A Review on Various Techniques of Microstrip Patch Antenna Design for Wireless Application

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ABSTRACT

The rapid development of electronics and wireless communications led to great demand for wireless devices that can operate at different standards. In modern communication devices over conventional antenna, microstrip patch antenna is commonly used due to their low profile and low volume. In this speedy dynamical world in wireless communication high gain, large bandwidth, multiband and high efficiency are playing a key role for wireless applications. This paper presents a review upon the most recent research efforts associated with those techniques to design microstrip patch antenna and enhance the overall performance.

Keywords

Microstrip patch antenna (MPA), stacked patch, metamaterial, Split Ring Resonator (SRR)

1. INTRODUCTION

Wireless communication, as a platform for 3C technology (computer technology, communications technology and control technology), is increasingly being introduced in all dimensions and areas of everyday life, providing intelligent and omnipresent solutions. The demand of wireless systems is due to their capabilities such as light weight, low profile, low cost, easily combined with design and technology, low power capability, compactness and relatively simple fabrication makes highly desirable and extremely important for modern communication system [1-3].

An antenna is the basic component of a wireless system which acts as the input and output interface for wireless equipments. An inexpensive, easy to fabricate, efficient and electrically small antenna system is the ideal choice for many new generation slim communication gadgets [2-5]. Microstrip antenna is a good candidate which fulfills all requirements of wireless devices with several features like light weight, low fabrication cost, capable of dual and triple band operations, low scattering cross section etc. The basic form of microstrip patch antenna is a metallic patch printed in a thin grounded dielectric substrate and has been used for long since it is started [6-8]. The major drawback of microstrip patch antennas is to achieve the performance indices such as high gain, large bandwidth and better efficiency in a compact size. The demand of high data rate and channel bandwidth is always a primary area of concern in modern wireless communication systems.

In recent years various techniques has been introduced for this purpose [9-13]. Antennas that are electrically small, efficient and have significant bandwidth would fulfill many of today's emerging wireless technology requirements, especially in the areas of communications and sensor networks**.** Multiband antennas with frequency notched function are useful for wireless communications because a single antenna can cover several different frequency bands while decreasing noise interference at frequencies outside of the selected band. The increased use of wireless technologies for improve performance characteristics of several radiating and scattering systems there are various approaches in this research field. This article is a review of various techniques attempted for increasing the overall performance like gain, bandwidth, directivity etc. of MPA. This includes slotting technique, stack patches, defected ground plane and metamaterial loading etc. [9-16].

2. ANTENNA DESIGN PARAMETERS

A rectangular microstrip patch antenna is designed using three essential parameters, the resonant frequency (f_o), the thickness dielectric substrate (h) and the dielectric constant (ε_r). A thick substrate having low dielectric constant provides large bandwidth, better efficiency with reasonable gain and good radiation.

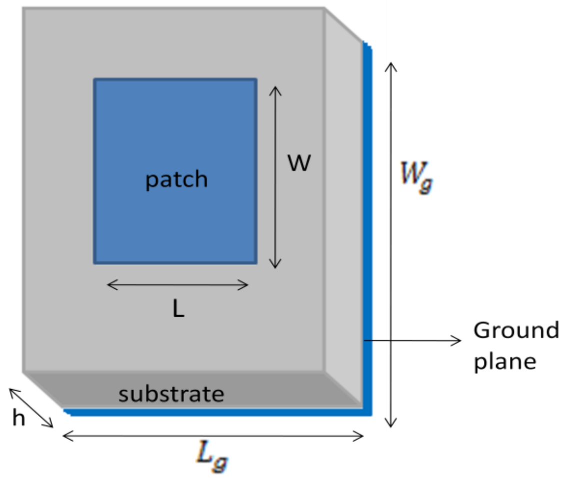

Fig 1: The structure of a microstrip patch antenna

To calculate the dimensions of the antenna using the transmission line method are given as follows.

Calculation of the width,

$$W = \frac{1}{2f_r\sqrt{\mu_o \varepsilon_o}}\sqrt{\frac{2}{\varepsilon_r + 1}} = \frac{c}{2f_r}\sqrt{\frac{2}{\varepsilon_r + 1}}$$

Where C=Free space velocity of light.

ε_r= Dielectric constant of the substrate.

The effective dielectric constant of the rectangular microstrip patch antenna,

$$\varepsilon_{eff} = \frac{\varepsilon_r + 1}{2} + \frac{\varepsilon_r - 1}{2}(1 + \frac{12h}{w})^{-1/2}$$

The actual length of the patch,

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

Where,

$$L_{eff} = \frac{c}{2f_r\sqrt{\varepsilon_{eff}}}$$

For calculation of length extension,

$$\frac{\Delta L}{h} = 0.412\ \frac{\left(\varepsilon_{eff} + 0.3\right)\left(\frac{W}{h} + 0.264\right)}{\left(\varepsilon_{eff} - 0.258\right)\left(\frac{W}{h} + 0.8\right)}$$

And calculation of dimension of the Ground,

$$L_g = 6h + L$$

$$W_g = 6h + W$$

For designing and simulation the rectangular microstrip patch antenna (MPA), there are various designing software's are available. Some of them are Zeland IE3D, Ansoft HFSS (High Frequency System Simulator), CST (Computer Simulation Technology) etc.

3. LITERATURE SURVEY

This section reviews and discusses some techniques to design an MPA for better performance offered by various researchers. A simple technique used by researchers is etching slots or cuts on the patch or on ground. A number of antennas have been achieved by using this technique because the slots of different shapes influence the current paths on the patch and results various modes at the resonant frequencies [17-18].

A triband bowtie antenna is proposed using this simple technique [19]. This antenna was obtained by inserting two pairs of slot with different length of isosceles triangle without increasing area of triangle. This antenna is designed to operate for three different bands in wireless applications. Antenna was resonated at three different bands but its dimensions were made for middle frequency band. This antenna was resonated for 3.5 GHz, 4.5 GHz and 5.8 GHz.

A very wide impedance bandwidth of 162% is reported in [20] and it is achieved by circle like slot with printing C-shaped stubs on the bottom of the substrate. This antenna covers the range of frequencies between 2.5 and 25 GHz with dual band-notched characteristics of frequencies 5.1-6.2 GHz and 3-3.8 GHz for WLAN and WiMAX application.

An Ultra Wide Band (UWB) monopole antenna with dual band notch characteristics is reported in [21]. Modified crown-square shaped fractal slots in the ground-plane are implemented to enhance the impedance bandwidth to around 58%. In addition to this, two omega-shaped slots have been incorporated in the radiating patch to render band-notch characteristics centered at 5.5 GHz band assigned to IEEE802.11a and HIPERLAN/2 as well as X-band for satellite communication centered at 7.5 GHz band. Measured antenna gain is stable over the entire UWB region.

Another simple technique is stack patch in which a parasitic patch is stacked above the driven patch. This technique can be used for dual frequency operation and also for broadband because the bandwidth is enhanced due to strong coupling between two resonances of the patches [22-23].

A dual-band characteristic of stacked rectangular microstrip antenna is experimentally reported in [24]. This paper has investigated the effect of introducing dimensions variation of parasitic patches on the performance of an electromagnetically coupled stacked rectangular microstrip antenna. The broad band width is achieved 45% of the rectangular microstrip antenna by stacking the patches. Therefore the proposed antenna can be used for mobile communication.

Another work is [25] reported where the return loss reduction can be achieved using double U– slot stacked patch technique using FR4 epoxy material in microstrip patch antenna which is fed by coaxial probe. The best return loss i.e. RL = -49.16 dB at resonate frequency fr = 3.53dB is achieved by this design technique for S-band application.

Currently, investigation of metamaterial is one of the most active frontiers in Engineering and Physics to achieved remarkable gain, bandwidth and directivity. There are numerous papers with metamaterial loading are reported for overall good performance of the antenna [14-15, 26]. MTM structures are artificial, they are not found in nature and they exhibit negative permittivity and permeability and some structures are split ring resonator (SRR), circular split ring resonator (CSRR), spiral and labyrinth etc.

D. N. Patel et. al. [27] has proposed a high gain antenna based on zero index metamaterial structure for WLAN applications. The gain enhancement is achieved by loading a microstrip antenna operating at 5.28 GHz WLAN band with single layer superstrate metamaterial structure. Compared to existing designs, the proposed antenna configuration provides reasonably good gain enhancement of 8.1 dBi.

A microstrip patch antenna array loaded with Metamaterial SRR is reported in [28]. The proposed antenna array can be used for IEEE 802.16a 5.8GHz Wi-MAX applications. When the conventional microstrip patch antenna array is loaded with a pair of SRRs, gain improves by 1.4 dBi, and bandwidth enhances by 3%. Loading of SRR reduces the surface waves and mutual coupling between the elements of array.

From all of the above reviews it is concluded that slot antennas are used typically at frequencies between 300MHz and 24GHz and are popular because they can be cut out of whatever surface they are to be mounted on, and have radiation patterns that are roughly omnidirectional. The polarization of the slot antenna is linear. The slot size, shape and the cavity offer design variables that can be used to tune performance. The stack patch technique is useful for dual frequency operation and also for broadband because the bandwidth is enhanced due to strong coupling between two resonances of the patches. Metamaterial loading is an ideal approach in which the metamaterial unit cell is closely placed near the patch and due to magnetic coupling effect; electric field is induced in the unit cell. After loading the patch with the metamaterial unit cell, the resonant frequency of the patch antenna is reduced making the antenna as Electrically Small Antenna (ESA).

4. CONCLUDING REMARKS

This review has only briefly touched upon some selective research efforts associated with some significant techniques and their antenna applications. Designing an antenna and its applications is a very fertile research area and this article reviews on latest trends and advances of the last few years' development in this area. It is reviewed that in MPA design it is very hard to achieve wide impedance bandwidth as well as high gain. In multiband operation the devices operate on different frequencies and to make antenna resonates on this multiple frequencies is very difficult.

By using one of any above mentioned technique some of the limitations of conventional microstrip characteristics are improved. Most of the methods developed in designing the antenna for wireless applications resulted in significant degradation in antenna gain. There are ample opportunities for the use of metamaterials as a promising approach to enhance the gain, efficiency, bandwidth, and directivity of several basic radiating and scattering systems.

Nevertheless, useful solution are still less and suffer from different problems like complexity of structure, reduced bandwidth, reduction of gain etc. There remain many challenging and potentially rewarding problems left to solve; we all look forward to sharing these solutions in the near future. The initial seed physics efforts are only now beginning to bear some engineering applications fruit.

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