Electronically Rewritable Chipless RFID Tags Fabricated Through Thermal Transfer Printing on Flexible PET Substrates

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Abstract—We present an electronically rewritable chipless RFID tag based on integrated nonvolatile Conductive Bridging Random Access Memory (CBRAM) RF switches. CBRAM is a nonvolatile memory technology, which is identified as an innovative RF switching solution in this decade. Reconfigurable resonator or RF encoding particle (REP) used in this tag is a closed-loop resonator integrated with two switches each to tune its electrical length, and encodes three states each, to represent more than one bit per REP. Presented tag is composed of three such REPs to represent a total of 27 unique states. This chipless RFID tag with CBRAM switches could be written/rewritten electronically using DC voltage pulses, to encode a desired code from a given combination. Thermal impression transfer printing is utilized for printing metallic layers of the presented chipless tag. Complete fabrication steps of presented tag with integrated CBRAM switches are carried out without any "clean room" processes. An insight to working mechanism of presented rewritable REPs using electrical models is included in this article. Proof of concept of a potential hybrid data encoding technique combining frequency shift coding and Radar Cross Section (RCS) magnitude level coding, through experimental studies, for presented REPs, is also given herewith.

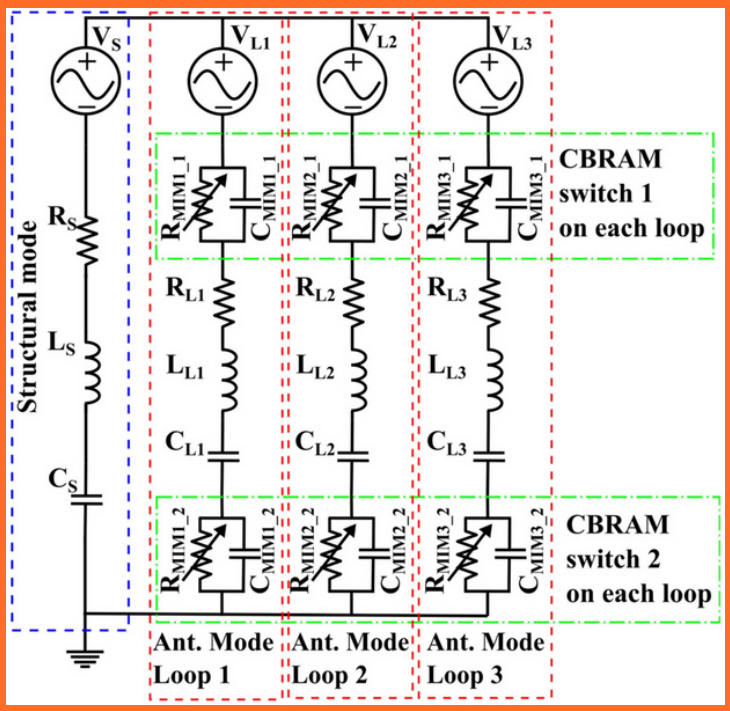

Fig. Electrical equivalent model of proposed electronically rewritable chipless RFID tag

Conclusion - In this article, we have presented the main aspects of design and realization of a fully printed fully passive electronically rewritable chipless RFID tag, utilizing solid state nonvolatile CBRAM switching technology, on PET substrates, through thermal transfer printing techniques. We have affirmatively introduced the following advances and novelties through this study in electronically rewritable chipless RFID technology.

1) This is the first time such a printing process compatible with roll-to-roll printing technique is utilized to realize CBRAM RF switches, or an electronically rewritable chipless RFID tag using these switches.

2) Proposed tags were realized on flexible PET laminates. Tags consist of three rewritable resonators (REP) each. And, one REP represents three coded states each. Fabricated tags were successfully programmed and exhibit distinct readable resonant RCS backscatter response for all possible 27 switch combinations showing reliability of the design.

3) We have presented and validated successfully an electrical model that precisely approximates behavior of the proposed chipless tag, and assuage the requirement of waiting for results of time-consuming multiple 3-D full-wave EM simulation studies, for all possible combinations defined by a given electronically rewritable chipless RFID tag of the proposed type.

4) We have also presented the idea of quantization (or control) of RCS magnitude values of a rewritable resonator, by controlling the filament resistance values of integrated CBRAM switch. This experiment and its outcome trigger the conception of a possible novel hybrid encoding technique that could be used in future works.

Electronically rewritable chipless RFID tags presented herewith could find their potential application, as a superior replacement of optical barcodes. Moreover, such a technology of fabrication of electronically rewritable chipless RFID tags as presented herewith is compatible with mass production in an industrial environment and could contribute to cheap and efficient smart identifiers of the future.

Future works related to these electronically rewritable chipless RFID tags, and the concept of fully printed reconfigurable RF/microwave devices based on CBRAM switching technology, include detailed analysis of features such as maximum number of switching cycles, investigation of techniques for impedance control of CBRAM switches, miniaturization of chosen resonators, research on strategies to maximize RCS magnitude, studies on real-world environmental interactions of presented tags, effects of orientations of tag with respect to reader system, and similar.

Index Terms—Chipless RFID, Conductive Bridging Random Access Memory (CBRAM), electronically rewritable chipless RFID, metal–insulator–metal (MIM) switches, printing, rewritable chipless RFID, thermal transfer printing