Optimization of Microstrip Patch Antenna by Using Taylor and Chebyshev Series

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Abstract:With the advancement in wireless communications, there is a demand to implement antennas that are "smart" to tune their operating characteristics (frequency, polarization, radiation pattern) according to the ever changing communication requirements. Moreover Modern wireless communication system also requires low profile, light weight, high gain, ease of installation, high efficiency, simple in structure to assure reliability and mobility characteristics. Microstrip antennas satisfy such requirements. The goal of this paper is to decrease the size of the antenna and at the same time to improve the radiation performance of the patch antenna in terms of directivity, maximum radiation, return loss and efficiency. Evolutionary computation techniques like the Taylor Method and Chebyshev Method are efficient in designing new kinds of antennas with challenging designs. This technique can be utilized to optimize the shape of an antenna to achieve maximum possible frequency reconfigurability for obtaining a wideband performance.

Keywords: Reconfigurable Antenna, Microstrip Patch Antenna, Return loss, Chebyshev method, Taylor method.

I. INTRODUCTION

Antennas are our electronic eyes and ears of the world. They are our links with space. They are an essential and integral part of our civilization. With the rapid growth of the wireless communication system, the future technologies need a very small and multiband antenna. Nowadays, people demand multiband wireless phone supporting more than one network, having different frequencies and simultaneous transmission of audio, video, and data.[1] Also antennas are integrated with other parts of circuit. So there is highly requirement of compact size antenna. Also now-a-days mobile antenna perform only one wireless application so, many antennas are required to achieve different wireless application. Hence it is need to design only single antenna which can perform all the wireless application. In this way, reconfiguration comes into picture.[2]

Reconfigurable antennas are those antennas that are able to vary its frequency and radiation pattern in a controlled and adjustable way. Reconfigurable antennas differ from smart antennas as a result of the reconfiguration mechanism lies within the antenna instead of in an external beam forming arrangement. The reconfiguration capability of reconfigurable antennas are used to maximize the antenna performance in a very varied state of affairs or to satisfy dynamical and effective necessities. Reconfigurable antennas are more beneficial as compared to the conventional antennas where by using a single antenna allow supporting multiple operating frequencies, radiation patterns and polarization. The basic working principle of these reconfigurable antennas is achieved by switching the status of an RF switch and thus affects the current distribution of the antenna. It can be realized through the change of the antenna structure without changing the whole dimensions of the antenna by using RF switches such as MEMs switches, varactor diodes, PIN diodes. However, PIN diode switches are the optimum choices because it has low insertion loss, fast response, low control voltage and are reliable.[3] And this type of antennas are called Electrically Reconfigurable Antennas. In the second technique optical switches are used to achieve reconfiguration and such antennas are called Optically Reconfigurable Antennas. The third, achieved by means of physical alteration of the antenna radiating parts are called Physical Reconfigurable Antennas. And also the antennas made reconfigurable through changes in the substrate characteristics by using materials such as ferrites, liquid crystals, etc.[4] Parallel to the growing importance of personal wireless communication systems, efforts are on the way in the designing and implementation of plain and simple novel microstrip structures that can be easily integrated with miniaturized electronic circuits.[5]

A microstrip antenna is an antenna that is fabricated using microstriptechniques on a printed circuit board (PCB). They are frequently used at microwave frequencies. A single microstrip antenna comprises of a patch made of metal foil of several shapes (a patch antenna) on the surface of a PCB, with a metal foil ground plane on the other side of the board. The patch conductors which are made of copper or gold can be supposed to be of any shape. However, conventional shapes are usually used to make analysis and performance prediction simpler. The feedlines and the radiating components are photo etched on the dielectric substrate. Most commonly used configuration of radiating patch is rectangular, square, circular, ring, elliptical. Rectangular, Square, and circular shapes are mostly used because of simpler fabrication and analysis.[6]

II. RELATED WORK

A Frequency Reconfigurable Stacked Patch Microstrip Antenna (FRSPMA) is combined with a radio frequency (RF) switch that comprised of three substrate layers. All layers use RT-Rogers 5880 with a width of h1=0.787 mm. A new coupling method is applied in an aperture coupled technique which is controlled by the switching circuit. In this design, two different shapes of aperture slots (I-shape and H-shape) were etched on the ground plane. The position of each aperture slot is located at the center with reference to the bottom and top patch position. [3]

A wide band rectangular shaped single-patch microstrip patch antenna with circular slot is proposed in[5]. Circular shaped slot over the rectangular patch is combined together to expand the bandwidth of the antenna. A compact size of 19 mm by 23 mm with duroid material is chosen for design. Optimization using HFSS simulation software is applied to optimize the structure of the antenna. The effect of circular slot is compared without the slot structure. It is observed that the bandwidth expands up to 0.7 GHz with a uniform radiation pattern.

By reconfiguring and tuning the antenna, the antenna can be used for various combinations of wireless applications. In the work by Yeole [2] a rectangular patch is designed with U-shape slotted antenna using ADS software and pin diodes are used for reconfiguration i.e. to select different frequency band depending upon wireless application. The main advantage of this design is that it is having low profile, light weight, and easy to fabricate.

Joseph Costantine in [7] presents a new methodology for the design of a multi-wideband microstrip-patch antenna. The radiating elements in this antenna comprised of rectangular slots. These slots follow Chebyshev distribution of order 10 around a central rectangular slot, and an additional triangular slot. The antenna was analyzed, simulated, fabricated, and tested. There was good agreement between the computed and test results.

III. PROPOSED METHODOLOGY

The proposed antenna is a compact reconfigurable microstrip patch antenna.Evolutionary computation techniques like the Taylor Method and Chebyshev Method are efficient in designing new kinds of antennas. The shape of the antenna is optimized to achieve maximum possible frequency reconfigurability. After optimizing the slot length amplitude error is calculated for each slot length. The slot lengths that achieve maximum gain are selected. Hence performance characteristics are improved with the decrease in the size of the antenna

Radiation pattern reconfigurability is obtained by spherical distribution of the radiation pattern. The antenna is designed so that it is able to reconfigure its radiation pattern during operation such that in the absence of interferences, it maintains its broad pattern and when the interfering signals arrive at the antenna, it must be capable of narrowing its pattern to these unwanted signals as much as possible.

IV. PERFORMANCE EVALUATION

In this section, we present the result of experimental simulation to evaluate our proposed approach. We compare our results by applying both taylor and chebyshev series. Simulation result shows enhanced performance and hence increase the efficiency of antenna.

A. Simulation Environment: The simulation was done by using MATLAB tool. The simulation environment is shown in table below.

Table I: Simulation Environment

Type of Series	Coefficient of Slot length	Dielectric Losses	Efficiency (%)	Amp Error
Taylor	0.05013,0.07922, 0.1266, 0.1779, 0.2164, 0.2251, 0.1973, 0.1638	0.673 dB	76.06	-
Optimize Taylor	0.5, 0.5026, 0.5105, 0.5162, 0.5203, 0.5223, 0.5235, 0.5235	0.5928dB	82.66	0 .1314
Chebysh ev	0.03762,0.0773, 0.131, 0.186, 0.2285, 0.2404, 0.2022, 0.1282	0.6483dB	76.78	-
Optimize Chebysh ev	0.5, 0.5021, 0.5109, 0.5172, 0.5208, 0.5335, 0.5235, 0.5211	0.5649dB	82.88	0.3335

B Simulation Results:

Figure 1 and 2 represents the GUI of antenna design that shows the estimation of radiation pattern with optimized taylor and chebyshev series respectively when input of 10GHz is applied.

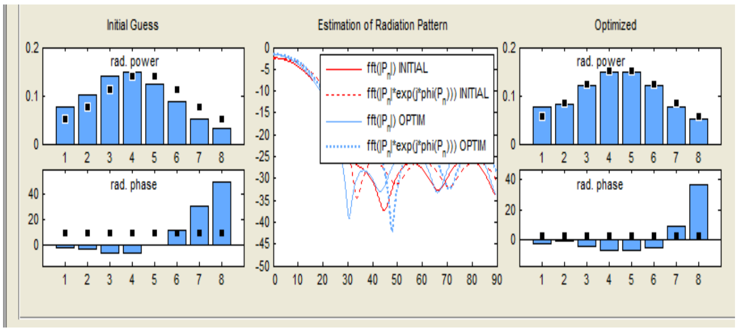

Figure 1 Radiation Pattern of antenna with optimize taylor series

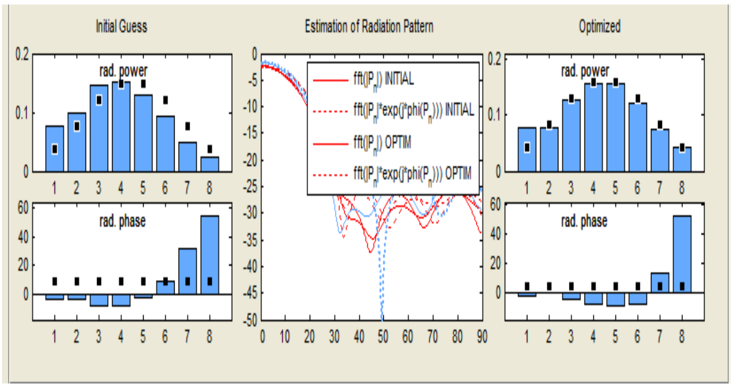

Figure2 Radiation Pattern of antenna with optimize chebyshev series

Figure 3 shows graphical representation of antenna efficiency. It is clear from given figure that efficiency of antenna increases when we optimize the slot length of antenna by using Taylor and Chebyshev series. The radiation efficiency is greater in case of optimized chebyshef series ie 82.88%.

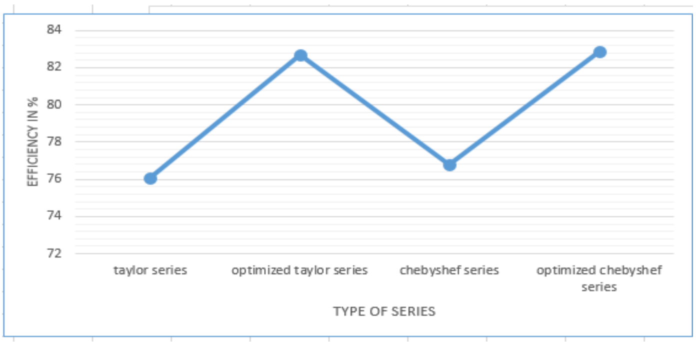

Figure 3 Efficiency of Antenna

Figure 4 shows that at 5.7GHz the gain is maximum i.e. 29dB. Hence antenna work efficiently at 5.7 GHz.

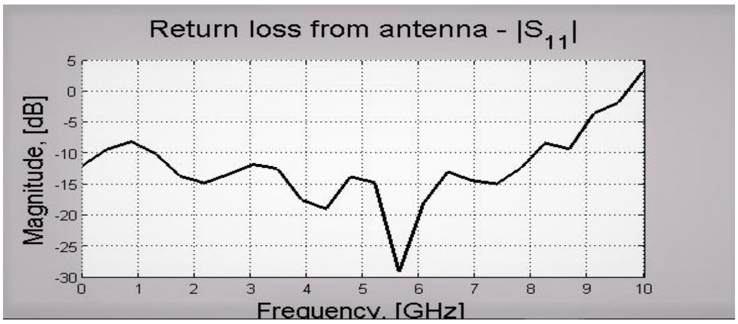

Figure 4 Simulated Return loss from antenna

V. CONCLUSION

A compact reconfigurable microstrip patch antenna is presented. The reconfigurability is achieved with the help of two pin diodes. By applying the taylor and chebyshev series dimensions of the antenna are optimized with the increase in the performance characteristics of antenna in terms of gain, efficiency, return loss etc. MATLAB software is used to simulate and obtain the desired result. Simulated results are compared for both the types of series. Result shows that efficiency of antenna increases when we optimize the slot length of antenna by using Taylor and Chebyshev series. The radiation efficiency is greater in case of optimized chebyshev series ie 82.88%. Also return loss of antenna is calculated and maximum gain of 29 dB is obtained 5.7 GHz which shows that antenna work efficiently at this frequency. The proposed antenna can be used for wireless communication

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