Design Analysis of a Slotted Microstrip Antenna for Wireless Communication

Norbahiah Misran, Mohammed N. Shakib, Mohammad T. Islam, and Baharudin Yatim

Abstract**—**In this paper, a new design technique for enhancing bandwidth that improves the performance of a conventional microstrip patch antenna is proposed. This paper presents a novel wideband probe fed inverted slotted microstrip patch antenna. The design adopts contemporary techniques; coaxial probe feeding, inverted patch structure and slotted patch. The composite effect of integrating these techniques and by introducing the proposed patch, offer a low profile, broadband, high gain, and low cross-polarization level. The results for the VSWR, gain and co-and cross-polarization patterns are presented. The antenna operating the band of 1.80-2.36 GHz shows an impedance bandwidth (2:1 VSWR) of 27% and a gain of 10.18 dBi with a gain variation of 1.12 dBi. Good radiation characteristics, including a cross-polarization level in *xz*-plane less than -42 dB, have been obtained.

Keywords**—**Slotted antenna, microstrip patch antenna, wideband, coaxial probe fed.

I. Introduction

THE explosive growth of wireless system and booming demand for a variety of new wireless application, it is important to design broadband antennas to cover a wide frequency range. The design of an efficient wide band small size antenna, for recent wireless applications, is a major challenge [1]. Microstrip patch antennas have found extensive application in wireless communication system owing to their advantages such as low-profile, conformability, low-cost fabrication and ease of integration with feed-networks [2]. However, conventional microstrip patch antenna suffers from very narrow bandwidth, typically about 5% bandwidth with respect to the center frequency. This poses a design challenge for the microstrip antenna designer to meet the broadband techniques [3], [4]. There are numerous and well-known methods to increase the bandwidth of antennas, including increase of the substrate thickness, the use of a low dielectric substrate, the use of various impedance matching and feeding techniques, the use of multiple resonators, and the use of slot antenna geometry [3], [5], [6]. However, the bandwidth and the size of an antenna are generally mutually conflicting properties, that is, improvement of one of the characteristics normally results in degradation of the other.

Recently, several techniques have been proposed to enhance the bandwidth. A novel single layer wide-band rectangular patch antenna with achievable impedance bandwidth of greater than 20% has been demonstrated [7]. Utilizing the shorting pins or shorting walls on the unequal arms of a U-shaped patch, U-slot patch, or L-probe feed patch antennas, wideband and dual-band impedance bandwidth have been achieved with electrically small size [8]-[10].

In this paper, a novel slotted double E shape patch is investigated for enhancing the impedance bandwidth. A better cross-polarization and wider impedance bandwidth of 27% is achieved compared to the design reported in [11].

II. Antenna Design Layout

Fig. 1 depicts the geometry of the proposed patch antenna. The inverted rectangular patch, with width *W* and length *L* is supported by a low dielectric superstrate with dielectric permittivity ε_l and thickness h_l. An air-filled substrate with dielectric permittivity ε_o and thickness h_o is sandwiched between the superstrate and a ground plane. The proposed patch integrates the double E shaped patch on the same radiating element. For the main E-shaped, the slots are embedded in parallel on the radiating edge of the patch symmetrically with respect to the centerline (x-axis) of the patch and it is incorporated extra E shaped slot on the same radiating edge of opposite side. The patch is fed by a coaxial probe along the centerline (x-axis) at a distance f_P from the edge of the patch as shown in Fig. 1(b). Table I shows the optimized design parameters obtained for the proposed patch antenna. A dielectric substrate with dielectric permittivity, ε_l of 2.2 and thickness, h_l of 1.5748mm has been used in this research. The thickness of the air-filled substrate, h_o is 12.5 mm. An Aluminum plate with dimensions of $1.393\,\lambda_0 \times 1.254\,\lambda_0$ (where λ_0 is the guided wavelength of the centre operating frequency) and thickness of 1 mm is used as the ground plane. The proposed antenna is designed to operate at 1.80 GHz to 2.36 GHz region.

This design employs contemporary techniques namely, the coaxial probe feeding, inverted patch, and slotted patch techniques to meet the design requirement. The use of probe feeding technique with a thick air-filled substrate provides the bandwidth enhancement, while the application of superstrate with inverted radiating patch offers a gain enhancement, and the use of parallel slots also reduce the size of the patch. The

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use of superstrate on the other hand would also provide the necessary protections for the patch from the environmental effects. By incorporating extra E shape slots in radiating edges, the gain and cross-polarization has been improved. These techniques offer easy patch fabrications, especially for array structures.

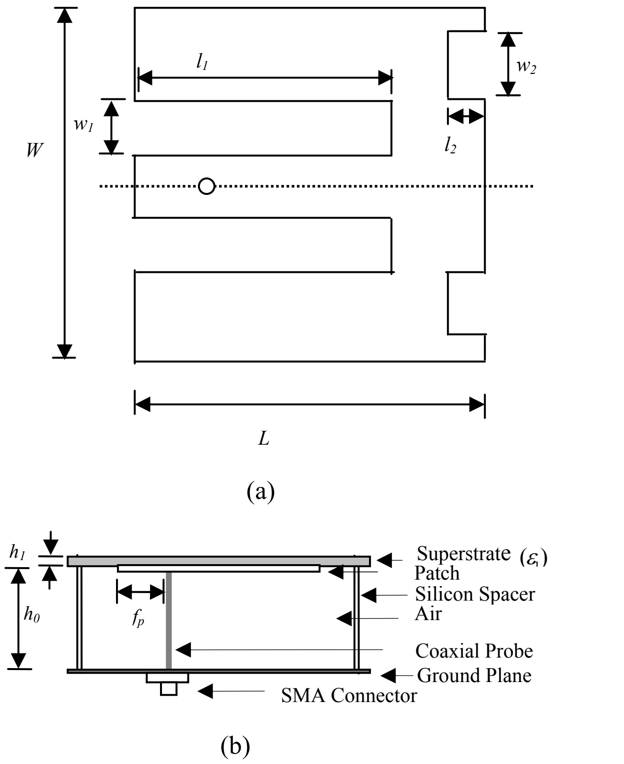

Fig.1 Geometry of proposed patch antenna. (a) Top view, (b) Side view

TABLE I
PROPOSED PATCH ANTENNA DESIGN PARAMETERS IN MILLIMETERS (MM)

Dimension	W	L	w_1	l_1	w_2
(mm)	79	53	10	37	17
Dimension	l_2	h_0	h_1	f_p	
(mm)	6	12.5	1.5748	12	

III. RESULT AND DISCUSSIONS

A simulator "Ansoft HFSS" based on finite element method has been used to calculate return loss, impedance bandwidth, radiation pattern and gains. Fig. 2 shows the simulated result of the VSWR of the proposed antenna. The two closely excited resonant frequencies at 1.85 GHz and at 2.2 GHz as shown in the figure gives the measure of the wideband characteristic of the patch antenna. The simulated impedance bandwidth of 26.92% from 1.80 GHz to 2.36 GHz is achieved at 10 dB return loss (VSWR≤2).

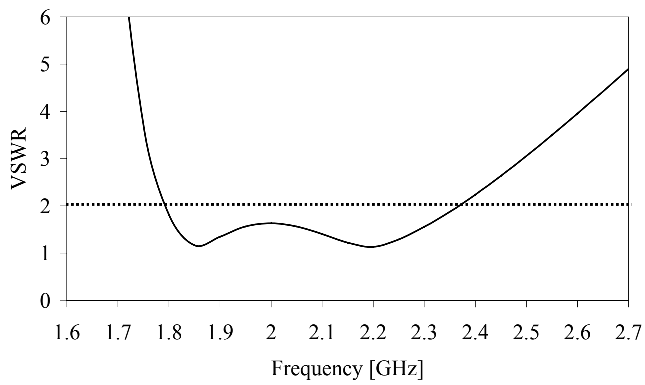

Fig. 2 Simulated VSWR of the proposed patch antenna

Fig. 3 shows the simulated *xz*-plane and *yz*-plane radiation pattern of the proposed antenna at 2.2 GHz. As shown in figure, the designed antenna displays good broadside radiation patterns in the *xz*-plane and *yz*-plane. It can be seen that 3-dB beamwidth of 60º and 46º for *xz*-plane and *yz*-plane respectively at 2.2 GHz. The peak cross-polarization level of the antenna is observed to be about -42dB and -13dB below the copolarization level of the main lobe at *xz*-plane and *yz*-plane respectively at the frequency of 2.2 GHz. The proposed patch antenna exhibits better cross-polarization than the design reported in [11]. Notable, the radiation characteristics of the proposed patch antenna are better to those of the conventional patch antenna. The radiation patterns at other bands, which are similar to those at 1.85 GHz, are not presented here in detail.

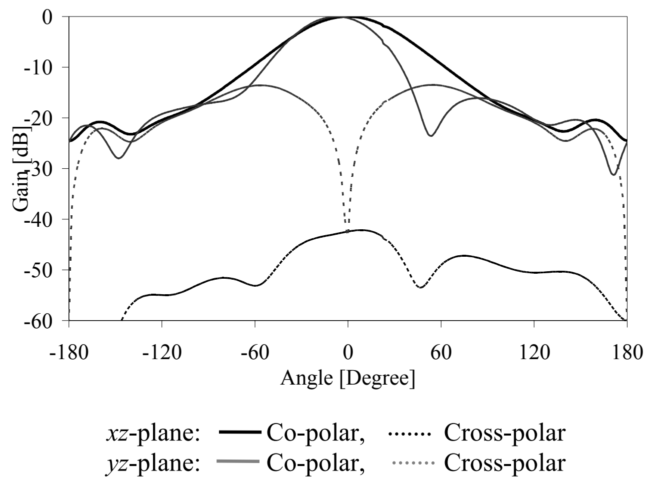

Fig. 3 Radiation pattern of proposed patch antenna at 2.2 GHz for *xz*-plane and *yz*-plane

The simulated gain of the proposed patch antenna at various frequencies is shown in Fig. 4. As shown in the figure, the maximum achievable gain is 10.18 dBi at the frequency of 2.05 GHz and the gain variation is 1.12 dBi between the frequency ranges of 1.80 GHz to 2.36 GHz.

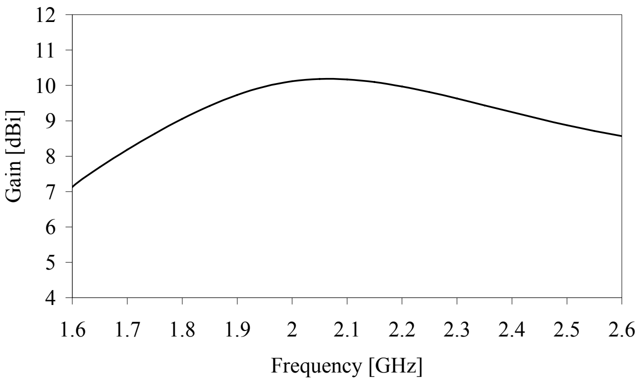

Fig. 4 Simulated gain of proposed patch antennas at different frequencies

IV. Conclusion

A new double E shaped patch for enhancing bandwidth of microstrip patch antenna is successfully designed in this paper. By employing proposed slotted patch shaped design, inverted patch, and coaxial probe feeding techniques, an impedance bandwidth of 27% is achieved in this design with respect to the centre frequency of 2.08 GHz. In addition, good antenna gain and radiation characteristics have also been obtained. The proposed patch has a simple structure with dimension of $0.516\lambda_0 \times 0.383\lambda_0$. The design is suitable for array applications with respect to a given frequency of 1.80-2.36 GHz.

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