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A New Survey of Slot-Based Microstrip Patch Antenna

K.Rajender[1], A.Vaani[2], P.Srilatha[3], K.Padma[4]Y.Rajani [5]
[1,2,3,4] Assistant Professor, Department of ECE, Sri Indu Institute of Engineering & Technology, Hyderabad

Abstract: ***Antenna is backbone of communication system with the advent of technology a lot of innovation happens to develop the antenna. Antenna is smart devices which not only transmits and receive but also work as transducers. This paper presents literature review on microstrip patch antenna based on slots and effect of slots on microstrip patch antenna has been discussed. The effect is shown on bandwidth, gain, radiation pattern, return loss, axial ratio and size of an antenna. The slots on the patch or on the ground plane will help to design an antenna with improved bandwidth and efficiency.***

Keywords: Microstrip patch antenna, Radiation pattern, Gain, Bandwidth

1. Introduction

Microstrip slot antenna is simple in structure. It consists of microstrip feed that couples electromagnetic waves through the slot above and slot radiates them. A microstrip fed antenna offers a better isolations between the feed and the material under measurement compared to the microstrip fed microstrip antenna. They are more flexible in integration with other active and passive device in a hybrid MIC and MMIC design. Furthermore they are capable of producing omnidirectional radiation patterns by simply inserting quarter wave thick foam and reflector. We find the great use of slot antennas for fixed stations satellite ground stations and becon with proper mounting a slot antenna can also be used in microwave mobile.

Microstrip antennas are attractive due to their light weight, conformability and low cost. These antennas can be integrated with printed strip-line feed networks and active devices. This is a relatively new area of antenna engineering. The radiation properties of micro strip structures have been known since the mid 1950's. The application of this type of antennas started in early 1970's when conformal antennas were required for missiles. Rectangular and circular micro strip resonant patches have been used extensively in a variety of array configurations. Feed line and matching networks are fabricated along with antenna structure. If the substrate is flexible, conformal antennas are possible. Etching is done with the standard photolithographic processes [1]. The accuracy of etching process also ensures uniformity of different parts over a production run. The main reason for using micro strip patches is the ability to construct array antennas with the feed network and the radiating elements on a single surface. This arrangement means that the antennas are fed by a micro strip connected directly to the patch [2-3]. The advantages of microstrip antennas make them suitable for various applications like, vehicle based satellite link antennas [4], global positioning systems (GPS) [3], radar for missiles and telemetry and mobile handheld radios or communication devices.

With the wide spread proliferation of wireless communication technology in recent years, the demand for compact, low profile and broadband antennas has increased significantly. To meet the requirement, the microstrip patch antenna has been proposed because of its low profile, light weight and low cost [5]. However, conventional microstrip patch antenna suffers from very narrow bandwidth, typically about 5% bandwidth with respect to the center frequency. This poses a design challenge for the microstrip antenna designer to meet the broadband techniques.

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Basically there are four feeding techniques available to us while designing of antenna. These are line feed, probe feed, aperture coupled feed and proximity coupled feed. The feed that is used here is probe feed (or coaxial feed).

2. Related Work

Various papers on design of circular microstrip patch antenna with slots are analysed. Summarized details of the research papers are furnished below including the description of necessary parameters.

A circular microstrip patch antenna having concentric diamond shape slot is analysed. The side lengths and angles of inserted diamond shape slot have been optimized to achieve a single layer multi frequency microstrip patch antenna applicable for C band space communication system. Bandwidth and gain are improved compared to conventional circular microstrip patch antenna, also fulfils all requirements for antennas used in satellite communication system. [6].

A circular microstrip patch antenna with L-slit is introduced at the right edge of the patch to reduce the resonant frequency. Introduction of L-slit reduces the size of antenna and increase the bandwidth compared to conventional circular microstrip patch antenna. Moreover, size reduction is used to enhance the return loss and bandwidth. Thus by introducing various slot shape in a patch antenna performance parameters can be enhanced and also reduces the size of antenna [7].

A circular patch antenna with a fractals is analysed. The designed antenna has been feed with L probe feeding technique. A circular patch antenna with fractals produces a dual band application for C-Band application. Different performance parameters like return loss, bandwidth etc areenhanced and such kind of antennas are useful in Wi-Fi, Radar, military applications [8].

The design and development of a dual linearly polarized aperture coupled circular microstrip patch antenna at C-band is analysed. The antenna uses a novel configuration of symmetric and asymmetric coupling slots. Variations in isolation between orthogonal feed lines and antenna axial ratio with the position of coupling slots are studied and broadband isolation and axial ratio are achieved. The result shows that performance parameters of the antenna are enhanced [9].

A slotted circular patch antenna is analysed for dual band applications. Circular patches were reported to lose less energy by radiation and thus provide larger quality factors than other configurations e. g. rectangular patches. The directivity of circular or disk patch antenna is more when compared with rectangular patch antenna. To achieve higher gain and bandwidth structures are modified by introducing slots for different applications. By introducing cross slot at centre of circular patch a dual band is achieved. Also various performance parameters are enhanced [10]

U. Chakraborty, et. al designed and proposed a compact dual-band rectangular microstrip antenna (RMSA) by two different single-slots on rectangular microstrip antennas with slotted ground plane. Group's have been initially designed two-10dB impedance bands by two dissimilar designs of compact microstrip antennas with same dimensional slotted ground-plane geometry. After, these two designs are united to form the geometry of the dual-band (5.15–5.35 GHz and 5.725–5.825 GHz) antenna. Each open-ended slot in the single-slotted antenna is in charge to generate a wide impedance band that is shifted to lower frequencies by the effect of the slot in ground. Authors achieved compactness of about 54% with respect to a conventional unslotted rectangular microstrip patch antenna. [11]

A new H-Slot is proposed for differentially microstrip antennas for improved bandwidth. The researcher has designed and proposed that the H-slot provides the improved bandwidth of about 4%. However, it has been experimental that there is no substantial enhancement in the gain of the antenna [12].

The analyses of slot microstrip patch antenna using equivalent circuit concept are studied by S. Sharma, and B. R. Vishvakarma. The slot is considered as capacitive reactance on the patch. It is also found that resonance frequency decreases with increase in slot width for a givenslot length. There is also the decrease in resonance frequency in the higher side for lower slot length and it is minimum for longest slot length. The placing of slot in thepatch makes resonating frequency shift from its actual position, it affects the bandwidth, input impedance and gain [13].

Further to this a novel feeding technique for microstrip patch antenna is presented, which consists of a coaxial probe and shorting pin divided by a narrow slot which is centrally cut at the radiating patch. The impedance, radiation characteristics of a usual probe-fed microstrip patch antenna and the proposed antenna are examined and compared by researcher. The property of the slot length on the antenna operation is also discussed and experimented [14].

A new broadband design of a probe-fed microstrip patch antenna with a pair of wide slots is proposed and studied by Kin-Lu Wong and Wen-Hsiu Hsu. The design is with an air substrate, and results show that, simply by inserting a pair of wide slots at one of the radiating edges of the patch, good impedance matching over a wide bandwidth (400 MHz) can easily be achieved for the designed antenna. With an air substrate of thickness about 8.5% of the wavelength of the base operating frequency, the proposed antenna has an impedance bandwidth of about 25%. For frequencies within the bandwidth, have good radiation, with a peak antenna gain of about 7.20 dBi [15].

A Dual-band patch antenna array element has been proposed for Dual-band operation (1.34 GHz and 2.87 GHz) by modifying the primary resonant mode of the patch antenna and its higher order modes. Resonant frequencies are achieved by adding the antenna with non radiating slots at planned locations along the microstip patch. This results is a compact, dual-band antenna with symmetric radiation patterns and same radiation characteristics at both bands. The microstrip patch antennas are broadly used in wireless communication system, though the conventional microstrip patches antennas have the drawback of narrow bandwidth. The U- slotted antenna has been proposed by Shing-Lung Stevan Yang et. al. By adding of U shaped slot on the microstrip patch antenna is technique proposed to enhance the impedance bandwidth (2.65-3.35 GHz). With the use of U shaped slot antenna can further add additional mode to the resonant frequency helps to design the dual band antenna [16].

A large operating bandwidth for a single; coaxially fed rectangular microstrip patch antenna is obtained by adding a U-shaped slot on the patch. This antenna structure has newly been found to provide impedance bandwidths of 10%–40% experimentally, even with non air substrates [17].

With the pair of right-angle slots and a modified U shaped slot in rectangular microstrip patch, bandwidth enhancement (1.1%) of microstrip antennas is proposed. Necessary dimensions of the right-angle slots and U-shaped slot for bandwidth improvement with good radiating characteristics have been determined experimentally and achieved an antenna bandwidth as large as about 2.4 times that of a subsequent unslotted rectangular microstrip antenna [18].

A compact tri-band microstrip-fed printed monopole antenna for WLAN and Wi-MAX has been proposed. The antenna consists of a rectangular radiating patch with L and U design slots and ground plane. A study on the lengths of the U and L shaped slots of the designed antenna is provided to obtain the required operational frequency bands for, WLAN (2.4, 5.2 and 5.8GHz) and WiMAX (2.5, 3.5 and 5.5 GHz). The proposed antenna is small (15x15x1.6 mm), when compared to previously known double and triple band microstrip antennas [19].

A planar dual-band antenna with a very compact radiator to cover the frequencies 2.4/5.2/5.8 GHz for WLAN operating bands is proposed. The antenna consists of L-shaped and Eshaped elements which are resonating at around 5.5 and 2.44 GHz, respectively [20].

The L shaped is microstrip fed and the E-element is placed very close to the L shaped and is coupled fed through the L shaped radiator. As only one feed point is used for the two different elements, the overall size is very small. The antenna is designed and analyzed using the EMsimulation software CST. A rectangular microstrip patch antenna with many rectangular slots has been proposed. A dual band, compact single probe-feed rectangular microstrip patch antenna with miniaturize in size has proposed. The single layered antenna has been tested to resonate in two frequency mode (3.1 GHz and 5.5 GHz). The new design is achieved by cutting rectangular slots at two sides of the patch. As compared with the conventional rectangular patch antenna, proposedantenna can achieve reduction in patch size up to 70%. [21].

A novel dual frequency and wideband operations of a triangular microstrip antenna is proposed by adding properly arranged slots in a patch antenna. The design consist of two pair of thin slots in the triangular patch in which one of the slot is close to the side edges of patch and second one is inserted at the bottom edges of patch with small width [22].

The outcome is two operating frequencies (1.71 GHz and 3.37 GHz) and have same polarization planes Also researcher gets bandwidth 2.5 times more than conventional triangular microstrip patch antenna. Wireless communication is one of the major areas of research in the present world of communication systems. With the fast advancement of various applications these antenna need to work at different frequency band such as dual, triple, and multiband operations are needed. The proposed antenna is supplied by a single probe feed connected to a capacitive feed. This radiating patch and feed are etched on the same dielectric substrate. The SMA Connector used to connect

the feed strip which couples the power to a radiating patchby capacitive feed [23].

A vertical slot is added to get antenna operate and work at lower frequency with proper impedance matching.

To improve the antenna performance scientists presented a single band microstrip patch antenna with two slots in radiation patch. The antenna was proposed for WLAN application mostly. In respected work, a simple rectangular patch antenna was designed for frequency of
2.4 GHz and analyzed by transmission line model [24].

3. Effect of slots on microstrip patchantenna

3.1 Effect of slots on bandwidth

Bandwidth is also defined in terms of radiation parameters. It is defined as frequency range over which radiations parameters such as gain, HPBW, side lobes levels are within specified minimum and maximum limits. In terms of voltage standing wave ratio or input impedance variation with frequency or in terms of radiation pattern. The VSWR or impedance bandwidth of microstrip patch antenna is defined as the frequency range over which it is matched with that of fed line with in specified limits. The bandwidth of microstrip patch antenna is defined as the frequency range over which it is matched with that of feed line within specified limits. The bandwidth of microstrip patch antenna is inversely proportional to it quality factor Q.

The bandwidth is usually specified as frequency range over which VSWR is less than two. Some times for stringent application the VSWR requirement. The bandwidth of the antenna increases with the help of slots. These structures are periodic in nature that forbids the propagation of all electromagnetic surface waves within a particular frequency band called band gap thus permitting additional control of the behaviour of electromagnetic waves other than conventional guiding /filtering structure [25].

3.2 Effect on slots on the gain

Gain relates the intensity of antenna in a given direction tothe intensity that would be produced by a hypothetical ideal antenna that radiates equally in all direction or isotropically and has no losses. By using high permittivity substrate and by different shape of slot we can enhance thegain of antenna [26].

3.3 Effect of slot on radiation pattern

Radiation patterns of slots are computed by using E fields slot behave as magnetic dipole when the slots are at ground plane. The E plane radiation pattern changes significantly for the finite size ground plane. This is due to diffraction effects from the edges of the finite size ground planes. The E plane radiation pattern extended ground plane shows that the slots tends to become magnetic dipole. Due to lack of some experimental facilities the measured results are not provided. The radiation pattern by slot show the diffraction effects from the edges of finite size ground plane only affects the E plane radiation patterns of slots [27].

3.4 Effect of slots on return loss

The difference between forward and reflected power in dB generally measured at the input to the coaxial cable connected to the antenna. For maximum power transferthe return loss should be as small as possible. This means ratio ⁄ should be small as possible. For example a return loss of-40 dB is better than one of-20 db [28].

3.5 Effect of slot on axial ratio

It is defined as ratio between minor and major axis of polarization ellipse. Shorter slot length produces narrower axial ratio bandwidth.

3.6 Effect of slot on size of antenna

With the help of slot size of microstrip patch antenna is reduced. This effect can be done by changing the path of current. When slots are cut into patch current is changed. Current travels extra patch as compare to the without slot microstrip patch antenna.

4. Conclusion

In this review microstrip patch antenna based on slots has been discussed. By using different shape of slots we can improve efficiency of antenna as compare to conventional microstrip patch antenna. In this paper we have seen the effect of slot on microstrip patch antenna. By inserting a proper shape slot will enhances the gain, bandwidth and reduction in the size of microstrip patch antennas. It also helps to achieve the multiband operation with considerable gain and bandwidth. By the use of slot microstrip antenna can be used in many application.

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