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A Novel Triple Band Planar Microstrip Patch Antenna with Defected Ground Structure

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Abstract

Compact multi band and wide band antennas are having numerous applications in the communication operations. Design and implementation of these antennas require simple structure with considerable bandwidth and gain. A Novel Triple band antenna with defected ground structure is proposed in this paper to address the current communication system requirements. Simple square patch with corner truncated defected ground structure is used in this design to achieve the triple band characteristics. The proposed antenna is showing good Impedance, VSWR and radiation characteristics at resonating frequencies.

Keywords: HFSS, Impedance, Microstrip Patch Antenna, Radiation Pattern, VSWR, Wideband

1. Introduction

Nowadays the requirement to operate with multiband or triple band operation, an antenna is essential for merging multi communication system standards in a single compact structure which has been growing for modern mobile, satellite and wireless communication systems. For this requirement low profile, low cost, light weight, easy to fabrication and flexible structure is needed, known as microstrip patch antenna. Due to selectivity for operating frequency, polarization and pattern microstrip patch antennas received great consideration in wireless communication system. Microstrip patch antennas have ground plane on one side of dielectric substrate and radiating patch on the other side. Because of its simple configuration the planner monopole radiating element is suitable for wireless applications which are proposed by various feed structures such as inset fed[1,2], probe fed[3,4] and Coplanar Waveguide (CPW) [5,6]. Due to attractive reasons like easy integration, broad band width and simplest structure with no soldering points, the Coplanar (CPW) antennas have been used in wireless communication[7–9]. However, the difficulty in designing antenna challenges engineers when the size of the antenna reduces[10–12] and the number of operating frequency bands increases.

Today research of Defected Ground Structure[13–15] has attained to an extremely large research significance including antenna performance, improvements of size reduction[16,17], gain enhancement as well as multiband operations[18,19] which stimulate additional resonance modes. Defected ground structure[20,21] is accomplished by etching the ground plane with certain shapes such as circle, dumbbells, concentric ring, V, U, elliptical and spiral shapes which disturb the current distribution[22,23] of the antenna.

In this paper, a small and low-profile microstrip-fed monopole antenna for triple-frequency operation is proposed. The radiating element was modified by loading it with protrudent strips and feeding it with a cross-shaped stripline. In addition, unlike the conventional microstrip-fed antenna prototype using a solid ground plane, in this design the ground was cut out by shaped slots and thus forms a DGS.

2. Antenna Geometry

Figure 1 shows the geometry of DGS monopole antennas. These antennas are designed on duroid substrate with dielectric constant of 2.2 and thickness of 1.6 mm. The

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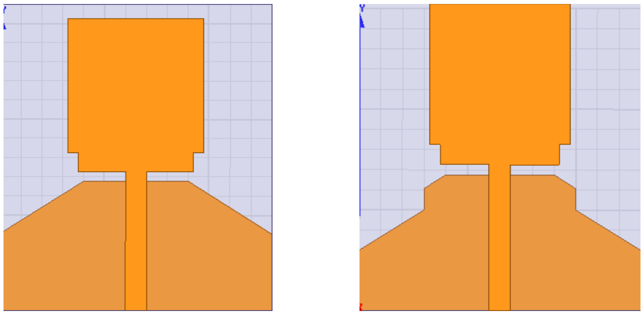

(a) (b)

Figure 1. (**a**) DGS antenna, (**b**) Modified DGS antenna.

radiating element and feeding line are printed on the top side of the substrate and the ground plane on the bottom side. The width of the microstrip feed line is chosen as 2 mm to achieve the characteristic impedance of 50 ohms.

3. Results and Discussion

Return loss is a way to express the reflection coefficient in logarithmic terms (decibels) and it is the number of decibels that the reflected signal is below the incident signal. Figure 2 shows the return loss of the DGS antenna and it is showing dual band characteristics. At fundamental resonant frequency, antenna is showing low bandwidth, but at second resonant frequency, antenna shows large bandwidth of 6.2 GHz. Figure 3 shows the return loss curve of modified DGS antenna with triple band characteristics. Another common term used to express reflection is Voltage Standing Wave Ratio (VSWR), which is defined as the maximum value of the RF envelope over the minimum value of the RF envelope. Figure 4 shows the VSWR of DGS antenna and Figure 5 shows VSWR of modified DGS antenna, which shows 2:1 ratio at resonant frequencies. Figure 6 shows parametric analysis of modified DGS antenna return loss with change on 'g' and Figure 7 parametric analysis of modified DGS antenna VSWR with change on 'g'.

The impedance matching and band width have been controlled by important parameter gap between the radiations patch and ground plane. The patch and the ground plane form an equivalent dipole antenna. The smooth transition from one resonant mode to another, stable gain over a broad frequency range and establish good impedance match by slope ground plane. i.e, Figure 9 and Figure 10 represent the gains of the antennas with and without bevel on the ground plane. The proposed antenna can achieve high gain at low and high frequency with bevel on the ground plane.

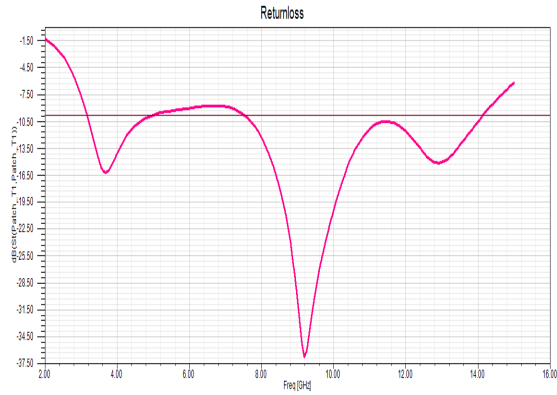

Figure 2. Return loss of DGS antenna.

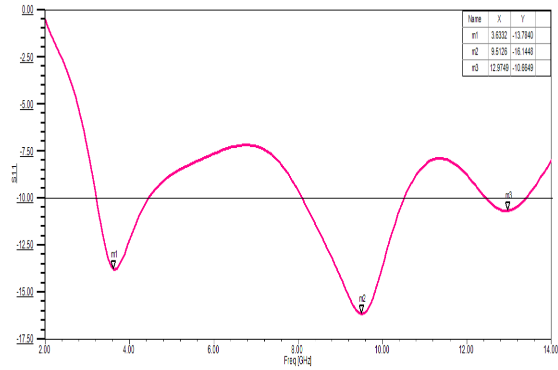

Figure 3. Return loss of modified DGS antenna.

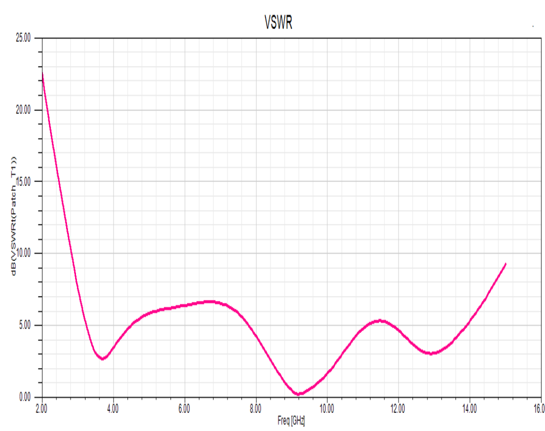

Figure 4. VSWR of DGS antenna.

Figure 8 represent the radiation patterns of the proposed antennas were observed. The observed far-field radiation patterns of the proposed antennas in the E-plane and H-plane at the frequencies of 3.6, 9.5 and 12.9 GHz are plotted in Figure 8. It can be seen that the radiation patterns in the yz-plane are nearly omnidirectional, but

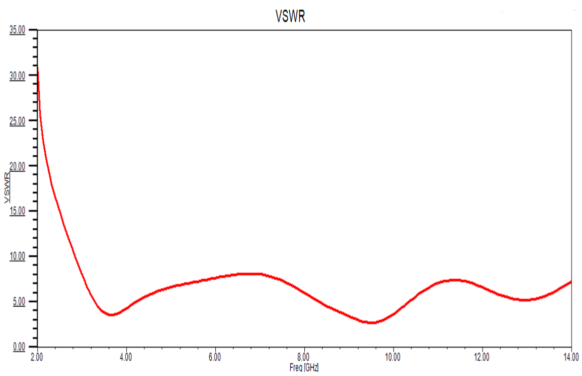

Figure 5. VSWR of modified DGS antenna.

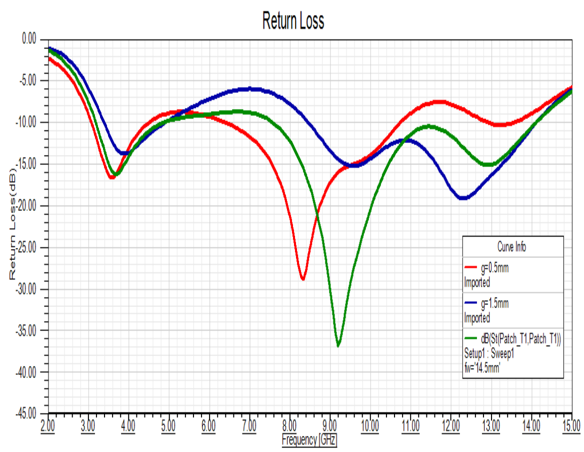

Figure 6. Parametric analysis of modified DGS antenna return loss with change on 'g'.

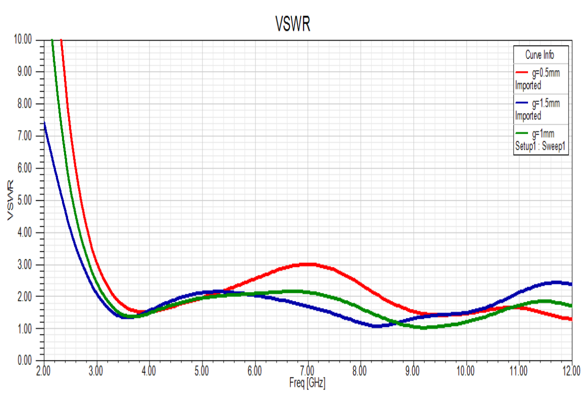

Figure 7. Parametric analysis of modified DGS antenna VSWR with change on 'g'.

more directive in the higher band. The simulated gain of the antennas, from 2 to 12 GHz, is also plotted in Figure 9 and 10. As expected, the gain decreases obviously with increase in the frequency value. The current distribution

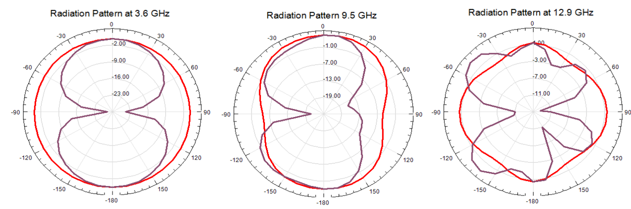

Figure 8. Radiation pattern of modified DGS antenna at 3.6, 9.5 and 12.9 GHz.

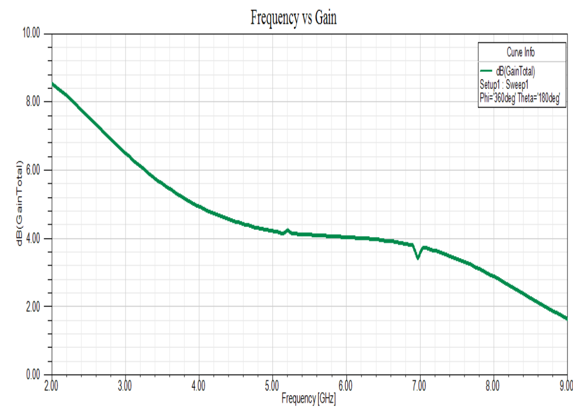

Figure 9. Gain vs. frequency of DGS antenna.

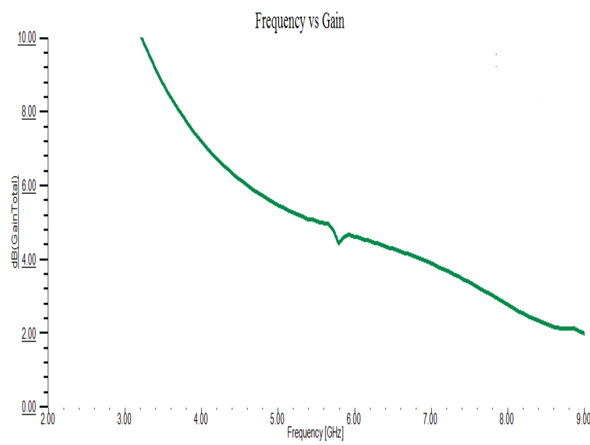

Figure 10. Gain vs. frequency of modified DGS antenna.

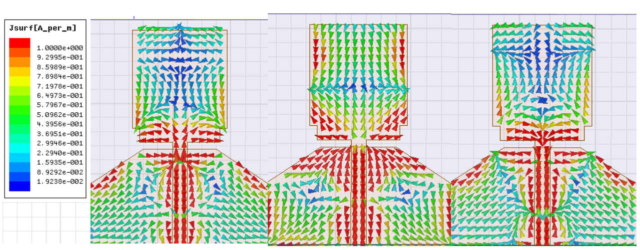

Figure 11. Current distribution of DGS antenna at resonant frequencies.

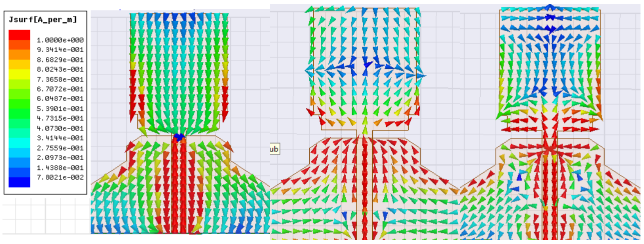

Figure 12. Current distribution of modified DGS antenna at resonant frequencies.

of the antenna models are plotted in Figure 11 and 12 at resonant frequencies. At centre frequency most of the current distribution is focussed on DGS and at other bands it is been observed that current is focussed on feed line and lower part of the patch.

4. Conclusion

A novel compact printed antennas with dual and triple band characteristics used for UWB applications has been presented. Adjusting the gap between the radiation patch and ground plane, a wide impedance bandwidth is achieved. By introducing modified ground in the antenna beside the feed line, gain of the antenna is increased. The radiation pattern of this antenna shows good directional performance throughout the operating frequency range and considerable gain in the UWB band is realized. Accordingly, the proposed modified DGS antenna is expected to be a good candidate in various communication systems at its operating bands.

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