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Multiband Planar Antenna for Long Term Evolution and Wireless Local Area Network Applications

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Abstract: In this paper, a planar antenna for Long Term Evolution (LTE) bands and Wireless Local Area Network (WLAN) is proposed. The antenna is based on a meandered coupled-fed monopole with a distributed inductor, a direct-fed monopole with a chip inductor of 20nH, and a grounded strip connected to the copper plate. These three components form two bands of operations. A multiband of low resonant mode at between 0.717 GHz and 1.0215 GHz and high resonant mode between 2.114 GHz to 2.887 GHz are achieved. The two operating bands satisfy the WMTS 610, UMTS 1700, LTE 1800, LTE 1900, LTE 2100, WLAN 2400, LTE 2600, and WLAN 3600 applications based on the -6 dB for the handset. The proposed antenna having dimensions 75 × 10 × 0.8 mm^3 is suitable for the top edge of a mobile handset and a copper plate of 75 × 100 mm^2 (5 inches screen plate), is used as the ground plane system.

Keywords: Antenna, Long Term Evolution, Multiband, Wireless Local Area Network.

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1. INTRODUCTION

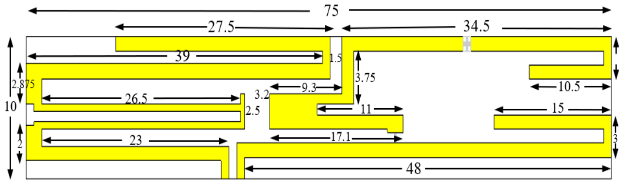
Recently, the popularity of multifunctional [1] portable devices using LTE and WLAN applications has been increasing rapidly. The multiband antennas inside the portable devices must be as small as possible. Although miniaturization of the antennas is highly challenging not just because of the limited space available inside the wireless portable devices but also unable to cover the whole frequency bands, due to narrow bandwidth at the lower frequency band [2]–[7].

Appropriate antenna size or thickness is the key requirement for sufficient bandwidths. Some of them are very difficult to be integrated within mobile devices or portable wireless modules [8]–[11]. Therefore, one of the solutions for the design of a small antenna is by using the meander loop-type antenna [12]–[14]. For multiband applications, a bent or folded monopole is used [15]. Moreover, monopole with a shorted parasitic element helps to produce dual-band [16]. In addition, monopole antennas with small dimensions are appropriate for portable devices; cover multiple bands of frequency for WLAN and LTE applications. Alternative solutions can be either by bending planar inverted-F antennas (PIFAs) [17]–[19] to achieve a small size three-dimensional (3-D) structures or by employing a chip inductor on the metal part of an antenna to get a small antenna size [20], [21]. In addition, a coupled-fed technique can be used to obtain multiband and wider impedance bandwidth for LTE and WLAN applications [12]–[14]. Therefore, the techniques of meander structure together with a chip inductor are proposed to miniaturize the size of the antenna.

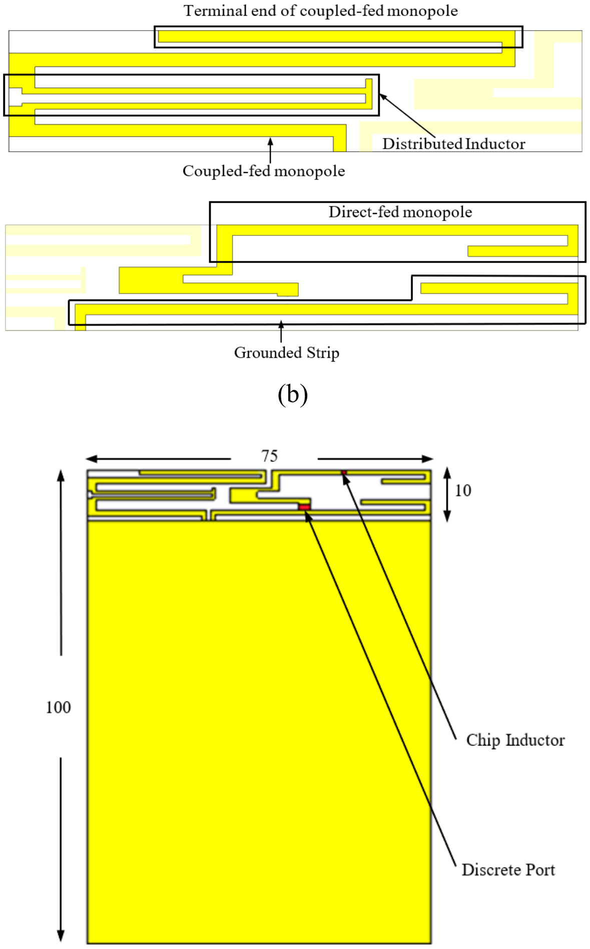
2. ANTENNA DESIGN

The initial antenna design of this work was based on [22]. The components of our antenna consists of a coupled-fed monopole with a distributed inductor, a direct-fed monopole and a grounded strip connected to the ground plane as shown in Figure 1. The ground plane of the proposed antenna was resized to 75 × 100 mm^2 (5 inches) to fit into the mobile phone ground plane. The ground plane length is reduced by 71% from 260 mm to 75 mm, while its width is reduced by 50% from 200 mm to 100 mm. The overall ground plane was reduced by 61.5%. To cover WLAN and LTE band operations, the L-shaped element introduced in [22] was completely removed.

The multiband planar antenna was fabricated on the FR-4 glass epoxy with a height (h) of 0.8 mm, a loss tangent of 0.025, and a relative permittivity (ε_r) of 4.3. A chip inductor of 20 nH is soldered to the direct-fed monopole to achieve the small size planar antenna. The discrete port between the direct-fed monopole and the grounded strip is where the input signal is fed. The proposed antenna complete with components and dimensions is all shown in Figure 1. The antenna design is simulated using CST Simulation software.



(a)



(b)

(c)

Figure 1. (a) Antenna element without ground plane (b) Components of the proposed antenna (c) Proposed antenna with new ground plane size

3. RESULTS AND DISCUSSION

Figure 2 shows the simulation result of the proposed antenna. The distributed inductor is used to control the higher modes of resonant frequencies at 2.11 GHz and 2.887 GHz. As for the grounded strip connected to the system ground can operates in a resonant mode at 0.717 GHz and 2.887 GHz. By adding a coupled-fed monopole and a grounded strip connected to the system ground can contributes a multiband of low resonant mode at between 0.717 GHz and 1.0215 GHz and high resonant mode between 2.114 GHz to 2.887 GHz are achieved for LTE 700, GSM 850, and GSM 900 (low mode), LTE 2100, LTE 2300, WLAN 2400, LTE 2500, and LTE 2600 applications (high mode) respectively. The bandwidth at low frequency band is approximately 0.347 GHz (0.698 GHz - 1.045) while a close to 1 GHz (2.03 GHz – 3.02 GHz) is achieved at a high operating band based on the -6 dB antenna design specification required for mobile handset. The -6 dB S_{11} was considered as it is commonly used as a standard reflection coefficient for mobile phone and compact antennas [23-25]. The low and high operating bands can form a dual-band WLAN and LTE antenna for the mobile handset. Figure 3 shows the prototype of the planar antenna with the new ground plane size for the mobile handset.

The prototype of the planar antenna with the new ground plane size for the mobile handset is shown in Figure 3. A 50 Ω coaxial line feed is connected to the direct-fed monopole and the shielding connected to the grounded strip, which enables RF signal input. The simulated and measured S_{11} result was compared as shown in Figure 4. The measured result has four resonant at 0.6050 GHz, 1.690 GHz, 2.0225 GHz, and 2.2850 GHz with a return loss of -10.4518 dB, -7.7044 dB, -9.7823 dB, and -32.9820 dB respectively. Comparing the two results, the measured result has downshifted to the lower frequency as compared to the simulated result at about 0.607 GHz. The possible reason was that the relative permittivity of the substrate FR-4 used for fabrication may not be at 4.3 but higher than that, which is illustrated from the simulation in Figure 5. However, generally, the trend of the S_{11} is similar to the simulated results. The measured result also shows that the proposed antenna has a low operating band at 0.61 GHz, and two operating bands from 1.67 GHz to 2.8 GHz with the bandwidth measured approximately about 1.13 GHz under -6 dB, and finally, the 3.6 GHz which is suitable for WMTS 610, UMTS 1700, LTE 1800, LTE 1900, LTE 2100, WLAN 2400, LTE 2600 and WLAN 3600 applications.

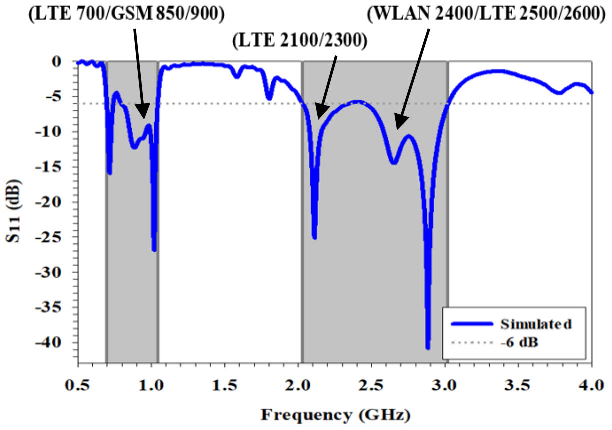


Figure 2. Simulated reflected coefficient S_{11} of the proposed antenna

Figure 3. Fabricated modified planar antenna

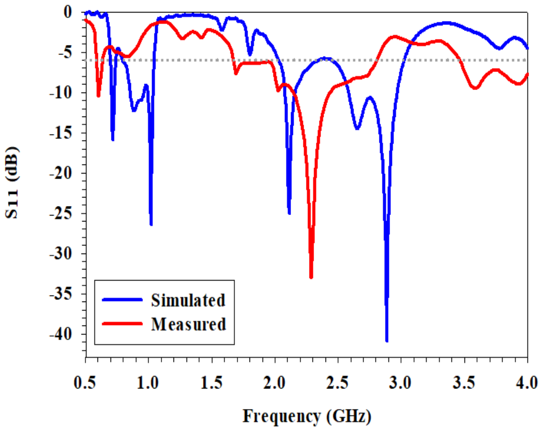


Figure 4. Measured and simulated reflection coefficient (S_{11}) for the proposed antenna

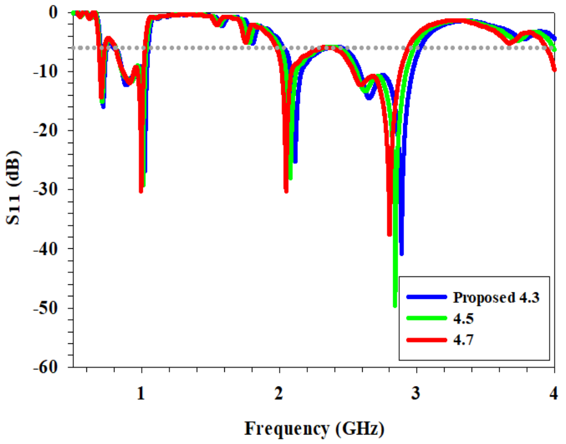
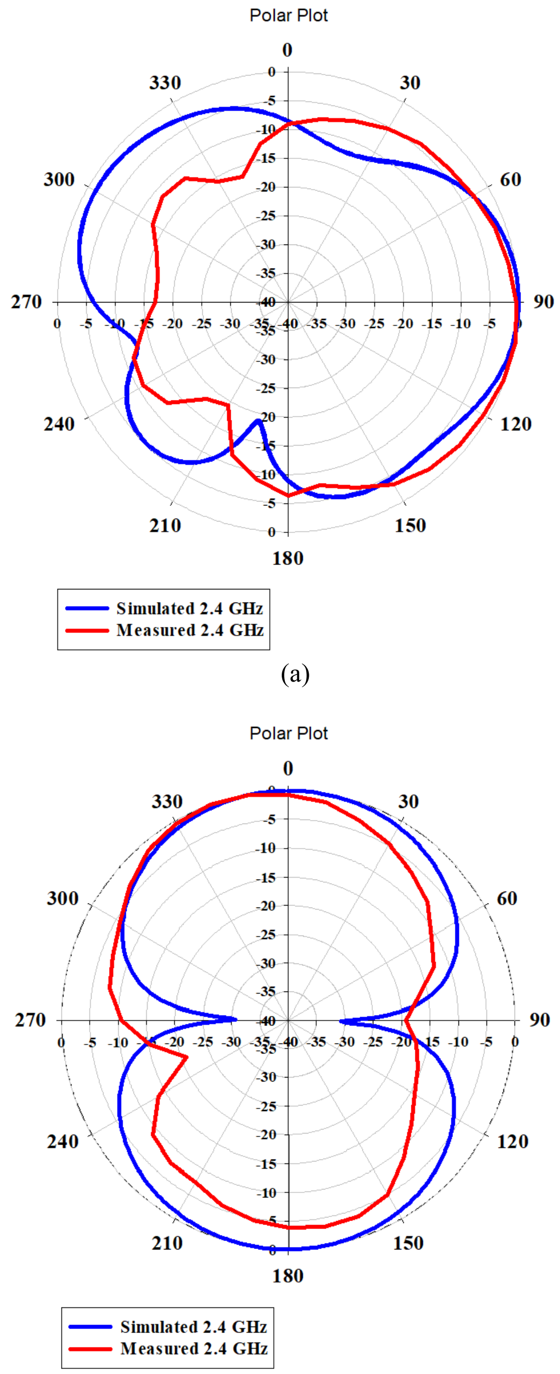


Figure 5. Simulated reflection coefficient (S_{11}) of the proposed antenna using different relative permittivity of the substrate FR-4

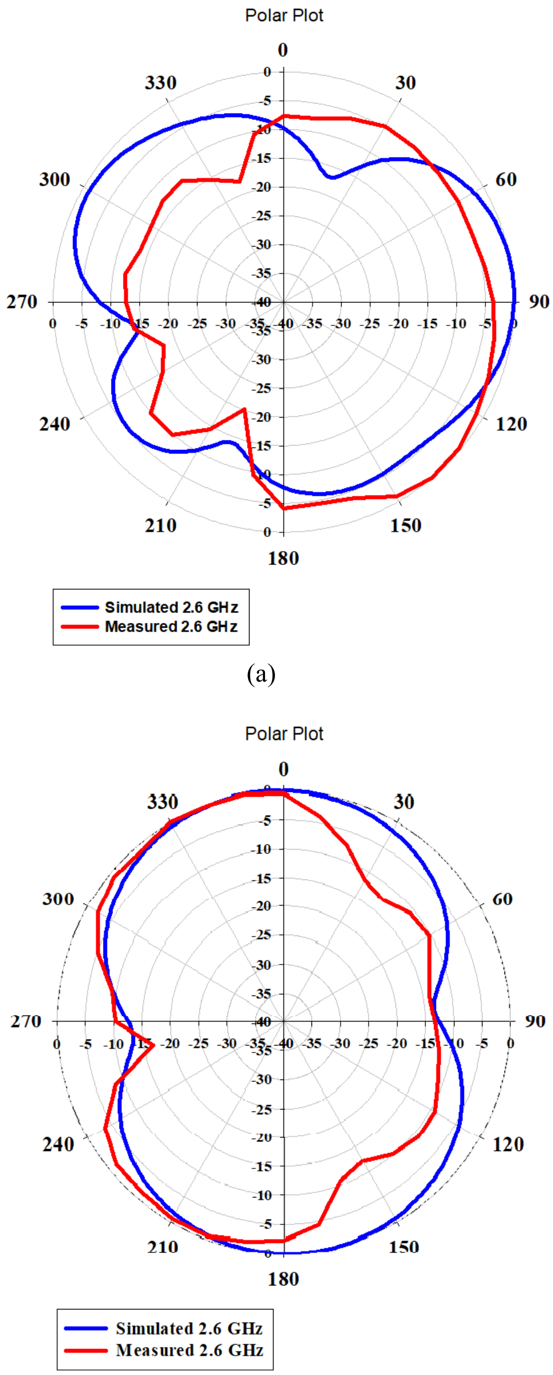
The simulated and measured results of H-plane and E-plane of the proposed antenna were compared at 2.4 GHz (WLAN) and 2.6 GHz (LTE) as shown in Figure 6 – Figure 7. The E-plane patterns show good agreement. However the H-plane patterns show some discrepancies at the back side of the antenna which may due to the some blockage from the pole of the antenna holder. In general, the measured and simulated radiation patterns were in good agreement. During the measurement process, the result was obtained carefully by repeating the rotation of the aerial platform manually which reduced errors. The results show that the planar antenna has a stable radiation pattern and contribute to nearly omni-directional at H-plane and eight-shaped pattern at E-plane.The simulated realized gain values at 2.4 GHz and 2.6 GHz are 2.245 dBi and 2.647 dBi respectively.



(a)

(b)

Figure 6. (a) H-plane at 2.4 GHz
(b) E-plane at 2.4 GHz



(a)

(b)

Figure 7. (a) H-plane at 2.6 GHz
(b) E-plane at 2.6 GHz

4. CONCLUSION

A Multiband Planar Antenna consists of two mechanisms namely direct-fed and coupled-fed have been designed to cover LTE and WLAN bands from 1.67 GHz to 2.8 GHz and 3.6 GHz. The proposed antenna has an area of 75 × 10 mm^2, with an additional chip inductor of 20nH soldered to the direct-fed monopole to achieve a small size. The antenna size is one of the important requirements for sufficient bandwidth applications. The proposed antenna shows a stable radiation pattern in the LTE and WLAN bands and can potentially be used as an internal antenna for the mobile handset.

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REFERENCES

[1] A. Abdalrazik, A. Gomaa and A. A. Kishk, "A Hexaband Quad-Circular-Polarization Slotted Patch Antenna for 5G, GPS, WLAN, LTE, and Radio Navigation Applications," in IEEE Antennas and Wireless Propagation Letters, vol. 20, no. 8, pp. 1438-1442, Aug. 2021

[2] Y. W. Chi, and K. L. Wong, "Quarter-wavelength printed loop antenna with an internal printed matching circuit for GSM/DCS/PCS/UMTS operation in the mobile phone," *IEEE Transactions on Antennas and Propagation*, *57*(9), 2541-2547, Sep. 2009.

[3] C. Sun, "A Design of Low Profile Microstrip Patch Antenna With Bandwidth Enhancement," in *IEEE Access*, vol. 8, pp. 181988-181997, 2020

[4] D. Gallardo, D. Monasterio, R. Finger, F. P. Mena and L. Bronfman, "A Compact Metamaterial-Based Antenna for Multiband Phased Array Applications," in *IEEE Transactions on Antennas and Propagation*,2021

[5] R. A. Bhatti and S. O. Park, "Hepta-band internal antenna for personal communication handsets," *IEEE Transactions on antennas and propagation*, *55*(12), 3398-3403, Dec. 2007

[6] C. Sun, "A Design of Compact Ultrawideband Circularly Polarized Microstrip Patch Antenna," in *IEEE Transactions on Antennas and Propagation*, vol. 67, no. 9, pp. 6170-6175, Sept. 2019

[7] R. A. Bhatti, Y. T. Im, and S. O. Park, "Compact PIFA for mobile terminals supporting multiple cellular and non-cellular standards," *IEEE Transactions on Antennas and Propagation*, *57*(9), 2534-2540, Sep. 2009

[8] S. Y. Lin, "Multiband folded planar monopole antenna for mobile handset," *IEEE Transactions on Antennas and Propagation*, *52*(7), 1790-1794, July 2004.

[9] *A. T. Abed and A. M. Jawad, "Compact Size MIMO Amer Fractal Slot Antenna for 3G, LTE (4G), WLAN, WiMAX, ISM and 5G Communications," in IEEE Access, vol. 7, pp. 125542-125551, 2019*

[10] T. K. Nguyen, B. Kim, H. Choo, and I. Park, "Multiband dual spiral stripline-loaded monopole antenna," *IEEE Antennas and Wireless Propagation Letters*, *8*, 57-59, Jan. 2009.

[11] Y. Liu, Y. Li, L. Ge, J. Wang and B. Ai, "A Compact Hepta-Band Mode-Composite Antenna for Sub (6,

28, and 38) GHz Applications," in *IEEE Transactions on Antennas and Propagation*, vol. 68, no. 4, pp. 2593-2602, April 2020

[12] Y. C. Lin, W. S. Chen, B. Y. Lee, S. Y. Lin, and H. W. Wu, "Small inverted-U loop antenna for GPS application," *Journal of Electromagnetic Waves and Applications*, *24*(8-9), 1033-1044, April. 2012.

[13] S. S. Alja'afreh *et al*., "Ten Antenna Array Using a Small Footprint Capacitive-Coupled-Shorted Loop Antenna for 3.5 GHz 5G Smartphone Applications," in *IEEE Access*, vol. 9, pp. 33796-33810, 2021

[14] Y. J. Zhang, D. Wang and M. S. Tong, "An Adjustable Quarter-Wavelength Meandered Dipole Antenna With Slotted Ground for Metallically and Airily Mounted RFID Tag," in *IEEE Transactions on Antennas and Propagation*, vol. 65, no. 6, pp. 2890-2898, June 2017.

[15] W. S. Chen and B. Y. Lee, "Novel printed monopole antenna for PDA phone and WLAN applications," *Journal of Electromagnetic Waves and Applications*, *23*(14-15), 2073-2088, 2009.

[16] C. Y. Huang and P. Y. Chiu, "Dual-band monopole antenna with shorted parasitic element. *Electronics Letters*, *41*(21), 1154-1155, 2005.

[17] Z. Shao and Y. P. Zhang, "Miniaturization of Differentially-Driven Microstrip Planar Inverted F Antenna," in *IEEE Transactions on Antennas and Propagation*, vol. 67, no. 2, pp. 1280-1283, Feb. 2019

[18] J. Deng, J. Li, L. Zhao and L. Guo, "A Dual-Band Inverted-F MIMO Antenna With Enhanced Isolation for WLAN Applications," in *IEEE Antennas and Wireless Propagation Letters*, vol. 16, pp. 2270-2273, 2017

[19] Y. S. Jeong, S. H. Lee, J. H. Yoon, W. Y. Lee, W. Y. Choi, and Y. J. Yoon, "Internal mobile antenna for LTE/GSM850/GSM900/PCS1900/WiMAX/WLAN, " In *Radio and Wireless Symposium (RWS), 2010 IEEE* (pp. 559-562). IEEE, Jan. 2010.

[20] K. L. Wong, W. Y. Chen, C. Y. Wu, and W. Y. Li, "Small-size internal eight-band LTE/WWAN mobile phone antenna with internal distributed LC matching circuit," *Microwave and Optical Technology Letters*, *52*(10), 2244-2250, July. 2010.

[21] T. W. Kang and K. L. Wong, "Chip-inductor-embedded small-size printed strip monopole for WWAN operation in the mobile phone," *Microwave and Optical Technology Letters*, *51*(4), 966-971.

[22] W. S. Chen and W. C. Jhang, "A planar WWAN/LTE antenna for portable devices," *IEEE Antennas and Wireless Propagation Letters*, *12*, 19-22, 2013.

[23] H. Chen and A. Zhao, "LTE Antenna Design for Mobile Phone With Metal Frame," in *IEEE Antennas and Wireless Propagation Letters*, vol. 15, pp. 1462-1465, 2016

[24] Huang, D, Du, Z. Compact nine-band antenna for 4G/5G smartphones. *Int J RF Microw Comput Aided Eng*. 2019

[25] D. Hui, "A new type of multi-band mobile phone antenna for 3G&4G network," *2017 IEEE 9th International Conference on Communication Software and Networks (ICCSN)*, 2017, pp. 659-663.