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Research Paper

Microstrip Patch Antennas - Survey and Performance Analysis

Engineering

KEYWORDS : Aperture feed, proximity feed, cross polarization, coaxial probe, dielectric substrate, Multifunction arrays and adaptive smart skin apertures.

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ABSTRACT

This paper provides an overview of the development of microstrip patch antennas. Primarily various microstrip antennas that have been used in the past years have been evaluated as part of this research. Detailed analysis of the previously available microstrip antennas as well as their technologies involved. Applications of microstrip antennas, their present situation and the future trends of microstrip antennas are examined in this paper.

INTRODUCTION

Microstrip antennas are widely used in wireless communication systems for microwave frequency range because they can be easily fabricated and weighs less [1]. NowadaysSince microstrip patch antennas are commonlyused in wireless devices, it is very important to reduce the antenna size which in turn would minimize the entire size of the communication system.Some of the advantages of microstrip patch antennas include reducedweight, easy fabrication, conformability to mounting hosts and bandwidth enhancement.All these parameters mentioned above play a vital role in designing of microstrip patch antennas. In spite of being advantageous, conventional microstrip patch antenna suffers from very narrow bandwidth, which is typically about 5% bandwidth with respect to the center frequency, low power, excitation of surface waves and relatively high level of cross polarization radiation which limits their applications. Researchers have developed a number of numerical methods to ease the design procedures of microstrip antennas to meet broadband criteria. Microstrip antennas are applicable in GHz-range (f > 0.5 GHz).

Some of the feeding mechanisms include probe feeds, aperture feeds, microstrip line feeds and proximity feeds, each of these feeding technique has certain advantage.

HISTORY OF MICROSTRIP PATCH ANTENNA

Microstrip patch antennas basically originated in 1953, it was proposed by Deschamps that microstrip feed lines can be used to feed an array of printed antenna elements. The printed antenna elements introduced were actually flared palnar horns and not microstrip patches. Later Microstrip patch antenna was first introduced by Munson in a symposium paper during the year 1972,followed by a journal paper in 1974. After Munson, Howell a researcher discussed rectangular patch antennas in his symposium papercrediting Munson's journal paper. Howell also introduced circular patch and circularly polarized patch antenna in a later journal paper[5].

MICROSTRIP ANTENNAS

Basically all microstrip antennas are divided into four basic categories namely

i. Microstrip Patch Antennas
ii. Microstrip Dipoles
iii. Printed Slot Antennas
iv. Microwave Travelling-wave Antennas

A microstrip patch antenna usually consists of a conducting patch as shown in figure 1; this conducting patch can either be planar or non-planar in geometry on one side of the dielectric substrate and a ground plane on other side. These types of microstrip patch antennas are popularly known as'printed resonant antenna'and are used for narrow-band microwave wireless links where semi-hemispherical coverage is required [6]. Large numbers of microstrip patch antennas have been studied till datebecause of their low profile and fabrication ease. As already mentioned in this paper rectangular and circular patches are one of the basic and most commonly used microstrip antennas. Generally, rectangular and circular microstrip patches are used for simplest and most demanding applications [7].

FEEDING MECHANISMS

Most popular feeding techniques are coaxial probe feed, microstrip line feed, aperture coupling and proximity coupling [12].

In Coaxial probe feeding techniques the inner conductor of the coaxial is attached to the radiating patch of the microstrip antenna, while the outer conductor is connected to the ground plane as shown in Figure 2.

Some of the advantages of coaxial feeding technique include easy fabrication, easy matching and minimal spurious radiation. The greatest disadvantageof coaxial feeding technique is narrow bandwidth. When thick substrates are used modelling becomes difficult[4].

Since there is just a conducting strip connecting to the patch in microstrip line feeds they can be easily fabricated. Hence they can be considered as an extension of patch[3]. Microstrip line feeds can be easily modeled and matched. However, disadvantages of this method includeincrease in substrate thickness, increase in surface wave and spurious feed radiation which in turn limits the bandwidth[2].

Aperture coupled feeds consist of two different substrates separated by a ground plane. Bottom of the lower substrate contains microstrip feed line whose energy is coupled with the patch through a slot on the ground plane. This arrangement is shown in Figure 3 and allows independent optimization of the feeding mechanism and the radiating element [11]. The top substrate uses low a dielectric constant material while the bottom substrate uses high dielectric material.

The ground plane placed in the middle isolates the feed and the radiation element which in turn minimizes interference of spurious radiation for pattern formation and polarization. Advantage of aperture coupled feed is that it allows independent optimization of the feed mechanism element.Proximity coupling technique provides the largest bandwidth and has low spurious radiation. Fabrication is difficult when this technique is used [3]. Coupling mechanismsare capacitive in nature. Proximity coupled microstrip patch antenna is shown in Figure 4. Difficulty in fabrication is one of the main disadvantages of proximity coupled feeding technique; this is because both the dielectric layers used needs proper alignment [10].

Antenna models consist of various Microstrip antenna structures;in general there are four main parts in the antenna:

They are:

- Patch

- Dielectric Substrate
- Ground Plane
- Feed Line

METHODS OF ANALYSIS

Some of the most popular analysis models of Microstrip patch antennas are transmission line model, cavity model, and full wave model.Simplest analysis model is the transmission line model, though the physical insight is good it is less accurate. Cavity model is more accurate when compared with transmission line model and it gives good physical insight but it is complex in nature. Full wave models are extremely accurate and versatile [6].

BANDWIDTH ENHANCEMENT TECHNIQUES

In Microstrip patch antennas the pattern bandwidth is usually larger than the impedance bandwidth. There are three existing methods to increasing the bandwidth of microstrip antennas [5]. In the first technique just the thickness of the substrate is increased. Though thicker substrate supports surface waves, it in turn deteriorates the radiation patterns as well as theradiation efficiency which is the major disadvantage when thicker substrates are used. Feeding problems also occur while using thicker substrates [2].

Next technique used to increase the bandwidth is by decreasing the relative permittivity, with an obvious limitation based on size [1]. The third method is done by means of using a wideband matching network. This method is practically not feasible until impedance matching came into account.

APPLICATIONS

Microstrip patch antennas have a wide range of applications in various fields such as medicine, satellites, military systems, aircrafts missiles etc. Nowadays the usage of microstrip antennas are commercialised too due to cost effectiveness of the material used and fabrication [3]. Further advancements in the field of microstrip antennas can also lead to the replacement of conventional antennas with microstrip antennas. Some of the applications of microstrip patch antennas are discussed as below:

MICROSTRIP ANTENNAS IN COMMUNICATION SYSTEMS

Small, low-cost, low profile antennas are the basic requirements for any communication system. In satellite communication systems circularly polarized radiation patterns are required.

GPS

Substrates with high permittivity sintered material are used for global positioning system nowadays [11]. These types of antennas are circularly polarized, very compact but quite expensive. There is also a possibility that millions of GPS receivers will be used in vehicles, aircraft for accurate positioning [8].

RADAR& RECTENNA APPLICATION

Radar basically requires low profile, light weight antennas, which in turn makes microstrip antennas an ideal choice [4][5].

Rectifying antennas are usually termed as Rectenna, this is a special type of antenna whichwill directly convert microwave energy into DC power. A combination of Antenna, pre rectification filter, rectifier, post rectification filter form the rectenna system. The main aim of rectenna is long distance transfer ofDC power through wireless links; which becomes possible only by increasing the electrical size of the antenna [6].

EMERGING TRENDS

Multifunction arrays and adaptive smart skin apertures are advancements of microstrip antennas in the field of defence and communication. Recently, Superconducting microstrip antennas are becoming popular due to high efficiency and low loss. Active microstrip antennas are another emerging area where antenna elements areintegrated with rest of the active electronics in that particular system [8].

CONCLUSION

A theoretical survey and performance analysis of microstrip patch antenna is presented. Microstrip antennas have evolved from simple patch structure to complex multilayer configurations for over two decades. Low profile microstrip antennas met the needs of most communications, electronic warfare (EW) and surveillance applications. In case of radars, with new needs like active phased arrays and wide band transceiver technologies antennas have new challenges to meet with the wideband, small and agile platforms and the microstrip antennas are an optimum choice to meet with these requirements.Some effect of disadvantages can be minimized. Some factors are involved in the selection of feeding technique. Depending on the necessity a specific microstrip patch antenna can be designed.

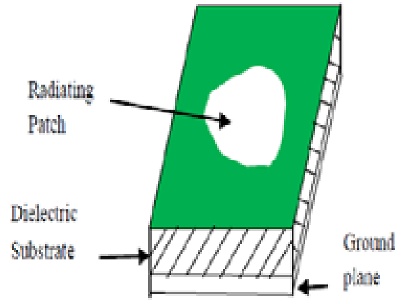

Figure 1: Microstrip Antenna – structure

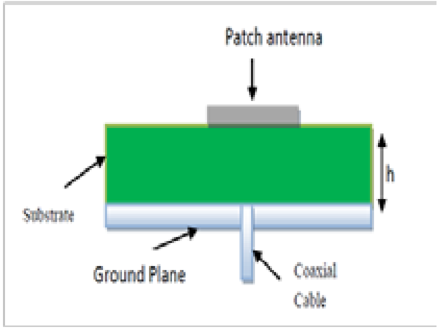

Figure 2: Coaxial probe feed

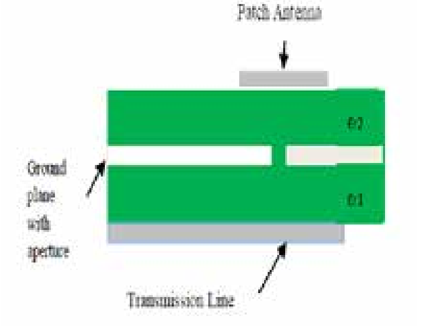

Figure 3: Aperture Coupled Feed

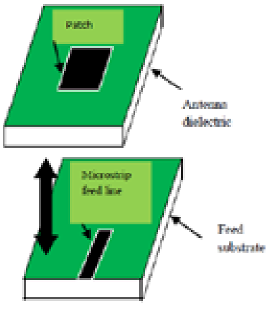

Figure 4: Proximity Coupled Microstrip Patch Antenna

REFERENCE

[1] Douglas, H. W., R. L. Haupt, and P. L. Werner, Fractal antenna engineering: The theory and design of fractal antenna arrays," IEEE Antennas and Propagation Magazine, Vol. 41, No. 5, 37-59, 1999. | [2] Howell, J., "Microstrip antennas," Antennas and Propagation, IEEE Transactionson, vol.23, no.1, pp. 90-93, Jan 1975. | [3] G. A. Deschamps, "Microstrip microwave antennas," presented at the Third | USAF Symp. on Antennas, 1953. | [4] James j., and P.S. Hall (Eds), Handbook of microstrip antenna, Peter Peregrinus, London, UK, 1989. | [5] J. D. Kraus, R. J. Marhefka, "Antenna for all applications" 3rd Ed., McGraw- Hill, 2002. | [6]H. Pues et al., "Broadband Microstrip Resonator Antennas," 1978 IEEE Antennas & Propagation International Symposium Digest, pp. 268 - 271. | [7] H. Pues et al., "Wideband Quasi-log-periodic Microstrip Antenna," IEE Proceedings, Part H, Vol. 128, No. 3, 1981, pp. 159-163. | [8] P.S. Hall, "New Wideband Microstrip Antenna Using Log-periodic Technique," Electronic Letters, Vol. 16, No. 4, 1980, pp. 127-128. | [9] T.H. Büttgenbach et al., "A Broadband Low Noise SIS Receiver for Submillimeter Astronomy," IEEETransactions on Microwave Theory and Techniques, Vol. 36, No. 12, 1988, pp. 1720-1726. | [10] M. Du Plessis and J.H. Cloete, "Tuning Stubs for Microstrip Patch Antennas," 1993 IEEE Antennas &Propagation International Symposium Digest, pp. 964-967. | [11] Kawase, D., Sakakibara, K. ; Seo, K. ; Kikuma, N. ; Hirayama, H., "Design of microstrip antennas fed by four-microstrip-port waveguide transition with slot radiators", Antennas and Propagation (ISAP), 2012 International Symposium on Pp .54 – 57. | [12] Jagdish. M. Rathod, "Comparative Study of Microstrip Patch Antennafor Wireless Communication Application", International Journal of Innovation, Management and Technology, Vol. 1, No. 2, June 2010. |