An Overview on Defected Ground Structure in Aspect of Microstrip Patch Antenna

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Abstract:-Micro strip patch antenna has gained a lot of attention now a day, only because of their attractive features like small size, low profile, low manufacturing cost and easy to integrate with other microwave circuits, but it has also some disadvantages like narrow bandwidth, low gain and low efficiency. Several techniques have been evolved to improve the various characteristics of antenna; they are photonic band gap (PBG), electromagnetic band gap structures (EBG), defected ground structure (DGS). Among three methods DGS is very versatile, it is being used in various microwave devices in microwave amplifiers, microwave oscillators, microwave filter design and in microwave coupling to reduce coupling etc. now a day it is being also used in the field of antenna design as to enhance bandwidth, improve gain, size reduction, harmonic suppression, reduce cross polarization etc. The equivalent of DGS is a simple LC resonator circuit. Inductance and capacitance value of ground varies with respect to the size and location of cut. As DGS is applied to the ground inductance and capacitance value increases because of that resonating frequency gets decreases. So by varying the size and location of cut in ground we can get a desired resonating frequency. In this paper, effect of various DGS in enhancement of antenna parameter is studied.

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I. INTRODUCTION

Now a day there is a boom in progress of wireless communication. Everything is becoming wireless from wired. In wireless communication there is a need of transducer which converts electrical signal into RF signal at transmitter side and RF signal to electrical energy at receiver side. Antenna is also a transducer which does the same as transducer. Among various antennas micro strip antenna is more in use because of its various features like small size, low manufacturing cost and easily integrate with other microwave devices but along with these features it has also some drawbacks that is narrow bandwidth, low gain and low efficiency. Several techniques developed to improve the band width, gain and efficiency of micro strip patch antenna they are defected ground structure and electromagnetic band gap structure. Defected ground structure is more useful in enhancing various antenna parameters. DGS is used in reducing size of antenna, reducing cross polarization, reducing mutual coupling, harmonic suppression, increasing gain, increasing bandwidth and also in improving return loss of antenna. Basically DGS is realized by etching off a simple shape in the ground plane, which affects the shielded current distribution of ground plane. By varying size of shape and location of cut in the ground plane its capacitance and inductance values can be changed which shifts the resonating frequency, so by varying size and location of DGS we can obtain resonating frequency of our own desired. Different shapes of DGS like rectangular, square, circular, concentric circular, hexagonal, U-shape, H-shape, I- shape, E-shape, dumbbell shape and various combined structure have been appeared in this literature.

II. PBG AND DGS

Photonic band gap structures are periodic structures etched in the ground plane to reduce surface wave radiation in a particular frequency band that is why name called as band gap. Whereas defected ground structures are any structure etched in the ground plane. Difference between photonic band gap structures and defected ground structures is shown below in table (1):

	PBG	DGS
Geometry	Only periodic structures	Any type of structures
Microwave circuit properties	Same	Same
Equivalent circuit	Difficult	Relatively simple

PBG improves the characteristics impedance and propagation constant of micro strip line whereas DGS is any slot in the ground plane. It is motivated by a study of PBG to change guided wave properties. DGS makes one or a few of PGB etched ground elements in the ground plane .The shape of slot is modified from a simple hole to a more complicated shape depending upon the requirement. The DGS structure found in both one-dimensional and two dimensional forms as shown in Fig. 1

III. DGS UNIT CELL

The dumbbell DGS below the transmission line is shown in figure (1), the dumbbell DGS consists of two rectangular areas and one connecting shape slot in the ground plane. The DGS underneath the micro strip line provides the better

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band rejection property. The cutoff frequency of DGS depends on the etched square area in the ground plane. An attenuation pole is present due to the gap in the etched.

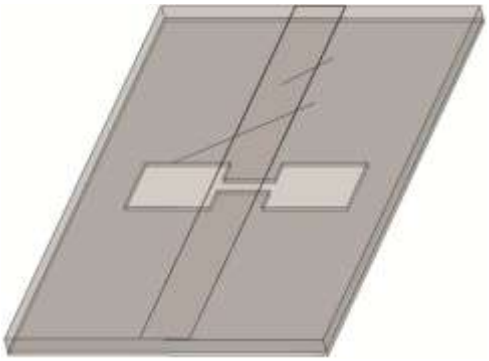

Figure 1: Dumbbell DGS

IV. EQUIVALENT CIRCUIT OF DEFECTED GROUND STRUCTURES

The equivalent circuit of defected ground structure is very simple as compared to photonic band gap structure which is relatively difficult. The equivalent circuit of defected ground structure is simply a LC resonating circuit which is given below in figure (2):

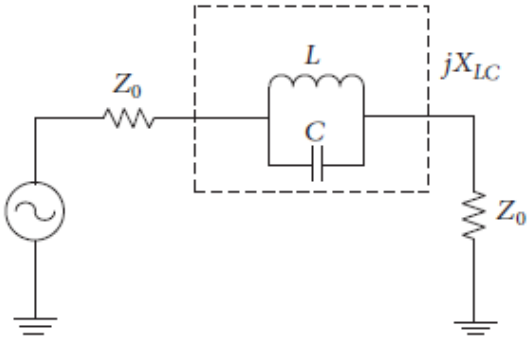

Figure 2: Equivalent circuit of dumbbell DGS

V. FLOW CHART OF DUMBBELL SHAPE DGS

Basically using DGS in micro strip patch antenna is a hit and trial method. In DGS application simply any dimension and shape of DGS is considered then the various performance parameters like return loss, gain and bandwidth etc. are observed. If the result is proper according to the application of antenna then this DGS shape and size is accepted for their design else the same procedure repeats again and again until the result is not proper. Flow chart is given in figure (3):

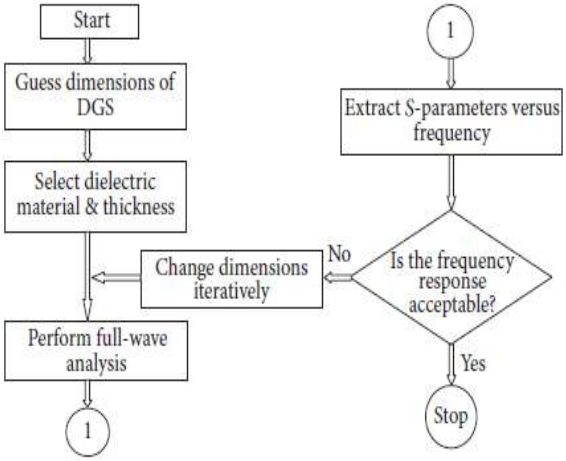

Figure 3: Flow chart of dumbbell shape DGS

VI. APPLICATIONS OF DGS IN VARIOUS MICROWAVES TECHNOLOGIES

Defected ground structure is most widely used technology all over the world in the field of filters, microwave amplifiers, microwave oscillators and mainly in antenna. Each DGS shape has its own features and it affects the performance of devices in different manners. DGS is used in miniaturizing of antenna, reduction of harmonic suppression, bandwidth enhancement, gain enhancement and also in cross polarization reduction.

VII. CONCLUSION

In this paper we have discussed about the effects of defected ground structure on the micro strip antenna performances. The equivalent circuit of DGS consists of parallel LC circuit which has resonating characteristics. Effects of Various shapes of DGS at different locations on antenna parameters like gain, bandwidth, return loss, cross polarization, mutual coupling has been discussed. Further DGS can be used to other parameters of antenna also.

VIII. LITERATURE SURVEY

The survey reveals that various DGS shapes have been tried to improve the performance of antenna with respect to bandwidth enhancement, gain enhancement, improving return loss, reducing mutual coupling between two networks and in reducing cross polarization. N. Ripin has proposed an micro strip antenna with I- shaped DGS which improved the bandwidth to 118% and other antenna parameters are also improved like gain, return loss and radiation pattern [1]. A.K Arya has used two dumbbell shape DGS underneath the proximity coupling feed to reject the higher order modes of antenna which increases the gain of antenna. Gain without DGS is 8.165 db and with DGS it is 9.25 db [2]. Alamdeep kaur has proposed a micro strip patch antenna in which upper surface of substrate has a slotted square shaped patch and the lower surface of substrate has a defected ground

surface.The slotted defected ground surface and an inverted L shaped slot in the patch yields enhancement in bandwidth and improves the return loss [3].Sagar B. Pokharkar has proposed a micro strip patch antenna with two square shape DGS below the patch. This improves the return loss, efficiency and compactness of antenna. The bandwidth is increases from 44.6 MHz to 90.8MHz, return loss is enhanced from -13.94 dB to -39.25dB, and radiation efficiency is improved 79.91% to 98.91%, and compactness is achieved over the conventional antenna [4]. Anuja Raj N has used DGS in micro strip patch antenna having hexagonal patch which is fed with coaxial probe feed. The designed micro strip antenna has a higher gain of 6.2 db and return loss of less than 10 dB at 2.4 GHz, 4.2 GHz, and 5.8 GHz [5]. Vivek Singh Kushwah has designed a micro strip patch antenna with FR4 substrate which is fed by micro strip line. By using square shape DGS below the patch return loss improved from -25.65 db to -31.55 db [6]. Siddique Naushad Ather has proposed a stacked patch micro strip antenna fed by coaxial probe method. By inserting slot in the ground plane bandwidth of proposed antenna becomes approximately double to reference antenna [7]. Sara Mahmud has proposed a elliptical patch micro strip antenna with DGS which reduces the mutual coupling between two antenna ports and maintained the compactness of antenna [8]. The proposed simple micro strip patch antenna using two serial rectangular DGS in ground plane gives the isolation of below -20 db. The patch antenna operates at 3.5 GHz for LTE tablet as well as Wi-MAX applications [9]. Varun vaid has designed a micro strip antenna with fractal geometry for multi band operation, further to improve various antenna parameters DGS is being used which shows that bandwidth of antenna increases by 10% [10]. Abolghasem Zamanifekr has presented an filtering antenna also called as filtenna for VSAT application. DGS has been used in filtenna to reduce mutual coupling between transmitter and receiver end [11]. Author has proposed a approach to generate circular polarization using fractal boundary has been presented with defected ground structure (DGS) and single feed. The excellent circular polarization is achieved by adjusting the feed position moving along the diagonal of the square patch [12]. Ashwini K. Arya has proposed a micro strip patch antenna for efficiency enhancement. A dumbbell shape DGS has been used to increase the efficiency of antenna [13]. Susmita Bisbas has presented a micro strip patch antenna with DGS to suppress higher order harmonics so that the antenna resonates at desired frequency and give good return loss [14]. In this paper, the author has proposed a micro strip patch antenna with L- shape DGS and V-slot in patch. L-shape DGS is used for dual band and V- slot in patch is used for triple band operation. The proposed antenna is successfully designed at 3.5 GHz, 5.8 GHz and 7.5 GHz for WLAN/Wi-MAX applications [15]. In this key paper, the author has proposed a rectangular patch antenna in which two equal sides are cut. Then, five slots are cut in the patch two U-slots, two inverted U-slots and one I-slot. Further by applying defected ground structure, bandwidth gets increased from 1.03GHz to 1.21 GHz. Proposed antenna finds application for C band and X band. In these bands antenna can be used for RADAR application [16]. In this paper a triple-band antenna for simultaneous Wireless applications has been presented. The proposed triple band antenna can excite at the desired triple-resonant frequencies at (l.24, 3.7 and 5.15) GHz respectively. Further by applying DGS return loss is improved [17]. In this paper the author has proposed a micro strip patch antenna with various structures of DGS has been designed and simulated .Among various shapes antenna with Psi shape DGS achieved the maximum Bandwidth of 302 MHz which can be used for WLAN application. It is observed from the results obtained that more complex DGS structure in ground plane more we get the bandwidth [18]. Alaa A. Yassin has proposed a micro strip patch antenna with C-slot in patch and two parallel strip slot in ground plane. By using these slots bandwidth and gain is enhanced [19]. The author has proposed a hybrid shaped fractal micro strip patch antenna. Further to improve various parameters like band width and return loss of antenna plus shape DGS is applied, maximum bandwidth achieved is 705 MHz [20]. In this paper, an improved UWB antenna with a DGS structure has been presented. Open-end Wing Stub loaded gives the stable return loss and radiation pattern over entire UWB range. Introduction of DGS technique with rectangular dumbbell shape has been found to improve the return loss and gain of the antenna, especially at the upper UWB frequency band [21]. In this paper author has presented an effective technique for diminishing the mutual coupling of closely spaced micro strip array elements. By suppressing surface waves through a triple rectangular DGS about 16.5 dB further reductions as compared to conventional array in mutual coupling is achieved [22]. Chandan Bhagera has proposed a triple band micro strip antenna using DGS with reduced size. With micro strip patch using defected ground structure, a size reduction of 36.8 % is achieved operable at triple band of frequencies 2.98 GHz, 4.56 GHz and 5.58 GHz [23]. Pragya shilpi has proposed a dual band micro strip line fed multi band antenna. Then by using strip different size of strip type DGS in the ground plane below the patch antenna bandwidth enhance by 95% and return loss is also improved[24]. Sushil kakkar has proposed a micro strip patch anten na for emergency management, by using meander shape DGS in ground plane below the feed line input impedance of patch is reduced and hence the impedance matching is better in proposed antenna as compared to reference antenna [25].

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