Proceedings of the 12th World Congress on Electrical Engineering and Computer Systems and Sciences (EECSS 2026)
August 16 – 18, 2026 – London, United Kingdom
DOI: 10.11159/eee26.001

The Past, Present, and Future of Chipless RFID Technology

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Extended Abstract

The development of chipless RFID technology has roots in early electromagnetic tagging efforts. Richard Ribon Fletcher's 2002 MIT doctoral thesis, "Low-Cost Electromagnetic Tagging: Design and Implementation," offers a key overview of its history [1]. His work traces the evolution from initial harmonic-diode tags to low-cost electromagnetic systems used in the 1970s by companies like Sensormatic and Checkpoint, foundational to current Electronic Article Surveillance (EAS). Fletcher improved these concepts with compact, planar LC resonators that employed distributed capacitance and multiple inductive branches, thereby creating the first near-field, circuit-based chipless tags. After a period of little progress, interest revived between 2005 and 2009, as researchers explored far-field, chipless RF identification using resonant scatterers in relation with small, loaded antennas earlier conceptualized by Harrington and Green. A significant breakthrough was Jalaly et al.'s 2005 invention of "RF barcodes," where metallic dipoles of different lengths encoded data via distinct resonant frequencies [2]. This method adapted optical barcode logic for RF and became a key concept in chipless RFID. A second revolution involved physically and conceptually eliminating antennas at the tag level. This led to the development of a novel concept in the early 2010s where tags consist solely of resonant scatterers [3]. Each element is a single unit, dispersed throughout the tag, with no functional division between the transmitting/receiving components and the encoding parts, such as antennas and loads. The outcome is RF encoding particles (REP), which inherently possess a unique radar signature (resonance) that can be directly linked to information. The functions of receiving, signal processing, and transmitting are now integrated, both conceptually and in design. These antenna-free tags, introduced by E. Perret et al. in their 2010 patent US8556184 titled "Chipless passive RFID tag," lack antennas and transmission lines, making them less cumbersome and more adaptable for developing chipless RFID technology [4].

Chipless RFID holds great promise as a practical alternative to barcodes and chipped RFID for identification [5]. Initially confined to academic work, recent support from companies has led to the first commercially available systems, making the technology more accessible [6, 7]. The presentation will review the origins of the technology, showcase the different radar-based technologies developed, and highlight the current performance in communication and sensing [8]. The final section will cover the latest developments aimed at resolving remaining issues and exploring new research topics [9], potentially opening the door to future business opportunities.

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