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Compact CSRR TAG Antennas for Use at 50 GHz

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***Abstract**: The author presents a novel approach for creating an antenna system for radio frequency identification (RFID) transponder devices. RFID antenna designers use silicon technologies to integrate slot-ring antennas with coplanar waveguide excitations for their infrastructure. The RFID frequency operates on the worldwide available 50-GHz band. The structure simulation occurs with Computer Simulation Technology (CST). The suggested antenna achieves a gain boost of 3.82 dB which could lead to extended reading capabilities.*

***Keywords**: RFID, split-ring resonator, millimeter wave identification, frequency identification, and coplanar waveguide (CPW)*

I. Introduction

RFID systems proved their success in their transition from laboratory research to industrial deployment while establishing many practical usage scenarios [2-3]. RFID systems operate mainly within the frequency ranges spanning from 125 kHz up to 5.8 GHz. The growing number of such systems saturates these bands which creates difficulties for new system additions. This research develops a new approach which advocates for millimetre wave spectrum instead of conventional radio frequency identification bands under 3 GHz [5]. The findings demonstrate a movement pattern toward frequency ranges that continuously increase. This paper proposes the adoption of millimetre waves to identify objects in different scenarios [10-11]. The device referred to as millimetre RFID exists under the name of Millimetre Wave Identification (MMID). Various research activities take place simultaneously on systems development as well as propagation modeling and antennas engineering and circuit design and component manufacturing. Affordable and efficient millimetre technology leads to more advanced implementation of its systems. Millimetre Wave Identification (MMID) introduced the method to transition traditional RFID from HF and UHF radio frequency bands to 60 GHz millimetre wave band operations according to [6].

The authors successfully designed and tested a 50 GHz semi-active MMID tag during their research in [7] to demonstrate the concept of MMID technology. MMID provides several advantages over RFID systems through its capability to support high data-rate transmissions which exceed gigabit capacity at millimetre frequencies like 50 GHz. Pursula et al. [6] explain that raising carrier frequency provides three benefits: it enables smaller tags by using smaller antennas, results in more compact reader modules and delivers narrow beams with enhanced reader antenna array gain. Implementation of fast and wireless battery less mass memory storage would yield an exciting application scenario. Directional antennas have limited functionality at millimetre wavelength frequencies. Pointing the reader device equipped with a small directing antenna allows users to select a transponder. The extensive size of UHF RFID system antennas makes such an approach impossible to implement [10]. An antenna with directional capabilities would be advantageous in dense sensor networks and item level tagging since it facilitates the detection of transponders spread throughout large areas. Millimeter-wave radars find existing applications in car radar systems and additional sectors. The paper authored by D. Hou et al. [8] introduces a novel 100GHz frequency resonant antenna.

The proposed antenna uses a combination of meander line with slot approach and dielectric resonators as separate design techniques. C. Liu et al. have developed a 60 GHz helical array system. The designed circular polarization appears as the primary trait of the planned array's 4x4 unit structure [8]. A wideband planar dielectric antenna for W-Band and up-millimeter wave applications exists according to N. Ghassemi et al. in reference [1] through their use of substrate integrated non-radioactive dielectric. M. Henry et al. establish an innovative antenna design system among their scientific contributions. The suggested idea received testing through millimetre band frequencies. The proposed meta-material inspired loop antenna offers simultaneous advantages of bandwidth expansion while achieving size reduction and frequency scanning capabilities. A modified rectangular loop element connects with CSRR components in order to build the proposed antenna design. Simulation of the proposed antenna depends on the Computer Simulation Technology (CST) Studio Suite 2012 platform. The document follows this sequence of structure [11]. We designed a 50 GHz resonant CSRR antenna in the initial part of our model. A parasitic element serves to decrease antenna dimensions in the second segment. We make a via-hole cut in the third segment to study how this change affects the two layers' relationship. Our research finishes with a section including productive feedback.

II. Proposed Design

The implementation method of the proposed split-ring resonator-based RFID loop antenna appears in Figure 1.a. The modulated loop element serves as the main antenna design which is printed onto Roger's substrate [11]. An in-depth depiction of the on-chip antenna appears in Figure 1.a. The ring width appears as S1 with space between rings at S and end spaces become W. The silicon material forms the built-in feeding structure of the device. The antenna feeds from a CPW joined with a slot ring structure [8].

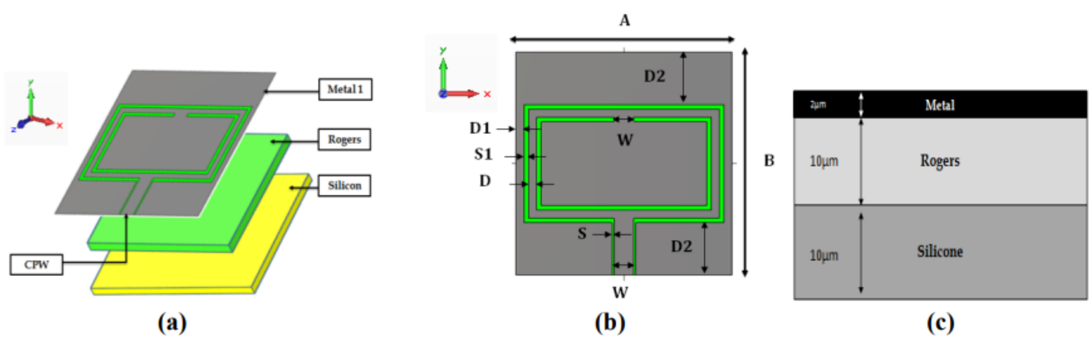

Fig 1: Geometry of the proposed antenna (All dimensions in µm)

A carefully designed antenna for 50-GHz µ RFID tags represents an optimal solution for CPW (Coplanar waveguide) implementation. Laboratory findings from [8] demonstrate that creating CPW transmission lines solely on the top metal layer induces substantial substrate losses but these findings from the work prove otherwise when implementing HR substrates. The main advantage of antenna design through meta-material components involves obtaining a final antenna size that surpasses conventional printed antenna dimensions. A design incorporating printed antennas built with meta-material elements upon two ungrounded dielectrics has been established [7-9]. The split ring resonator (CSRR) functions as the main element behind the distinctive features present in the proposed loop antenna. A single CSRR unit cell is composed of two rings joined by an internal split in their final segments. The front perspective view of the loop antenna appears in Figure 1.b. The loop antenna holds a 2µm tall rectangular shape located right in the center of its metal structure. Three conductors arranged on the upper surface of the second Rogers layer construct the coplanar line.

III. Simulation Results

The resonant frequency of this antenna is designed to be approximately 50 GHz. Finding the outcomes of the antenna simulations was aided by simulations conducted under CST. On a Rogers and Silicon substrate, a 50 GHz antenna with a coplanar feed is created. The antenna's simulated reflection coefficient values (| S22 | dB) are displayed in Figure 2.

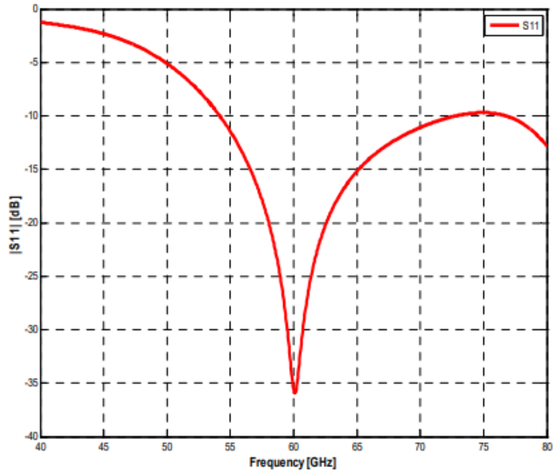

Fig 2: Simulated reflection coefficient for the proposed antenna

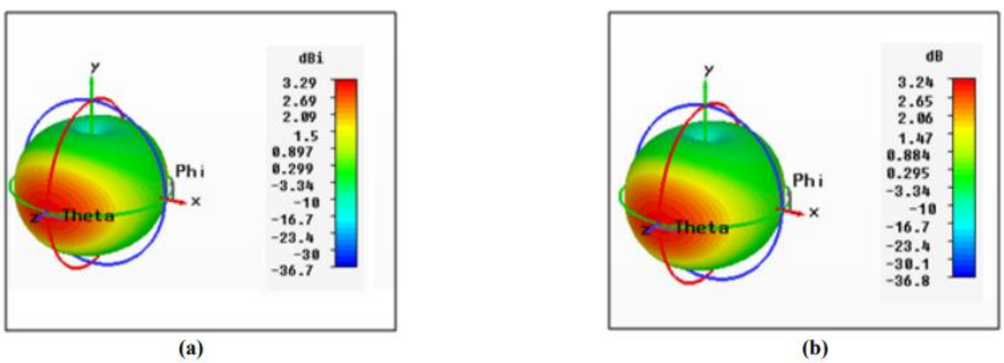

Fig 3: Far Field parameters of the proposed antenna

IV. A Miniatured CSRR Antennas

The element's size and structure are depicted in Figure 4.b. Its conductor is made on a cheap substrate with a thickness of 0.07 mm and an effective dielectric constant of 4.48.

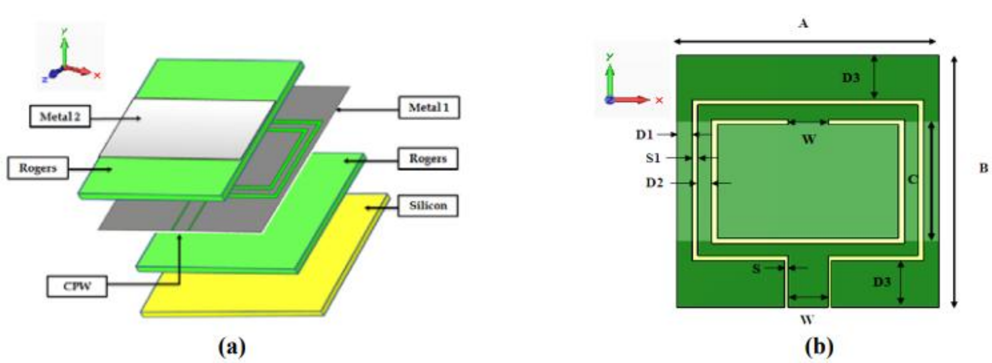

Fig 4: Geometry of the proposed antenna (All dimensions in µm)

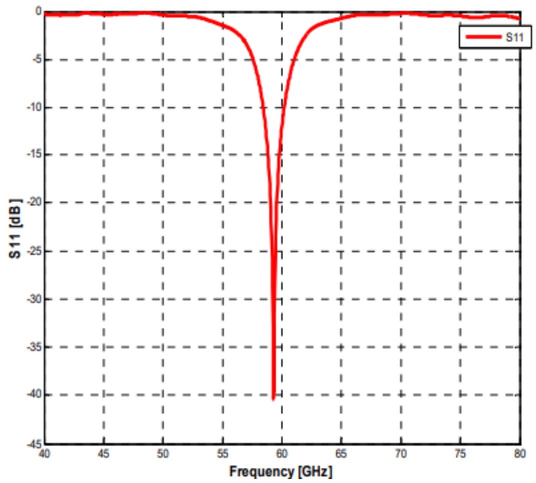

Fig 5: Simulated reflection coefficient for the proposed antenna with parasitic antenna

Figure 6 shows that the simulated antenna offers a suitable gain and directivity for the required application.

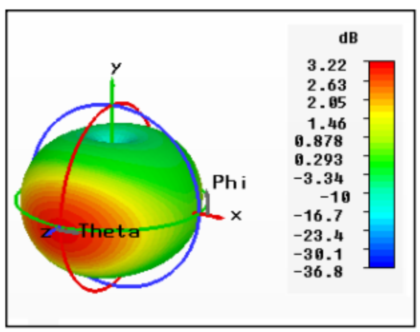

Fig 6: Simulated gain of proposed antenna

V. Conclusion

This study develops a 50 GHz miniaturized antenna. The resulting antenna is the result of combining two methods: via-hole insertion and parasitic element. Additionally, the antenna has a reasonable impedance and an appropriate gain. For a future MMID application, the innovative antenna might be the ideal option. One of the initial steps in MMID is this study, and we hope to utilize our antenna in MMID TAG Chip-Less in the future.

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