

A Novel Technique to Design UWB Patch Antenna for Multi-Band Operation at Multi-Resonance Frequencies by Using DGS/DMS

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Abstract

In this research a multi-band notch antenna radiating at different frequencies is presented. The result is obtained by etching two symmetrical slots Defected Microstrip Structure (DMS) at patch to perturb current and Defected Ground Structure (DGS) at ground under feed line to create stop band. The proposed antenna is radiated at multiband band of frequencies with variable bandwidth. First band is from 2.7 GHz -3.0 GHz, second band from 4.26 GHz to 7.1 GHz and third wideband ranging from 7.8 GHz to 29.3 GHz. The proposed antenna shows various band operations as highly selective in lower band and highly sensitive in higher band.

Keywords

DMS, DGS, Hexagonal, Multi Band, Multi Resonance

I. Introduction

Microstrip radiating elements are a category of resonant antennas, and they can support many resonant modes. When the microstrip resonant antenna is designed at the fundamental mode, it has a minimum patch size, but the obtained impedance bandwidth has ultra wide band or narrow band. In UWB it has no practical use for communication due to addition of noise, and for narrow band often not enough to cover the operating frequencies of present wireless communication systems. Various methods to enhance the microstrip antenna bandwidth have been proposed [1–5]. One of the method to improve the impedance bandwidth is using a thick substrate with low permittivity. However, some unwanted higher-order modes of the microstrip antenna will be emerged with increasing substrate thickness[6], and their transverse current distributions on the radiating patch may result in polarization impurity. Moreover, if the microstrip antenna with a thick substrate is fed by a direct coaxial probe, the current distributions near the feed point on the radiating patch will be distorted [7]. The distorted current distributions as well as probe radiations itself will lead to an asymmetric pattern in E-plane and an obvious cross polarization (XP) in H-plane. Therefore, the XP for a broadband probe-fed microstrip antenna mainly stems from the higher-order modes and feeding probe. Recently, several technologies for suppressing the radiation sources of the XP have been proposed [7– 14]. From the obtained results, it is found that the probe radiation can be considerably reduced by a meandering probe [8–10], and the unwanted higher-order modes and distorted current distributions can be effectively suppressed by employing a dual-feed system with a 180° phase shift [11–13]. In addition, a balance-like feeding mechanism described in [14], which is single-feed, has the similar characteristics to the dual-feed system, but it does not need any phase-delay circuit. To avoid the degradation of the radiation performance induced by the feeding probe, an alternative method uses an aperture-coupling feed to excite the microstrip antenna. For conventional aperture coupled microstrip antennas, a thin linear slot is often used as a coupling aperture. As the substrate

thickness of the antenna is increased, the length of the thin slot has to be enlarged to achieve impedance matching, and the impedance bandwidth can be significantly enhanced while the coupling-slot size is close to its resonant length [15]. The dual-feed system using aperture coupling also has been applied to the microstrip antenna with a thick substrate in order to symmetrically excite the radiating patch and suppress the higher-order modes [16]. However, considerable back radiations will be produced by the slots, especially when the slot is near resonant. The problem can be improved by loading additional slots at the ends of the thin slot, and some types of the reformed slots have been reported, such as H-shaped slots [17] and dog-bone slots [18].

II. Design & Analysis of Proposed Antenna

The resonance behavior of this antenna is similar to that of an antenna with slots. One of the well-known approaches is to introduce notch in ultra-wide band antenna to improve the selectivity of antenna.

For designing, first we design an antenna for UWB band and then create notch by using slot step by step like fractal. Optimize the shape and position of slot to control polarization and gain. All the degrees of freedom should be optimized to achieve a multiband operation. The simulation revealed that the resonant frequencies of the antenna were mainly determined by the dimension and position of slot on ground plane (DGS) and on patch (DMS). Moreover, the simulation suggested that the insertion of symmetrical slots at effective place to perturbing the current creates stop band but due to symmetry polarization remain same.

Here antenna is designed at FR-4 Epoxy having board thickness of 0.8mm with length and breadth are 31mm and 20 mm respectively and loss tangent of 0.02. The shape of patch is belcha shape. The patch was a square shaped with side 17mm and angular cut of 45 degree, which makes this square shaped to belcha shaped patch shown in Fig. 1 & Fig. 2 shows back & front view structure of the antenna. All dimensions are tabulated. Ground is finite which has dimension $20 \times 10.45 \text{ mm}^2$. When we simulate this reference antenna on 3-D EM simulator we get a wide band 5.8GHz (3.3 GHz to 9.1 GHz) at two resonance frequencies at 4 GHz and 7.5 GHz. Now on the basis of filter theory and DGS we insert a symmetrical DMS at feed line and on patch along the non-resonating edge. After simulation and optimizations of DMS slot length and DGS on ground we get two stop bands in between the 3.0 GHz to 4.26 GHz. & 7.1 GHz to 7.8 GHz. Antenna has five resonance frequencies 2.9 GHz., 5 GHz., 8.4 GHz., 9.1 GHz., 22.65 GHz.

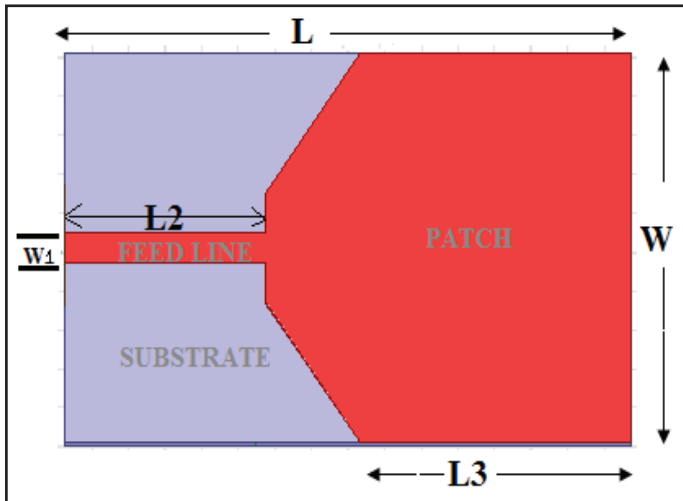


Fig. 1: Front View of reference antenna

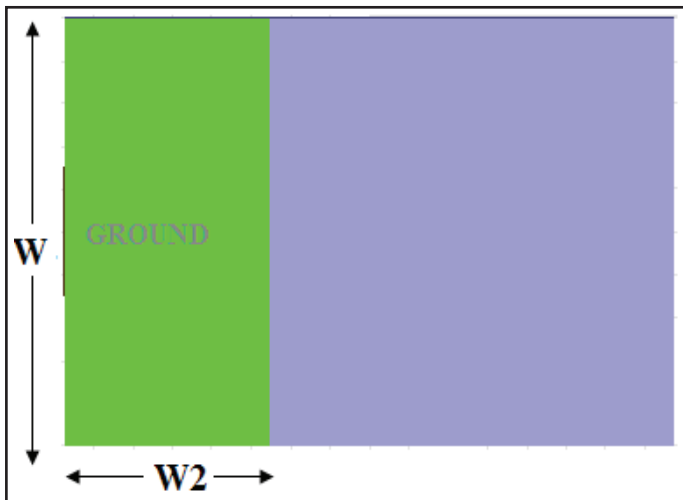


Fig. 2: Back View of Reference Antenna

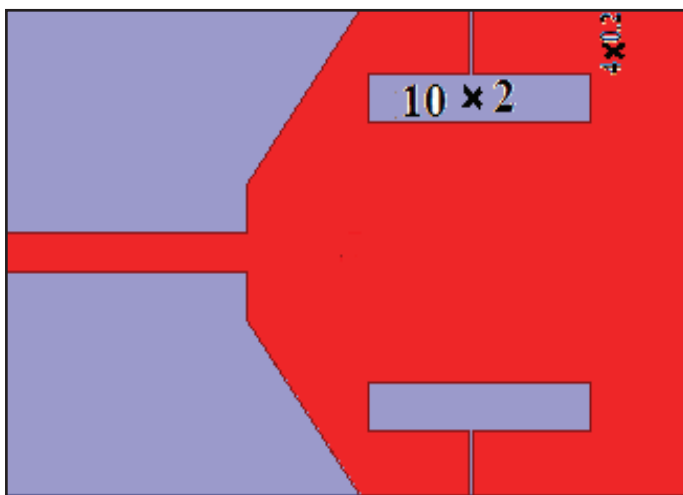


Fig. 3: Front View of Proposed Antenna With Slots

Table 1:

| L | L2 | L3 | W | W1 | W2 | All Units are in mm. |
|----|----|-------|----|-------|-------|----------------------|
| 31 | 14 | 14.85 | 20 | 1.525 | 10.45 | |

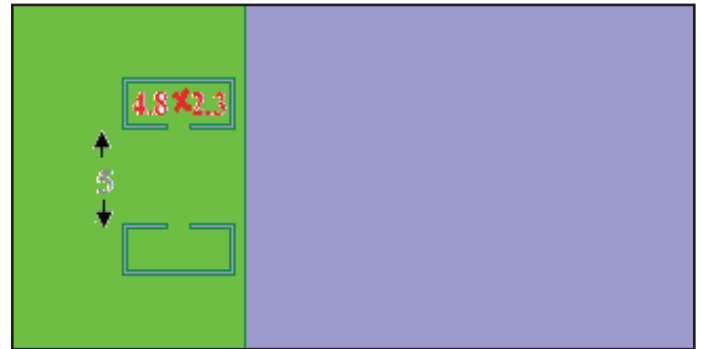


Fig. 4: Back View of Proposed Antenna With DGS Dimension

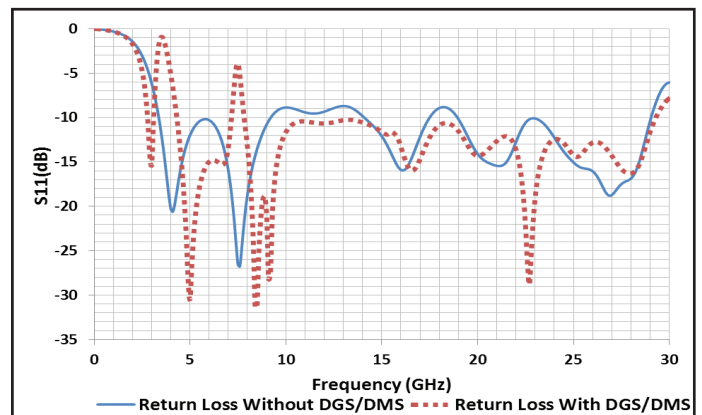
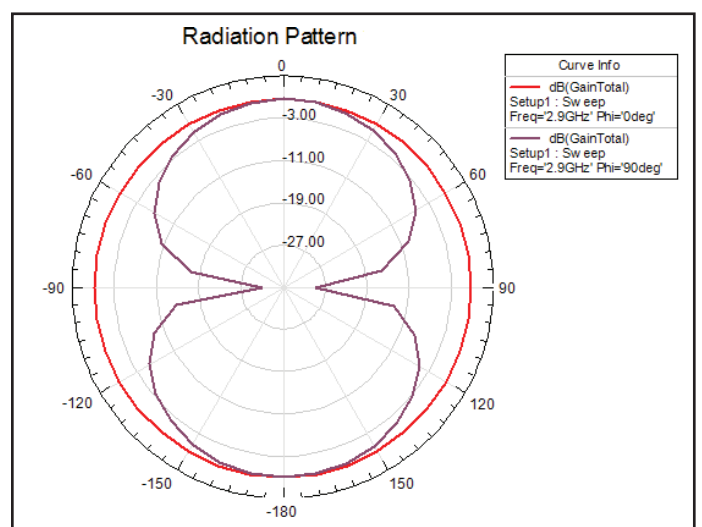


Fig. 5: Return Loss

Table 2:

| | Resonance Frequencies | Band Width |
|-------------------|-----------------------------|-----------------------|
| Reference Antenna | 4 GHz, 7.5 GHz. | 3.3-9.1 GHz = 5.8 GHz |
| Proposed Antenna | 2.9 GHz | 2.7-3.0 = 0.3 GHz |
| | 5 GHz | 4.26-7.1 = 2.84 GHz |
| | 8.4 GHz, 9.1 GHz, 22.65 GHz | 7.8-29.3 = 21.5 GHz |

Here we plot the gain pattern of proposed antenna with slotted DGS /DMS at these five resonance frequencies. There are four pattern look like omnidirectional pattern and fifth at 22.65 GHz is highly selective means fluctuating like in fractal. Gain Pattern Results are tabulated in Table 3



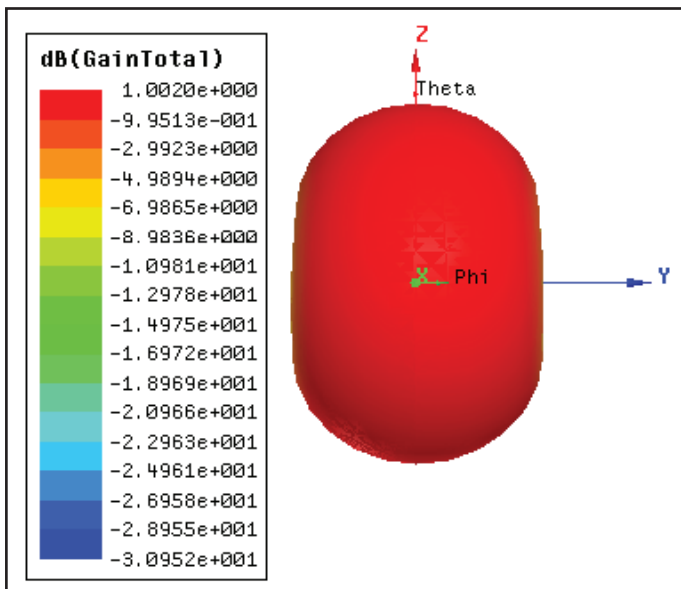


Fig. 6: Polar ($\phi=0^\circ, \phi=90^\circ$) and 3-D plot Gain in dB at Frequency 2.9 GHz of Proposed Antenna

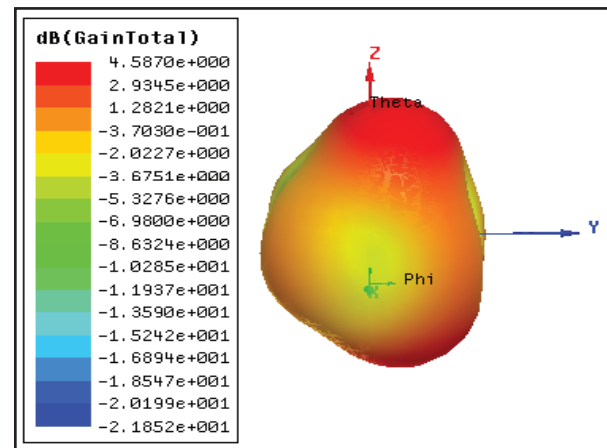
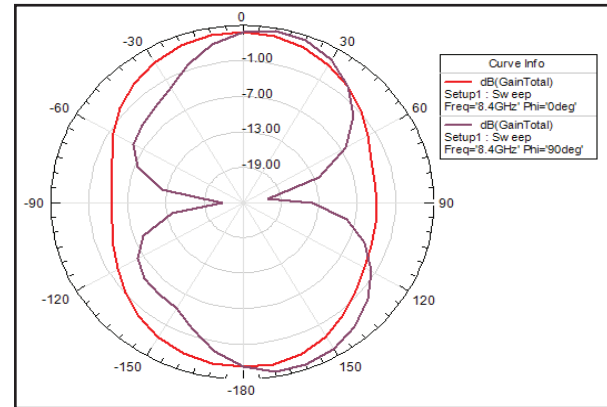


Fig. 8: Polar ($\phi=0^\circ, \phi=90^\circ$) and 3-D Pattern of Gain in dB at Frequency 8.4 GHz of Proposed Antenna

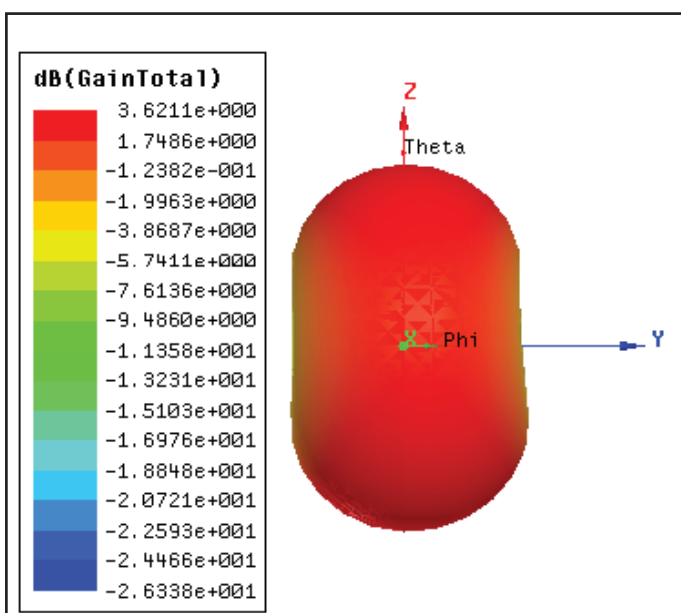
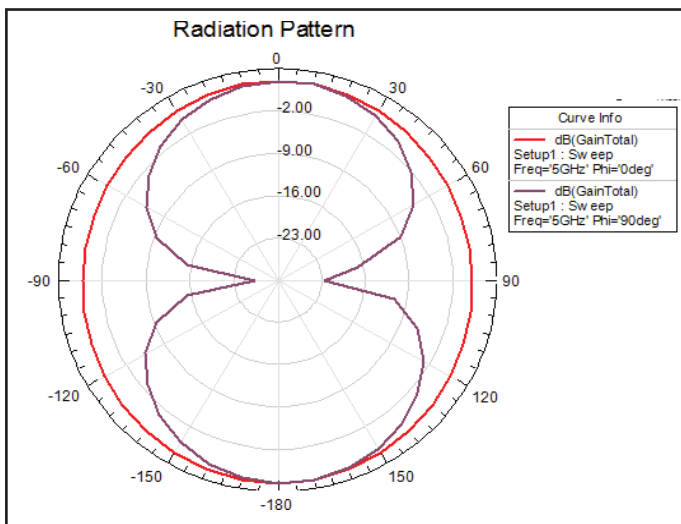


Fig. 7: Polar ($\phi=0^\circ, \phi=90^\circ$) and 3-D Pattern of Gain in dB at Frequency 5 GHz of Proposed Antenna

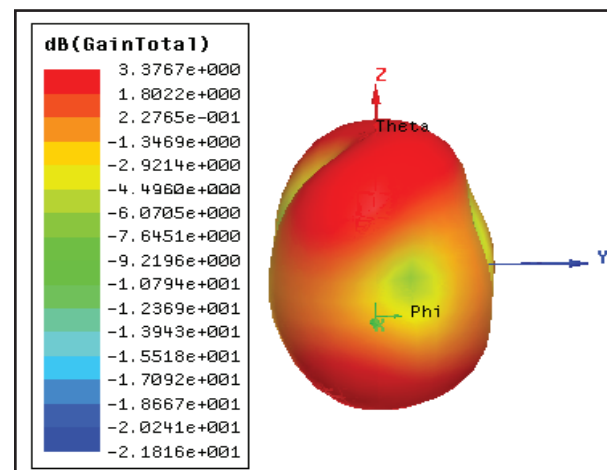
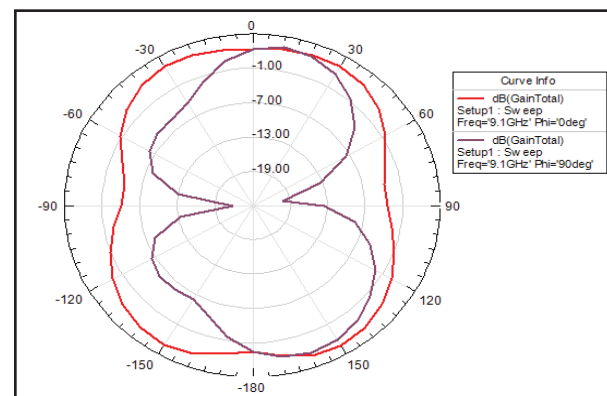


Fig. 9: Polar ($\phi=0^\circ, \phi=90^\circ$) and 3-D pattern of Gain in dB at frequency 9.1 GHz of proposed Antenna

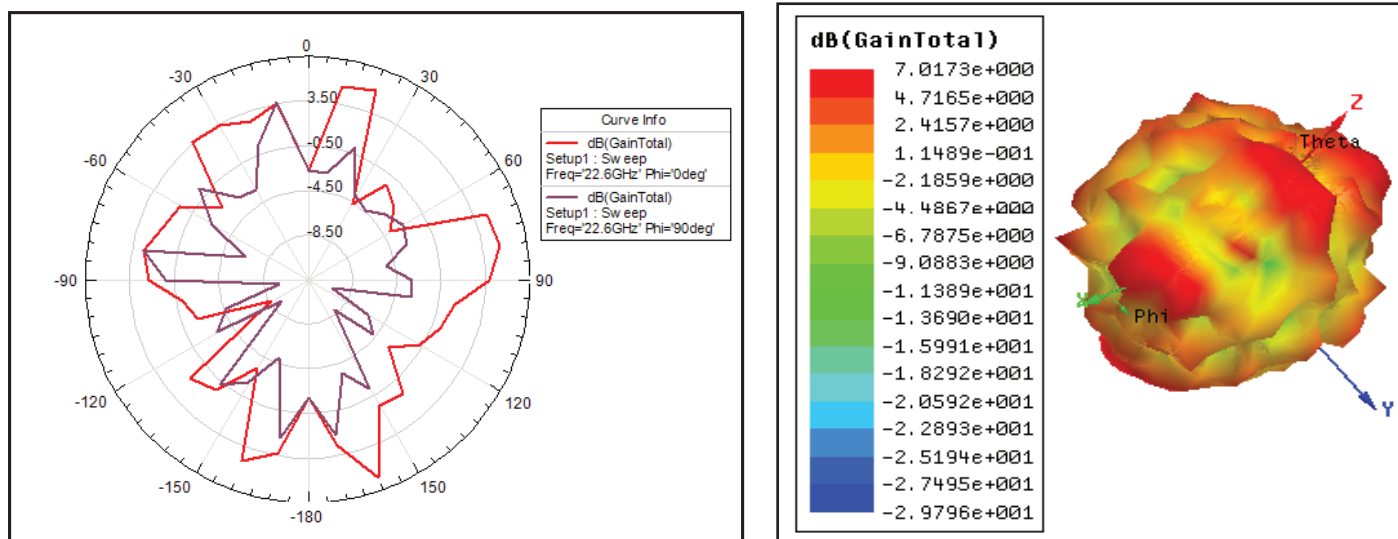


Fig. 10: Polar (phi=0, phi=90 Degree) and 3-D Pattern of Gain in dB at Frequency 22.65 GHz of Proposed Antenna

Table 3:

| Resonance Frequencies (GHz) | Max Gain (dB) | Gain (dB) at $\Phi=0, \Theta=0$ | Gain (dB) at $\Phi=0, \Theta=90$ | Gain (dB) at $\Phi=90, \Theta=0$ | Gain (dB) at $\Phi=90, \Theta=90$ |
|-----------------------------|---|---------------------------------|----------------------------------|----------------------------------|-----------------------------------|
| 2.9 | 1.002 | 1.002 | 1.002 | 1.002 | -28 |
| 5 | 3.6 | 3.6 | 3.6 | 3.6 | -23 |
| 8.4 | 4.7 | 4.13 | -4 | 4.1354 | -21 |
| 9.1 | 3.2 | 2.9 | -3 | 2.7 | -20 |
| 22.65 | 5.6 (at elevation angle $14.8^\circ, 78^\circ, 160^\circ$) | -2 | 4 | -2 | -3 |

III. Conclusion

Here we have successfully design multi band antenna resonating at multi frequencies and created multi notch with respect to reference antenna which makes antenna highly selective operation for S,C band and for wider application in X,KU,K, Ka band by using current perturbation structure like DGS and DMS. The radiation characteristics and pattern is like monopole antenna.

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