



Volume: 2, Issue: 7, 191-194
July 2015
www.allsubjectjournal.com
e-ISSN: 2349-4182
p-ISSN: 2349-5979
Impact Factor: 3.762

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A Modified E-Shaped Stacked Broadband Patch Antenna

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Abstract

A coaxial feed modified E-shaped patch antenna has been presented with parametric study of the antenna parameters. The proposed antenna is designed for WLAN and WiMAX applications from 5 – 6 GHz. The 5 – 6 GHz band has been chosen because it provides higher data rate (>50 Mbps) for laptops, note-book computers and many new wireless digital applications devices without interference. Although current 5.0 GHz wireless computer network systems operated from 5.15 GHz – 5.35 GHz band. But in future, for faster data rate 5.725 – 5.85 GHz band becomes popular in addition to 5.15 – 5.35 GHz.

Keywords: Slotted patch, E-shaped, WiMax, WLAN, Stacked layers.

1. Introduction

Stacking patches ^[1, 4] is the most common procedure utilized to enhance the bandwidth of a microstrip antenna, in which two or more patches on different layer of the dielectric substrates are stacked on each other. This kind of configuration is categorized as electro-magnetically coupled microstrip antenna. In the coaxial feed technique, the microwave signals are coupled from the coaxial feed through the circular slot in the ground plane to the bottom patch, which in turn excites top patches due to electromagnetic coupling with the bottom patch. The patches can be fabricated on different substrates, and air gap or foam material can be placed between these layers to create height thus increasing the bandwidth. The effect of stack of patches was first studied by Sanford in 1978 ^[5]. His work was further developed a year later by Long and Walton ^[6] and another patent was issued for Jones *et al.* for developing stacked or so called piggyback microstrip antennas for missiles applications ^[7, 8]. The size of upper patch is slightly different from that of the lower patch to obtain slightly different resonant frequency.

A number of variables are used in the multilayer configuration for example, substrate thickness, dielectric constants, offset between the centers of the patches, patch sizes and feed Locations. These variables can be adjusted to obtain antennas for various applications. For dual frequency operations ^[6], the size of the patches is determined by the two frequencies of operations. For broadband operations, the various parameters are optimized for maximum bandwidth. For offsets patches, a shift of patches in the x and y directions has a significant effect on impedance bandwidth and the radiation patterns. A study shows that offsets patch give rise to wider bandwidth, impedance bandwidths of 10.0% to 29.0% have been achieved by probe feed stacked patch and 18.0% to 67.0% by the aperture coupled stacked patch ^[9].

2. Development of Antenna Design

Fig 1 shows the side view of the antenna structure. The Rogers RT/duroid 5880 having dielectric constant of 2.2 with the thickness of 1.6 mm has been used as substrate of the antenna. The substrate and ground size has been considered as 23.15 mm x 27.16 mm. Stacking of two more substrates of equal size and same material have been done on this substrate. The antenna is coaxial probe fed and the probe is located at (-1.00 mm, -11.00 mm).

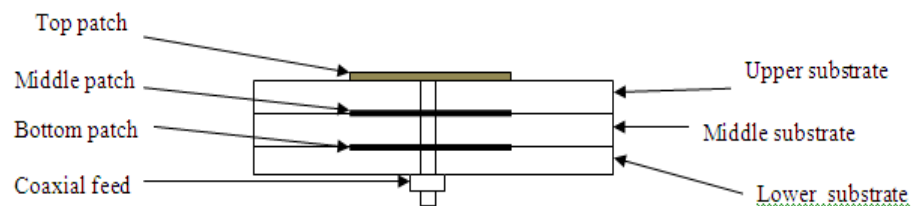
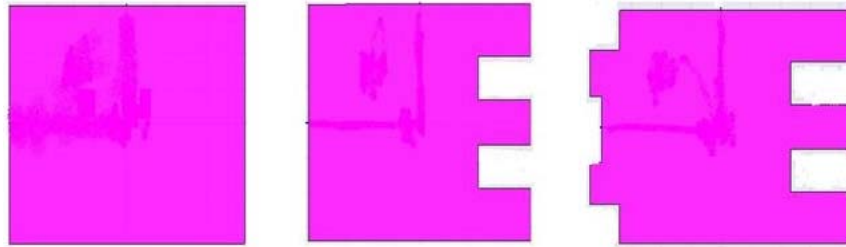


Fig. 1 Proposed antenna structure

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The modified E-shaped patch antenna has been designed in three steps. As shown in Fig. 2, in step 1, a simple rectangular patch antenna has been designed to resonate at 5.75 GHz by

using the standard equations [10]. In the step 2, two rectangular shaped slots



Step1: Simple patch Step2: E-shaped patch Step3: Optimized antenna

Fig 2: Development of design

have been removed from the right edge of the patch. These rectangular slots make the design similar to E-shape. In the final step, three rectangular slots have been introduced at two left corners and middle of left edge of the patch. The final

design has resulted in required lower and higher cut off frequencies as well as the bandwidth. The return loss plots for all the three steps have been shown in Fig. 3.

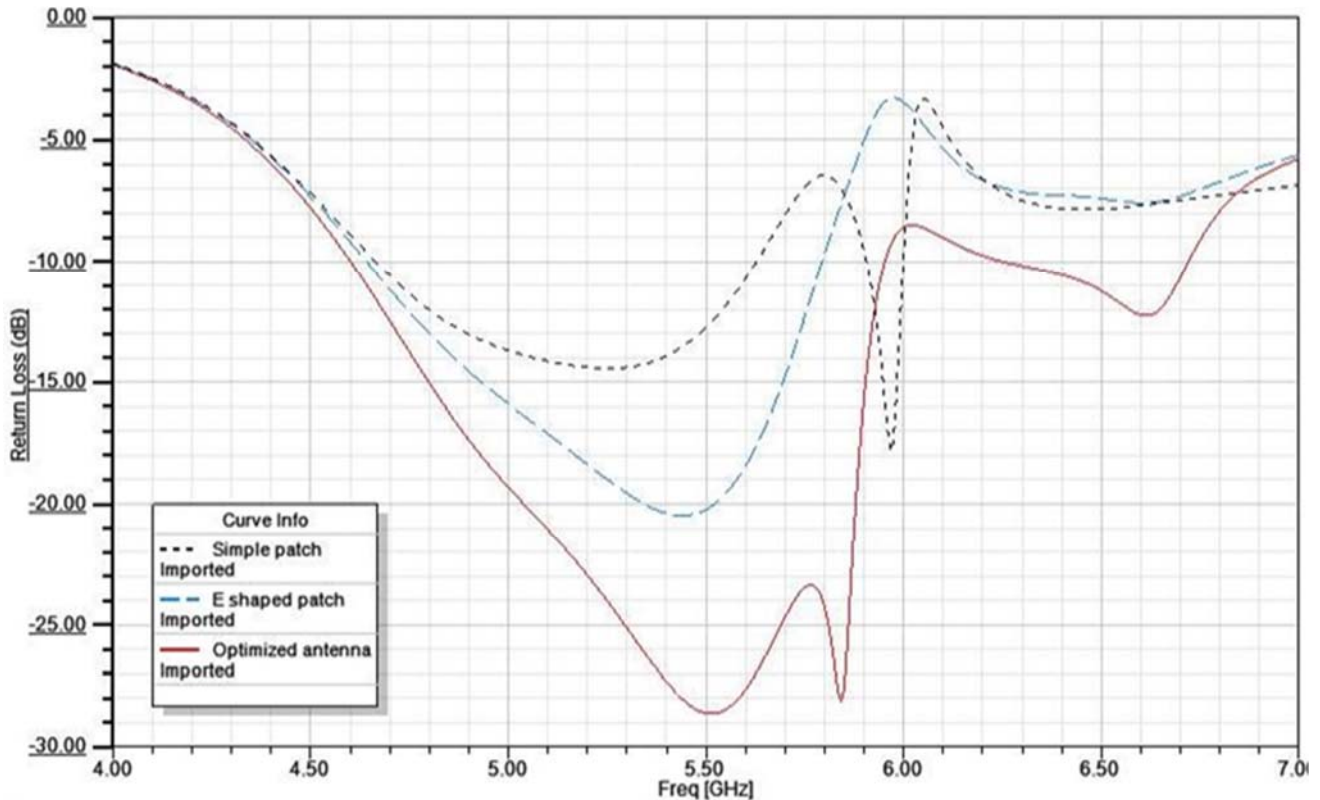


Fig 3: Return loss plots for various steps in development in the design

Table 1: Results of Return Loss Plots for Development of the Design

Design steps	f_L (GHz)	f_H (GHz)	Bandwidth (GHz)
Step1	4.66	5.63	0.96
Step2	4.64	5.79	1.15
Step3	4.60	5.95	1.35

3. Design of Optimized E-Shaped Patch Antenna at 4.60-5.95 GHz

The final antenna geometry with all design parameters has been shown in Fig. 4. The antenna design parameters of the proposed antenna have been shown in Table 2.

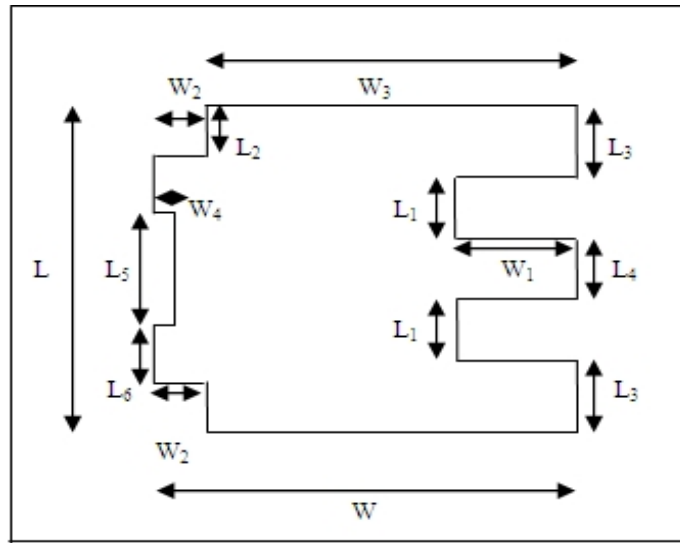


Fig 4: Modified E-shaped patch geometry

Table 2: Dimensions of the Patch and Feed of the Antenna

Parameters	Dimensions (mm)
L	13.55
W	17.66
L1	2.5
L2	2.3
L3	3.0
L4	2.55
L5	3.8
L6	2.57
W1	4.2
W2	2.0
W3	15.66
W4	0.8

4. Simulated Result of the Optimized Antenna

The software used to designed and simulate the proposed modified E-shaped antenna is Ansoft High Frequency Structure Simulator (HFSS). The HFSS uses the Finite Element Method (FEM).

In industry, Ansoft HFSS is the tool of choice for high-productivity research, development, and virtual prototyping. The HFSS can be used to calculate the return loss plot, radiation pattern, smith chart, E-field and H-field etc. The simulated results of the proposed antenna are presented below figures.

A. Return Loss Plot and Bandwidth

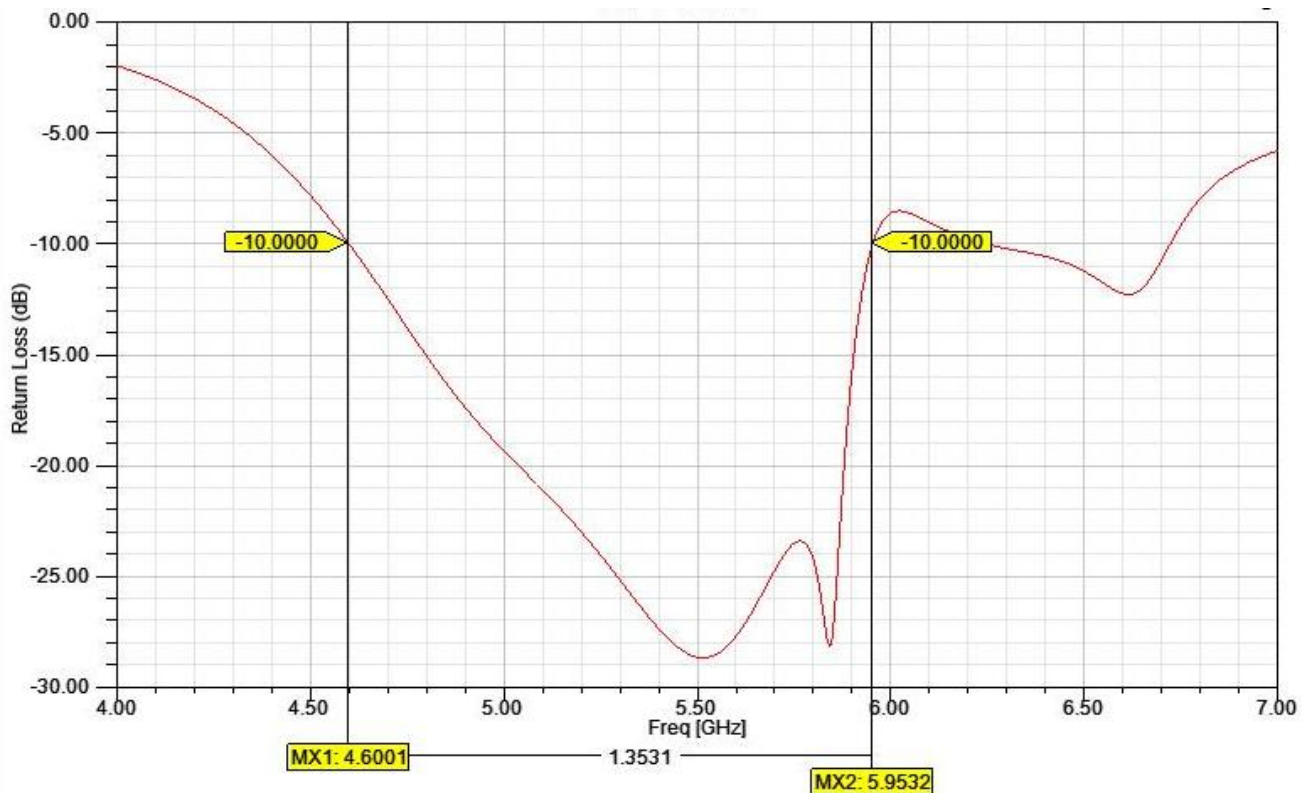


Fig 5: Return loss plot of optimized antenna

Return loss is the measure of the effectiveness of electrical energy delivery from feed to an antenna. For maximum energy transfer the return loss should be minimum. Fig 5 shows the S_{11} parameters (Return loss) for the proposed antenna. The bandwidth of the antenna considers those ranges of frequencies over which the return loss is less than -10 dB (around VSWR of 2). Thus from the Fig 5, the graph shows that the return loss below the -10 dB is started from 4.6001 GHz to 5.9532 GHz which cover the entire range of WiMAX and WLAN

applications. The bandwidth of the proposed antenna is 1.3531 GHz.

B. Gain V/S Frequency Curve

Fig 6 shows the variations in the gain with respect to frequency. It has revealed that the gain performance of the proposed antenna is satisfactory within the desired frequency range. The maximum gain is equal to 5.1 dB at 5.8 GHz frequency. The gain is 4.9 dB at 5.7 GHz frequency and 4.6 dB at 5.5 GHz frequency.

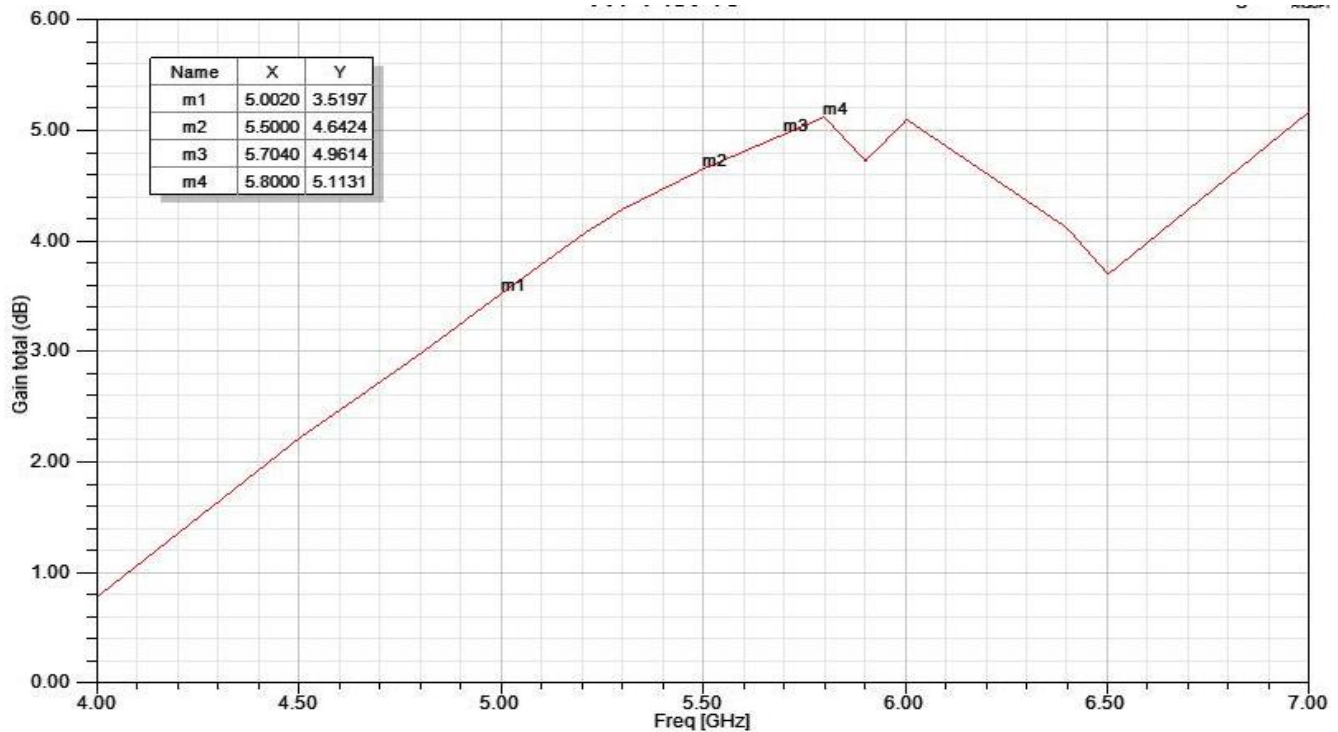


Fig 6: Gain v/s Frequency curve for optimized antenna

5. Conclusion

The proposed antenna was designed to increase the bandwidth with operation between 5 to 6 GHz frequency band. The development of the antenna design has also been described. The RT/duroid 5880 dielectric material has been used as substrate of the antenna. A rectangular patch has been designed to resonate at 5.5 GHz. Then two rectangular slots have been cut from the main patch to produce E-shape. Further, to get the desired bandwidth, three rectangular slots have been cut from two left corners and middle of left edge of the E-shape patch. Height of the antenna is increased by using three substrates as a result impedance bandwidth is improved. The proposed antenna is resonating from 4.60 GHz to 5.95 GHz, giving an impedance bandwidth of 1.35 GHz at -10 dB return loss. The maximum gain of the antenna has been found as 5.1 dB. These features are very useful for worldwide portability of wireless communication equipments.

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