Effect of a Slot on Rectangular Microstrip Antenna using Proximity Fed Technique

Dinesh B. Ganure[1] S. L. Mallikarjun[2] P. M. Hadalgi[3] P. V. Hunagund[4]
[1]Research Scholar [2]Guest Faculty [3,4]Professor
[1,2,3,4]Department of Applied Electronics
[1,2,3,4]Gulbarga University, Kalaburagi – 585106, Karnataka, India

Abstract— This paper presents the effect of slot on rectangular microstrip patch antenna using proximity feed technique. The antenna uses two-layer substrate with the microstrip-line on the lower layer and the patch antenna on upper layer such as the feed line terminates in an open end underneath the patch. In this study a slot is etched on a rectangular patch such that the antenna is resonating for four frequency bands and 4.85 times more when compared to the antenna without a slot. The other antenna parameters such as radiation pattern, return loss, VSWR and HPBW are presented and discussed. The proposed antenna finds the application in modern wireless communication systems.

Key words: Microstrip Antenna, Proximity Feed, Quad Band, And VSWR

I. INTRODUCTION

In the present-time communication, antennas cover a wide range of applications in different areas, such as mobile communication, satellite navigation, internet services, automobiles and radars. Especially they are applied to microstrip antennas, because of its characteristics like low profile, lightweight and low power handling capacity [1-4]. However, gain and bandwidth are sometimes low and not sufficient in most of applications. Modification of shape and using special materials could be useful to solve such backlashes of this type of antennas. Therefore it becomes very important to develop a technique to increase the bandwidth and gain of the microstrip antenna.

In modern wireless communication GPS, Bluetooth, WLAN and Wi-MAX have been widely applied in mobile devices such as hand held computers and smart phones. These two techniques have been widely recognized as a viable, cost-effective, and high- speed data connectivity solution, enabling user mobility with the rapid development of the modern wireless communication system, antenna design has turned to focus on wide multiband and small simple structures that can be easy to fabricate. Compact, multiband, low-profile and low-cost antennas are widely used in personal communication devices along with the rapid development of the wireless communication systems. Similarly various studies on slots have seen in the literature in order to achieve two or more than two band operations were reported. A quad-band U-slot microstrip patch antenna using co-axial feeding technique for wireless application is presented [5]. Design of quad band operation of antenna at four different bands of frequencies which is possible by constructing two rhombus slots on rectangular microstrip patch element [6]. A new quad-band small size microstrip handset antenna is designed using different substrate material [7]. A single feed dual layer rectangular microstrip antenna with single short pin which gives quad-band antenna can operate effectively in four frequency bands [8].

The present study is made by designing a rectangular slot on patch of the radiating element. It uses a two –layer substrate with the microstrip line on the lower layer and the patch antenna on the upper layer. The feed line terminates in an open end underneath the patch [9, 10].

II. ANTENNA DESIGN

The proposed antenna using proximity feeding technique is designed using a commercially available low cost glass epoxy substrate material with relative permittivity $\varepsilon_r = 4.2$ and dielectric loss tangent $\tan\delta = 0.02$.

Figure 1 shows geometry of the proposed antenna. The dimensions of the rectangular patch length L = 2.39 cm and width W = 3.10 cm. The microstripline feed of length L_f = 24.971 cm and width W_f = 3.166 cm is etched on the top surface of substrate S_2. The substrate S_2 is placed below substrate S_1 and the bottom surface of the substrate S_2 acts as the ground plane of dimension L_g = 33.570 cm and W_g = 40.608 cm. The dimensions of the Rectangular shaped slot is Wp = 0.8 cm ($\lambda_0/12.5$) and Lp = 0.2 cm ($\lambda_0/50$).

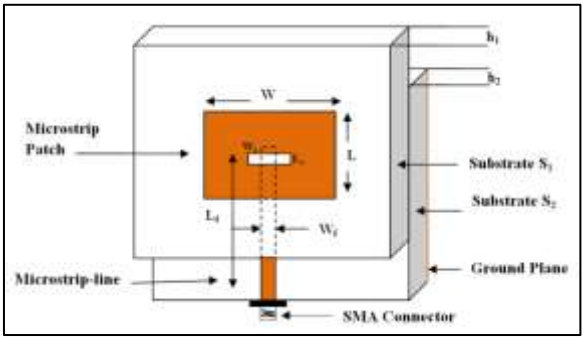

Fig. 1: Geometry of proposed antenna

The proposed has been designed for 3 GHz. The art work of the proposed antenna is sketched by using computer software Auto-CAD 2006 to achieve better accuracy and the substrate material of thickness of h = 0.16 cm is same for two layers. At the tip of microstrip feed line, a 50 Ω coaxial SMA connector is connected for feeding the microwave power.

III. EXPERIMENTAL RESULTS

The impedance bandwidth over return loss less than -10dB for the proposed antenna is measured which is shown in Figure 2. The experimental impedance bandwidth is defined as,

$$\text{Impedance Bandwidth (\%)} = \left[\frac{f_H - f_L}{f_C}\right] \times 100 \quad \text{..... (1)}$$

Where, f_H is the higher cutoff frequency and f_L is the lower cutoff frequency and f_C is central frequency of the bands.

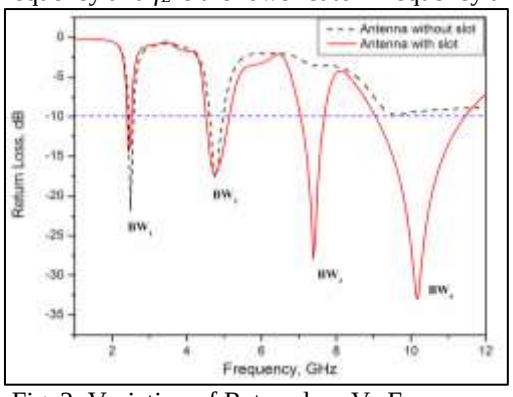

Fig. 2: Variation of Return loss Vs Frequency

From the figure it is observed that, the antenna without slot resonates for two bands at 2.49 GHz and 4.78 GHz giving the impedance bandwidth of 90 MHz (3.62%) and 300 MHz (6.25%) respectively. Similarly the proposed antenna operates for quad band of frequencies at 2.49 GHz, 4.74 GHz, 7.38 GHz and 10.19 GHz. The experimental impedance bandwidth (BW_1) at 2.43 GHz is found to be 70 MHz (2.83%), at 4.74 GHz the impedance bandwidth (BW_2) is 610 MHz (12.64%), at 7.38 GHz the impedance bandwidth (BW_3) is 610 MHz (8.29%) and the impedance bandwidth (BW_4) at 10.19 GHz is 2480 MHz (24.14%). When compared with antenna without slot it is 4.85 times giving more bandwidth without affecting the initial resonance. Also, the minimum return loss measured in this antenna is found to be -14.47 dB, -17.37 dB, -27.9 dB and -32.98 dB respectively.

The theta-phi plane radiation patterns of antenna are obtained at their resonating frequencies and the radiation pattern at 2.49 GHz is shown in Figures 3. The figure indicates that the antenna shows broader side radiation characteristic. The cross-polarization level of this antenna is found to be below -22dB. The three dimensional ration patterns is also shown in the Figure 4.

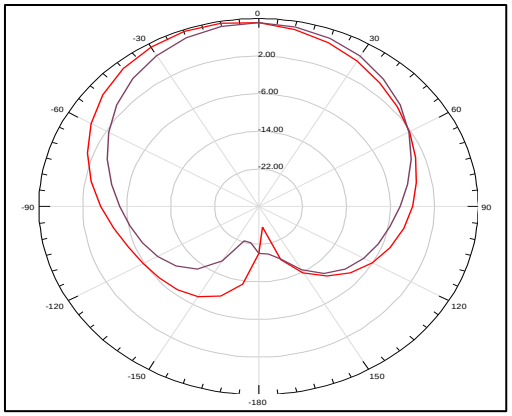

Fig. 3: Radiation Pattern Profile

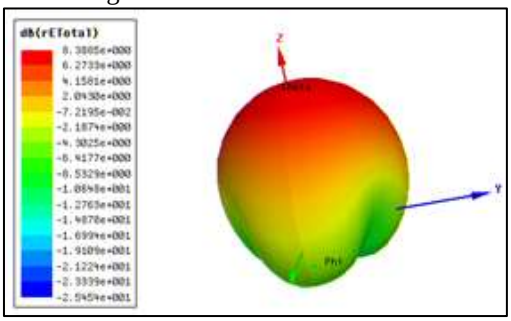

Fig. 4: Three dimensional Radiation Pattern

The Half Power Beam Width (HPBW) is found to be 140^0. Similarly, Voltage Standing Wave Ratio (VSWR) is found to be less than 2 and this corresponds to a perfect match [11] for the antenna and the values of VSWR found at their resonating frequencies are 1.8, 1.25, 1.81 and 1.18 which is shown in the below Figure 5.

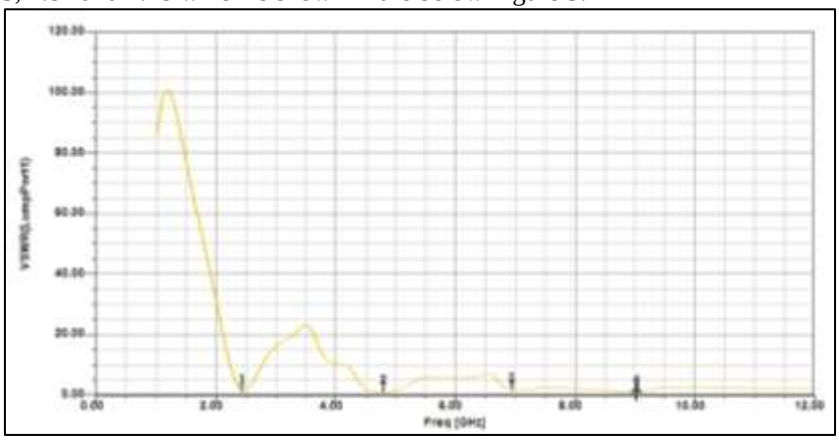

Fig. 5: VSWR

IV. CONCLUSION

The experimental study illustrates that the antenna is relatively simple in design and fabrication and quite good in enhancing the bandwidth by quad frequency operation and giving better broadside radiation pattern. The other antenna parameter return loss, and VSWR are found to be good for this antenna. This antenna is better as it uses low cost substrate material and finds applications in S C and X-band frequency ranges such as in modern wireless communication systems.

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