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# DIAGONAL SLOT-LOADED RECTANGULAR MICROSTRIP PATCH ANTENNA

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## ABSTRACT

**In this paper, a study on rectangular microstrip antenna using proximity feeding technique is made. The fabricated antenna uses two-layer substrate with the microstrip-line on the lower layer and the patch antenna on upper layer such that the feed line ends in an open end underneath the patch. The study is made by inserting two diagonal slots on the radiating element of microstrip patch and the antenna resonates for dual frequency bands below the designed frequency. The antenna parameters such as impedance bandwidth, return loss, radiation pattern, Gain, VSWR and HPBW are calculated and presented. The antenna may find the applications in modern communication systems.**

**KEYWORDS:** Rectangular Microstrip Patch, Proximity Feed, Impedance Bandwidth, Gain

Recent communication terminals employ either separate antennas or a combination of two in one embodiment, in order to achieve multiband coverage of cellular and PCS bands. A single low-cost mobile terminal equipped to operate in several regions of the world, each with different operating frequency, is essential for future generation mobile wireless systems. Especially they are applied to microstrip antennas, because of their characteristics like low profile, lightweight and low power handling capacity (Bahl and Bhartia 1980 & Girish Kumar and K.P. Ray, 2003). 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 disadvantages of these types of antennas (Fan Yang, et.al, 2001). WiMAX (Wireless Interoperability for Microwave Access) is one of the latest wireless technologies. This technology can be used in numerous numbers of applications; the broadband services such as Voice over IP (VOIP), portable mobile connectivity, Digital Subscriber Line (DSL), etc (Yahya Entiefa Mansour, 2014).

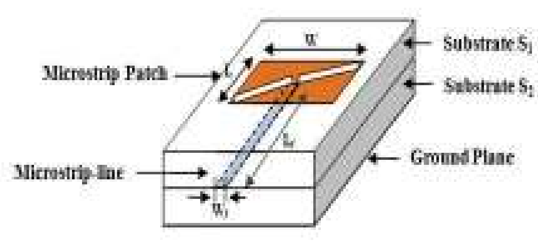
Basically a microstrip antenna consists of a planar radiating structure of desired geometrical shape on one side of a dielectric substrate and a ground plane on the other (David Pozar, 1990). Commonly used microstrip radiating geometries are rectangular, triangular and circular (Ramesh Garg, 2001). However, other shapes are also considered depending upon the application.

The present study is made by fabricating rectangular microstrip patch antenna using proximity feeding method. 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 (Ramesh Garg, 2001).

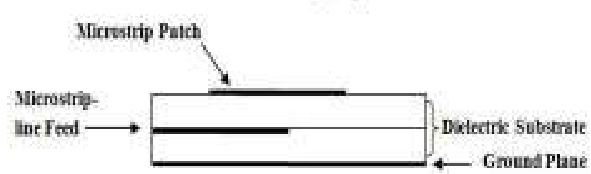
## ANTENNA DESIGN

The Proximity-coupled Rectangular Microstrip Antenna (PRMSA) is fabricated 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 the top view as well as side view geometry of PRMSA. The PRMSA consists of a patch of length L and width W etched on top surface of substrate $S_1$. The microstripline feed of length $L_f$ and width $W_f$ 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. Two diagonal slots are etched on the rectangular patch on substrate $S_1$.




(a) Top-View




(a) Side-View

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**Figure 1: Geometry of PRMSA**

The PRMSA has been designed for 3 GHz. The physical dimensions of rectangular radiating patch and feedline are shown in the T-1.

**Table 1: Design parameters of proposed antenna**

| Antenna Geometry Parameters | Dimensions |
|---|---|
| Length of the patch, L | 23.90mm |
| Width of the patch, W | 31.00mm |
| Length of feedline, $L_f$ | 12.69mm |
| Width of feedline, $W_f$ | 3.16mm |
| Thickness of the substrate | $S_1$ = 1.6mm & $S_2$ = 1.6mm |

## 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. The variation of return loss versus frequency of PRMSA with same thickness of substrates such as $S_1 = S_2 = 1.6$ mm by keeping the same permittivity is measured. The experimental impedance bandwidth is calculated from the equation (1).

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

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.

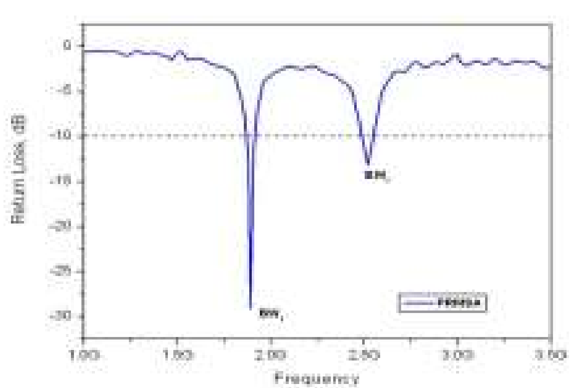


**Figure 2: Variation of Return loss Vs Frequency of PRMSA**

The variation of return loss versus frequency of the designed antenna is shown in Figure 2. It is observed that, PRMSA with two diagonal slots on the radiating patch resonates for dual band operation at 1.89 GHz and 2.52 GHz frequency. The experimental impedance bandwidth ($BW_1$) at 1.89 GHz is found to be 40 MHz (2.11%) and the impedance bandwidth ($BW_2$) at 2.52 GHz is 60 MHz (2.39%). The minimum return loss measured in this antenna is -29.12 dB and -13.16 dB respectively.

The X-Y plane co-polar and cross-polar radiation patterns of PRSMA are measured at their resonating frequencies and the radiation pattern at 1.89 GHz is shown in Figures 3. The figure indicates that the antenna shows broader side radiation characteristics. The cross-polarization level of this antenna is found to be below -4dB.

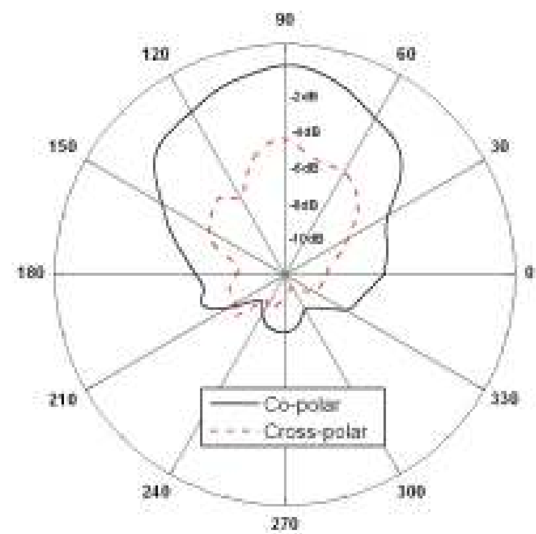


**Figure 3: Radiation pattern at 1.89 GHz**

The half power beam width (HPBW) and gain for the proposed antenna are calculated for its resonating frequencies and are shown in T-2.

The gain of proposed antenna is calculated using absolute gain method given by the equation (Ramesh Garg, 2001),

$$\mathbf{G(dB)} = \mathbf{10log}\left(\frac{P_r}{P_t}\right) - \mathbf{(Gt)dB} - \mathbf{20log}\left(\frac{\lambda_0}{4\pi R}\right)\mathbf{dB} \ldots\ldots (2)$$

where, Pt and Pr are transmitted and received power respectively. Gt 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 T-2. Similarly, Voltage standing wave ratio (VSWR) is found to be around 1 and this corresponds to a perfect match (John Ojha and Marc Peters, 2014) which is shown in Figure 4.

**Table 2: Calculated Gain, HPBW and VSWR**

| Substrate Height | Freq. in GHz | Gain in dB | HPBW in degrees | VSWR |
|---|---|---|---|---|
| $S_1$=1.6mm<br>$S_2$=1.6mm | 1.89 | 10.26 | $108^0$ | 1.08 |

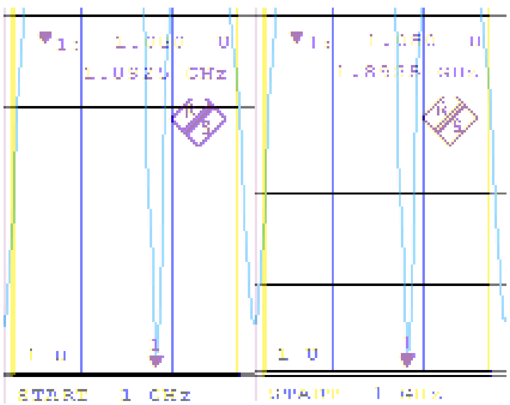

**Figure 4: VSWR at 1.89 GHz**

The input impedance shown has a loop at the center of Smith chart which illustrates the matching of the feedline and radiating patch at 50Ω (Mallikarjun, et.al, 2010) which is shown in Figure 5.

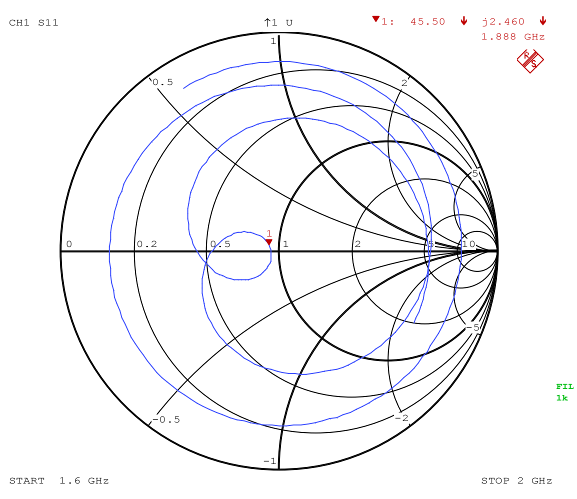


**Figure 5: Smith chart profile**

## CONCLUSIONS

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

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