

Chipless RFID Solution: Printed Tags on Flexible Substrates for Sustainable Packaging

Peio Lopez-Iturri⁽¹⁾, Rafael Ruiz-Feliú⁽¹⁾, Imanol Picallo⁽¹⁾, Hicham Klaina⁽¹⁾, Pablo Martínez⁽²⁾, Javier Bravo⁽³⁾, José I. Oteiza⁽²⁾, and Francisco Falcone^(1,4)

(1) Dept. of Electric, Electronic and Communication Engineering and the Institute of Smart Cities, Public University of Navarre, 31006 Pamplona

(2) Ulzama Gráficas, Digital and Packaging, 31620 Huarte

(3) Naitec-Mobility and Mechatronics Technology Centre, 31006 Pamplona

(4) School of Engineering and Sciences, Tecnológico de Monterrey, Monterrey 64849, Mexico.

The Internet of Things (IoT) has boosted the rapid growth of RFID technology, which plays a critical role in enhancing supply tracking and document security. Despite its advantages, traditional RFID systems rely on chips for each labeled item, raising costs and contributing to environmental waste. To address these challenges, chipless RFID solutions are gaining significance, offering a more sustainable alternative by enabling tags to be printed directly on shipping materials. This shift not only reduces production costs but also reduces the ecological footprint, positioning it as a valuable innovation for industries such as packaging that benefit from end-to-end product traceability.

This work focuses on the design and implementation of 2D geometrical structures similar to metasurfaces' spectral signatures, forming the basis of an advanced chipless RFID system. While the concept itself is not entirely new and has been previously explored in the literature, our work proposes alternative printing techniques using conductive inks on flexible substrates, such as paper for the fabrication of the tags. Remarkably, the printed inks demonstrated lower resistivity than initially expected, achieving performance comparable to copper on thicker FR-4 substrates. This advancement marks a significant step forward in making RFID systems cost-effective and environmentally friendly. To improve reliability and minimize waste, an automated printing quality control system has been developed, integrating artificial vision with a robotic arm. Additionally, a compact, low-cost reader based on software-defined radio (SDR) technology has been developed allowing the extraction of encoded information from the designed patterns. Operating from 0 to 12 GHz, this reader provides performance comparable to a commercial vector network analyzer (VNA).

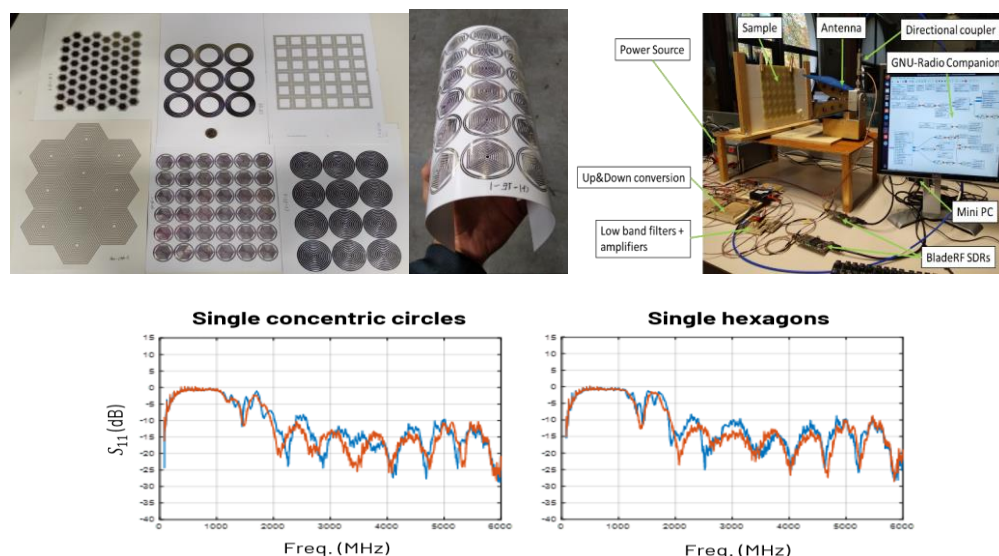


Figure 1. Different patterns printed based on canonic shapes; Implemented reader version; S_{11} comparison between FR4-based samples (blue curve) and paper-based printed samples (orange curve).