NOVEL RFID ANTENNAS FOR A MODERN LIBRARY

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Abstract

Novel RFID Antennas for a Modern Library
為現代化圖書館而設的新穎射頻識別系統天線
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This thesis presents a series of novel Radio Frequency Identification (RFID) reader and tag antennas for a modern library. To be a modern library, an intelligent RFID system is a key stone to achieve the goal. It includes many parts such as smart bookshelves, multi-book borrowing and returning system, smart book sorting, security gateway and tags for library resources. The performance of the antenna system is the most critical element of any RFID installation. However, “one antenna fits all” concept can not be applied here. Instead of the conventional circularly polarized patch antenna, specific designs are necessary for effective handling of smart bookshelves, multi-book borrowing and returning system and multi-media resources. Consequently, four different types of antennas are investigated including a directional beam tilted wire antenna, a compact sequential rotated PIFAs array, a printed CP antenna with EBG structure and a compact ring folded dipole tag antenna, for the UHF RFID library system.

Attention is first focused on design and investigation use of wire helix to achieve directional beam tilted circular polarization (CP) for a multi-book check out and return system. Unlike the conventional helical antenna, an accordion shaped monofilar axial mode helix designed by curving the helix along the axis is investigated. This antenna
is low profile as the 10-turn helix’s axial length is 0.354\(\lambda\). It has an impedance bandwidth (SWR<1.5) of 9\% from frequency of 880MHz to 963MHz and the axial ratio bandwidth (AR<3dB) of 6.5\%. This antenna achieved a measured gain of 10.2 dBi and tilted by 17° to the curving side.

In the second part, the idea of designing a low cost smart bookshelf antenna is presented. A compact sequentially rotated printed inverted-F antenna (PIFAs) array printed on a low cost material FR4 is investigated. In this design, the sequentially rotated feeding technique is firstly introduced to top loaded PIFAs, to achieve a small size, low profile, wide axial ratio bandwidth and a wide radiation beam. A numerical analysis based on the method of moment is carried out to predict the characteristics of the antenna. Different from the conventional sequential CP patch array, the proposed design is small in size and offers a wide beam width of over 110˚; it also preserves a wide impedance bandwidth of 26.8\% and axial ratio bandwidth of 11.6\%.

In the following part, to further provide a low profile and low cost solution to replace the conventional CP patch antenna for smart bookshelf and smart sorting system, a printed CP patch antenna backed with a double-layer Electromagnetic band gap (EBG) structure is proposed. The antenna is printed on 3 layers of low cost material FR4 with thickness of 1.6mm (0.006\(\lambda\)). It achieves 80\% thickness reduction by compared to the conventional patch antenna but maintains the antenna gain of about 6dBi.

Finally, a compact ring tag antenna is specifically designed for multi-media resources in the library. The antenna is modeled with the circular plastic CD. Therefore, the impedance characteristic can be well conjugated matched with the
Application Specific Integrated Circuit’s (ASIC) and the read range can be maintained even when tagged on multi-media resources. The ASIC Philips NXP EPC global Class 1 Generation2 RFID chip has a threshold power of -13dBm and chip-on-board impedance is 16-j380Ω. The tag antenna is operated at the center frequency of 915MHz when placed on a 1.2mm thickness CD disk and the maximum read range is 1.5 meter.

The characteristics of the proposed architectures were investigated using the commercial software Mat-Lab and IE3D, and measurements were carried out to verify the simulations. With the specifically designed antennas, the performance of the modern intelligent RFID system should improve greatly.
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