Wearable UHF RFID Tag Antenna based Meta-material

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***Abstract*—** This paper presents a RFID tag antenna application can be worn for personal use by people with a mobile phone or smartwatch. It can identify and track tags attached to an object. The main drawback of the UHF RFID tag antenna is the large size of the antenna. In this paper, this research is to develop a wearable RFID application that is flexible, compact, low-cost, and suitable for the human body. The study's main goal is to design, build, and test a small and flexible RFID wristband tag antenna with UHF RFID operating frequency at 910 MHz. The result shows a good radiation pattern and an almost ideal VSWR which 1.09. Thus, a wearable UHF RFID tag antenna is designed with a gain of -11.87 dB for bending analysis. The tag features a meander dipole antenna with two square split-ring resonators (SRR) cells. A meander dipole antenna with two square split-ring resonators (SRR) cells is featured on the tag. It's built on a 0.277mm thick photo paper substrate with a dielectric constant of 3.2 and a loss tangent of 0.05. The proposed antenna is then combined with an RFID tag (NXP SL3S1213 UCODE G2iL chip) with an impedance of 23-j224 to evaluate its performance in terms of reflection coefficient, antenna gain, and maximum reading range. The overall size of the antenna tag dimensions is 117 mm x 26 mm.

Keywords— Antenna and Propagation, UHF RFID tag, wearable RFID, metamaterial.

I. Introduction

RFID is a radio frequency technology used for auto identification on objects. Charles Walton was one of the first owners of the system, which consists of two components: readers and tags. It uses electromagnetic energy to automatically identify and monitor data in thousands of applications. There are four types of frequency bands used, with the cost efficiency being slightly lower than barcode technology. RFID applications have been enhanced to the wireless body area network and there is interest in wearable and textile antennas. The human or body-worn recognition application is a trending RFID application due to the electrical properties of the body. Ideas have been suggested to enhance the performance.

II. Antenna Design

A. RFID Tag Antenna

The basic antenna structure is shown in Fig.1 which is (a) is the front view of proposed antenna and (b) is the metamaterial unit cell structure with split ring resonator embedded in a TEM waveguide. The dimension of the tag antenna is 76.6 mm x 25 mm x 0.25 mm which consists of two layer which are silver trace and HP photo paper. In the silver trace layer formed several structures, shows a double T-match (red) and a meander line (blue) A chip from NCP Semiconductor will attached at the center of silver trace and will be present as discrete port in CST Simulation software. This antenna will design to operate in the frequency range of 860 – 960 MHz.

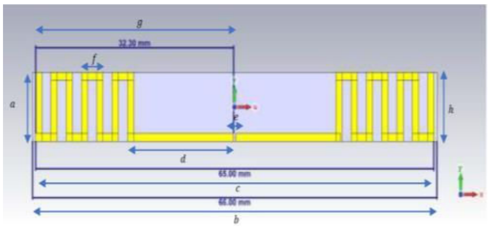


Fig. 1. Proposed RFID tag antenna

TABLE I. Parameters and dimensions of tag antenna

Parameter	Dimension (mm)
Width of substrate, yd	10
Length of substrate, xd	400
Thickness of substrate, h	0.27
Width of conductive, ys	2.5
Length of conductive, xs	329.7
Thickness of conductive, t	0.0025

The simulated reflection coefficient (S11) of tag antenna is shown in Fig 2. the S11 parameters lie in the desired frequency in the range of acceptable performance.

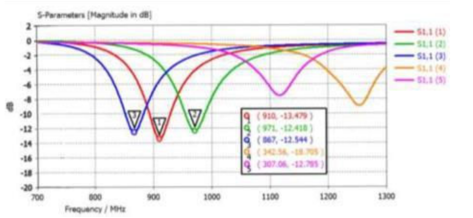


Fig. 2. Simulated magnitude of S11 graph overall parameter sweep from 700 – 1300 MHz for the proposed tag antenna.

B. Square Split Ring Resonator Design

The modeling of the proposed left-handed metamaterial unit cell will be described in this section. To begin, the traditional square split ring resonators have a negative permeability at the UHF band, as illustrated in Figure 3, and the dimensions of the metamaterial unit cell are described in Table 2. An HP photopaper with a total dimension of 26 mm x 26 mm, a permittivity of 3.2, a loss tangent of 0.005, and a thickness of 0.0027mm was utilized as the substrate. The square SRR on the same face of the substrate is then loaded with a thin wire that has a double negative permittivity.

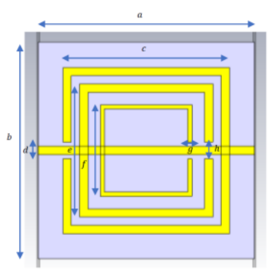


Fig. 3. Proposed metamaterial unit cell structure

TABLE II. Parameters and dimension of square SRR design

Parameter	Dimension (mm)
a	26
b	26
c	20
d	1
e	16
f	11
g	0.5
h	2

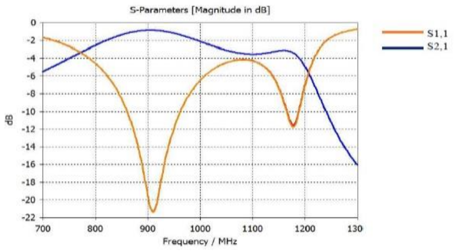


Fig. 4. S_{11} and S_{21} results oof DNG SRR unit cell in dB.

C. Integration of Tag Antenna with Square SRRs

The schematic of the tag antenna design with two Square SRR elements, one at each end of the meander line, is shown in Fig. 5. This new structure has the same thickness and is 117 mm x 26 mm overall.

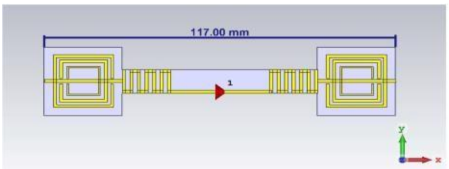


Fig. 5. Overview of Meander Dipole Antenna

III. RESULTS AND DISCUSSIONS

The main parameter in any antenna study is the reflection coefficient, also known as S11 magnitude. A good antenna should have a reflection coefficient of less than -10dB to absorb more than 90% of the feed power. The antenna's size and shape are proportional to the desired frequency, and the simulation resulted in a small rise in frequency to 936.4 MHz. This is permissible because the tag still functions in the UHF band.

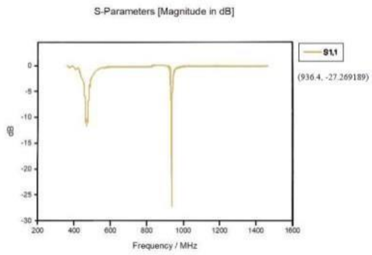
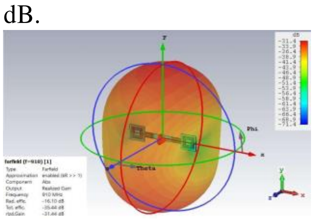
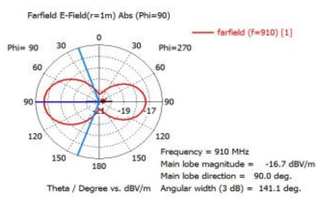


Fig. 6. Simulation of S11 result.

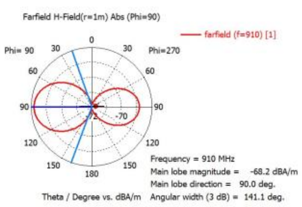
The E and H plane is the antenna performance, with an omni-directional radiation pattern at 910 MHz with farfield gain of -11.87 dB and main lobe direction of -11.9 dB.



(a)



(b)



(c)

Figure 7 (a)Radiation pattern for 910 MHz UHF RFID tag antenna integration with metamaterial (b)Simulated E-Field pattern at 910 MHz (c)Simulated H-Field pattern at 910 MHz.

IV. CONCLUSION

This research focused on passive RFID tag antenna design for the 910 MHz UHF frequency band. Performance and bending of the tag were studied using simulated and real reflection coefficients. The tag prototype is low-cost, small-in-size, and simple to make. Further study can be made on different bending conditions.

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