Design and Implementation of Reconfigurable Antenna

Pagire T. G
Department of E&TC
Pune University, GHRCOEM, Ahmednagar, India

Abstract:
In this project, antenna reconfiguration is done using a improved & effective technique or method. Conventional antennas operate at a specific frequency range hence that is designed for particular application and we cannot operate it on multiple frequencies. Prior to conventional antennas, reconfigurable antennas discussed in this paper operate at different frequency ranges. It improves the performance as it uses single antenna structure to operate at multiple frequencies. For this, here we used frequency reconfiguration techniques i.e. PIN diode switching due to which it can switch among different frequency band. HFSS software is used for simulation and analysis.

Keywords: Reconfigurable antenna, PIN diode, frequency reconfigurability, microstrip patch.

I. INTRODUCTION

With increase in number of wireless communication system and development of modern satellite communication, especially in case of MIMO system, many applications requires integrated, adaptive, multifunctional terminals. Reconfigurable antenna represents recent innovations in antenna design that dynamically changes frequency, pattern polarization to modifiable structures that can be adapted. The new technique of PIN diode is used as the switching device. There are various reconfiguration parameters such as frequency, polarization, radiation pattern, input voltages and compound patterns. Here we are implementing frequency reconfigurable antenna. Because it is probably easy feature to reform. It switches the frequency from one to another. This frequency switching can be done by using PIN diode switching circuitry. PIN diodes are having advantages of less insertion loss, provides better isolation, and power handling capacity of PIN diode is high and low cost. In case of pattern reconfiguration, it is related to radiation pattern of individual antenna and we cannot change it in different ways. Polarization reconfigurability demonstrated by linear polarization (LP) or circular polarization (CP). The microstrip antennas are used for simulating the reconfigurable antenna in software tool. HFSS is used for getting simulation results. The patch antennas provide advantage of light weight, less size, low fabrication cost, capable of dual and triple frequency observation. The main aim is to compact size of antenna hence we use patch antenna. Here we analyze the simulated results in HFSS software, and we get return loss of less than -10dB shows antenna efficiency. The frequency tuning is achieved by inserting switches and depending on the status of switch the range of frequency operation is selected. As we compare MEMS switches with PIN diode, PIN diode switch finds efficient as it is having high switching speed, high power handling capability, very reliable since there are no moving parts and low cost. On the other hand MEMS switch circuitry contains mechanical movable parts, less switching speed hence we use PIN diode switch for tuning frequency of antenna. For design of reconfigurable antenna we use microstrip patch antenna. Microstrip antennas are planar resonant cavity that leak from their edges and radiate EM waves. It consists of radiating patch on one side of a dielectric substrate having a ground plane on other side. The basic patch antenna is as shown in fig.1 below.

II. DESIGN OF ANTENNA

For designing Microstrip reconfigurable antenna we have to first select the proper substrate material. Here we use FR-4 as a substrate. Rogers’s material for PCB that is FR-4 material provides the base standard for the PCB substrate, it deliver a effective maintenance of cost, various electrical properties, manufacturability, performance and durability.
A substrate having a high dielectric constant is to be selected so that antenna dimensions are reduced. In order to increase radiated power a low value of dielectric constant should be selected

**B. Design Specifications**

There are three necessary parameters for designing of a rectangular Microstrip Patch Antenna:

- **Operating Frequency (fo):** Appropriate Resonating frequency of the antenna is first selected. The antenna is designed in a manner such that it must satisfy the operating range of frequency. I have selected the resonant frequency selected for my design as 2.4 GHz.

- **Dielectric constant of the PCB substrate (εr):** The dielectric material is selected as FR4 for our design which is having a dielectric constant of 4.4. High dielectric constant substrate has been selected because it reduces the antenna dimensions.

- **Dielectric substrate height (h):** In case of microstrip patch antenna to be used in mobile phones, the essential factor is the weight of the antenna. Hence, we select 1.6 mm the height of the dielectric substrate. Hence, the parameters that are necessary for the design are:

  \[
  \begin{align*}
  f_0 &= 2.4 \text{ GHz} \\
  \varepsilon_r &= 4.4 \\
  h &= 1.68 \text{mm}
  \end{align*}
  \]

1) **Calculation for 2.4GHz frequency**

**Step 1:** Calculation of the Width of antenna (W):

Microstrip patch antenna’s width (W) is given as:

\[
W = \frac{c}{(2f_0\varepsilon_r)^{1/2}}
\]  

Substituting \( c = 3.00 \times 10^8 \text{ m/s} \), effective dielectric \( \varepsilon_r = 4.4 \) and resonance frequency \( f_0 = 2.4 \text{ GHz} \), we get:

\[
W = 38.036 \text{mm}
\]

**Step 2:** Calculation of Effective dielectric constant (\( \varepsilon_{eff} \)):

The formula for calculation of effective dielectric constant is:

\[
\varepsilon_{eff} = \frac{(\varepsilon_r+1)}{2} + \frac{\varepsilon_r-1}{2} \left[ 1 + 12 \frac{h}{w} \right]^{1/2}
\]  

Substituting \( \varepsilon_r = 4.4 \), \( W = 38.036 \text{ mm} \) and \( h = 1.6 \text{mm} \) we get:

\[
\varepsilon_{eff} = 4.085
\]

**Step 3:** Calculation of the Effective length (\( L_{eff} \)):

The effective length is:

\[
L_{eff} = \frac{c}{(2f_0\varepsilon_{eff})}
\]  

Substituting \( \varepsilon_{eff} = 4.085 \), \( c = 3.00 \times 10^8 \text{ m/s} \) and \( f_0 = 2.4 \text{ GHz} \) we get:

\[
L_{eff} = 30.92 \text{mm}
\]

**Step 4:** Calculation of the extending length (\( \Delta L \)):

The extension length is:

\[
\Delta L = \frac{0.4128 \left[ (\varepsilon_{eff}+0.3)(\frac{h}{w}+0.264) \right]}{(\varepsilon_{eff}-0.258)(\frac{h}{w}+0.8)}
\]  

**Step 5:** Calculation of actual patch length (\( L \)):

The actual length is obtained by:

\[
L = L_{eff} - 2\Delta L
\]

Substitute \( \varepsilon_{eff} = 4.085 \), \( W = 38.036 \text{mm} \) and \( h = 1.68 \text{mm} \) we get:

\[
\Delta L = 0.7388 \text{ mm}
\]

\[
L = 29.44 \text{mm}
\]

**Step 6:** Calculation of the dimensions of ground plane (\( L_g \) and \( W_g \)):

The transmission line model is applicable only for infinite ground planes. However, for practical considerations, there is necessity of finite ground plane. It has been shown by that similar results for finite and in order to obtain infinite ground plane size of the ground plane should be greater than the patch dimensions by approximately the multiple of six times the substrate thickness all around the periphery. Hence ground plane dimensions for the proposed design would be given as:

\[
L_g = 6h + L
\]

\[
= 6(1.6) + 29.44
= 39.04 \text{ mm}
\]

\[
W_g = 6h + W
\]

\[
= 6(1.6) + 38.036
= 47.636 \text{ mm}
\]

**III. SYSTEM DEVELOPMENT**

1. **SYSTEM FLOW**

   ![System Flow Diagram](http://ijesc.org/)

   - START
   - DATA ANALYSIS
   - SELECTION OF ANTENNA
   - SIMULATION
   - DEFINE WAVEPORT
   - BOUNDARY SELECTION
   - ANALYZE THE RESULT

2. HARDWARE DESIGN
3. SOFTWARE DESIGN
Proposed antenna structure designed in HFSS software is as shown in fig. 3. In order to generate radiation a space or the environment for the patch antenna is created by inserting an air box around antenna. An air box has to be inserted in to model open space due to which the radiation from the structure is not reflected back and totally absorbed. Hence rectangular patch antenna design is enclosed in an air container in order to achieve reconfiguration.

As we compare the gain measured we conclude that antenna with reflector is having higher gain than it is achieved by antenna without reflector. VSWR structure for the designed antenna is shown in fig. 5.

The designed microstrip patch antenna is simulated using HFSS software the desired two frequencies of 1.36GHz and 1.6GHz with VSWR values of 1 and 1.1 respectively are achieved.

V. CONCLUSIONS

The proposed antenna design is having resonant frequencies as 1.36GHz and 1.6GHz with VSWR values of 1 and 1.1 respectively. The antenna is simulated using HFSS software tool which is efficient one. The proposed antenna is having compact structure and provides easy integration and fabrication with other components of microwave communication. Comparing the measured results with simulated results provides very good agreement.

VI. REFERENCES

[1]. Joseph Costantine1, Youssef Tawk, Jonathan Woodland, Noah Flaum, Christos G. Christodoulou, “Reconfigurable antenna system with a movable ground plane for cognitive radio”, Published in IET Microwaves, Antennas & Propagation March 2014


