A Compact Multi-Band Antenna for Mobile Devices and its Impedance Matching Limit Study

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Compact and multiband antennas are highly desired for mobile device applications. However, design of compact antennas can be challenging for some mobile devices, especially if it involves close by metallic packaging. In addition, to satisfy required bandwidth for various practical applications, impedance matching circuit is often utilized. In this work, we report a compact multiband antenna design compatible with a metallic packaging. Moreover, fundamental matching limit for the targeted frequency bands are studied to understand the design limitation.

The antenna is designed to be placed on a 132 mm × 66 mm × 9 mm metallic frame, as illustrated in Fig. 1(a). The antenna takes a space of 4 mm × 66.8 mm ×10.8 mm. It consists of an inverted-F antenna element and two parasitic elements, which in turn generate different current paths, thus multiple resonant frequencies, specifically, 770 MHz, 1850 MHz, 2070 MHz and 2160 MHz. A four-component lumped-element matching circuit is designed to achieve wider impedance bandwidth. Fig. 1(b) depicts the simulated S_{11} of the proposed antenna after matching. The frequency bands from 698 MHz to 787 MHz (band-1) and from 1710 MHz to 2155 MHz (band-2) have S_{11} better than -6 dB. The bandwidth covers the LTE bands 2, 4, 12, and 13. The antenna prototype is fabricated using copper tape on foam substrate ($\varepsilon_r \approx 1$) and measured. As illustrated in Fig. 1(b), the measured S_{11} agrees with the simulated S_{11}. In addition, radiation pattern measurement results also agree with the simulation results.

Moreover, Bode-Fano's matching criterion has been applied to estimate the matching bandwidth limit of the antenna. The theoretical estimation shows that the antenna matching limit is 46% and 58% fractional bandwidth for band-1 and band-2, respectively, for -6 dB impedance bandwidth standard. The mobile device antenna requires 12.6% fractional bandwidth for band-1 and 23% fractional bandwidth for band-2, which illustrates that considerable amount of margin is still available with more complex matching circuit.

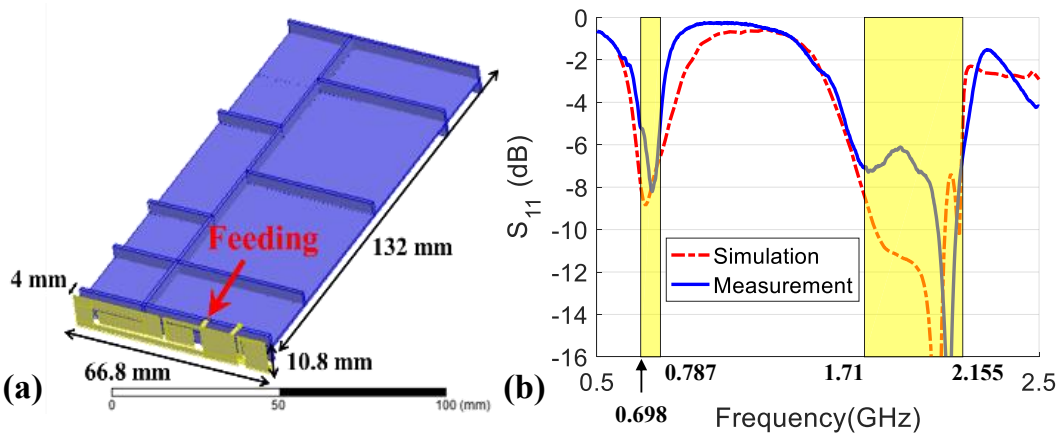

Figure 1. (a) Metallic frame (blue part) and the antenna structure (yellow part). (b) Simulated and measured S_{11} of the antenna with matching circuit.