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CSRR Loaded Multi Substrate Antenna for 4G LTE and Wi-MAX Applications

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Abstract

This paper examines the Dual Layer substrate with Dual patch Microstrip antenna (DLDM). Radiation characteristics of dual substrate antenna with active E-shape patch between the substrates and passive complementary strip ring resonator loaded Microstrip Patch Antenna (MPA) is analyzed. Because of this dual layer substrate miniaturization of antenna is reported. Multi band frequency resonance and shift in the resonant frequency is possible with Complementary Split Ring Resonator (CSRR) loaded passive patch. Comparison of normal E-shape patch and DLDM are studied, and results are discussed. This structure provides ~9.0 dBi gain with triple band resonance which can be used for 4G LTE and Wi-MAX wireless LAN applications.

Keywords: 4G, Complementary Split Ring Resonator, E-Shape, LAN, Wi-MAX

1. Introduction

It is recommended to use low profile, low cost, easy to integrate with microwave circuits and miniaturized antenna in general and particular for wireless LAN applications such as Wi-MAX and 4G Long-Term Evolution (LTE)[1-3]. Microstrip Patch Antenna (MPA) with Complementary Split Ring Resonator (CSRR) can provide all above features with limitation of narrow bandwidth. Various techniques have been reported to enhance the bandwidth such as using air as substrate[4] increase in substrate thickness, adding parasitic elements and making slots in patch[5]. Using different shapes of patches such as E-shape[6-8] and U-shape[9] 300-400 MHz band width has been achieved. However these structures are resonant at only single frequency. There is need of a compact antenna with multiband capability with miniaturization.

In this paper a multi band antenna is proposed to design numerically for applications in L- and S- bands with high gain. The antenna is designed with dual layer substrate. A layer of substrate is constituted with two superimposing substrates with different relative dielectric constant. The substrates used herein are FR-4 and Foam whose permittivities (ε_r) are 4.4 and 1.06 respectively. The proposed antenna is designed using Computer Simulation Technology (CST) package software[10]. Here, three antennas are designed and results are compared for suitable applications.

2. Details of Antenna Geometry

The E-shape MPA with only one substrate has been used for wide band applications [3]. It is proposed to design three antennas with single and dual layer substrates with E-shape patch as a feed point in each design. Geometry of proposed design-1 antenna is 'Ls' ×'Ws'× (h1+h2) mm^3 and design parameters of design -2 and -3 are 'Ls' ×'Ws'× 2(h1+h2) mm^3 Table.-1 shows the antenna dimensions for all three designs.

1. Antenna Design-1

Figure 1 shows the E-shape patch *Micro-strip Patch Antenna* (MPA) with foam and FR-4 as substrate.

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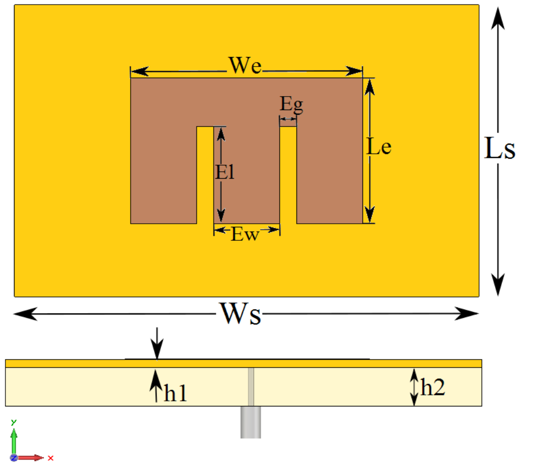


Figure 1. E-shape patch MPA with foam and FR-4 as substrate (Design-1).

2. Antenna Designs-2 and 3

The design-2 composed as top to bottom passive patch(copper) with dimensions 'Lp'×'Wp' mm^2, layer-1(substrate(FR-4) with thickness 'h1', foam with thickness 'h2'), layer-2(substrate(FR-4) with thickness 'h1', foam with thickness 'h2') and ground (copper) shown in Figure 2. Similarly the design-3 is composed as top to bottom, passive patch loaded with CSRR (copper), layer-1, layer-2 and ground as shown in Figure 2.

Table 1. Parameter values

Parameter	Value	Parameter	Value
We	70mm	Ew	20mm
Le	45mm	Wp	45mm
Ws	140mm	Lp	20mm
Ls	90mm	Wpp	45mm
h1	1.6mm	Lpp	20mm
h2	8mm	Spp	21.5mm
Eg	5mm	Bpp	2mm
El	30mm	Gpp	2mm

3. Results and Discussions

The simulation results are presented in this section. The results includes returnloss, Surface Current Distribution (SCD), radiation pattern and 3D gain.

Figure 3 shows the return loss versus frequency for the three designs 1, 2 and 3. It is observed that design-1 has wide band at center frequency 2.25GHz with range of bandwidth from 2.06-2.38GHz. Design-2 has shown wide bandwidth at center frequency 2.15GHz with range from 1.93-2.35GHz respectively. While the design-3 showed resonance at three frequencies 1.13, 1.77 and 2.4GHz. ~250 MHz bandwidth is observed at central frequency 2.4 GHz. However, this design showed poor BW at frequenciews in L-band region.

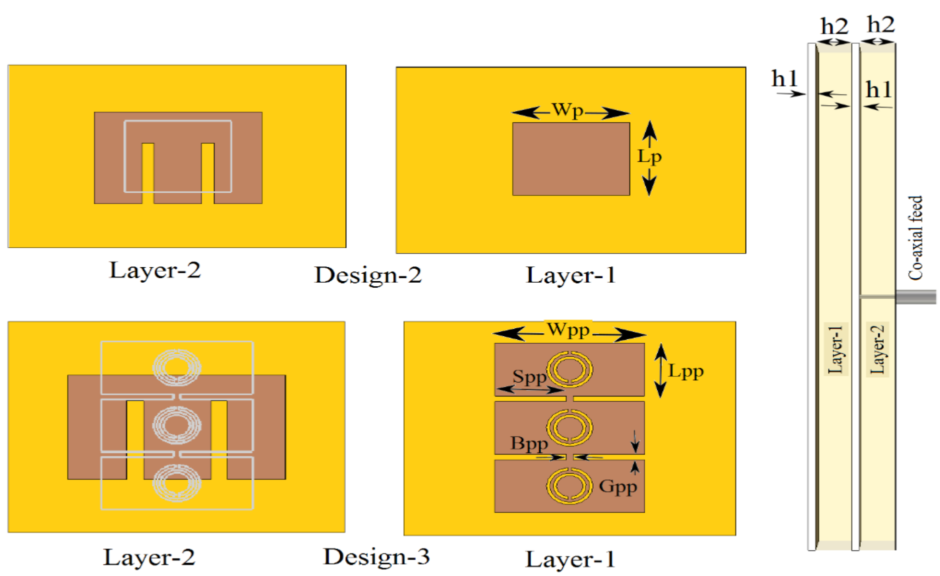


Figure 2. a.Top view of designs 2&3. b. side view of designs 2&3.

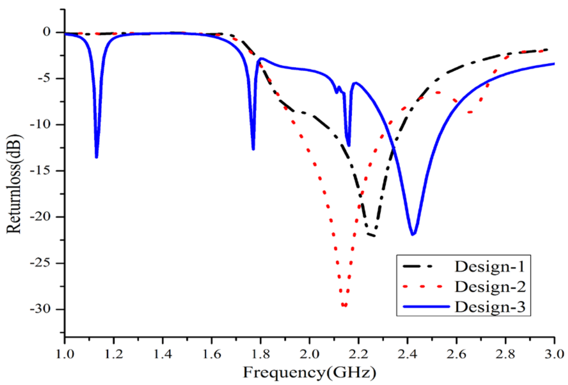


Figure 3. Returnloss comparision between three designs.

1. Analysis of Design-1

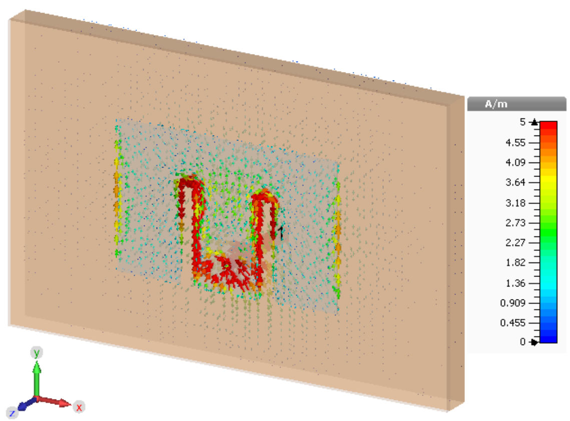


Figure 4. Surface Current Distribution (SCD) of design-1 at frequency 2.25GHz.

The SCD of design-1 antenna at resonant frequency 2.25GHz is shown in Figure 4. Maximum current distribution is observed in the patch especially between the slots in the design-1 which corresponds to the radiation from this section of the patch.

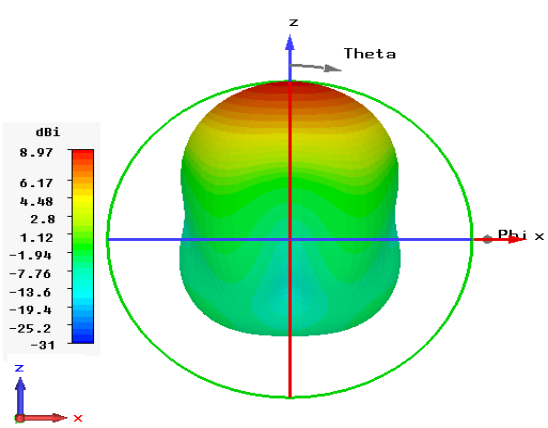


Figure 5. 3D gain of a design-1 at frequency 2.25GHz.

The 3D gain of design-1 is shown in Figure 5. The simulated gain of design-1 is given 8.97dBi at frequency 2.25GHz.

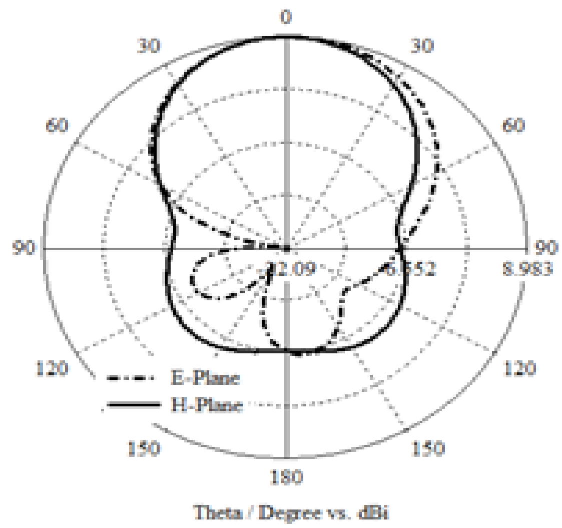


Figure 6. E & H-Plane radiation patterns of design-1 at frequency 2.25GHz.

The radiation pattern in E & H planes for a design-1 at resonance frequency 2.25GHz is shown in Figure 6.

2. Analysis of Design-2

The SCD of design-2 at 2.15 GHz is shown in Figure 7. It is observed that active E-shape patch is coupling with the passive patch.

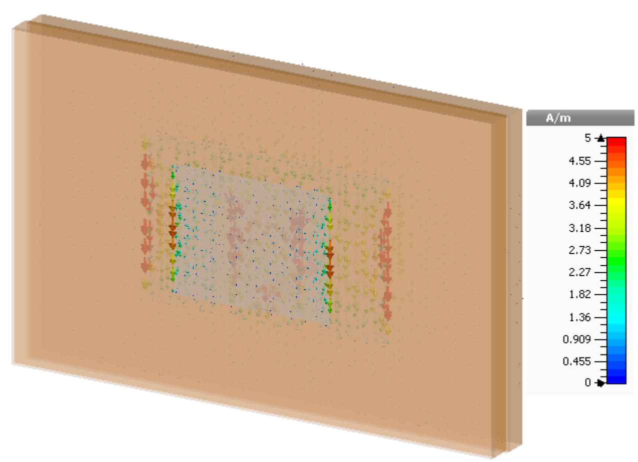


Figure 7. SCD of design-2 at frequency 2.15GHz.

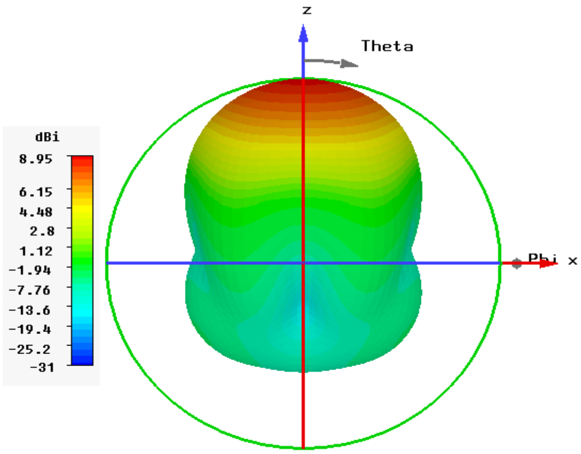


Figure 8. 3D gain at frequency 2.15GHz of a design-2.

The 3D gain of design-2 is shown in Figure 8. The simulted gain for design-2 is as much as 8.95dBi at frequency 2.15GHz.

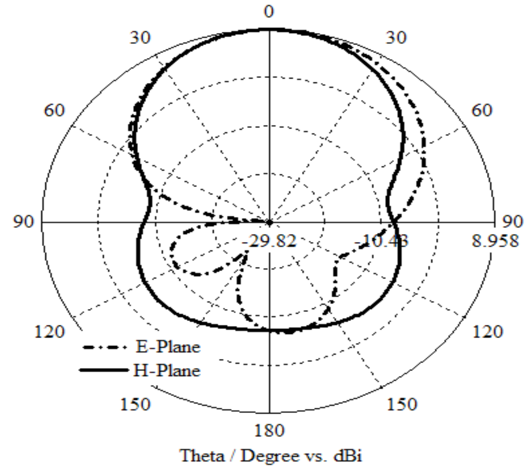
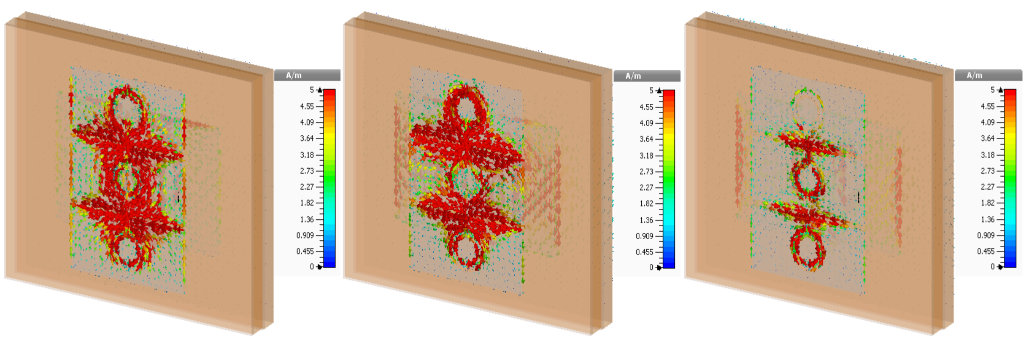


Figure 9. E & H-Plane radiation patterns of design-2 at frequency 2.15GHz.

The radiation properties of design-2 at frequency 2.15GHz is shown in Figure 9.



(a) (b) (c)

Figure 10. SCD's of design-3 at frequencies a. 1.13, b. 1.77 and c. 2.4GHz.

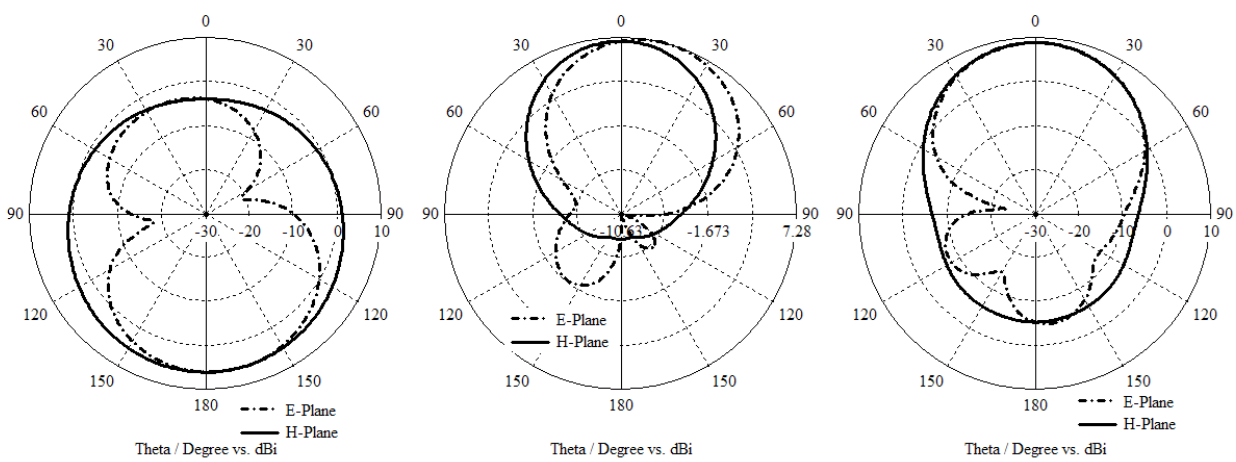


Figure 11. E & H-Plane radiation patterns of design-3 at frequencies a.1.13, b. 1.77 and c. 2.4GHz.

3. Analysis of Design-3

Design-3 has three CSRR structures on the passive patch. The SCD of design-3 is shown in Figure 10 at three frequencies. It is observed that SCD is maximum at the CSRR structure at respective three frequencies. The gain of all three frequencies 1.13, 1.77 and 2.4GHz are 4.2, 7.28 & 9.01dBi. This is high gain that can be observed from a low profile MPA.

Figure 11a, b and c shows the normalized fields patterns in E-and H- planes at 1.13, 1.77 and 2.4GHz respectively.

4. Conclusion

A multiband multi-layer substrate antenna with E-shape active patch CSRR antenna has been designed for 4G LTE and WiMAX wireless LAN applications. By incorporating CSRR in design-3 it was observed design-3 resonanted at three frequencies 1.13, 1.77 and 2.4GHz with gains as much as 4.2, 7.28 and 9.01dBi. ~250 MHz bandwidth was observed at central frequency 2.4 GHz. It has covered frequencies in L and S-bands.

5. Acknowledgment

The simulation work has been carried out at the Microwave lab, School of Electronics Engineering (SENSE), VIT University, Vellore, Tamil Nadu, and India.

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