Reconfigurable Microstrip Antenna Array

Vidya B. Babare1, S. B. Deosarkar2
E&TC Department, Pune University1,2
VPCOE Baramati

Abstract

A reconfigurable antenna is another solution to achieve a wide impedance bandwidth by switching ON and OFF some parts of the antenna. To allow the operating frequencies and the bandwidths to be reconfigurable, switching components are normally used. When all the switches are in the OFF state, the total radiation pattern is formed by the pattern radiated by each small patch. As a result, the antenna resonates at a higher frequency band. When all switches are turned ON, the antenna effective area is clearly larger than the area of a singular patch array. The antenna accordingly resonates at a lower frequency band. In this paper Rectangular patch antenna array and Reconfigurable rectangular patch antenna array is designed and simulated for Bluetooth (2.4GHz-2.48GHz band) and GPS (1.5GHz) application. Comparative analysis of these antennas is presented by using HFSS software.

1. Introduction

There is an extensive research on microstrip antennas which exploiting their disadvantage such as narrow bandwidth which can limit their use in some modern wireless applications.[1] So there is an increasing demand for low-profile, easy to manufacture, and multiband/wideband antennas which can be easily integrated within communication systems.

Recent trends have seen the development of wideband antennas, multi-band antennas or reconfigurable antennas receiving much attention to fulfils different applications in just one single terminal. Single terminals or devices could have many applications such as, GPS, GSM, WLAN, Bluetooth, etc. To suit such applications Wideband, multi-band or reconfigurable antennas have been developed.

A variety of studies have come up with different techniques to achieve multiband and wideband operation for printed antennas. Some of the techniques employed are changing the physical size of the antenna, modifying the radiator shape to allow current paths to travel at longer distances (which sometime increases the antenna size), and adding additional parts such as multi layers or gaps which again makes the antenna larger and of a higher profile.

Some other techniques are also proposed like U-slot array, folded shorting wall , Y-V Slot, stacked patch , pair of slits on the patch, E shape patch on thick substrate and using circular arc shaped slot on thick substrate but these antennas are large in sizes and difficult to fit into small and slim devices.

So Looking to increase the functionality of current wireless platforms and to improve their quality of service, we have explored the merits of using reconfigurable antennas as an alternative for multiband antennas. The reconfigurable approach offers significant advantages of compactness and flexibility.

Microstrip antennas in simplest form consist of a radiating patch on one side of a dielectric substrate and ground plane on other side. The MSA has proved to be an excellent radiator for many applications because of its several advantages such as low weight, low volume, low cost, conformal configuration, compatibility with integrated circuits and so on. [1]

But it also has several disadvantages such as Narrow bandwidth, Lower gain, and Low power-handling capability. Increasing the BW of MSAs has been the major thrust of research in this field. [1]

The rectangular and circular patches are the basic and most commonly used microstrip antennas. Rectangular geometries are separable in nature and their analysis is also simple. The enhancement of the bandwidth and the achievement of multifrequency operation are major challenges for the antenna designer and many techniques have been proposed for this purpose.

There are several ways to achieve multiband and wideband such as slots, suspended ground, changing feeding techniques, by changing radiator shapes etc. Which makes the antenna larger and of a higher profile.

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2. Frequency Reconfiguration

An antenna that possesses the ability to modify its characteristics, such as operating frequency, polarization or radiation pattern, in real time condition is referred to as a reconfigurable antenna.

Reconfigurable antennae can be simply used to reduce the number of antennae necessary for intended system function. Reconfigurable antennae can be a cheaper alternative to traditional adaptive arrays or they can be incorporated into adaptive arrays to improve their performance by providing additional degrees of freedom.

Antenna reconfiguration is normally achieved in one of three ways:

- Selectively switching in or out parts of the antenna structure
- Changing the antenna geometry by mechanical movement
- Adjusting the loading or matching of the antenna externally.

In mobile multiradio platforms particularly, implementation of such reconfigurable multiband antennas would greatly reduce the complexity and increase the capability of the antenna system as a whole.

Modern communication systems demand transmitters and receivers with multi-band operation, as a result, numerous techniques for achieving frequency reconfigurability have been proposed in system where weight and area are critical issues.

3. Introduction to Bluetooth

The IEEE 802.15.1 standar is the basis for the Bluetooth wireless communication technology. Bluetooth is a low tier, ad hoc, terrestrial, wireless standard for short range communication.

It is designed for small and low cost devices with low power consumption. The technology operates with three different classes of devices: Class 1, class 2 and class 3 where the range is about 100 meters, 10 meters and 1 meter respectively.

Wireless LAN operates in the same 2.4 GHz frequency band as Bluetooth, but the two technologies use different signaling methods which should prevent interference.

4. Design Specifications

The three essential parameters for the design of microstrip patch antenna are carried out in this paper.

- **Frequency of operation (Fr)**

The resonant frequency of antenna must be appropriately selected. The Bluetooth uses frequency band from 2.4 - 2.48GHz. So antenna should operate in this frequency range. For design condition frequency selected is 2.4GHz.

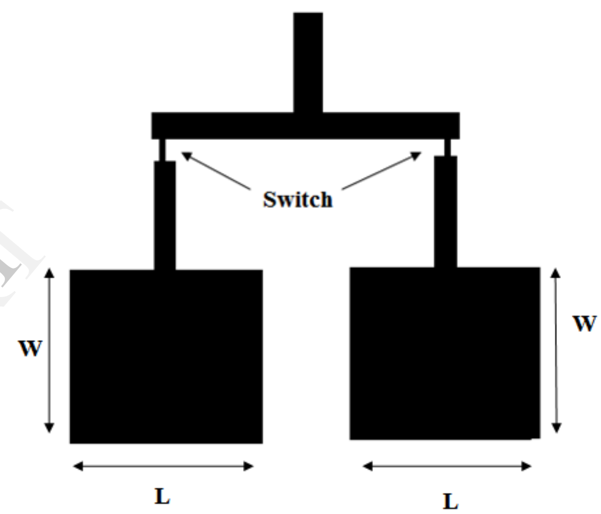
- **Dielectric constant of the substrate (€r)**

A substrate with high dielectric constant is selected for to reduce dimensions of antenna. FR4 glass epoxy substrate having dielectric constant 4.4 is selected for design. FR4 is selected because it is very cost effective.

- **Height of dielectric substrate (h)**

For the microstrip antenna is used for low profile applications, it is essential that the antenna is not bulky. Hence height of the substrate is selected as 1.6mm. The parameters for the design are,

Fr =2.4GHz, €r = 4.4, h =1.6mm



igure 1: Reconfigurable microstrip antenna array

[1] Calculation of the Width (W): The Width of the Microstrip patch antenna is given by equation.

$$W = \frac{C_0}{2Fr}\sqrt{\frac{2}{\varepsilon r+1}} \qquad (1)$$

Where λ0= C0/Fr

Since C0 is velocity of light.

Fr is frequency of operation.

[2] Calculation of Effective dielectric constant (εef)

$$\varepsilon_{eff} = \frac{\varepsilon r+1}{2} + \frac{\varepsilon r-1}{2}\left[1+12\frac{h}{w}\right]^{-\frac{1}{2}} \qquad (2)$$

Where εr is dielectric constant of the substrate,

H is height of substrate.

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W is width of patch.

[3] Calculation of the length extension(ΔL)-

$$\Delta L = 0.412h \frac{[\varepsilon_{eff}+0.3][\frac{W}{h}+0.264]}{[\varepsilon_{eff}-0.258][\frac{W}{h}+0.8]} \quad (3)$$

[4] Calculation of effective length (Leff)-

$$L_{eff} = \frac{C_0}{2Fr\sqrt{\varepsilon_{eff}}} \quad (4)$$

[5] Calculation of the length of the patch (L)-

$$L = Leff - \Delta L \quad (5)$$

[6] Calculation of the ground plane dimensions (Lg and Wg):

The transmission line model is applicable to infinite ground planes only. However, for practical considerations, it is essential to have a finite ground plane. It has been shown by that similar results for finite and infinite ground plane can be obtained if the size of the ground plane is greater than the patch dimensions by approximately six times the substrate thickness all around the periphery. Hence, for this design, the ground plane dimensions would be given as:

$$Lg = 2(6h + L)$$
$$Wg = 2(6h + W) \quad (6)$$

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5. Antenna Configuration

The proposed antenna design is shown in figure1. It consists of reconfigurable rectangular patch array. In this paper several parameters have been investigated and a parametric study of the structure is made in order to obtain the best possible size. The dielectric material selected for design is FR4 having dielectric constant 4.4 with height 1.6mm.

A 50Ω inset microstripline feed attached to the microstrip antenna with length Lt and width Wt. The inset length Y0 is chosen such that impedance matching is achieved. Length of feed is 19mm width is 2.8mm and inset length is 7mm and width is 5mm.

Overall dimensions of the antenna are as follows:

L= 39mm, W= 28.2mm

6. Simulated Results

Simulated results for simple rectangular patch array:

The software package Ansoft HFSS was used to model the microstrip patch antenna

a) S parameters:

These are the scattering parameters. We get the return loss, resonant frequency, and return loss bandwidth. From graph we get the results for 2.4 and 1.5 GHz band.

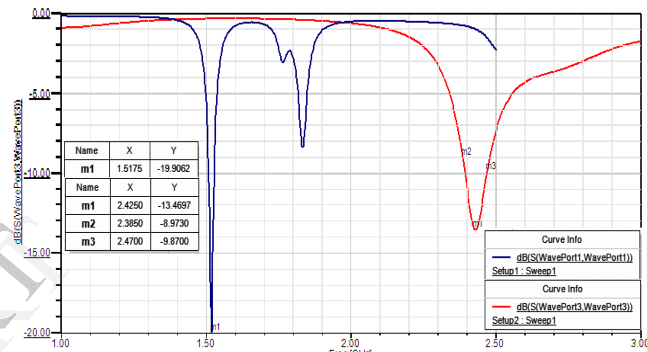

Figure 2 : Simulated S parameters for Reconfigurable patch antenna array

b) VSWR

This is the voltage standing wave ratio. Ideally it should be 1. VSWR bandwidth is taken at 2 i.e. the 11% reflected power or -10db return loss.

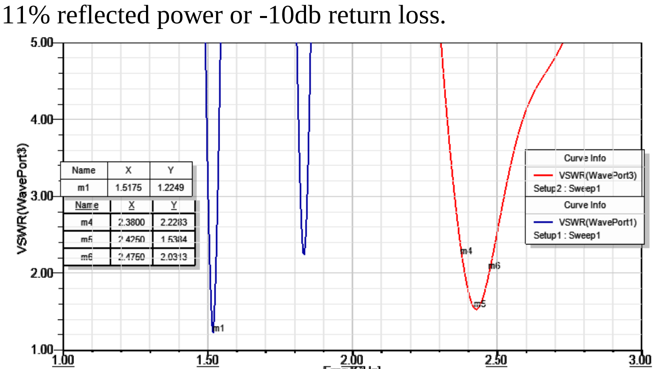

Figure 3: Simulated VSWR for Reconfigurable patch antenna array.

c) Radiation Pattern

Power flux density or gain is plotted on polar plot we get certain pattern of that property called radiation pattern. The radiation pattern for this antenna is illustrated in Figure showing an omnidirectional pattern.

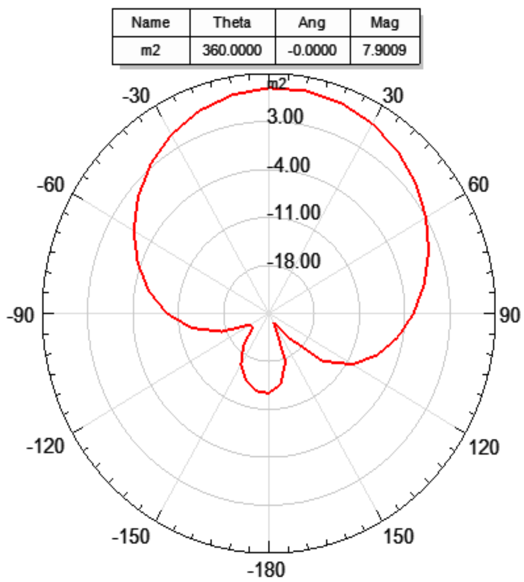

Figure 4 : Simulated Radiation Pattern for Reconfigurable patch antenna array when switches are in off state.

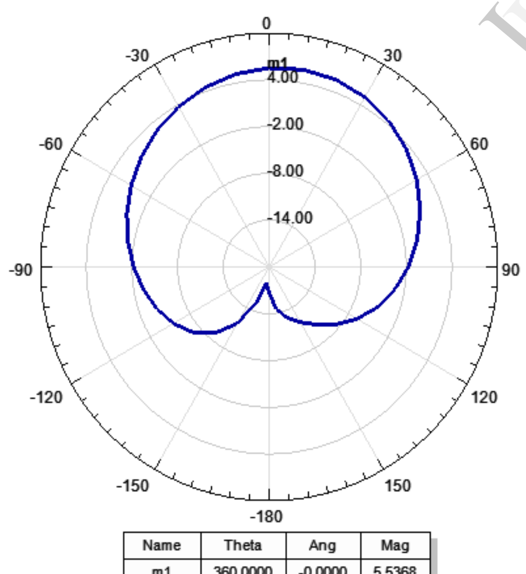

Figure 5 : Simulated Radiation Pattern for Reconfigurabler patch antenna array when switches are in on state.

d) Current Distribution

Current distribution on the final antenna design at f= 2.4 GHz. The current distribution on the patch antenna is quite dense and well spread. This implies good matching between the inset line and the patch.

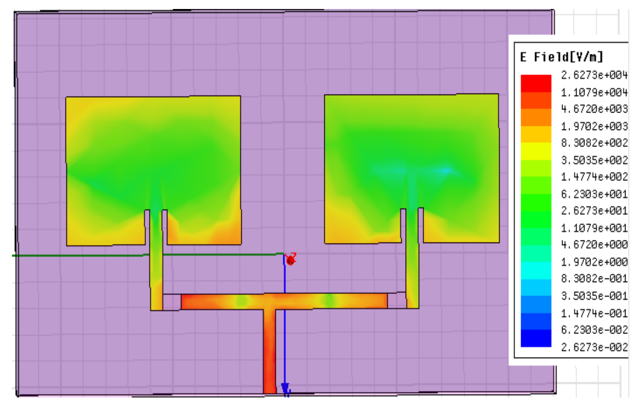

Figure 6 : Simulated current distribution for Reconfigurable patch antenna array

7. Simulated Results: - Table 1

Antenna	Freq	S parameter	VSWR	Gain	BW (MHz)
Array	2.42	-15.44	1.40	7.85	90
Slotted array	1.5	-19.9	1.22	5.5	30

8. Conclusion

The Reconfigurable patch antenna array design is carried out, which covers the Bluetooth and GPS applications. The further extension to the patch array may increase the gain at the cost of reduced bandwidth.

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