Compact and Broadband Monopole Triangular Microstrip Patch Antenna with Shorting Pin

Avisankar Roy, P. P. Sarkar, Sunandan Bhunia

Abstract*— *A monopole triangular shaped, broadband, compact microstrip patch antenna with shorting pin is presented in this paper. By defecting the ground plane bandwidth of 38.7% with respect to center frequency of a Microstrip patch antenna has been achieved which can be used for WLAN application. 82.4% size reduction has also been achieved by using shorting pin of a microstrip patch antenna with inset feed. The simulation is done by using the Method of Moment based commercially available standard software.

Index Terms*— *Microstrip antenna, shorting pin, compact, broad band, defected ground

I. INTRODUCTION

Microstrip patch antennas have remarkable advantages such as low profile, light weight, compatibility with planer and non-planer surfaces, suitable for multi frequency operation and simplicity of manufacturing [1-24]. Microstrip patch antennas are widely used in Portable devices such as mobile phones, laptops with wireless connection, wireless universal serial bus (USB) dongles etc., and Microstrip patch antenna plays a very significant role for the miniaturization of these devices [1-3]. In modern communication systems the compact microstrip patch antennas are desirable. At lower frequencies the size of the microstrip antennas becomes large. There are various techniques to reduce the size of the microstrip antennas [4-8]. A common technique to reduce the overall size of a microstrip patch antenna is to terminate one of the radiating edges with a short circuit. The short circuit can be in the form of a metal clamp or a series of shorting posts [9-11]. However, there are some limitations on the applications of microstrip antennas due to their inherent narrow bandwidth. Depending on the feeding techniques the band width of the antenna varies slightly. Maximum bandwidth of about 13% can be achieved using proximity coupling method of feeding for a regular microstrip patch antenna structure. A number of bandwidth enhancement methods for microstrip antenna elements have been investigated. Using electrically thick elements, stacked multi patch, multilayer elements, multiple resonator elements [12-16], BW can be enhanced. All these methods however, increase the complexity and/or enlarge the size of the radiating structures. Shorting pin or shorting wall can also be used to enhance the bandwidth [12-13].

Mahmoud N et al., [7] proposed a dual frequency antenna with stacking structure with very narrow bandwidth. *Sarkar.S* et al.,[8] proposed an antenna with about 90% size reduction with only 12.8% BW which radiates in a single frequency. Wenquan Cao et. al. [13] has proposed a broadband microstrip antenna loaded with shorting pin and 9.5% bandwidth in 2GHz has been achieved. *Yikai Chen* et al.,[14] proposed an antenna with bandwidth of about 9% of the center frequency. *E. A´ vila-Navarro* et al.[15], designed a novel antenna operating in a single frequency with about 50%BW. In this paper microstrip antenna with bandwidth of 37.8% has been designed by defecting the ground plane and using shorting pin.The size of antenna has been also reduced by 82.4%. The bandwidth enhancement has been achieved because of the shorted pin which acts like a reactive element, which modifies the frequency variation of the input impedance. By adjusting the radius of the shorting pin and its location along the microstrip patch antenna, a good impedance match over a relatively bandwidth can be achieved.

II. ANTENNA DESIGN

The conventional equilateral triangular microstrip patch antennas were studies in [17-23].

The microstrip patch antenna radiates at 5.8 GHz has been designed from the equation [1], $L = \frac{2C}{3fr\sqrt{r}}$ for the triangular shaped antenna. Each side of the equilateral triangle is L=16mm with the parameters, dielectric constant ε_r= 4.4(FR4) and thickness h=1.5875mm.

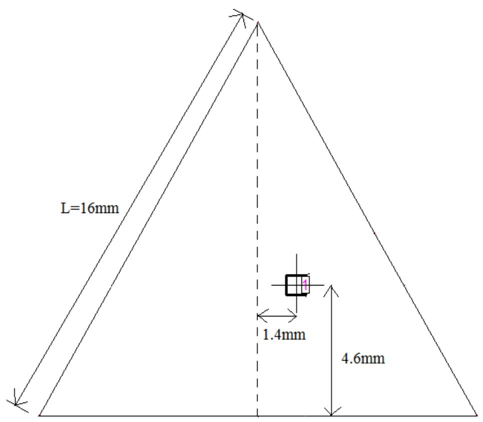

Figure 1: Antenna 1

Antenna 1 is fed at optimum feeding location with coaxial cable of 0.5mm radius shown in figure 1.

Antenna2 structure has been designed by taking finite ground plane. All other parameters of Antenna2 structure are same as Antenna1.The optimum results found for the ground plane of width W_g= 18mm and length L_g= 34mm. Antenna 2

Manuscript received on January, 2013.
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is fed at optimum feeding location with a microstrip line shown in figure 2.

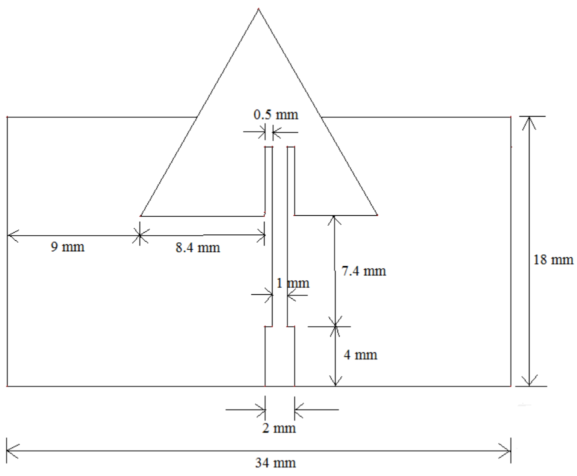

Figure 2: Antenna 2

Antenna 3 structure has been designed to get the wide bandwidth with slotted patch and shorting pin. All the parameters of Antenna 3 are same as Antenna 1 and Antenna 3 structure is fed with microstrip line in optimum location. The slot length and widths all are shown in figure 3-4.

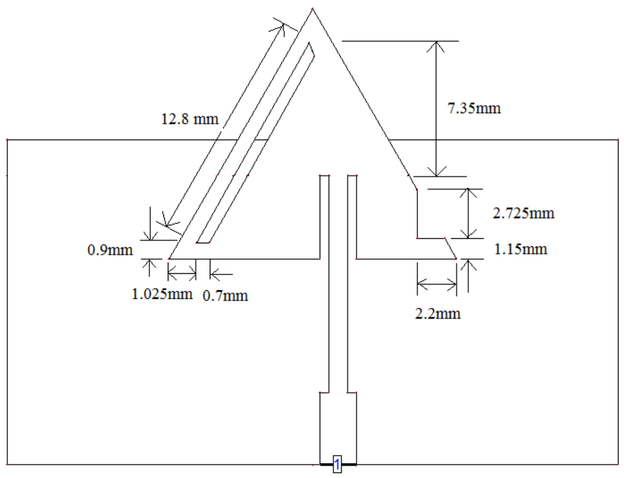

Figure 3: Antenna 3 (Without pin)

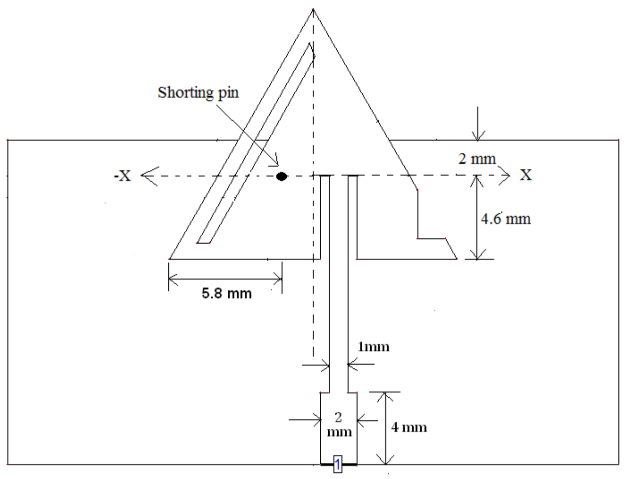

Figure 4: Antenna 3 (With pin)

III. RESULTS AND DISCUSSION

For the Antenna1 structure, the resonant frequency is at 5.58GHz with return loss of about 35.29dB and 10dB bandwidth is 114MHz i.e. 2.04% of the center frequency. The resonant frequency for the Antenna 2 (without pin) structure is at 5.26GHz with return loss 12.4dB and 10dB bandwidth is 1.782GHz i.e. 33.9% of the center frequency. Antenna 2 structure with shorting pin at optimum location resonates at two frequencies such as f_1=2.5GHz with return loss 14dB and f_2=5.29GHz with return loss 11.62dB. Bandwidths of these two bands are 146 MHz i.e. 5.84% and 1.844 GHz i.e. 34.87% respectively. The resonant frequency for Antenna 3 structure without shorting pin shows almost equal result with Antenna 2 structure without pin. But the resonant frequencies for the Antenna 3 structure with shorting pin at optimum location are at f_1=2.5GHz with return loss 14dB and 10dB bandwidth is 138MHz i.e. 5.42% of the center frequency and f_2=5.17GHz with return loss 14.2dB with 10dB bandwidth is 2GHz i.e. 38.67% of the center frequency. The bandwidth enhancement has been achieved on the Antenna 3 structure using shorting pin of 0.16mm radius located at optimum location shown in figure - 4.

It has been observed that when the shorting pin is used the designed antenna (Antenna 2 & Antenna 3) resonates in two frequencies. Due to the presence of shorting pin the antenna impedance in the reactive part changes in such a way that antennas are resonating in another frequency. The new resonant frequency is also in other band (S band), hence the designed antenna may be used as dual band dual frequency mode.

Due the insertion of the shorting pin the impedance matching can be achieved to wide range of frequencies (Antenna-3 with shorting pin) which results enhancement of bandwidth.

The simulated results for Antenna 1, Antenna 2 and Antenna 3 structures are given in the Table – 1.

Table – 1: Simulated Results

Antenna	Resonant Frequency (GHz)	Return Loss (dB)	Simulated Bandwidth (MHz)	Simulated % Bandwidth
Antenna 1	5.58	35.29	114	2.04
Antenna 2 without pin	5.26	12.4	1782	33.9
Antenna 2 with pin	f_1 = 2.5 f_2 = 5.29	14 11.62	146 1844	5.84 34.87
Antenna 3 without pin	5.28	11.2	1793	33.94
Antenna 3 with pin	f_1 = 2.5 f_2 = 5.17	14 14.2	138 2000	5.42 38.67

Figure 5-6 show the return loss vs frequency graph for Antenna 1, Antenna 2 and Antenna 3.

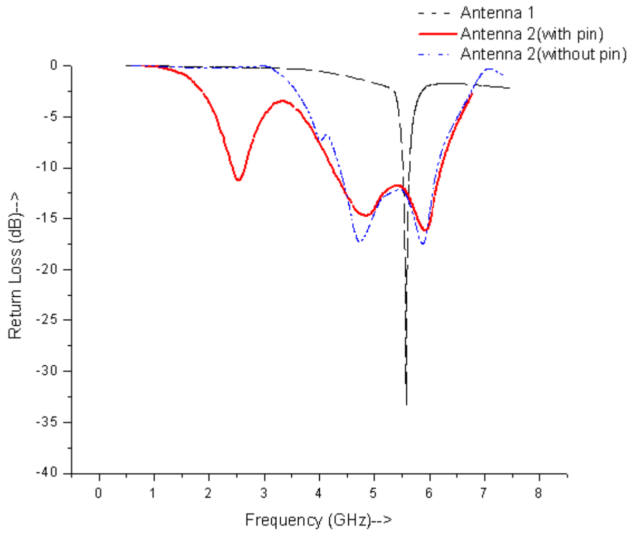

Figure 5: Return Loss for Antenna 1 and Antenna 2

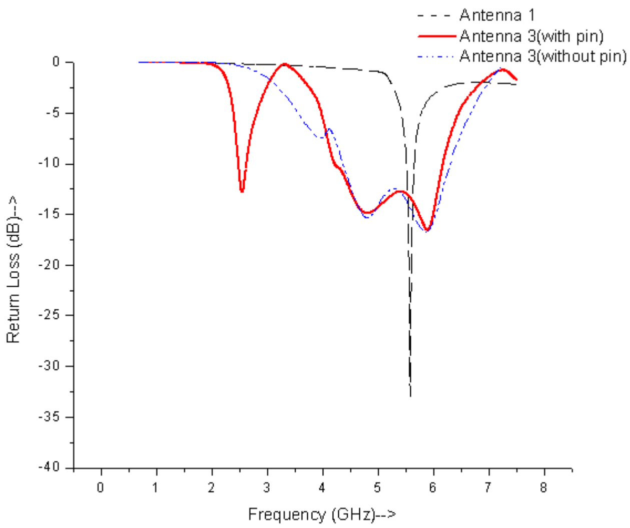

Figure 6: Return Loss for Antenna1 and Antenna 3

The radiation patterns for E-field and H-field of the reference and designed antennas are shown in Figure-7-10.

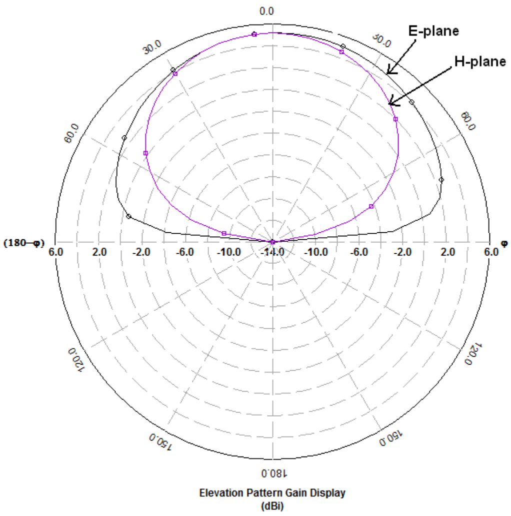

Figure 7: Radiation pattern for Antenna 1 at 5.58GHz

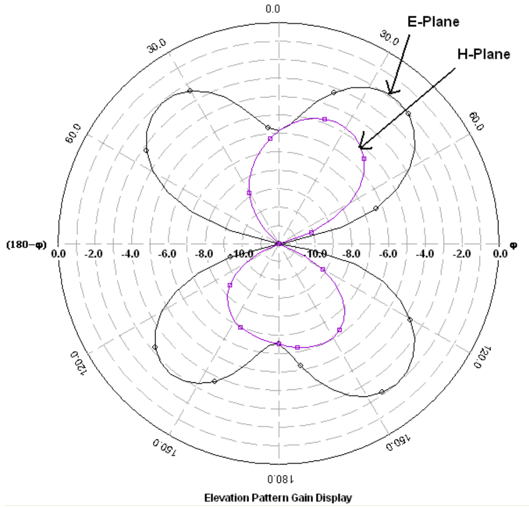

Figure 8: Radiation pattern for Antenna 3 without pin at 5.28GHz

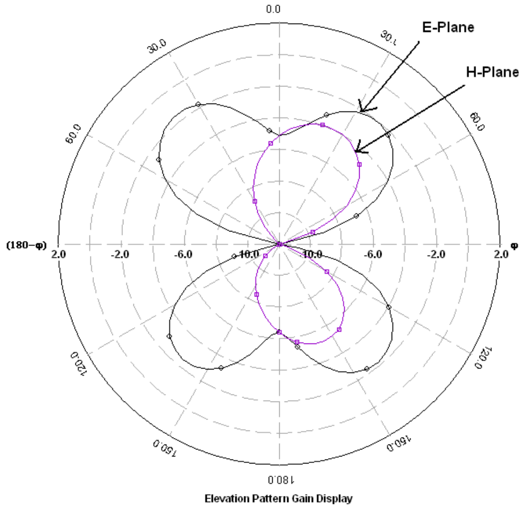

Figure 9: Radiation pattern for Antenna 3 with pin at 5.17GHz

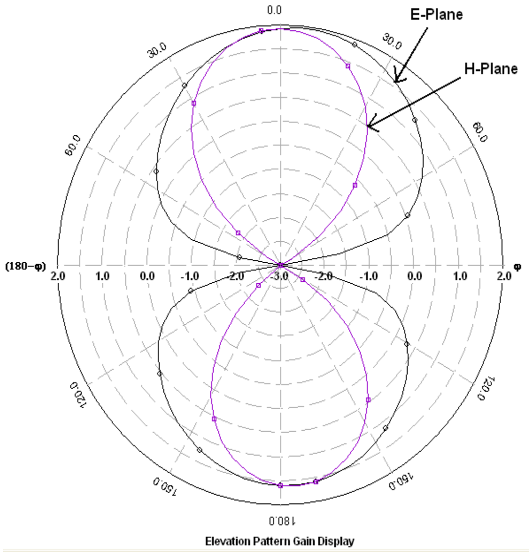

Figure 10: Radiation Pattern for Antenna 3 with pin at 2.5GHz

The radiation patterns of Antenna 2 are almost same as the radiation patterns of Antenna 3. The absolute gain for Antenna 3 at 2.5GHz is 2dBi and -3dB beam width for E-plane is 162.72^0 and for H-plane is 128.16^0. The current distributions of Antenna 3 without shorting pin and with shorting pin are shown in figure 11-12.

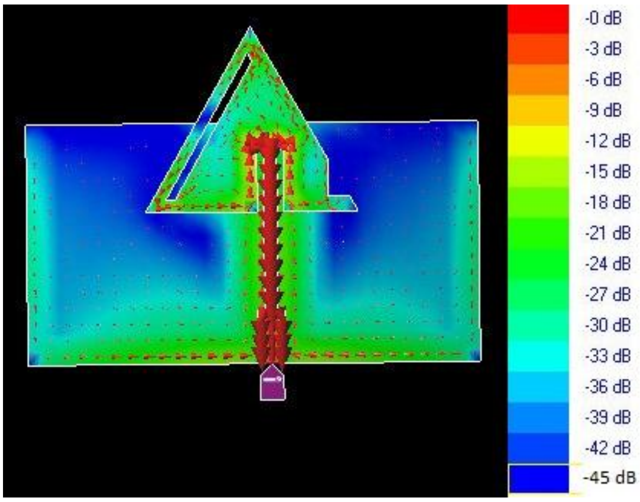

Figure 11: Current distribution of Antenna 3 without shorting pin

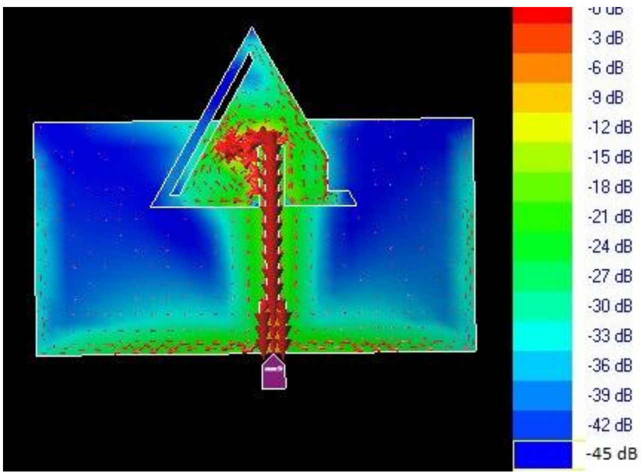

Figure 12: Current distribution of Antenna 3 with shorting pin

IV. CONCLUSION

The size of the microstrip antennas can be reduced by the concept of loading a microstrip antenna with shorting pin. Here single layered, single fed, shorting pin loaded and defecting grounded, slotted triangular patch Microstrip antennas are proposed and designed for broadband operation with compact size. Microstrip antenna with slotted patch and defected ground plane offers a huge bandwidth of about 38.67% of the center frequency suitable for WLAN application in C band which is very much encouraging. By using the shorting pin, antenna size is also been reduced about 82.4% of its original size. The proposed antenna resonates at dual band (S band) at 2.5GHz and (C band) at 5.17GHz with remarkable return loss which may be used in dual band operation. The antenna gains of the proposed structures are not good but it can be enhanced by using the stacked structures or any other gain enhancement scheme.

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