Wideband Circularly Polarized Microstrip Patch Antenna for Wireless LAN Applications

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Abstract

A small wideband microstrip patch antenna is introduced. The antenna is designed to function in the 5-6 GHz wireless LAN bands. It achieves multi-band functionality through the addition of a slot to a square patch (21 mm by 21 mm by 2.6 mm). The proposed antenna also generates circular polarization and has a 3 dB axial ratio bandwidth of 2.8%. The impedance bandwidth of the antenna is more than 14% within 2:1 VSWR.

Introduction

Wireless local area network (WLAN) applications are proliferating very rapidly to replace short distance tethered communication links between devices, sensors, and computers [1]-[3]. Such communication link can also be envisioned between wireless power sensors and a central control station for a power distribution system. These sensors will make real-time measurements on a power line and the status of power flow including power-line faults will be communicated to a central station. In the event there is a power failure the sensors will shut down a certain distribution system and reroute power along an alternative route.

To establish a direct line of sight high gain data communication link between a sensor and the central station, we propose a wideband microstrip patch antenna design. Wideband operation of the antenna will allow various sensors operating at specific closely spaced frequency bands to utilize the same radiating structure. Recent examples of research on broadband microstrip patch design can be found in [4]-[5]. The studies presented in [4]-[5] address the bandwidth issue in two ways: L-probe proximity fed annular ring patch and E-shaped patch.

The antenna design proposed in [4]-[5] are on thick substrates which will make it difficult to integrate on miniaturized sensors. We propose a different approach where a much thinner (0.04 λ) slotted microstrip patch antenna has been designed for wideband operation. Recently there has been interest on designing CP antennas for WLAN [6]. Our proposed design is also capable of generating circular polarization (CP) with a 3 dB axial ratio bandwidth of 2.8%. The utility of the circular polarization characteristic of the proposed antenna will be studied in future in the context of practical WLAN communications. Effort is also in place to widen the axial ratio bandwidth and make it comparable to the impedance bandwidth. The wide impedance bandwidth has been achieved by incorporating two rectangular slots as shown in Fig. 1. The slots create two closely spaced (in frequency) hybrid operating modes that result in wide bandwidth.

Antenna Design

The geometry of the proposed antenna is shown in Fig. 1. The antenna parameters are also given in Fig.1. The antenna is mounted on a foam substrate and fed by a coaxial transmission line. Simulations were performed using HFSS. Convergence was tested for each case separately in terms of evaluating S11 (dB) at a single frequency for a number of times. Once convergence was obtained, simulations were conducted in order to obtain swept frequency response extending from 5 to 6 GHz. The swept response gave us the S11, which was used to calculate the VSWR referred to a 50 Ω transmission line. After that radiation pattern was computed.

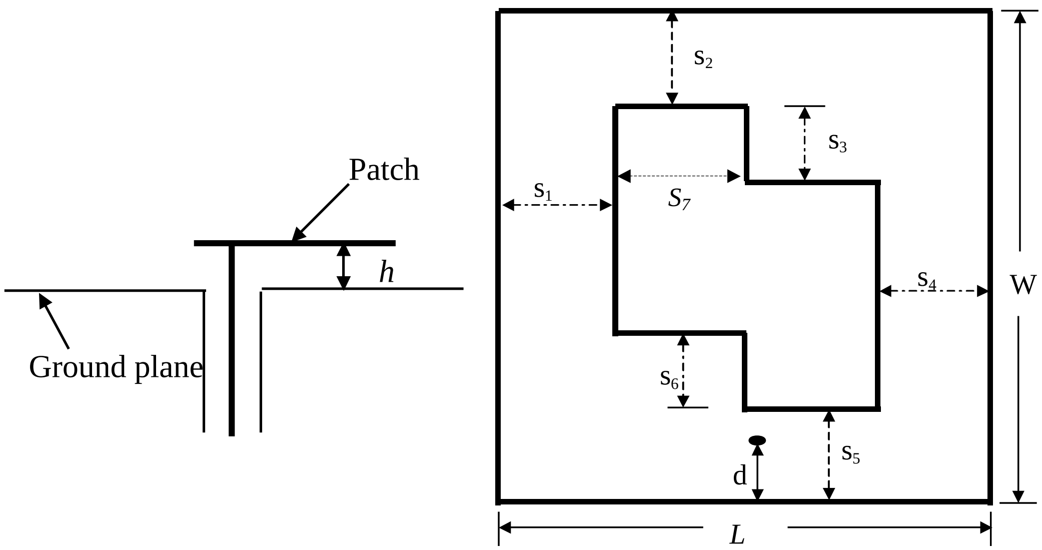


Figure 1: Antenna geometrical configuration. Parameters are: *L=21* mm, *W=21* mm, s_1=*4.5* mm, s_2=*5.5* mm, s_3=*3.5* mm, s_4=*4.5* mm, s_5=*5.5* mm, *d=3.5* mm, s_6=*3* mm, s_7=*6.5* mm, *h=2.5* mm, ε_r=1.0.

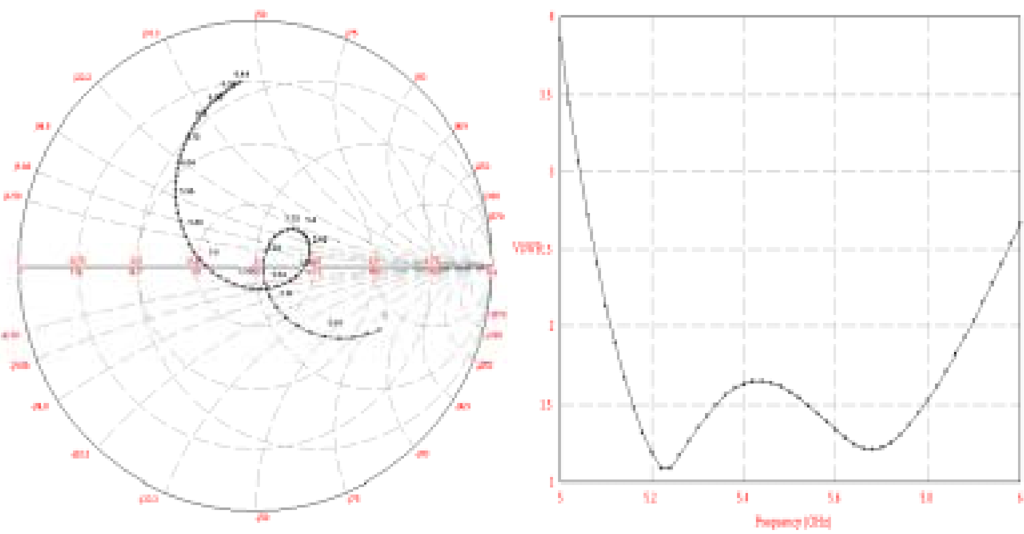
Results

Initially we started with slots symmetrically positioned at the center of the patch. In that case $s_1=s_4$, $s_2=s_5$ and the slot lengths and widths were the same. However, it was observed that in order to achieve proper impedance bandwidth slot position and dimensions need to be adjusted accordingly. This resulted in the geometry given in Fig. 1.

Computed input impedance data for the proposed antenna have been plotted on the Smith chart in Fig. 2 a. Wideband impedance characteristics is apparent from the tight knot in the impedance locus. Corresponding VSWR data are shown plotted in Fig. 2b. The antenna bandwidth extends from 5120-5900

MHz or 14% within 2:1 VSWR. Thus the antenna can clearly support the IEEE 802.11a WLAN bands at 5.15-5.35 GHz and 5.725-5.825 GHz.

Computed current distribution of the proposed antenna is shown in Fig. 3. Clearly currents are concentrated at the edges of the slots. The two slots create unequal lengths for two separate current paths. These current paths correspond to two hybrid operating modes which result in wideband characteristics. Computed radiation pattern data at 5.3 GHz are shown in Fig. 4a. The left-hand circularly polarized component is the dominant component here. The cross-polarization component is below about 9 dB. The peak gain is about 9 dBiC. Corresponding axial ratio data are plotted in Fig. 4b as function of frequency. Axial ratio data are computed at boresight. Note that the 3 dB axial ratio bandwidth is about 2.8%.



(a) (b)

Figure 2: Computed (a) input impedance and (b) VSWR versus frequency.

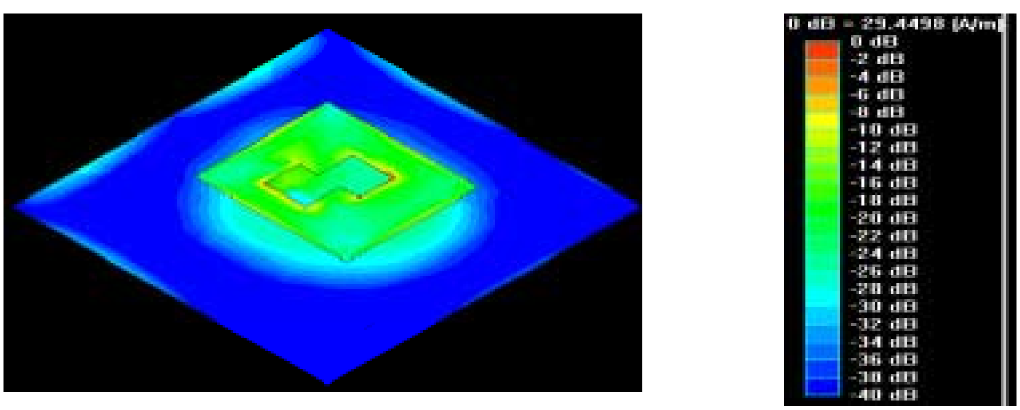
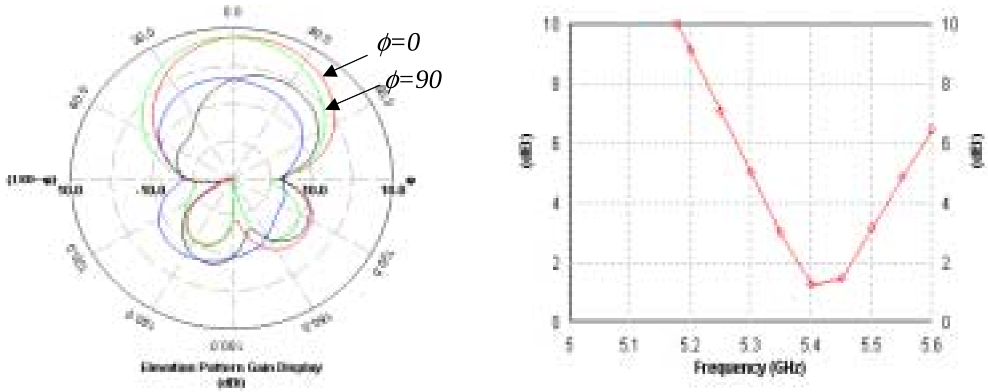
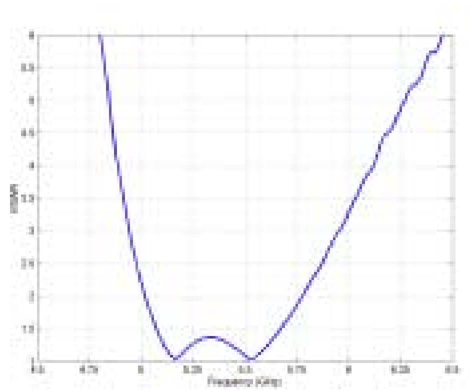


Figure 3: Computed current distribution.



(a) (b)

Figure 4: Computed (a) radiation pattern and (b) axial ratio.



A prototype antenna was fabricated. Measured VSWR frequency response is shown in Fig. 5. It is apparent that the antenna bandwidth extends from 5 to 5.75 GHz within 2:1 VSWR. This data is close to the computed data [Fig. 2a]. The experimental frequency is slightly shifted toward the lower frequency, which will be further tuned.

Figure 5: Measured VSWR versus frequency data of proposed antenna.

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