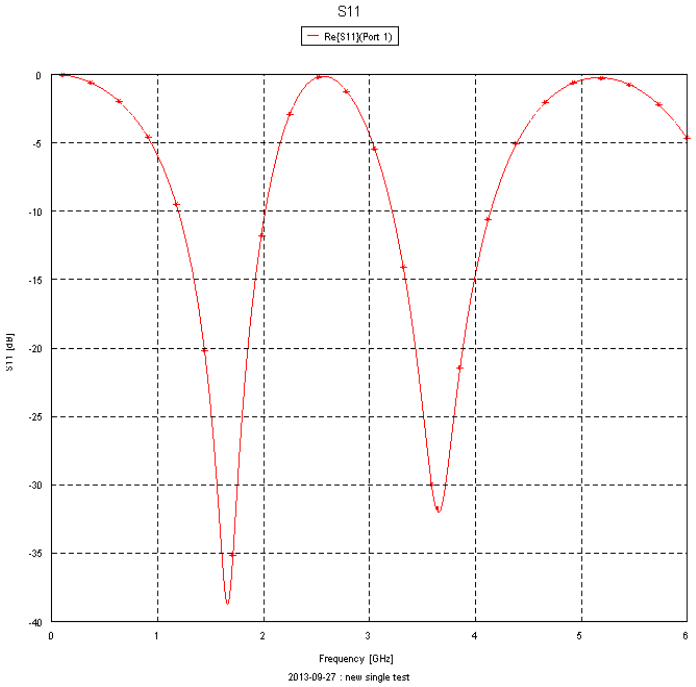

Figure 4 Return Loss of dual band antenna (S_{11} in dB).

The VSWR plot for single geometry antenna is shown in Figure 5. Ideally, VSWR must lie in the range of 1-2 which has been achieved for the frequencies 1.65 and 3.64 GHz. The value for VSWR is 1.6 and 1.1.

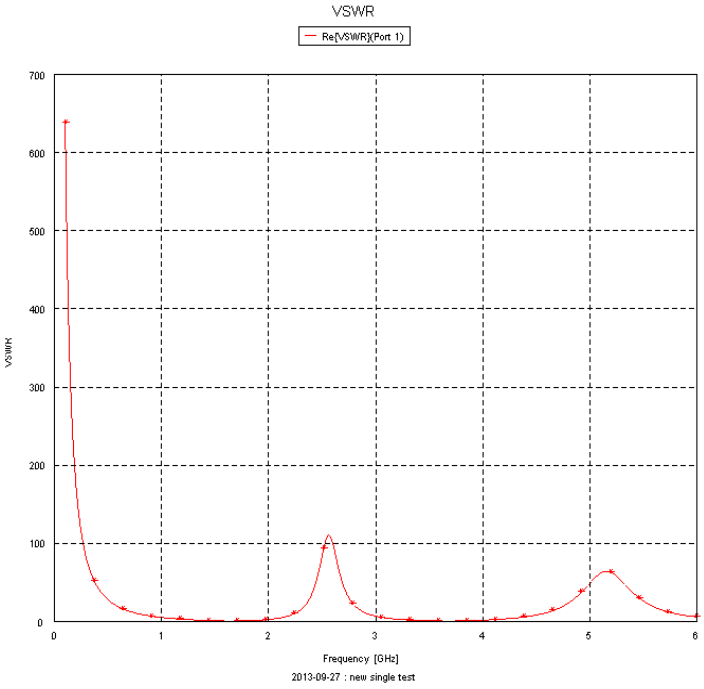

Figure 5. VSWR Versus Frequency Plot of dual band antenna

Figure 6shows the S_{11} parameters (return loss) for the proposed tribandantenna.

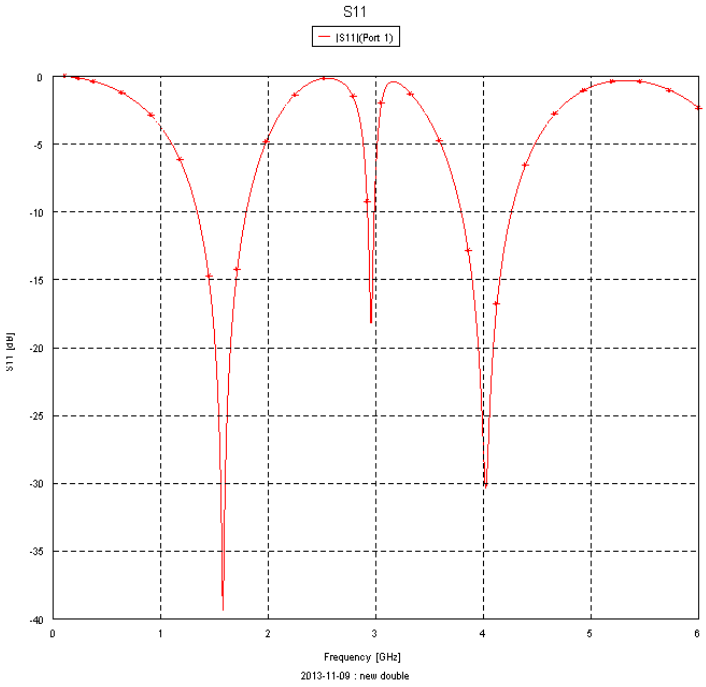

Figure 6 Return Loss of triband antenna (S_{11} in dB)

The designed antenna resonates at 1.57, 2.95 and 4.05 GHz. The return loss at 1.57 GHz frequency is -39 dB, at 2.95 GHz is -18 dB and at 4.05 GHz frequency is -30dB. Ideally, VSWR must lie in the range of 1-2 which has been achieved for the frequencies 1.57, 2.95 and 4.05 GHz. The value for VSWR obtained is 1.6, 1.65 and 1.17. The impedance for double geometry antenna is obtained as 59, 57 and 52 Ohm for 1.57, 2.95 and 4.05 GHz.

The VSWR plot for double geometry antenna is shown in Figure 7. Ideally, VSWR must lie in the range of 1-2 which has been achieved for the frequencies 1.57, 2.95 and 4.05 GHz. The value for VSWR is 1.6, 1.65 and 1.17.

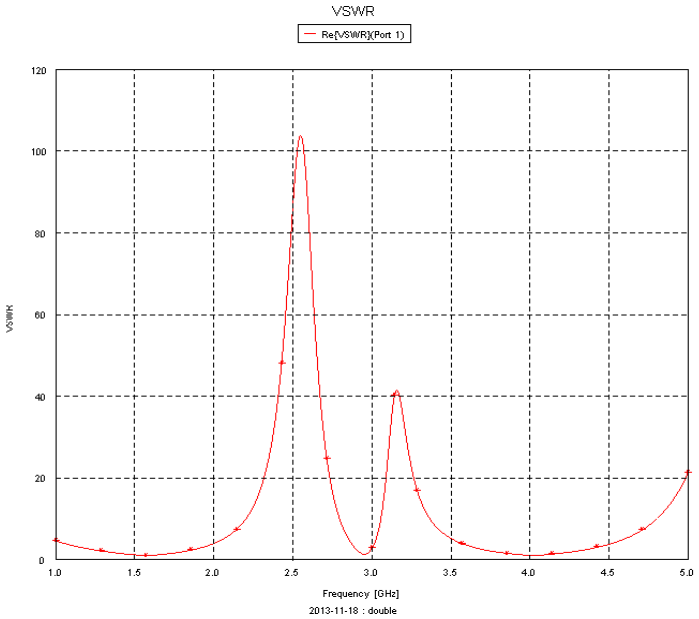

Figure 7 VSWR Versus Frequency Plot of Tri band antenna

Resonating Frequency (GHz)	Return Loss S_{11} (dB)	VSWR	Impedance (Ω)	Bandwidth (MHz)
1.57	-39	1.6	59	460
2.95	-18	1.65	57	80
4.05	-30	1.17	52	460

Table 1 Return Loss, VSWR and Impedance at Resonating frequencies for Triband Structure.

Table 1 shows the simulated results of return loss, VSWR and impedance. This miniature Tri band antenna has wide application in GSM, UMTS, Wi-Max and Wi-Fi/WLAN of wireless communication and clearly reflects that increase in number of resonating structures definitely increases the multibanding but the center bands are having less bandwidth as compared to outer bands for the designed model. Outer bands are having bandwidth of 460 MHz whereas center band is having bandwidth of 80MHz.

V. Conclusion

The purpose of this work is successfully completed asstudied and designed the antenna using a modified resonating structure microstripantenna. The simulated result of the return lossof the microstrip-fed Microstrip patch antenna yields Tri band.The radiation pattern is unidirectional pattern for all ofoperation bandwidth.The simulation gave results good enough to satisfy ourrequirements to fabricate it on hardware which can be usedproposed wireless applications. The proposed work has been limited mostly totheoretical studies and simulations due to lack of fabricationfacilities. Detailed experimental studies can be taken up at alater stage to design the multiband resonating structures antenna.Thus, antenna is proposed for GPS/GSM, UMTS and Wi-Fi/WLAN wireless communication applications provided with greater bandwidth.

Acknowledgment

The author is very grateful to Gyan Ganga Institute of Technology and Management, Bhopal for providing adequate infrastructure and CADFEKO software simulation lab for completing this research.

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