Three Notch Multilayer Antenna for C-Band Applications

Sonal Trivedi

PG Student's NIIST Bhopal

Rajeev Thakur

Asst Prof NIIST
Bhopal

Saket Pandey

Asst Prof NIIST
Bhopal

ABSTRACT

A three notch multilayer antenna for C-Band applications is presented in this paper. The proposed antenna is composed of a FR-4 and air gap Dielectric material, By introducing the two parts, the impedance bandwidth of the antenna can be significantly enhanced. Analysis done with ground plan. Simulation results show that the proposed antenna can operate from 3.2GHz to 4.8 GHz with low VSWRs $\leq$ 2. Stable antenna gain (dB) is also achieved over the entire operating frequency band. Furthermore, the size of the proposed antenna is very compact, which is only at the centre of the operating frequency band.

Keywords

Broadband antenna, L-Slot, Radom, miniaturized antenna, square slot, C-Band.

1. INTRODUCTION

A variety of broadband techniques have been developed using the three approaches categorized. It is known that the factors affecting the bandwidth of a microstrip patch antenna are primarily the shape of the radiator, the feeding scheme, the substrate and the arrangements of radiating and parasitic elements. Essentially, the broad bandwidth of a microstrip patch antenna can be attributed to its low Q value and simultaneously well excited multiple resonances. If the antenna is considered as a high-Q filter, lowering the Q by reducing the energy around the radiator or increasing losses broadens the bandwidth at its resonance. Alternatively, by inserting a broadband impedance network between the antenna and the feeder, good matching over a broad frequency range can be attained. If two or more adjacent modes are well excited simultaneously, the bandwidth can be twice or more than that for the single resonance. microstrip patch antenna having a larger sphere suffers from a narrow bandwidth as the whole volume of the enclosing sphere is not utilized effectively .Therefore, a microstrip patch antenna can be considered as a high-Q circuit, so one way to alleviate the narrow bandwidth problem is to reduce the Q. Investigations have shown that the shape of a radiator affects the impedance bandwidth, even for the same maximum dimensions. However, the improvement in the bandwidth is quite limited.[7]-[9].The shape of a radiator, which affects the operating modes is critical for its radiation performance. Therefore, this technique is hardly employed in practical designs [26]. As an alternative, a thick substrate with low dielectric constant is good for improving the impedance bandwidth of these antennas.[7][27–34].

This monotonically reduces the Q and broadens the bandwidth. Another important consideration is the increase in losses due to undesired surface waves, which lowers the radiation efficiency, excites spurious radiations, and degrades the radiation patterns. Investigations have shown that the impedance bandwidth monotonically increases with the substrate thickness while radiation efficiency rapidly decreases [7]. However, the achievable bandwidth will decrease when the thickness exceeds a certain value

2. ANTENNA DESIGN AND CONFIGURATION

The proposed design analyses with and without ground plan, analyses done by considering the effect of ground plan for enhancing bandwidth

2.1 Antenna Design without Airgap

The configuration of the proposed antenna is shown in Fig.1. The antenna is analyzed and optimized by IE3DTM software. The proposed antenna is composed of a FR-4 and air gap Dielectric material, The dimensions of design at 5 GHz are

Top layer dimension is

L=17.77mm, W=20 mm

Middle layer dimension is

Bottom layer consists with ground plan, in first geometry analyses proposed design with effect of ground plan of dimension Lg = 26.77mm, Wg = 31mm. In second design analysis proposed antenna with multilayer combination FR-4-Air - FR-4 consideration of effect of ground plan. Air gap is used for protection of radiation of antenna from atmospheric obstacle and radiation of other object

In fig 1 depicts Proposed Design Antenna with Ground Plan, in fig 2 depicts multilayer with ground plane.

2.2 Numerical Analysis:

The main objective of antenna analysis is to calculate all radiation characteristic of antenna. It is simple and possible to provide the proposed accuracy for impedance and radiation properties. There are three types of model available for analysis of antenna:

The Transmission line model.

The Cavity model.

The Full – wave model.

Equivalent dielectric constant for combination of two dielectrics can be calculated as:

$$\varepsilon_{eq} = \frac{\varepsilon_{r1}\varepsilon_{r2}(h_1 + h_2)}{\varepsilon_{r1}\varepsilon_{r2}h_1 + (h_1 + h_2)}$$

Generally, the relationship of width (W), height (h), effective dielectric constant and relative dielectric constant of substrate is given as follow:

$$\varepsilon_{reff} = \frac{\varepsilon_r + 1}{2} + \frac{\varepsilon_r - 1}{2}[1 + 12\frac{h}{w}]^{\frac{1}{2}}$$

The dimensions of patch along its length have now been extended on each end by the a distance ΔL, given by:

$$\Delta L = \frac{0.412h(\varepsilon_{reff} + 0.3)(\frac{w}{h} + 0.264)}{(\varepsilon_{reff} - 0.258)(\frac{w}{h} + 0.8)}$$

Since the effective length of the patch has been extended on both side by ΔL, the effective length is given by:

$$L = L_{eff} - 2\Delta L$$

For the effective radiation the design of the structure is the important aspect and for this width is calculated as:

$$w = \frac{c}{2f_0\sqrt{\frac{\varepsilon_r + 1}{2}}}$$
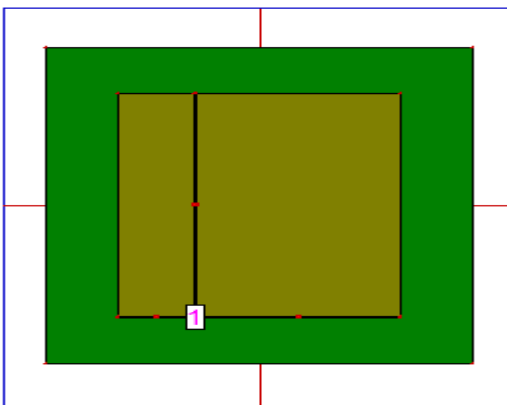
2.3 Basic design

Figure 1 Proposed Multilayer Antenna Design

2.4 Antenna Design with Air gap and multilayer
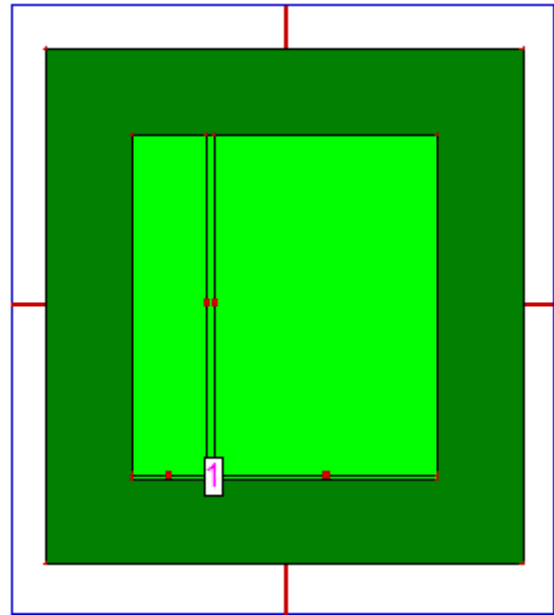

Figure 2 Antenna Design with Multilayer layer

In fig 2 depicts Antenna Design with multilayer and airgap.

3. RESUTS AND DISCUSSION
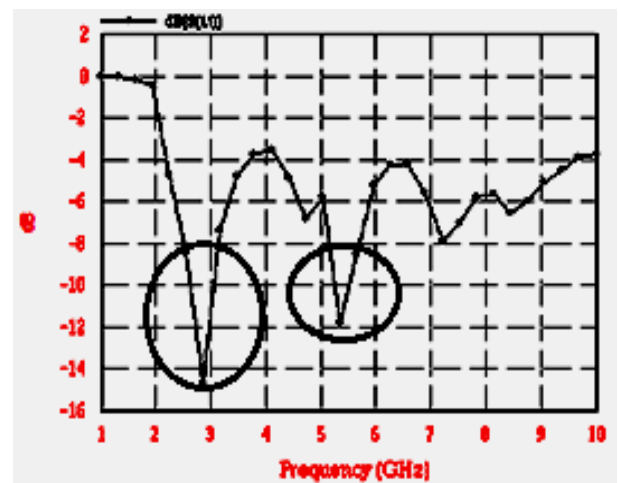### 3.1 Antenna Design with Ground plan

Figure 3 Return loss Vs Frequency

Fig 3 depicts Return loss of proposed design with respect to frequency. Firstly designed conventional design on IE3D Simulator, after simulation we found that reflection at 3GHz is low, return loss obtain up to -15dB, and -12dB, obtain at frequency 5.5GHz. This is a theoretical design with respect to centre frequency but with respect to standard system results cannot be useable.

For effective useable design, required good impedance matching, for providing good impedance matching, used multilayer concept with air-gap. The appropriate dimension of ground plan is found using transmission line theory. The multilayer FR-4-Air-FR-4 Stack geometry discuss in section 3.2.
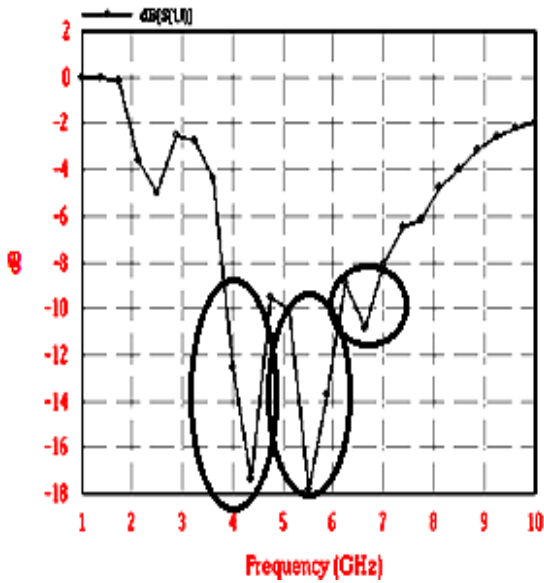
3.2 Microstrip Multilayer Patch Antenna

Figure 4 Return loss Vs Frequency

Fig 4 depicts Return loss of proposed design with respect to frequency. The proposed design on IE3D Simulator, after simulation found three notches in fig 4, notches exists at 4.5GHz with 10% impedance bandwidth, at 5.GHz with 12% impedance bandwidth and 6.5GHz, that reflection at 4.5GHz is low, return loss obtain up to -17.5dB, and -18dB obtain at frequency 5.5GHz. This is a proposed design with respect to centre frequency and applicable for C-Band application.
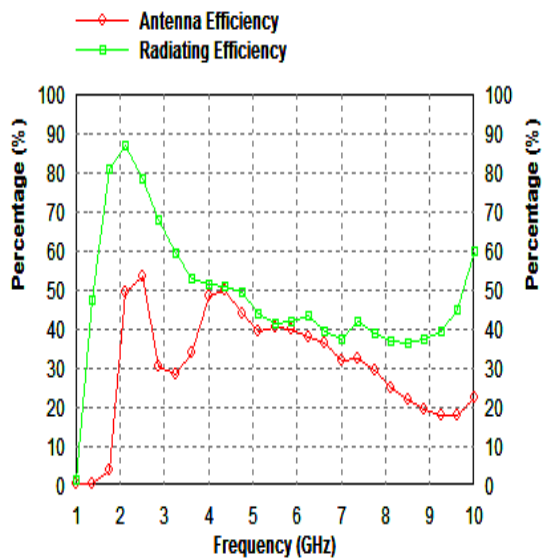

Figure 5 Efficiency Vs frequency

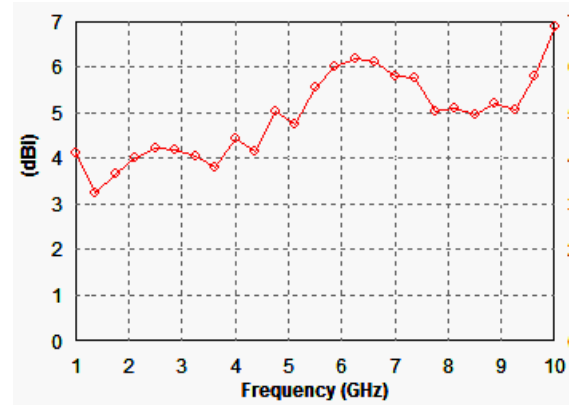Fig 5 shows radiating and antenna efficiency for proposed design.

Figure 6 Directivity Vs Frequency

Fig 6 represents directive gain of antenna, obtain directivity up to 5.5dBi.
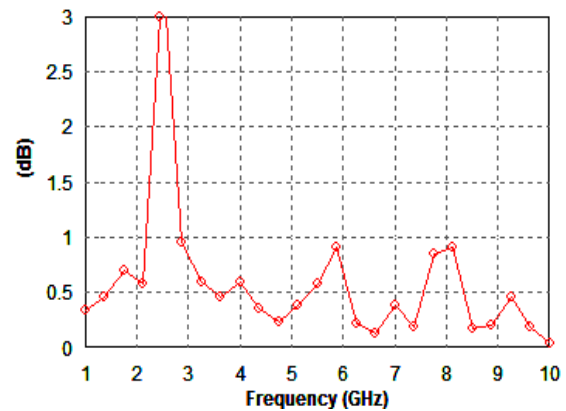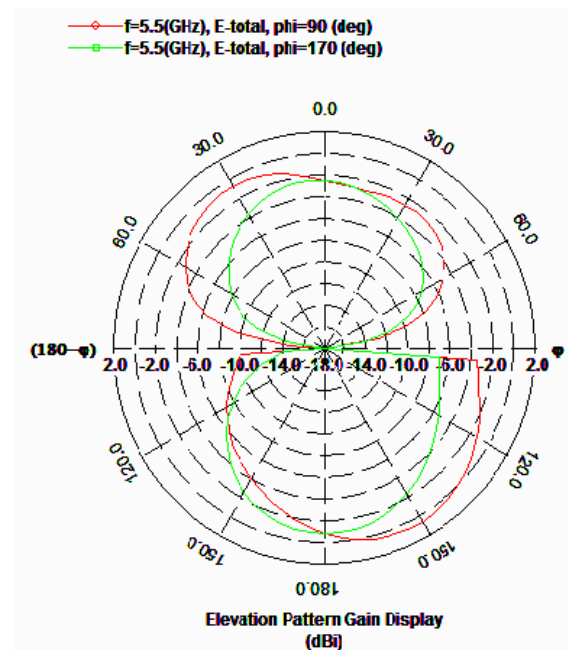

Figure 7 Axial Ratio Vs Frequency

Figure 8 Elevation pattern at 5.5GHz

Fig 7 represents polarization of antenna, for all three notches 4.5GHz,5.5GHz and 6.5GHz axial ratio is less 1dB, So that antenna is circular polarized
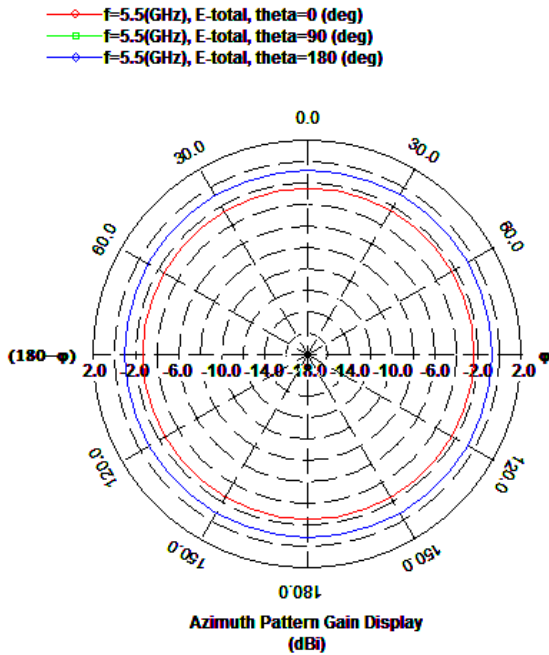
- ← f=5.5(GHz), E-total, theta=0 (deg)
- ← f=5.5(GHz), E-total, theta=90 (deg)
- ← f=5.5(GHz), E-total, theta=180 (deg)

Azimuth Pattern Gain Display (dBi)

Figure 9 Azimuth pattern at 5.5 GHz

In fig 8&9 , depicts   elevation and azimuth pattern for proposed design with ground plan, in table summarized all results.

Table 1 Result Summary

Frequency	5.5 (GHz)
Input Power	0.00983777 (W)
Radiated Power	0.0040479 (W)
Average Radiated Power	0.000322122 (W/s)
Radiation Efficiency	41.1465%
Antenna Efficiency	40.479%
Linear Properties	
Linear Gain	1.63694 dBi
Linear Directivity	5.56464 dBi
Linear Maximum	at (130, 60) deg.
3dB Beam Width	(57.4595, 96.2808) deg.
LH Circular Properties	
Circular Gain	-1.26924 dBi
Circular Directivity	2.65846 dBi
Circular Maximum	at (120, 50) deg.
3dB Beam Width	(52.4748, 86.48) deg.

4. CONCLUSION

A three notch multilayer   antenna for C-Band applications is presented in this paper. The proposed antenna is composed of a FR-4 and air gap dielectric material. For optimization transmission line model. Analysis done with and without air-gap. From this analysis we concluded that appropriate dimensions of ground plan with air-gap severely effect the return loss impedance bandwidth and return loss, Simulation results show that the proposed antenna with ground can operate from 4.5GHz, 5.5 GHz and 6.5GHz with low return less than -10dB, by using AIR-GAP achieved 10% and 12% impedance bandwidth and -18dB, Return loss at 5.5GHz, Stable antenna gain (5.5dBi) is also achieved at 6.5GHz frequency. Furthermore, the size of the proposed antenna is very compact; the proposed antenna can be used for C-Band application.

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