Design Techniques for Compact Microstrip Antennas

K.Anusha

Abstract ***- Microstrip patch antenna are extensively deployed in presenteras in applications relating to wireless communication and Telemedicine. Patch antennas are replacing the conventional antennas in many applications, these advancements necessitate Microstrip patch antenna design that can incorporate wide range of specifications. The design of multiband antenna places constrains on the geometrical dimension and antenna parameters specifications of gain and efficiency. To integrate the specifications various design methodologies have been employed. Variations in geometry, inclusion of slots, switching devices, FSS, EBG or PBG structures and Ring resonators have a huge impact on the performance of the antenna. This paper provides a comprehensive review of the design practices employed in a microstrip Patch antenna.***

Key Words: Microstrip Antenna,Slots,EBG,PBG,DGS

1. INTRODUCTION

The present-day wireless system escalates the demand for antenna that are capable compact and provide a variety of services to the end user. Antenna is an essential device in a communication system. Compact miniaturized antenna integrated into RF systems are the requirement of the present generation wireless antennas. The antenna must also have a wide band frequency of operation across varied platforms.

Low profile and cost antennas that are efficient, conformable, and have compatibility to support multiple bands is the need of the hour. The features of small size, low profile, conformable, and cost effectiveness of the

Micro strip patch antenna renders them to be the ideal choice of wireless communication system. Reduction in Antenna dimension with capability of functioning in multiple bands is a thriving research area in antenna design. This paper aims to present a comprehensive review of the various techniques and designs for compact microstrip antennas.

II. DESIGN TECHNIQUES

The various design techniques that are employed to enhance the performance parameters of Microstrip antenna are reviewed in this section

A. Geometrical Variations

A simple micro strip patch antenna is generally designed using conventional shape metal patch over a grounded dielectric substrate. A radiating element with larger bandwidth can be fabricated if we move into composite shapes from the conventional shapes .For specific applications that require multi-band operation a deviation from the standard geometry gives a better performance.

When the dimension and area of the patch geometries are retained the same variations in geometrical shape have indicated different band width efficiency [1]. when all other antenna parameters of the simulation are kept constant, it is seen that a bandwidth obtained is 10.57 times larger as a result of Seljuk star design compared to circular and square patch.

Typical shapes and the modification in the shape of patch antenna is illustrated in Figure 1 and Figure 2 The Table 1 gives comprehensive comparison of the gain improvement in bandwidth efficiency.

Table 1.Comparison of bandwidth efficiency

Geometry	Resonating Frequency		Bandwidth %
	Theoretical	Simulation	
Seljuk Star	5800	5630	1.48
Square	5800	5550	0.13
Circle	5800	5800	5800

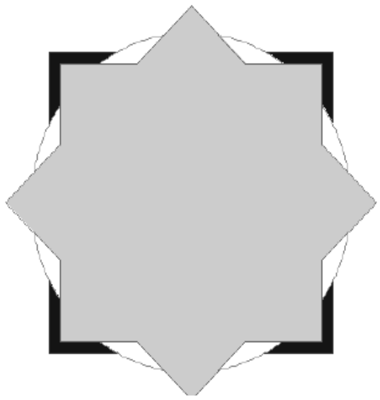

Fig 1: Different conventional shapes

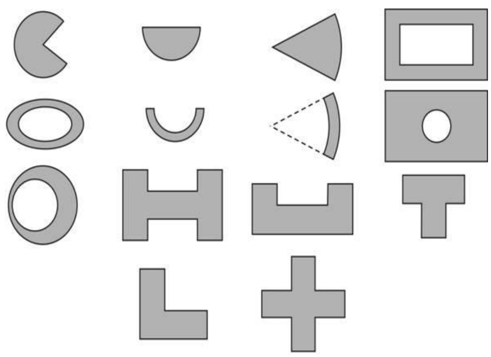

Fig 2 : Modified Geometrical structure

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Deviation from regular shaped planar microstrip patch antennas to redefined shapes has been proposed [2-5] by many researchers. These optimized geometries have better radiation performance and are capable of operating in different frequency bands. The refinement is shape also aids in miniaturization of the antenna

B. Inclusion of Slots

A microstrip patch antenna is generally limited by narrowband bandwidth characteristics.The rectangular micro strip patch antenna can be designed with or without slots. The inclusion of slots in the antenna results in a better bandwidthutilization. The impedance matching imperfection can also be reduced by adding slots in the antenna can also be obtained. By employing the slotting technique percentage bandwidth can be enhanced around the operating frequency [3].The gain of the antenna is also increased with the inclusion of slots. The bandwidth efficiency improves as the number of slots are increased till an optimum value depending on the frequency of operation of the system [4] The gain of the antenna can be improved by addition of arcs in the structure. [5,10]. The various primary slot shapes included in a patch antenna is shown in Figure 3

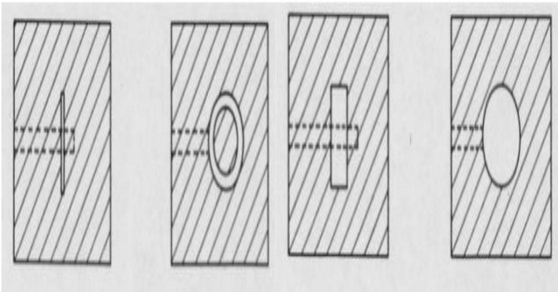

Fig 3.Slots in a microstrip patch antenna

C. Addition Of Superstrate Layers

The incorporation of the HIS and FSS structures enable us to achieve a compact and high-directivity antenna. In general, the conventional FSS super substrate requires multilayer to achieve the resonant frequency for a high-directivity antenna.

Inclusion of additional layer of FR-4, coated with copper on a unidirectional and low profile microstrip patch antenna [6], the back lobe in the radiation pattern is reduced and gain is enhanced up to 5.4 dB as well as the directivity improved up to 7.74 dBi with F/B ratio of 9.5 dB. For applications that require Ultra wide bandwidth capabilities double layer structure that replicate a unit cell can be deployed [5]. When such structures are utilised the gain enhancement of the antenna is high.[5].A FSS structure using a square loop is shown in Figure 4 and the corresponding gain enhancement is shown in Figure 5.

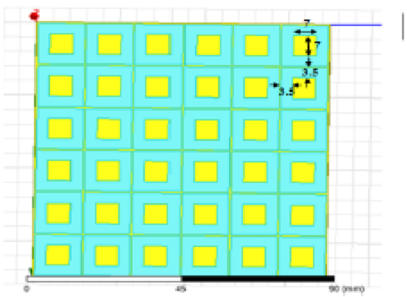

Fig 4: FSS Structure

D. Electromagnetic Bandgap Structures(EBG)

Electromagnetic band gap structures are artificial periodicelements acting as a filter. The basic design of EBG structure and its equivalent circuit is shown in Figure 5. The structure is identified as mushroom EBG structure [7]. The structure acts as a filter due to high surface impedance.

EBG structures can aid in the reduction of mutual coupling by blocking surface wave's propagation in a particular operating frequencyrange. A dual-layer EBG structure [7]has a lower resonant frequency than the single-layer one.

A radical reduction of the unit cell size is achieved in the structure by increasing the series capacitance between neighbor cells. The resulting structure has a substantial reduction in mutual coupling.

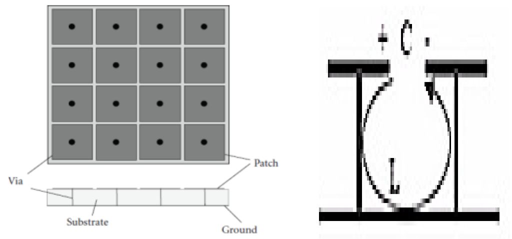

Fig 5: EBG Structure and its -equivalent circuit.

E. Defected Ground Plane Structures (DGS)

DGS are periodic or non-periodic defects etched beneatha planar transmission line in the ground plane. The inclusion of the defects alters the capacitance and inductance of the system. . A unit DGS (dumbbell) encompasses of two rectangular areas etched in the ground plane connectedthrough a slot. Multiband operations having specified stop band frequencies can be designed using DGS structures [8-9]. The typical DGS widely used in design techniques is shown in Figure6.

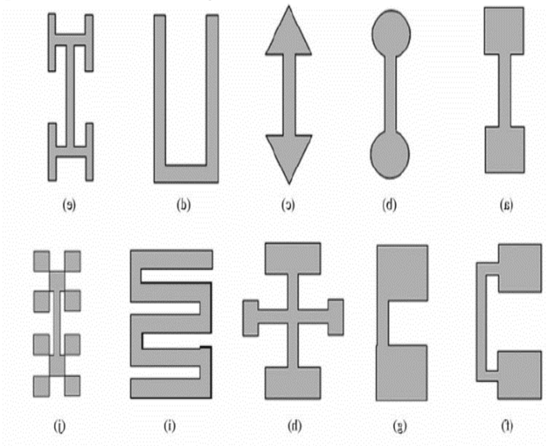

Fig.6.Different EBG structures

F. Photonic Band Gap Structures (PBG)

Photonic Band Gap (PBG) structures are periodic structures etched on the ground plane toregulate propagation of electromagnetic waves. Current distribution in the element varies due to the inclusion of periodic structures in the ground plane. This has anenormous effect on the propagation of

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electromagnetic waves and radiation characteristics of the antenna. PBG acts as resonant cavity and forms filter structure.

PBG increases the directivity of antennas and impedance bandwidth. [11-12].A typical PBG structure is indicated in Figure 7.

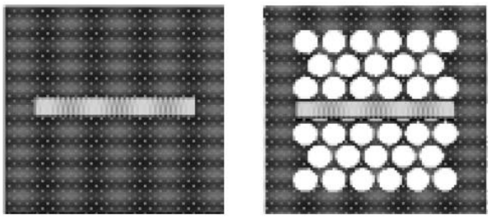

Fig 7. Microstrip line on a usable substrate and PBG substrate

III. EXPERIMENTAL RESULT

A FSS structure using a square loop is shown in Figure 4 and the corresponding gain enhancement is shown in Figure 8.

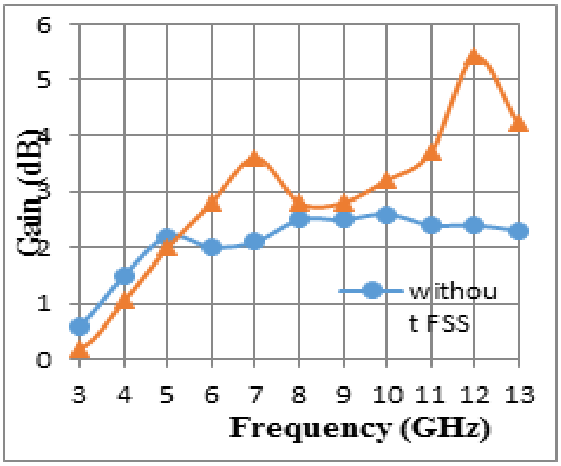

Fig 8: Comparison of Gain[5]

1V. CONCLUSION

A comprehensive review of design techniques deployed in micro strip antenna design is provided. To indicate the characteristic features of micro strip antennas, variation of antenna elements and their correlation to enhanced characteristics with their variation in parameters is presented. By varying the geometrical features the bandwidth of the antenna can be enhanced. Addition of slots, layers and defects in ground plane will lead to multi band operation features. The field of antenna engineering is a challenging domain as the efficiency of the complete communication system relies on the effectiveness of the transmitting and the receiving antenna .Innovative advancement in the antenna design will lead to better performance of the system.

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