



Alternate Rectangular Slots loaded Proximity Fed Antenna

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ABSTRACT: This paper presents the effect of alternate slots on rectangular microstrip patch antenna using proximity feed technique. The fabricated 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 four alternate rectangular slots are etched on a rectangular patch such that four alternate rectangular patches are formed where each patch is resonating for different frequency by providing quad band operation. The other antenna parameters such as radiation pattern, return loss, gain, VSWR and HPBW are presented and discussed. The proposed antenna finds the application in modern wireless communication systems.

KEYWORDS: Microstrip antenna, proximity feed, quad band, gain 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 WiMAX 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 etching alternate rectangular slots on patch such that alternate small patches are created on 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]. The dimensions of the Rectangular shaped slots are as $W_p = 7.252 \text{ cm}$ ($\lambda_0/1.379$) and $L_p = 11.987 \text{ cm}$ ($\lambda_0/0.834$).

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II. ANTENNA DESIGN

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

Figure 1 shows geometry of the proposed antenna. It consists of four rectangular slots on top surface of substrate S_1 . 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.

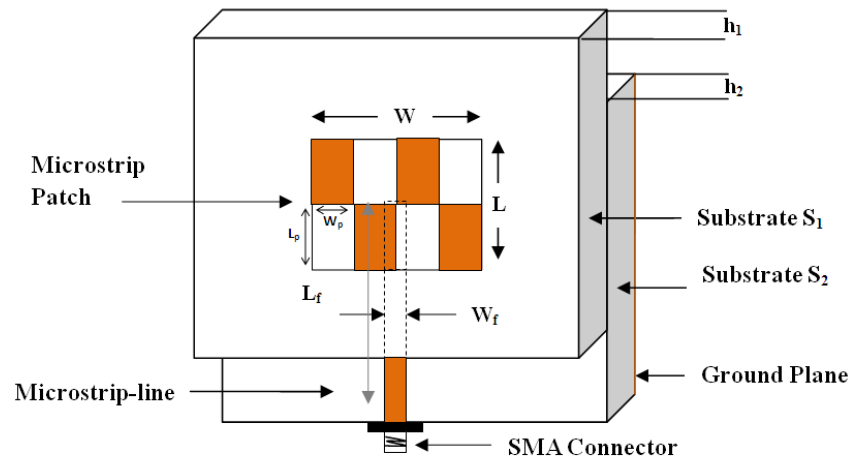


Fig. 1 Geometry of proposed antenna

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 $h = 1.66$ mm is same for two layers. At the tip of microstrip feed line, a 50Ω coaxial SMA connector is connected for feeding the microwave power.

III. EXPERIMENTAL RESULTS

The measurements are taken on Vector Network Analyzer (Rohde & Schwarz, German make ZVK Model No. 1127.8651). 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,

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

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

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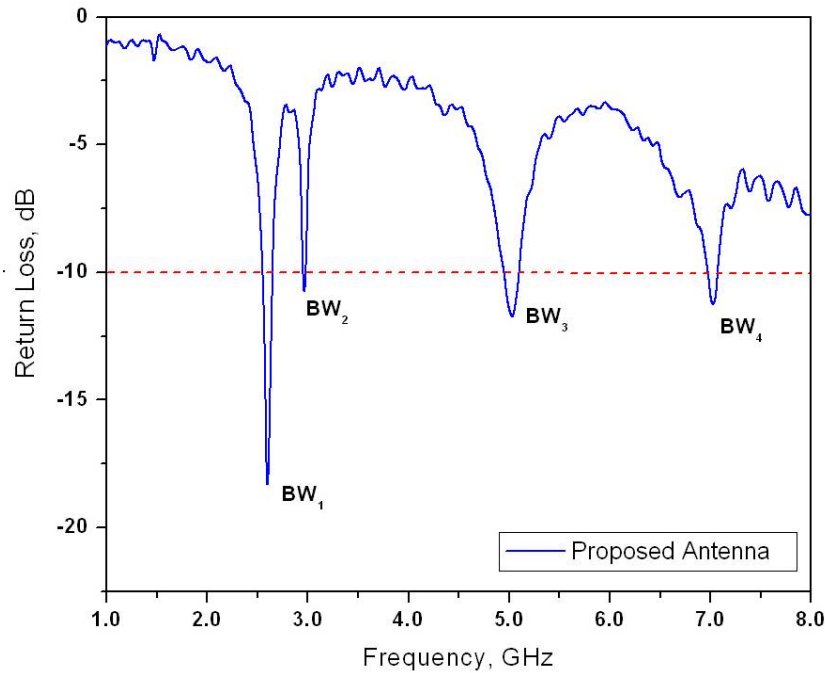


Fig. 2: Variation of Return loss Vs Frequency

From the figure it is observed that, antenna operates for quad band of frequencies at 2.61 GHz, 2.96 GHz, 5.02 GHz and 7.02 GHz. The experimental impedance bandwidth (BW_1) at 2.61 GHz is found to be 87 MHz (3.36%), at 2.96 GHz the impedance bandwidth (BW_2) is 17.5 MHz (0.58%), at 5.02 GHz the impedance bandwidth (BW_3) is 157.5 MHz (3.13%) and the impedance bandwidth (BW_4) at 7.02 GHz is 105 MHz (1.49%). Similarly the minimum return loss measured in this antenna is found to be -18.75 dB, -11.18 dB, -11.75 dB and -11.27 dB respectively.

The X-Y plane co-polar and cross-polar radiation patterns of antenna are measured at their resonating frequencies and the radiation pattern at 2.61 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 -11dB.

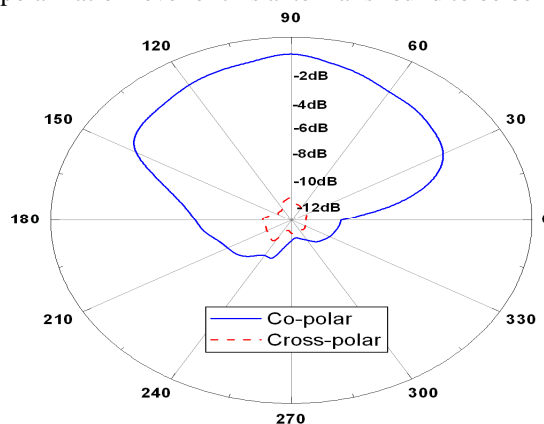


Fig. 3: Radiation pattern at 2.61 GHz

The half power beam width (HPBW) and gain for the proposed antenna are calculated for the resonating frequency at 2.61 GHz and are shown in Table 1. The gain of proposed antenna is calculated using absolute gain method given by the equation, [9]

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$$G(dB) = 10 \log\left(\frac{P_t}{P_r}\right) - (G_t)dB - 20 \log\left(\frac{4\pi R}{\lambda}\right)dB \dots\dots\dots (2)$$

where, P_t and P_r are transmitted and received powers respectively, G_t is the gain of the pyramidal horn antenna and R is the distance between transmitting antenna and antenna under test. The gain of the antenna is tabulated in Table 1. Similarly, Voltage Standing Wave Ratio (VSWR) is found to be 1.177 and this corresponds to a perfect match [11] which is shown in Figure 4.

Table 1: Calculated Gain, HPBW and VSWR

Substrate Height	Freq. in GHz	Gain in dB	HPBW in degrees	VSWR
$S_1=1.6\text{mm}$ $S_2=1.6\text{mm}$	2.61	9.433	127	1.177

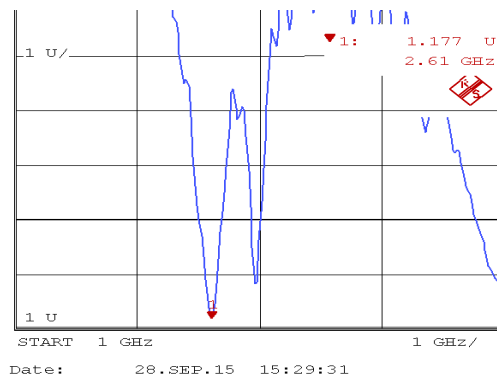


Fig. 4: VSWR

The input impedance shown has a loops at the center of Smith chart which validated its quad band nature and the impedance matching is found at $42.53-j2.236$ which illustrates the nearly matching of the feedline and radiating patch at 50Ω to the standard [6] which is shown in Figure 5.

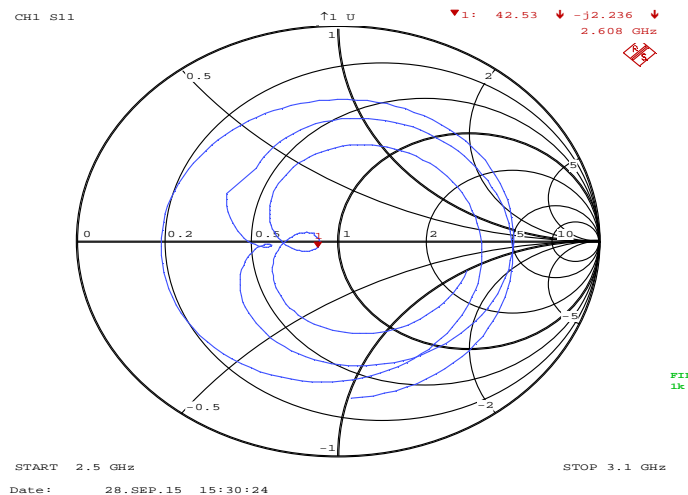


Fig. 5: Smith chart profile



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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, gain 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 and C-band frequency ranges such as in modern wireless communication systems.

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