PROXIMITY FED MICROSTRIP PATCH ANTENNA FOR BROADBAND OPERATIONS

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Abstract- This paper represents the design of a broadband microstrip antenna with a simple close ended proximity-coupled feed covering applications like TD-LTE 2500 (2555-2575 MHz), TD-LTE 2600 (2575-2635 and 2635-2655 MHz), Bluetooth (2400-2500 MHz), WIMAX (2500-2690 MHz, 3400-3600 MHz), BMT (2.7-2.9 GHz, 3.4-4.2 GHz) and WLAN (2400-2484 MHz, 5.725-5.825 GHz). The design of antenna is quite simple, consisting of 0.1 mm thick rectangular patch with two elongated rectangular slots joined together forming a Plus symbol and a ground plane with an open ended rectangular slot etched in it. It consists of a rectangular proximity-coupled feed sandwiched between two FR4 substrates, each 5-mm-thick with a dielectric constant of 4.3. The results are obtained by simulating designed antenna using CST software (Version-10).

Keywords- Microstrip Patch Antenna, Proximity Coupled feed, Defected Ground Slot, Broadband.

I. INTRODUCTION

Due to rapid progress in communication system in recent years, communication technology needs antenna having light weight, low profile, superior performance and broadband operation. Wi-MAX, WLAN technologies are most rapidly growing in the area of modern wireless communication. These technologies give users the mobility to move around within a large coverage area and still be connected to the network. For the home user, wireless has become popular due to ease of installation and accessibility. So, there is continuously increasing requirements of efficient and high performance antenna. Microstrip patch antenna can fulfill these requirements. Broadband antennas are preferred to avoid using multiple antennas for different operating frequencies.

Recently, with the increasing demand of Fourth Generation (4G) devices in the market, wireless communication antennas are also required to cover 4G Long-Term Evolution (LTE) frequency bands, such as Time-division LTE (TD-LTE) 2500 (2555-2575 MHz), TD-LTE 2600 (2575-2635 and 2635-2655 MHz) [1]. However, it’s a challenging task to design an antenna that will simultaneously cover TD-LTE, Bluetooth, WLAN, WiMAX bands for various communication services.

Since the slots are etched in the microstrip antenna patch, due to these slots the radiation pattern of the antenna will get affected along with the patch size. Different planar monopole antennas achieve broadband and multiband operations by fabricating a microstrip antenna on a thicker, lower-dielectric-constant substrate along with a proximity-coupled feed line. A broad-band has been realized while maintaining the same patch size by cutting rectangular slots of various shapes like V shape covering WLAN and Bluetooth bands [2], U Shape covering S-band [3], Psi (Ψ) Shape [4] covering WiMAX and WLAN band.

Different feeding techniques are used to achieve broadband applications, such as microstrip line feed, Coaxial Probe Feed, Proximity-coupled feed etc. To provide Proximity-Coupled feed, feed-line is sandwiched between two substrates with same or different widths and dielectric constants [5]. Through the electromagnetic coupling between patch and the strip, a broader bandwidth is obtained. An advantage of using proximity-coupled feeding technique is that for the same substrate thickness, this technique gives larger bandwidth [6]. The Proximity-coupled feed is also provided by using strips of various shapes like dual U-shaped monopole strips so as to perform broadband operations [7].

Also different slots are etched in the Ground plane so as to obtain broadband responses. The study and comparison of various meandering slots in the rectangular microstrip antenna ground plane, i.e; smaller, longer and open – ended slots for compact broadband operation is presented [8], in which an open – ended slot provides broader bandwidth. A microstrip line fed planar multiband monopole antenna is presented [9], with crescent-shaped radiator patch, microstrip feed line and defected ground structure (DGS). This antenna is suitable for integration with a variety of mobile terminals operating over DCS, PCS, UMTS and Bluetooth bands. A novel proximity-coupled multiband microstrip antenna covering all the standard of UMTS, LTE, Bluetooth, WiMAX, and WLAN is proposed [10], using slotted ground plane which is excited electromagnetically by a meander microstrip feed. For impedance matching, a corner-truncated rectangular patch with a rectangular slot at its center.
along with horizontal open and close ended slots in the ground plane is used. In this paper, firstly a rectangular microstrip patch antenna is designed using Proximity-coupled feed and then different rectangular slots are etched in both patch and ground plane so as to achieve Broadband antenna performance.

Fig. 1. Configuration of the proposed antenna: (a) Geometry of patch (b) Geometry of ground and feed.

![Fig. 1](image1.png)  
![Fig. 1](image2.png)

TABLE 1 PARAMETER VALUES OF PROPOSED ANTENNA (All Dimensions are in mm)

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<thead>
<tr>
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<th>Wsub1</th>
<th>Lsub2</th>
<th>Wsub2</th>
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<td>Lf</td>
<td>G4</td>
<td>Wgs</td>
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II. ANTENNA DESIGN AND ANALYSIS

Fig. 1(a) and (b) shows the construction of Patch and Ground Plane of the proposed multiband antenna along with the dimensions. Two layers of FR4 substrates are used, each having relative permittivity of 4.3, Loss Tangent of 0.025 and thickness of 5mm. Proximity coupling is obtained by using a rectangular feed line printed on the top of the lower substrate. The slotted ground structure is on the lower side of the lower substrate. CST Software (Version 10) is used to design the proposed antenna. In this proposed antenna, a Plus slot is etched in the upper layer of the antenna by adding horizontal and vertical rectangular slots. Slot of Plus symbol is etched because it makes the antenna radiates at two different frequencies showing dual band behavior. The slots are also etched in the ground plane because the open – ended slot in the ground plane helps in increasing the overall performance of the antenna by increasing the return loss, broadening the resonance bands and increased gain [8]. After etching each slot on the ground plane as discussed in [10], only one slot seems to be favorable because the return loss starts increasing for different bands. Final antenna is shown in figure 2.

![Fig. 2](image3.png)  
![Fig. 2](image4.png)

III. RESULTS AND DISCUSSIONS

The proposed antenna is simulated without any slot in patch and ground plane with proximity-coupled feed. Without any slot, antenna radiates at resonance...
frequency of 1.68 GHz only, with low return loss of about -12 dB. Two rectangular slots i.e; horizontal and vertical are etched separately in the patch. Due to Horizontal slot, antenna radiates at resonance frequency of 1.25 GHz with return loss of -32 dB. Due to Vertical slot, antenna radiates at resonance frequency of 6.44 GHz with return loss of -45 dB. To obtain dualband behavior, a Plus symbol is used which is formed by etching both vertical and horizontal slots in the patch. Dual band behavior is observed because the antenna thus formed radiates at both frequencies as radiated separately by Horizontal and Vertical slots. The antenna radiates at two resonance frequencies 3.54 GHz and 6.44 GHz respectively. But the return loss for both the resonance frequencies is low. After formation of plus slot, a conclusion came that the antenna radiates at same frequency as radiated by vertical slot but the resonance frequency due to horizontal slot gets shifted towards right side of the frequency spectrum. The results are shown in Fig 3.

The Feed is moved towards right edge of the antenna [7] because multiple bands are formed and are broader than the bands formed due to etching of plus slot, i.e: Bandwidth of about 1.2 GHz for resonance frequency of 2.91 GHz and 758 MHz for resonance frequency of 4.33 GHz. The return loss for each band thus appeared is also high, i.e; -30dB, -17.74dB, -24dB and -28dB respectively. The results are shown in Fig 4.

The length and width of the horizontal and vertical rectangular slots are also varied so as to get best results. Finally, the antenna radiates at resonance frequencies of 3.28 GHz and 6.12 GHz as shown in figure 5. At 3.28 GHz, the return loss is -38.25 dB and at 6.12 GHz, the return loss is -27 dB. Both the bands thus formed are also broader as compared to band thus formed when no slot was etched in the patch. Observed Bandwidth for both the bands is of about 2.1 GHz for resonance frequency of 3.28 GHz and about 3.24 GHz for resonance frequency of 6.12 GHz.

Directivity means, how much an antenna can radiate in one particular direction. More will be the directivity, good will be the performance of antenna. For 3.28 GHz, directivity is 3.5dBi and for 6.12 GHz, directivity is 3.7dBi.

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Value of VSWR for any antenna should be in the range 0 to 2. Smaller will be the value of VSWR, larger will be the return loss and hence broader bandwidth. For 3.28 GHz, VSWR is 1(< 2) and for 6.12 GHz, VSWR is 1.1 (< 2). VSWR Plot is shown in figure 8.
IV. SENSITIVITY ANALYSIS

Various factors affecting antenna performance are discussed in this section. The first factor for which the antenna results are sensitive is Open – ended slot in the ground plane. When the Open – ended slot is etched in the ground plane, the resonance curves formed becomes broader and also gives the return loss more than -10 dB. After comparing the bands formed using different values of slot width in the ground plane, one optimum value is selected, i.e; G4=1.

Value of G4 is so selected because the bands formed with this value are broader and gives high return loss as compared to all other values of G4. The results are shown in figure 9.

Second factor for which the antenna results are sensitive is feed length (Lf). Feed length is defined in terms of Length of upper substrate (Lsub1) and Mf as Lf = Lsub1/2 + Mf, where Lf is the feed length, Lsub1 is length of upper substrate and Mf is the feed length above centre point of the antenna. For increasing feed length (Lf), value of Lsub1 remains unchanged and value of Mf is varied. After comparing the bands formed using different values of Mf, one optimum value is to be selected by taking into account various factors like High return loss, and width etc. For Mf=5, return loss is -25 dB and bandwidth is 1.13 GHz. Value of G4 is so selected because the bands formed with this value are broader and gives High return loss as compared to all other values of G4. Comparison of the results is shown in figure 10.

CONCLUSION

An impudent configuration of a Broadband microstrip antenna is shown that present synchronous operation at LTE-TD, Bluetooth, IMT, WIMAX and WLAN bands. Symbolic slot, i.e; Plus slot is etched in the Patch instead of traditional alphabetical slots. Broadband behavior with high return loss shown by the antenna is achieved due to slotted ground structure, increase in the height of feed and movement of feed line towards right edge of the antenna. These features make the antenna a good nominee for the modern wireless communication applications. The size of the antenna is almost same to the antenna proposed in [5], also it is easy to fabricate. It provides nearly all the wireless communication bands as observed in [1]-[10].

REFERENCES