

A Compact Monopole Antenna for WWAN/LTE Applications

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1. Introduction

Owing to the rapid development of modern wireless communication systems, many types of portable devices, such as mobile phones, laptop computers, as well as the light, thin, and small tablet PC become parts of our life. The antennas used for the portable devices including PIFA, monopole, loop, and slot [1-5] are required to be compact and multi-band. To maintain small size, PIFA and monopole are commonly used because their 0.25 wavelength excitation modes can effectively reduce the antenna size. Especially, the antenna for tablet or laptop computer is usually placed on top edge of the device with a small width about 10 to 12 mm. Therefore, antenna with small width is required in these applications. To obtain multi-band and wide-band, coupled-fed method attracts more interests for its wide impedance bandwidth, particularly applying at low frequency band. This design uses both directed-fed and coupled-fed monopoles to operate wide operation bands for WWAN/LTE application and 0.25 wavelength excitation modes with meandered structure to reduce antenna size.

2. Antenna Design and Operation Band

The geometric and detailed dimensions of the proposed antenna shown in Fig. 1 are connected to antenna's system ground plane that has a size of 200 mm × 260 mm and is about the size of commercial 13-inch screen. The antenna portion occupied a dimension of 74 × 10 × 0.8 mm³ is printed on an FR-4 substrate with relative permittivity of 4.4, loss tangent of 0.0245. On the left hand side of the substrate, a grounded strip extended from the system ground operates two resonant modes at 0.96 and 2.73 GHz. A directed-fed monopole, which is located on upper side of the grounded strip and contains a 19 nH chip inductor, is used to increase the impedance matching. On the right hand side of the substrate, a coupled-fed monopole extended from the system ground excites a 1/4 λ fundamental mode at 0.73 GHz and its higher modes. A distributed inductor is used to control its higher modes, which are 0.75 λ at 1.52 GHz, 1.25 λ at 1.76 GHz, and 2.25 λ at 2.23 GHz as shown in Fig. 2. The 0.73 and 0.96 GHz frequency modes formed a lower operation band for LTE700, GSM 850 and GSM 900 applications, while the higher mode of 0.73 GHz and the 2.73 GHz mode generate a higher operation band for GSM 1800, GSM 1900, UMTS, LTE 2300 and LTE 2500 applications. To the feeding mechanism, a 50Ω coaxial line is used for RF signal input from the feeding point (point A). The measured and simulated results shown in Fig. 2 have good agreements, and the measured S₁₁ at LTE 700 (0.698-0.787 GHz) /GSM 850 (0.824-0.894 GHz) /GSM 900 (0.88-0.96 GHz) /GSM 1800 (1.71-1.88 GHz) /GSM 1900 (1.85-1.99 GHz) /UMTS (1.92-2.17 GHz) /LTE 2300(2.305-2.4 GHz) /LTE 2500 (2.500-2.69 GHz) application bands are all less than -6 dB.

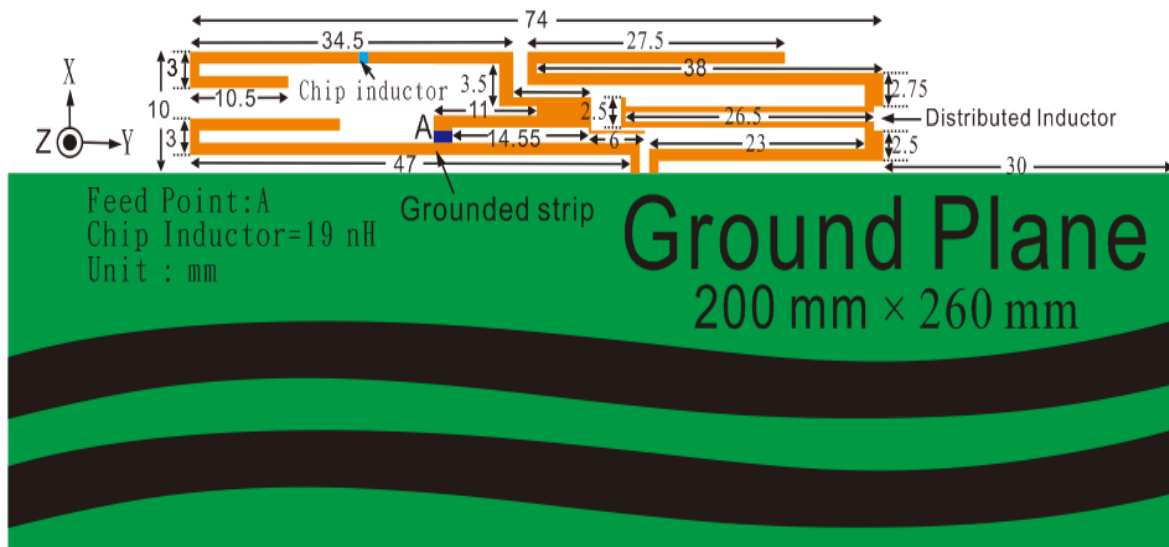


Figure 1: The geometric and dimensions of the proposed antenna.

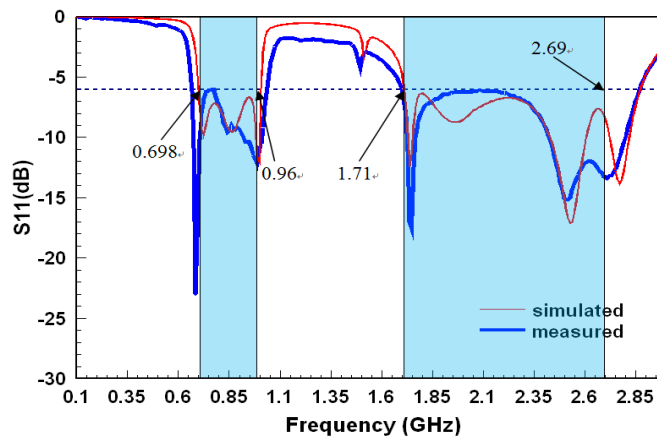


Figure 2: Measured and simulated S11 of the proposed antenna.

3. Parametric Study and Discussion

Fig. 3 shows the simulated S11 of the proposed antenna with and without the coupled-fed monopole element. From the results, the frequency modes at 0.73, 1.52, 1.75 and 2.33 GHz, which are resonated by the coupled-fed monopole, are disappeared. Fig. 4 shows the simulated S11 for antenna with and without the chip inductor. From the results, the 2.73 GHz mode shifts to higher frequency band for the proposed design without the chip inductor. The other modes only change their impedance matching. Fig. 5 shows the simulated S11 of the proposed antenna with different lengths of grounded strip. Due to the $\lambda/4$ fundamental mode having a null at the end of its path, the 0.96 GHz mode has slightly changes when the length of grounded strip is shortened from 15 to 9 mm. On the contrary, the higher mode at 2.73 GHz proportional shifts to higher band as the length decreases. The 0.96 and 2.73 GHz modes resonated by the grounded strip can be proved. Fig. 6 shows the simulated S11 of proposed antenna with different lengths of the distributed inductor. From the results, the 0.73 GHz fundamental mode proportional shifts to higher mode as the length of distributed inductor decreases. At length of 6 mm, the fundamental mode combines with the 0.96 GHz mode resonated by the grounded strip. The higher modes are also rapidly changed by this change.

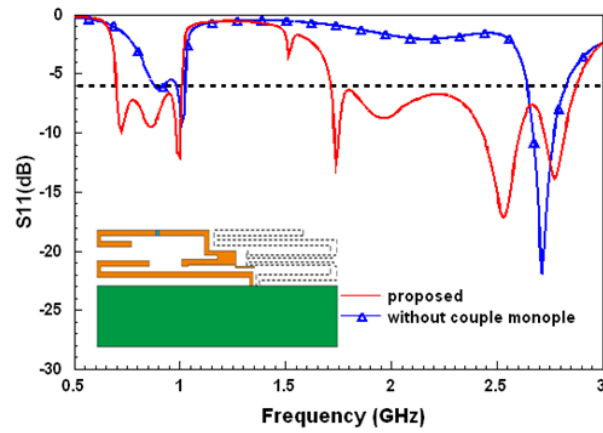


Figure 3: Simulated S11 of the proposed antenna with and without the coupled-fed monopole element.

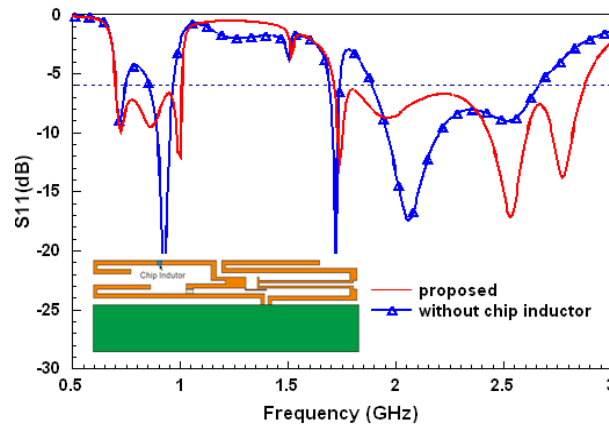


Figure 2: Simulated S11 of the proposed antenna with and without chip inductor.

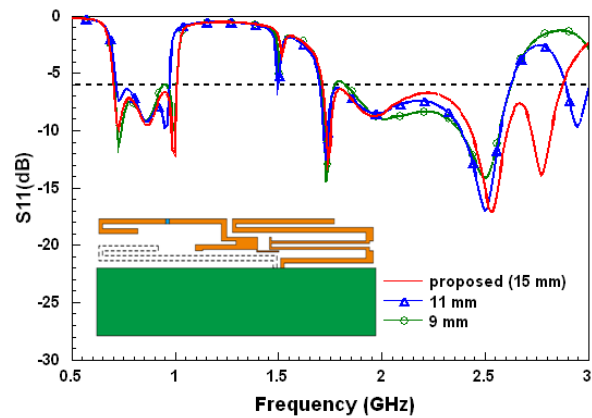


Figure 5: Simulated S11 of the proposed antenna with different lengths of grounded strip.

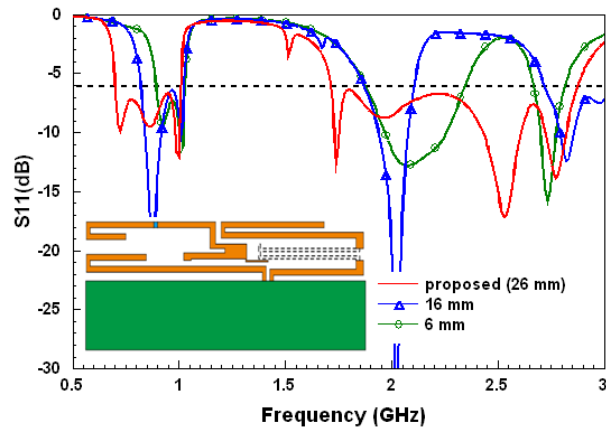


Figure 6: Simulated S11 of the proposed antenna change the distributed inductor length.

4. Conclusion

The directed-fed and coupled-fed monopoles for portable device applications have been proposed and verified. By adding a distributed inductor in the coupled-fed monopole, the 0.73 GHz mode is excited and combines with the 0.96 GHz mode operated by the directed-fed monopole to form wide low frequency band. The higher modes of the proposed monopole create wide high frequency band. The operating bands based on -6 dB of S11 are 0.69–0.96 and 1.71–2.69 GHz for LTE and WWAN applications. The compact dimensions of $75 \times 10 \times 0.8 \text{ mm}^3$ can be easily applied in top edge of tablet computer or laptop computer.

References

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