# Slotted-L Printed Antenna for C-Band Application

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**Abstract –** Slotted-L Printed antenna designed and tested using HFSS and vector network analyzer which is operating at a frequency 5.8 GHz. When tested practically is approximately matching with design specification. C- Band is intended for highly secure, high-speed wireless communication between vehicles and the infrastructure. It is found that the incorporation of a slot in the patch can provide a flat input resistance and a linear input reactance across a wider bandwidth of about 94.2 % with equivalent gain of 2.8dB.

**Keywords –** Patch antenna, C-Band, Printed antenna wireless application.

## I. INTRODUCTION

To support the high mobility necessity for a wireless telecommunication device, a small and light weight antenna is likely to be preferred. For this purpose, Compact Microstrip antenna is one of the most suitable applications. The development of antenna for wireless communication also requires an antenna with more than one operating frequency. This is due to many reasons, mainly because there are various wireless communication systems and many telecommunication operators using various frequencies.[1]. Microstrip antenna structures are most common option used to realize millimetre wave monolithic integrated circuits for microwave, radar an
d communication purposes. The shape and operating mode of the patch are selected, designs become very versatile in terms of operating frequency, polarization, pattern and impedance [2]. Using a rectangular slot in the radiating patch increases the upper-edge frequency, and it is possible to control this frequency by adjusting the slot width. By cutting a modified slot of suitable dimensions at the radiating patch a new fed configuration can be constructed [3]. Dielectric material of the substrate (or) selected for this design is FR-4 Epoxy which has a dielectric constant of 4.4 and loss tangent equal to 0.0284. The dielectric constant of the substrate material is an important design parameter.

The low value of dielectric constant increases the fringing field at the patch periphery and thus increases the radiated power [4]. The effect of very high operating frequency in GHz range which increases chances calculation error in the model. The proposed antenna in this paper can be used for broadcasting, remote sensing, aeronautical radio navigation and mobile satellite applications [5]. Conventional Microstrip patch antenna designs with thick substrate layer causes major problem associated with impedance matching. Applications include airborne antenna system, light weight feed network, military radar systems, missile guidance system [6]. Microstrip Patch Antenna (MSA) is one of the most favoured antenna structures because of its ease of fabrication and have many applications in wireless communication. [7]. A Broadband and highly directive microstrip patch antenna is designed using RT Duroid 5880 substrate and their simulation and results has robots. The proposed design has a simple structure and can easily be constructed at low cost [8].

## II. ANTENNA DESIGN

The dielectric constant of the substrate is closely related to the size and the bandwidth of the slotted-L Printed antenna. Low dielectric constant of the substrate produces larger bandwidth. [9] The resonant frequency of microstrip antenna and the size of the radiation patch can be similar to the following formulas while the high dielectric constant of the substrate results in smaller size of antenna. [10] The proposed structure of the antenna is shown in Fig. 1. The optimized geometry of proposed microstrip antenna with coaxial feed as shown below. The size of Printed patch is (30X30) mm^2 printed on top of the dielectric substrate with thickness 1.6mm and relative dielectric constant of 4.4. are mounted on a ground plane of dimension (60X70) mm^2 with relevant dimensions of simulated and fabricated antenna as shown in Fig.2

A practical width (W) is calculated for Printed Antenna leads to better radiation efficiency. The mathematical equation to calculate the antenna width is given in the Eq. (1).

$$W = \frac{c}{2f_r}\sqrt{\frac{2}{\varepsilon_r+1}} \tag{1}$$

Where, $c$ is denoted as velocity of the light $(3 \times 10^8 m/s)$, $\varepsilon_r$ is stated as relative permittivity $(\varepsilon_r = 4.4)$, and $f_r$ is indicated as resonating frequency $(f_r = 5.8\ GHZ)$.

*Calculation of effective dielectric constant* $(\varepsilon_r^{eff})$

In Printed Antenna, the effective dielectric constant $\varepsilon_r^{eff}$ is estimated on the basis of air dielectric boundary as shown in the Eq. (2).

$$\varepsilon_r^{eff} = \frac{\varepsilon_r+1}{2} + \frac{\varepsilon_r-1}{2}[1+12(h/W]^{-1/2} \quad (2)$$

Where, $\varepsilon_r = 4.4$.

*Calculation of antenna length* $(L_{eff})$

Generally, the width and length of Printed is calculated by selecting the substrate. The initial approximation of the length is made for a half wave MPA as represented in Eq. (3).

$$L_{eff} = \frac{c}{2\sqrt{\varepsilon_r^{eff}}}\left(\frac{1}{f_r}\right) \quad (3)$$

Where, $f_r = 5.8\ GHZ$, $C = 3 \times 10^8 m/s$, and, $\varepsilon_r^{eff} = 0.1$ .

*Calculation of length extension* $(\Delta \boldsymbol{L})$

Hence, there is a line extension related with a patch, due to fringing fields and radiating edges of the antenna. The length extension $\Delta L$ is mathematically denoted in the Eq. (4).

$$\Delta L = 0.412h\left[\frac{\left(\varepsilon_r^{eff}+0.3\right)\left(\frac{W}{h}+0.264\right)}{\left(\varepsilon_r^{eff}-0.258\right)\left(\frac{W}{h}+0.8\right)}\right] \quad (4)$$

Where, $\varepsilon_r^{eff} = 0.1$ .

*Calculation of patch length* $(L)$

Usually, the patch length is determined by using the Eq. (5).

$L = L_{eff} - 2\Delta L (5)$

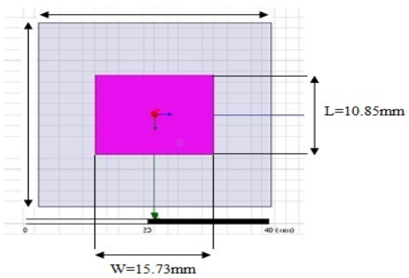



**Fig 1(a)**

**Fig 1(b)**

**Fig 1 (a, b).** The Proposed Structure of the Antenna

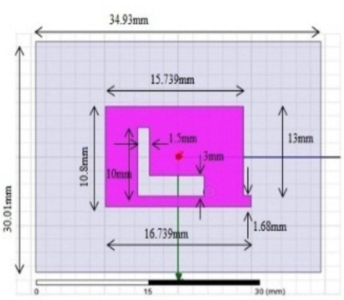



**Fig 2(a)**

**Fig 2(b)**

**Fig 2 (a, b).** Simulated and Fabricated Antenna

## III. ANTENNA DESIGN

The proposed Slotted-L printed design has been simulated using HFSS simulation package that's characteristic of the Slotted L shaped printed Antenna in terms of Return loss and its impedance bandwidth is synthesized and analysed through smith chart. Practical results are in good agreement with simulated results. Results are verified through analysed through vector network make Agilent technology E8363C (40GHz), characteristics of above are depicted in Fig. 3, Fig.4, Fig.5 and Fig 6. Comparisons of results for reference and L shaped slotted antenna in terms of bandwidth, return loss and gain are summarized in table1.

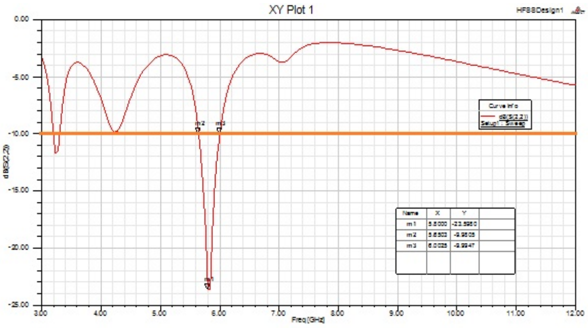



**Fig 3**. Simulated Return loss characteristic of designed slotted-L printed antenna

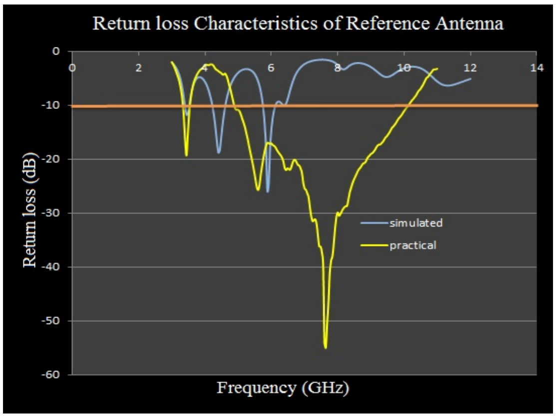



**Fig 4**. Practical Return loss characteristic of designed slotted-L printed antenna

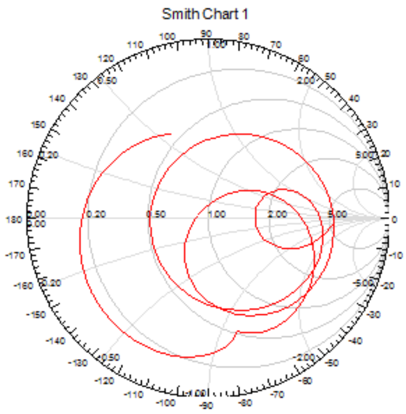



**Fig 5.** Characteristic Impedance in terms Smith chart of slotted-L printed Antenna

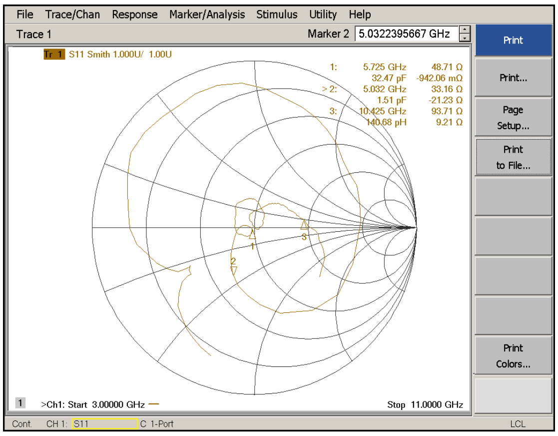
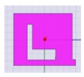



**Fig 6.** Characteristic Impedance in terms Smith chart of slotted-L printed Antenna Practical

**Table 1**. Summarizing reference and Slotted-L Printed antennas in terms of Bandwidth with Gain

| Design | Frequency (GHz) | | Return loss (dB) | | %bandwidth | | Gain (dB) | |
|---|---|---|---|---|---|---|---|---|
| | sim | prct | sim | prct | sim | prct | sim | prct |
|  | 5.88 | 5.63 | -25.7 | -26.1 | 6.5 | 20.68 | 1.93 | 2.1 |
|  | 5.8 | 5.73 | -23.6 | -34.1 | 6.9 | 94.2 | 2.06 | 2.8 |

## IV. CONCLUSION

Design Prototype practical Antenna is tested using Network Analyzer Agilent technology E8363C. Antenna design is worked out at a frequency 5.8 GHz. Performance characteristic of Design antenna tested using electromagnetic simulated software (HFSS) and tested practically is approximately matching with design specification. Specified bandwidths of 94.2% are obtained with relative gain of 2.8 db.

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