Design and Analysis of Microstrip Antenna for 5G Applications

T Satyabhama [1], K Rama Devi [2]

[1,2]*UCEK, JNTUK, Kakinada, India*

Abstract - *This paper presents a novel antisymmetric L-probe feeding method with E-shaped stack patch antenna A feeding structure is specially designed to achieve required bandwidth and gain. The proposed antenna is sufficient to cover a wide operating frequency band from 1500 to 2700 MHz. Some techniques has been extensively used to enhance the performance of dual-polarized patch antenna. The analysis of an antennas was performed numerically using a commercial finite-element method software, namely Ansoft High Frequency Structure Simulator (HFSS). An E-shaped stack patch antenna and a dual polarized feed technique is introduced to achieve good isolation between input ports.*

Key Words: Antenna, dual-polarization antenna, antenna feeds, patch antenna, SWR plots

1. INTRODUCTION

The growing demand for wireless networks and systems is the main reason for many researches on more efficient and smaller radiating structures these days. Microstrip antennas are one of the best choices due to their low weight, low cost, robustness when mounted on rigid surfaces [1], manufacturing simplicity and compatibility with MMIC designs. Microstrip antennas are also known as the patch or printed antennas. This antenna is a patch connected to the feed on a flat surface and this whole patch is printed on a rectangular flat surface which is called the ground plane. The substrate is the dielectric layer that separates both the patch and the ground plane.The patch antenna is a good choice over other kinds of antennas due to its low profile, light weight, low costs, and easy fabrication for dual-polarization implementation [2]. However, patch antennas have a main disadvantage: narrow bandwidth. Researchers have made many efforts to overcome this problem and many configurations have been presented to extend the bandwidth. The conventional method to increase the bandwidth is using parasitic patches. In [4], the authors presented a multiple resonator wide-band microstrip antenna. The parasitic patches are located on the same layer with the main patch.Many techniques have been extensively investigated to enhance the operating band of patch antennas. The approach is to make a modified feeding probe so that additional capacitance can be introduced to the patch for impedance matching. The L-shaped probe [3], [5], [6], F-shaped probe [8], [10], T-shaped probe [11], and meandering probe[9] , [12] antennas are the typical examples. The microstrip antenna [7], [13], [18] has been widely applied in different applications

In view of this, a novel antisymmetric L-probe feeding method with E-shaped stack patch is proposed for broadband operation. The feeding portion is simply printed on a low-cost printed circuit board (PCB), and no additional circuitries or metallic walls are integrated in the dual-polarized case for high gain and isolation between input ports. E-shaped patch antenna is simpler in construction. By only adjusting the length, width, and position of the slots, one can obtain satisfactory performances.

2. DUAL POLARIZED ANTENNNA DESIGN

The geometry of the dual-polarized L-probe fed E-shaped patch antenna feed structure is depicted in Fig1. In this design, two pairs of anti symmetric L-shaped probes are, respectively, etched on feedline substrate 1 and feedline substrate 2. The two pieces of PCB dielectric substrates join together at the center below the radiating patch. A groove is cut into each board to half their thickness so as to allow them overlap each other when joined. Such arrangement allows the accommodation of the dual-orthogonal polarization in a compact area. A parasitic patch is thus employed in the dual-polarized case in order to retain wideband operation.

As shown in Fig1 an antisymmetric L-shaped probes on feedline substrate 1 is designed to feed the patch for −45° polarization (port 1), while the one on feedline substrate 2 is for +45° polarization (port 2). Here two patches are placed above PCB substrates. The lengths of the lower and the upper patches are w= 38 mm and L_p = 48 mm respectively. The heights of the upper and the lower square patches are 22 mm and 26 mm, respectively. It is noted that, in the dual-polarized case, the side length of the square ground is only 100 mm for shortening the simulation time. The PCB is sandwiched between the patch and the ground plane, which is aligned perpendicular to the patch and the ground plane. Regarding the excitation, the end of the feedline is soldered to the inner conductor of an SMA connector underneath the ground, while the outer conductor of the connector is attached on the ground plane. The dual-polarized L-probe fed E-shaped patch antenna is designed to get better results of isolation loss and gain when compared to the dual-polarized L-probe fed patch antenna. The dual-polarized L-probe fed E-shaped patch antenna with front view and top view are shown in Fig. 2(a) and Fig. 2(b). Fig.2 (a) represents the geometry of the E-shaped patch antenna. The topological shape of the patch resembles the letter "E," hence the name E-shaped patch antenna. The slot length (a), width (w) are important parameters in controlling the achievable bandwidth.Table 1 represents the parameter dimensions of the antenna .It used a E-shaped patch to increase the gain and to get better result.

Patch Width and Length are calculated by using equations (1) & (2)

Patch width

$$W = \frac{\lambda_0}{2} \frac{1}{\sqrt{\frac{\varepsilon_r + 1}{2}}} \quad \text{——— (1)}$$

Patch length

$$L_p = \frac{\lambda_0}{2} \frac{1}{\sqrt{\varepsilon_{re}}} - 2\Delta\ell \quad \text{——— (2)}$$

$$\varepsilon_{re} = \frac{\varepsilon_r + 1}{2} + \frac{\varepsilon_r - 1}{2}\left(1 + \frac{10h}{W_p}\right)^{-0.5}$$

$$\frac{\Delta\ell}{h} = 0.412 \frac{\varepsilon_{re} + 0.300}{\varepsilon_{re} - 0.258} \frac{W_p/h + 0.262}{W_p/h + 0.813}$$

Where f_r is the resonant frequency,

c is the velocity of light in free space and

ε_r is the relative permittivity.

Table -1: DIMENSIONS (IN MILLMETERS) OF THE ANTENNA

Parameters	Lp	h	d	s	tw
Units in Mm	48	44	2.5	1.5	1.8
Antenna Parameter	a_x	t_1	t_2	W	a_1
Units in mm	0.65	13.175	21.72	4.0	14.975
Antenna Parameter	a_2	a_3	a_4	a	b
Units in mm	16.5	14	25.93	5	30

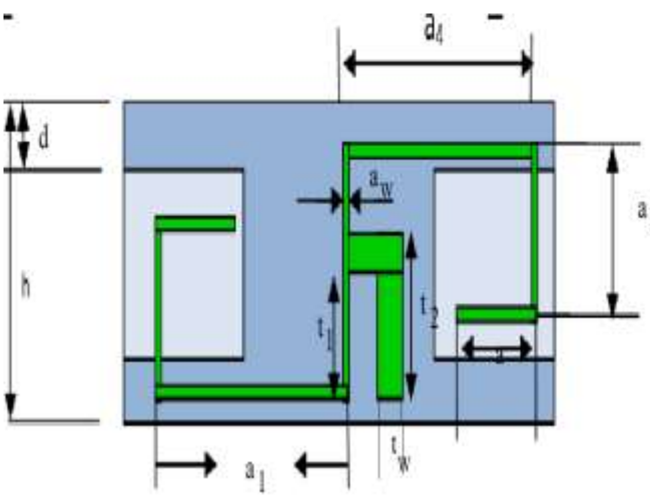
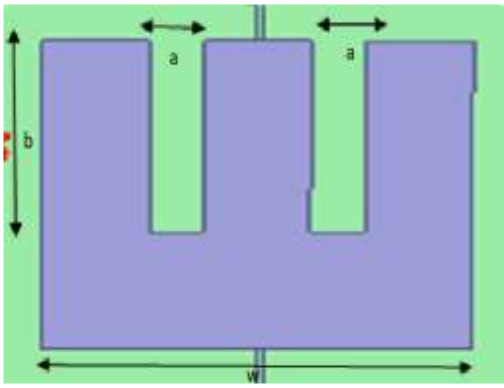
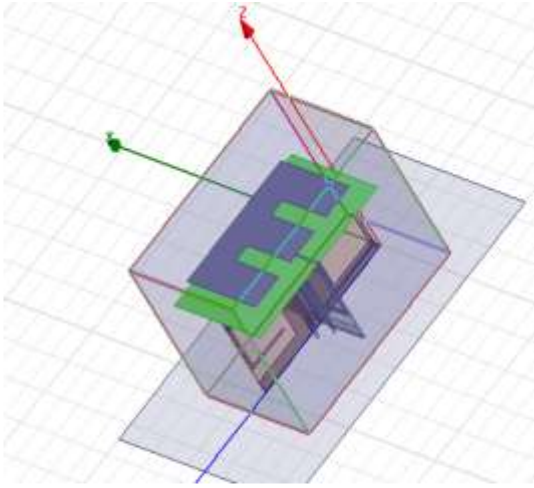


Fig.1 Geometry of the antenna Feeding structure



(a)



(b)

Fig.2 Geometry of the dual-polarized L-probe fed E-shaped patch antenna(a)Top view (b)front view

3. SIMULATION RESULTS AND DISCUSSION

The substrate used in the design is Roger RT/Duroid 5880 with ε_r = 2.2 and thickness 0.5mm.The simulated SWR of the proposed antenna with dual polarization are shown in Fig. 3(a). The simulated SWR for the two ports are less than 2(SWR<2) over the bandwidth from 1.50 to 2.70 GHz. The simulated gains performance is shown in Fig. 3(c) over the bandwidth from 1.50 to 2.70GHZ.

Over the operating frequencies, the gains are higher than 10dBi. At the two ports, it is noted that relatively higher gains obtained at high frequencies. It is because beamwidths gradually a decrease with the increase of frequencies. The isolation over operating band is better than 20dB. L-shaped probe feeds with relatively longer lengths. The peak gain is 12.6 dBi. Fig (4) represents the Current distributions of dual-polarized L-probe fed E-shaped.Table-2 represents the Performance analysis of microstrip patch antenna.

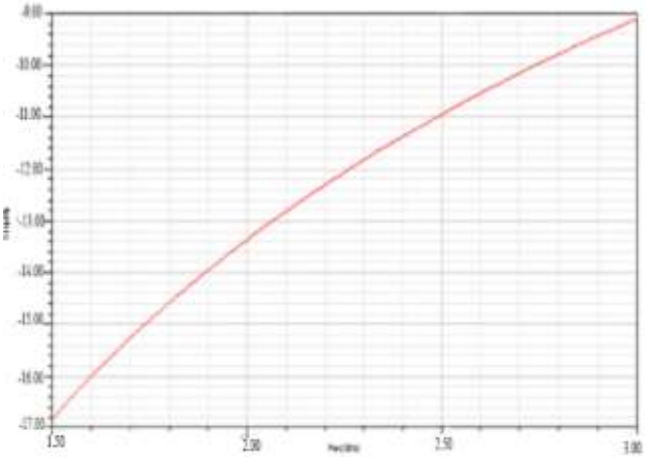


Fig. 3 (a)Return loss

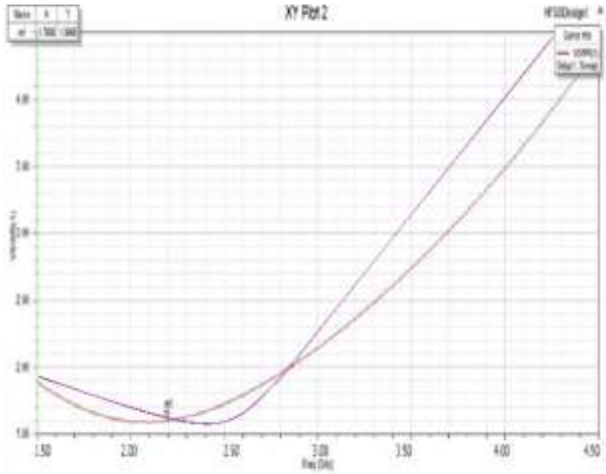


Fig. 3 (b) SWR plots for port 1 and port2

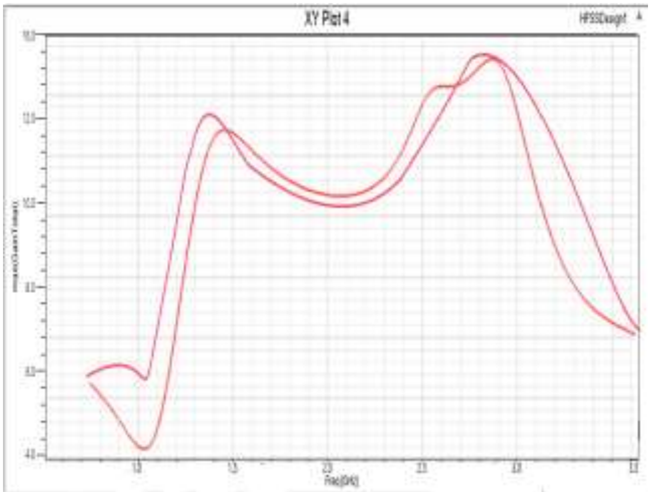


Fig. 3 (c) gain plots for port1 and port 2 patch antenna

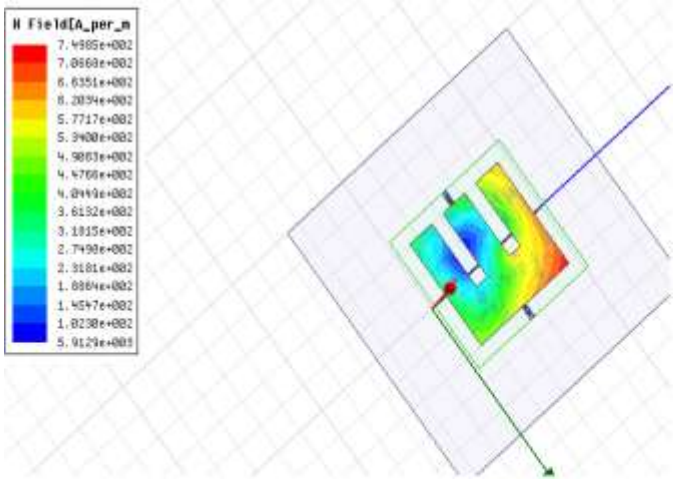


Fig. 4 Current distributions of dual-polarized L-probe fed E-shaped

Table -2 : Performance analysis of microstrip patch antenna

Parameters	Existing method	Proposed method
Gain	Above 8 dB	Above10 dB
Size of patch antenna	(0.38x0.38) λ_0^2	(0.34 x 0.34) λ_0^2

4.CONCLUSION:

Compared to conventional wide-band microstrip patch antennas, it has the attractive features of simplicity and small size. The proposed and designed antenna applicable to modern wireless communication frequencies of 1.5GHZ to 2.7 GHZ. These ranges of frequencies are very desirable in modern wireless communications. The antenna has required gain. The size of proposed antenna is (0.34 x 0.34) λ_0^2 projection area . The gain of the antenna system can further be improved by using different patch shapes and feeding techniques.

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