Reconfigurable Antennas and Systems

Thesis Abstract

The increasing demand of compact and multi-functional antennas and RF systems is driving this research activity, where the reconfigurability concept is used to enhance the capability and performance of a rat-race coupler, an UHF RFID antenna and a phased array based on Rotman lens as beamforming network. In each of the three designs it has been considered manufacturing and component/material costs, in order to introduce novel solutions that are ready to be applied in a “real world” scenario.

In particular, a method to extend the scan range of a phased array based on Rotman lens as beamformer is demonstrated through simulation and measurements. The scan range extension is based on a reconfigurable phase shifting architecture, named Phase Management Unit, located between the Beam Forming Network and a linear antenna array. Two different approaches for the realization of the switching phase shifters, responsible for the scanning mode selection, are described. Moreover, in the design it has been employed a novel method to efficiently illuminate the Rotman lens and, at the same time, to generate a cosine type amplitude tapering. A compact design has been manufactured and measured, employing standard PCB technology, showing an actual increase of the scan range of a factor two, in comparison with the standard approach. Moreover, by the application of this method the number of the scanning beams is increased, thus keeping a fine spatial resolution and very good coverage.

The second research topic is focused on the development of a miniaturized and frequency reconfigurable rat-race coupler operating in two frequency bands, centered at 900 MHz and 1.7 GHz. The concept of artificial transmission lines is here exploited to design a very compact coupler, which can operate in two different frequency bands, by acting on CMOS switches. The reconfigurable method, based on addition and subtraction of line sections of proper length, is enhanced by a novel theory for balancing the phase characteristic of the miniaturized branches of the rat-race coupler, including also the effect of the switching elements. The measurement on the prototype have shown good agreement with both analytical and simulated results.

Moreover, the frequency and polarization reconfigurability concept have been used to realize a compact and more efficient UHF RFID reader antenna. The proposed antenna, with multiple reconfiguration capability, employs the concept of the reconfigurable feeding network. By employing this technique, the frequency reconfigurability allows the antenna to operate in two UHF RFID regional bands (i.e. European and North American), while the polarization agility greatly reduces the polarization loss factor which occur between the

RFID Tag (linearly polarized) and the UHF RFID reader antenna, typically circular polarized. In particular, it is demonstrated how the polarization reconfigurability can be a breakthrough in UHF RFID reader antenna application, in order to improve the efficiency of the RFID reader to Tag communication, by removing the static three dB loss caused by the circular to linear polarization mismatch. Based on an electrically small suspended patch antenna, several methods for the application of both frequency and polarization agility are investigated, each of them focused on the optimization of a particular aspect, showing promising results.