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# Analysis of L-strip Fed Circular Disk Patch Antenna for Dualband Operation*

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**Abstract:** A dual frequency resonance antenna achieved by introducing L-strip fed in circular disk patch is analysed by using circuit theory concept. The resonance frequency is found to be 5.19 GHz and 10.44 GHz for lower and upper resonance frequency respectively and the bandwidth of the proposed antenna for lower and upper resonance frequency is found to be 11.54 % and 13.12 %. When the notch is cut on the circular disk patch dual resonance frequency is shifted higher side and the resonance frequency is found to be 5.84 GHz and 10.54 GHz. It is found that the resonance frequency is observed 1.860 and 1.824 respectively. The theoretical results are compared with IE3D simulation results which are in good agreement.

## 1. Introduction

The L-strip proximity fed disk patch antenna is simple in structure and is a good candidate for various communication systems[1, 2]. Here we have proposed new type of L-strip fed circular disk patch antenna, which exhibits dualband behaviour. In this paper, the L-strip proximity fed circular disk microstrip antenna is investigated using Modal expansion cavity model and circuit theory concept. Resonance frequency is tuned by changing the dimensions of the L-strip. A parametric study has been carried out using the circuit theory concept to calculate various antenna parameters as a function of frequency for different value of length and width of L-strip.

## 2. Configuration and Analysis

The geometry of the L-strip proximity fed circular disk microstrip antenna is shown in Fig. 1.

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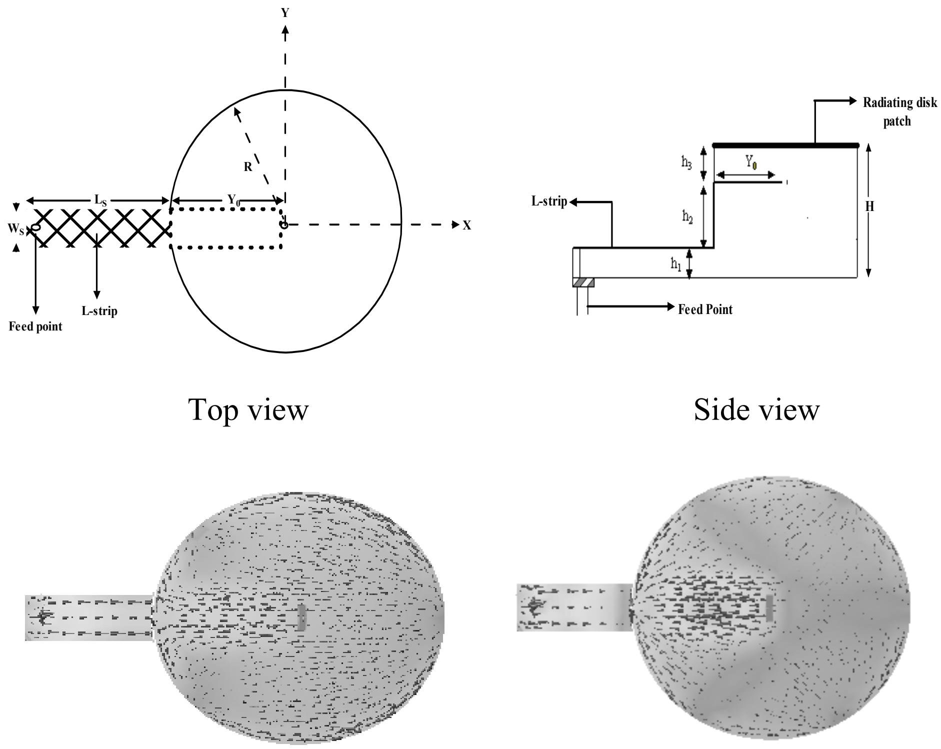


(a) $fr_1$=5.18GHz (b) $fr_2$= 10.15 GHz

Fig.1. Geometry of L-strip fed circular disk patch antenna with current distribution of lower and higher resonance frequency (a) $fr_1$=5.18GHz (b) $fr_2$= 10.15 GHz

L-strip is introduced at the end of the microstrip line so that the spacing between the patch and the feed line can be reduced. The horizontal part of L-strip in corporate with patch provides a capacitance to suppress the inductance introduced by the vertical part of L-strip. The L-strip equivalent circuit is shown in Fig. 2.

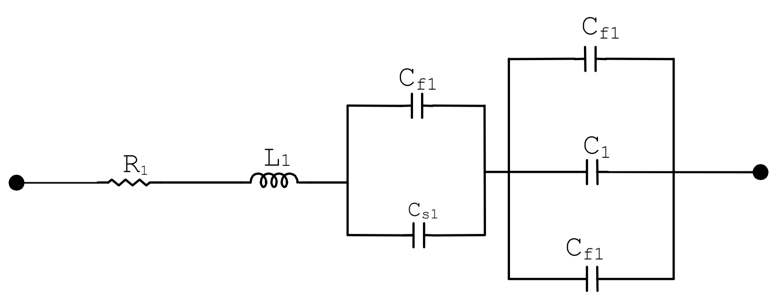


Fig.2. Equivalent circuit of L-strip

L-strip is equivalent to a series combination of resistance ($R_s$) and inductance ($L_s$). The resistance $R_s$ is because of finite conductivity of copper used. The expression for the resistance $R_s$ and inductance $L_s$ are given by [3]

The horizontal portion of the L-strip and the patch are perfect conductors separated by finite distance $h_3$ which provides a capacitance $c_1$ in series with vertical portion of the L-strip and this can be calculated by

(1) $$c_1 = \frac{\varepsilon_r \varepsilon_0 y_0 w_s}{h_3}.$$

Also there is a parallel plate capacitance ($c_{s1}$) between horizontal part of the L-strip and the ground plane and is given by [4]. The open end of the L-strip which is under the patch will have fringing fields, which can be considered as small increase in the length of the L-strip. This will have an extra capacitance ($c_f$) given as in the texts of Hoffman[3] and Edwards[4].

**2.1 Analysis of circular disk patch antenna**

The resonance frequency of circular disk patch is given as [5]

(2) $$f_r = \frac{k_{nm}\, c}{2\pi a_e \sqrt{\varepsilon_e}},$$

where $k_{nm}$ is the $m^{th}$ zero root of the derivative of Bessel function of order n, c is the velocity of light and $\varepsilon_e$ is the effective dielectric constant of the substrate and $a_e$ effective radius of the circular disk patch[6].

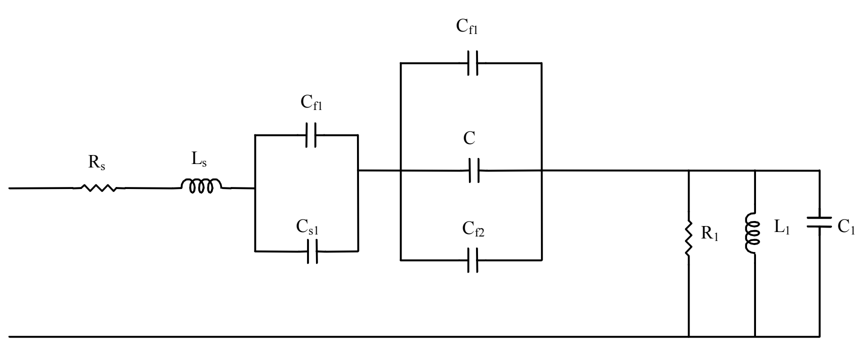


Fig. 3. Equivalent circuit of L-strip fed circular disk microstrip patch antenna

Hence, the total input impedance of the L-strip feed circular disk patch antenna can be calculated from Fig.3 as

(3) $$Z = Z_{strip} + Z_{patch} ,$$

in which $Z_{patch}$ is total input impedance of circular disk patch can be given as

$$Z_{Patch} = \frac{1}{\frac{1}{R_1} + j\omega C_1 + \frac{1}{j\omega L_1}}$$

and $Z_{strip}$ is the total input impedance of L-strip line can be given as

$$Z_{strip} = R_s + j\omega L_s + \frac{1}{j\omega c_{ec}} ,$$

where $c_{ec}$ is the equivalent capacitance due to capacitance $C$, $C_{s1}$, $C_{f1}$, $C_{f2}$ and given as [3,4]

## 3. Design Specifications

Table.1 Design specification of proposed L-strip proximity fed disk patch antenna

| | |
|---|---|
| Substrate material used | Foam |
| Relative permittivity of the substrate ( $\varepsilon_r$ ) | 1.07 |
| Thickness of the dielectric substrate of first layer( $h_1$) | 1.5 mm |
| Thickness of the second layer ($h_2$) | 7.0 mm |
| Thickness of the third layer ($h_3$) | 1.5mm |
| Length of the L-strip(Ls) | 45 mm |
| Width of the L-strip ($W_s$) | 6.0 mm |
| Length the notch ($L_n$) | 15mm |
| Width of the notch ($W_n$) | 2.0mm |
| Feed location ( $x_0, y_0$ ) | (0.325mm,-8.625mm) |

## 4. Result and Discussion

The variation of return loss with frequency for L-strip fed circular disk patch antenna is shown in Fig.6 along with simulated results using IE3D [7]. It is observed that the antenna resonates at two frequencies 5.44 GHz and 10.12 GHz (simulated $fr_1$=5.19 GHz, $fr_2$=10.14GHz) and bandwidth is found to be 11.54% for lower resonance whereas 13.12% for upper resonance frequency (simulated 11.06% and 13.81%).

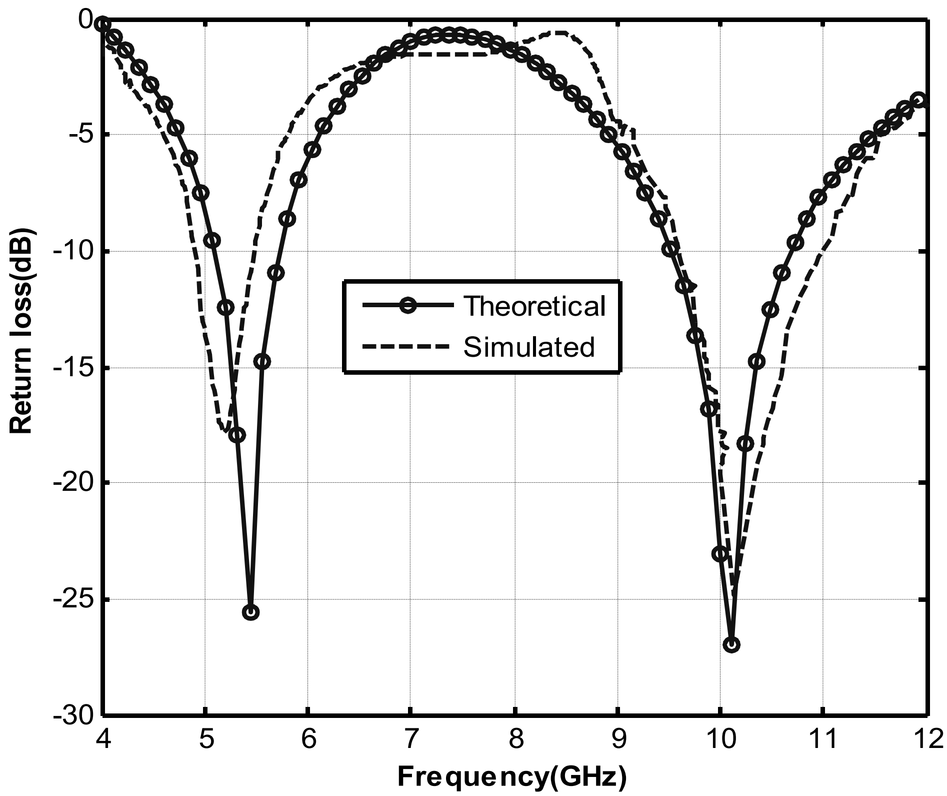


Fig.6. Comparative plot of return loss with frequency along with simulated result

Fig.7 shows the return loss along with simulated results for the notch loaded L-strip fed disk patch. It is observed that the antenna resonates at two frequencies 5.84 GHz and 11.84 GHz (simulated $fr_1$=5.9GHz, $fr_2$=11.95GHz) and bandwidth is found to be 13.64% for lower resonance whereas the bandwidth is 21.85 % for upper resonance frequency (simulated 12.65% and 18.66%).

The variation of return loss with frequency of circular disk patch antenna for different value of height and width of the L-strip is shown in Figs. 8 and 9. From the Fig.8, it is observed that both the frequencies is shifted i.e. lower resonance frequency shifts to right side to right side and higher resonance frequency shifts to left side whereas the lower resonance frequency shifts to lower side while upper resonance frequency remains almost constant (Fig.9)

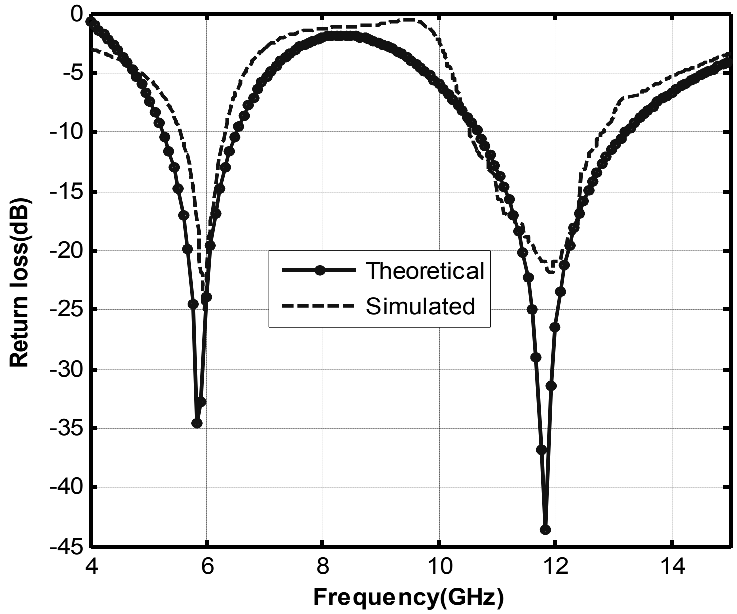


Fig.7. Variation of return loss with frequency of L-strip proximity coupled notch loaded disk patch antenna along with simulated result

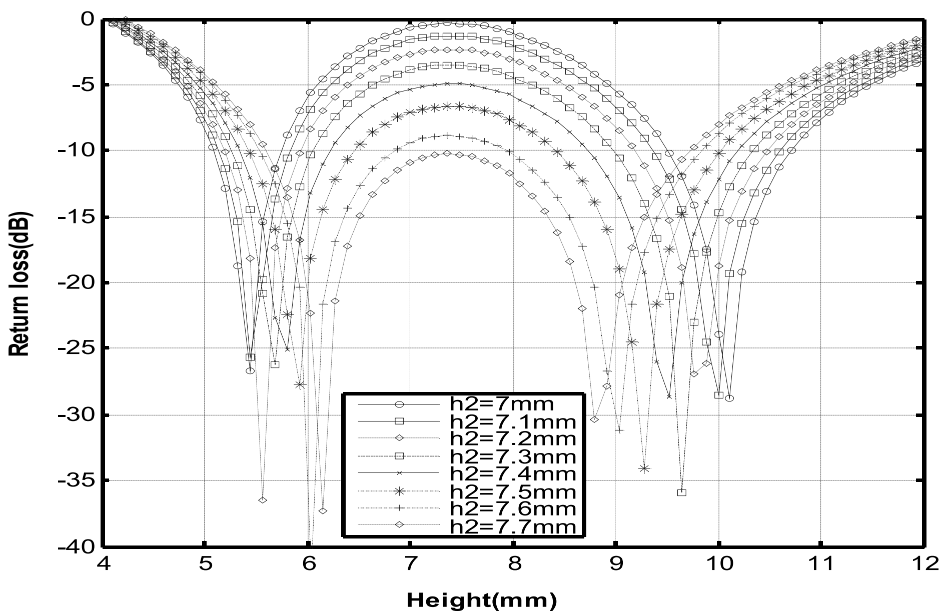


Fig.8. Variation of return loss with frequency of circular disk patch antenna for different value of height of the L-strip '$h_2$'

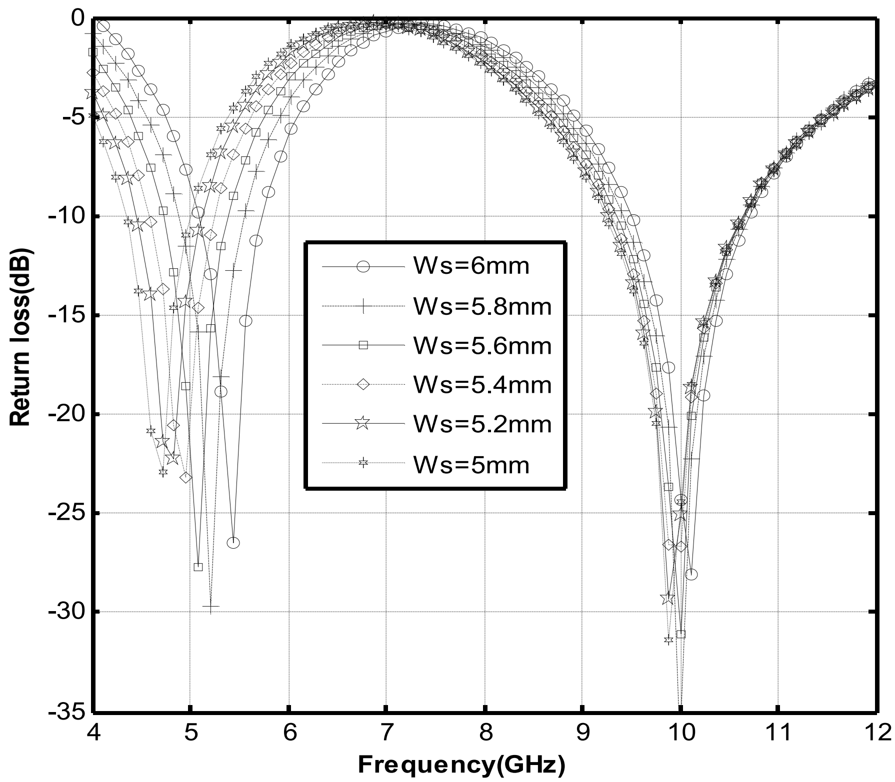


Fig.9. Variation of return loss with frequency of circular disk patch antenna for different value of width of L-strip

## 5. Conclusion

From the analysis it is found that the notch loaded patch shows better directivity at upper resonance frequency and radiation power improves by 3.2dB.

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