Challenges in Low-Cost Inkjet Antennas

Barışcan Karaosmanoğlu*, Tolga Çiftçi, and Özgür Ergül
Middle East Technical University, Ankara, Turkey

Inkjet antennas that are based on inkjet printing on paper and similar substrates have recently attracted great interest due to their low costs, flexibility, and environment-friendly properties (A. Rida, L. Yang, R. Vyas, and M. M. Tentzeris, *IEEE Antennas Propag. Mag.*, **51**, 2009, pp. 13-1056). In addition to special-purpose material printers that are designed particularly for metallic printing, one can use silver-based inks in ordinary desktop printers for producing such antennas. This study is devoted to this second class of inkjet antennas, emphasizing major challenges encountered in their manufacture, as well as their combinations with microchips for passive tags in radio-frequency identification (RFID) systems. Considering the production of a few hundred tags (small-scale manufacturing), the cost of each tag is around 1.5 USD including the printers, silver inks, and microchips.

Major parameters in producing low-cost inkjet antennas include but not limited to printer type and configurations, printer age, ink type (silver ratios and ingredients), paper type, curing temperature and duration, and post processing. Alternative applications of these parameters and their effects on the quality of these antennas are studied in detail, with the major emphasis on the cost, flexibility, and compatibility with RFID microchips. Matching to these chips that are highly capacitive without using a matching circuit brings another major challenge in terms of antenna design. While small sizes of these antennas bring important advantages for quasi-isotropic radiation patterns, parasitic parts are often required for increasing the range of RFID systems. Measurements of the produced antennas further need extensive efforts for properly connecting probes to the terminals of these sensitive structures without damaging the paper substrate. Producing inkjet antennas using desktop printers also involves stability problems, as depicted in the figure below. In this figure, the measured power reflection coefficient values (when matched to a complex impedance value) are plotted with respect to the frequency for eight "identical" antennas produced under the same conditions. It can be observed that the power reflection values can vary significantly, making it essential to have broadband antennas to eliminate disastrous effects. These instabilities are natural as these printers are designed for readability of the output rather than the uniformity of the ink. Despite many challenges in designing and producing low-cost inkjet antennas, this study demonstrates how to overcome these obstacles to exploit the beneficial and promising features of these interesting devices.