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Dual-Frequency Planar Inverted F-L-Antenna (PIFLA) for WLAN and Short Range Communication Systems

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Abstract

The design and analysis is presented of a low profile and dualfrequency inverted L-F antenna for WLAN and short range wireless communications, providing a compromise between size reduction and attainable bandwidth. The optimum (minimized) volume of 30 30 8 mm of the proposed antenna gives 8% bandwidth at lower resonant mode of 2400 MHz, while at the higher resonant mode of 5500 MHz a bandwidth of 12.2% is obtained. Both the simulated and measured characteristics of the proposed antenna are shown.

Keywords

Dual-frequency antenna, inverted L-F antenna, short range wireless communication, WLAN.

Disciplines

Computer Engineering | Computer Sciences

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***Abstract*—The design and analysis is presented of a low profile and dual-frequency inverted L-F antenna for WLAN and short range wireless communications, providing a compromise between size reduction and attainable bandwidth. The optimum (minimized) volume of 30 × 30 × 8 mm of the proposed antenna gives 8% bandwidth at lower resonant mode of 2400 MHz, while at the higher resonant mode of 5500 MHz a bandwidth of 12.2% is obtained. Both the simulated and measured characteristics of the proposed antenna are shown.**

***Index Terms*—Dual-frequency antenna, inverted L-F antenna, short range wireless communication, WLAN.**

I. Introduction

With the rapid growth of wireless LAN applications, there is a concomitant demand for low cost and small sized antenna designs for commercial markets. Due to its low profile and ability to cover the existing wireless communication frequency bands, the planar inverted F-antenna (PIFA) has been widely adopted in portable wireless units [1]–[6]. Due to the limited space available on the printed circuit board (PCB) of a wireless device, antenna miniaturization is crucial to keep the size of this type of antenna small and appropriate for portable wireless units, without degradation of performance in terms of bandwidth and radiation patterns. Studies of ground plane effects [7] and bandwidth enhancement methods [8], [9] of such antennas have been reported.

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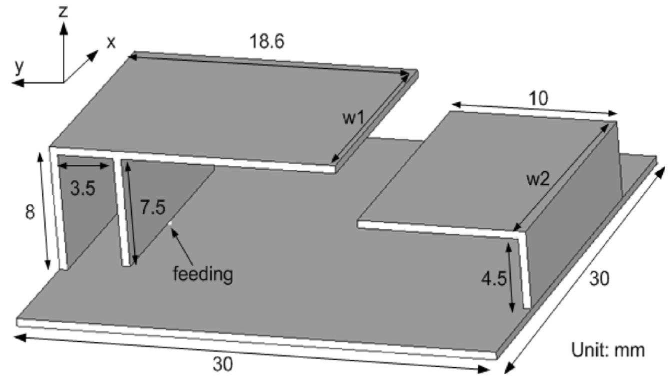


Fig. 1. Geometry of the proposed F-L antenna.

By adapting the research outcomes of authors [7]–[10], this paper presents a new dual-frequency (2.5/5.5 GHz) compact planar inverted F-L-shaped antenna with overall size of 30 mm × 15 mm × 8 mm, mounted on a 30 mm × 30 mm finite ground plane. The target frequencies were chosen to cover IEEE802.11x and systems such as Bluetooth and ZigBee.

II. Antenna Design

Fig. 1 depicts the geometry of the proposed antenna, the maximum dimension being about a quarter-wavelength at the centre frequency for IEEE 802.11b/g and Bluetooth (2450 MHz): the maximum height of the antenna from the finite ground plane is about 7% of the free space operating wavelength and the thickness of the copper conductors is 0.5 mm. A modified planar inverted F radiating element is adopted, having a rectangular plate feed element because of its attractive enhanced bandwidth characteristics [8].

The object of the proposed design is to implement multiple radiating elements, i.e., inverted F and L, each of them supporting strong currents and radiation at the two resonances. The inverted F antenna is designed to operate at fundamental resonant frequency, while the inverted L antenna is introduced to operate at the desired upper operating frequency. Due to the strong coupling between the two radiating elements, simple design formulas cannot be found, and so two EM simulators (CST [11] and IE3D [12]) were used to perform the analysis and achieve the optimum performance of the proposed antenna. It should be noted that the ground plane size of the antenna was chosen to fit in the limited space available in most wireless transceiver circuit board and casings for portable devices.

As can be seen from Fig. 1, there are two variable parameters, w1 and w2. To assess the influence of these parameters on the impedance bandwidth, a parametric study was carried out by varying each parameter sequentially, while holding the remaining parameter values at their initial values (arbitrarily chosen to be well within the desired envelope): these values for w1 and w2 were 10 mm and 17 mm respectively. The results (using CST) are shown in Fig. 2(a) and (b), from which the optimum values of w1 and w2 were found to be 15 mm and 11 mm

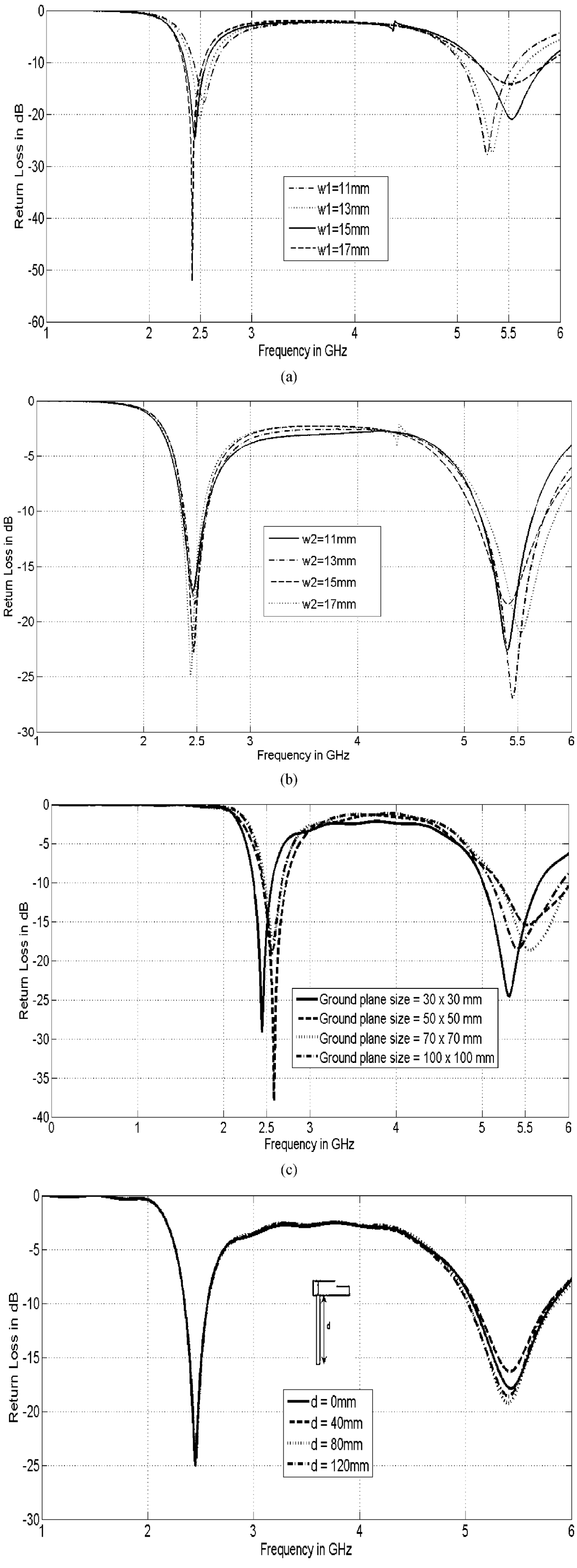


Fig. 2. Simulated return losses with variation of parameters: (a) $\mathbf{w1}$; (b) $\mathbf{w2}$; (c) ground plane size; (d) coaxial length $\mathbf{d}$.

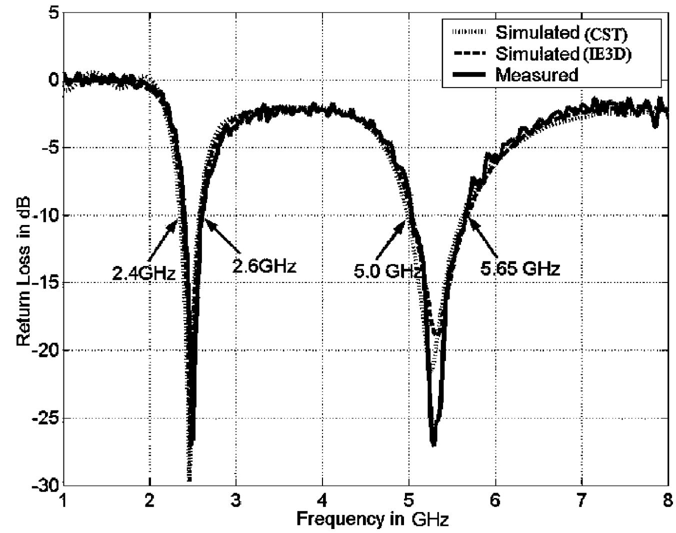


Fig. 3. Measured and simulated return losses.

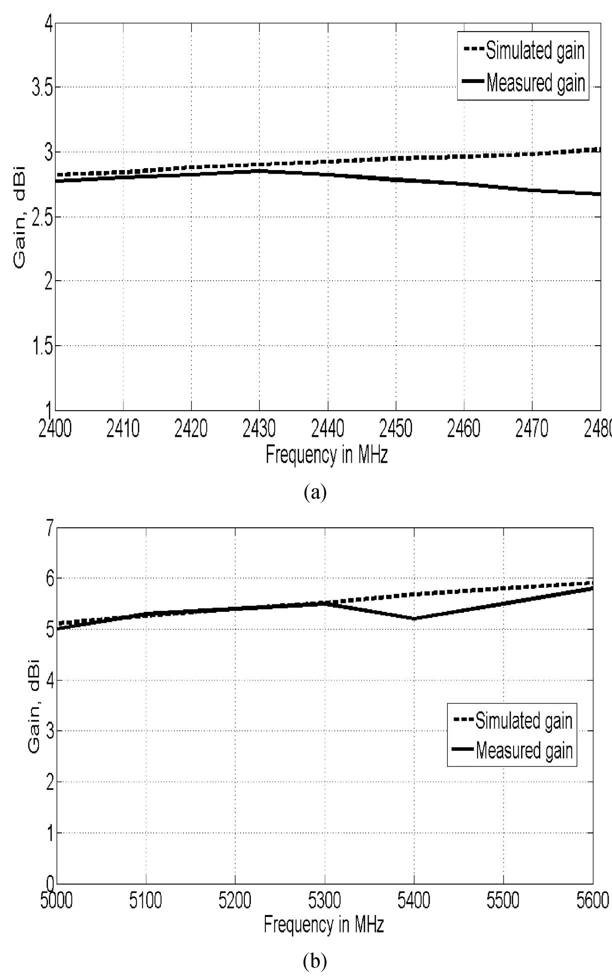
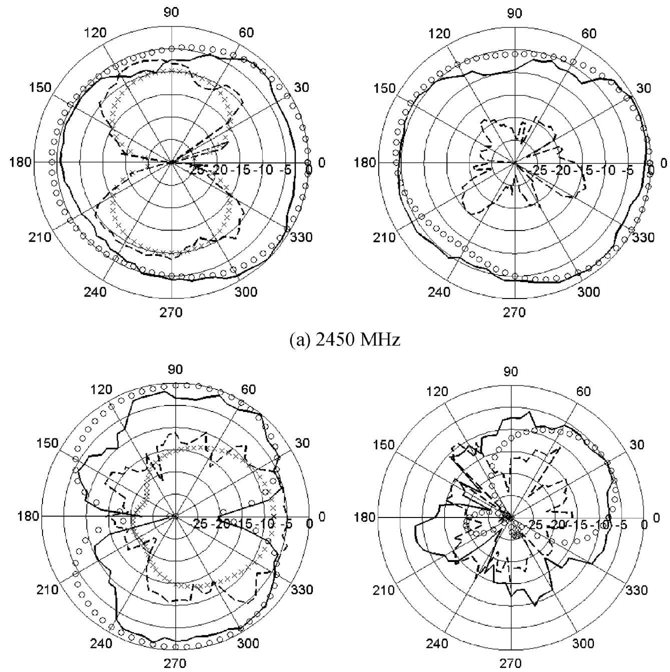


Fig. 4. Measured gains for proposed antenna: (a) upper band; (b) lower band.

respectively, for the best performance of the proposed antenna at resonant frequencies of 2450 MHz and 5200 MHz. Moreover, in order to understand the effect of the ground plane of the proposed antenna, simulations were conducted to check the variations of the return loss against the size of the ground plane. From Fig. 2(c), it is seen that increased ground plane sizes, from 50 mm to 100 mm, do not contribute any significant bandwidth enhancement. Conversely, the larger ground planes make the antenna inconvenient for personal devices and move



(a) 2450 MHz

(b) 5200 MHz

Fig. 5. Simulated and measured normalized radiation patterns of the proposed antenna for two planes (left: $\mathbf{x}$-$\mathbf{z}$ plane, right: $\mathbf{y}$-$\mathbf{z}$ plane) at (a) 2450 MHz and (b) 5200 MHz. "xxxx" simulated cross-polarization, "oooo" simulated co-polarization, "------" measured cross-polarization, " ——" measured co-polarization.

it away from its desired operating frequencies. According to [13], this is because the ground plane resonates at the operating frequency of the antenna element, so the bandwidth of the antenna-chassis combination will improve considerably. On the contrary, if the ground plane resonates far away from the operating frequency, the bandwidth will be decreased due to the insignificant contribution of the ground plane.

Next, a coaxial cable was connected to the antenna and the change of the return loss investigated when the length of the cable (d) was varied from 0 to 120 mm. As seen in Fig. 2(d), all the return loss curves for various coaxial lengths are approximately identical, and this confirms the configuration of the selected ground and unbalanced feed to this particular antenna design.

III. Results and Discussion

A physical realization of the proposed antenna was tested with an HP8720B network analyzer, and the computed return loss was predicted by using two commercial packages (CST [11] and IE3D [12]). Fig. 3 illustrates the computed and measured return loss of the proposed antenna: here it can be clearly seen that two resonant modes of the proposed antenna are observed at 2.5 GHz and 5.3 GHz. The lower mode provides 8% relative bandwidth from 2400–2600 MHz at a minimum return loss of -10 dB or less, completely encompassing the desired IEEE802.11b/g, Bluetooth and ZigBee frequency band (2400–2485 MHz). The upper mode around 5.3 GHz fully covers the IEEE 802.11a (5.15–5.35 GHz) band. As can be observed, simulated and measured results were found to be in excellent agreement.

Fig. 4(a) and (b) shows the simulated and measured gain of the designed antenna in the broadside direction over the frequency ranges from 2400–2480 MHz and 5000–5600 MHz, respectively. At the lower band, a stable measured gain can be observed from 2.6–2.8 dBi. For the upper band, the range of the measured gain varies from about 5.0–5.8 dBi. The overall gain variations are less than 0.8 dBi. Both simulated and measured gains are indistinguishable.

Fig. 5(a) and (b) describes the simulated and measured normalized radiation patterns of both co-polarization and cross-polarization in the x-z and y-z planes at 2450 MHz and 5200 MHz for the proposed antenna. The simulated and measured radiation patterns are seen to be in good agreement.

IV. Conclusion

A dual-frequency planar inverted F-L antenna has been proposed and studied experimentally and theoretically. By balancing the size and bandwidth constraints, the proposed antenna has a compact envelope dimension of 30 mm × 30 mm × 8 mm and covers the required operating frequency band for the IEEE 802.11a/b/g, Bluetooth and ZigBee standards. These features make the proposed antenna an attractive candidate for application in a range of mobile terminals.

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