Review Paper For Analysis of A Compact Wideband Circular Slotted Microstrip Patch Antenna

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Abstract- *In this review paper an antenna is presented for S-band and C-band for wireless network applications. The proposed antenna will designed by using five circular slots using microstrip line feeding technique. In this paper the antenna will be designed using four small circular slots and a big size circular slot that will be cut from patch and analysis will be done by changing positions of four small circular slots. The Paper will give a better understanding of design parameters of an antenna and their effect on return loss, S-Parameters, smith chart, radiation pattern, bandwidth, VSWR and resonant frequency. The software used for simulation is HFSS*

Keywords- Circular slots, C-band, Microstrip patch antenna, S-Parameters, Smith chart, Radiation pattern, Bandwidth, VSWR, HFSS.

I. INTRODUCTION

Micro strip patch antenna consists of a dielectric substrate, with a ground plane on the other side. If the antenna is excited at a resonant frequency, a strong field is set up inside the cavity, and a strong current on the surface of the patch. Advantages such as less weight, low costs and capability to integrate with microwave integrated circuits technology makes the Microstrip as research interest area. The micro strip patch antenna is very well suited for applications such as wireless communications system, cellular phones. Narrow bandwidth available from printed microstrip patches has been recognized as one of the most significant factor limiting the widespread applications of antenna[1]. Through decades of research, it was identified that the performance and operation of a microstrip antenna is driven mainly by the geometry of the printed patch and the material characteristics of the substrate onto which the antenna is printed. Hence, it is realizable that with proper manipulations to the substrate can improve the performance of micro strip antenna. It is well known that the size of the antenna will impact its performance, specifically in terms of bandwidth and gain. In general, antennas can be split into two main types - resonant structures (e.g. microstrip patch antennas, dipoles, loops) and travelling wave structures (e.g. horns, helixes, spirals). Travelling wave antennas range in size from a wavelength up to many 10's of wavelengths in size, and in general have wider bandwidths. This increased bandwidth results from the antennas creating a smooth transition to couple energy from a guided wave to free space radiation as it propagates through the structure. Their larger size also allows for more directive antennas. Conversely, resonant antennas couple energy to free space via a structure proportionate to the operating wavelength, and only efficiently over limited frequency ranges[1,2].

In its most basic form, a microstrip patch antenna consists of a radiating patch on one side of a dielectric substrate, which has a ground plane on the other side as shown in Figure1.1

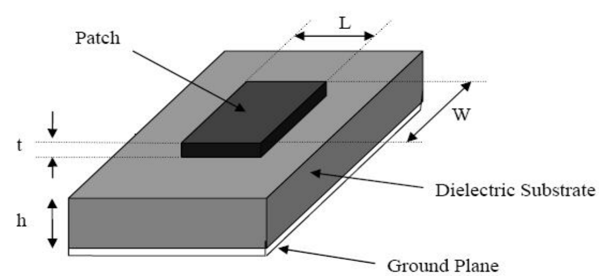

Figure 1. Structure of a microstrip patch antenna[1]

The patch is generally made of conducting material such as copper or gold and can take any possible shape. The radiating patch and the feed lines are usually photo etched on the dielectric substrate.

In order to simplify analysis and performance prediction, the patch is generally square, rectangular, circular, triangular, and elliptical or some other common shapes. Rectangular patches are probably the most utilized patch geometry.

It has the largest impedance bandwidth compared to other types of geometries, and is the main research interest in this project. Circular and elliptical shapes are slightly smaller than of rectangular patches. Thus it will have smaller bandwidth and gain. This circular geometry patches were difficult to analyze due to its inherent geometry.

Triangular patch is even smaller than both rectangular and circular geometries. However, this will produce even lower gain and smaller bandwidth. It will also produce higher cross-polarization due to its unsymmetrical geometry. Dual polarized patch could be generated from these geometries.

Circular ring patches has relatively the smallest conductor size, but at the expense of bandwidth and gain. Furthermore, for this geometry, it will not be easy to excite lower order modes and obtain a good impedance match for resonance. Non-contacting forms of excitation are normally turned to for this shape.

For a rectangular patch, the length L of the patch is 0.3333 λo< L< 0.5λo, where λo<< is the free-space wavelength. The patch is selected to be very thin such that t<<λo (where t is the patch thickness). The height h of the dielectric substrate is 03333.0≤ h ≤ 0.5λo. The dielectric constant of the substrate is typically in the range $2.2< \varepsilon_r <12$

Microstrip patch antennas radiate primarily because of the fringing fields between the patch edge and the ground plane. For good antenna performance, a thick dielectric substrate having a low dielectric constant is desirable since this provides better efficiency, larger bandwidth and better radiation. However, such a configuration leads to a larger antenna size[1,2].

Wireless Communication is the process of transmitting radio waves or micro waves over a distance between the two points without any physical wire attachment. It encompasses various types of devices such as Bluetooth, remote control, Hand-held walkie-talkies, personal digital assistant, wireless computer mice and so on.

Many applications including aviation (aeronautical radio navigation and radio navigation satellite), satellite communication and maritime aviation (space operation, mobile satellite and earth exploration satellite), wireless communication (mobile except aeronautical mobile and broadcasting satellite), private land mobile (space research), fixed microwave devices, ISM equipment, personal land mobile, personal radio and amateur radio utilize the microstrip patch antennas that have a radiating patch mounted on a dielectric layer (substrate) supported by a ground plane. These microstrip patch antennas provide significant performance with an appreciable bandwidth. Several recent microstrip patch antennas have been studied in this literature review. In yet another work, maximum attained gain is 3.4 dBi. Also both of and slotted rectangular patches in offer a peak gain less than the proposed antenna. Even the triangular slot microstrip patch antenna for wireless communication as in offers a much less gain[3].

International Telecommunication Union's (ITU) Radio Regulations(RR),fixed-satellite service (abbreviated as FSS and alternatively termed as fixed-satellite radio communication service) is defined as a radio communication service between earth stations at given positions, when one or more satellites are used. The given position may be a specified fixed point or any fixed point within specified areas; in some cases this service includes satellite-to-satellite links, which may also be operated in the inter-satellite service; the fixed-satellite service may also include feeder links for other space radio communication services. In addition to private land mobile applications including the fixed satellite services and mobile except aeronautical mobile, the microstrip patch antennas also get used for aviation applications including radio location and aeronautical radio navigation. These microstrip patch antennas have caused a tremendous revolution in the field of space technology owing to their promising. The microstrip patch antennas provide for an appreciable quality performance over a wide range of frequencies and require minimum installation setup. The various recent literatures exhibit a much less gain as compared to the proposed prototype.. The novel design is formed by considering a triangular patch and making a rectangular and circular slots in the patch. The designed structure, thus, provides an efficient reflection coefficient, gain and considerable bandwidth[4].

II. LITERATURE SURVEY

Gurpreet Kaur *et al.* [2016] In this paper an rectangular patch with parasitic stub whose edge have been cut , with two slots near the feed line has been proposed. The antenna is designed using HFSS software. The designed antenna shows wideband characteristics having simulated bandwidth of 96 %.The overall dimension of the antenna are 35×35×1.6 mm^3.This antenna obtained maximum gain of 9.55dB having VSWR is less than 2 [5].

R. K.Sharan *et al.* [2016] This paper proposed an edge tapered wideband rectangular patch antenna with one slot at the center and parasitic stubs on two sides of the patch. In this paper partial ground is used. The height of the ground is varied from 8.6mm to 9.2mm and their effect on return loss was measured. Also the effect of varying the length of parasitic stub was measured. Length was varied from 4 to 8 mm. This antenna was designed for wideband applications having bandwidth of 112%. [6].

M. Tarikul Islam *et al.* [2016] In this paper, a new compact spectacles shaped patch UWB antenna using a microstrip fed line is proposed. The new design is consist of a spectacles shaped patch along with tapered slot ground plane. The proposed antenna has a compact electrical dimension of 0.24 λ × 0.21 λ × 0.016 λ and fed with a 50- ohm microstrip transmission line. Computer Simulation Technology (CST) based on finite-difference time-domain method and High Frequency Structural Simulator (HFSS) based on finite element method is implemented in this research. In simulation, a wider frequency bandwidth of 8.5 GHz (3.0 - 11.5 GHz) with excellent impedance matching which covers entire UWB frequency, stable radiation pattern and constant gain is achieved. The proposed antenna is low profile, inexpensive and has excellent characteristics of UWB [7].

G.Sridhar Kumar et. Al [2017], Design of an adapted E-shaped microstrip patch antenna for dual-band operation is presented in this paper. Tuning of the resonant frequencies is achieved by using an adjustable air-gap. The proposed patch consists of Roggers RT/duroid 5880 substrate suspended on air-gap above the ground plane. By varying the height of air-gap, the resonant frequencies of the patch are tuned between 1.99 GHz – 2.634 GHz. Tuning is done for variable heights of air-gap and at different values of thickness of duroid substrate. The patch is excited by a coaxial probe. Good input impedance matching, return loss and a gain of9.86 dB is achieved in the results over the tuned frequencies.[8]

Abhinav Srivastav et. Al [2017], Most of the devices are small in size and require small-size antennas. In this paper, we have investigated a unique design of microstrip antenna with three PLUS-slot of equal area. The geometry is such that three PLUS symbol at an angle of 0º, 45º and 90º. Simulation has been made using HFSS software. Results of proposed antenna proves it to be a good candidate for Bluetooth and WiMAX applications. Good bandwidth, uniform radiation pattern, VSWR value nearly equal to 1 gives excellent impedance matching and better gain of the antenna are achieved.[9]

M.M.Ali et. Al [2017], Compact microstrip-fed slot antenna's one design and analysis is represented in this paper. The proposed antenna has an easy structure containing a rectangular patch with a half circle cut out and a partial ground plane. The general dimension of the antenna is 22 mm × 20 mm × 1.5 mm and fed by 50ohm microstrip transmission line. On low-cost FR-4 substrate with 4.4 of Dielectric constant and 1.5 mm of thickness, proposed antenna is designed. The structures of this antenna were simulated by using the HFSS and CST microwave simulation software. The simulation result shows that the antennas impedance bandwidth reaches about 72.24% (4.25GHz-7.32GHz), where the return loss <10 dB over the preferred frequency range. The antenna was built on a 1.5-mm thick FR4_epoxy substrate with a loss tangent of 0.02 and a permittivity = 4.4. The substrate dimensions are 22 mm × 20 mm. A rectangular patch of dimensions Ws × Ys with a half circle cut out placed middle on the substrate. The patch is fed by 50ohm microstrip line. The proposed antenna gives wider bandwidth along with Omnidirectional radiation pattern.

In this paper, a wideband Rectangular Patch with half circle cut out antenna is designed for wireless communications to meet the 4.25 - 7.32 GHz frequency band. The theoretic simulations are implemented using HFSS and CST software.[10]

Jaiverdhan et. Al [2017], A dual band double slot loaded microstrip antenna with a diagonal coaxial feeding is proposed. Rectangular patch is used as radiator over which two narrow slots are created. These slot and feed position make antenna both frequency and polarization reconfigurable. The bandwidth of this slotted antenna is 550 MHz and 180 MHz at 4.0 and 4.9 GHz respectively. This bandwidth is sufficient for many applications like satellite and radar communication. The antenna is analyzed and simulated using HFSS V.17.0. The 10:1 gain bandwidth of the simulated antenna with respect to center frequency is 12.5% at 4.9 GHz and 4.7% at 4 GHz. The proposed work provides 7.8dBi gain at frequency 4.9 GHz and 7.1dBi at 4 GHz. The proposed antenna provides circular polarization (both LHCP and RHCP). This antenna having an overall dimension of 60 x 60 x 3.8 mm3 and the dimension of slots created over patch is 18 x 1 mm which is very compact compared to the conventional antenna.[11]

Anamika Banwari et. Al. [2017], This paper reported a design of a semicircular slotted microstrip patch antenna which has low loss and high gain, also suitable for ISM band applications. The antenna is fed through the coaxial probe and resonates at ISM band frequency of 2.4 GHz. The dimension of microstrip slotted patch is 8.3×7.1×0.16 cm3. This slotted patch is designed on the Rogers RT/Duroid substrate with relative permittivity of 2.2. The designed antenna is simulated using High-Frequency Structural Simulator software which gives the result with a return loss of – 39.5782 dB, VSWR of 1.0212 at 2.4 GHz and the total gain of 7.67dB. It is very compact and very easy to fabricate. The proposed slotted antenna is highly suitable for wireless communication of various ISM band applications like as W-LAN, WiFi, ZigBee, and Bluetooth etc.[12]

Singh, S. et. al [2018], A microstrip antenna with circular patch and partial ground structure for the X-band applications is presented in this paper. The return loss of -22.32 dB is obtained at 10 GHz frequency with a wide bandwidth of 4.61 GHz ranging from 6.83 GHz to 11.44 GHz. This antenna is made to work at resonance frequency of 10GHz. The radiating circular patch is printed on 1.6mm thick FR4 substrate. Simulation of proposed antenna is done using Ansoft HFSS software. This paper presents a circular patch antenna for X band applications. A wide bandwidth of 4.61 GHz is obtained using partial ground plane along with rectangular slot in the patch. A resonance is generated at the frequency of 10 GHz with return loss of -22.32dB. Maximum Peak gain of 6.5 dB and good radiation efficiency is obtained. Hence, the measured results including reflection coefficient, VSWR, gain and radiation efficiency, implies that the proposed antenna gives good radiation characteristics for X band applications. This antenna can be utilized for various applications like Air traffic control, Satellite communication, and Radar Engineering etc.[13]

Gangwar, S. et. al [2018], Design of a compact microstrip patch antenna with five circular slots for wideband applications is presented in this paper. The proposed antenna is printed on both sides of a single substrate. On one side of square substrate, first a square patch is printed and then five circular slots are etched. On the other side of the substrate, a rectangular microstrip line is printed to feed the antenna. The antenna is simulated using high frequency structure simulation (HFSS) software and the optimal location and dimension of the slots and feed element are obtained. Further, the proposed antenna is fabricated on a glass epoxy FR-4 substrate. The proposed antenna has a wideband from 1.91GHz to 6.19 GHz with four resonant frequencies of 2.05 GHz, 2.86 GHz, 3.49 GHz and 5.11 GHz. The simulated and measured results are compared and these are in good agreement. The antenna can be used for wideband applications in frequency range from 1.91 GHz to 6.19 GHz.[14]

III. METHODOLOGY AND SOFTWARE USED

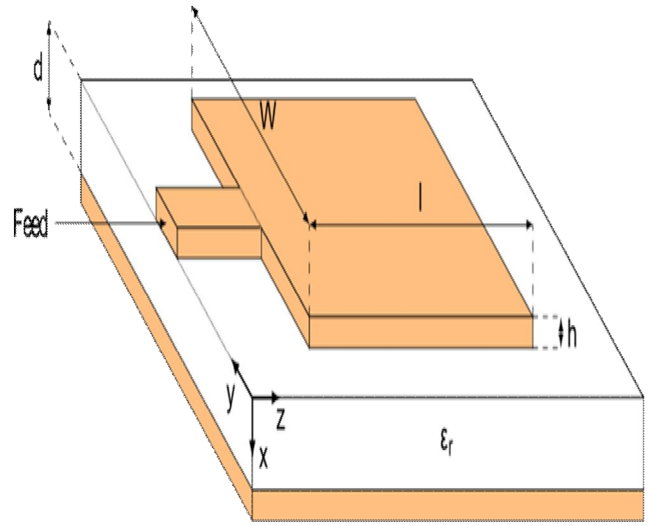

Figure 2 Basic Geometry of Microstrip Patch Antenna[1]

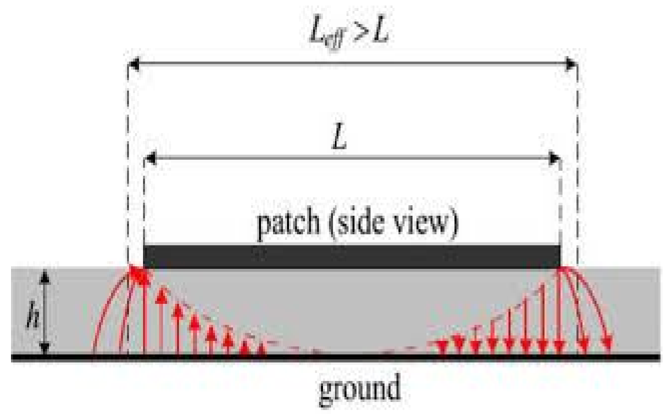

Figure 3. Effect on length due to Fringing[1]

In order to design any microstrip antenna it is necessary to have knowledge of ground and patch dimensions, application for which antenna is designed. There are different applications at different frequency, based on applications, frequency is decided which further decide dimensions. Benefit of carrying out this procedure is that one can first design zero iteration basic antennas for desired applications, then improve its characteristics by use of circular geometry and slot configuration. There are three basic parameters that are decided for designing antennas. Following are steps used in process.

Table 1 Various Frequency Bands of Wireless Communication

Microwave Band	Frequency range	Applications
L Band	1 to 2 GHz	Military telemetry, GPS, Mobile phones (GSM), Amateur radio
S Band	2 to 4 GHz	WLAN, Bluetooth, cellular phones, Wi-Fi
C Band	4 to 8 GHz	Long distance radio telecommunications, Satellite, Microwave relay
X Band	8 to 12 GHz	Radars, space & Broadband communications
Ku-Band	12 to 18 GHz	Satellite communications
K-Band	18 to 26 GHz	Astronomical observations and radars
Ka-Band	26 to 40 GHz	Medical Applications

Step 1: Selection of resonant frequency for desired application (f_r): Different wireless band applications use different frequency of operation. Entire frequency band is divided into different bands. Each band has a frequency range with different application as shown in table 4.1. Hence frequency is decided first.

Step 2: Substrate selection: It is important parameter that decides dimensions of patch. There are two most commonly substrate used which are FR-4 epoxy with dielectric constant of 4.4, loss tangent of 0.02, Rogers RT Duroid 5880 with dielectric constant of 2.2 and loss tangent of 0.0009. It was found that as dielectric constant increases, dimensions of antenna decreases and efficiency and gain also decreases. Hence for selection, these factors are taken into account.

Step 3: Substrate thickness (h): It is find that increase in thickness of substrate causes efficiency and bandwidth to increase but this makes antenna more bulky. In proposed design substrate of thickness 1.6 mm has been used. Comparison is made by changing thickness at different values and characteristics of antenna are compared to obtain best results.

Step 4: Choosing square dimensions: After selecting all three parameters, dimensions can be obtained. It is not necessary that whatever calculations obtained will be used. Optometric analysis has been carried out in order to select that dimensions that give best results.

Step 5: Selection of feed point: There are five different feeding techniques but most commonly used are microstrip and coaxial feeding technique. Advantage of using coaxial feed is that feed point can be adjusted such that impedance matching takes place. And other used feeding techniques are coplanar waveguide, proximity coupled feed and aperture coupled feed. Parametric analysis has been done for feed point selection.

Step 6: Calculation of ground dimensions: It is essential to have finite ground plane for practical considerations. The size of ground plane is selected to be greater than patch dimensions by approximately six times the substrate thickness all around periphery. The dimensions of ground depend on thickness of substrate and dimensions of patch.

Various formulas for designing a microstrip patch antenna are written below.

Calculation of effective dielectric constant, εreff, which is given by:

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

Calculation of the length extension ΔL, which is given by:

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

For efficient radiation, the width W is

$$W = \frac{\lambda_0}{2\sqrt{(\epsilon_r + 1)/2}}$$

Now to calculate the length of patch becomes:

$$L = \frac{\lambda_0}{2\sqrt{\varepsilon_{reff}}} - 2\Delta L$$

Length and width of the ground is:

$$L_g = 6h + L$$
$$W_g = 6h + W$$

IV. CONCLUSION

A single wide band Microstrip patch antenna for wireless application of S-Band will be designed and simulated using HFSS software. A simulation will made in terms of bandwidth, return loss, VSWR and patch size and smith chart. So, we can see that the feeding technique for a microstrip patch antenna can be selected in such a way that it provide maximum bandwidth, minimum losses and it also affects other parameters.

The proposed antenna will be designed by using four small circular slots and one large circular slot that will be cut from patch and using microstrip line feeding technique. We can also conclude that by changing the feed point where matching is perfect, the high return loss can be achieved at the resonant frequency.

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