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Micro Strip Patch Antenna for UWB Wireless Applications: A Review

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***Abstract:* Microstrip patch antennas have become the favourite of antenna designers because of its versatility and advantages of planar profile, ease of fabrication, compatibility with integrated circuit technology, and conformability with a shaped surface. Microstrip Patch antenna (MPA) is basically a low profile antenna used mostly in all wireless communication devices. In this paper a comparative study of various shapes of patches (E, Hexagonal, Circular, Z, and Sawtooth) with their characteristics & applications is discussed.**

***Keywords:* Microstrip patch antennas, low profile, E, Hexagonal, Circular, Z, Sawtooth patch.**

I. INTRODUCTION

In recent days of fast growing & nanotechnology, the research on low profile antennas for wireless communication devices has increased the interest of researchers & engineers.

Microstrip antenna are used in communication systems owing to their advantages such as low profile, conformability, low manufacturing cost and easy association with other circuit components [1]. Microstrip or patch antennas are becoming increasingly useful because they can be printed directly onto a circuit board.

Microstrip antennas are becoming very widespread within the mobile phone market. Patch antennas are low cost, have a low profile and are easily fabricated.

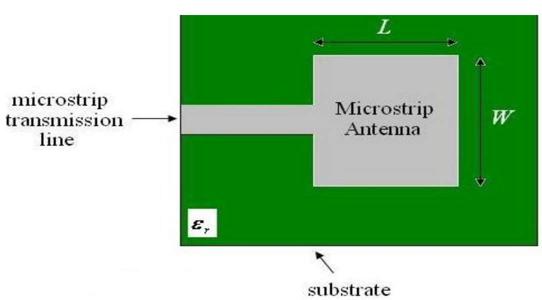

Fig.1 Top View of Rectangular Microstrip Patch Antenna

Simple microstrip antenna is shown in Figure 1, fed by a microstrip transmission line. The patch antenna, microstrip transmission line and ground plane are made of high conductivity metal (typically copper). The patch is of length *L*, width *W*, and sitting on top of a substrate (some dielectric circuit board) of thickness *h* with permittivity Ɛr. The thickness of the ground plane or of the microstrip is not critically important. Typically the height *h* is much smaller than the wavelength of operation, but not much smaller than 0.05 of a wavelength. [2]

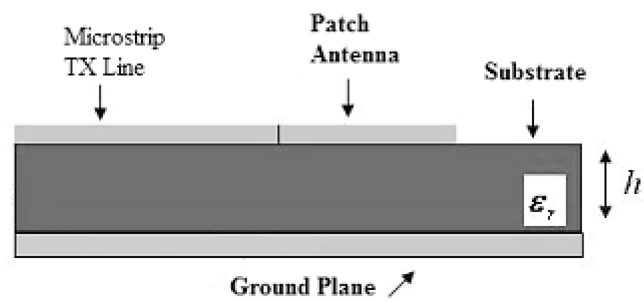

Fig. 2 Side View of Rectangular Microstrip Patch Antenna

The advantages of printed microstrip antenna are light weight and low volume, low profile planar configuration which can be easily made conformal to host surface, low fabrication cost, hence can be manufactured in large quantities, supports both, linear as well as circular polarization. Microstrip antenna can be easily integrated with microwave integrated circuits (MICs), and mechanically robust when mounted on rigid surfaces. [8]

Along with the advantages this type of antenna has certain disadvantages as well such as low bandwidth, lesser gain, low efficiency which influence the capability of this antenna [1]. Various researches are being done by the researchers to overcome these disadvantages by using different patch geometry such as using E shaped patch, U shaped patch ,L shaped patch etc. Other methods to overcome these disadvantages includes use of different dielectric materials ,use of substrate of different thickness, cutting various notches and slots in the patch geometry, antenna array etc. for improving the performance which make this antenna suitable for different applications such as cellular phones, pagers, radar systems, and satellite communications systems. [3]

II. LITERATURE REVIEW

Microstrip antenna was first introduced in the 1950s. However, this concept had to wait for about 20 years to be realized after the development of the printed circuit board (PCB) technology in the 1970s. The rapid development of microstrip antenna technology began in the late 1970s. By the early 1980s basic microstrip antenna elements and arrays were fairly well established in terms of design and modelling, and workers were turning their attentions to improving antenna performance features (e.g., bandwidth), and to the increased application of the technology. [14]

Now a day, size & weight of the wireless communication devices are becoming lighter & lighter. So there is an urgent requirement of smaller size devices for all such applications. The basic idea is to design low profile antenna. The microstrip antennas are very useful for all wireless communication applications.

A microstrip patch antenna (MPA) consists of a conducting patch of any planar or nonplanar geometry on one side of a dielectric substrate with a ground plane on other side. It is a popular printed resonant antenna for narrow-band microwave wireless links that require semi-hemispherical coverage. [13] 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. [13]

"Ramna" has proposed Design of Rectangular Microstrip Patch Antenna Using Particle Swarm Optimization. In this Particle swarm optimization is a popular optimization algorithm used for the design of microstrip patch antenna. He has presented design using soft computing technique, particle swarm optimization (PSO) of probe fed rectangular microstrip patch antenna for WCDMA. For the design of microstrip patch antenna a substrate with dielectric constant of 4.4 and height 1.588 mm has been used. To optimize the parameters like patch length, width and feed position at center frequency of 1.95 GHz using Sonnet13.52,PSO has been used. Microstrip patch antenna resonated at exact 1.95GHz.PSO saves time as compared to the design of patch antenna without optimization algorithm. [4, 6]

Shuo Liu, Wen Wu, has proposed a new design for single-feed dual-layer dual-band patch antenna with linear polarization. The dual-band performance is achieved by E-shaped and U-slot patches. The proposed bands of the antenna are WLAN (2.40 GHz-2.4835 GHz) and WiMax (3.40 GHz-3.61 GHz) bands with impedance bandwidth of 26.9% & 7.1%& peak gains of 7.1 dBi & 7.4 dBi respectively for two different applications. [5]

Tung-Hung Hsieh, Yi-Ming Cheng, and Pi-Wei Chen, has researched that the use of distortion of metallic patch to design Z shape microstrip antenna for dual-band operation. There are two modes of operation with resonant frequencies of the antenna are 2.07 and 3.04 GHz, respectively. Here 10 dB cross-polarization of the lower mode is not reduced perfectly. Perhaps this problem can be solved by the adjustment of structure parameters. [7]

M. A. Sulaiman, M.T.Ali, I. Pasya, N. Ramli, H. Alias, and N. Ya'acob has presented UWB Microstrip Antenna Based On Circular Patch Topology with Stepped Blocks (Wing). This antenna was designed with dielectric substrate, $\varepsilon r = 2.2$. The result obtained was 10 dB return loss, bandwidth from 3.37 GHz to 10.44 GHz based on 50Ω characteristic impedance for the transmission line model . The design geometry of the UWB topology with stepped blocks (Wing).The wing design has larger bandwidth and better maintained return loss. The bandwidth for the wing design gets from 2.85 to 10.82 GHz and its bandwidth about 7.97 GHz (116.63 %) .There is an improvement in bandwidth of about 734MHz as compared with the previous design. [8]

R. Bargavi, K. Sankar and S. Arivumani Samson has presented Compact Triple band H-Shaped Slotted Circular Patch Antenna. The design utilizes the circular patch of radius 20mm and obtains triple band at the frequencies 2.4GHz, 4.5 GHz and 6.5 GHz. The return loss was measured as -25db, -24db, -15db and the gain obtained as 7db, 5db, 4.2db in the respective frequencies. [9]

Shweta Yadav, Mayank Rai, Jimmy Gautam has proposed Design of Dual Band Sawtooth Patch Antenna Using Photonic Band Gap (PBG) Structure for X-band and Ku-band (11.13 GHz to 13.88 GHz).They have shown the bandwidth improvement of 22% with return loss -34db. This patch antenna is very useful for the vehicle antennas and it comes in range of X and Ku band which is used in satellite communication. [10]

Y.S.Santawani, S.R.Suralkar, has proposed hexagonal shaped patch antenna feed by Co-Planar Waveguide (CPW).The antenna is fabricated using a substrate having a dielectric constant of 4.4 (relative permittivity=4.4) and thickness of 1.6mm. The antenna is having a return loss less than -10dB from 2.9GHz to 12GHz which is applicable to (UWB) Application.[11]

III. ANTENNA DESIGNING PARAMETERS

There are three important parameters of the microstrip antenna such as resonant frequency (fc), height of dielectric substrate (h) & relative permittivity of the dielectric substrate ($\mathcal{E}r$). All of the parameters in a rectangular patch antenna design control the properties of the antenna.

First, the length of the patch L controls the resonant frequency. The length of the longest path on the microstrip controls the lowest frequency of operation.

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Second, the width W controls the input impedance and the radiation pattern. The wider the patch becomes the lower the input impedance is.

The permittivity Ɛr of the substrate controls the fringing fields - lower permittivities 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 permitivities.

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. [12]

Equation (1) below gives the relationship between the resonant frequency and the patch length:

$$f_c \approx \frac{c}{2L\sqrt{\varepsilon_r}} = \frac{1}{2L\sqrt{\varepsilon_0 \varepsilon_r \mu_0}} \quad (1)$$

Hence the length of the antenna is given as:

$$L \approx \frac{1}{2f_c\sqrt{\varepsilon_0 \varepsilon_r \mu_0}} \quad (2)$$

The height of the substrate h also controls the bandwidth - increasing the height increases the bandwidth. The following equation roughly describes how the bandwidth scales with these parameters:

$$B \propto \frac{\varepsilon_r - 1}{\varepsilon_r^2}\frac{W}{L}h \quad (3)$$

Length of the Patch-[15]

The effective constant can be obtained by (Pozar et al, 1995):

$$\varepsilon_{reff} = \frac{(\varepsilon_r + 1)}{2} + \frac{(\varepsilon_r - 1)}{2}\left[1 + 12\frac{h}{w}\right]^{\frac{1}{2}} \quad (4)$$

Where

ε_{reff} = Effective dielectric constatn

ε_r = Dielectric constant of substrate

h = height of dielectric substrate

w = Width of the patch

The dimensions of the patch along its length have now been extended on each end by a distance ΔL, which is given empirically by

$$\Delta L = 0.412h\frac{(\varepsilon_{reff} + 0.3)\left(\frac{W}{h} + 0.264\right)}{(\varepsilon_{reff} - 0.258)\left(\frac{W}{h} + 0.8\right)} \quad (5)$$

The actual length L of the patch is given as (Pozar et al, 1995):

$$L = \frac{\lambda_0}{2} - 2\Delta L \quad (6)$$

IV. ADVANTAGES & DISADVANTAGES

Microstrip Patch Antenna has several advantages over conventional microwave antenna but both are working on the same frequency range from 100MHz to 100GHz.[13]

Table I. Advantages & Disadvantages:

Sr. No.	Advantage	Disadvantage
1.	Low weight	Low efficiency
2.	Low profile	Low gain
3.	Thin profile	Large ohmic loss in the feed structure of arrays
4.	Required no cavity backing	Low power handling capacity
5.	Linear and circulation polarization	Excitation of surface waves
6.	Capable of dual and triple frequency operation	Polarization purity is difficult to achieve
7.	Feed lines and matching network can be fabricated simultaneously	Complex feed structures require high performance arrays

V. LITERATURE REVIEW TABLE:

Ref. No.	Type of Patch on Antenna	Bandwidth/ Resonant Frequency	Dielectric substrate with permittivity.	Ret urn loss	Peak Gain	Applications
5	E - Shape	(2.40 GHz-2.4835 GHz) and (3.40 GHz-3.61 GHz)	Air	----	7.1dBi 7.4dBi	WLAN WiMax

7	Z- Shape	2.07 GHz and 3.04GHz	----	----	----	Dual band
8	Circular	3.37 GHz to 10.44 GHz	2.2	10dB	----	UWB
10	Sawtooth	(11.13 GHz to 13.88 GHz).	----	-34dB	----	Vehicle antennas-Satellite communication.
11	Hexagonal	2.9GHz to 12GHz	FR- 4 (4.4)	<-10dB	4.7dBi	UWB

V. CONCLUSION

This review paper shows the effect of various types of patches for Microstrip Patch Antennas on the resonant frequency, bandwidth, return loss & peak gain. These antennas can be used for various Wireless communication applications. Number of parameters such as bandwidth, Return loss, VSWR, Radiation pattern, can be improved by changing the parameters such as operating frequency, type of substrate, substrate dimensions, feeding techniques etc.

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