MULTIPLET SLOT MICROSTRIP PATCH ANTENNA WITH SHORTING PIN CONFIGURATION FOR WIMAX APPLICATIONS

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ABSTRACT

In this paper, a low profile, less weight and low cost microstrip patch antenna with frequency agility is used to achieve broad bandwidth with high radiation efficiency which is the basic requirement of today’s wireless application. This is achieved by cutting six symmetrical slots of unequal sizes in the rectangular patch to increase the current intensity which in turn increases the bandwidth and efficiency. The trade off between antenna size and bandwidth is compensated by introducing a shorting pin at the center line of the patch. The result is simulated using HFSS software in the middle band of WiMAX and the antenna is found to be resonating at 3.7GHz. The observed bandwidth is 51.98 percent with a return loss of -16.94dB.

Keywords: crostrip; slot antenna; bandwidth; WiMAX; efficiency

1. INTRODUCTION

Wireless communication is the fastest growing segment of the communication industry. As such, it has captured the attention of the media and the imagination of the public. Wireless local area networks currently supplement or replace the wired networks in many homes and businesses. The current generations of wireless LANs, based on the family of IEEE 802.11 standards, have better performance, although the data rates are still relatively low and the coverage area is still small-around 150m. Wired Ethernet today offer data rates of 100 Mbps, and the performance gap between wired and wireless LANs is likely to increase over time without additional spectrum allocation. Each wireless technology is designed to serve a specific usage segment. The requirements for each usage segment are based on a variety of variables, including Bandwidth needs, Distance needs and Power.

WiMAX is one of the hottest broadband wireless technologies around today. It is based on IEEE 802.16 specification and it is expected to deliver high quality broadband services. WiMAX is the acronym for Worldwide Interoperability for Microwave Access. WiMAX would operate similar to Wi-Fi, but at higher speeds over greater distances and for a greater number of users. WiMAX has the ability to provide service even in areas that are difficult for wired infrastructure to reach and the ability to overcome the physical limitations of traditional wired infrastructure. WiMAX can support very high bandwidth solutions where large spectrum deployments (i.e. >10 MHz) are desired using existing infrastructure keeping costs down while delivering the bandwidth needed to support a full range of high-value multimedia services. Communication antennas are all around us and a major part of the way we live our lives. Antennas transform wire propagated waves into space propagated waves. Antennas create a series of oscillation waves with specified frequencies and wavelengths. The electromagnetic wave travels away from the antenna up to a distance where the energy is completely damped by the environment. The requirements on the antennas needed for the ever expanding networks are becoming continually higher.

1. Strictly defined radiation patterns for a most accurate network planning. 2. Growing concern for the level of inter modulation due to the radiation of many HF-carriers via one antenna. 3. Dual polarization. 4. Electrical down tilting of the vertical diagram. 5. Unobtrusive design.

A patch antenna (also known as a rectangular microstrip antenna) is a type of radio antenna with a low profile, which can be mounted on a flat surface. It consists of a flat rectangular sheet or “patch” of metal, mounted over a larger sheet of metal called a ground plane. They are the original type of microstrip antenna described by Howell in 1972. The two metal sheets together form a resonant piece of microstrip transmission line with a length of approximately one-half wavelength of the radio waves. Slot antennas are used typically at frequencies between 300 MHz and 24 GHz.

The slot antenna is popular because they can be cut out of whatever surface they are to be mounted on, and have radiation patterns that are roughly omni directional similar to a linear wire antenna. The polarization of the slot antenna is linear. The slot size, shape and what is behind it i.e. the cavity offer design variables that can be used to tune performance. Due to its planar configuration and ease of integration with microstrip technology, the micro strip patch antenna has been heavily studied and is often used as elements for an array.

The rectangular and circular patches are the basic and most commonly used microstrip antennas. These patches are used for the simplest and the most demanding applications. Rectangular geometries are separable in nature and their analysis is also simple. The circular patch antenna has the advantage of their radiation pattern being symmetric. The gap between the current and emerging systems and the vision for future wireless applications indicates that much work remains to be done to make this vision a reality.

Various methods have been employed for the bandwidth enhancement of Microstrip patch antenna.
In [1], a compact reconfigurable antenna is designed using the concept of T-slot in the radiating patch, which separates antenna into three parts and an E-slot in the ground plane. The radiating patch is connected by two PIN diodes for the reconfigurable operation. Here, the microstrip feed line is used to feed the antenna. In [2], direct probe feed technique with integrated multiple shaped patch which offers low profile, wide bandwidth and high gain was designed. In [3], the impedance was matched by an open-circuit tuning stub connected in shunt with the feed line to enhance the narrow bandwidth of the basic element. In [4], a new waveguide shunt-slot feed for a microstrip patch antenna is analyzed using a formulation based on the method-of-moments.

In [5], pattern reconfigurable microstrip patch antenna using electrical reconfiguration method is used. Here, a design of a compact microstrip patch antenna with the ability of controlling the number of bands and the operating frequencies independently is presented. In [6], microstrip patch antenna with U slot is designed to resonate at 1.8 GHz. In [7], U-slotted patch antennas are designed for wireless communication with non inverted patch substrate and gain achieved is 6.5dBi.

In [8], a rectangular patch antenna with T-shaped slot is designed and the directivity of the antenna is significantly improved. In [9], stacked square patch antenna with tuning stubs is designed on glass epoxy FR-4 substrate. The overall thickness of the structure is 9.18mm and circular polarization is achieved with reduced directivity. In [10], the microstrip patch antenna array is designed for WLAN applications, at an operating frequency of 2.4 GHz with microstrip line feed and power dividers.

II. DESIGN FORMULAS

All of the parameters in a rectangular patch antenna design (L, W, h, permittivity) control the properties of the antenna. The length of the patch L controls the resonant frequency. There exists a tradeoff between size of an antenna and its bandwidth. The relationship between the resonant frequency and the patch length is given by

\[ f_r \approx \frac{c}{2L\sqrt{\varepsilon_r}} = \frac{1}{2L\sqrt{\varepsilon_r \varepsilon_0 \mu_0}} \]

The width W of the substrate, controls the input impedance and the radiation pattern is calculated as follows.

\[ W = \frac{1}{2f_r \sqrt{\varepsilon_r \varepsilon_0 \mu_0}} \sqrt{2} = \frac{c}{2f_r \varepsilon_r + 1} \]

Where, \( c \) = free space velocity of light.
\( \varepsilon_r \) = dielectric constant of substrate.

The permittivity \( \varepsilon_r \) of the substrate controls the fringing fields - lower permittivity have wider fringes and therefore better radiation. Decreasing the permittivity also increases the antenna’s bandwidth. The efficiency is also increased with a lower value for the permittivity. The impedance of the antenna increases with higher permittivity. Higher values of permittivity allow a "shrinking" of the patch antenna. Particularly in cell phones, the designers are given very little space and want the antenna to be a half-wavelength long. One technique is to use a substrate with a very high permittivity. The height of the substrate h also controls the bandwidth - increasing the height increases the bandwidth.

The effective dielectric constant of the rectangular microstrip patch antenna is

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

The actual length of the patch (L) is

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

Where \( L_{eff} = \frac{C}{2f_r \sqrt{\varepsilon_{eff}}} \)

The extension length is calculated as

\[ L = \frac{0.412}{\varepsilon_{eff} + 0.3} \left( \frac{W}{h} + 0.264 \right) \]

\[ L = \frac{0.412}{\varepsilon_{eff} - 0.258} \left( \frac{W}{h} + 0.8 \right) \]

The following equation describes how the bandwidth scales with these parameters:

\[ \frac{\varepsilon_r - 1}{W} \cdot \frac{\varepsilon_r^2}{L} \]

III. ANTENNA DESIGN

In this design, a pair of symmetrical T crossed slots is etched out from the two halves of the surface. The proposed antenna is designed by cutting six unequal sized symmetrical slots in rectangular patch forming a multiple T shaped antenna. Cutting of these slots in antenna increases the current path which increases current intensity as a result bandwidth and efficiency is increased. The substrate dielectric material is Glass Epoxy PCB with dielectric constant 4.2. The bandwidth of the microstrip antenna can be increased using various techniques such as by loading a patch, by using a thicker substrate, by reducing the dielectric constant, by using gap-coupled multi-resonator etc.

However, using a thicker substrate causes generation of spurious radiation and there are some prac-
tical problems in decreasing the dielectric constant. The spurious radiation degrades the antenna parameters. Among various antenna bandwidth enhancement configurations, the two gap-coupled circular microstrip patch antenna is most elegant one. So, gap coupling is the suitable method for enhancing the impedance bandwidth of the antennas. In the configuration of gap-coupled microstrip antennas method, two patches are placed close to each other. The gap-coupled microstrip antennas generate two resonant frequencies and the bandwidth of the microstrip antennas can be increased. The rectangular microstrip antenna is loaded with shorting pin at the center line of the patch. This type of loading produces two lowest resonant frequencies with the same polarization. The size reduction of the antenna at the lowest frequency is roughly 2.6.

The substrate thickness is 1.6mm and loss tangent is 0.019. The dimension of the ground plane is taken as (70mm x 70mm) and the total bandwidth achieved is 51.98% for VSWR< 2.7 and efficiency is nearly 78%.
IV. RESULT AND DISCUSSION

The proposed antenna is simulated using HFSS software which is a high performance full wave electromagnetic (EM) field simulator for arbitrary 3D volumetric passive device modeling that takes advantage of the familiar Microsoft Windows graphical user interface. It integrates simulation, visualization, solid modeling, and automation. Fig 6 shows the return loss and Fig 7 shows the return loss in 3D. Fig 8 shows the VSWR value and Fig 9 shows the radiation pattern in 3D.

V. CONCLUSION

Thus, a microstrip patch antenna with multiple T slot and shorting pin configuration is designed. Antenna dimension shows the compactness of the design with a dielectric constant of 4.3(FR4). The result shows Ultra wide bandwidth at 3.7 GHz (51.98%) with high return loss of -16.94dB. This antenna has a very simple structure printed on a very cheap FR4 substrate for commercial purposes. The efficiency of the Microstrip patch antenna can be enhanced by choosing the substrate thickness as large as possible to maximize bandwidth, but not so large to minimize the risk of surface wave excitation.

References


