WIDEBAND MICROSTRIP PATCH ANTENNA WITH REDUCTION OF CROSS POLARIZATION

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Abstract

In the designing the size and bandwidth reduction mechanism improves the performance of a conventional microstrip patch antenna on a relatively thin substrate. The design adopts contemporary techniques L-probe feeding, inverted patch structure with slotted patch and air-filled dielectric. The simulated impedance bandwidth of the proposed antenna is about 23%. The proposed patch has a compact dimension of 0.554λ0 × 0.285 λ0. The design is suitable for array applications with respect to a given frequency of 1.85-2.31 GHz. The composite effect of integrating these techniques and by introducing the slotted patch, offer a low profile, broadband, high gain and compact antenna element.

Keywords:- Microstrip patch antenna, Broadband antenna, Slotted patch antenna, L-probe fed.

I. INTRODUCTION

The design of an efficient wide band small size antenna, for recent wireless applications, is a major challenge.With the ever-increasing need for mobile communication and the emergence of many systems,it is important to design broadband antennas to cover a wide frequency range. 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 feednetworks. However, conventional microstrip patch antenna suffers from very narrow bandwidth,typically about 6% bandwidth with respect to the center frequency. This poses a design challenge for the microstrip antenna designer to meet the broadband techniques.There are numerous and well-known methods to increase the bandwidth of antennas, includingincrease 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.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.

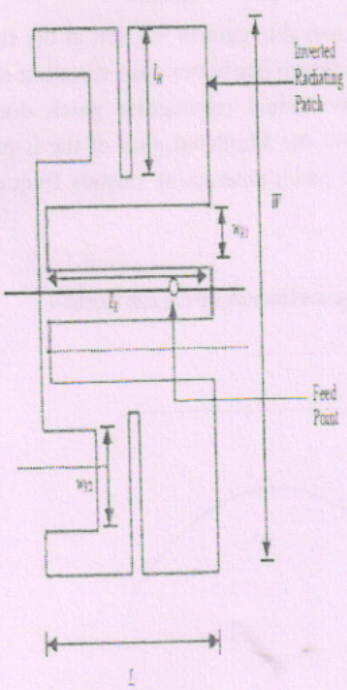
Recently, several techniques have been proposed to enhance the bandwidth. A novel single layer wide-band rectangular patch antenna with achievable impedance bandwidth of greater than 21% has been demonstrated.Utilizing the shorting pins or shorting walls on the unequal arms of a U-shaped patch, U-slot patch, or L-probe feed patch antennas, wideband and dual-band impedance bandwidth have been achieved with electrically small size in.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.A slotted shape patch is investigated for enhancing the impedance bandwidth on a thin substrate.The design employs contemporary techniques namely, the L-probe feeding, inverted patch, and slotted patch techniques to meet the design requirement.In this paper, the design and simulations results of the novel wideband microstrip patch antenna,is described.

II. DESIGN AND STRUCTURE

A patch antenna design that can reduce the probe inductance will enlarge the impedance bandwidth. It is known that increasing the thickness of the patch antenna will increase the impedance bandwidth.However, the thicker the substrate of the antenna, the longer the coaxial probe will be used and, thus,more probe inductance will be introduced,which limits the impedance bandwidth. Figure 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_1 and thickness h_1. 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 E- and H-shaped patch on the same radiating element. For the E-shaped, the slots are embedded in parallel on the radiating edge of the patch symmetrically with respect to the centerline of the patch and for the H-shaped the slots are embedded in serial on the non-radiating edge of the patch. The E- and H-shaped are shown in figure, where, *l* and *w* are the length and width of the slots. The patch is fed by an L-shaped probe with height, *hP* and horizontal length, *lP* along the centerline at a distance *fP* from the edge of the patch as shown in figure. Table shows the optimized design parameters obtained for the proposed patch antenna. A Rogers RT 5880 Duroid™ dielectric substrate with dielectric permittivity, $\varepsilon 1$ of 2.3 and thickness, *h1* of 0.02λ0 has been used in this paper. The thickness of the air-filled substrate, *ho* is 16.6 mm. An Aluminum plate with dimensions of 1.388λ0 × 1.24λ0 and thickness of 1 mm is used as the ground plane. The proposed antenna is designed to operate in the 1.89 GHz to 2.23 GHz region. The use of Lprobe 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 and series 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 extra slots in radiating edges, the gain and cross polarization has been improved.

Figure 1: The L-probe fed proposed patch antenna. (a) Top view and (b) side view.



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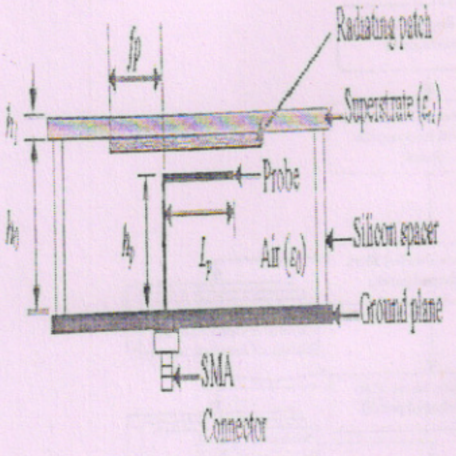


1(b)

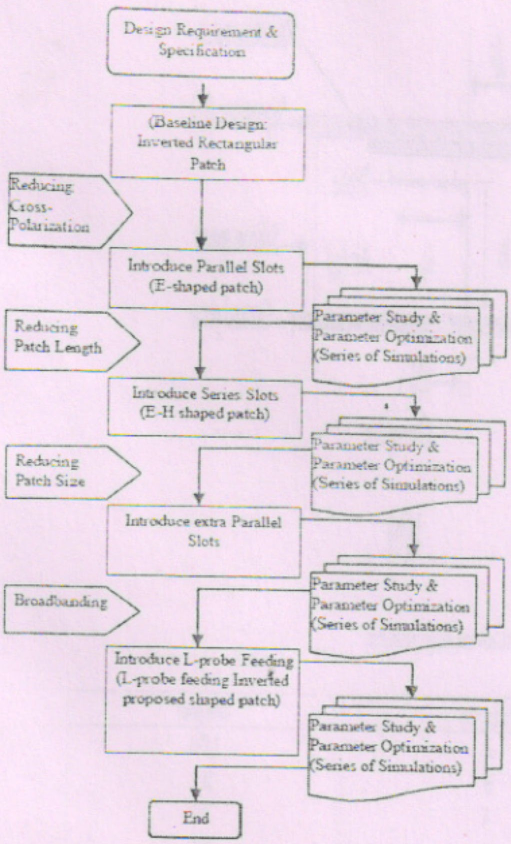
Table 1: Proposed patch antenna design parameter.

Parameters	Value [mm]
h_1	1.5748
H_0	16.5
W	79.0
L	38.0
l_H	18.0
l_{E1}	37.0
w_{E1}	4.0
w_{E2}	11
f_P	7.0
h_p	13.5
l_p	25.0

III. SETUP

The design flow diagram is shown in Figure 2, starting with a baseline design of the inverted rectangular patch with an air-filled dielectric, the baseline parameters are determined at centre frequency, *fo* and dielectric permittivity $\varepsilon 1$. The H- and double E-shaped are then introduced on the patch with the initial values slots parameters to reduce the patch size and crosspolarization level. Next, the L-probe is introduced to feed the patch and its parameters are adjusted to achieve the broadband requirement. The resonant properties of the proposed antenna have been predicted and optimized using a frequency domain three- dimensional full wave electromagnetic field solver.

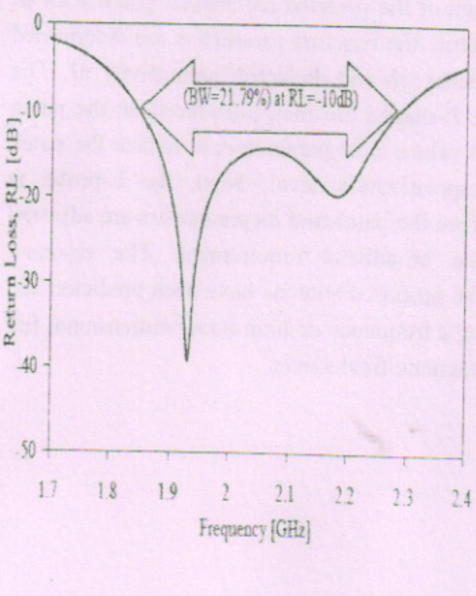
Figure 2: Design flow diagram for the proposed patch antenna



IV. RESULTS

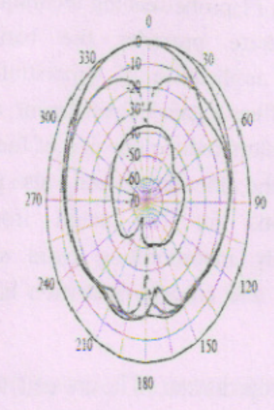
The two closely excited resonant frequencies at 1.94 GHz and at 2.19 GHz as shown in the figure gives the measure of the wideband characteristic of the patch antenna.The simulated impedance bandwidth of 21.80% from 1.85 GHz to 2.30 GHz is achieved at 10 dB return loss.

Figure 3: Simulated return loss of the proposed patch antenna.



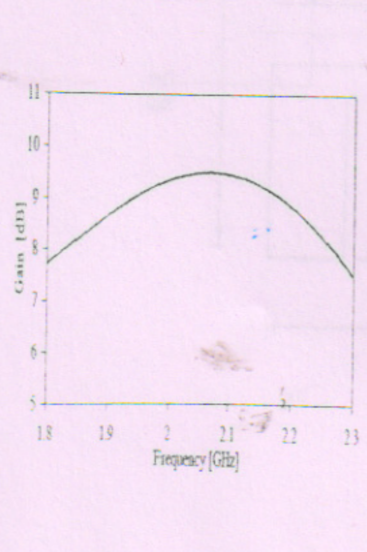
For the sake of brevity, only calculated radiation pattern for second resonance frequency is given in this paper. The simulated radiation patterns at the second resonant frequency in the *xz*-plane and *yz*-plane are plotted in figure and the designed antenna displays good broadside radiation patterns in the *xz*-plane and *yz*-plane at upper resonant frequency. The L-probe inverted proposed patch antenna exhibits better crosspolarization than the design reported in.Notable, the radiation characteristics of the proposed antenna are better to those of the conventional patch antenna.The radiation patterns at other bands, which are similar to those at 1.94 GHz, are not presented here in detail. It can be seen that 3-dB beamwidth of 65° and 50° for xz-plane and yz-plane respectively at 2.19 GHz. The crosspolarization pattern is lower than about -35dB in *xz*-plane.

Figure 4: Radiation pattern of proposed patch antenna at 2.18 GHz for xz-plane and yz-plane.



The maximum achievable gain is 9.6 dBi at the frequency of 2.09GHz. The design has better gain variation of 0.9dBi compared to conventional rectangular patch due to the embedded slots and the simulated gain of the L-probe fed inverted proposed patch antenna at various frequencies is shown in figure.

Figure 5: Simulated gain of proposed patch antennas at different frequencies.



V. CONCLUSION

This technique for enhancing bandwidth of microstrip patch antenna is designed successfully in this research. Simulation results of a wideband microstrip patch antenna covering 1.895 to 2.23 GHz frequency have been presented.The proposed microstrip patch antenna achieves a fractional bandwidth of 21.80% at 10 dB return loss. The maximum achievable gain of the antenna is 9.5 dBi with gain variation of 0.9dB. The proposed patch has a compact dimension of $0.554\lambda 0 \times 0.285\lambda 0$.The wideband characteristic of the antenna is achieved by using the L-shaped probe feeding techniques, the use of series slots and use of another pair of parallel slots lead to the patch size reduction. Better radiation performance is achieved by embedding parallel slots onto the patch while the use of inverted patch improves the gain of the antenna. The composite effect of integrating these techniques offer a low profile, broadband, high gain, and compact antenna element suitable for array applications. Techniques for microstrip broadbanding, size reduction, and crosspolarization reduction are applied with significant improvement in the design by employing proposed slotted patch shaped design, inverted patch, and L-probe feeding.

VI. ACKNOWLEDGMENT

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