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Design of reconfigurable antenna arrray for WLAN and WIMAX application.

R. Saranya[1] and Mr. K. RamPrakash[2].
[1,2]Department of Electronics and Communication Engineering,
[1]Adithya Institute of Technology, Coimbatore-641107.
[2]Kumaraguru College Of Technology, Coimbatore 641006.
E-mail id:saranravi1986@gmail.com,

***Abstract* -In this paper we have presented the use of reconfigurable microstrip patch antenna elements in adaptive arrays. The combination of both reconfigurability and adaptivity in a single array is investigated. As the different standards have different requirements and use different frequency bands mainly around 2.4GHz to 5 GHz, the RF circuits and antennas designed for each system must be able to work at different frequency bands. For this purpose dual-band inset-fed reconfigurable antenna is designed and RF-MEMS switches are being used to switch between different frequency bands.**

***Keywords*- Reconfigurable antenna, adaptive array, WLAN, WIMAX.**

I. INTRODUCTION

With the tremendous advancement in communication technology followed by ever growing consumer demands the need for multi functional wireless communication devices is more than ever felt. Currently, different systems work with different standards such like cellular phones, WLAN and satellite communications in [1,2] . These different standards have different requirements. Many of the systems are being designed for to be compatible with more than one of these standards. For this reason they require to design for different RF circuits and antennas.

Reconfigurable antennas have recently received significant attention for their applications in communications, electronic surveillance and countermeasures. In reconfigurable antennas, changing the shape of radiating element is achieved by switching. The switching property allows the user to roam any existing network and have only a single handset to access a great number of services in [3].

A smart antenna is an array of antenna elements that is able to change its radiation pattern dynamically for preventing from noise, interference, and multipath fading. The smart antenna systems can be divided into two categories. These are: switched beam system, and adaptive arrays. In this paper adaptive arrays are investigated and used for smart antenna model. In adaptive beamforming, the goal is to adapt the beam by adjusting the gain and phase on each antenna element such that a desirable pattern is formed.

In this paper RF-MEMS switches is used for switching. It is also possible to use PIN diodes as switching element but we preferred MEMS switch for their significant better RF characteristics than conventional PIN diodes or FET switches and consumes less power Ref[4]. Both switches and antenna are to be designed and simulated on Ansoft HFSS.

The combination of both reconfigurability and adaptivity performance is investigated. Wiener Hopf algorithm is used for this purpose. Using MATLAB these performance characteristics were investigated.

II RECONFIGURABLE MICROSTRIP PATCH ANTENNA DESIGN

The patch antenna was first designed based on the equations from the transmission line model (TLM) approximation . That approximation states that the operating frequency of a patch antenna is given in (1)

$$f_r = \frac{1}{2(L+\Delta L)\sqrt{\varepsilon_{eff}}\sqrt{\mu_0\varepsilon_0}} \qquad (1)$$

where L is the length of the antenna, ϵ_0 and μ_0 are the free space dielectric permitivity and permeability, ϵ_{reff} is the effective dielectric permittivity:

$$\varepsilon_{reff} = \frac{\varepsilon_r+1}{2} + \frac{\varepsilon_r-1}{2}\left[1+12\frac{h}{W}\right]^{\frac{1}{2}} \qquad (2)$$

where ϵ_r and h are the relative dielectric permitivity and thickness of the substrate, and W is the width of the patch in (2). Because of fringing effects, the antenna looks larger than its physical dimensions. ΔL takes this effect in account and can be computed from,

$$\Delta L = 0.412h\frac{(\varepsilon_{reff}+0.3)\cdot(W/h+0.264)}{(\varepsilon_{reff}-0.258)\cdot(W/h+0.8)} \qquad (3)$$

The input impedance of the antenna must be matched to the feed line by choosing the correct position for the feeding point. Because the antenna must be fed with the microstrip, the connection to a point inside the metal patch requires the use of an inset.

There are two types of switching hard and soft switching. Here hard switching is being used for the reconfigurable antenna due to its high gain and efficiency. Figure 1 gives the design for the antenna. For low frequency the switch will be on and get connected. Similarly for high frequency the switch will be in off condition.

Using the values given by TLM approximation (1), parameters for the antenna was calculated for 2.4 GHz and 3.5 GHz bands. The dielectric substrate is chosen to be corning glass (ϵ_r = 5.75) and substrate width h = 0.5mm is used. To provide dual frequency operation another U-like shaped patch is attached to 3.5 GHz antenna for enlarging the radiating length. For connecting two patches six capacitive RF-MEMS switches are used. This new antenna resonates at 2.40 GHz (Switch ON) in (2) and 3.48 GHz (Switch OFF) in (3). RF-MEMS switches designed on the same substrate. The RF-MEMS switches are modeled as two port devices with s-parameter data

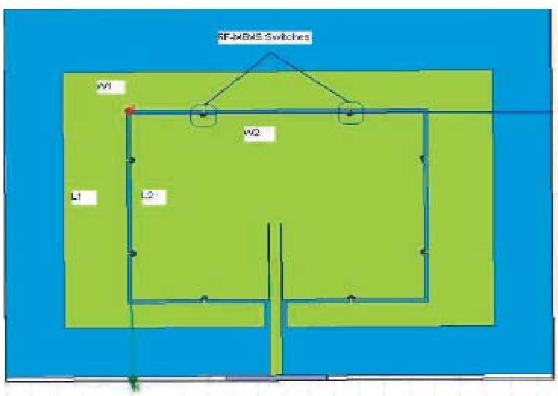

Fig.1. Antenna design.

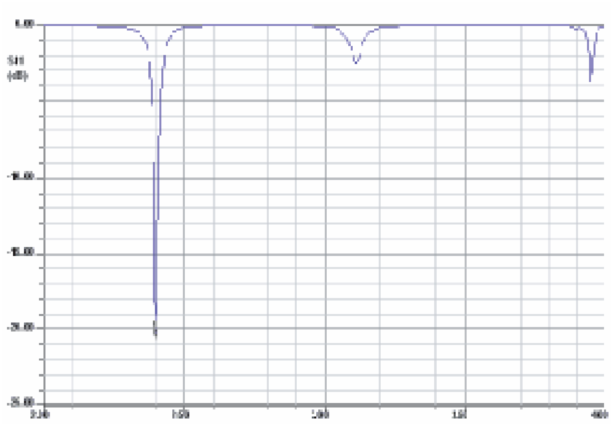

Fig. 2. Antenna output when switch is on.

III ADAPTIVE ANTENNA ARRAY

An adaptive array is an antenna system that can modify its beam pattern or other parameters, by means of internal feedback control while the antenna system is operating. Adaptive arrays are also known as adaptive beam formers or smart antennas. Smart antenna technology can have great effect on many important parameters in the wireless communication. Benefits to be gained are among others in the area of bandwidth, bit rates, interference rejection, power economy, and reliability .

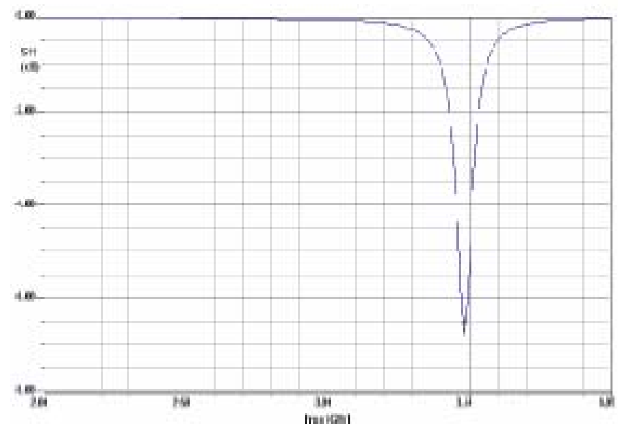

Fig. 3. Antenna output when switch is off.

The basic idea behind smart antennas is that multiple antennas processed simultaneously allow static or dynamical spatial processing with fixed antenna topology. The pattern of the antenna in its totality is now depending partly on its geometry but even more on the processing of the signals of the antennas individually .

Adaptive Beamforming is a technique in which an array of antennas is exploited to achieve maximum reception in a specified direction by estimating the signal arrival from a desired direction (in the presence of noise) while signals of the same frequency from other directions are rejected. This is achieved by varying the weights of each of the sensors (antennas) used in the array.

In adaptive beamforming the optimum weights are iteratively computed using complex algorithms based upon different criteria. Adaptive algorithms form the heart of the array-processing network. Several algorithms have been developed based on different criteria to compute the complex weights.

For this purpose new methodology using Wiener Hopf algorithm is being proposed. The resultant performance is being compared with the standard LMS algorithm. Both calculates the weights in a time recursive manner but the advantage of Wiener Hopf algorithm is that error is comparative reduced compared to LMS. The steps in the derivation are given as follows:

The output of the algorithm is obtained using (4),

$$y(n)=w^H x(n) \qquad (4)$$

The error present in the algorithm is obtained using (5)

$$E(n)=d^* - y(n) \qquad (5)$$

The weight calculation is done using (6)

$$W(n+1)=w(n) + \mu x(n)e^{*}(n) \qquad (6)$$

μ is a step size parameter which is related to the rate of convergence; however, convergence of the w(n) is assured by the following condition $0<\mu<1/\lambda_{max}$.

IV SIMULATION RESULTS

When an array of 4 antennas is used with as separation of $\lambda/2$ (λ is wavelength), there is a maximum of 3 nulls that can eliminate the interferer λ is determined for 2.4 GHz band. The true array output $y(t)$ is converging to the desired signal $d(t)$. The resulting antenna array gain pattern as shown below.

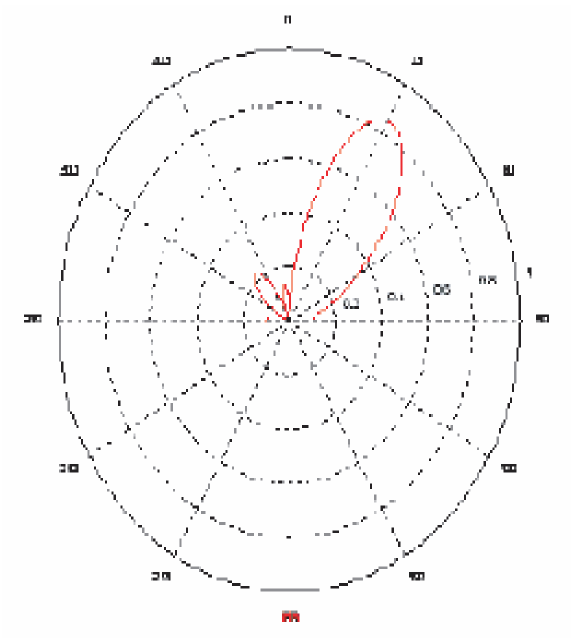

Fig. 4. Gain calculated using MATLAB.

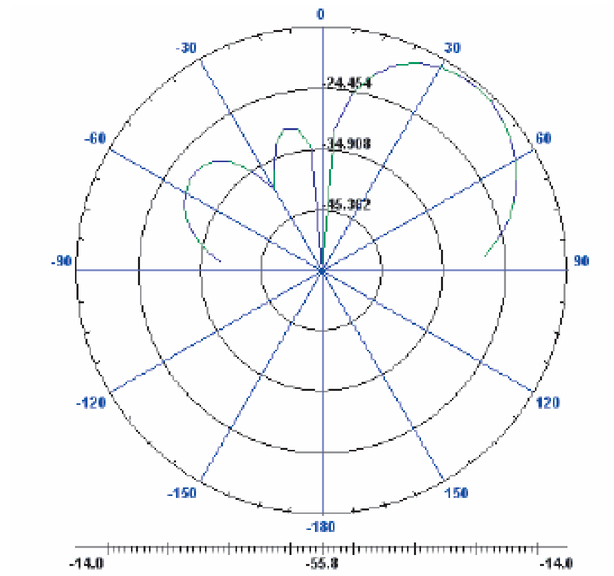

Fig. 5. Reconfigurable antenna gain pattern for 2.4 GHz

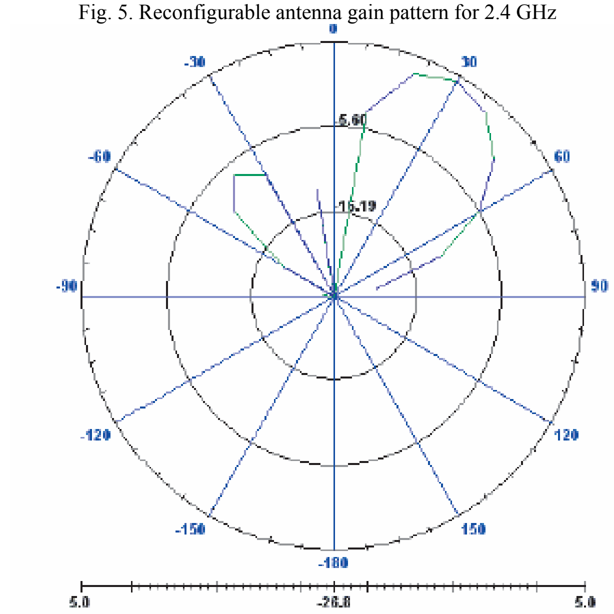

Fig. 6. Reconfigurable antenna gain pattern for 3.5GHz

V CONCLUSION

A novel microstrip antenna capable of changing frequency operation using RF MEMS switches is being investigated in this paper. Also this work demonstrates that these antennas are feasible for integration on smart antenna systems. And also comparison of two algorithm is also investigated.

Development of optimum signal processing algorithms and antenna designs will be studied to improve the reconfigurability and adaptivity performance of these systems.

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