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# PARAMETRIC STUDY AND DESIGN OF E-SHAPED PATCH ANTENNA AND SLOTTED E-SHAPED PATCH ANTENNA

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**Abstract:** In this paper we have analyzed and designed E shaped patch antenna and Slotted E-shaped patch antenna for high speed wireless local area network at 5-6 GHz frequency. A parametric study of both the antenna has been carried out, to analyze and understand the effects of dimensional parameters. Main disadvantage of the microstrip patch antenna is its narrow bandwidth. However, in this paper slotting technique has been used to increase the bandwidth of the patch antenna. In this design, two parallel slots are incorporated into Rectangular patch antenna so that it becomes E-shaped patch antenna. It gives fractional bandwidth of 14.56% with the center frequency 5.56GHz. The antenna frequency band, with –10 db return loss covers the frequency range of 5.16–5.97GHz. Slotted E-shaped patch antenna provides a fractional bandwidth of 15%. The design of patch antenna has been completed using IE3D software. The antenna is designed on 0.5mm RT duroid 5880 substrate with dielectric constant of 2.2 and loss tangent 0.0004 operating at 5.25 GHz. A substrate of low dielectric constant is selected to obtain a compact radiating structure that meets the demanding bandwidth specification.

**Keywords:** E-shaped patch antenna, slotted E-shaped patch antenna, Bandwidth, WLAN.

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## INTRODUCTION

Wireless local area networks (WLAN) are widely used worldwide. The IEEE 802.11b and 802.11g standards utilize the 2.4-GHz ISM band. The frequency band is license-free; hence the WLAN equipment will suffer interference from microwave ovens, cordless phone, Bluetooth devices and other appliances that use this same band. The 802.11a standard uses the 5-GHz band which is cleaner to support high-speed WLAN [3].

Microstrip patch antenna are widely used for many applications in recent wireless communications because of their light weight, low volume, ease in fabrication, low cost, etc. However microstrip antennas suffer from number of disadvantages. Narrow bandwidth is a serious limitation of these microstrip patch antenna. Different techniques are analyzed to improve the bandwidth such as increasing the substrate thickness, introducing parasitic element either in coplanar or stack configuration, and modifying the shape of a common radiator patch by incorporating slots. The last approach is particularly attractive because it can provide excellent bandwidth improvement and maintain a single-layer radiating structure to preserve the antenna's thin profile [1][3]

In this paper: (i) E-shaped patch antenna (ii) Slotted E-shaped patch antenna is designed at 5-6 GHz and a comparative and parametric analysis has been done.

The antenna is designed on 0.5mm RT duroid 5880 substrate with dielectric constant of 2.2 and loss tangent 0.0004 operating at 5.25 GHz. Co-axial feed is used to fed this antenna because this feeding technique is much simpler and have least radiation losses in comparison to other feed technique like microstrip line feed, Aperture couple feed, proximity feed. In probe feeding we have chosen trial and error method to calculate the feed point where, desirable result is obtained is taken as final feed point ($X_0$, $Y_0$).

The rest of the paper is organized as follows. Analysis of antenna design is explained in section II. Parametric study is given in section III. Experimental results are presented in section IV. Concluding remarks are given in section V.

- **ANTENNA DESIGN**

  - ***Analysis of E-shaped Patch Antenna***

Firstly, a Rectangular patch antenna is designed of length (L), width (W) at 5.25 GHz frequency. When two parallel slots are incorporated into the rectangular microstrip patch antenna, it becomes an E-shaped microstrip patch antenna .The E-shaped microstrip patch antenna is simpler in construction and also reduces the size of the antenna. The slot length (*Ls*), slot width (*Ws*), of the E-shaped patch control the frequency of the second resonant mode and the achievable bandwidth.

It is fed by coaxial feed point at (X0=1.8, Y0=10). Geometry of E-shaped patch is shown in figure 1. Simulations are performed by using IE3D software. The two parameters *Ls*, *Ws* are set as variable and their effects on the impedance bandwidth is studied.

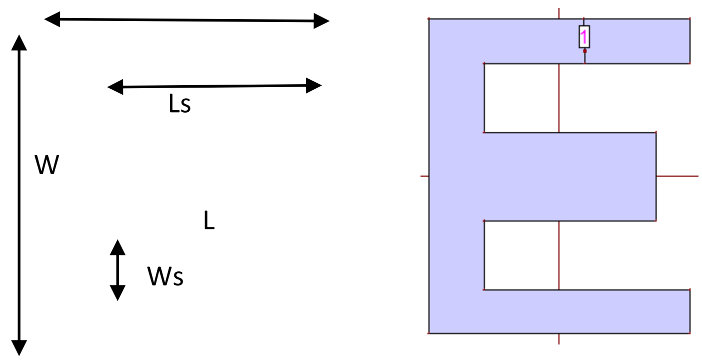


**Figure 1 : E shaped patch antenna at (1.8, 10) feed point**

- ***Analysis of Slotted E-shaped Patch Antenna***

Two slots of length (Lt) and width (Wt) are incorporated into E-shaped patch antenna, which will still reduces the size of the antenna. It is feed by co-axial feed at location (X0=2, Y0=10)

The two parameters *Lt, Wt* are set as variable to study their effects on the resonant frequencies. Geometry of slotted E-shaped antenna is shown in figure 2.

- **PARAMETRIC STUDY**

- ***E-shaped patch antenna***

Figure 3 and figure 4 shows the reflection

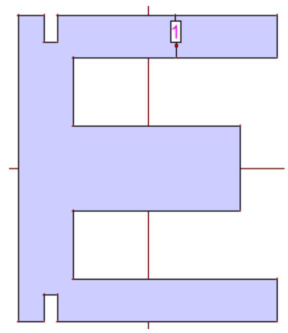

**Figure 2 : Slotted E shaped patch antenna at (2,10) feed point coefficient of E-shaped patch antenna for different values of slot length and width. The antenna parameters are in mm (L, W, h) = (19.03, 22.58, 0.5).**

The slot width (Ws) is varied from 1mm to 5mm keeping Ls=15mm. The effect of slot width is shown in figure 3. The wider the slot, lesser is the second resonant frequency. Since wider the slot, higher is the inductance of equivalent circuit of E-shaped patch. The resonant frequency of the fundamental resonant mode remains unaffected. The slot length (Ls) is varied from 9mm to 15mm keeping Ws=5mm. The effect of slot length is shown in figure 4. As the length increases, the second resonant frequency decreases.

**B. *Slotted E-shaped patch antenna***

In this design, E-shaped patch is selected with Ls=15mm and Ws=5mm, and two slots are introduced into the patch. Introducing two more slots will reduce the size of the antenna.

Parametric study is performed by varying Lt and Wt. The slot width (Wt) is varied from 1mm to 3mm keeping Lt=2mm. The effect slot width is shown in figure 5. The wider the slot, higher is the second resonant frequency.

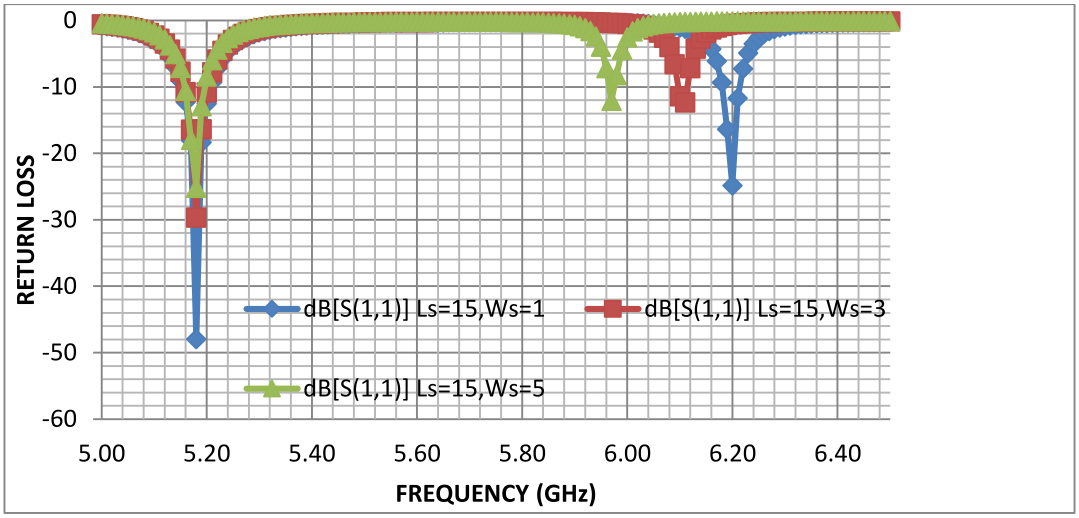


**Figure 3: Graph of Return loss v/s Frequency of E-shaped patch antenna (Ls=15, Ws=1,3 ,5)**

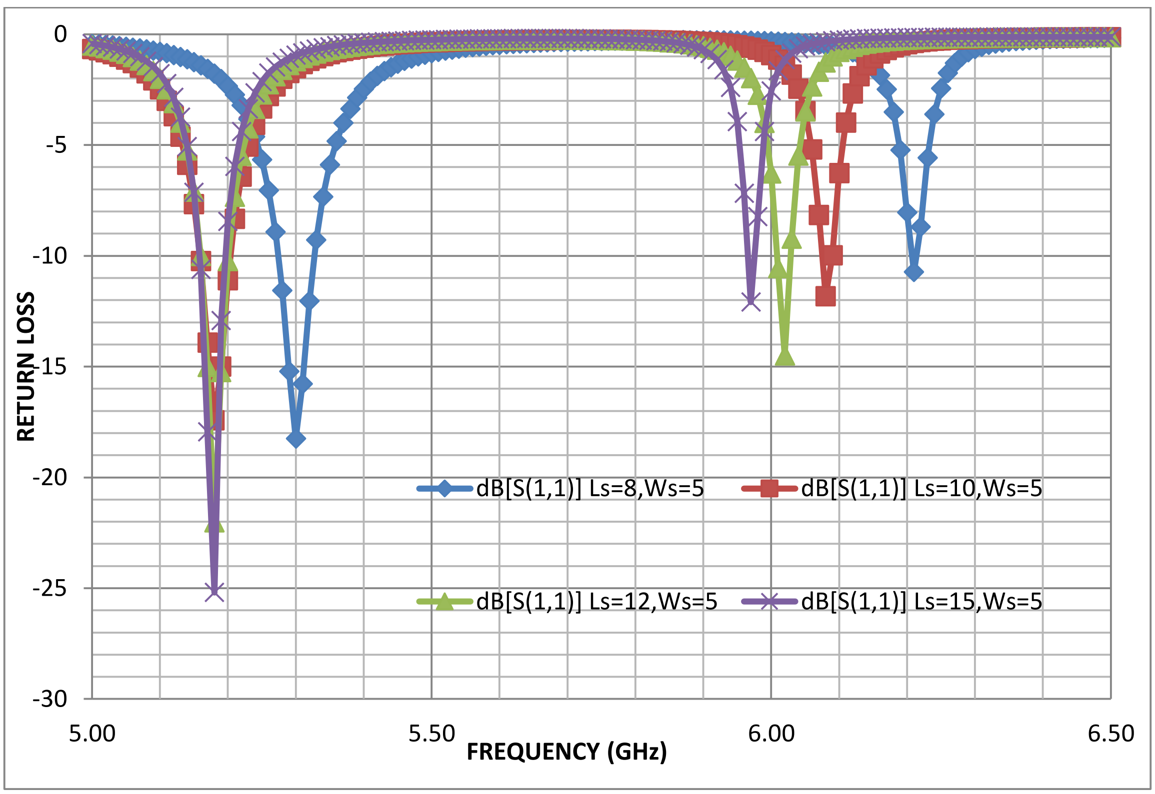


**Figure 4: Graph of Return loss v/s Frequency of E-shaped patch antenna (Ws=5, Ls=8, 10, 12,13)**

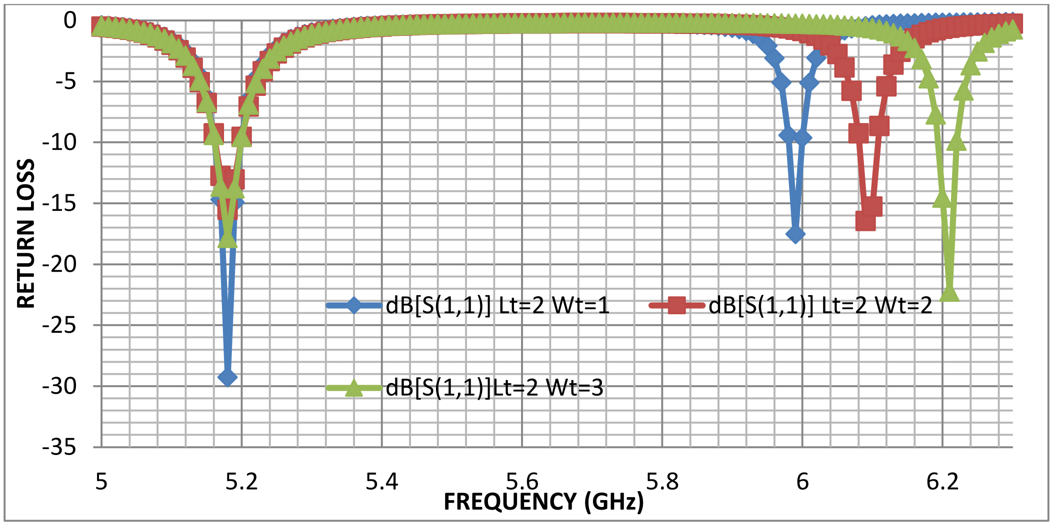


**Figure 5: Graph of Return loss v/s Frequency of Slotted E- shaped patch antenna (Lt=2, Wt=1,2,3)**

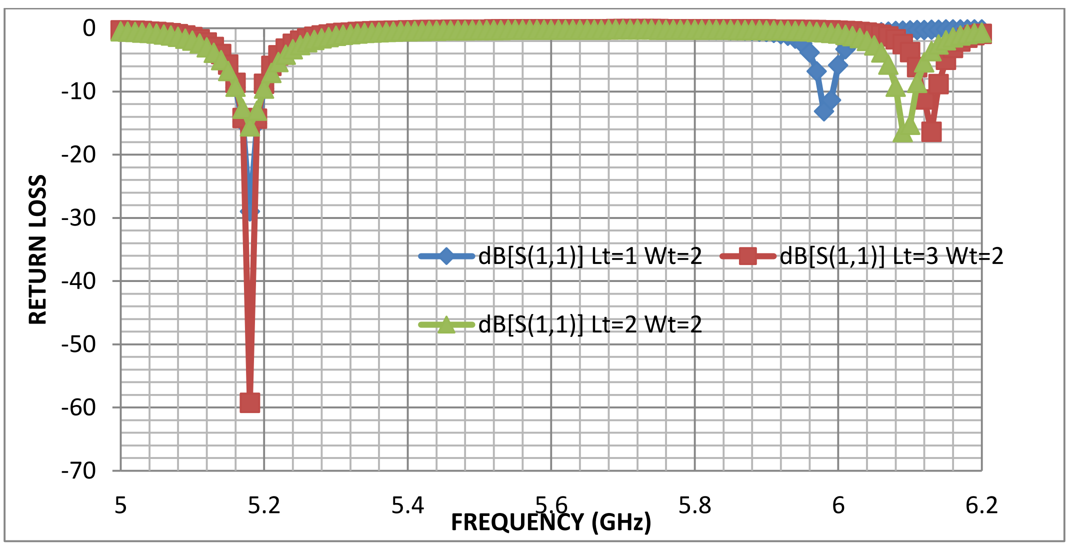


**Figure 6: Graph of Return loss v/s Frequency of Slotted E-shaped patch antenna ( Wt=2, Lt=1,2,3)**

The resonant frequency of the fundamental resonant mode remains unaffected. The slot length (Lt) is varied from 1mm to 3mm by keeping Wt=2mm. The effect of slot length is shown in figure 6. As the length increases, the second resonant frequency increases.

- **RESULTS AND DISCUSSIONS**

For E shaped patch, Ls=15mm and Ws=5mm is selected and for slotted E shaped patch, Lt=2mm and Wt=1mm is selected and design is simulated using IE3D software and fractional bandwidth is calculated. Simulated results are shown in figure 7 and figure 8.

E shaped antenna gives impedance bandwidth of 14.56% with the center frequency 5.56GHz. The antenna frequency band, with –10 db return loss covers the frequency range of 5.16–5.97GHz.

Both the antennas are compared based on some parameters as shown in table 1. Slotted E-shaped patch antenna provides a fractional bandwidth of 15% and also antenna efficiency is better than E-shaped patch.

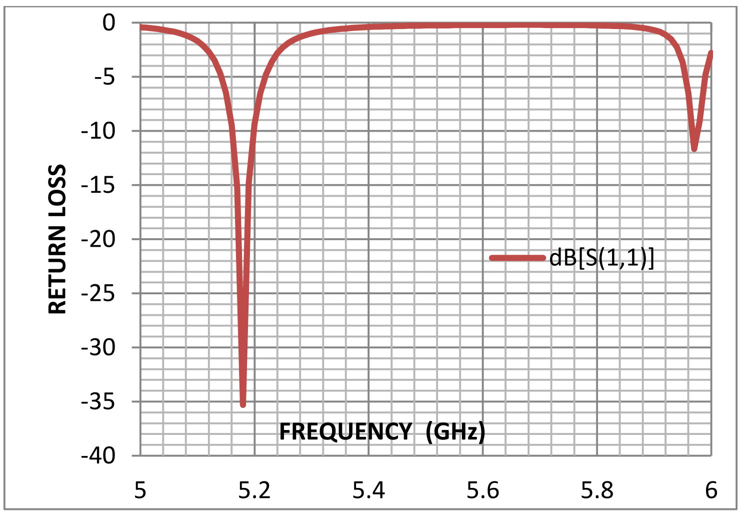


**Figure 7: Graph of Return loss v/s Frequency of E- shaped patch antenna (Ls=15, Ws=5)**

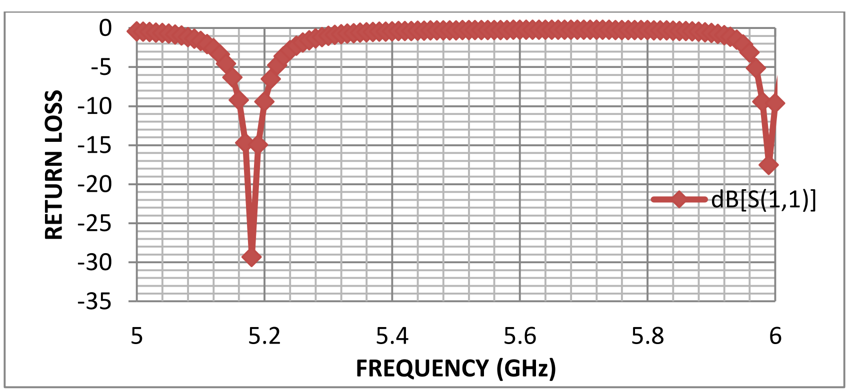


**Figure 8: Graph of Return loss v/s Frequency of Slotted E- shaped patch antenna ( Lt=2,Wt=1)**

- **CONCLUSION**

In this paper, analysis and comparative study of E and Slotted E-shaped has been done. Parametric study is carried out of Slot length and Slot width. It is found that in E shape as the slot length and slot width is increased, the second resonant frequency starts decreasing where as fundamental resonant frequency remains almost unchanged. Also, in Slotted E- shape as slot length and width is increased, the second resonant frequency also increases. Finally, for comparative purpose, E shape with Ls=15mm and Ws=5mm is simulated and Slotted E- shape with Lt=2mm and Wt= 1mm is simulated and both results are compared. It shows that bandwidth in slotted E is greater than E shaped patch and antenna efficiency is better in slotted E as compared to E shape patch antenna. comparision of e and slotted e shaped patch

| Parameters | E-shaped patch | | Slotted E-shaped patch | |
|---|---|---|---|---|
| | Frequency | | Frequency | |
| | 5.18 GHz | 5.97 GHz | 5.18 GHz | 5.99 GHz |
| Return Loss (db) | -35.3 | -11.6 | -17.5 | -29.28 |
| VSWR | 1.0 | 1.07 | 1.1 | 1.3 |
| Gain (dBi) | 7 | 4 | 6.1 | 4.1 |
| Antenna Efficiency (%) | 70 | 49 | 75 | 55 |
| Radiation Efficiency (%) | 77 | 65 | 77.5 | 65 |
| Bandwidth (%) | 14.53 | | 15 | |

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