Compact Quasi-Yagi Antenna Loaded with Artificial Transmission Lines for RFID applications

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***Abstract*— A compact omnidirectional printed patch dipole antenna for RFID applications is presented. To reduce the size of the antenna, the radiating elements of the quasi-Yagi antenna is loaded by Artificial Transmission Line (ATL). The proposed antenna operates at 915 MHz with 66% size reduction. Finally, the designed RFID antenna is fabricated and tested. The experimental data are in good agreement with the simulation results.**

I. INTRODUCTION

Radio Frequency Identification (RFID) systems was introduced for the first time in 1930, and was investigated from 1960 to 1970 [1]. For the LF and HF RFID systems, information and power transformation is generally based on the coupling inductance. Moreover, for UHF and Microwave Frequency (MF), the communication between the reader and the tag is based on the Electromagnetic (EM) wave propagation. The two most important part of a RFID system are transponder and reader [2].

An extensive research and development has been done to improve the antennas for RFID applications. A microstrip patch antenna has been introduced in [3]. Moreover Yagi antennas has been introduced for RFID application in [4]. Loop antenna for near field RFID readers is another option[5]. In some other articles, dipole antennas has been introduced as RFID antenna that are too large for some practical applications.

In this paper, a compact omnidirectional printed qusi-yagi antenna by loading artificial transmission line(ATL) structures has been introduced. By means of quasi-lumped elements, the ATL has the ability to synthesize a variety of per unit length inductance and capacitance value of microstrip line and may therefore significantly reduced the required physical lengths of both high and low impedance lines. In the proposed antenna, a new microstrip artificial transmission line that is based on the proposed ATL in [6] is used for loading the radiating arm of the quasi-Yagi antenna. The antenna dimension is 52×77mm with 0.1 λ_g for arm's length that is 60% shorter than an ordinary type with 0.25 λ_g length. In the below, at first a unit cell of ATL is surveyed and then the antenna design method is proposed.

II. ARTIFICIAL TRANSMISSION LINE

A unit cell of artificial transmission line and the its equivalent lumped circuit model is shown in the Fig.1.

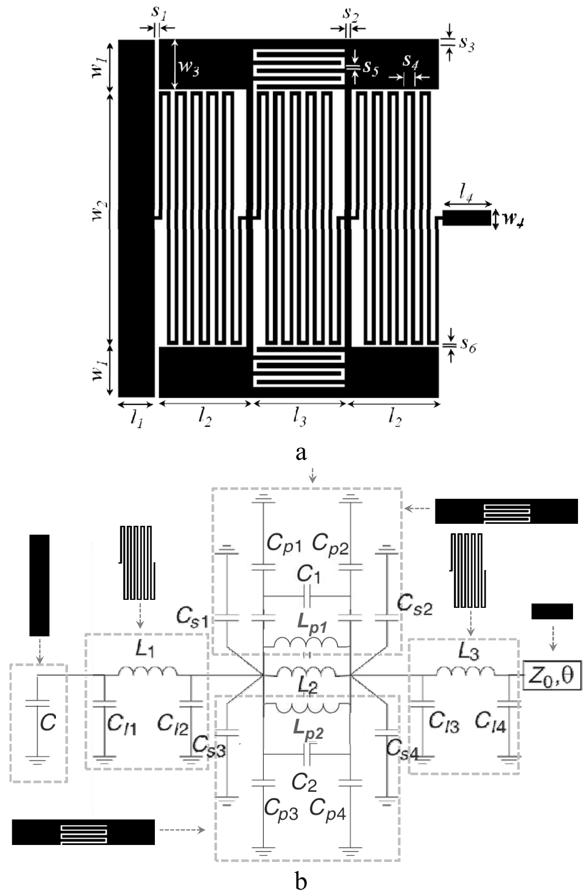

Fig.1. Unit Cell of Artificial transmission line a) Circuit Layout b) Equivalent lumped circuit model

The relationship between the parameters of equivalent impedance, wave guided number, inductance, and capacitances are described as below.

$$Z_{0,ATL} = \sqrt{L_{ATL}/C_{ATL}} \tag{1}$$

$$\beta_{g,ATL} = \omega\sqrt{L_{ATL}.C_{ATL}} \tag{2}$$

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where

$$L_{ATL} = L_1 + L_2 + L_3 \tag{3}$$

$$C_{ATL} = C_{l1} + C_{l2} + C_{l3} + C_{l4} + C_{p1} + C_{p2} + C_{p3} + C_{p4} + C_{s1} + C_{s2} + C_{s3} + C_{s4} \tag{4}$$

Obviously, if L_{ATL} and C_{ATL} increase proportionally, then the wave guided number can be increased efficiently. However, the characteristic impedance remains unchanged, and this is equals to the increase of wave number, β_g, and the decrease of physical length - required for the line- for the that particular electrical length and characteristic impedance.

III. ANTENNA DESIGN

The proposed quasi-Yagi antenna is shown in the Fig.3. The radiating arms on the top and bottom are loaded by the introduced artificial transmission line. The HFSS simulation software was used for tuning the value of parameters to match the antenna input impedance in the 915MHz with the reduced length 0.1 λ_g.

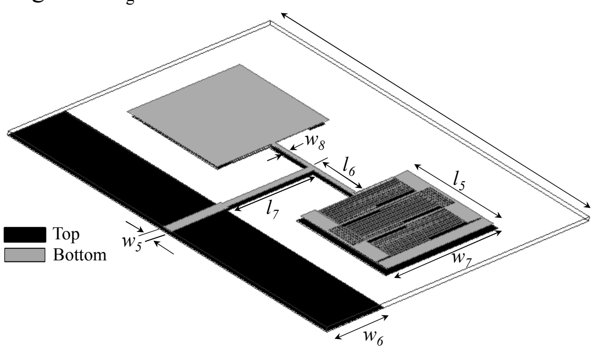

Fig. 2. The prospective view of proposed antenna by ATL

The RO4003™ with Height=0.8mm and εr=3.35 is considered for simulation and fabrication. The final dimension on the substrate is 52×77 mm, and the designing parameters are: w1=3.2, w2=9.5, w3=9.7, w4=0.93, w5=1.8, w6=12, w7=23.5, w8=1.25, S1=0.2, S2=0.4, S3=0.25, S4=0.3, S5=0.25, S6=0.25, l1=2.3, l2=5.9, l3=5.9, l4=6.1, l5=21, l6=8.29, l7=11.5 (mm).

I. SIMULATION AND MEASUREMENT

Fig. 3 shows the manufactured antenna printed on the RO4003 substrate. The antenna has an omnidirectional pattern in the elevation direction (H-Plane) that is useful for RFID application.

The comparison of the simulation and measurement S11 of antenna is shown in Fig.4. The antenna has a good matching in the RFID frequency, 915MHz. Moreover, the H-plane radiation pattern the fabricated antenna in 915MHz is plotted in the Fig.5. A good agreement is observed between the full-wave simulation and measured results for the proposed antenna.

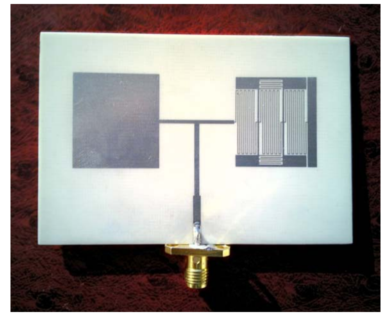

Fig.3. The fabricated antenna

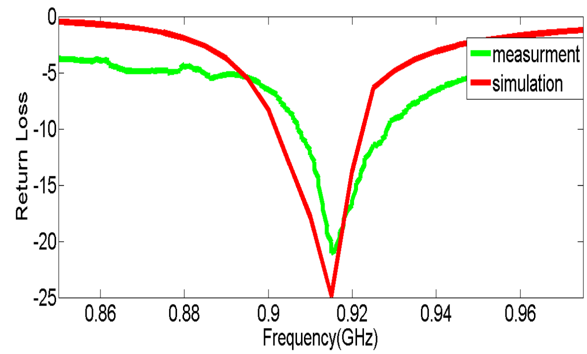

Fig. 4. The measured and simulated return loss of antenna

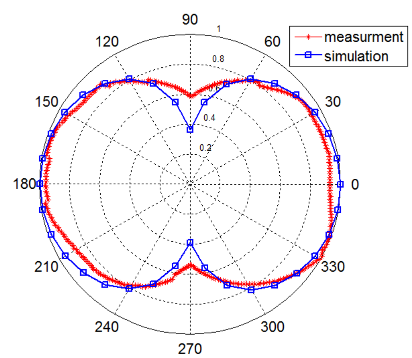

Fig.5. The measured and simulated radiation patterns of the antenna in 915MHz for H-plane

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