MINIATURIZATION OF DUAL-BAND MEANDER LINE ANTENNAS FOR WLAN

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ABSTRACT—In this paper, two meander line antennas (MLAs) have been presented, both the antennas are formed by combining two meander strips. The proposed antennas are fed by a transmission line, situated on the same plane as the radiating meander patch while a ground plane is located on the opposite side of the radiating patch and transmission line. The designed antennas have been studied to observe the effects of radiating patch size, transmission line size and ground plane size on the input impedance. Both the antennas have been designed for dual-band operation, the first antenna is resonant on two frequency bands, IEEE 802.11 a/b (2.41-2.49 and 5.15-5.35) GHz. The return loss result of the second antenna confirms its resonances from 2.41-2.49 GHz and 5.46-5.9 GHz.

Keywords*—meander line antenna; low profile; bandwidth; dual band antenna; WLAN*

1. INTRODUCTION

In recent years, the emergence of wireless local area networks (WLAN) has replaced the tangled wires running through the work and leisure environments. The WLAN has been assigned the frequencies at the designated 2.4-2.8 GHz and 5 GHz bands. It is desirable to develop a lightweight antenna that has a compact size, wide bandwidth and significant gain at the transmission frequencies. The antenna designs have been significantly improved over the past few years to match these requirements. However, antenna engineers have to compromise the performance at the expense of size miniaturization. Small antennas are prone to the cable effects and size of ground plane. Moreover, their dimensions should be proportionate to the operating wavelength.

Several techniques have been proposed to realize the different forms of meander line antenna. By virtue of its design, meander line antennas can reduce the antenna size while maintaining the bandwidth requirements. A simple technique such as an extension of a conductor line, stretched along a rectangular monopole antenna has realized the dual frequency operation at 900 and 1800 MHz Bands [1]. A multiband (AMPS 800, GSM 900 and GSM 1900) internal antenna has been introduced in [2]. The antenna consists of a driven meander line element and two parasitic elements. In the literature, a vast number of antennas have been proposed which are comprised of meander slot. A folded meander line slot antenna has been proposed in [3]. In this antenna, for the improvement of impedance match, a short circuit near the feed location has been introduced. An antenna geometry with a modified meander slot in the ground plane and a microstrip feeding line were proposed in [4]. The U-shaped conductor line was connected between the ground plane and feeding line to suppress the harmonics. Another meander slot antenna with parallel plate mode suppression has been proposed with plated-through-holes. Here, the leakage of the electromagnetic modes into the substrate has been reduced through the via fences that are located around the meandered slot line [5]. A two branched, triple band internal antenna, operating at PCS, IMT2000, and Bluetooth has been proposed in [6]. In this antenna, tuning has been performed on the radiating patch and size of each strip line section to enhance the bandwidth. The non-uniform, folded, meander line antenna has been proposed for 2.4 GHz and 5 GHz bands [7]. Two different sized S-shaped, parallel placed meander lines have been introduced for multiband operation in [8]. A modified multiband meander line antenna for GPS, DCS, PCS, UMTS and WiBro bands has been proposed in [9] for broadband operation. The meander line feeding has been suggested for the whip antenna and coupled with a stub for the improvement of the bandwidth [10]. A multiband antenna for several wireless technologies such as DVB-H/DCS1800/PCS1900/IMT2000/Wibro/WLAN/S-DMB has been introduced in [11].

In this paper, the design of a conventional meander line antenna has been modified by placing the two meander elements together and are joined by a strip. Moreover, a study has been carried out to study the effects of various parameters such as patch size, transmission line feed size and ground plane size on the impedance bandwidth. The two antennas have been designed to cover the 2.45 GHz and 5 GHz bands of the WLAN. The performance of the proposed antennas has been optimized using commercial full-wave simulation software CST Microwave Studio (MWS). Moreover, the simulated return loss results have been validated through the measurements.

2. PROPOSED ANTENNA DESIGNS

The dimensions of the modified MLAs have been presented in this section. The first antenna design has been shown in Fig. 1. The overall dimensions of this antenna are 38 × 18 mm^2, and it has a thickness of 1.6 mm. The second antenna design has the same thickness as the first antenna while its overall dimensions are different from the first antenna design. The dimensions of the second antenna design are 40 × 20 mm2. The feeding mechanism in both proposed antenna designs has been achieved through the 50 Ω transmission line. Although, the two models looks similar, however, there are few differences in their design aspects. The first antenna design has the larger patch size than the second antenna. The second antenna design has the narrower, but longer transmission line width and it also possess an increased ground plane. The modification of the parameters of the second antenna has resulted in better impedance matching at the desired frequency bands.

The meander antenna has been derived from the basic folded antenna. As an extension, the folded elements are included in many linear patterns. Owing to the meander geometry, much lower resonant frequencies are produced than the resonances generated by a single-element antenna having similar dimensions. In meander antennas, the size reduction factor β is related to few aspects. The β is dependent on the

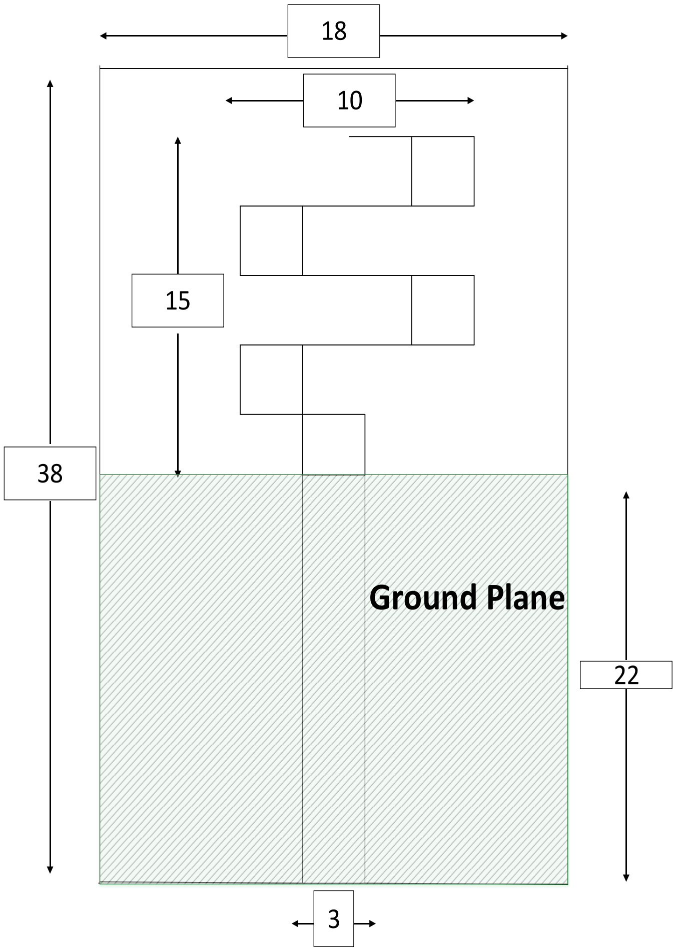


Fig. 1. Dimensions of the first antenna design.

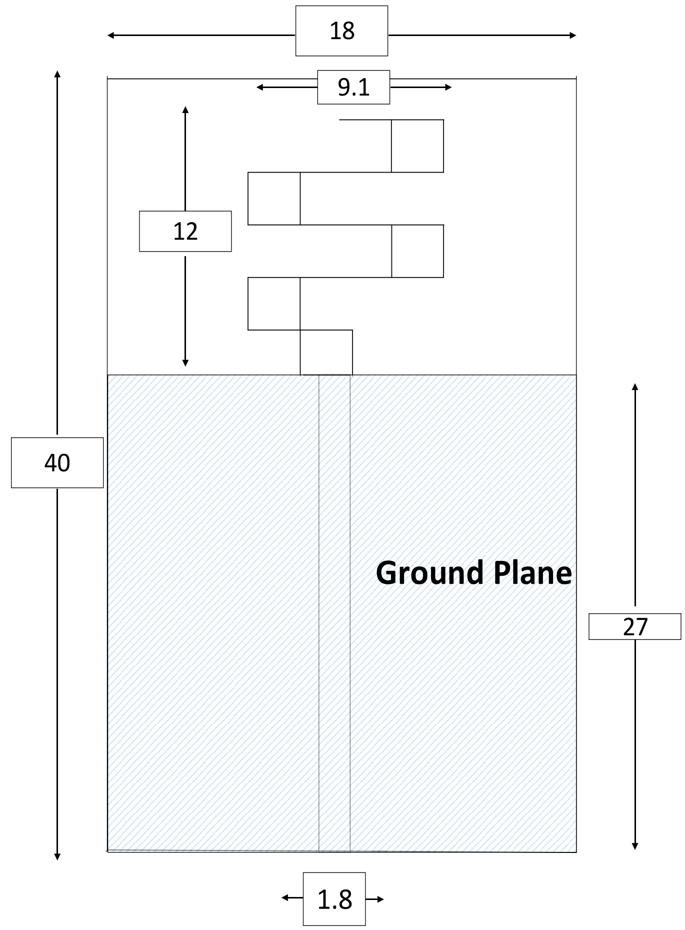


Fig. 2. Dimensions of the second antenna design.

The relationship to relate the size reduction factor β with the meander antenna length l and monopole antenna of length L is given as $\beta = {}^{l}/_{L}$.

In comparison to the monopole that has the same length, higher frequency resonances may occur in the meander antenna. This is due to the cancellation and reinforcement of the various currents. In meander antennas, the tuning of the lower frequencies is often easier because of the low voltage Standing wave ratio (VSWR) at, the lower resonances. Therefore, it is possible to tune these frequencies using the same tuning elements. The advantage is, over a given frequency range, fewer tuning element are required for tuning the frequencies.

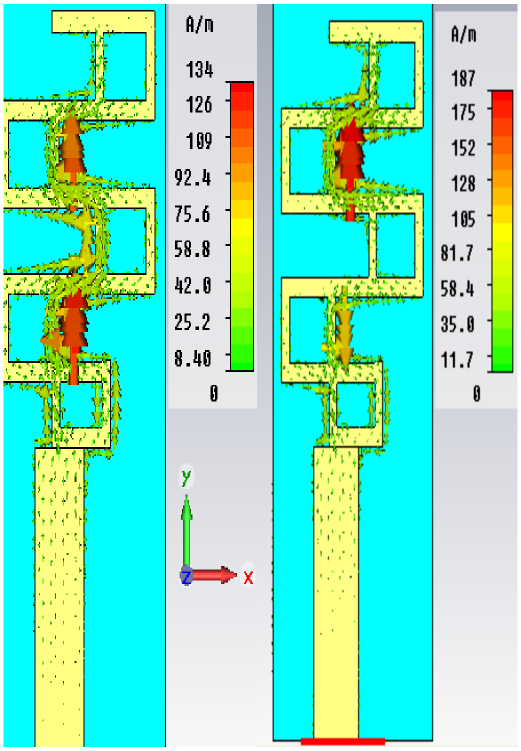
The multiband behavior of the modified MLA has been linked with the surface current distribution on the antenna segments. In case of MLA, the radiation from an antenna at any specific frequency band is due to the current distribution on the antenna segments. Fig. 3 shows the simulated current distribution on the surface of MLA. From the inspection of Fig. 3(a), it could be noticed that the current concentration on upper and lower vertical sections are responsible for radiation at the lower frequency of operation, i.e., 2.45 GHz. The position of these segments is in the middle of the modified MLA structure. However, at 5 GHz band, the lower spatialcurrent distribution on MLA suggests that the current distribution is mainly concentrated in the middle of the MLA upper region.

During the simulations, the current distribution on the ground plane was also studied along with the study of current distribution on the various sections of the modified MLA. A shift in the resonant frequencies has been noticed due to the change in ground plane size. This change in resonant frequencies is because, in small antennas, the ground plane plays a major part in radiation.

3. RESULTS

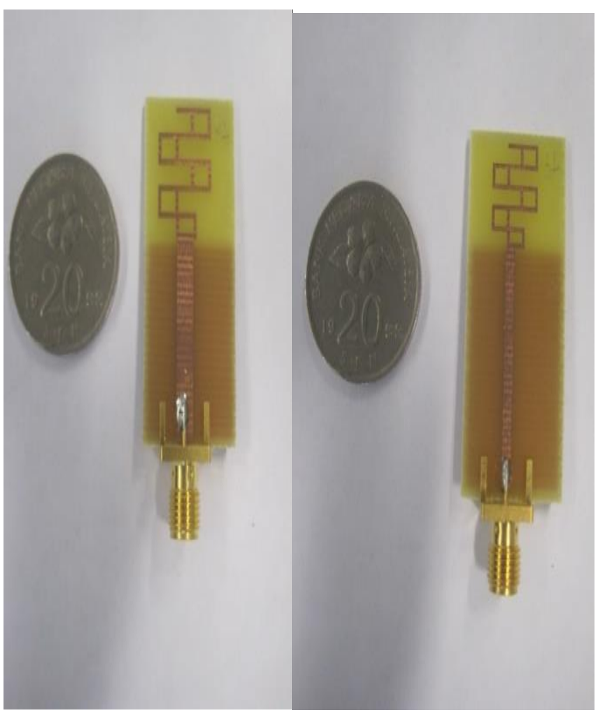
In this section, the comparison of the simulated and measured return loss of the two proposed antennas have been presented. The Fabricated prototypes of the first and second antennas have been illustrated in Fig. 4 (a) and Fig. 4(b), respectively. The first antenna has been designed to operate on the 2.45 GHz band and the lower region of the 5 GHz band. Fig. 5 depicts the comparison between the simulated and measured return loss results of the first antenna. In this plot, an acceptable agreement can be seen between the simulated and measured results.

Fig. 6 presents the comparison of return loss plots of the second antenna. This antenna has been designed to operate on frequency bands of 2.45 GHz and 5.8 GHz. The discrepancy can be noticed between the simulated and measured results. This disagreement is mainly due to the imperfections and tolerances of the fabrication process and soldering of the connector to the antenna structure.



(a) (b)

Fig. 3. Surface current distribution on MLA at (a) 2.45 GHz; (b) 5 GHz.



(a) (b)

Fig. 4. Fabricated prototypes of the presented antennas (a) first antenna; (b)Second antenna.

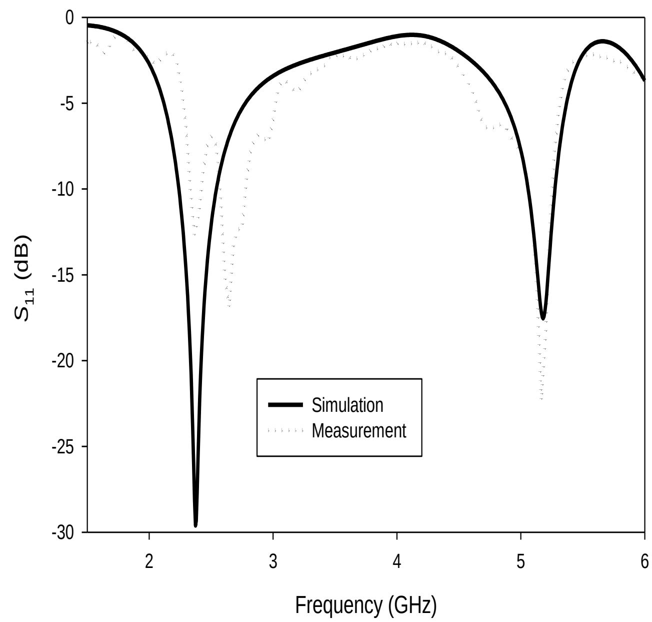


Fig. 5. Simulated and measurement results of first antenna design.

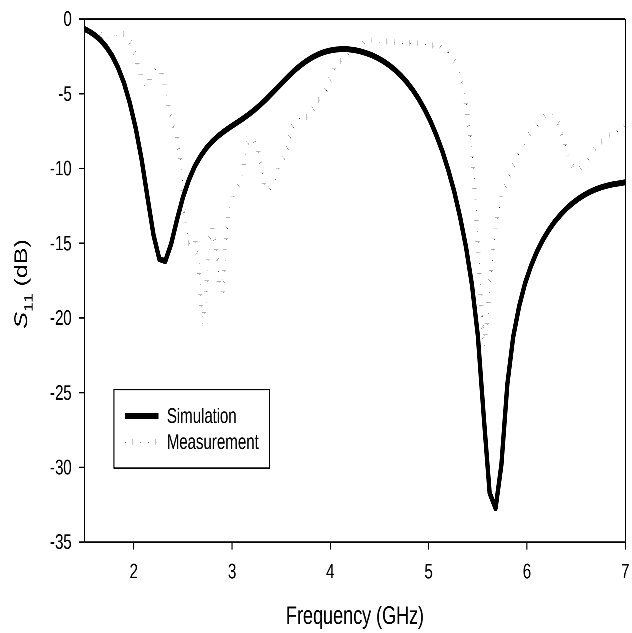


Fig. 6. Simulated and measurement results of the second antenna design.

4. CONCLUSION

In this paper, two modified meander line antennas have been proposed. The modification of the shape has been achieved by unifying the two MLA elements, placed parallel to each another and joined by a strip line. This altered geometry helped in better input impedance matching with the MLA elements and consequently achieving the dual band operation. Moreover, the proposed, two antenna designs have different dimensions. The first antenna design has a larger meandering patch than the second antenna design whereas the ground plane size and width of transmission line have been increased in the second antenna. These modifications have achieved the two mode operation of the antennas. From the simulated and measured return loss curves, the first antenna design has the operation from 2.22 GHz–2.52 GHz and 5.04 GHz -5.25 GHz. For the second antenna, the measured return loss curve at -10 dB shows the dual band frequency operation at 2.45 – 3.3 GHz and 5.46 -5.9 GHz.

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