Dgs Structure Array Design For Multiband Communication

Sarmistha Satrusallya, Mihir Narayan Mohanty

Abstract: The array antenna provides a better performance as compared to a single element antenna. The requirement of array in many application demands more bandwidth and gain. This paper analyze a multiband antenna array designed for X band and Ku band application. The antenna structure is in the form of a set of three numbers of E shaped antennas. The antenna is printed on a defective ground structure that provides comparatively high gain and suppressed higher mode harmonics. DGS has the advantage of decreasing the mutual coupling between the adjacent elements. FR4 epoxy with dielectric constant of 4.4 is considered as the substrate with a dimension of 20X20mm^{2}and thickness of 1.6mm. The variety of slot provides the higher bandwidth due to its geometry, where the feed line is through microstrip feeding technique. The antenna resonates at 8.5 GHz with an impedance bandwidth of 4.8GHz and at 12.5GHz with an impedance bandwidth of 2.8GHz. The resonating frequencies lie in the range of X band and Ku band. The proposed design is suitable for application in satellite communication.

Keywords: E-Shaped Antenna, Array Antenna, Multiband Communication, Bandwidth, Return Loss, DGS, Ku-Band.

1. INTRODUCTION

NARROW bandwidth is one the major constraint of microstrip antenna. The next generation communication system requires wider bandwidth with a smaller size. The size of the antenna plays an important role in designing different systems. The antenna performance can be better by appropriately choosing the substrate material and thickness of the substrate. The selection of slots in the patch element and ground plane also enhances the performance. The introduction of different shaped patch antenna helps in increasing the bandwidth. The basic patch element of the antenna is rectangular. But the shape can be chosen as E, C, U,S or V shaped [1]. But sometimes it is difficult to design an antenna for low frequency range. In [2] an E shaped antenna was designed for AMPS band operating in 860 MHz. Various work on antenna array was proposed by different researcher in the recent years. The array with different shapes were designed for different application. It may be for higher bandwidth, higher gain, low mutual coupling or operation in different frequency band [1, 3, 5, 7, and 11]. Authors proposed a dual E shaped antenna in [5] to operate in three bands. The dual E shape is achieved by cutting four notches in the rectangular patch. The arrangement of different shape patch antenna provide a better performance as compared in [11] to the other design. The combination contain E, C and S shaped antenna. The E shaped antenna with modified geometry also used for wireless local area network with a range of 5.15GHZ to 5.82GHz. The antenna contains two parallel slots with a substrate of low dielectric constant [1]. In [3] an E shaped antenna operating in multiband was proposed for MIMO application with the introduction of two rectangular slots in the patch. A patch antenna with two L slots was designed for application in the Ku band [4]. A T slot was introduced in the work to enhance bandwidth. Further optimization with GA was done to improve the performance [6].

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Optimized H slot in the antenna was used to increase the performance of the antenna [12]. For WLAN operation antenna array of 2X2 with spiral ring resonator was also proposed considering E shaped array elements [7]. For the application in digital radio system authors proposed a 3X3 array having eight numbers of rectangular parasitic patches surrounding a corner truncated rectangular patch with coaxial feeding[8]. Also 1X8 array antenna with E shaped patch was considered for 60GHz application with a very high gain and bandwidth [9]. A 96 element (16X6) patch array was designed and analysed. The bandwidth was calculated to be 700MHz with a high gain of 24dBic. The array had an excellent CP radiation with less bandwidth [10]. Array with dual band operating in 12.5GHz and 14.2 GHz and E shaped array with a liner variation were proposed for better performance in [13-14]. In the same manner a 1X5 array having rectangular patches and with a coaxial feed was proposed in [15] with a gain 5.71dB and bandwidth of 1GHz for health monitoring system through satellite. In [16] a multiband antenna array was designed with dumb bell shaped DGS to decrease the mutual coupling effect. The design consists of a substrate of 1.52 mm thickness and dielectric constant of 2.2. The top part contains the combination of U and S shaped patch. The bottom part was the DGS structure. Similarly A dual band two element antenna array was proposed for WiMAX application with a U shaped DGS in [17]. DGS was used to change the resonating frequency without changing the dimension of the patch [18]. Authors also designed E shaped patch antenna with unequal slots for improved axial ratio[19]. Planner linear array with quarter wavelength antenna slots were described for high bandwidth and gain [20].In [21-22] E shaped antenna with shorted pin was designed for triple band application in LTE communication and corner cut E shaped antenna with slots was proposed for GPS and IRNSS. Designing of E shaped patch at the edge of the substrate increased the fractional bandwidth with reduced size [23]. In [24] an array with rectangular element in the 2.45GHz range was used for wireless power transmission system application. An array with 1X3 dimension was proposed with T shaped and rectangular ring shaped DGS for decoupling and MIMO application [25]. In this work a 1X3 array antenna is proposed. It is designed on a rectangular substrate. The substrate material is considered to be FR4 with ε_r=4.4 and a thickness of 1.6mm. The antenna is designed over a defective ground plane having two rectangular slot of dimension 8.5X20mm². The proposed design is fed by a 50 ohm transmission line.

2 ANTENNA DESIGN

Mutual coupling effect is one of the problems in microstrip array. Defective Ground Structure abbreviated as DGS is applicable to reduce the surface wave in antenna. DGS is achieved by etching the ground plane with a particular shape to change the current allotment of the antenna. The DGS may take any shape. The shape may be rectangular, circular, spiral etc. Each DGS shape may be expressed in terms of a combination of inductor and capacitor. Bandwidth enhancement is achieved using DGS. E shaped patch elements are used for designing the array. The array is a combination of three E shaped patch connected through three vertical lines. The vertical lines are connected to a common 50 ohm transmission line with microstrip feed. The chosen substrate is FR4 with a dielectric constant of 4.4. The dimension of the substrate is 20X20mm² with a thickness of 1.6mm. The ground plane is selected to be a defective ground structure. It consists of two rectangular slots having dimension of 8.5X20mm². The gap between the slots maintains an equal distance from the upper and lower boundary. The parameters required for designing the array is given in Table 1. The proposed design is represented in Fig. 1 and the design of partial ground plane is given in Fig. 2.

TABLE 1 *DESIGN SPECIFICATION OF THE ANTENNA ARRAY*

Parameters	Value(mm)
A	12
B	1
C	2
D	6
E	4
F	5
G	20

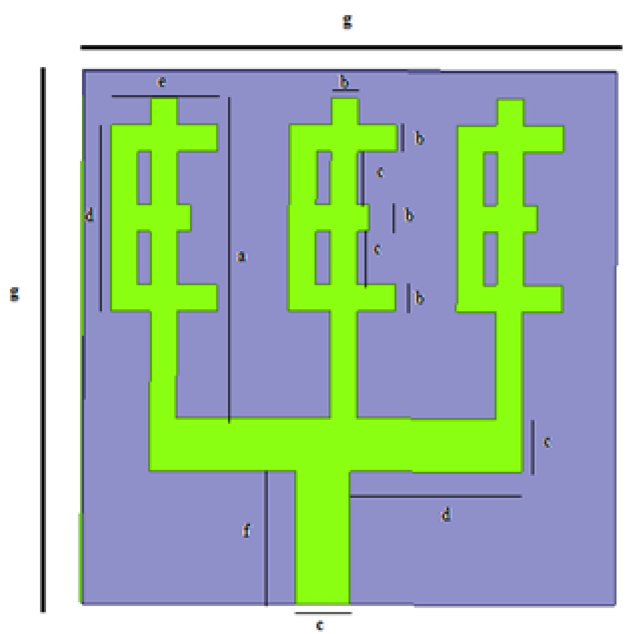

Fig. 1. *Front view of the antenna array*

Fig. 2. *Back view of the antenna array*

3. RESULTS AND DISCUSSION

HFSS was used to analysis the antenna performance. Fig. 3 describes the VSWR of the antenna. The VSWR value at 8.3GHz and 12.2 GHz was computed to be 1.01. It indicates the antenna is prepared to receive more power with the matched transmission line.

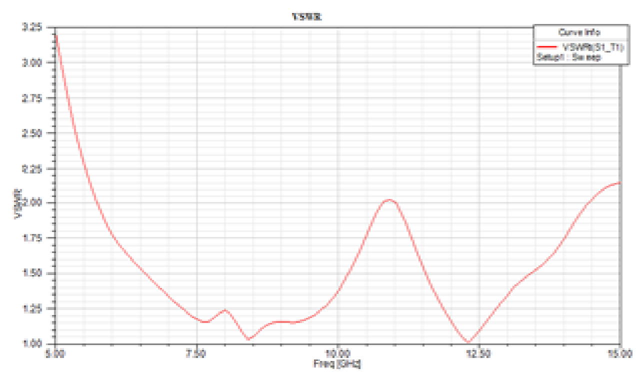

Fig. 3. *VSWR of the antenna array*

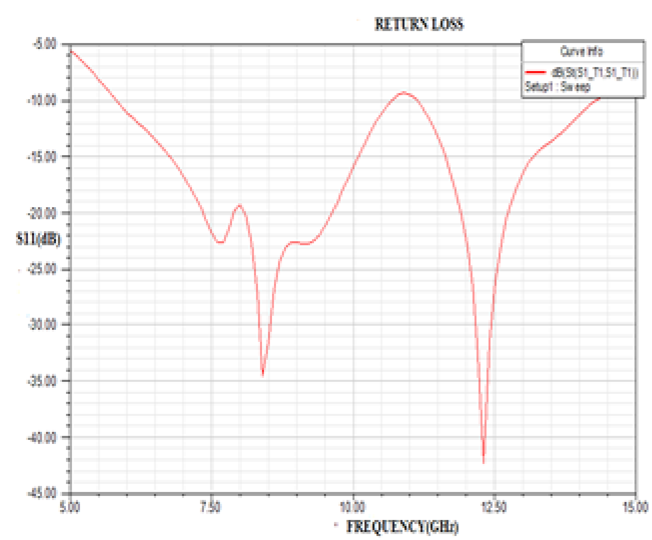

Fig. 4. *Impedance bandwidth of the antenna array*

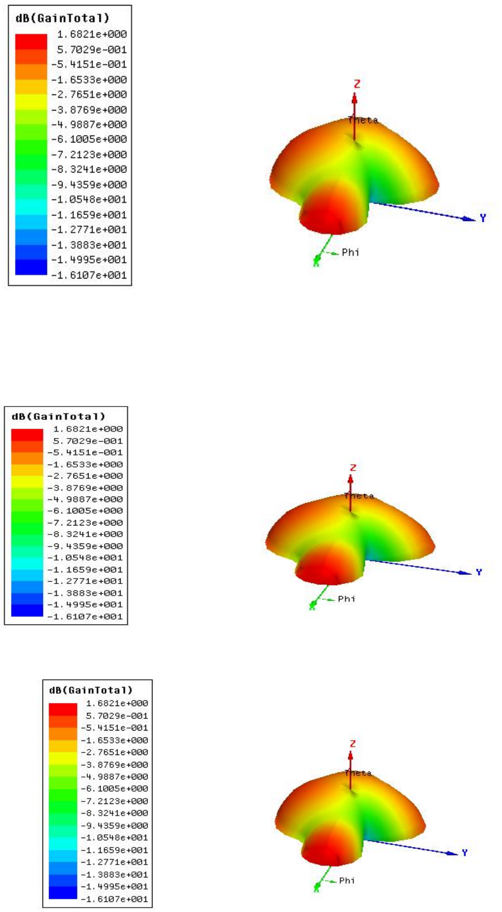

***Fig. 5. 3D** polar plot of the antenna array*

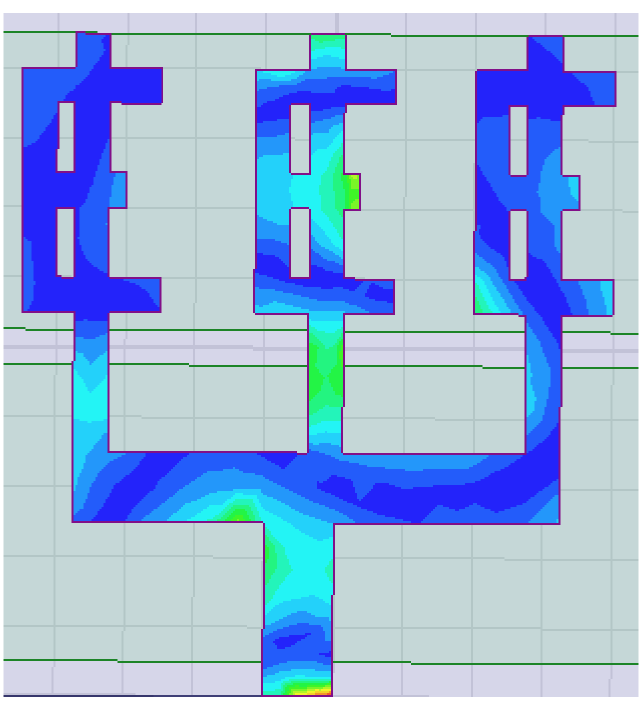

***Fig. 5**. Electric field representation of the antenna array*

Return loss and the bandwidth is described in Fig. 4. The antenna resonates at two frequencies 8.3GHz and 12.2GHz with a return loss of -34dB and -42dB.The bandwidth was calculated to be of 4.9GHz(5.8GHz-10.7GHz) and 3.11GHz(11GHz-14.2GHz). Fig. 5 represents the gain of the antenna. The gain was calculated to be 1.68dB. The value was small as DGS was applied. DGS was used to increase the bandwidth which was suitably achieved. Fig. 6 represent the electric flow in the proposed design. The flow of current has higher value in the center patch as compared to the other patch. The microstrip line has a smooth current conduction. Table 2 represents the performance analysis of the proposed work with the related earlier works.

***TABLE 2** COMPARISON OF THE RESULT OBTAINED THROUGH PROPOSED DESIGN WITH SOME EARLIER WORKS*

Reference	Resonating frequency (GHz)	Return loss (dB)	Bandwidth	Gain (dB)
[1]	5.25		400MHz	7.5
[4]	11.95	-42	510MHz	7.2
	14.28	-43	100MHz	5.7
[7]	5.25	-27	225MHz	12.45
[10]	11.9	-40	700MHz	24
[11]	2.41	-35	553MHz	7.3
	4.8	-35	201MHz	8.3
[14]	7.23		264MHz	9.86
	10		270MHz	8
	11.7		362MHz	8.13
Proposed Design	8.3	-34	4.9GHz	1.68
	12.2	-42	3.2GHz	2

4. CONCLUSIONS

The 1X3 array was analyzed using HFSS. The antenna resonates at 8.3GHz and 12.2 GHz with a return loss of -34dB and -42dB. The DGS provide a better bandwidth of 4.9GHz and 3.2GHz at the resonating frequency. The antenna is suitable for application in X band and Ku band. The bandwidth of the antenna can be improved by using different shape DGS.

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