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Design of Trapezoidal Patch Antenna with Inverted and Non-Inverted V-Shape Slot

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ABSTRACT
This paper covers two aspects of microstrip antenna design. The first is the analysis of trapezoidal patch microstrip antenna with V-shaped slot which operate at the centre frequency of 5.5 GHz. The second aspects are the analysis and design of inverted V-shaped slot cut trapezoidal microstrip antenna operates at centre frequency of 4.1 GHz. The simulation has been done through IE3D simulator. The properties of antenna such as Bandwidth, S-parameter, and VSWR has been investigated and compared between a trapezoidal microstrip antenna with or without inverted V-shape slot.
Keywords **-** V-shape, Coaxial probe, WLAN, micro-strip antenna, RT duroid 5880.

I. 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. In the US, the 802.11a system may use the 5.15-5.35 GHz band and 5.725-5.825 GHz band. Some countries allow the operation in the 5.47-5.825 GHz band. A traveller with 802.11a transceiver that can cover the frequency range from 5.15GHz to 5.825GHz will be able to gain access to a local WLAN network in different part of the world. Japan UWB lower band uses 3.4-4.8 GHz frequency.

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 method 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]. Recently, several techniques have been proposed to enhance the bandwidth. A novel single layer wide-band rectangular patch antenna with achievable impedance bandwidth of greater than 20% has been demonstrated [4].Utilising the shorting pin on the unequal arm of a U-shaped patch antennas, wideband and dual-band impedance bandwidth have been achieved with electrically small size [5].

Jeen-Sheen Row [6] demonstrates that a triangular planar inveted-F antenna with a V-shaped slot has impedance bandwidth of 30%.Diego *et al.* proposed a wide band E-shaped patch antenna on a low dielectric substrate that enables an impedance bandwidth of about 29.8% by cutting a zigzag slot in the patch [7].

M.N shakib[8],proposed a W-shape microstrip patch antenna which exhibit an impedance bandwidth (2:1 VSWR) of 20.79% at the centre frequency of 2.11 GHz. Yogesh *et al.*[9] applied V-shape slot on triangular microstrip antenna having impedance bandwidth of 9.2%. Sudhir *et.al* [10] applied an H-shaped slot in a rectangular microstrip antenna to make its broadband structure while improved bandwidth up to 9.5 %.

Wong & Hsu [11] 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[12].
In this paper, firstly present a trapezoidal patch antenna with V-shaped slot. it exhibits an impedance bandwidth in the frequency range of 5.1-5.94 GHz .i.e. 15.6% of the centre frequency, secondly present a trapezoidal patch antenna with inverted V-Shape slot which exhibit an impedance bandwidth of 30% in frequency range from 3.54-4.85 GHz.

II. TRAPEZOIDAL PATCH WITH V SHAPE SLOT (ANTENNA 1)

The configuration of proposed antenna 1 is shown in figure1.The antenna consist of a trapezoidal microstrip patch with V-shaped slot, support on a grounded dielectric sheet of thickness h and dielectric constant ε_r.

The trapezoidal patch has an upper side of length L1, 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 $d_{(}$x.y) from the bottom edge of trapezoidal patch.

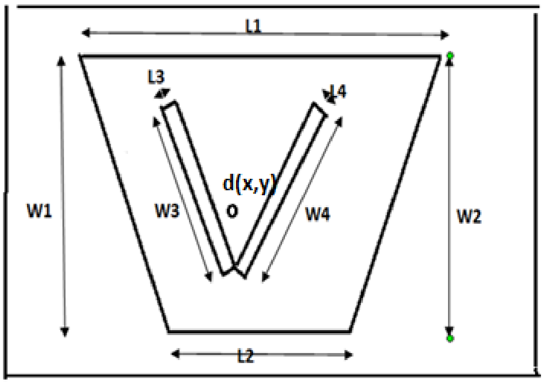

Figure1. Geometry of proposed antenna 1

The dimension of trapezoidal patch with V-shape slot is tabulated in table 1.

Table 1. Dimension of proposed antenna 1

o.	arameter	Explanation	
.		Upper side of trapezoidal patch	n
.		of the trapezoidal patch	ı
.	/2	t of the trapezoidal patch	mm
.		h of the V- shape slot	
	/4	of the V-shape slot	ı
.		Dielectric constant	n
		t of dielectric constant	
		angent	8
		on of probe feed	

III. RESULTS AND DISCUSSION

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

1.1 Return loss

Figure2.Show the variation of return loss with frequency. The proposed antenna satisfies the 10dB return loss requirement from 5.1 GHz to 5.94 GHz with impedance bandwidth of 15.6%.

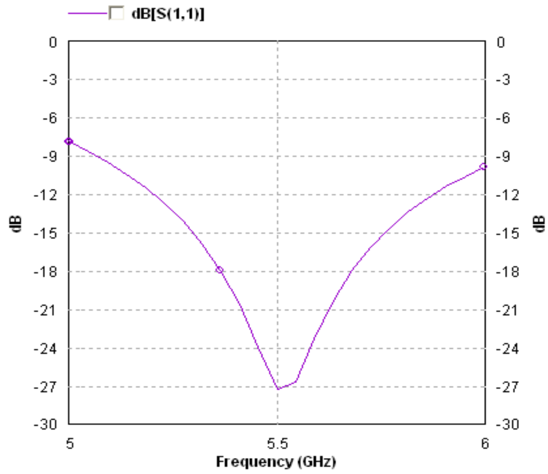

Figure 2. Return loss

It is shown that resonant frequency occurs at 5.5 GHZ in the simulation. By adding a V-shaped slot in the centre of the radiating patch, a wide band is achieved that cover all the 5.2 GHz/5.8 GHz WLAN, 5.5 GHz WiMAX .

1.2 VSWR

Figure3. Shows the variation of VSWR with frequency for proposed antenna

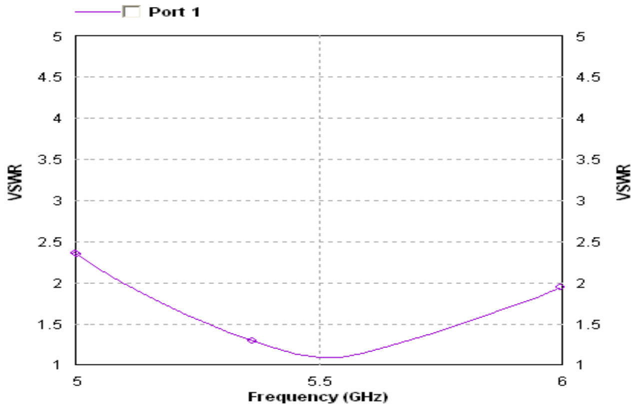

Figure 3. VSWR

It shown that the VSWR occur at resonant frequency is 1.09. This depict that there is good impedance matching between probe-fed microstrip transmission line and the trapezoidal radiating element in the frequency band from 5.1 GHz-5.94GHz. The impedance bandwidth of the antenna is 15.6%.

3.3 Radiation pattern

Radiation pattern is a graph which shows the variation of field strength of electromagnetic field at all points which are at equal distance from antenna. The simulated two dimensional E and H plane elevation pattern of trapezoidal patch with V-shaped slot micro strip antenna at frequencies covering (5.1-5.94) GHz band is realized. The direction of maximum radiation of radiation pattern is normal to the patch geometry.
The simulated co and cross polar pattern of this antenna in E and H planes at frequency 5.5 GHz is

shown in figure 4. In E-plane, the co-polar pattern are nearly 7.92dB higher than cross polar pattern; while in H-plane, the co-polar pattern are nearly 7.89dB higher than cross polar.

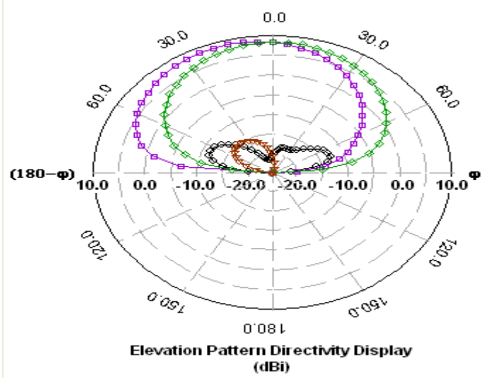

Figure 4. Simulated co- and cross polarization radiation pattern for proposed antenna at 5.5 GHz

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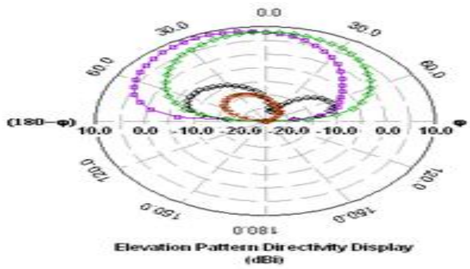

Figure 5. Simulated co- and cross polarization radiation pattern for proposed antenna at 5.8 GHz

The simulated co and cross polar pattern of this antenna in E and H planes at frequency 5.8 GHz is shown in figure 5. In E-plane, the co-polar pattern are nearly 8.24dB higher than cross polar pattern; while in H-plane, the co-polar pattern are nearly 8.26dB higher than cross polar.

IV. TRAPEZOIDAL PATCH WITH INVERTED V-SHAPE SLOT (ANTENNA 2)

The configuration of proposed antenna 2 is shown in figure 6.The antenna consist of a trapezoidal microstrip patch with inverted V-shaped slot, support on a grounded dielectric sheet of thickness h and dielectric constant ε_r.

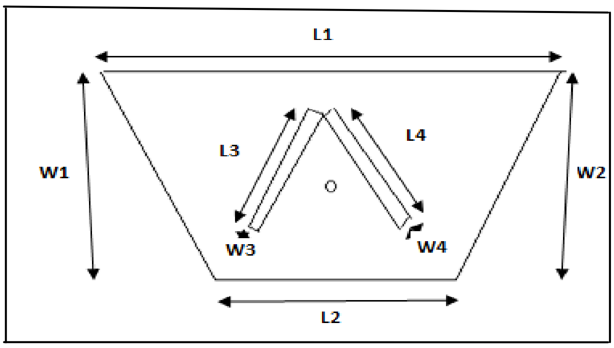

Figure 6. Geometry of proposed antenna 2

The dimension and feed position of proposed antenna 2 is same as antenna 1 except inverted v slot is used as compared to antenna 1.

V. RESULTS AND DISCUSSION

5.1 Return loss

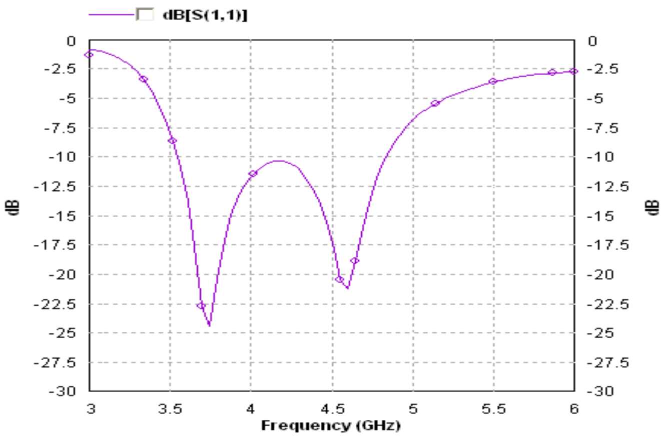

Figure 7. Return loss

Figure7. Show the variation of return loss with frequency. The proposed antenna satisfies the 10dB return loss requirement from 3.54 GHz to 4.85 GHz with impedance bandwidth of 30%. By adding an inverted V-shaped slot in the centre of the radiating patch, a wide band is achieved that cover Japan UWB lower band uses 3.4-4.8 GHz frequency and C band (3.625-4.2) GHz.

5.2 VSWR

The simulated result for VSWR for the frequency range from 3.54-4.85 GHz is shown in the figure 9. The value of VSWR can be seen to be within 1 to 2 in the operating range This depict that there is good impedance matching between probe-fed microstrip transmission line and the trapezoidal radiating element in the frequency band from 3.54 GHz-4.85GHz

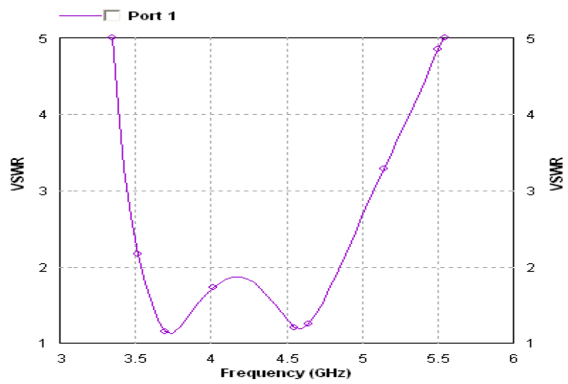

Figure 8. VSWR

5.3 Radiation pattern

The simulated co and cross polar pattern of this antenna 2 in E and H planes at frequency 4.6 GHz is shown in figure 10. In E-plane, the co-polar pattern are nearly 8.86dB higher than cross polar pattern; while in H-plane, the co-polar pattern are nearly 8.94dB higher than cross polar.

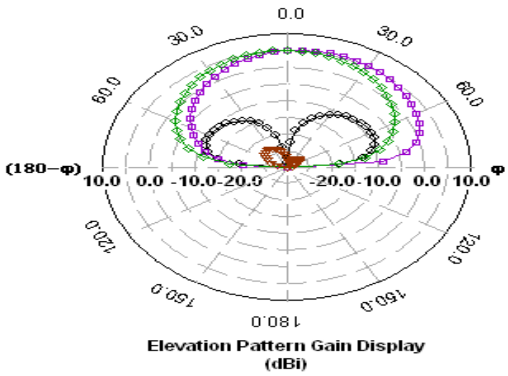

Figure 9. Simulated co- and cross polarization radiation pattern for proposed antenna at 4.6 GHz

VI. COMPARISION

In this section, Trapezoidal patch with V-shaped slot presented with RT duroid substrate and thickness h=6mm and got return loss bandwidth of 15.6%. In Trapezoidal patch with inverted V-shaped slot with same substrate and thickness presented and got 30% bandwidth. Comparison between trapezoidal patch with or without inverted V-shaped slot microstrip antenna is tabulated in table 2.

Table 2. Comparison between trapezoidal patch with or without inverted V-slot.

S.no	Antenna type properties	Trapezoidal patch MSA with V-slot	Trapezoidal patch MSA with inverted V-slot
1.	Bandwidth	15.6%	30%
2.	Frequency range	(5.1-5.94)GHz	(3.54-4.85)GHz

VII. CONCLUSION

Two aspects of microstrip antennas have been studied. The first aspect is the design of trapezoidal patch with V-shaped slot microstrip antenna with 15.6% impedance bandwidth for WLAN/WiMAX applications and the second is the design of trapezoidal patch with inverted v shaped slot with impedance bandwidth of 30% for radar and Japan UWB application.

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