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Design of Ultra Wide Band Trapezoidal Antenna for Wireless and Satellite Applications

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ABSTRACT

In this paper, the design of Co-planar waveguide (CPW) Trapezoidal shaped antenna for ultra wide band (1.7 to 9.65 GHz) applications is proposed. The proposed antenna has trapezoidal radiating patch with CPW feeding. The defected ground plane consists of tapered triangular etches on three sides with U shaped slots on two opposite sides. The overall dimension of the antenna is 40×55 mm^2 designed over FR4 substrate of height 1.6mm. The designed antenna can be useful for wireless and satellite applications in the 1.7 to 9.65 GHz range.

Key words: Fr4-epoxy, Trapezoidal Antenna, Wireless applications, UWB.

1. INTRODUCTION

Antenna is a device that can transmit and receive the electromagnetic signals. In fast development in communication technologies the speed of transmitting and receiving the signals is important aspect, so they need a broader bandwidth to cover all wireless applications. The ultrawide band (UWB) antenna has emerged has intensive subject in the field of wireless communications due to its special aspects such as transmitting and receiving the signals in short durations with minimum distortion.

UWB antennas are very small in size and inexpensive with high performance. Ultra wide band antennas are most used in the field of wireless applications due to low energy consumption and availability of boarder bandwidth. In the year 2004 the federal communications commission assigns the band 3.1GHz-10.6GHz (unlicensed band) for wide band applications[1] .

In [2] ultrawide band trapezoidal antenna has the bandwidth of 4GHz was proposed. This antenna structure makes use of partial ground planes, co-planner wave guide feed and slots i n the ground plane to get the desired reflection coefficient [3], [4].

Many efforts are made to fulfill the requirements of modern wireless applications [5], [6].The development in wireless personal area communication of ultra wide band antenna is discussed in [7]. Insert feeding [8]. The UWB characteristics can be controlled by altering the shape of the micro strip feed line in conjunction with slots cut in the defected ground plane [9], [10]. The Ultra wide frequency is selected because of high data transfer rate, very small in size, and low cost, the latest development in the wireless communication we can communicate within a neuron [11]. Simple shaped radiators with unique substrates such as rubber were utilized to realize UWB [1]. The bandwidth can be improved by introducing various slots in the ground plane and deflected ground structure [12], [13].

In this paper, the investigation on a 40mm× 55mm× 1.6mm ultra wide band trapezoidal antenna for better impedance bandwidth. The slot is feed by a 50Ω feed line terminated to the trapezoidal patch. The shape of the ground plane is changed by adding triangles and slots to improve the bandwidth. To design a ultra wide band antenna which is suitable for modern wireless technologies many antenna parameters like return loss, VSWR, impedance bandwidth, radiation pattern and gain are calculated. The performance of the antenna can be studied by obtaining simulations on Ansoft HFSS software.

2. ANTENNA DESIGN AND ANALYSIS

The proposed design uses glass epoxy(FR4) substrate with height (h) 1.6 mm. The trapezoidal shape radiating patch is placed on the top of the substrate along with the ground plane. Table 1 gives the dimensions of proposed antenna.
The bottom and top width of the trapezoidal patch are 14mm and 7mm respectively and the length of the trapezoidal is 6.5mm. The positioning of the strip line, trapezoid are adjusted to proper gap with respect to ground plane to achieve better impedance matching which is shown in Figure 1 and Table 1. The width and length of the micro strip line is given by 4.92mm and 14.62mm.

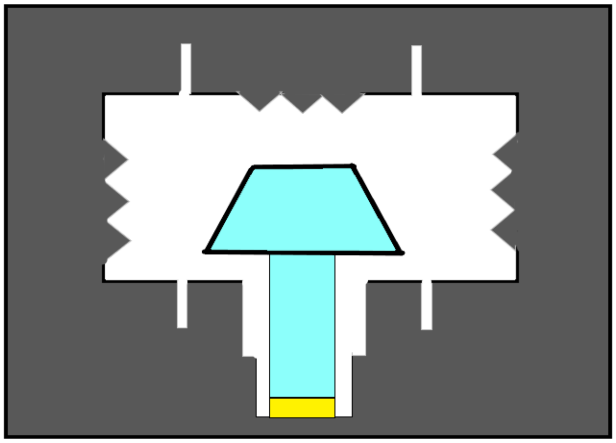


Figure 1: Design of proposed antenna

Table 1: Dimensions of the proposed antenna

Name of the parameter	Measurements
Length of substrate	40 mm
Width of substrate	55 mm
Height of substrate	1.6 mm
Frequency	6.5 GHz
Feed line length	14.62 mm
Feed line width	4.92 mm
Length of trapezoidal patch	14mm
Upper Width of trapezoidal patch	7 mm
Lower width of the trapezoidal patch	14mm
Port length	1 mm
Port width	4.92 mm
Substrate	Fr-4 epoxy
Length of slots 1,2,5,6	5 mm
Width of slots 1,2,5,6	1 mm
Length of slots 3,4	7 mm
Width of slots 3,4	1.3 mm
Triangles	4×2.5mm

The modifications in the defected ground plane are carefully implemented to accomplish an improved reflection coefficient with better impedance bandwidth. A study on the effect of ground plane modifications on the impedance bandwidth is performed. Six evolution stages are considered, as shown in Figure 2.

Figure 2a shows the basic design of the antenna. As seen from the figure 2a, the antenna1 ground plane having dimensions 12× 55mm^{2}is imprinted on a FR4 material having loss tangent tanı = 0.0019, relative permittivity εr= 4.4 and height h = 1.6mm. The dimensions of the rectangular slot on ground plane are 6.5mm× 11mm and it is excited by 50Ω CPW feed line and another end of the feed line is connected to trapezoidal patch. The feed line dimensions are 4.92×14.62mm^2 respectively.

Antenna 2 is constructed the same as antenna one, but the ground shape is varied. The ground plane is having dimensions 40×55mm^2, which is the same as the substrate length and width. In the ground plane, we have two rectangular slots having the dimensions of 4×14.62mm^2 for slot1, 18×36mm^{2}for slot2.

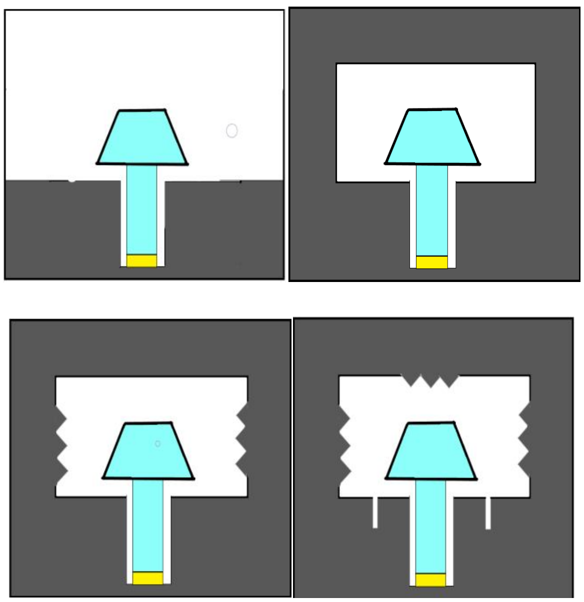
Antenna 3 is constructed by adding six triangles on the ground plane to antenna 2, the three triangles placed on one side of the rectangular slot two remaining three triangles place on another side of the rectangular slot 2. The six triangles having the dimensions 4× 2.5mm^2 all are of equal length and height.

The antenna 4 is created by adding three triangles and two rectangular slots on the ground to antenna 3, the three triangles are placed on the top the rectangular slot two, and the remaining slots are placed on the opposite side of rectangular slot2. The three triangles having the dimensions 4×2mm^2 all are of equal length and height, and the length and width of the slot are 5×1mm^2 respectively.

Antenna 5 is constructed by adding two rectangular slots to antenna four on the ground plane the two slots are placed on either side of rectangular slot one and having dimensions 7×1.3mm^2 length and width respectively.

Antenna 6 (proposed antenna) is constructed by adding two rectangular slots to antenna 5, and the slots are placed on the top side of the rectangular slot two and this slots having dimensions of 5mm length and 1mm width. By comparing the impedance bandwidth of six antenna's the antenna 6 covers a wider bandwidth. The bandwidth covered by the antenna 6 is 1.7-9.65 GHz.

The antenna is designed by changing the the ground plane shape and dimensions of the feed line for better reflection coefficient and bandwidth. The antenna evolution is shown in figure 2 and their reflection coefficients in figure 3. By comparing the antenna bandwidth the antenna 6 has good bandwidth and better refection coefficients.



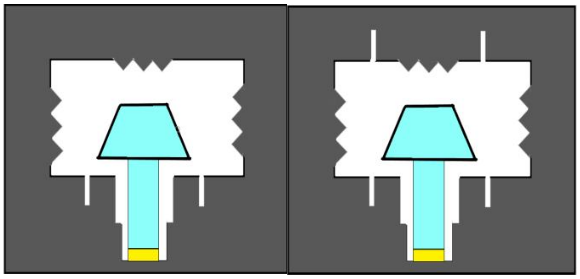


Figure 2: Evolution of antenna
Figure 2a: Antenna1, **Figure 2b:** Antenna 2, **Figure 2c:**Antenna 3, **Figure 2d:**Antenna 4, **Figure 2e:**Antenna 5,**Figure 2f:**Antenna 6

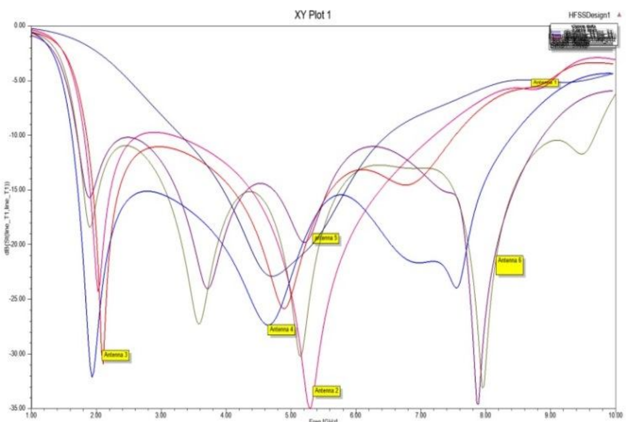


Figure 3: Comparisonof antenna's frequency vs S11 parameter

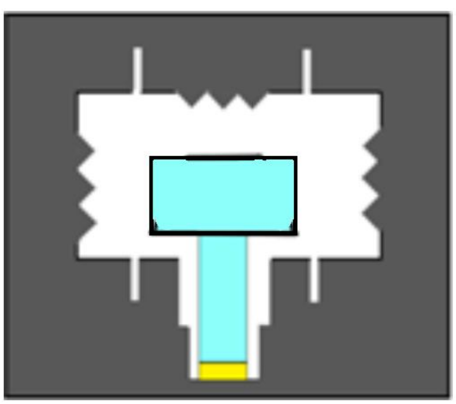


Figure 4: Antenna design of rectangular patch

3. RESULTS AND DISCUSSIONS

3.1 Return Loss

Compared to rectangular patch the trapezoidal patch achieves better impendence. The reflection return loss of rectangular patch is show in below figure 5. As observed in figure 5 the reflection coefficient of rectangular patch stays below −10 dB from about 2.6 GHz to 8.6 GHz. The figure 5 shows the plot of reflection coefficients of the proposed antenna. As observed from the figure 5, the reflection coefficient maintains a good return loss less than −10 dB in the range of 1.7 GHz to 9.65 GHz.

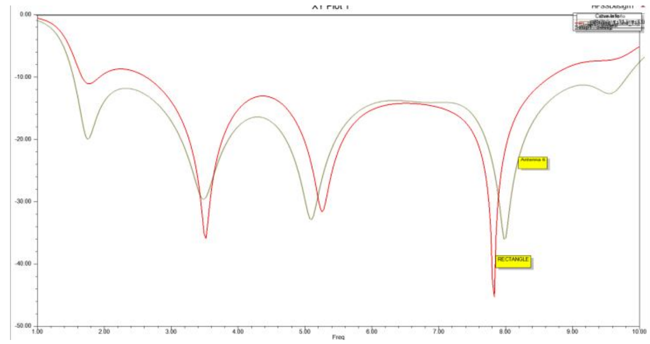


Figure 5:S11 parameter Vs frequency plot

3.2 VSWR

Figure 6 depicts the plot of Voltage Standing-Wave Ratio (VSWR) for the proposed antenna. The VSWR for the entire frequency range of 1.7-9.65GHz is maintained under 2.5.

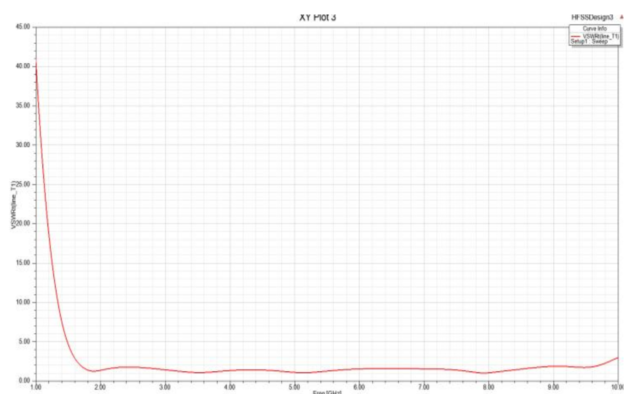
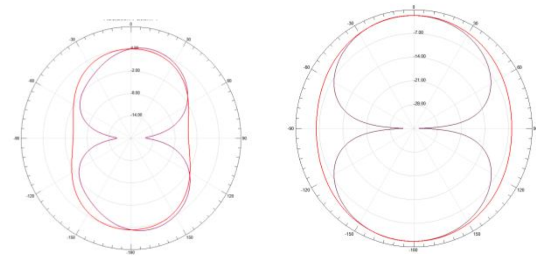


Figure 6: VSWR measurements

3.3 Radiation Pattern



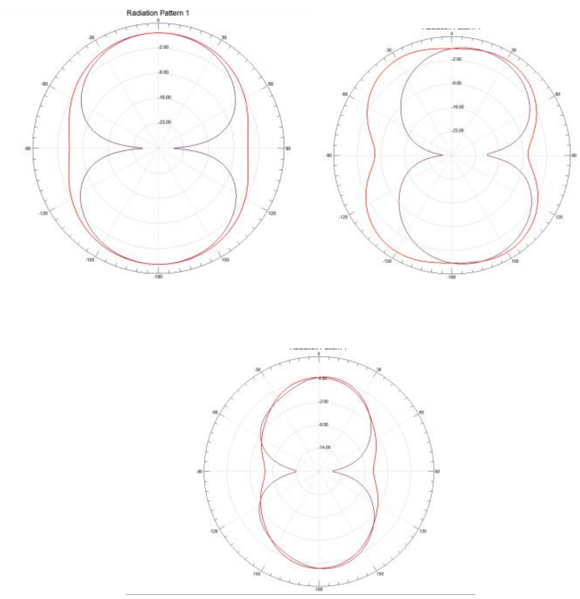


Figure 7a: Radiation pattern at 6.5GHz, **Figure 7b:** Radiation pattern at 1.88GHz, **Figure 7c:** Radiation pattern at 3.58GHz, **Figure 7d:** Radiation pattern at 5.12GHz, **Figure 7e:** Radiation pattern at 7.9GHz.

3.4 Gain

The gain vs frequency plot of Figure 8 shows a linear increase in gain with increase in frequency. The antenna is observed to be omni directional at lower frequencies (<4GHz) and directional at higher frequencies (>4GHz).

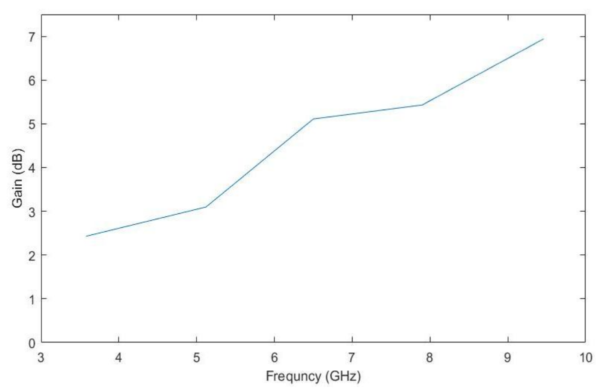


Figure 8: Frequency vs Gain graph of proposed antenna

4. CONCULSIONS

In this paper an ultra wide band trapezoidal shaped antenna has been proposed which has a impedance band width of 8GHz. The proposed antenna exhibits the reflection coefficient (S11) below 10dB over the frequency range of 1.7GHz – 9.65GHz with good gain and radiation characteristics. Also the study presents the superiority of Trapezoidal radiator when compared to rectangular radiator in impedance bandwidth characteristics.

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