Studies of Multi-Functional Printed and Dielectric Resonator Antennas using Split Ring Resonators and Metallic Structures

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by

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ABSTRACT

Designing compact antennas and microwave circuit components has always been an important issue because of the tremendous growth in electronic communication systems. This growing demand of wireless communications and introduction of new communication protocols stipulate the re-design of wireless systems to cater different recent needs. Allocation of ultra-wideband (UWB) spectrum by FCC in 2002 attracted the antenna community to design compatible antenna systems covering the UWB band ranging from 3.1-10.6 GHz. Numerous radiating structures have been investigated utilizing radiating elements of different shapes, including circles, ellipses and squares. Complexity of designing such UWB antennas has increased many folds in recent years due to co-existence of various narrowband services within the UWB spectrum, like, WiMAX (3.3 3.7 GHz), WLAN (5.15 5.85 GHz) and X-band satellite downlink (7.25 7.75 GHz) which demand the mitigation of these interfering narrow bands for efficient communication using the UWB spectrum. Such antennas, requires in-built frequency notching feature and are known as frequency-notched UWB antenna. Introduction of recent communication protocols like software defined radio (SDR) and cognitive radio (CR) for an efficient spectrum allocation has escalated the antenna design challenges further. Antennas for this system requires special attention as it necessities an UWB and narrow band antennas in common platform. The first antenna performs spectrum sensing of unused carrier frequencies and is called sensing antenna. On the other hand, the second antenna needs to be reconfigurable one, operating over a limited bandwidth and is known as communicating antenna or “transmit/receive antenna”. Present PhD thesis deals with the design, development and practical realization of multi-functional planar compact antennas for modern wireless applications. The work is systematically planned and realized as follows:

1. Metamaterial based structures (SRR and/or shunt wires) have been successfully designed and developed for realization of notched filter. Multiple rotational SRR loaded coplanar waveguide (CPW) line based frequency notched

filter is realized with an aim of using them for printed antennas for modern wireless applications.

2. The recent requirement of frequency-notched antenna design is demonstrated using planar antennas of various shapes and configuration, like, monopoles, tapered slot antennas. Seamless applications of the planar filters realized in previous section, is very efficiently used in design of such frequency notched antennas.

3. A significant contribution of the present thesis is successful realization of multi-functional antennas aimed for CR and SDR applications. This new multi-functional antenna uses a single radiating element coupled with metamaterial based structures (SRRs) and/or switches around its ground plane. Combinatorial loading of the SRRs and/or the switches in this antenna provides multiple antenna functionalities. The notch frequency and narrowband frequency in this antenna can be controlled by changing the physical dimensions of Split Ring Resonator (SRR) and are independent of the antenna configuration. Various experimental aspects involving challenges and concerns in characterizing these types of antennas have also been thoroughly considered in this work.

4. A practical realization of the proposed multi-functional antennas using commercial RF switches (PIN diodes) is another significant contribution in this thesis. The realized antenna is characterized for impedance and radiation pattern measurements and provides good correspondence with theoretical estimations and simulation results. Moreover, frequency tunablity of the antenna is demonstrated using a stepper motor based rotational mechanism using rack-pinion structures.

5. A bandwidth controllable cylindrical ring dielectric resonator (CRDR) antenna is proposed. The bandwidth controllability is achieved by structurally loading the CRDR antenna with metallic cap and sleeve loading. Bandwidth controllability is demonstrated without perturbing the antenna radiation characteristics.