

Design of Nested H slot Passive UHF RFID Tag



SudhaSurwase, Ravi Yadahalli, Shankar Nawale

Abstract— RFID is a short distance communication system which comprises of a RFID tag, a RFID reader and a personal computer with desired software that can maintain the related information. These RFID tags can be of active or passive types. This paper focuses on design, simulation and fabrication of passive ultra-high frequency RFID tag (microchip and an antenna) which resonates at the frequency 866 MHz in the Industrial Scientific Medical Band. The nested H-slot inverted-F microstrip antenna structure is used for the design of passive RFID tag. It examines the specific tag geometry and its characteristics to optimize the PIFA antenna and in turn RFID tag’s performance.

Keywords—Impedance, PIFA, RFID tag, UHF

I. INTRODUCTION

The most simplest and straightforward approach for (Radio Frequency Identification) RFID communication is the near field coupling and has components as shown in fig.1 but has drawback that as the frequency increases, the range over which communication may happen between reader and tag decreases. In the mid-21st century, RFID tags with smaller size were implemented and advancements in the IC technology were in its boom. The number of components was reduced to two, a single CMOS IC and an antenna. Thus, it results in the emerging of RFID tags with different shapes and characteristics. The RFID technology assigns a unique identifier to each product and allows significant development in wireless monitoring and control applications. The UHF RFID uses backscattering communication. The backscattering coupling uses electromagnetic waves and inductive coupling uses magnetic field to exchange data between tag and reader [2]. The RFID reader generates an electro-magnetic field which induces a current into the tag’s antenna. The current is used to power the chip. In passive tags the current also charges a condenser which assures uninterrupted power for the chip. Hence, RFID communication becomes the noncontact, non-line-of-sight communication, the long distance can be covered with high-speed reading, and other advantages make the UHF

RFID becoming the most popular automatic identification technology around the world. The important characteristics of RFID systems are the operating frequency and the resulting range of the system. The frequency at which the reader transmits is the operating frequency of an RFID system. The transmission frequency of the transponder is disregarded [1]. In most cases it is the same as the transmission frequency of the reader (load modulation, backscatter). However, the transponder’s ‘transmitting power’ may be set several powers of ten lower than that of the reader [1].

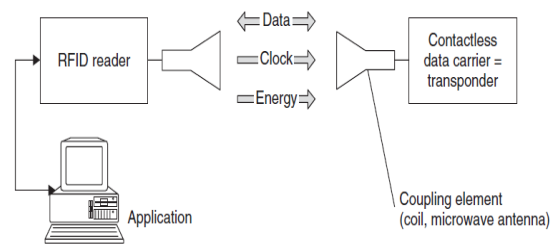


Fig.1: Components of RFID systems [1]

II. RFID TAGS AND ANTENNAS

A. ACTIVE AND PASSIVE TAGS

An essential and very important feature of RFID systems is the power supply to the transponder (antenna). Passive transponders do not have their own power supply, and therefore all power required for the operation of a passive transponder must be drawn from the (electrical/magnetic) field of the reader. Table 1 below shows the comparison of active and passive tags.

TABLE.1. COMPARISON OF ACTIVE AND PASSIVE TAGS [3]

	Active	Passive
Signal Strength	Stronger	Weaker
Signal availability	Always on	Responds when read
Size	Larger	Smaller
Initial cost	Higher	Lower
Maintenance	Replace every 2–3 years	Indefinite lifetime
Environment	Available for all environments	Available for all environments

By comparing, the cost of active tags is much higher than the passive tags. The signal availability as ‘always on’ for the active tags, adds to its higher cost.

B. PLANAR INVERTED F ANTENNAS

A shorted patch antenna fed by an aperture-coupled feed is a promising design for achieving broadband operation [2]. As shown in fig.2, there is a H shaped coupling slot and a patch of width W and length L shorted to the ground plane.

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The size of a planar inverted F antenna can be determined approximately from equation [3]

$$f_0 = \frac{C}{4(W + L)} \dots \dots \dots (1)$$

Where, C is the velocity of light and f_0 is operating frequency

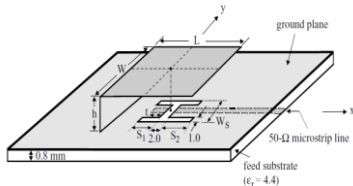


Fig. 2: Geometry of Broadband aperture coupled shorted patch antenna [2]

III. IMPEDANCE MATCHING AND SIZE REDUCTION IN PIFA ANTENNAS

Two size reduction strategies can be used successfully to design RFID tags: meandering and inverted-F structures.

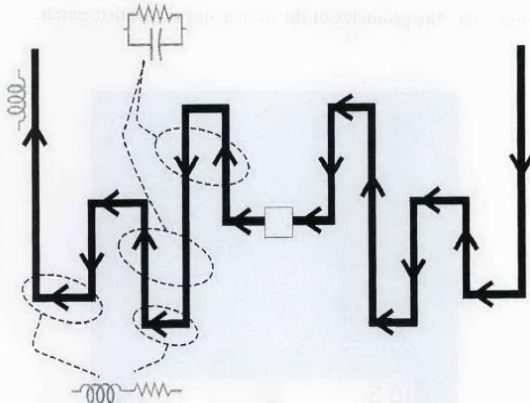


Fig. 3. Meander line antenna with unequal turns affects the inductance [5]

Both require a single or even multiple folding of the radiating body. Fig. 3 shows the meandered antenna with unequal turns which can be used to increase the gain. The inverted-F antennas additionally include a finite approximation of a ground plane as shown in fig.4 [5].

The nested slot can be used for the impedance matching. Due to the inductive reactance of a nonresonant slot, the feeding strategy has the relevant capability of complex impedance matching, even when the tag is attached onto a high-permittivity substrate[5]. The discontinuity in the structure provides energy storage. The antenna impedance can be changed by changing the aspect ratio i.e. parameters ‘a’ and ‘b’ (the dimensions of the slot).

Fig. 5 shows the Qualitative behavior of antenna impedance, chip impedance, and read range as functions of frequency for a typical RFID tag [6]. The tag resonates at the frequency over which peak is obtained and bandwidth is the range of frequency over which tag offers minimum read range.

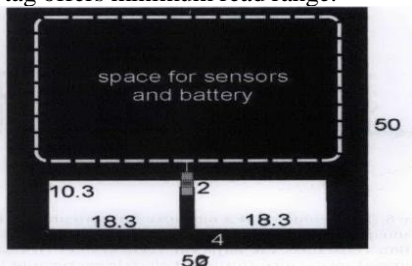


Fig. 4: An example of RFID tag for better impedance matching[5]

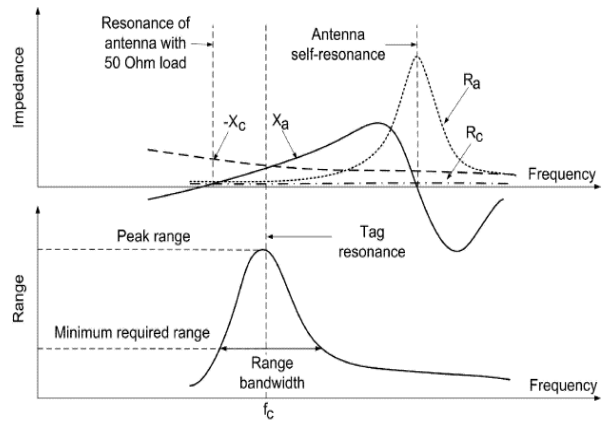


Fig. 5. Antenna impedance, chip impedance, and readrange as functions of frequency for a typical RFID tag

IV. THE PROPOSED METHODOLOGY

The passive RFID tag antenna is simulated using CST Studio. The dimensions of the tag antenna are decided based on the relations as given by [7].

TABLE- II : DESIGN PARAMETER LIST

Parameter	Dimensions in mm
s1	5
lg	60
s2	2
a	15
l	52.5
g	1.5
b	5
p	14
wg	60
ld	7.5
a1	9
a2	3
s	10
t	0.05
hs	4

The length of the patch is decided as $\lambda_{eff}/4$ where λ_{eff} is the effective wavelength obtained from ϵ_{eff} . Fig. 6 shows the perspective view of the antenna which is simulated using CST microwave studio.

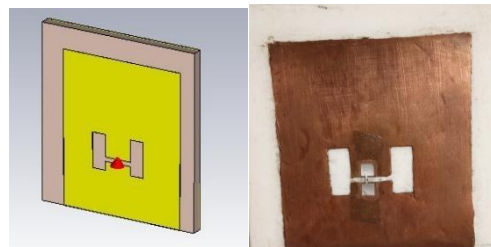


Fig. 6: Perspective view of simulated antenna and the fabricated antenna

The adhesive Copper sheet with thickness 0.05mm in actual fabrication is folded from the ground plane to the front side.

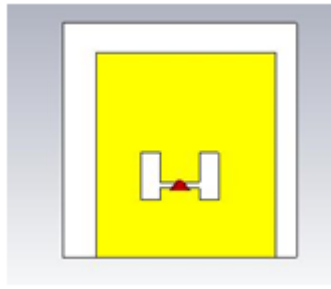


Fig. 7(a): Front view of simulated antenna

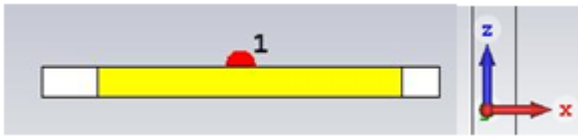


Fig. 7(b): Bottom view of designed tag

Fig. 7(a) and Fig. 7(b) shows the front and bottom view of the RFID tag simulated using CST microwave studio. The PIFA fold is as shown in the bottom view of the designed tag. As per the maximum power transfer theorem, the RFID antenna impedance should be matched to the microchip impedance which is generally capacitive in nature.

V. RESULT ANALYSIS

The antenna impedance is thus complex conjugate of the microchip impedance to assure maximum range. The designed RFID antenna has real part of impedance as 12.94 and imaginary part of impedance as 142.75 ohms as shown in fig. 8(a) and 8(b) respectively at 866 MHz.

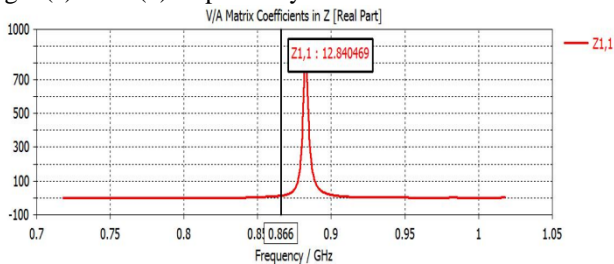


Fig. 8(a): Real part of impedance

The impedance of the tag can be varied by changing the various parameters as p

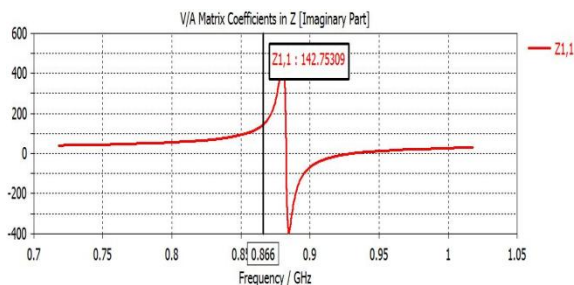


Fig. 8(b): Imaginary part of impedance

(the distance of lower section of centre slot to the PIFA fold), a1, a2 (the vertical dimensions of the tag above and below the centre slot) and b (the width of the slot i.e. Distance between the centre of microchip slot to the H slot width) [8]. The experimental work has been performed by varying the tag parameters. The parameter 'a' and 'b' are varied and corresponding tag impedance is noted. It has been found that with the decrease in dimensions 'a' and 'b' of the tag antenna, the impedance of the antenna also decreases as in fig. 9.

Table- III: Effect on impedance by varying tag parameters

Variation in 'a'	Impedance	
	Real	Imaginary
a=22	7.32	168.64
a=20	5.54	145.26
a=18	3.51	125.93
Variation in 'b'	Impedance	
	Real	Imaginary
b=14	207.57	796.23
b=12	14.64	199.74
b=10	3.76	125.62

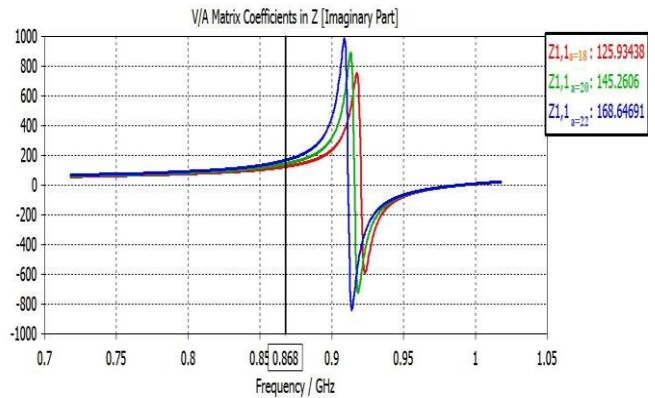


Fig. 9: Impedance variations by varying tag dimensions 'a'

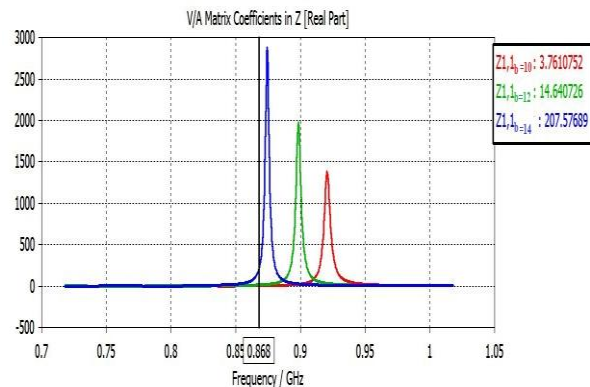


Fig. 10: Impedance variations by varying tag dimensions 'b'

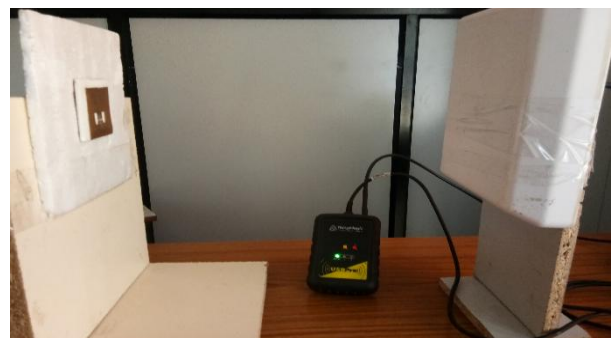


Fig. 11: Experimental Setup for antenna measurements

The experimental set up as shown in fig. 11 was used to take the antenna measurements. The communication between the RFID reader and RFID tag takes place at 866MHz.

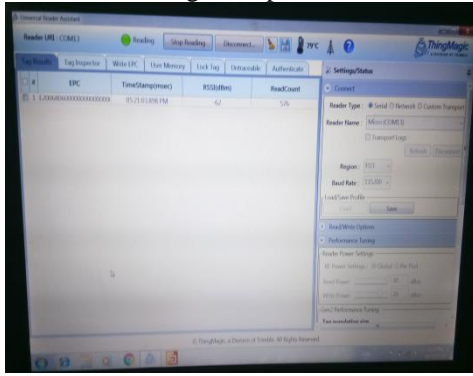


Fig. 12: Tag read by the Thingmagic universal software

An external antenna is used along with the UHF RFID reader to increase the read range. Fig. 12 shows the RSSI reading for the designed tag. More variations in the background and distance of the tag from the reader can be made to have precise results.

VI. CONCLUSION

The PIFA structure design considerations for RFID tag are discussed in this paper. Prior to the actual fabrication of the PIFA antenna, simulation of the RFID tag antenna is done to get the proper impedance matching of the antenna with the microchip impedance. Finally the fabricated antenna with the same dimensions is presented. The ground plane separates the antenna from its location, is more suitable to environmental and body-centric applications.

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