A Compact Multi-antenna System with Low Mutual Coupling

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Mobile phone antenna design becomes more and more complicated due to the demand of ever faster data rate, carrier and regulatory requirements. Multiple-Input Multiple-Output (MIMO) is considered the mainstream technology to improve data rate and channel capacity without occupying additional already crowded wireless spectrum. Multiple antennas within the size of a compact mobile device are required, for example, supporting LTE 4×4 MIMO needs the minimal 4 antennas, to cover the same single or multiple frequency bands. For better ID appearance smart phones are getting slimmer on thickness while its screen-to-body ratio getting increasingly bigger. Therefore, the space remains for antennas is extremely limited. On the other hand, high isolation between antennas is crucial for the RF front-end system to achieve good radiation performance and receive sensitivity. A compact multi-antenna system with low mutual coupling is highly desired.

One common way is to place a metamaterial-inspired type of structure between two antenna elements (P. Ferrer *et al.*, Microw. Opt. Technol. Lett., 50, 1414–1417, May 2008.), such as, electromagnetic band gap (EBG) structure, defect ground system (DGS), split ring resonators (SRRs) etc. to reduce the mutual coupling. But the implementation of this type of structure often involves large formation which is less appealing in nowadays compact mobile devices. The other common way which has been used in many mobile devices, e.g. USB wireless adapter, other than spacing antenna by the largest available space, or bulky grounding separation, is using neutralization line (A. Diallo et al., IEEE Trans. Antennas Propag., 54, 11, 3063–3074, Nov. 2006). However, not only the implementation of the neutralization line requires PCB space which is rarely available inside already packed device between the antenna elements, but also it is difficult to lower the mutual coupling across a wide range of frequency bands.

Here, we propose an antenna system to utilize the part of mobile device body, such as, phone's metal chassis, metal frame or battery cover and other mechanical parts. The antenna system consists of two or more antennas nearby which can be equivalent to adjacent current radiator and voltage radiators whose voltage or currents orientation is orthogonal or close to orthogonal to each other (patent No. 62/446,173). The current radiator type antenna, such as, dipole, monopole, inverted-F antenna (IFA), etc. can be realized by using part of the phone metal frame. The voltage radiators type antenna, such as, aperture antenna, etc. can utilize both phone metal frame and chassis. The adjacent current and voltage radiators share the same ground, e.g. the IFA grounding leg also acts as the ground which forms the aperture of the slot antenna. As a result, the radiation pattern of adjacent antennas is close to orthogonal to each other therefore the isolation will be improved compared with the same type of antennas with the same distance of separation. As a proof-of-concept, simulation performed in xFDTD implement the concept into a realistic phone and simulation results shows the considerable lower mutual coupling with the worst case -11dB across the entire frequency bands from 699MHz to 6000MHz in a compact form factor.