

Design and Analysis of a Microstrip-Line-Fed Printed Wide-Slot Antenna for L-Band Operation

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Abstract – In this present work, Microstrip printed antenna loaded with symmetrically wide-slot fed by a fork like tuning stub for better improvement in the impedance bandwidth enhancement & reduction in the return loss at operating frequency 1.9189 GHz are proposed and experimentally investigated. The details investigations have been performed on the design of a microstrip antenna of given specifications using HFSS, an electromagnetic structure from Ansys. Here a new idea of wide slot has been used to increase the bandwidth of the antenna for L- Band operation. The resonant frequency of operation 1.9189 GHz with a return loss of -59.8373 dB. The antenna design and performs are analyzed using HFSS is a commercial finite element method solver for electromagnetic structures from Ansys.

Keywords – Printed Antenna, Gain, Resonant Frequency, Bandwidth, Slot, Substrate.

I. INTRODUCTION

The microstrip- line-fed printed slot antenna is one of the most preferred able antenna structures for small size, light weight, low cost on mass production, low profile, conformal shaping, high efficiency and easy integration to circuits. This antenna is widely implemented in many applications, especially in microwave communication and wireless systems [6-12].

However the major disadvantage of the microstrip slot antenna is its inherently narrow impedance bandwidth [5]. These slot antennas are used as simple and for the widest and most demanding applications. Intensive research has been done in recent years to develop bandwidth enhancement techniques. This technique includes the utilization of wide slot and high dielectric constant for bandwidth enhancement. Dual characteristics, circular polarizations, frequency operation, frequency agility, broad band width, feed line flexibility; beam scanning can be easily obtained from these wide slot antennas.

The L band defined by an IEEE standard for radio waves and radar engineering with frequencies that ranges from 1.0 to 2.0 GHz [1-4] respectively. The L-Band is also used for military telemetry, GPS, mobile phones, low earth orbit satellites, amateur radio and terrestrial wireless connections like GSM mobile phones [12]. It is also used as an intermediate frequency for satellite TV where the Ku or Ka band signals are down-converted to L-Band at the antenna LNB, to make it easier to transport from the antenna to the below deck, or indoor equipment [15].

This frequency band is preferred for the operation of long –range air-surveillance radars, these radars are mostly

used for clear air turbulence studies [13]. This band is held by the military for telemetry, thereby forcing digital radio to in-band on-channel solutions. The GPS carriers are in the L band frequencies. GSM mobile phones operate at 800–900 and 1800–1900 MHz. The Radio Regulations allow amateur radio operations in the frequency range 1240 to 1300 MHz. It is used in optical communications to refer to the wavelength range 1565 nm to 1625 nm [14]. The L- band (1452-1492 MHz) is currently allocated use by terrestrial and satellite digital audio broadcasting (DAB) services in most European countries.

MATHEMATICAL ANALYSIS

The configuration of the slot printed antenna is shown with L=54 mm, W=54 mm, substrate (FR4) thickness h = 1.6 mm, dielectric constant $\epsilon_r = 4.4$. Now practical printed slot antennas width using this equation [2]

$$\text{Width of the patch (w): } w = \frac{c}{2f_0 \sqrt{\frac{1+\epsilon_r}{2}}}$$

Where, c = velocity of light in free space. Using the following equation [2] we determined the practical length L (=6mm).

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

Where, the extended length of antenna

$$\Delta L = \left[0.412h \times \frac{(\epsilon_{\text{reff}} + 0.3) \times (W/h + 0.264)}{(\epsilon_{\text{reff}} - 0.258) \times (W/h + 0.8)} \right]$$

Assuming practical microstrip slot antenna substrate length and width are 110 mm for efficient radiation and using the equation [2],

$$f_r = \frac{c}{2W} \times \sqrt{\frac{2}{1+\epsilon_r}}$$

and Effective dielectric constant of antenna (ϵ_{reff}):

$$\epsilon_{\text{reff}} = \left[\left(\frac{\epsilon_r + 1}{2} \right) + \frac{\epsilon_r - 1}{\left(2 \times \sqrt{1 + 12 \times \frac{h}{W}} \right)} \right] \quad [9]$$

and Effective dielectric length of antenna

$$(L_{\text{eff}}): L_{\text{eff}} = \left[\frac{c}{2 \times f_r \times \sqrt{\epsilon_{\text{reff}}}} \right]$$

Where, L_{eff} = Effective length of the patch

$\Delta L/h$ = Normalized extension of the patch length

ϵ_{reff} = Effective dielectric constant.

Voltage Standing Wave Ratio (VSWR):

$$\text{VSWR} = \frac{V_{\text{max}}}{V_{\text{min}}} = \frac{1+|\tau|}{1-|\tau|}$$

As the reflection coefficient ranges from 0 to 1, the VSWR ranges from 1 to ∞

III. ANTENNA DESIGN

The proposed microstrip slot antenna is shown in fig. 1 & fig. 2 with length and width respectively 54 mm, 54 mm for 1.9189 GHz.

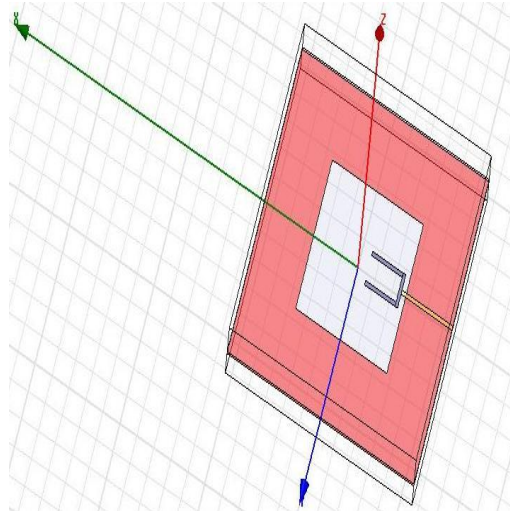


Fig.1. Simulated Printed Slot Antenna 3D View

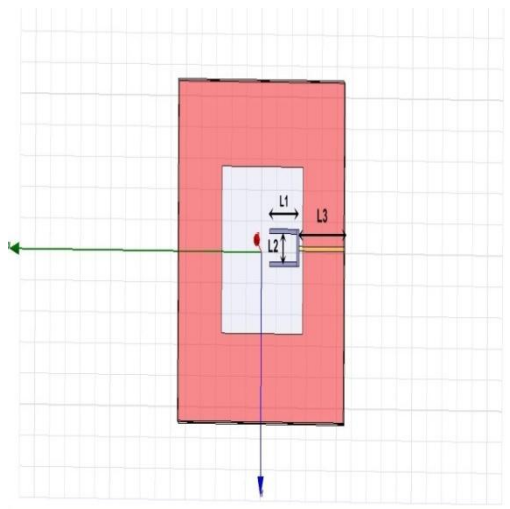


Fig.2. Simulated Printed Antenna 2D View configuration

Fig.2 shows the configuration of 2D view simulated printed antenna designed with similar FR4 substrate.

Table I: Optimised Antenna Parameters

ANTENNA PARAMETERS	Values
Length of the Slot(L)	54 mm
Width of the Slot (W)	54 mm
Resonant Frequency(f_0)	1.9189 GHz
Return Loss	-59.8373 dB
Dielectric Constant of the Substrate (ϵ_r)	4.4
Thickness (h)	1.6 mm
Substrate Length	110 mm
Substrate Width	110 mm
Bandwidth difference between 1.56 GHz to 2.7027 GHz	1.1427 GHz
Two Branch Section of Equal Lengths (L_1)	18 mm
Spacing Between the Edges of the	9 mm

Two Branch Sections (L_2)	
Straight Section of Length (L_3)	30 mm

The proposed antenna simulated using high frequency structural simulator (HFSS) [16] software is best operated at L band frequencies for telecommunication applications [2].

IV. RESULTS AND DISCUSSION

Simulated (using HFSS [16]) results of return loss in simulated slot antenna structures are shown in figure 3. A significant improvement of E-Total radiation pattern at 1.91 GHz shown in figure 4.

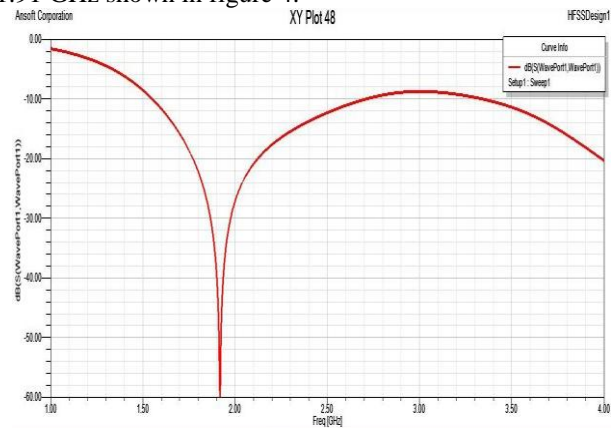


Fig.3. Return Loss vs. Frequency (Slotted Antenna)

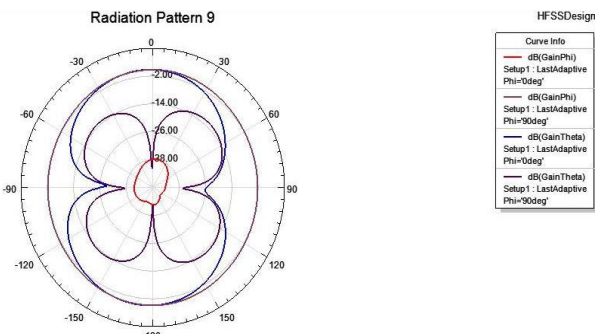


Fig.4. E-Total Radiation Pattern for Slotted Antenna at 1.91 GHz

The simulated 3D Cartesian plot and E Total 3D polar plot for slotted antenna at 1.91 GHz has shown in figure 5 & 6.

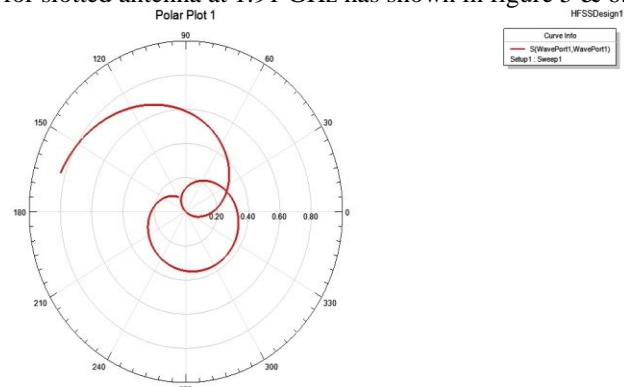


Fig.7. Simulated Polar Plot for slotted antenna at 1.91 GHz

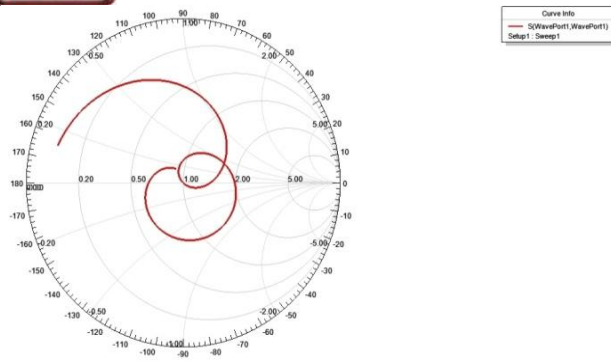


Fig.8. Simulated Smith Chart for slotted antenna at 1.91 GHz

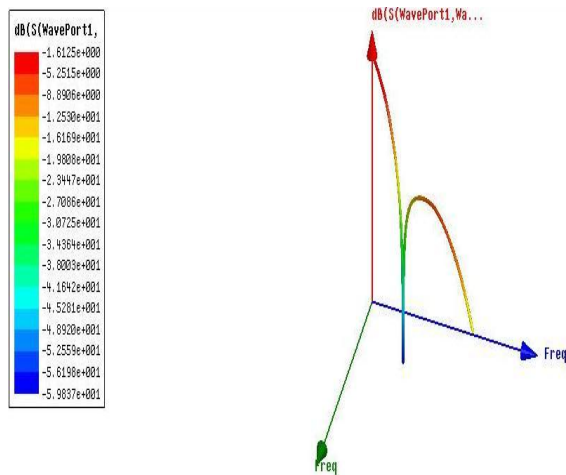


Fig.5. 3D Cartesian Plot for Slotted Antenna at 1.91 GHz

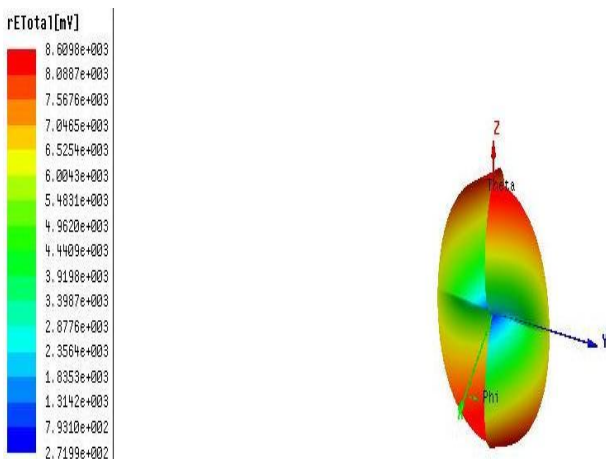


Fig.6. E Total 3D Polar Plot for Slotted Antenna at 1.91 GHz

The simulated polar plot and smith chart at 1910 MHz are shown in figure 7 & figure 8.

The simulated impedance vs. frequency plot and VSWR for slotted antenna is shown in figure 9 & 10.

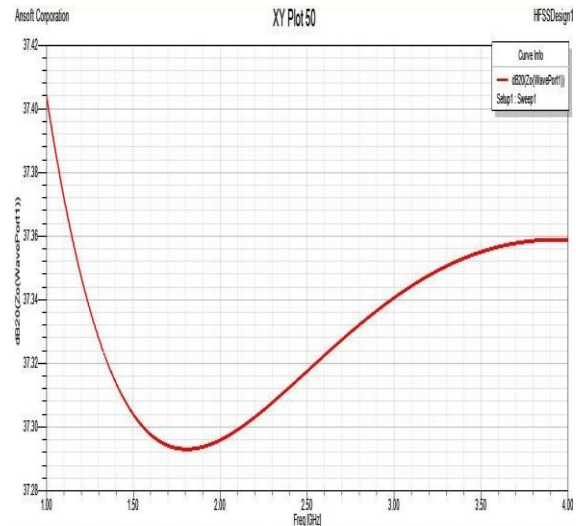


Fig.9. Simulated Impedance vs. Frequency Plot for Slotted antenna

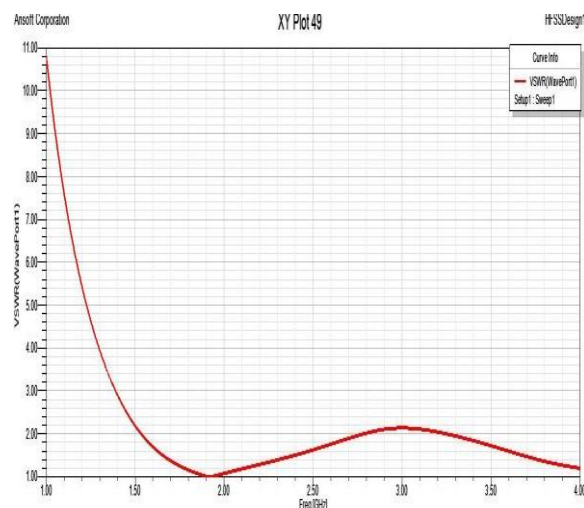


Fig.10. Simulated VSWR for Slotted antenna

V. CONCLUSION

The wide-slot microstrip antennas have been simulated and studied which can be implemented for and wireless applications and L-band applications. Simulation studies of a Microstrip-Line-Fed Printed Wide-Slot antenna have been carried out using finite element method based software HFSS [16]. The results of the slot antenna i.e. return loss, VSWR plot, resonant frequency, substrate length, substrate width shown of the proposed design. The slotted antenna resonant frequencies at 1.9189 GHz (L-band). The return loss obtained is -59.8373 dB. Communication devices require different frequency operations and these requirements are fulfilled using a pair of slots on the microstrip antenna. In order to increase this bandwidth for a higher extent with overall performance of the proposed antenna by varying the type of substrate its thickness, length and width of the slot the same can also be achieved. The designed antenna can be used for L-band applications, such as a useful for satellite navigation, cellular phones etc.

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