Experimental Validation of a Tunable Metamaterial Inspired Miniaturized Patch Antenna

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The recent rapidly growing markets of mobile handsets and computers demand packing more and more functionality into smaller devices. As a result, the need for compact antennas to cover multiple wireless communications frequency bands has increased dramatically. Typical solutions to miniaturize the size of an antenna require the use of slots or high-permittivity dielectrics, and methods of introducing extra circuits or special substrates to tune the resonance frequency have been commonly adopted. These techniques, however, suffer from limited size reduction, increased manufacturing complexity, and high overall cost.

In this paper, a technique to create highly-miniaturized and tunable metamaterial-inspired patch antennas is proposed. The miniaturization is achieved by loading a circular resonant disk parallel to the radiating patch (Ouedraogo et al., IEEE Trans. AP, vol.60, no.5, 2012). The structure on the resonant disk is optimized to form specific complimentary slots. Full wave simulations using HFSS have been conducted to assess the performance of the antenna and initial results have demonstrated that placing lumped components such as capacitors across a certain region on the complementary slot will alter the coupling between the slots and thus tune the resonance frequency of the circular patch. In light of this, it is proposed that the resonance frequency of the miniaturized antenna can be continuously tuned by replacing a properly chosen capacitor with a single varactor diode. This has been investigated in simulations, but it remains to be demonstrated in practice.

A prototype circular patch antenna that contains both a resonant disk and a varactor diode is fabricated and measured to demonstrate the feasibility of the proposed design. By choosing a proper varactor diode and supplying an appropriate range of voltages, a patch antenna miniaturized to 1/16 its original surface area can be tuned from its initial operating frequency of 2.4GHz across a 50% tuning range. The radiation patterns and efficiency of the antenna will also be measured and compared with simulations and with the unloaded prototype.