Compact dual-polarised square microstrip antenna with triangular slots for wireless communication

D. Das Krishna, M. Gopikrishna, C.K. Aanandan, P. Mohanan and K. Vasudevan

Design of a dual linearly-polarised microstrip patch antenna, excited by two orthogonal microstrip feed lines, is presented. A reduction in patch size of 35% is obtained when compared to a square patch operating at the same frequency. The polarisations are oriented at +45 and −45° with an isolation of more than 36 dB between the ports. Unlike earlier designs, the proposed structure provides better gain.

Introduction: A dual linearly-polarised antenna is one that is capable of operating with two orthogonally polarised waves. Consequently, the antenna finds applications in frequency reuse, or simultaneous transmit–receive operation at the same frequency [1]. In satellite communication systems, frequency reuse involving the use of orthogonal polarisations gives enhanced capacity. The deterioration of system performance as a result of multipath propagation in land mobile communications is reduced by incorporating polarisation diversity [2]. In simultaneous transmit–receive applications, dual-polarised microstrip patch antennas with two-port connections offer an alternative to the usual bulky combination of circulator and separate transmit–receive antennas. This is in addition to the advantages associated with microstrip patch antennas, such as lightness, compact size, planar structure and ease of fabrication [3]. For simultaneous receive and transmit operation, a higher level of isolation is needed for avoiding crosstalk [4].

In this Letter, we propose a dual feed, electromagnetically coupled square patch antenna with two triangular slots. The antenna exhibits dual linear polarisations when two orthogonal modes are simultaneously excited in the patch. By adjusting the feed lines, isolation better than 36 dB is observed between the ports. The antenna is 35% smaller than a square patch operating at the same frequency. The size reduction is achieved by means of reactive loading in the form of slots on the surface of the patch [5]. Such loading increases the surface current path and the electrical length of the element, which leads to a reduction of the patch size for a given resonant frequency. This configuration offers higher gain compared to earlier designs [6].

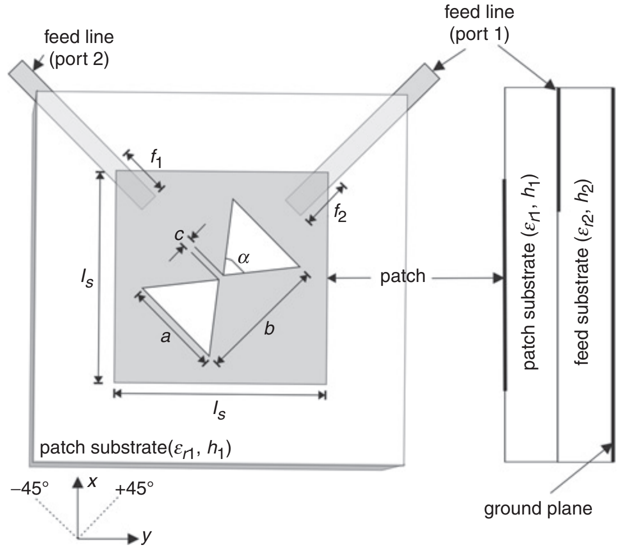

Fig. 1 *Geometry of proposed antenna*

Antenna design: The basic configuration of the proposed microstrip patch antenna for exciting dual bands and dual polarisation is shown in Fig. 1. A square patch with two triangular slots symmetric with respect to the patch diagonals is electromagnetically coupled to two 50 Ω feed lines. The current distribution on the patch, when either of the two ports is excited, is shown in Fig 2, where darker areas represent higher intensity. The polarisation at the two ports is along the diagonals of the square patch. The isolation between them can be improved by adjusting the feed position in the region where the electric field on the patch obtained by feeding the other port is minimum. Return loss and radiation characteristics measurements of the antenna, with the parameters $l_s = 40$ mm, $a = 12.6$ mm, $b = 17$ mm, $c = 0.8$ mm, $\alpha = 80°$, $f_1 = f_2 = 6.3$ mm, $\varepsilon_{r1} = 4.36$, $\varepsilon_{r2} = 3.1$, $h_1 = 1.6$ mm, $h_2 = 1.6$ mm, are carried out using an HP8510 network analyser. The antenna is also simulated using MoM software Zeland IE3D^{TM}.

Fig. 2 *Current path on patch*

a Port 1 excited
b Port 2 excited

Results: Fig. 3 shows the simulated and measured return loss and isolation of the antenna. It is observed that the antenna exhibits resonance at 1.65 GHz and an isolation greater than 36 dB at this frequency.

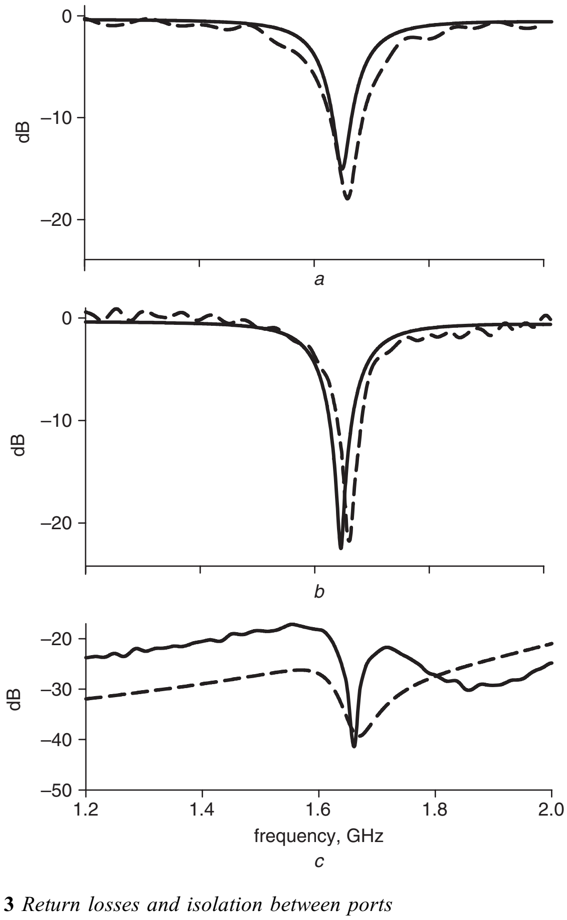

Fig. 3 *Return losses and isolation between ports*

a Return loss at port 1
b Return loss at port 2
c Isolation between ports
—— simulated
- - - experimental

For single-frequency dual-polarisation operation, it is critical that the surface currents around the slot in both the orthogonal directions have to traverse equal lengths. The resonant frequency of the proposed antenna can be varied by varying the *a* and *b* dimensions of the slot uniformly. Simulation studies show that a minimum resonant frequency of 1.5 GHz is observed for $a = 17$ mm and $b = 21.2$ mm while the rest of the antenna parameters remain same. For the same resonant frequency, an unslotted patch has a side dimension of 49.5 mm whereas the proposed antenna side is only 40 mm. Hence, a size reduction of 35% is achieved.

The transmitted power from the proposed antenna is compared with that of an unslotted square patch in Fig. 4. It is observed from the Figure that the gain of the proposed antenna is comparable with that of a square patch of the same size, even when a reduction in resonant frequency is obtained.

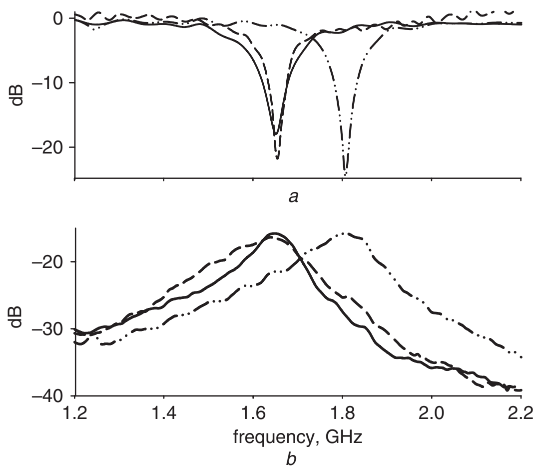

Fig. 4 *Measured reflection and transmission characteristics of antenna*

a Reflection characteristics
—— return loss at port 1
- - - - - return loss at port 2
—·· —·· return loss of unslotted square patch
b Transmission characteristics
—— transmitted power from port 1 (−45° plane)
- - - - - transmitted power from port 2 (+45° plane)
—·· —·· transmitted power from unslotted square patch

While obtaining the radiation patterns due to port 1, port 2 was terminated in its resonant impedance, and vice versa. The radiation patterns measured in the E- and H-planes for the proposed antenna are shown in Fig. 5. The radiation from the antenna is obtained along the ±45° planes, i.e. along the diagonals of the square patch. The cross-polarisation level for the antenna remains below −35 dB in the E-plane, but in the H-plane, it deteriorates slightly.

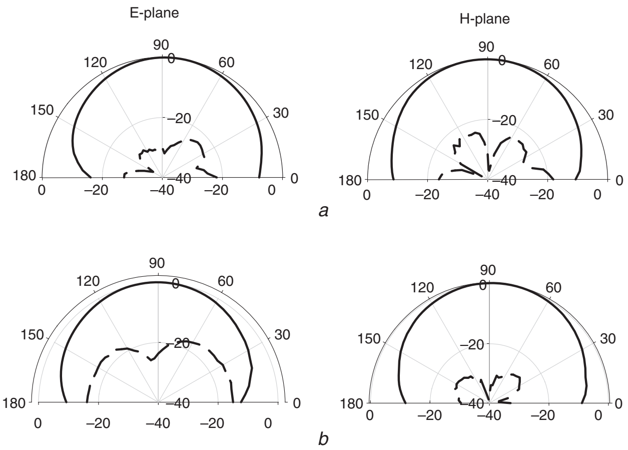

Fig. 5 *E-plane and H-plane radiation characteristics of proposed antenna*

a At port 1
b At port 2

Conclusions: Use of a square patch with two triangular slots as a compact dual linearly-polarised antenna with very good isolation has been reported. The antenna is excited by electromagnetically coupling from two 50 Ω feed lines. The antenna exhibits polarisation along ±45° at the ports. A high degree of isolation between the ports (better than 35 dB) was realised with good matching at both the ports. The cross-polarisation levels are lower than 25 dB in both ports. A reduction in patch size of 35% is obtained compared to the square patch operating at the same frequency without much reduction in gain.

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D. Das Krishna, M. Gopikrishna, C.K. Aanandan, P. Mohanan and K. Vasudevan (*Centre for Research in Electromagnetics and Antennas, Department of Electronics, Cochin University of Science & Technology, Cochin 682022, India*)

E-mail: anand@cusat.ac.in

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