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Rectangular Dual Band Microstrip Patch Antenna with Defected Ground Plane Using CST STUDIO

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Abstract: The rectangular dual-band microstrip patch antenna with defected ground plane for wireless communications that operates at 2.4-3.5 GHz. The antenna incorporates a rectangular patch with slot. The dielectric substrate used for antenna is RT Duroid 5880. According to position of etched slot are determined using parametric such as s-parameters and radiation pattern are simulated. The analyses are performed using CST STUDIO SUITE 2019.
Keywords: Misrostrip Antenna, Defected Ground Plane, Dual Band.

I. INTRODUCTION

There are some emerging challenges, along with the rapid development of application in wireless communication. To meet the requirement of a suitable antenna has become a big challenge in wireless communication. The microstrip patch antenna is very suitable for wireless applications due to its simple design because of its simple design, various shapes of geometries, ease of mounting, and flexibility with microwave and millimeter wave integrated circuit (MMICs) [1]. Microstrip patch antenna are an active research topic to seek solutions to narrow bandwidth, low efficiency, and poor performance [2]. A typical microstrip patch antennas oscillates in a single band. However, modern wireless communications require antenna hat can operate in multiple frequency bands. 1575.42/1227.60/1176.45MHz for Global Positioning System (GSM), 900/1800MHz for Global System for Mobile Communications(GSM), 2.4/5.2/5.8GHz for Wireless Local Area Network(WLAN), interoperability 2.5/3.5/5.5 GHz Microwave Access (Wi MAX) FOR 700/2300/2600 MHz for Long Term Evolution (LTE) [3-4].

Multiband wireless communication is considering using multiband antenna instead of broadband antenna. This is because while a broadband antenna meets the bandwidth requirements for the desired frequency band, it also. This approach increases the cost and complexity of the receiver unwanted signals in unwanted bands. Since the system works only in certain band, the receiver must use high-order filters to extract and remove the desired frequency band wasted frequency band. This approach increases receiver cost and complexity. Therefore, consider a multiband antenna and design the antenna for wide bandwidth and good gain on the desired band to meet your system requirements. Specifically, we modify a rectangular microstrip patch antenna with a flawed ground plane technique for 5.5/3.5 GHz dual-band operation. Monopole antennas and antennas with a monopole like radiation pattern. The reasons for choosing the rectangular microstrip patch antenna are its popularity, and ease of construction and calibration [2].

The performance of patch antennas also depends on the form of feed technology and various techniques such as lots in the patch, different geometries, and DGS [5]. Techniques such as etching slots from the radiating element, tapered structures fed by coplanar waveguides, integration of metallic materials with antennas, capacitive coupling patches, and multi-layer structures have been proposed [6]. However, these techniques deal with radiation spot modification and hardly achieve the bandwidth requirements of multi-band systems. Another technique, known as the flawed ground plane technique, is to change the ground plane of the radiating patch to meet multiband requirements. Ground plane defect techniques generally produce greater bandwidth compared to radiating patch repair techniques. This is because in the latter, slot etching creates imperfections in the ground plane of the radiating patch, leading to perturbations in the shield current distribution. As a result, the effective inductance and capacitance of the transmission line and the input impedance increase [7].

II. METHOD OF ANALYSIS

To design a microstrip patch antenna, choose the resonant frequency and permittivity for which the antenna is designed. The substrate used for the microstrip patch antenna is RT, 5880 with dimensions 96 × 96 mm^2 with height h= 1.6 mm^2, dielectric constant εr =2.2, and loss tangent tan δ=0.0009. The parameters to be calculated as,

A. *Width (W)*

The width of patch can be calculated by following equation [13].

$$w = \frac{c}{2f_0}\sqrt{\frac{2}{E+1}}. \qquad (1)$$

Where,
W= Wide of the patch,
c= speed of light
E=dielectric constant.

B. *Effective Refractive Index*

The effective refractive index value of the patch is an important parameter in the design process of microstrip patch antennas. Radiation emitted from the patch toward the ground propagates through the air and passes slightly through the substrate [13].

$$E_{reff} = \frac{(E+1)}{2} + \frac{(E-1)}{2} * \left[1 + \frac{12h}{w}\right]^{-\frac{1}{2}}. \qquad (2)$$

C. *Length*

Because of the fringing, the size of the antenna is increased by electrically [13].

$$\Delta L = 0.412.h\frac{(E_{reff}+0.3)\left(\frac{w}{h}+0.264\right)}{(E_{reff}+0.258)\left(\frac{w}{h}+0.8\right)}. \qquad (3)$$

Where, '*h*' =height of the substrate.

The length (L) of the patch is now to be calculated using the equation.

$$L_{reff} = \frac{c}{2f\sqrt{E_{reff}}}. \qquad (4)$$

$$L = L_{reff} - 2\Delta L. \qquad (5)$$

D. *Resonant Input Resistance*

Resonant input resistance R_{in} at distance $y=y_0$ from the edge the inset feed line [12].

$$R_{in}(y=y_0) = R_{in}(y=0) \bullet \cos^2\left(\pi\frac{y_0}{L}\right). \qquad (6)$$

All the parameters required for designing dual-band microstrip rectangular patch antenna are given in below table 1.

Sr	List of Parameter	Value
1	Ground plane length(L_G)	96.00 mm
2	Ground plane width(WG)	96.00mm
3	Patch length(L)	39.67mm
4	Patch width (W)	47.42mm
5	Feed line(W_0)	4.852mm
6	Gap of Inset feed (IFG)	2.426mm
7	Distance from the edge(DFE)	34.00mm
8	Distance between slot(DBS)	25.25mm
9	Inset feed distance(IFD)	6.500mm

10	Slot A Length(L_{SA})	78.00mm
11	Slot A Width(W_{SA})	16.00mm
12	Slot B_1 length (L_{SB1})	33.00mm
13	Slot B_1 Width(W_{SB1})	16.00mm
14	Slot B_2 Length(L_{SB2})	33.00mm
15	Slot B_2 Width(L_{SB2})	16.00mm
16	Distance between slot B_1 and slot B_2 (DBS(B_1,B_2))	12.00mm

Table 1. Dimensions of Designing the Microstrip Antenna

III.DESIGN AND DISCUSSIONS

The schematic of the is shown in rectangular microstrip patch antenna Fig. 1. 2.5 GHz Single band and Fig. 2. dual-band. There are two slots on the ground plane for dual-band operation. They are named as slot A and slot B is divided into two slot named as slot B1 and slot B2 as shown in Fig.2. Creating an etching of slot in the ground plane for radiating patches that disturbs the shield current distribution in the ground.

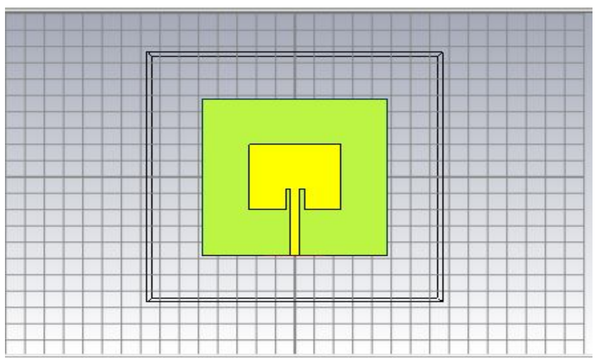

Fig 1. Single-band microstrip patch antenna.

This disturbance affects the input impedance and capacitance of the transmission line [7]. The etching of slot from the ground plane increases the bandwidth [10]. When etching slot in the ground plane, many parameters need to be investigated for dual-band (2.5-3.5 GHz). Frequency tuning is to be needed for achieving the specified resonant frequency. The concept of two slot on the patch for frequency tuning. Parameters such as distance from the edge (DFE), inset feed distance (IFD), and distance between slot (DBS) are tuned dual-band operation. The antenna is simulated in CST STUDIO SUITE 2019.

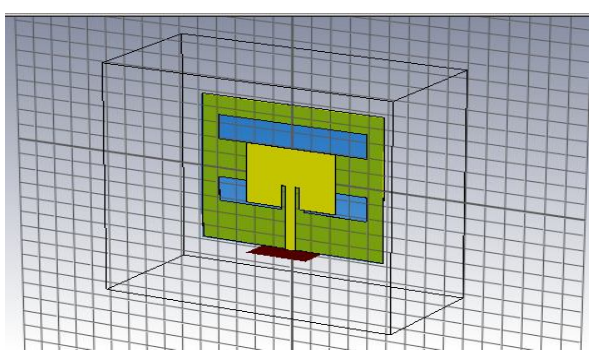

Fig 2. Microstrip patch antenna dual-band.

A. Effect that Change the Distance from the Edge (DFE)

All parameter values are in Table and the value of IFD=12.5 mm from single band patch antenna, for the dual-band resonance is see when DBS=21.5 mm and DFE=40mm as shown Fig. 3 (a) the effects of all parameter of IFD, DBS, and DFE on dual-band resonance separated, as DFE is changed from 40mm to 33mm at same time IFD and DBS is unchanged it fixed on same values.

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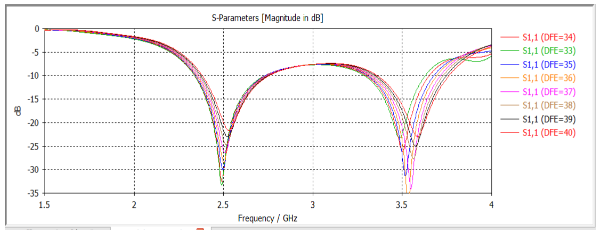

Fig 3. Return loss (a) DFE.

At DBS frequency f_{r1} is changes from 1.77 GHz to 1.8 GHz and f_{r2} change from 3.65 GHz to 3.93 GHz with different return loss. At the same time when DFE =34 mm, f_{r1} is -12.23 dB return loss at 1.82 GHz return loss at f_{r2} is -8.75dB return loss 3.72GHz.

B. Effects that Change the Distance Between slots (DBS).

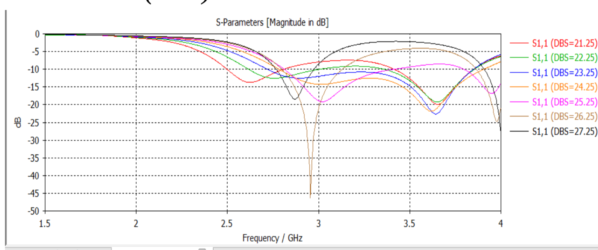

Fig 3(b). DBS.

When DFE=34 mm and IFD=12.5mm, same time DBS is changed from 21.25 mm to 27.25 mm at the same time. As shown in Fig.3(b) f_{r1} is changes from 1.81 GHz to 2.48GHz and f_{r2} changes from 3.664 GHz to 3.91GHz for different DBS values. Then fr_1 has a return loss of -5.8 dB at 2.40GHz and fr_2 has a return loss of -22 dB at 3.68 GHz when DBS=25.25 mm.

C. Effects that Change the Inset Feed Distance (IFD).

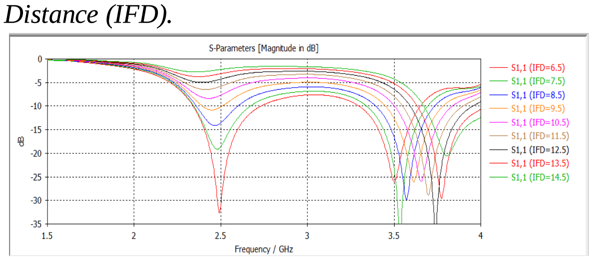

Fig 3(c). IFD.

When DFE=34 mm and DBS= 25.25 mm, IFD is change from 14.55 mm to 6.5 mm. As shown in Fig.3 (c) frequency f_{r1} is change from 2.38 GHz to a return loss 2.50 GHz. IFD is 6.5 mm, then fr_1 is -25.45 dB return loss 2.50 GHz and f_{r2} is -23.2 dB return loss at 3.50GHz.

IV. RESULTS OF ANTENNA

To overcome these major problems, the need of a suspension seats system arises as the driver sit on a scissor-type frame that provides up-and-down travel to cushion the driver over speed breaker and also in uneven roads.

A. Single-Band Antenna.

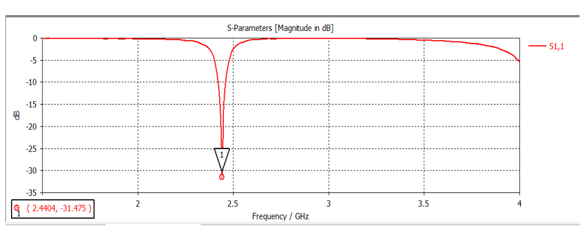

Fig 4. Microstrip patch antenna of single-band (a) Return loss.

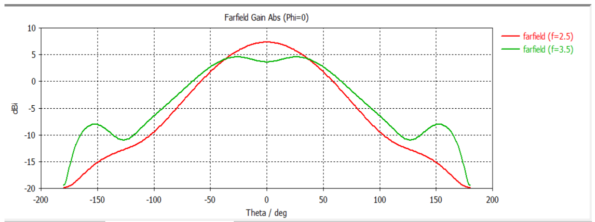

Fig 4(b). Rectangular plot in E-plane and H-plane.

Fig. 4(a). is a single-band patch antenna return loss. The best antenna-to- feed line match is -24.5dB at 2.5GHz. The -10dB bandwidth is the same at the center frequency of 2.5GHz. Fig. 4(b). is the 2-D radiation pattern in E and H planes of the rectangular diagram. The maximum gain for single-band antenna is 7.8dB at θ=0°.

B. Dual-Band Antenna.

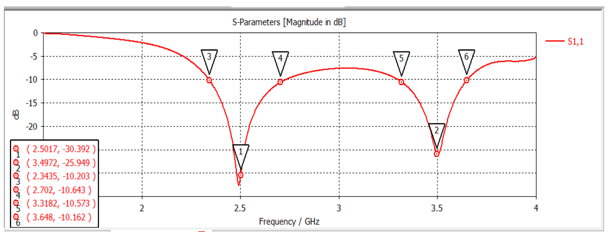

Fig 5(a). Return loss

Fig.5 (a). shows the measured and simulated dual-band patch antenna. The properties of the proposed antenna were b simulated by using of CST STUDIO SUITE 2019. The peak gain measured over the frequency range 2.7 – 3.3GHz for the proposed antenna. All parameters are tabulated for the final design. The -10dB bandwidth is the same for 339.4MHz with center frequency f_{r1}=2.5GHz and 362.5MHz with center frequency f_{r2} =3.5GHz.

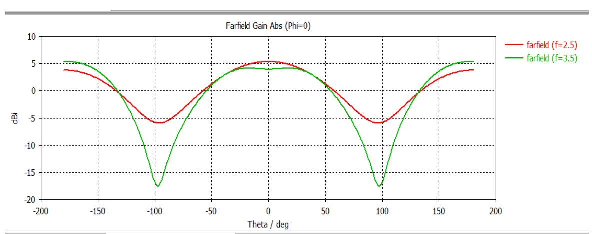

Fig 5(b). Rectangular plot of gain in E-pane.

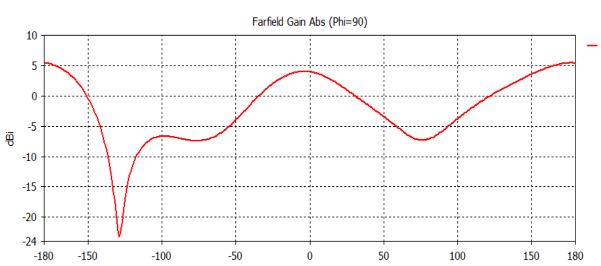

Fig 5(c). Rectangular plot of gain in H-plane.

The 2-D radiation pattern in E-plane and H-plane in rectangular diagram are shown in Fig.5 (b). and Fig.5(c). At 2.5 GHz, 6.7dB is maximum gain, at 3.5 GHz, 5.1 dB is maximum E-plane gain. At 2.5 GHz, 6.5dB and 3.5 GHz, 4.88dB is maximum H-plane gain.

V. CONCLUSIONS

About results, we can be concluding that, better result was obtained with the proposed defected ground plane, and we also observed an improvement in bandwidth compared to this standard microstrip antenna. A two-band resonance is obtained by etching a slot out of the ground plane. The antenna exhibits dual-band nature in the frequency band 2.7 to 3.3 GHz.

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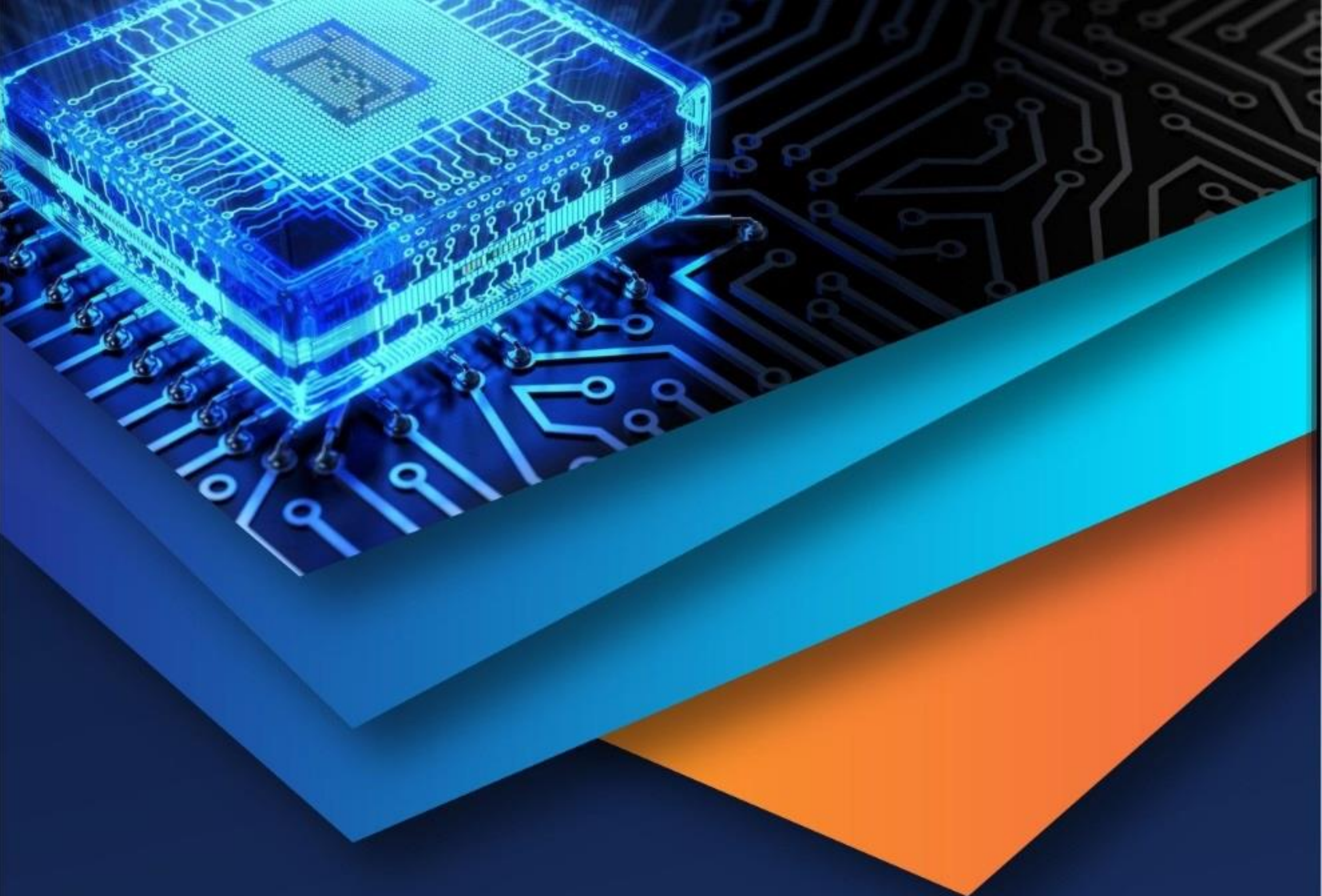

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