

# Trapezoidal Patch with V-shape Slot Microstrip Antenna for Dual Band

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**Abstract:** In this paper, dual operation trapezoidal patch with V-shaped slot feed by coaxial-probe is presented. The proposed antenna is designed on RT duroid substrate. A (10db) bandwidth of return loss (S11) characteristics for the dual band is 4% and 15.6% respectively. E-planes and H-planes for the dual operation frequencies are satisfactory within the bandwidth. Return loss, VSWR, gain and E-planes and H-planes radiation pattern are simulated by using IE3D simulator.

**Keywords:** V-shape slot, RT duroid, Dual band, WLAN, WiMAX.

## 1. INTRODUCTION

Wireless local area networks (WLAN) are widely used worldwide. The 802.11a standard uses the 5-GHz band which is cleaner to support high-speed WLAN. However, the segment of frequency band used varies from one region of the world to another. Dual frequency microstrip antennas with a single feed are required in various radar and communication systems, such as global positioning system (GPS), WiMAX, WLAN etc.

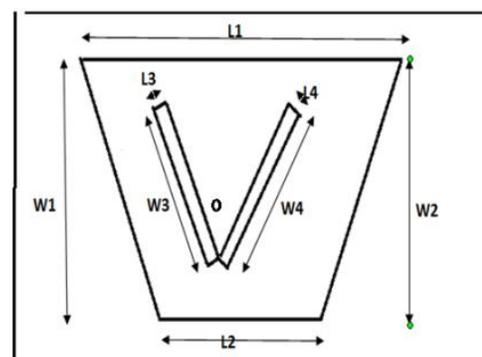
Microstrip antenna is the ideal choice for such an application due to low profile, light weight, conformal shaping, low cost, simplicity of manufacturing and easy integration to circuit[1]. However, conventional microstrip patch antenna suffers from very narrow bandwidth, typically about 5% bandwidth with respect to the central frequency. There are numerous and well-known methods to increase the bandwidth of antennas, including increase of the substrate thickness, the use of a low dielectric substrate, the use of multiple resonators, and the use of slot antenna geometry[2],[3].

Sudhir *et al.*[4] applied a H-shaped slot in a rectangular microstrip antenna to make its broadband structure while improved bandwidth up to 9.5%. Wong & Hsu[5] applied a U-shaped slot in an equilateral triangular microstrip antenna with improved bandwidth up to 8.67% was recently reported for a circular patch antenna having u-slot[6]. S.W Lee *et al.* proposed the trapezoidal shape patch antenna embedded with rectangular [7].

M.S *et al.* [8] demonstrates a rectangular patch microstrip antenna with V-slots and corner notches for IEEE802.11.A/HIPERLAN2 applications that enables an impedance bandwidth of 51%. Yogesh Bhomia *et al.* [9] applied V-shape slot on triangular microstrip antenna having impedance bandwidth of 9.2%. A dual slot-loaded microstrip antenna with dual-frequency operation has been reported in [10] and [11], where two parallel narrow slots are etched in the rectangular patch close to its radiation edge. The two slots are chosen to be close to the length of the radiating edge. Other dual-frequency antennas with square-slot and rectangular-slot loading are reported in [12] and [13]. A compact dual-frequency microstrip antenna is proposed in [14], which uses the rectangular microstrip patch loaded with one shorting pin. Some experimental results are also presented in [14].

In this paper, we design a trapezoidal patch with V-shaped antenna which works as a dual frequency. First resonance frequency  $f_1$  centered at 3.5 GHz frequency is due to its patch itself. Second resonant frequency  $f_2$  is due to V-shape slot, which is centered at 5.0 GHz.

## 2. ANTENNA STRUCTURE



**Fig.1: Geometry of proposed antenna**

The configuration of proposed antenna is shown in figure 1. The antenna consists of a trapezoidal microstrip patch with V-shaped slot, supported on a grounded dielectric sheet of thickness  $h$  and dielectric constant  $\epsilon_r$ . The trapezoidal patch has an upper side of length  $L_1$ , base of trapezoidal

patch of length L2 and height of trapezoidal patch of length W1, W2. V-shape slot has a length of L3, L4 and a width of W3, W4 which is loaded on trapezoidal patch. The feed point is located at the central line of the patch, with a distance of  $d_f(x,y)$  from the bottom edge of trapezoidal patch. The dimension of trapezoidal patch with V-shape slot are tabulated in table 1.

**Table 1. Dimension of proposed antenna**

| S.no | Parameter    | Explanation                     | Value(mm) |
|------|--------------|---------------------------------|-----------|
| 1.   | L1           | Upper side of trapezoidal patch | 30        |
| 2.   | L2           | Base of the trapezoidal patch   | 26        |
| 3.   | W1,W2        | Height of the trapezoidal patch | 21.04     |
| 4.   | L3,L4        | Length of the V- shape slot     | 0.5       |
| 5.   | W3,W4        | Width of the V- shape slot      | 15        |
| 6.   | $\epsilon_r$ | Dielectric constant             | 2.2       |
| 7.   | h            | Height of dielectric constant   | 6         |
| 8.   | $\tan\delta$ | Loss tangent                    | 0.0018    |
| 9.   | (x,y)        | Position of probe feed          | (13,8)    |

### 3. RESULTS AND DISCUSSION

In this section, the simulated results of various parameters like VSWR, Return loss, input impedance and radiation characteristics of proposed antenna are presented and discussed. The simulated results are obtained using IE3D Simulator.

#### A. Return loss

The simulated result for the return loss less than -10dB is shown in figure 2. From simulated result we get dual band.

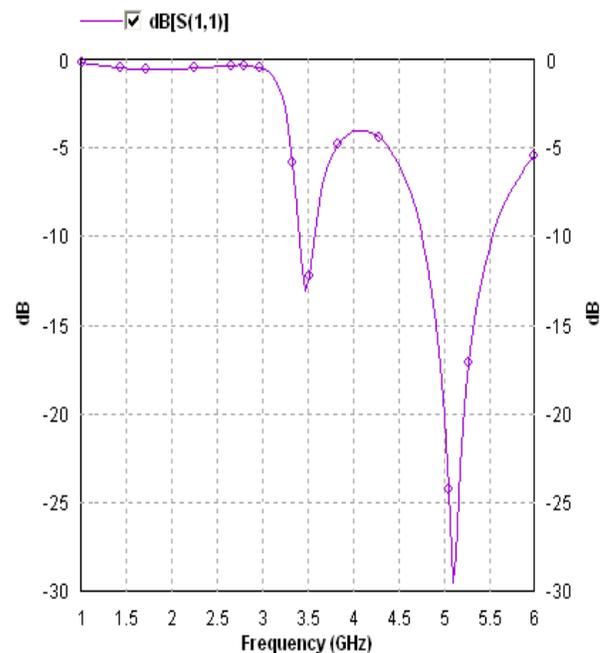


**Fig. 2: Return loss**

Based on a -10 dB return loss, 4% impedance bandwidth is obtained at first resonant frequencies  $f_1$  in the frequency range (3.41-3.57) GHz and 15.6 % impedance bandwidth is obtained at second resonance frequencies in the frequency range of 4.75-5.53 GHz.

#### B. VSWR

Figure 3. Shows the variation of VSWR with frequency for proposed antenna. It shown that the VSWR occur at first resonant frequency is 1.66 and second resonant frequency is 1.07. This depict that there is good impedance matching between probe-fed microstrip transmission line and the trapezoidal radiating element.

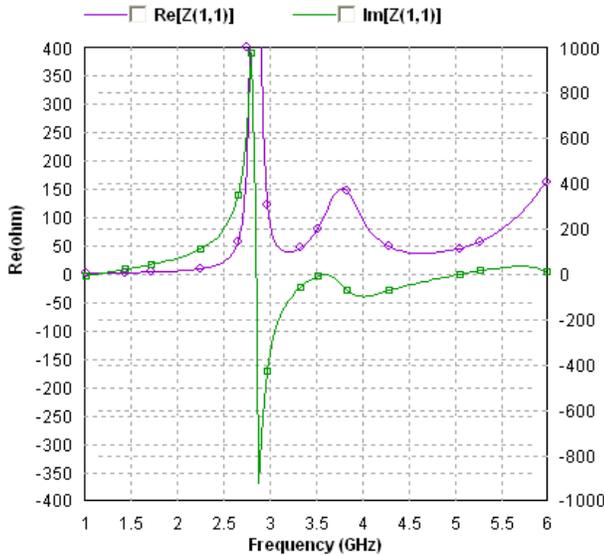


**Fig. 3: VSWR**

#### C. Input impedance

The simulated result for the antenna input impedance is plotted in figure 4. It is shown that the real part of the input impedance at first resonant frequency  $f_1$  oscillates around  $74.83\Omega$  with frequency while the imaginary part of the input impedance at resonant frequency oscillates around  $0\Omega$  with frequency.

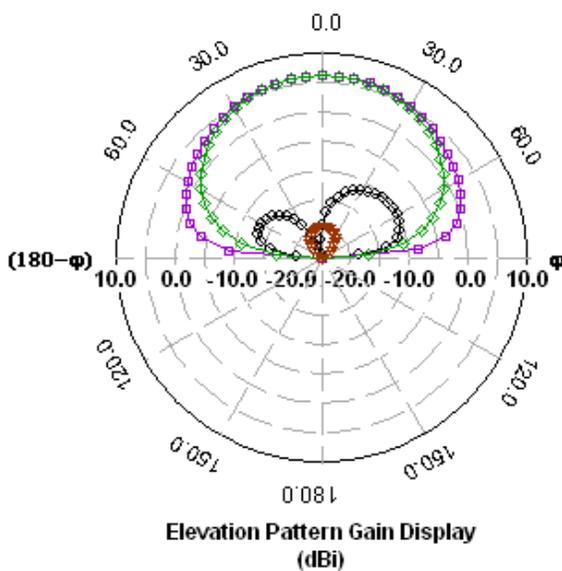
At second resonant frequency  $f_2$ , the real part of the input impedance at resonant frequency oscillates around  $50\Omega$  with frequency while the imaginary part of the input impedance at resonant frequency oscillates around  $0\Omega$  with frequency. Hence, from the graph it is clear that there is proper matching occur at both resonant frequencies.



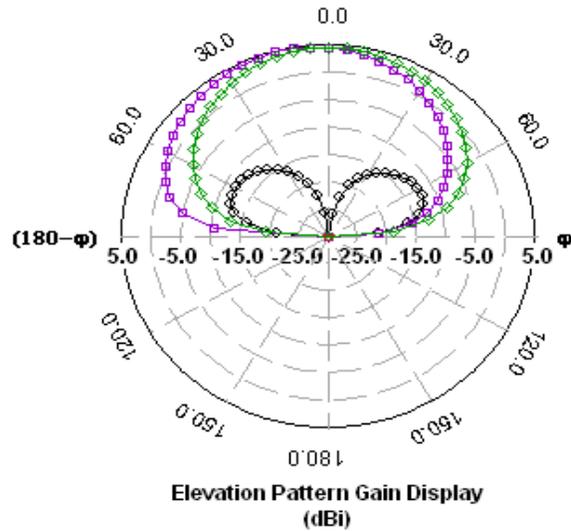
**Fig. 4: Real part and imaginary part of input impedance**

**D. Radiation pattern**

From figure 5. Shows the measured radiation pattern at first resonant frequency 3.5 GHz. it can be observed that in the  $\phi=0$  plane, the cross polarization is -13 db below the co polarization above the ground plane. In the  $\phi=90$  plane, the cross polarization is -19.3 dB below the co polarization level.



**Fig. 5: Radiation pattern at 3.5 GHz**

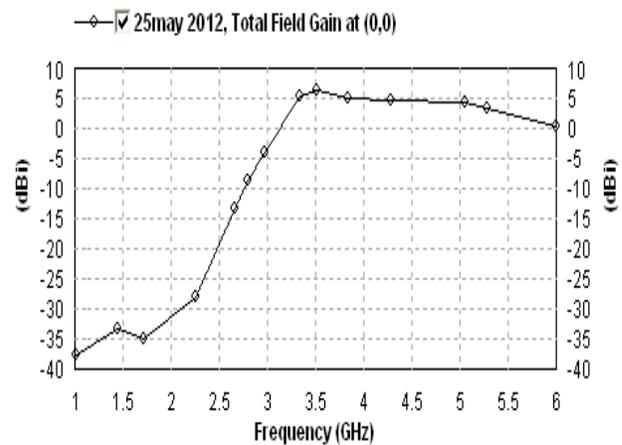


**Fig. 6: Radiation pattern at 5 GHz**

From figure 6. Shows the measured radiation pattern at second resonant frequency 5 GHz. it can be observed that in the  $\phi=0$  plane, the cross polarization is -25.03 db below the co polarization above the ground plane. In the  $\phi=90$  plane, the cross polarization is -20 dB below the co polarization level.

**E. Gain**

The gain of proposed antenna is shown in figure.7 which shows that the maximum achievable gain at first resonant frequency is about 5.90 dBi over the entire frequency band of 3.41-357 GHz and 4.14 dBi maximum gains is achieved at second resonant frequency and the gain show stable performance.



**Fig. 7: Gain versus frequency**

The simulated results are summarised in table 2.

**Table 2. Simulated data**

| Resonant frequency | F1             | F2             |
|--------------------|----------------|----------------|
| Centre frequency   | 3.5 GHz        | 5 GHz          |
| bandwidth          | 4.95           | 15.6%          |
| Frequency range    | (3.41-3.57)GHz | (4.75-5.53)GHz |
| Return loss        | -12.8 dB       | -29.37 dB      |
| VSWR               | 1.66           | 1.07           |
| Gain               | 5.9 dBi        | 4.14 dBi       |

#### 4. CONCLUSION

The dual frequency and wide-band operation of a trapezoidal patch with V-shaped slot have been studied and simulated. The proposed antenna is compact, occupies small volume and has simple structure compared to other antenna design. The antenna offers a 2:1 VSWR bandwidth of 4% from frequency range (3.41-3.57)GHz at first resonant frequency which covers 3.5 GHz band WiMAX applications. Second resonant frequency covers the WLAN(5.15-5.35) band application with impedance bandwidth of 15.6%. The simulated return loss, VSWR, radiation pattern and gain showed well performance.

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