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Design of Inverted U and E Shaped Slot Multiband Microstrip Patch Antenna for Wireless Applications

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ABSTRACT

This work presents the design of a multi band microstrip patch antenna for wireless applications. The proposed antenna has a compact size of 42mm x 32mm and is printed on FR4 material with height h=1.6mm, loss tangent of 0.02 and dielectric constant Er=4.4. The designed multiband antenna operates at three different frequencies of 5.6 GHz, 7.9 GHz and 11.9 GHz with return loss of -26.35 dB, -40.88 dB and -34.31 dB respectively. Multiband phenomenon in the designed antenna is reached by inserting a inverted U and E shaped slots inside a rectangular patch antenna in the ground plane. The influence of various design parameters on the resonance frequency has been investigated using CST and also presented here. The simulated results show good antenna performance for multiple applications in wireless communication.

Keywords— Multi Band Antenna, Slot on Patch, Return Loss, VSWR and Directivity.

I. INTRODUCTION

With the development of various wirelesscommunication systems, the concept of using an antenna for multiple applications is increasing day by day. Because the multipurpose applications of a single antenna play an important role for device miniaturizations and low power consumptions. In designing such multiband antennas, the microstrip patch become more attractive for many applications because of their low manufacturing cost as well as simple design [1] [2]. A number of works have been found in literature devoted in designing antennas for multiband operations, especially for wireless applications [3–7]. Among them, slot antenna in which a hole or slot of different shape and size is cut out on the metal surface of patch is a promising technique due to its very low profile, low fabrication cost, can be easily integrated with microwave integrated circuits and capable of dual and triple frequency operations [4] [6].

For dual and triple band operations, various slots of microstrip have been introduced which includes inverted cone slot [4], butterfly shape [5], inverted L-strip slot [6], multilayer structure using LTCC technology [7], inverted U shape slot [8], tapered slot with tuning patch [9], double U shape slot [10], defected structure shape with length and width variation on slot [11] and many other shapes [12]. The unnecessary band can be effectively filtrated by multiband antenna compared with the broadband antenna [13, 14], that can reduce system interference and complexity for multimode operations. However, the designing of slots for particular application (specific operating frequency) requires a very specific conditions in its geometry. This is very difficult to simulate, measure and achieve particularly for triple band operations, where the change in one dimension of the slot will affect the performance of all the three bands.

In this paper a triple band microstrip patch antenna has been proposed for wireless applications. The antenna is designed by making a UE slot on the rectangular patch. The resonance frequency of this antenna is 5.6 GHz for Wi-Fi and Wi-Max (5.25-5.85GHz), 7.9GHz for Satellite communication (7.24-7.57) GHz) and 11.9 GHz for radar applications (11.5–12.9 GHz). This antenna can also work for WLAN (2.4–2.48 GHz) application [12]. The antenna is simple and comparatively small in size with good radiation patterns and return loss. The designed antenna is simulated first by using CST Microwave Studio.

The next section (Section II) describe the methodology of designing the proposed antenna and its dimensions in detail. Section III presents the obtained simulated results due to the variation of different design parameters as well as the measured results. The performances of the proposed antenna are also compared in this section with several similar works form literature. Finally, section IV concludes all the discussion previously presented.

II. ANTENNA DESIGN

The schematic configuration of proposed antenna is shown in Fig.1 with different views of (a) Designed Multiband Patch antenna (b) Front view with inverted U and E shaped slots on the patch. The antenna consists of substrate, ground, patch, feed line, waveguide port and a slot on the patch. It is designed on FR4 substrate with dielectric constant Er of 4.4 and a thickness of 1.6 mm. The triple bands are achieved by making a UE slot on the patch. Without this slot, the antenna operates at a single band with a resonance frequency of 2.4 GHz. However, introducing this slot and properly choosing the dimensions, it resonates at three different frequencies. The proposed antenna is fed by 50 Ω microstrip line with loss tangent of 0.02. The size of the patch is 36×20 mm2 on which the UE slot is made. The inverted U and E shaped slot on the rectangular patch is designed with numerous cuts in order to improve the antenna performance. Here, in this design, seven cuts are sloted in the shape of inverted U and E with the changes in the dimensions of length and width respectively.The full ground plane is located on the backside of the dielectric substrate. Table I listed all the dimensions of the proposed antenna.

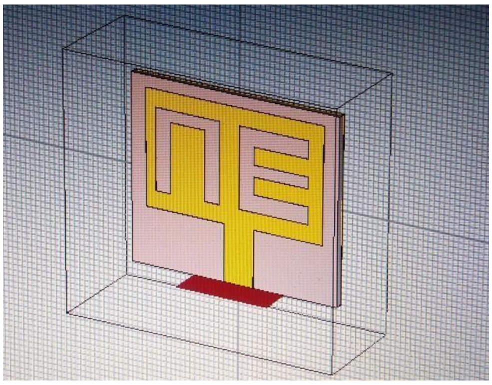

Fig1.(a) The designed Multiband Microstrip patch antenna

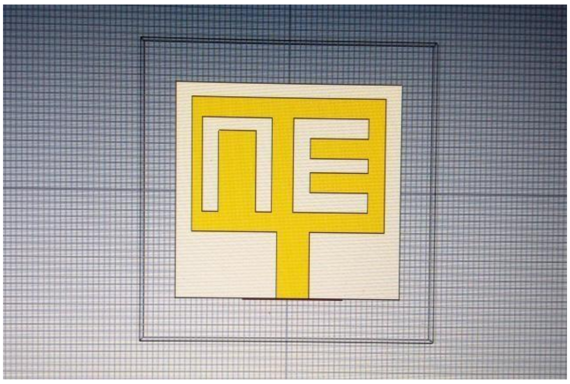

Fig 1.(b) Front View with inverted U and E shaped slots on the patch

TABLE I. DIMENSION OF THE PROPOSED ANTENNA

Parameters	Values (mm)	Parameters	Values (mm)
Wsub	32	Wg	32
Lsub	42	Lg	42
Tsub	1.6	Ws	24
Wp	36	Ls	30
Lp	20	Wf	6
Tp	0.05	Lf	22

III. RESULT AND DISCUSSION

Fig.2 shows the simulated return loss for various frequency bands at 5.6 GHz, 7.9 GHz and 11.9 GHz respectively. S parameters is the measure of how small the return or reflection is reflected. The value of return loss is found to be -26.35 dB at 5.6 GHz, -40.88 dB at 7.9 GHz and -34.31 dB at 11.99 GHz respectively. Fig.3 shows the simulated VSWR at three frequency bands.VSWR is an element of the reflection coefficient which portrays the force reflected from the antenna. The VSWR ratio of proposed antenna is found to be 1.11 at 5.6 GHz, 1.01 at 7.9 GHz and 1.04 at 11.9 GHz respectively.

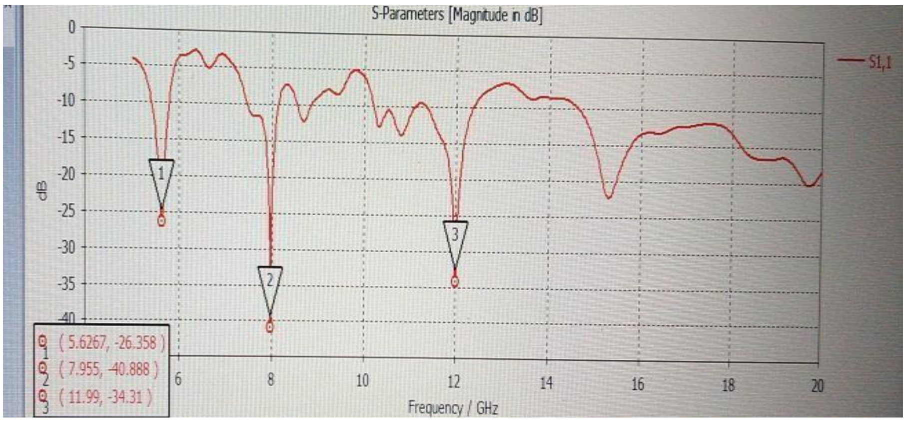

Fig 2. Return loss at three frequency bands

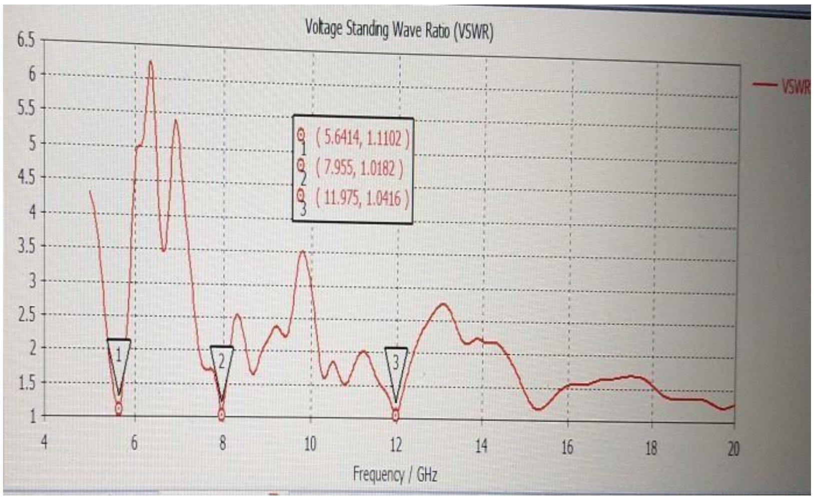

Fig 3. VSWR at threee frequency bands

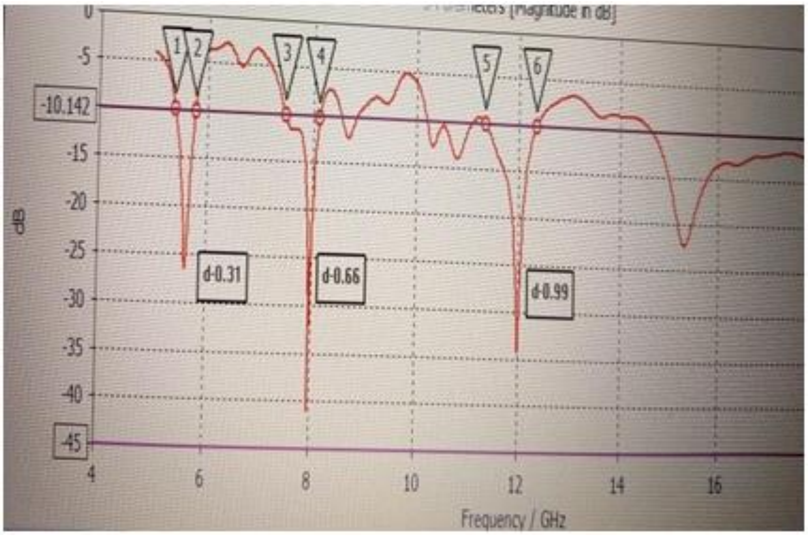

Fig 4. Bandwidth at three frequency bands

Bandwidth is the range of frequencies over which the antenna can operate correctly. For an antenna, bandwidth is calculated from the S parameters graph by drawing a line at -10 dB. As per the design, the bandwidth is 318 MHz at 5.6GHz, 661 MHz at 7.9GHz and 992 MHz at 11.9GHz respectively.

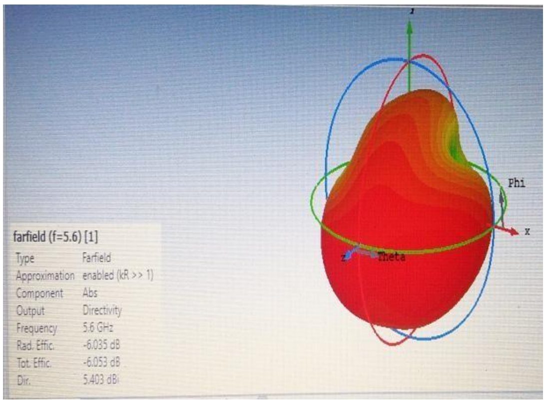

Fig 5.(a) Directivity at 5.6 GHz

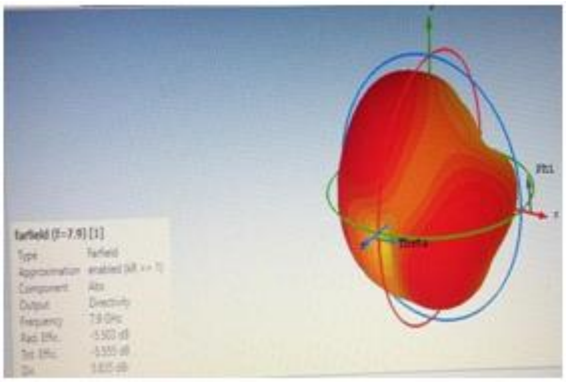

Fig 5.(b) Directivity at 7.9 GHz

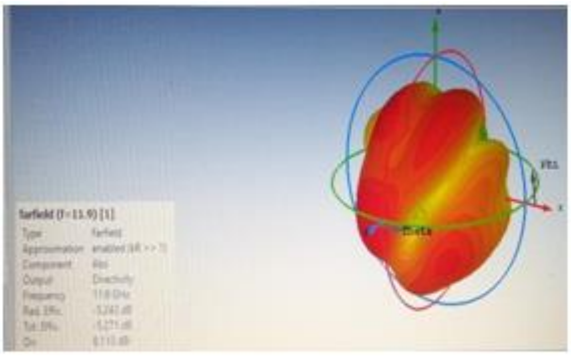

Fig 5.(c) Directivity at 11.9 GHz

Directivity is desirable to maximize the radiation pattern of the antenna response in a fixed direction in order to transmit or receive power. Likewise the directivity is dependent only on the shape of the radiation pattern. The achieved directivity of designed antenna is 5.403 dBi at 5.6 GHz, 5.835 dBi at 7.9 GHz and 8.110 dBi at 11.9 GHz respectively.

Since a multiband microstrip patch antenna radiates normal to its patch surface, the radiation pattern for phi= 900 would be important for antenna design. Fig 6 (a,b,c) shows the gain, radiated power and effective area of the simulated antenna for the frequency bands 5.6 GHz, 7.9 GHz and 11.9 GHz.

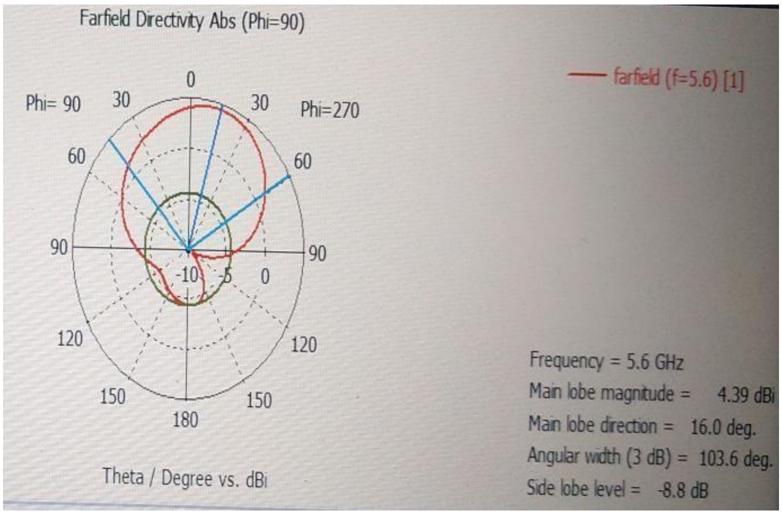

Fig 6.(a) Radiation pattern plots at 5.6 GHz

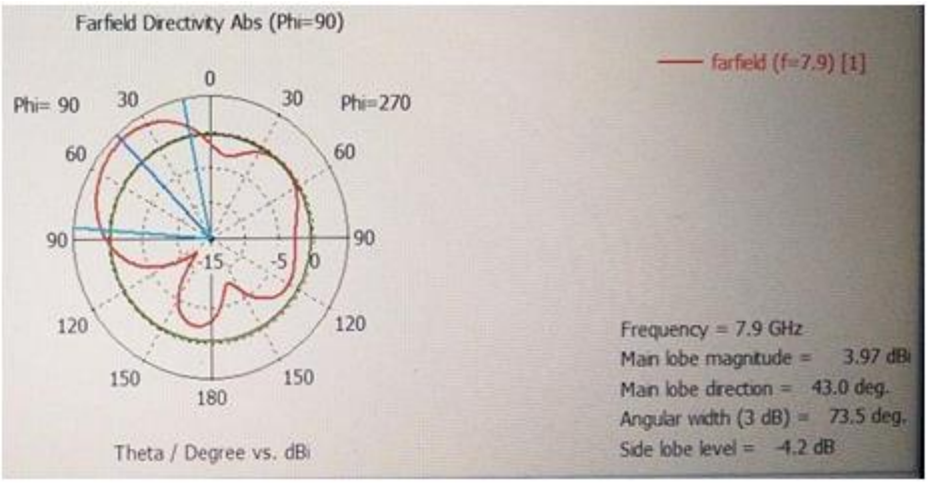

Fig 6.(b) Radiation pattern plots at 7.9 GHz

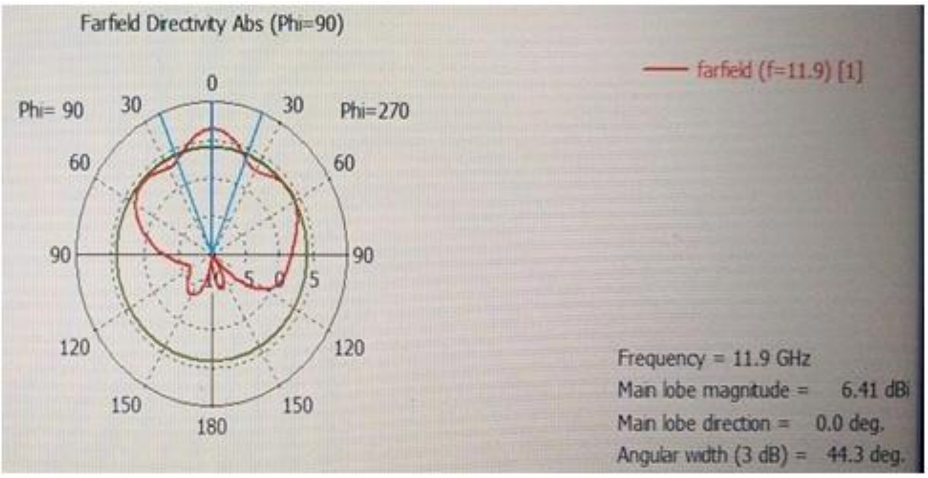

Fig 6.(c) Radiation pattern plots at 11.9 GHz

IV. CONCLUSION

A simple Multiband microstrip patch antenna has been proposed in this work for triple band wireless applications. The inverted U and E shaped slot with appropriate length and width has been introduced on the patch to generate the desired three operating bands at 5.6 GHz, 7.9 GHz and 11.9 GHz respectively. The proposed antenna is designed on FR4 substrate with its overall dimension of 42 × 32 × 1.6 mm3, which is relatively compact and its performance has been investigated both numerically and experimentally. The peak return loss of the proposed antenna is -40.88 dB and peak directivity is 8.11 dBi. The antenna exhibits stable radiation patterns in the entire frequency range. The proposed antenna is suitable for triple band applications of Wi-Fi and Wi-Max (5.25-5.85 GHz), satellite communications (7.24-7.57 GHz) and radar systems (11.5-12.9 GHz), which are verified by CST simulated results.

TABLE II. Multiband Microstrip Patch Antenna's Performance

Title	Overall dimension (mm^3)	Reference frequency (GHz)	Return Loss (dB)	VSWR	Bandwidth (MHz)	Gain (dB)	Directivity (dBi)
Design of inverted U and E shaped slot multiband microstrip patch antenna for wireless applications	42x32x1.6	5.6,7.9,11.9	-26.35,-40.88,-34.31	1.11,1.01,1.04	318,661,992	0.12,1.11 ,2.97	5.43,5.83,8.11

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