RFID INTEGRATED CIRCUITS AS NETWORK CONTROLLERS

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Abstract

This paper presents a novel approach for controlling reconfigurable antennas using passive Radio Frequency IDentification (RFID) Integrated Circuits (ICs) physically connected to the RF power generator through a transmission line to achieve RF signal path management. The feasibility of selectively activating the ICs through a wired link is demonstrated through the design and test of a custom PCB equipped with four ICs. Compared with traditional reconfiguration mechanisms, where external controllers and power supplies are required, the proposed architecture significantly reduces system cost, power consumption, and complexity, particularly in space-constrained applications.
Index Terms *– Dynamic Reconfiguration, RFID, Reconfigurable Antennas, Selective Activation.*

I. INTRODUCTION

The evolution of wireless communication technologies has driven the development of reconfigurable antennas capable of adapting to varying environmental conditions [1], [2]. Typically, reconfigurability is achieved through electronic switches like PIN diodes, varactors, and RF switches [3]. However, these components require microcontrollers and external power, increasing system cost and complexity. Recent studies have introduced Radio Frequency IDentification (RFID) technology for wireless control of reconfigurable antennas, providing wireless connectivity and basic computational capabilities without external power supplies. RFID Integrated Circuits, programmable via an RFID reader in the Ultra-High-Frequency (UHF) band (860-960 MHz), can control RF switches and serve as reconfigurable network controllers [4]–[7]. This innovative approach, described in detail in [4], [5], allows the achievement of reconfigurability without the need for external power supplies or wired connections, offering a more flexible and less intrusive method particularly beneficial for applications where space and accessibility are limited [8].

This paper demonstrates a proof-of-concept for *wired selective activation* of RFID ICs. A custom PCB equipped with four passive ICs (EM4152 [9]) is used for IC impedance matching to 50 Ω, and a selective activation protocol is implemented. This novel approach enables ICs to be distributed along an array's Beam-Forming Network (BFN) to provide dynamic and reprogrammable phase shifts or on microstrip antennas to connect or disconnect embedded transmission lines.

II. Rationale

As described in [4], the selected IC (EM4152) can be programmed to deliver a DC voltage when a compatible (in terms of frequency and power) RF source is available. Moreover, according to the EPC Gen2 communication protocol, an RFID reader can send a command to a specific IC by filtering it through its Electronic Product Code (EPC), a unique identification number. This feature can be exploited to selectively communicate with ICs physically connected to the same RFID reader, even if they are simultaneously reached by the same RF power.

The proposed architecture allows the distribution of several RFID ICs along an antenna feeding network or within any electronic circuit that involves signal routing. This enables dynamic modification of antenna characteristics or alteration of signal paths by physically connecting or disconnecting transmission line sections through RF switches, such as Single-Pole-Single-Throw (SPST) GaAs Monolithic Microwave Integrated Circuit (MMIC).

III. Prototype

The feasibility of the proposed architecture is demonstrated through a custom PCB with four EM4152 RFID ICs realized on a Rogers RO4003C substrate (Fig. 1). The prototype aims to distribute the input power among four RFID chips equally. Each IC ($Z_{IC} = 17.6 - j271.9\ \Omega$ [9]) is matched to 200 Ω at 900 MHz using a lumped elements L-network consisting of two inductors ($L_1 = 19\ nH,\ L_2 = 15\ nH$). These networks are then connected in parallel to achieve an overall input impedance of 50 Ω. Finally, two pads for connection to an external component (e.g., Varactor, RF switches, etc.) were embedded in the layout. The schematic representation of the network is shown in Fig. 1a, while Fig. 1.b shows the realized prototype.

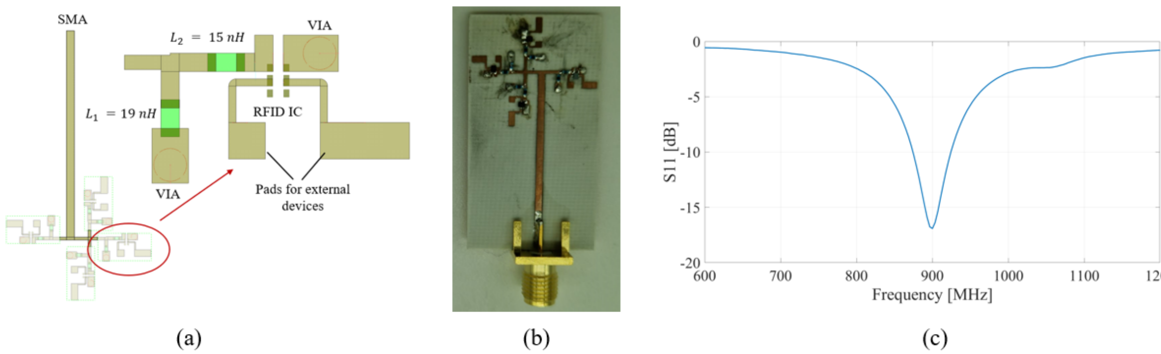

Figure 1: (a) The circuit schematic of the proposed layout for IC impedance matching. (b) Fabricated prototype. (c) S_{11} with $P_{VNA} = -12\ dBm$.

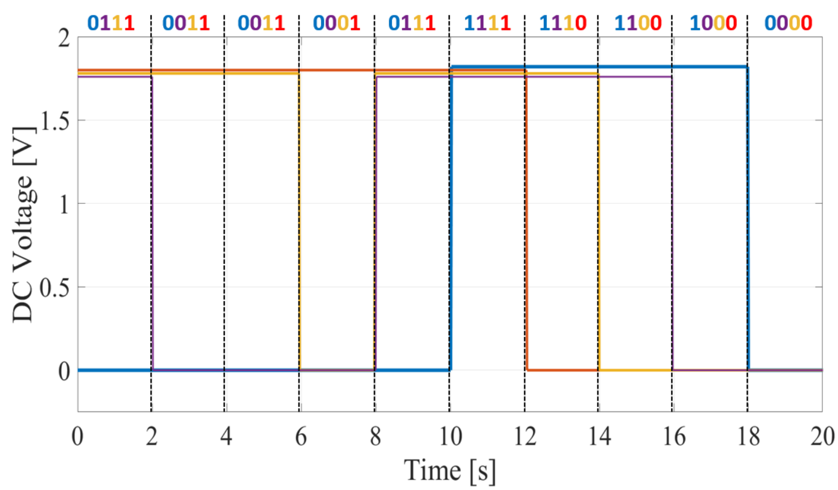

Figure 2: Output voltage of the four ICs versus time according to the chosen protocol (shown above the plot), where each bit corresponds to the state of a single chip.

IV. Results

The prototype was tested through the Pico108 Vector Network Analyzer (VNA). Since RFID ICs' equivalent impedance Z_{IC} is highly power-dependent, manufacturers always provide it at the IC power sensitivity p_c, i.e., the minimum operating RF power level. Therefore, accounting for the power split, measurements were conducted with VNA output power $P_{VNA} = -12\ dBm$ ($p_c = -18.8\ dBm$ [9]). The board's measured reflection coefficient S_{11} is shown in Fig. 1c.

Selective activation was tested by programming the ICs through the ThingMagic M6E RFID reader. The M6E was instructed to send the command 1 (DC output ON) or 0 (DC output OFF) to a specific IC, depending on the chosen protocol. After each RFID command, a Continous Wave (CW) at 900 MHz with a duration of 2 seconds was sent, and the output voltage of the ICs was acquired through the Pico2405B oscilloscope. As shown in Fig. 2, the ICs follow the imposed protocol selectively, delivering a stable voltage of approximately 1.8 V.

V. Conclusions

This study demonstrated the feasibility of employing RFID ICs as network controllers for reconfigurable antennas. The innovative approach described herein, which utilizes passive RFID ICs, could significantly advance over traditional control platforms that require microcontrollers and external power supplies. The selective activation of several RFID ICs is verified by designing and implementing a custom PCB equipped with four EM4152 ICs. Future studies will focus on integrating RF components in the layout, such as varactors and RF switches, and on realizing the first example of an antenna reconfigurable through the proposed mechanism.

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