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Modified E-H shaped microstrip patch antenna

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Abstract: A wideband L-probe fed microstrip patch antenna is proposed. By employing L-shaped feed and modification of E-H shaped patch, an antenna with 30% impedance bandwidth (return loss −10 dB) and a gain of 9.41 dBi is achieved. It is shown that the wide bandwidth is caused by a two-frequency resonance. The achievable experimental 3-dB beamwidth in the azimuth and elevation are 63.53° and 51.37° respectively at the center frequency.

Keywords: patch antenna, wideband antenna, L probe fed

Classification: Microwave and millimeter wave devices, circuits, and systems

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1 Introduction

The need for compact and multifunctional wireless communication systems has spurred the development of wideband antennas with small size. Microstrip patch antennas have several well-known advantages, such as low profile, low cost, light weight, ease of fabrication and conformity [1]. However, the microstrip antenna inherently has a low gain and a narrow bandwidth. To overcome its inherent limitation of narrow impedance bandwidth and low gain, many techniques have been suggested e.g., for probe fed stacked antenna, microstrip patch antennas on electrically thick substrate, slotted patch antenna and stacked shorted patches have been proposed and investigated [2]. 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, 4]. 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.

Several techniques have been proposed to enhance the bandwidth in the state-of-the art antenna research. A single layer wide-band rectangular patch antenna with achievable impedance bandwidth of greater than 20% has been demonstrated [5]. 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 in [6, 7, 8]. Other techniques involves employing multilayer structures with parasitic patches of various geometries such as E, V and H shapes, which excites multiple resonant modes. However, these antennas are generally fabricated on thicker substrates [9]. In this paper, a new modified E-H shaped patch antenna is investigated for enhancing the impedance bandwidth and gain. The design employs contemporary techniques namely, the L-probe feeding, inverted patch, and slotted patch techniques to meet the design requirement to achieve 30% impedance bandwidth with a high gain of 9.41 dBi.

2 Antenna structure

Fig. 1 depicts the geometry of the proposed patch antenna. The proposed patch with dimension of $0.592\lambda_0 \times 0.358\lambda_0$ (where λ_0 is the guided wavelength of the center operation frequency) integrates both the modified E (means slightly extending the edge of E shape) and H shaped patch on the same radiating element. For the modified E-shaped, the slots are embedded in

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parallel on the radiating edge of the patch symmetrically with respect to the centerline (x-axis) of the patch and for the H-shaped the slots are embedded in serial on the non-radiating edge of the patch. The modified E and H shaped slots on the patch are shown in Fig. 1 (a), where, l and w are the length and width of the slots. The patch is fed by an L-shaped probe with height, h_P and horizontal length, l_P along the centerline (x-axis) at a distance f_P from the edge of the patch as shown in Fig. 1 (b). The optimized design parameters obtained for the proposed patch antenna are $W = 86$ mm, $L = 52$ mm, $w_1 = 10$ mm, $l_1 = 1$ mm, $w_2 = 21$ mm, $l_2 = 41$ mm, $w_e = 6$ mm, $h_o = 16$ mm, $h_1 = 1.5748$ mm, $h_p = 14$ mm, $f_p = 16.5$ mm, $\epsilon_{r1} = 2.2$, $l_p = 24$ mm. An aluminum plate with dimensions of $1.378\lambda_0 \times 1.23\lambda_0$ and thickness of 1 mm is used as the ground plane. The proposed antenna is designed to operate at 1.76 GHz to 2.38 GHz region. The use of L-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 reduce the size of the patch. The use of superstrate on the other hand would also provide the necessary protections for the patch from the environmental effects. By incorporating modified E-

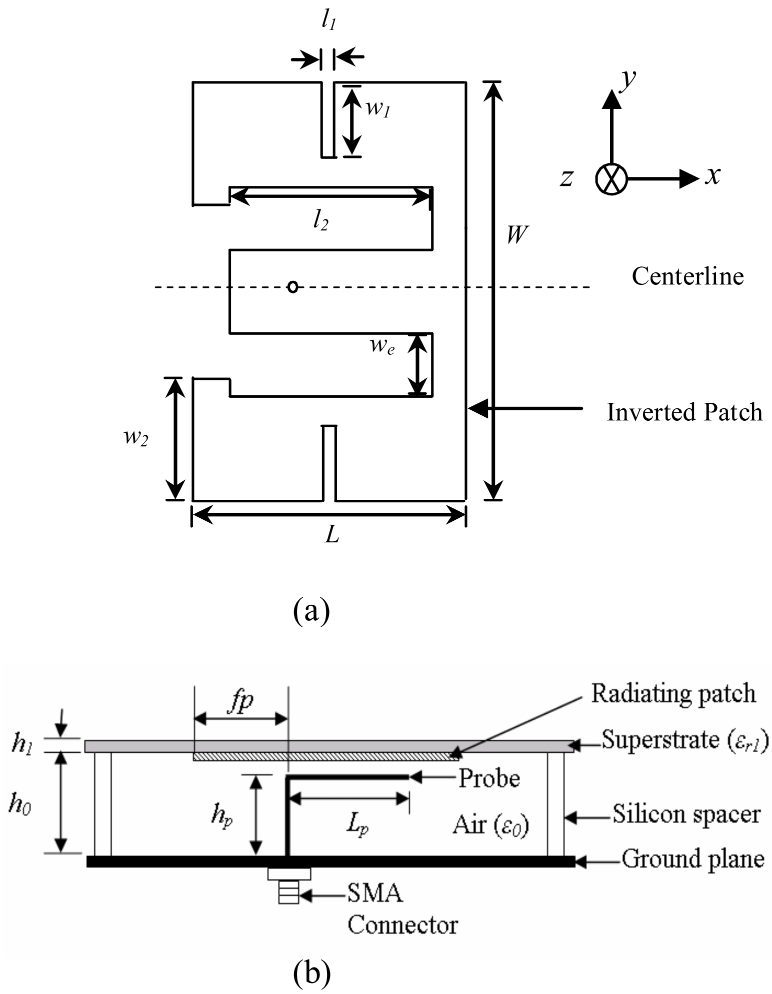

Fig. 1. Geometry of the proposed patch antenna. (a) Top view and (b) Side view.

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shape in radiating edges, the bandwidth has been improved. In addition, the antenna has wider impedance bandwidth in comparison with the rectangular loop antenna described in [10]. The proposed radiating patch comprises slots symmetrically surrounding near the excitation probe and defining a capacitive load for compensating an inductance of the excitation long probe so as to obtain good impedance bandwidth. The presences of slots also restrict the patch currents, at its resonance frequencies that provide lower return loss.

3 Experimental results

The resonant properties of the proposed antenna have been predicted and optimized using of a commercial software package HFSS^{TM}. It is measured by an Agilent 8753ES network analyzer and the dimension anechoic chamber is 5 m × 5 m × 5 m. Fig. 2 (a) shows the simulated and measured results of the return loss of the proposed patch antenna which are in good agreement. The two closely excited resonant frequencies at 1.91 GHz and at 2.21 GHz as shown in the figure gives the measure of the wideband characteristic of the patch antenna. The measured impedance bandwidth of 30% (1.76-2.38 GHz) is achieved at 10 dB return loss (VSWR $\leq$ 2) while the simulated patch gives a slightly lower impedance bandwidth of about 27% (1.78-2.34 GHz). The measured gain of the proposed patch antenna at various frequencies is shown in Fig. 2 (b). As shown in the figure, the maximum achievable gain is 9.41 dBi at the frequency of 2.1 GHz. and the gain is better compare to design reported in [6, 7, 8, 10]. In addition, the design in [6] is based on foam substrate that is more complex than our design which is based on air substrate. Fig. 2 (b) also shows the measured total efficiency of the patch antenna. The figure indicates antenna total efficiency over the operational frequency and it is around an average of 72%.

Fig. 3 shows the measured radiation patterns of the azimuth and the elevation, respectively. The radiation patterns are measured at resonant frequencies of 1.91 GHz and 2.21 GHZ and at the center frequency of 2.07 GHz. As shown in figure, the designed antenna displays good broadband radiation patterns in the azimuth and elevation. It can be seen that 3-dB beamwidth (HPBW) in the azimuth (yz-plane) and elevation (xz-plane) are 63.53° and

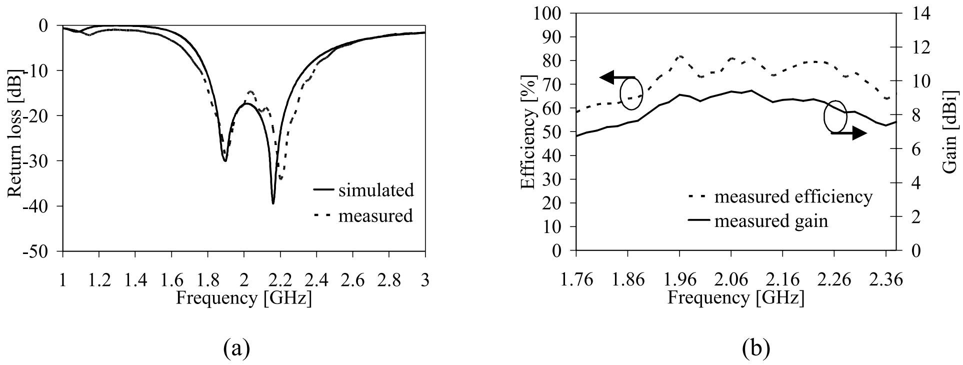

Fig. 2. (a) Return loss and (b) gain and efficiency of the proposed antenna.

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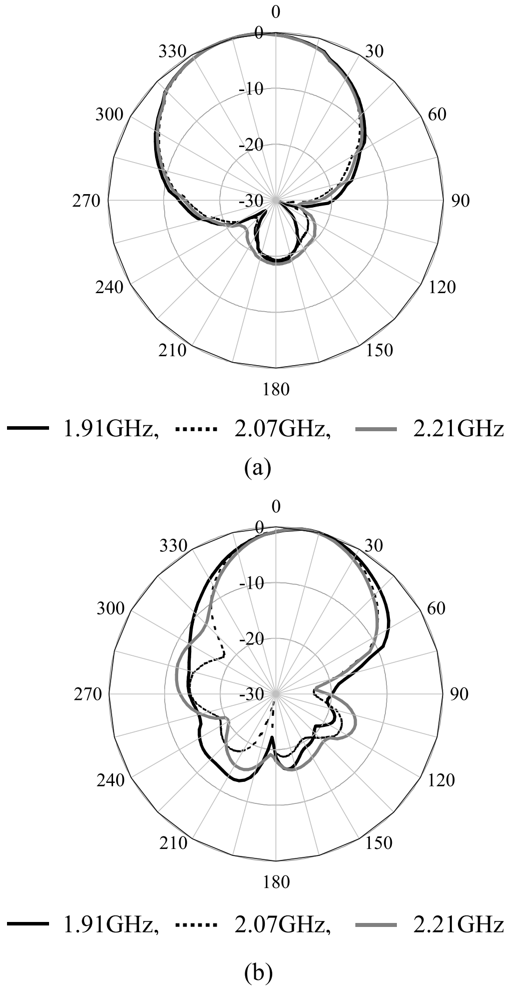

Fig. 3. Measured radiation pattern of the proposed antenna. (a) Azimuth and (b) Elevation.

51.37° at 2.07 GHz, respectively.

4 Conclusion

A new technique for enhancing the bandwidth and gain of a microstrip patch antenna has been developed and implemented successfully. The experimental results demonstrate that it has a wide impedance bandwidth of 30% at 10 dB return loss, covering from 1.76 to 2.38 GHz frequency. The maximum achievable gain of the antenna is 9.41 dBi. Techniques for microstrip broadbanding, size reduction, stable radiation pattern and gain enhancement are applied with significant improvement in this design by employing proposed modified E-H shaped patch design, inverted patch, and L-probe feeding.

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