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The Adaptation of a Microstrip Dipole Antenna for RFID Applications

Loubna Berrich, Lahbib Zenkouar

***Abstract:** Radio frequency identification (Radio Frequency Identification) is a technology used primarily to identify tagged objects or to track their locations. An RFID tag is composed of integrated circuit. To design the antennas, it is necessary that the antenna must have an impedance value equal to the conjugate of the impedance of the IC to have a good adaptation allowing the maximum transfer of power. For the implementation of the impedance matching, there are several techniques. In this work, we are interested in the technique of adaptation T-match and the technique of adaptation by coupling. The T-match technique is based on the insertion of a second folded dipole at the center of the first dipole. This technique is modeled by an equivalent circuit to be able to calculate the dimension of the folded dipole to have a new input impedance of the antenna equal to the conjugate of the impedance of the integrated circuit. The second technique is based on the supply of the dipole via a small loop with inductive coupling placed in close proximity to the radiating body. The software used in this work is the Ansoft HFSS software which is based on the finite element method (FEM). The results obtained are* **satisfactory** *with a reflection coefficient that exceeds -22 dB.*

***Index Terms**: Microruban Dipole Antenna, RFID, Tag.*

I. INTRODUCTION

The identification technology by radio frequency (RFID) was used for the first time during Second World War: Germany, Japan, United States and United Kingdom forces used radar that should send a signal integrating airplane's tags to distinguish the allied forces by the enemies. The first secure system identifying the friend and the foe (IFF) was the first form of RFID's technology. The 1950's was a historical era of exploration of RFID's technique as a continuity of the technical evolution of Radio and radar in 1930's and 1940's. In 1948, Stockman (Stockman.1948) proposed the identification from distance. He defended that it is possible to vary the amount of reflected power (also called load modulation antenna) by the alternation of the load of the tag antenna and consequently it has a modulation. Identification by radio frequency, known as RFID, is a smart technology that is very performed, flexible and more suitable to automatic operations. RFID is an automatic identification method using radio waves to read the data contained in the devices called tags RFID.

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It granted the non available advantages with other identification's technology like barcodes. The advantages of RFID are the following: it can be provided by reading only, or by reading and writing, contactless, it can function under a variety of environmental conditions, Allows storing a large amount of information and provides a high level of security. RFID technology is used for, identifying, and following objects, animals and people from distance by using radio waves. RFID tags are more expensive than barcodes, but the relationship "benefit-cost" is generally favorable. RFID system is composed by two main devices: RFID tag (label) and RFID reader (Base station). Today, this technology is used in access controls, distant payment system, security of means of transport, tracking both animals and patients in hospitals and other applications. Each country has its proper attributions of RFID's frequencies at the international level. RFID's tag is generally composed by integrated circuits IC and by an antenna. Tag antennas generally used are the right dipole or meandering dipole, their input impedances are very resistive and less reactive, and on the other hand the impedance of the equivalent circuits is very reactive and less resistive. To design antennas it is necessary that the antenna must have an impedance value equal to the conjugate of the impedance of the circuit equivalent to have a good adaptation allowing the maximum transfer of power. In this work, we are interested in the technique of adaptation T-match and the technique of adaptation by coupling. The T-match technique is based on the insertion of a second folded dipole at the center of the first dipole. This technique is modeled by an equivalent circuit to be able to calculate the dimension of the folded dipole to have a new input impedance of the antenna equal to the conjugate of the impedance of the integrated circuit. The second technique is based on the supply of the dipole via a small loop with inductive coupling placed in close proximity to the radiating body.

II. THE TECHNICAL T-MATCH

T-match is a technique of impedance matching of the microstrip dipoles antennas, with this method, the planar dipole with length l and width w is connected to a second planar dipole with length l' such as (l'< l) and width w', placed at a distance (s) from the first dipole center (figure 1(a)). This second dipole is considered a folded dipole two-leged. T-match behaves like the equivalent circuit, represented on (figure.1 (b)). It can be proven that the impedance at the antenna point source is given by:

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$$Z_{in} = R_{in} + jX_{in} = \frac{2Z_t\,[(1+\alpha)^2 Z_a]}{2Z_t + [(1+\alpha)^2 Z_a]} \quad (1)$$

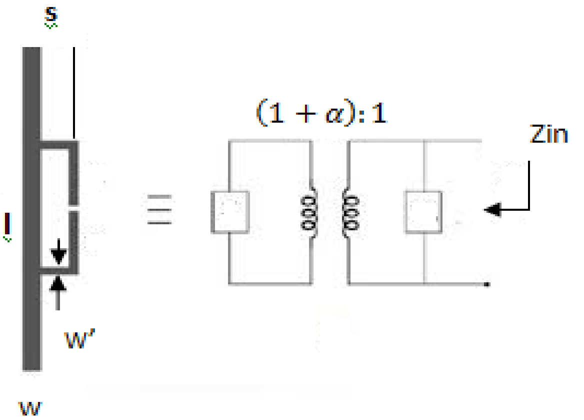
Or

$\alpha = \frac{ln(s/r_{e'})}{ln(s/r_e)}$ is the current division factor between the two

Conductors of length s, with re=0.25w et re′=0.25w′.

$Z_t = jZ_0 \tan\left(\frac{Kl'}{2}\right)$ is the impedance of short stub input,

formed by the transmission line of two conductors of length l'/2, width w and w' and the separation s (fig.2), with K= $2\pi/\lambda$ is the wave number, $Z_0 \cong 276 log_{10}\left(\frac{s}{\sqrt{r_e r_{e'}}}\right)$ is the characteristic of the two-conductor transmission line impedance .



(a) (b)

Fig. 1. T-Match. (a) For a Planar Dipole (b) The Equivalent Circuit.

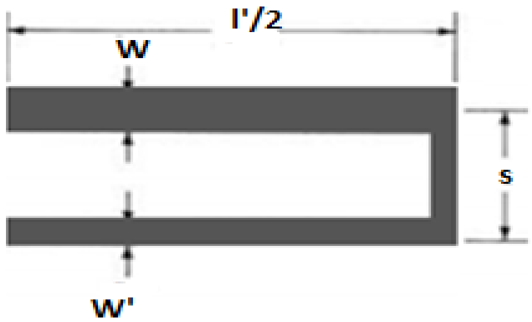


Fig. 2. Short-Circuit Formed by the Transmission Line of two Conductors of Length « l'/2 », width "w", "w'" 'and the Separation "s".

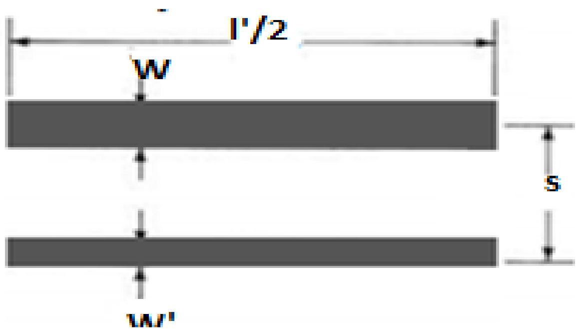


Fig. 3. Transmission Line has Two Conductors

The geometrical parameters, l', s and w' of T-match, can be adjested to have an antenna input impedance Zin equal to the conjugate of the impedance of integrated circuit Zlc. For this we have designed a planar half-wave dipole antenna with T-match using the platform Ansoft HFSS.

III. THE INDUCTIVE LOOP ADAPTATION TECHNIQUE

Instead of the T-match technique, the radiating dipole may be powered by a small inductively coupled loop, placed in close proximity to the radiating body (FIG. 4). The terminals of the loop are directly connected to the chip. This arrangement adds equivalent inductance in the antenna. The coupling force W, therefore the added reactance is controlled by the distance between the loop and the radiating body, as well as by the shape factor of the loop.

The inductive coupling can be modeled by a transformer, and the resultant input impedance seen from the terminals of the loop is:

$$Z_{in} = Z_{loop} + \frac{(2\pi f M)^2}{Z_A} \quad (2)$$

$Z_{loop} = j\,2\pi f\,L_{loop}$ is the input impedance of the inductive loop.

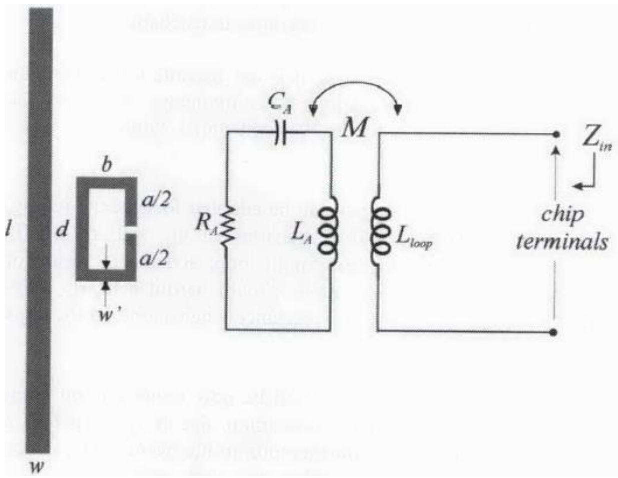


Fig. 4. The Inductive Loop Technique and the Equivalent Circuit

IV. SIMULATIONS & RESULTS

A. The Technical T-match

Figure (6) shows the antenna proposed for this work. This is the design of the planar half-wave dipole antenna adapted by the T-match technique. With the dipole dimensions are L = 78mm and a width w = 2 mm, we add to the preceding dipole a second dipole folded with two legs, as illustrated in (figure 6), such that l '= 10 mm, w' =1 mm. The antenna operates at 2.45 GHz resonant frequency. The substrate was chosen as epoxy FR4 having a relative permittivity εr = 4.6, and a height is 0.7 mm.

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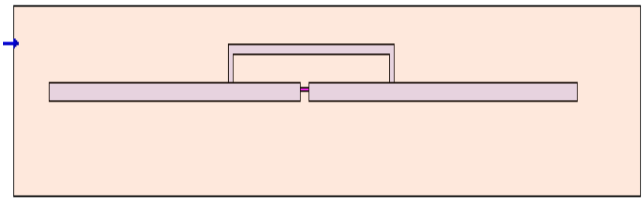


Fig. 5. Planar Dipole Antenna Adapted with T-match Technique

The simulation of this antenna with the software Ansoft HFSS gives the following results:

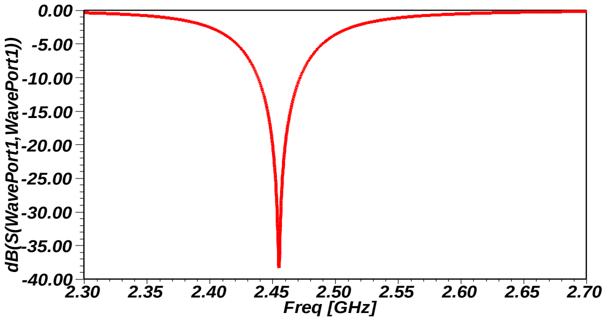


Fig. 6. Return Loss of the Antenna Adapted with the T-match

The shape of this curve shows a minimal reflection at the resonant frequency is equal to -38 dB. It is also noted that the bandwidth is 300 MHz

The shape of this curve shows the SWR of our antenna SWR<2.

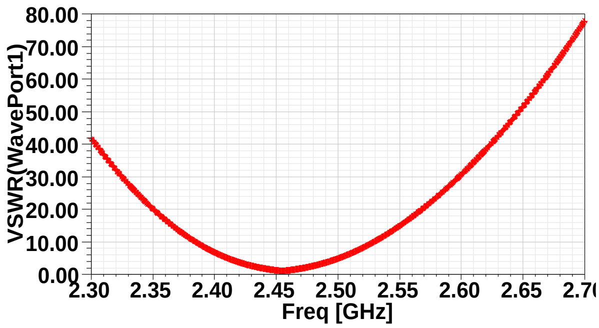


Fig. 7. SWR of the Antenna Adapted with the T-match Technique

Another primordial characteristic for knowing the parameters of the antenna is the radiation pattern in two dimensions in the E & H Plans which is illustrated in FIG. (9), which represents 2 main lobes.

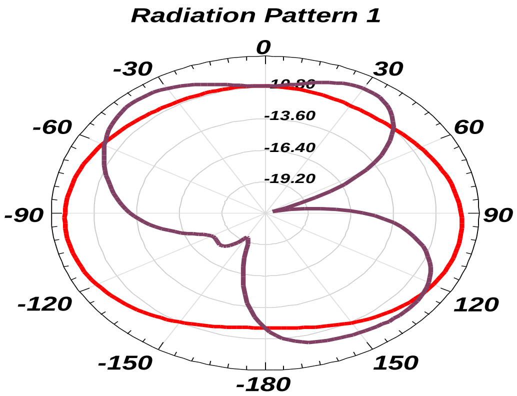


Fig. 8. Radiation Pattern

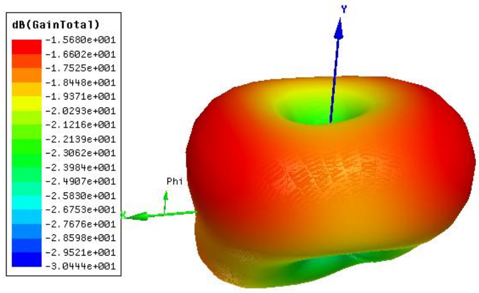


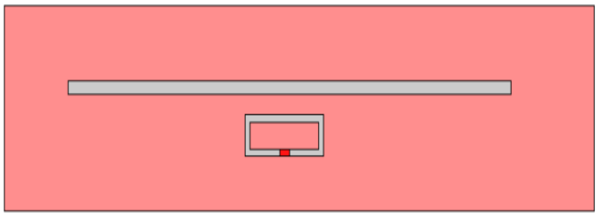
Fig. 9. 3D Radiation Diagram of the Adapted Antenna

The 3D radiation pattern shows that our antenna is omnidirectional according to the angle phi, and bidirectional according to the angle Theta.

B. Inductively Coupled Loop

For the design of the dipole antenna fed by an inductive loop, we chose the same type of materials.

Figure (11) shows the dipole antenna fed by an inductive loop, which operates at the frequency 5.8 GHz.



Figu. 10. Planar Dipole Antenna Adapted with Inductive Loop Technique

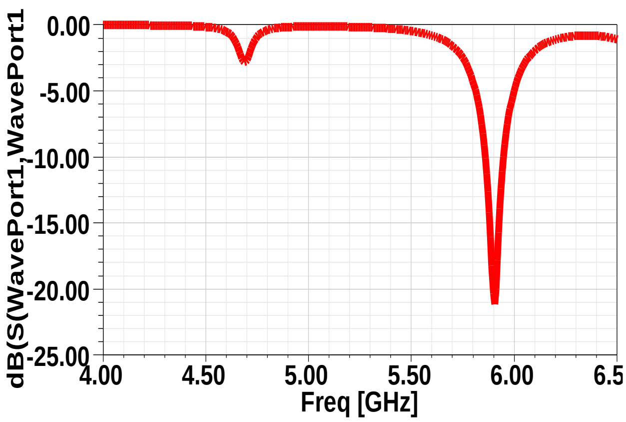


Fig. 11. Return Loss of the Antenna Fed by an Inductive Loop

The shape of this curve shows a return loss at the resonant frequency equal to -22 dB. As we also note that the bandwidth is 300 MHZ.

The shape of this curve shows the SWR of our antenna. SWR<2

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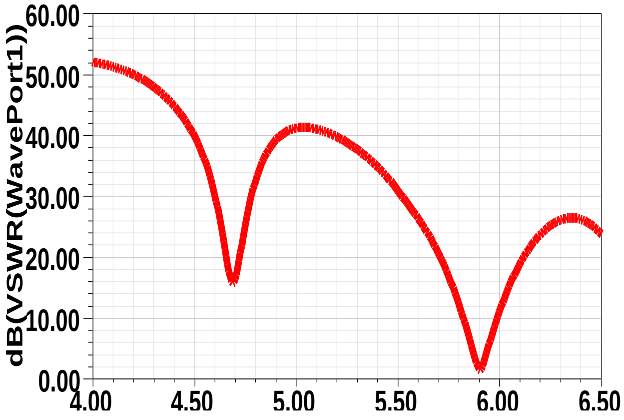

Fig. 12. SWR of the Antenna Fed by an Inductive Loop

The 3D radiation diagram shows that our antenna is omnidirectional according to the angle phi, and bidirectional according to the angle Theta.

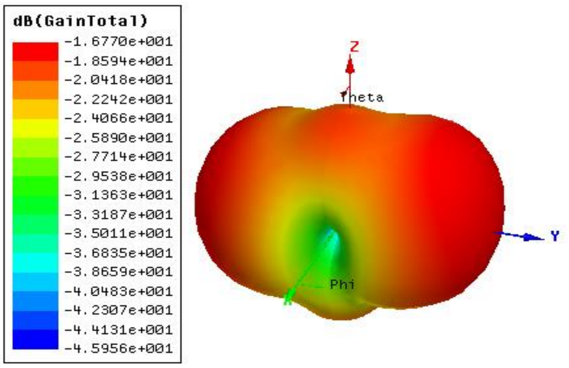

Fig. 13. 3D Radiation Diagram

Another primordial character to know the parameters of the antenna is radiation pattern in the Planes E and Plan H which is illustrated in the figure (15), which represents 2 main lobes.

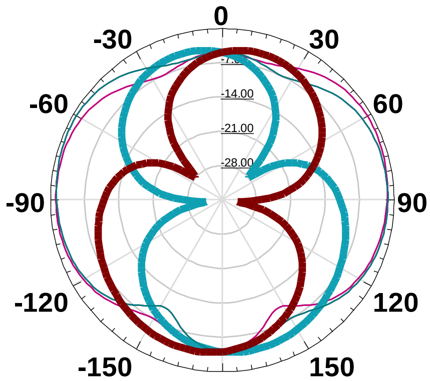

Fig. 14. Radiation Pattern

V. CONCLUSION

In the current article, we have presented two techniques for adapting dipole microstrip antennas. We studied and designed the T-Match technique at 2.45 GHZ, which is based on the insertion of a second folded dipole at the center of the first dipole. This technique is modeled by an equivalent circuit to be able to calculate the dimension of the folded dipole, in order to have a new input impedance of the antenna equal to the conjugate of the impedance of the equivalent circuit. A second study on another type of adaptation is inductively coupled loop at 5.8 GHz, which is based on the dipole feed via a small loop with inductive coupling, placed in close proximity to the radiating body. The software used in this work is the Ansoft HFSS software which is based on the finite element method (FEM). The results obtained are satisfactory with a reflection coefficient that exceeds -22 dB.

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