



## Design, simulation and analysis of reconfiguration microstrip patch antenna for wireless communication applications

Ravindra Kumar Sharma, Randheer Singh

Assistant Professor, Department of Electronics and Communication Engineering, IET, Alwar, Rajasthan, India

### Abstract

In this paper, micro strip patch antenna with frequency reconfiguration is designed which produce different radiation pattern without changing the antenna dimensions and used to achieve a greater efficiency. Frequency reconfiguration is achieved by electrical reconfiguration technique which uses the PIN diode that was placed to switch between two frequencies, because, varactor diode acts as a tunable device in RF circuits. Simulation is done by using the HFSS software (High Frequency Simulation Software). Because of compact size it can be used in receiver station of the IRNSS (Indian Regional Navigational Satellite) satellite system.

**Keywords:** micro strip patch, pin diode, size, meta material

### 1. Introduction

Microstrip patch antenna consists of a very thin metallic strip placed on above the ground plane with a dielectric material in-between the ground plane and metallic strip [1]. They are very compact size antennas having low radiation. The patch antennas are popular for low profile applications at frequencies above 100 Mhz usually, the micro strip patch is chosen to be square, circular or rectangular in shape for the easy of analysis and fabrication. The radiation pattern of micro strip patch antenna is board. It has low radiation power and narrow frequency bandwidth. Array of patch antenna is used to achieve a greater directivity [5]. Reconfigurable antennas are capable of modifying dynamically its frequency and radiation properties in a controlled and reversible manner. Frequency reconfigurable antennas can adjust dynamically their frequency of operation.

They are useful in situations where the multiple antennas are required that can be replaced by a single reconfigurable antenna. In other words it can be defined as changing the mode of operation. It takes millimeter waves and reconfigures that to the various wireless communication applications.

### 2. Antenna Design

In this paper, the micro strip patch antenna has been designed to operate at a center frequency range of 5.0 GHz with an input impedance of 50  $\Omega$  using a dielectric material GML-1000 with  $\epsilon_0 = 3.4$ , tangent loss  $\delta=0.002$  and thickness (h) of .762 mm. For micro strip antennas, the dielectric constants are usually in the range of  $2.2 < \epsilon_r < 12$ . The most popular models for the analysis of microstrip patch antennas are the transmission line model, cavity model and full wave model. The transmission line model is the simplest of all and it gives good physical insight but it is less accurate.

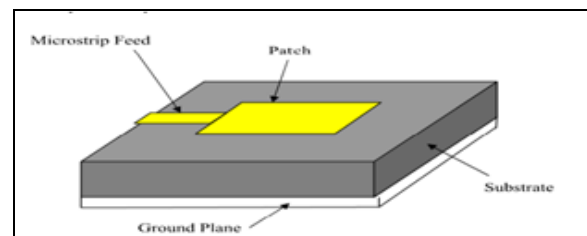


Fig 1: Microstrip feed line

The width of the micro strip patch antenna was computed with the following equation:

$$W = \frac{c}{2f_o \sqrt{\frac{(\epsilon_r + 1)}{2}}}$$

Where c is the speed of light ( $3 \times 10^8$  m/s),  $f_r$  is the operating frequency of 3.6 GHz and  $\epsilon_r$  is the dielectric permittivity of 4.28.

The length of micro strip patch antenna is given by the following equations:

$$\epsilon_{\text{reff}} = \frac{\epsilon_r + 1}{2} + \frac{\epsilon_r - 1}{2} \left[ 1 + 12 \frac{h}{W} \right]^{-\frac{1}{2}}$$

Where  $\epsilon_{\text{reff}}$  is the effective dielectric constant and h is the thickness of the dielectric substrate.

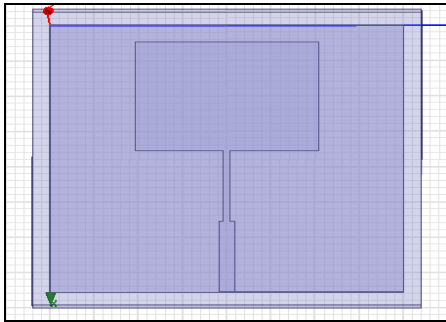
$$L_{\text{eff}} = \frac{c}{2f_o \sqrt{\epsilon_{\text{reff}}}} \quad \Delta L = 0.412h \frac{(\epsilon_{\text{reff}} + 0.3) \left( \frac{W}{h} + 0.264 \right)}{(\epsilon_{\text{reff}} - 0.258) \left( \frac{W}{h} + 0.8 \right)}$$

In the equation above  $\Delta L$  stands for length extension. Therefore, the actual length of the micro strip patch antenna is given by:

$$L_{eff} = L + 2\Delta L$$

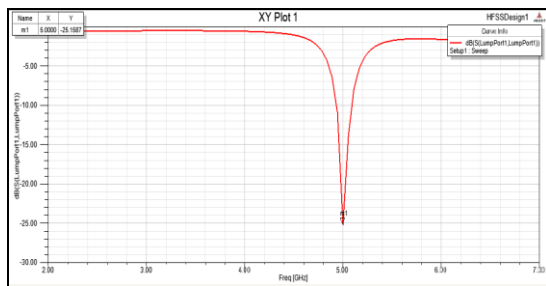
Hence, For the Resonance frequency  $f=5.0$  GHz the patch dimension are  $W= 20.7$ mm and  $L= 15.5$ mm.

**2.1 Simulation Results**



**Fig 2:** Ansoft HFSS generated antenna model

**Gain and Frequency**



**Fig 3:** Simulation result of return loss v/s freq.

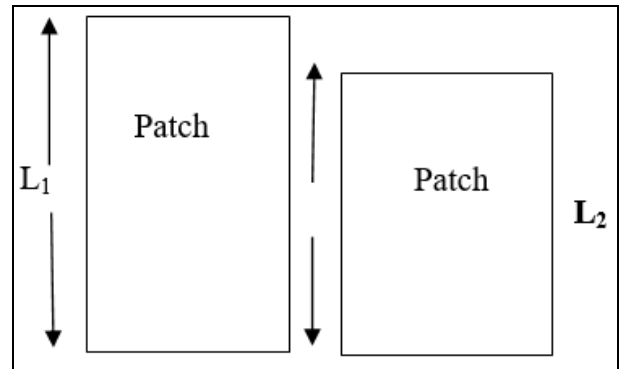
The design formulae are empirical and give reasonably good results. The numerical values obtained from these formulae should be used as initial values and several iterations may be done to get more accurate results. This process is called optimization. We were aim to design a rectangular Patch Antenna at a resonance frequency of 5.0 GHz, the simulation results obtained from HFSS-13.0 software.

**2.2 Reconfigurable frequency micro strip antenna- design and analysis**

The dimensions and configurations of a micro strip antenna affect the operating frequency, bandwidth, pattern and polarization of the far fields of the antenna. Therefore, changes in these dimensions and configurations can be used to reconfigure antenna properties.

The most straightforward conductor modification for micro strip patch antenna is a change in length, which nominally results in change in operating frequency. Many common approaches to these modifications are based on the fundamental theory of the basic microstrip patch antenna operating in its first resonant mode. These changes result in change in the antenna’s electric length to approximately an

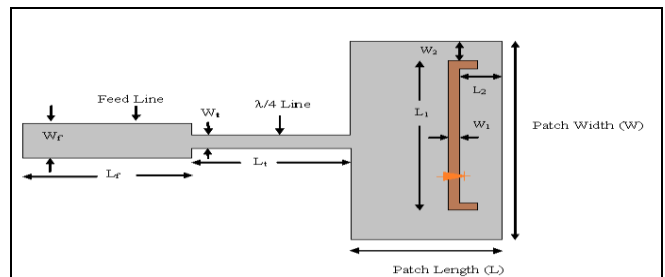
effective half wavelength, which is conditioned by the permittivity and permeability of the substrate material. If we require two different operating frequencies for two different applications, one frequency operates at  $t_1$  time and another frequency operates in  $t_2$  time then we design two antennas for such type of applications. Let us suppose one antenna operates on  $f_1$  frequency and another antenna operates on  $f_2$  frequency then for this kind of operation we see that the lengths of patches will be different. We suppose that for frequency  $f_1$ , the length of patch will be  $L_1$  and for frequency  $f_2$ , the length of patch will be  $L_2$ .



**Fig 4:** Two different lengths of patches for two different frequencies

The difficulty is that two patch lengths are required for two antennas for two operating frequencies. If the number of operating frequency is increased the number of antennas also increases. So that in recent years, there has been a considerable interest in the development of tunable antennas due to their properties of adapting with change in the environmental and system requirements. A single tunable antenna would eliminate the need for multiple antennas operating in various frequency bands. To achieve reconfigurability in an antenna, RF switching devices such as PIN diodes, photoconductive switches, micro-electromechanical system (MEMS) switches and FETs are required. Among the available RF switches, PIN diode switch is very popular in microwave circuit applications due to its fast switching speeds, reasonably high current handling capabilities, reliability and ease of modeling [12]. Using PIN diodes for switching, a single antenna can resonate at two different frequencies under different bias voltages.

**2.3 Geometry of conversion of reference antenna into an actual reconfigurable antenna**



**Fig 5:** Geometry of conversion of reference antenna into an actual reconfigurable antenna

Conversion of reference antenna into an actual reconfigurable antenna is achieved by a C shaped slot cut in the reference patch. This gives the desired lower resonant frequency. A PIN diode is incorporated in the antenna structure as shown in the figure. When the diode is switched on (by applying proper bias) the antenna starts resonating at the higher frequency.

The operational mechanism of the antenna can be understood by surface current path flow in the patch. Two paths are possible corresponding to two states of the diode. In the first state, when diode D is in reverse bias or off state, the surface current will flow along the slot. With this configuration, antenna will radiate at resonant frequency lower than the reference frequency. In the second state, when the diode is in forward bias or in on state the surface current in the antenna will flow through some additional path. This current path will lead to the resonant frequency of antenna to higher than the reference frequency.

We decide to work on C-slot on reference patch. After getting the results of conventional micro strip patch antenna (5.0 GHz), now we are converting it into switchable dual frequency micro strip patch antenna. Conversion of reference antenna into an actual reconfigurable antenna is achieved by a C shaped slot cut on the reference patch. This gives the desired lower resonant frequency. A PIN diode is incorporated in the antenna structure as shown in the figure shown below. When the diode is switched ON (by applying proper bias) the antenna starts resonating at the higher frequency. The geometry of the proposed antenna is shown with C shape slot the dimensions of the slot are  $L_1 \times W_1$ . The distance of the slot from non-radiating edge is denoted by  $W_2$  and distance of the slot from radiating edge is denoted by  $L_2$ .

#### 2.4 Simulation results when diode is in off condition

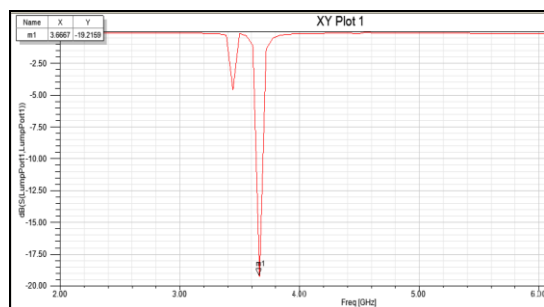


Fig 6: Graph between frequency and return loss (On State)

#### 2.5 Simulated result when diode is in on state

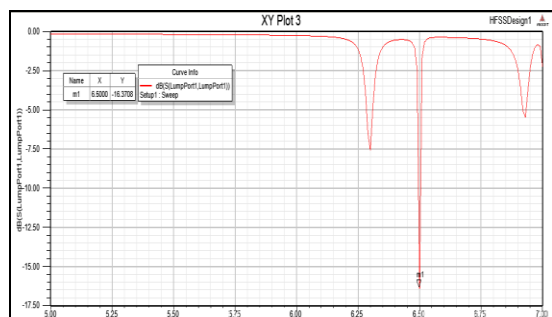


Fig 7: Graph between frequency and return loss (On State)

### 3. Conclusion

This Paper proposes a switchable micro strip rectangular patch antenna has been designed and simulated for dual frequency applications. Frequency re configurability is achieved by controlling the bias voltage of the PIN diode. The return loss versus frequency characteristics indicates that the proposed antennas can be switched over two frequency bands at 3.660 GHz, and 6.500 GHz. Due to their compactness and ease of fabrication, the proposed antennas can be useful for commercial wireless communication applications.

### 4. References

1. Manoj Parihar S, Ananjan Basu, Shibam Koul K. Novel Tri-state Dual band Frequency Reconfigurable Antenna proceedings of International Symposium on antenna and propagation (ISAP), Taipei, Taiwan, 2008; 27-30.
2. Sung YJ, Jang TU, Kim YS. A reconfigurable antenna for switchable polarization IEEE Microwave and Wireless Component Letters. 2004; 14(11):534-536.
3. Wang CJ, Tsai WT. A slot antenna module for switchable radiation patterns, IEEE Antennas Wireless Propag. Lett., 2005, 4(202-204).
4. JT Aberle, SH Oh, Auckland DT, Rogers SD. Reconfigurable antennas for portable wireless devices, IEEE Antennas Propag. Mag., 2003; 45(6):148-154.
5. Behdad N, Sarabandi K. A varactor-tuned dual-band slot antenna, IEEE Trans. Antennas Propag., 2006; 54(2):401-408.
6. Peroulis D, Sarabandi K, Katehi L. Design of reconfigurable slot antennas, IEEE Trans. Antennas Propag. 2005; 53(2):645-654.
7. Behdad N, Sarabandi K. Dual-Band reconfigurable antenna with a very wide tunability range, IEEE Transactions on Antennas and Propagation. 2006; 54(2):409-416.
8. Noyan Kinayman MI. Aksun Mordan Microwave circuits Arect House London 2005.
9. Yablonovitch E. Photonic band-gap structures Vol. 10, No. 2/February 1993/J. Opt. Soc. Am. B pp 283.
10. Rodney Waterhouse B, Waterhouse RB. Rod Waterhouse Microstrip Patch Antennas: A Designer's Guide Springer 1 edition 2003.
11. David Pozar M, Daniel Schaubert H. Microstrip Antennas: The Analysis and Design of Microstrip Antennas and Arrays Wiley-IEEE Press, 2008.
12. Youngje Sung. A Switchable Microstrip Patch Antenna for Dual Frequency operation ETRI Journal, 2008; 30(4).
13. Wang CJ, Tsai WT. A slot antenna module for switchable radiation patterns, IEEE Antennas Wireless Propag. Lett., 2005; 4:202-204.
14. Emre Erdil, Kagan Topalli, Mehmet Unlu, Ozlem Aydin Civi, Tayfun. Frequency Tunable Microstrip Patch Antenna Using RF MEMS Technology IEEE Transactions on Antennas and Propagation, 2007; 55(4).