Miniaturized Dual-band V-Shaped Monopole Antenna
fed by V-Stub

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Abstract
A miniaturized dual-band v-shaped monopole antenna fed by v-stub is presented. The proposed antenna performs two resonant modes covering dual-band of wireless standards, for operating in the IEEE 802.11 a,g,n WLAN (5.15-5.35 GHz and 5.725-5.825 GHz) and IEEE 802.16e WiMAX (3.3-3.69 GHz and 5.25-5.85 GHz) bands. The antenna is printed on a 1.6-mm thick FR-4 substrate and the relative permittivity of 4.4, is fed by cross v-stripe line a 50Ω with SMA connector. The antenna size is 18 mm × 26 mm × 1.6 mm in dimensions. The measured results show that the miniaturized size antenna achieves a broad operating bandwidth of 3.24–3.71 GHz and 4.85-5.87 GHz for |S1|< -10 dB and omnidirectional beam. The measured gains of the antenna at 3.5 GHz and 5.5 GHz frequencies are 1.51 dBi and 2.34 dBi, respectively.

Keywords: Dual-band antenna; Miniaturized antenna, Omnidirectional beam, WiMAX, WLAN

1. Introduction
Recently, in order to satisfy the development requirements of small size, multiband, and omnidirectional pattern antenna for multisystem, especially for the Wireless Local Area Network (WLAN: 2.4–2.48 GHz, 5.15–5.35 GHz, and 5.72–5.85 GHz) and the Worldwide Interoperability for Microwave Access (WiMAX: 2.5–2.69 GHz, 3.3–3.69 GHz, and 5.25–5.85 GHz),

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3.4–3.69 GHz, and 5.25–5.85 GHz) frequency bands into a single wireless device. The development of dual-band and multiband antennas with simple structure, miniaturized size, low profile, light weight and low cost. A great quantities of monopole printed antennas for dual-band or multi-bands operations have been reported in the literature [1–4]. However, they usually have complicated structures or the antenna larger space in dimensions horizontal and vertical directions. For the perspective operation, present a miniaturized dual-band v-shaped monopole antenna fed by v-stub for providing multiband operation covering all the operating bands of WLAN/WiMAX systems. The performance features of the proposed antenna are property in term of impedance bandwidth, gain and radiation patterns.

Details about the contents described by the divided as following: Part 1, presents the introduction of dual-band and multi-band antenna while Part 2, show the geometry of the proposed antenna. Simulation and measurement results are presented in Part 3. Finally, Part 4 concludes the paper.

2. Antenna Design

The antenna design of the proposed miniaturized dual-band v-shaped monopole antenna fed by v-stub is depicted in Fig. 1.

![Antenna Design Diagram](image)

Fig 1. Geometry of the proposed antenna.

Fig 2. Investigated designs of the proposed antenna.

Fig 3. Compared $|S_{11}|$ of the designs antenna.

The proposed antenna is fabricated on a low-cost FR-4 substrate with relative permittivity ($\varepsilon_r$) of 4.4 and thickness ($h$) of 1.6 mm. The total size of the antenna are 18 mm × 26 mm × 1.6 mm. This antenna compose of V-shaped monopole of length ($L_1 = L_2$) 10 mm and width ($W_1 = W_2$) 1.5 mm with the angle ($\theta_1 = \theta_2$) of 50 degree. A 50Ω microstrip line of width ($W_f$) 3 mm and length ($L_f$) 16 mm is used for feeding the antenna and additional V-stub of length ($L_4 = L_5$) 5 mm and width ($W_3 = W_4$) of 1.5 mm with the angle ($\theta_4 = \theta_5$) of 30 degree with gap the length ($L_6$) of 1.5 mm. The ground plane with the length ($G$) of 13.5 mm are placed on the opposite side of the V-shaped monopole.
The length \( (L_3) \) between the V-stub and the bottom of ground plane is 1.5 mm. The investigated of the design of the proposed antenna is presented in Fig. 2. Let us consider Fig.2 (a), the length of is a quarter wavelength \([5]\). Therefore, the obtained quarter wavelength is 16 mm that is initiated for the feeding line \((L_f)\). The middle frequency is determined from 3.3 GHz to 5.85 GHz frequency. On the results of the simulated \(|S_{11}|\) as shown in Fig. 3. Antenna I is initially operate by the simulated \(|S_{11}|\) below -10 dB covers the frequency range from 3.9 GHz to 4.82 GHz. Next step as shown in Fig. 2 (b), the Antenna II adjust the angle \( (\theta_3) \) of 50 degrees. It is obvious that the simulated \(|S_{11}|\) below -10 dB that cover the frequency range form 4.15 GHz to 6.55 GHz. It can improve the lower band and enhancement the higher band bandwidth.

Fig. 2 (c) illustrates the modifications to Antenna III with V-shaped feeding line, it has a powerful antenna wideband covers the frequency range from 3.69 GHz to 7.64 GHz and has trended to the dual-band operations. Fig. 2 (d) shows proposed antenna to which a V-stub, the effects of the identical lengths, widths and angle \( (\theta_4 = \theta_1) \). The matching impedance of the lower band and the higher band change. The frequencies of the lower band and higher band are downwards to the lower frequencies as lengths \( L_4 \) and \( L_5 \) and angle \( (\theta_4 = \theta_1) \) increase. The proposed antenna can achieve two resonant frequencies that cover the bandwidth in the lower band (3.19 GHz to 3.79 GHz) and higher band (4.73 GHz to 5.92 GHz) for the WLAN and WiMAX systems.

3. Experiment Result

In this section, the geometry of the proposed antenna that the physical dimensions are tabulated in Table 1 was fabricated as shown in Fig.4.

![Image](a) Top view                  (b) Bottom view

Fig 4. Image of the fabricated antenna.

### Table 1 Physical size of the proposed antenna.

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Description</th>
<th>Physical Size (mm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>W</td>
<td>Width of size antenna</td>
<td>18</td>
</tr>
<tr>
<td>L</td>
<td>Length of size antenna</td>
<td>26</td>
</tr>
<tr>
<td>( L_1 = L_2 )</td>
<td>Length of V-shaped structure</td>
<td>10</td>
</tr>
<tr>
<td>( W_1 = W_2 )</td>
<td>Width of V-shaped structure</td>
<td>1.5</td>
</tr>
<tr>
<td>( L_4 = L_5 )</td>
<td>Length of V-stub</td>
<td>5</td>
</tr>
<tr>
<td>( W_3 = W_4 )</td>
<td>Width of V-stub</td>
<td>1.5</td>
</tr>
<tr>
<td>( \theta_1 = \theta_2 )</td>
<td>Angle of V-shaped structure</td>
<td>50 degree</td>
</tr>
<tr>
<td>( \theta_4 = \theta_4 )</td>
<td>Angle of V-stub</td>
<td>30 degree</td>
</tr>
<tr>
<td>( W_f )</td>
<td>Width of feed line</td>
<td>3</td>
</tr>
<tr>
<td>( L_f )</td>
<td>Length of feed line</td>
<td>16</td>
</tr>
<tr>
<td>( L_3 )</td>
<td>Length of gap</td>
<td>1.5</td>
</tr>
<tr>
<td>G</td>
<td>Length of ground plane</td>
<td>13.5</td>
</tr>
<tr>
<td>h</td>
<td>Thickness of substrate</td>
<td>1.6</td>
</tr>
</tbody>
</table>
The measurements on $|S_{11}|$, gain and radiation patterns. Fig. 5 depicted the measured $|S_{11}|$ compared with the simulated results. For investigating the operation of the proposed antenna, two resonant modes at about 3.5 and 5.5 GHz are successfully excited. The first resonant at about 17.19% bandwidth covers from 3.19 to 3.79 GHz and the second resonant at about 22.34% bandwidth cover from 4.73 to 5.92 GHz from the simulated. The first resonant at about 13.52% bandwidth covers from 3.24 to 3.71 GHz and the second resonant at about 19.02% bandwidth cover from 4.85 to 5.87 GHz from the measured of WiMAX and WLAN operations, respectively. From Fig. 6, show that the simulated and measured average gains for the two operating bands are 1.82, 2.8 dBi and 1.51, 2.34 dBi at the frequency of 3.5 GHz and 5.5 GHz, respectively. The radiation patterns along the frequency range were measured. Fig. 7 (a)-(d) shows the radiation pattern in YZ-plane and XZ-plane at 3.5 GHz and 5.5 GHz, respectively. The omnidirectional beam along the frequency range are obtained. There is good agreement between the simulated and measured results.

4. Conclusion

The proposed a miniaturized dual-band v-shaped monopole antenna fed by v-stub is very promising for practical WLAN and WiMAX operations in the wireless devices. The antenna is easy to fabricate on a thin FR-4 substrate at miniaturized size, low profile and low cost. Good radiation characteristics and gains for frequencies over the operating bands have also been obtained.

References