A Review on Fundamental of Micro strip Patch Antenna

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Abstract— Micro strip antenna technology has been the most rapidly emerging topic in the antenna field in the last fifteen years, receiving the creative courtesies of academic, industrial, and government engineers and researchers throughout the world. Micro strip antennas have quickly evolved from academic novelty to commercial reality, with applications in a wide variety of microwave systems.

Keywords— Micro strip, EBG, UHF, UWB, MoM

I. INTRODUCTION

Micro strip Patch antennas are being studied extensively from past many years because of its low profile structure, light weight and low cost [1]. These are compatible with MMIC designs and are mechanically robust when mounted on rigid surfaces. Using PCB technology here, it is easy to install an antenna with embedded circuit board for any system. Micro strip Patch antennas are well suited in satellite, missile and aircraft application, radars, biomedical applications and reflector feeds [14]. Also compatible for embedded antennas in handheld wireless devices such as cellular phones and pagers etc. Size reduction, bandwidth and gain enhancement are becoming major design challenges for micro strip printed antennas to meet the miniaturization of mobile units. Narrow bandwidth from printed micro strip patches is one of the most significant factors limiting the widespread applications. The conventional micro strip antenna could not fulfil this requirement [16]. The requirement is from 2.4 GHz to 2.5 GHz operating frequency; at least double the bandwidth is required to avoid expensive tuning operation and to cause uncritical manufacturing. Therefore, there is a need to enhance the bandwidth of the micro strip antennas for wideband and multi band applications [5].

A micro strip antenna is one who offers low profile and light weight. It is a wide beam narrowband antenna can be manufactured easily by the printed circuit technology such as a metallic layers in a particular shape is bonded on a dielectric substrate which forms a radiating element and another continuous metallic layer on the other side of substrate as ground plane[4]. Not only the basic shapes any continuous shape can be used as the radiating patch. Instead of using dielectric substrate Some of the micro strip antennas use dielectric spacers which results in wider bandwidth but in the cost of less ruggedness [11]. Micro strip antennas are low profile antenna and mechanical rugged and can be easily mounted on any planar and non-planar surfaces. The size of micro strip antenna is related to the wavelength of operation generally λ/2. The applications of micro strip antennas are above the microwave frequency because below these frequency the use of micro strip antenna doesn’t make a sense because of the size of antenna [35]. At frequencies lower than microwave, micro strip patches don’t make sense because of the sizes required. Now a day’s micro strip antenna is used in commercial sectors due to its inexpensiveness and easy to manufacture benefit by advanced printed circuit technology. Due to the development and ongoing research in the area of micro strip antenna it is expected that in future after some time most of the conventional antenna will be replaced by micro strip antenna [20].

II. MICROSTRIP ANTENNA

In a most basic form a micro strip antenna comprises of two thin metallic layers (t<<λ₀) one as radiating patch and second as ground plane and a dielectric substrate sandwiched between them. The conductor patch is placed on the dielectric substrate and used as radiating element. On the other side of the substrate there is a conductive layer used as ground plane [1]. Copper and gold is used normally as a metallic layer.

Figure 1: Micro strip Patch Antenna
Radiating patch can be of any shape but simple shapes are used to design a patch because patches basic shapes are easy to analysis by the available theoretical models and it is easy to predict the performance. Square, rectangular, dipole, triangular, elliptical, circular are some basic shapes. Circular, rectangular and dipole are the most often used shapes because of easy of analysis and fabrication [2]. A variety of dielectric materials are available for the substrate with dielectric constants $2.2 \leq \varepsilon_r \leq 12$[8]. The height of substrate plays an important role in antenna characteristics generally are in the range $0.003 \lambda_0 \leq h \leq 0.05 \lambda_0$.

Microstrip antenna suffers from very narrow frequency bandwidth. However some application where narrow bandwidth is essential such as government security systems, micro strip antennas are useful. Bandwidth of micro strip antenna is directly proportional to height of substrate. There are two main techniques two improve the bandwidth; one circuit theory and second structural.

III. ADVANTAGES AND DISADVANTAGES

Micro strip antenna is a low profile antenna that has light weight and is very easy to installation due to which it is very popular in handheld wireless devices such as cell phones, pagers and in some high performance communication systems such as in satellite, missile, spacecraft, aircraft etc [34]. Some of the major advantages of micro strip antenna as discussed by [3] and [10] are given below:

- Inexpensive and easy to fabricate.
- Can be planted easily on any surface.
- Can easily get reconfigurable characteristics.
- Can easily design antenna with desired polarization.
- Mechanically robust, Resistant against vibration and shock.
- Suitable to microwave integrated circuits (MICs).
- For high gain and directivity Array of antennas can be easily formed.

Conversely micro strip antennas also have a number of disadvantages and limitations when compared to other antennas. Some of the major disadvantages of micro strip antennas are written below:

- High quality factor.
- Cross polarization.
- Poor polarization efficiency.

- Suffers from spurious feed radiation.
- Narrow impedance bandwidth (5% to 10% without any technique)
- High Dielectric and conductor losses.
- Sensitive to environment conditions like temperature and humidity.
- Suffers from surface wave when high dielectric constant material is used.
- Low gain and power handling capability.

There are various methods to overcome this limitations, bandwidth of micro strip antenna can be increase by using some special methods like defected ground plane strategy, stacked patches, slotted patches, parasitic patch. Gain and the power handling ability of antenna can be improved by making an antenna array. Use of Electromagnetic Band Gap (EBG) structure and met material also results in the improvement of the antenna characteristics [20].

IV. APPLICATIONS

After a number of limitations due to the several advantages micro strip antenna found very useful in different applications. Micro strip antenna widely used in the defence systems like missiles, aircraft, satellites and rockets. Now a day’s micro strip antenna is used in commercial sectors due to its inexpensiveness and easy to manufacture benefit by advanced printed circuit technology. Due to the development and ongoing research in the area of micro strip antenna it is expected that in future after some time most of the conventional antenna will be replaced by micro strip antenna. Some of the major applications of micro strip antennas are:

- Mobile Communication:-
  Antenna used in mobile applications should be light weight, small size. Micro strip antenna possesses this entire requirement. The most of mobile applications are handheld gadgets or pocket size equipment, cellular phones, UHF pagers and the radar applications in vehicles like car, planes, and ships. Various types of designs are made and used for radar applications like marine radar, radar for surveillance and for remote sensing.

- Satellite Communication :-
  In satellite communication antenna should have the circular polarization. One of the major benefit of micro strip antenna is that one can easily design an antenna with require polarization by using dual feed networks and different techniques. Parabolic antennas are used in satellite communication to broadcasting from satellite. A flat micro strip antenna array can be used in the place of parabolic reflector.

- Global Positioning System :-
  Initially the satellite based GPS system are used for only in military purposes but now a day’s GPS found
a large application in everyone’s life and now used commercially. GPS found an essential requirement in vehicles, ships and planes to track the exact location and position. 24 satellites are working in GPS encircling the earth in every 12 hours at altitude 20,200 km. GPS satellite using two frequencies in L-band to transmit the signal which is received by thousands of receivers on earth. The receiver antenna should be circularly polarized. An omnidirectional micro strip antenna has wide beam and low gain can be easily design with dual frequency operation in L-band.

- Direct Broadcast Satellite System:-

In many countries direct broadcasting system is used to provide the television services. A high gain (~33db) antenna should be used at the ground by the user side. A parabolic reflector antennas are generally used are bulky requires space and affected by snow and rain. An array of circularly polarized micro strip antenna can be used for direct broadcasting reception. Which are easy to install, has less affect from snow and rain and cheaper also.

- Antenna for Pedestrian:-

For pedestrian applications antenna should be as small as possible due to space constraints. Low profile, light weight and small structure antennas are generally used in the handheld pocket equipment. Micro strip antenna is the best candidate for that. Various types of techniques can be used to reducing the size of antenna like short circuiting the patch or using the high dielectric constant material. But it has a drawback that smaller antenna leads to poorer efficiency.

- In Radar Applications :-

Radar application such as Man pack radar, Marine radar and Secondary surveillance radar requires antenna with appropriate gain and beam width. An array of micro strip antenna with desired gain and desired beam width can be used. For some application such as sensing the ocean wave speed and direction. Determining the ground soil grades Synthetic Aperture radar method is used. Two arrays of patch antennas separated by a proper distance are used in this system.

- Application in Medical Science:-

In medical science for treating the malignant tumors microwave energy is used to induce hyperthermia. The microwave energy radiator used for this should be adaptable to the surface being treated and should be light weight. Micro strip patch antenna is the only one that can fulfil that requirement. Annular ring and circular disk micro strip antenna are some examples. A half circular flexible patch monopole micro strip applicator used is shown in figure below. Figure shows the geometry of the applicator that how it is conform on the curved surfaces [11].

V. LITERATURE REVIEW

Vikas et. al. (2014) In this paper an Ultra Wideband (UWB) micro strip antenna consisting of a circular monopole patch with stepped feed line, with a 10 dB return loss bandwidth from 3.1 to 10 GHz is proposed. This antenna was designed on FR4 substrate with overall size of 40 x 31.17 x 0.787 mm3 and dielectric substrate with $\varepsilon_r = 2.2$ This antenna operated at UWB frequency and it designed by using CST Software based on the characteristic impedance for the transmission line model. The parameters like substrate dimension, feed size and ground plane which affect the performance of the antenna in terms of its frequency domain and time domain characteristics are investigated.

Mithila R. Ghuge et. al. (2014) In the recent era of wireless communication, Microstrip antenna (MSA) is hot research topic attracting attentions of many researchers. MSA are low profile, lightweight and have a compatibility with integrated circuit technology. The major limitations of MSAs are their narrow impedance, axial ratio (AR), bandwidth, small gain and lower power handling capacity. Here the overview of an air fed high gain patch antenna is presented. Various gain enhancement methods like micro strip antenna array, superstrate structure, change in dielectric material and partial removal of substrate will be studied and the review is presented. Air is used as dielectric medium between feed patch and ground plane.

M. H. Diallo Yaccoub et. al.(2013) The printed antenna is one of the best antenna structures, due to its low cost and compact design. In this paper, we present a new approach to improve the radiation effectiveness and the performance of antennas by miniaturization of the size. Indeed, we have studied the performance of ultra wideband antenna which consists of a ring-shaped patch. This study was made for the whole frequency band of UWB ranging from 2.5GHz to 9.4GHz and the geometry of the antenna and the results were obtained using the simulation software CST Studio microwaves.
W. Mazhar et al. (2013) A novel design of compact micro strip UWB antenna with step impedance micro strip line is proposed. The antenna consists of a rectangular patch with slits on the top face and a partial ground with slots at the rear end. The antenna with dimension of 34mm £ 36mm (L £ W) is fabricated on FR-4 epoxy dielectric with relative permittivity of 4.4. The designed antenna has the capability of operating between 3 GHz to 10.26 GHz with a 7.26 GHz bandwidth (f0-f1). The proposed antenna has Omni-directional radiation pattern on most of the operating band. Radiation pattern is measured in antenna anechoic chamber. Feed line used has characteristic impedance of 50 Ω. The proposed antenna is analyzed in both frequency and time domain to check its appropriateness for UWB applications. SMA female connector is used for feeding. Antenna parameters such as return loss and radiation pattern show reasonable agreement with the simulated results.

Mustafa Abu Nasr et al. (2013) The design and analysis of a new ultra wideband micro strip antenna for optimum performance that satisfied a large bandwidth starting from 3.9GHz to 22.5GHz is introduced. The UWB antenna is capable of operating over an UWB as allocated by the Federal Communications Commission (FCC) with good radiation properties over the entire frequency range. The techniques of enhancing the bandwidth of microstrip UWB antenna were utilized to enhance the performance of the designed antenna. The effect of shifting feed line from the center of patch to the edges was studied in addition to the effect of changing the length of the ground plane. The antenna was designed and simulated using High Frequency Structure Simulator HFSS software packages.

Atser A. Roy et al. (2013) In this work, three different geometry shapes, the U, E and H are developed from a rectangular patch of the width (W) = 32mm and length (L) = 24mm. The proposed antennas are simulated using Sonnet software and the results compared with the conventional rectangular patch antenna. The results obtained clearly show that, bandwidth of conventional rectangular micro strip antenna can be enhanced from 4.81% (100MHz) to 28.71% (610 MHz), 28.89% (630MHz) and 9.13% (110MHz) respectively using U, E and H-patch over the substrate. The E-shaped patch antenna has the highest bandwidth followed by U-shaped patch antenna and H-shaped patch antenna. The substrate material used for the proposed antennas is Alumina 96%, with the dielectric constant of 9.4 and loss tangent of 4.0e-4. The proposed antennas may find applications in Wireless Local Area Network (WLAN).

Rajeshwar Lal Dua et al. (2012) In this paper, a rectangular micro strip patch antenna with DGS has been analyzed and simulated for the wireless applications. The proposed antenna has been simulated at 2.45 GHz frequency. This compact antenna fed by Quarter Transformer feeding. This type of feeding is mostly used for impedance matching purposes. The antenna is simulated by the software HFSS. HFSS, high frequency structure simulator is employed to analyze the proposed antenna and simulated results on return loss, the E and H plane radiation pattern and polar plot gain is presented. The resultant antenna with Defected Ground Structure has improved in parameters performance.

B. Mazumdar et all (2012) A single feed compact square micro strip antenna is proposed in this paper. Two L slits are introduced on the right edge of the patch to study the effect of the slit on radiation behavior with respect to a conventional micro strip patch. An extensive analysis of the return loss, radiation pattern and efficiency of the proposed antenna is shown in this paper. The characteristics of the designed structure are investigated by using MoM based electromagnetic solver, IE3D. The simple configuration, low profile nature, reduced size and quad band characteristics of the proposed antenna makes it suitable to operate in the frequency ranges of 2.165-2.176, 2.673-2.686, 3.208-3.244 and 4.343-4.392 GHz.

Yong Liu et al. (2012) the micro strip antenna has been extensively studied in the past few decades as one of the standard planar antennas, it still has a huge potential for further developments. The paper suggests three areas for further research based on our previous works on micro strip antenna elements and arrays. One is exploring the variety of micro strip antenna topologies to meet the desired requirement such as ultra wide band (UWB), high gain, miniaturization, circular polarization, multi polarized, and so on. Another is to apply micro strip antenna to form composite antenna which is more potent than the individual antenna. The last is growing towards highly integration of antenna/array and feeding network or operating at relatively high frequencies, like sub-millimeter wave or terahertz (THz) wave regime, by using the advanced machining techniques. To support our points of view, some examples of antennas developed in our group are presented and discussed.

Baskaran Kasi et al. (2011) a simple and compact ultra-wideband (UWB) patch antenna with rectangular slot is presented. The fabricated antenna consists of a rectangular patch tapered from a micro strip feeding structure and a truncated ground plane. The proposed antenna is etched onto a FR4 printed
circuit board (PCB) with an overall size of 28 mm × 29 mm × 1.6 mm. Simulated and experimental results are compared and are shown to be in good agreement. Experimental results indicate that the antenna achieved an UWB impedance bandwidth (S11 < −10 dB) ranges from 3.8 to 12 GHz. The small antenna exhibits a good voltage standing wave ratio (VSWR) performance and its E- and H-plane radiation patterns are stable over the UWB frequency range. The simulated result shows that the designed antenna can achieve a gain between 1.5 and 4.5 dBi against frequency. Besides, the group delay is less than 0.4 ns over the operating frequency band. These characteristics make the designed antenna suitable for various UWB applications.

Chia Ping Lee et. al.(2011) An Ultra Wideband (UWB) micro strip diamond slotted patch antenna with enhanced bandwidth is presented in this paper. The proposed antenna is simulated in CST Microwave Studio and fabricated for measurements. Its simulated result displays impedance bandwidth from 3.28 GHz to 19.64 GHz, whereas the measured result displays the frequency region from 2.01 GHz to 18.67 GHz. The antenna complies with the return loss of S11 < −10 dB and Voltage Standing Wave Ratio (VSWR) < 2 throughout the impedance bandwidth. Details of the antenna design and related results such as phase angle, input impedance and radiation patterns are discussed in this paper. This antenna has surpassed the bandwidth of UWB requirement, which is from 3.1 GHz to 10.6 GHz, and exhibits good UWB characteristics.

Peixeiro, C. et. al. (2011) This paper presents an historical perspective of the development of micro strip patch antennas. A survey on micro strip antenna papers is carried out initially to evaluate the evolution of the research activity on the topic along the last 40 years. The early years of the micro strip technology and specifically of micro strip antennas are analyzed in detail. The fast evolution of the research and development activities that happened in the last 30 years is described in the context of the associated technologies and areas of application. Finally, the present situation of the micro strip antenna field and trends of possible future evolution are examined.

VI. CONCLUSION

The antenna designed is compact in size, Size reduction, bandwidth and gain enhancement are becoming major design challenges for micro strip printed antennas to meet the miniaturization of mobile units. Narrow bandwidth from printed micro strip patches is one of the most significant factors limiting the widespread applications. The conventional micro strip antenna could not fulfill this requirement. The requirement is from 2.4 GHz to 2.5 GHz operating frequency; at least double the bandwidth is required to avoid expensive tuning operation and to cause uncrirical manufacturing. Therefore, there is a need to enhance the bandwidth of the micro strip antennas for wideband and multi band applications.

VII. REFERENCES