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PIFA ANTENNA FOR RFID APPLICATION AT 5.8 GHZ

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ABSTRACT

In this paper, we presented the design and simulation of a PIFA antenna, with and without T-shaped slot, to know the influence of the slot on the chosen antenna. We chose as the resonant frequency of the antenna for RFID applications the frequency 5.8 GHz. To improve the results, we have networked two PIFA antennas with slots. The results obtained by the Ansoft HFSS software are satisfactory with a reflection coefficient that exceeds -25 dB and a very suitable gain for RFID applications.

Keyword: the antennas PIFA, RFID, slot, return loss.

1. 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. 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's antennas generally used are rectangular or circular microstrip antennas powered by microstrip inset feed line, thanks to their low cost and small size.

The purpose of this article is to design a PIFA antenna with a T-slot, then to compare the results obtained with simulation results of a PIFA antenna without slot. And finally to network two PIFA antennas adapted with T slots to improve the results obtained. The PIFA antennas consist of a radiating element o f length equal to the quarter wave and of a short circuit of several types: plane, tongue or wire. This structure has advantages over a traditional patch antenna: cost and ease of manufacture, reduced size, thin profile, bandwidth, SAR. The PIFA antenna is a rectangular microstrip antenna, it is mainly characterized by the presence of a plate or tongue which acts as a short circuit between the radiating patch and the ground plane: H is the height of the short circuit, w is its width and D is the distance between the short-circuit and the supply point of the patch antenna.

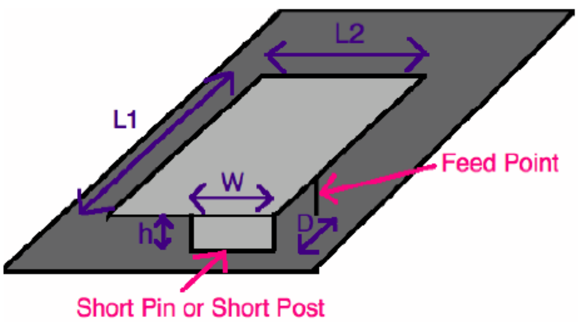

Figure-1. The PIFA antenna.

The PIFA antenna has evolved gradually from two antennas ILA and IFA in order to overcome certain limitations in its structure as shown in the Figure-2, which presents the different geometries of the inverted antennas.

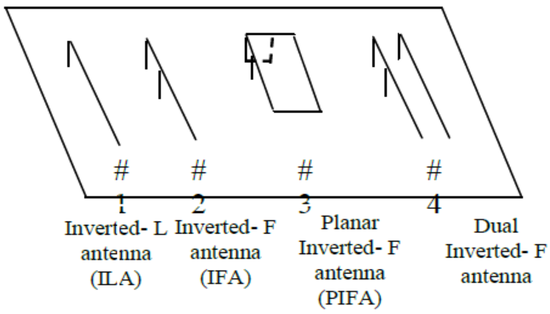

Figure-2. The different geometries of the inverted antennas.

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The ILA antenna consists of a short vertical monopole with the addition of a long horizontal arm at the top.

Its input impedance is almost equivalent to that of the short monopole with the addition of the reactance caused by the horizontal wire above the ground plane. In general, it is difficult to match the impedance to a power supply line since its input impedance consists of low resistance and high reactance.

Adding the additional inverted L element adjusts the input impedance of the antenna.

The impedance bandwidth of the IFA antenna is less than 2% on the center frequency. One way to increase the bandwidth of the IFA antenna is to replace the upper horizontal arm with a plate oriented parallel to the ground plane to form the inverted plane antenna F (PIFA). More generally called PIFA (Planar Inverted -FAntenna) in the scientific literature, they have the advantage of being compact with a wide bandwidth

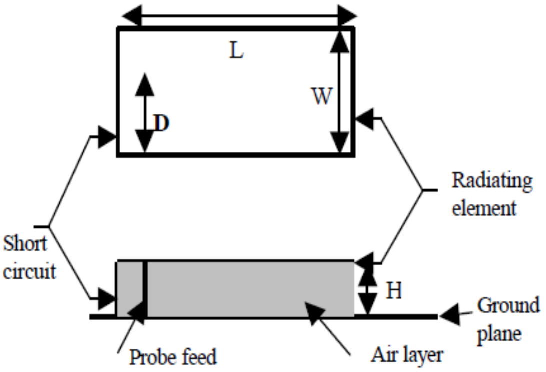

Figure-3. The PIFA antenna.

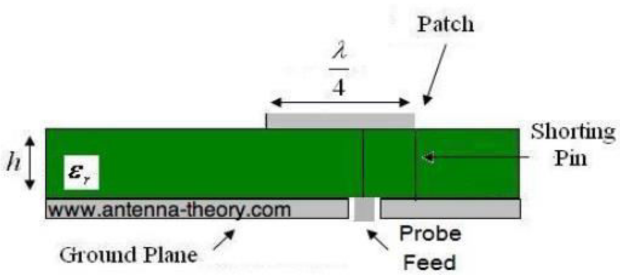

Figure-4. The PIFA antenna (side view).

The resonance frequency of a PIFA antenna is approximated by equation (1):

$$L1 + L2 - W = \frac{\lambda}{4} \quad (1)$$

With L1 and L2 the dimensions of the radiating patch, λ is the calculated wavelength for the medium separating the patch and the ground plane

2. DESCRIPTION OF ANTENNA

The antenna proposed is an antenna of a rectangular patch of a width W= 20 mm and a length L=18 mm, placed on a substrate of a width W=30 mm and of length L=30 mm using as a material FR4_epoxy characterized by a relative permittivity of 4.4, a relative permeability of 1, The tg δ of the dielectric losses = 0.02, c and a thickness e =0.7 mm. The antenna is connected to the ground plane through a tongue of a height h=10 mm and of width 10 mm.

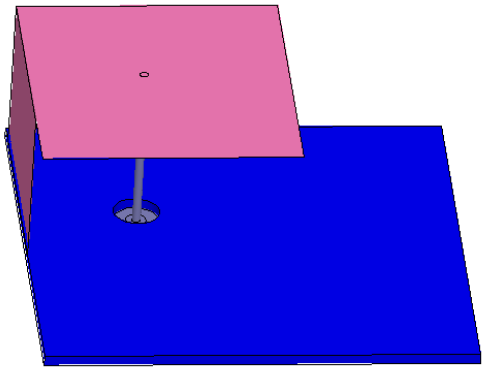

Figure-5. The structure of the PIFA antenna on HFSS.

Unlike a conventional PIFA antenna, the short circuit is not realized over the entire width of the antenna but through a plane short circuit but is a metallic tongue of width W. A T-slot with a width of 0.5 mm in the metal radiating element ensures a good match between the impedance of the chip and the input impedance of the PIFA antenna. The geometry of this antenna is shown in Figure-4.

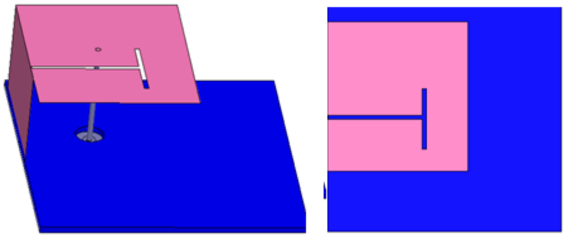

Figure-6. The structure of the PIFA antenna in slot T on HFSS (a) side view, (b) top view.

The Ansoft HFSS (High Frequency Simulator Structure) software is a very high performance microwave simulator that models and simulates in 3D the global fields radiated by microwave structures (antennas, filters, guides, connectors, PCB cards ...) and provides Characteristics for antennas like (gain, SAR, VSWR, Sij ..). It is based on the finite element model which consists in solving the equations of the field in discrete points defined in an ordered way in the complete domain of the structure. It directly solves Maxwell's equations in their differential form by replacing the differential operators by difference operators thus achieving an approximation by discretization. Simulations of PIFA antennas with and without a T-slot which resonate at the resonance frequency 5.8 GHz give as results:

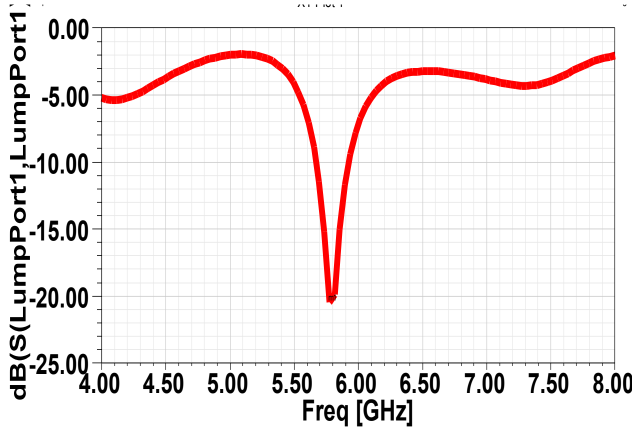

Figure-7. Return loss of antenna without slot.

Figure-7 shows the return loss of the PIFA antenna, S11 = -21dB with a bandwidth of 300 MHz

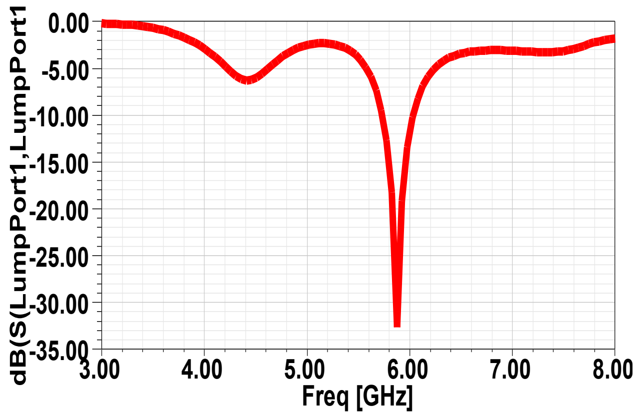

Figure-8. Return loss of antenna with T-slot.

Figure-8 shows the return loss of the PIFA antenna, S11 = -33dB.

Figure-9 shows the SWR of the PIFA antenna SWR = 1.09 <2

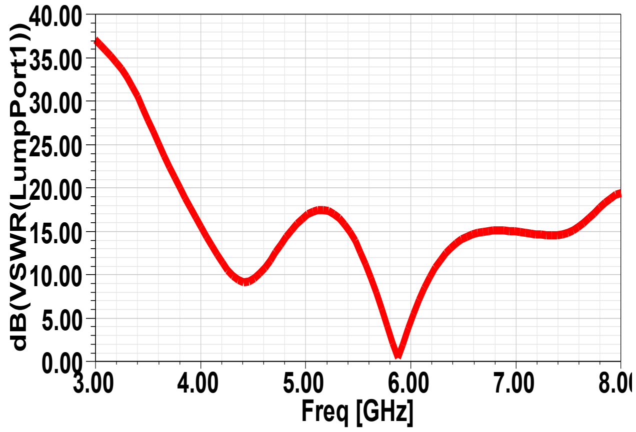

Figure-9. SWR of antenna with T-slot.

The SWR parameter of the PIFA antenna matched with a T-slot is less than 2.

For the radiation diagram in The planes E and H correspond to the planes (xz) and (yz).The results concerning the fields for Phi equal to 0 and 90 ° are given by the Figures (11, 12).

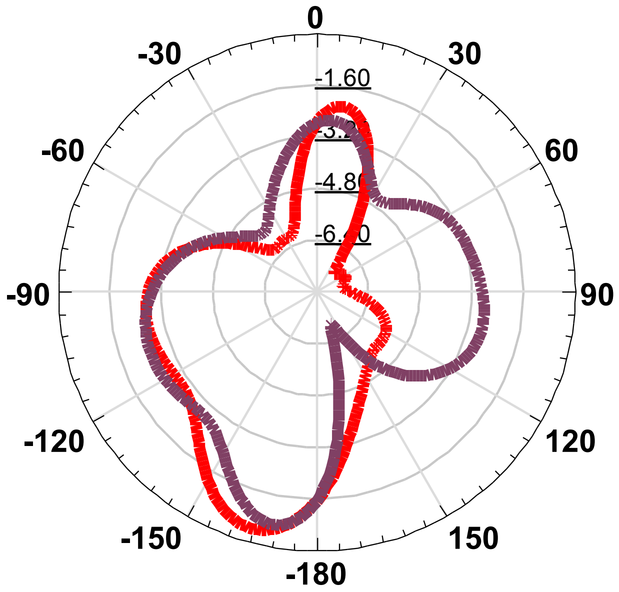

Figure-10. Radiation Pattern of antenna.

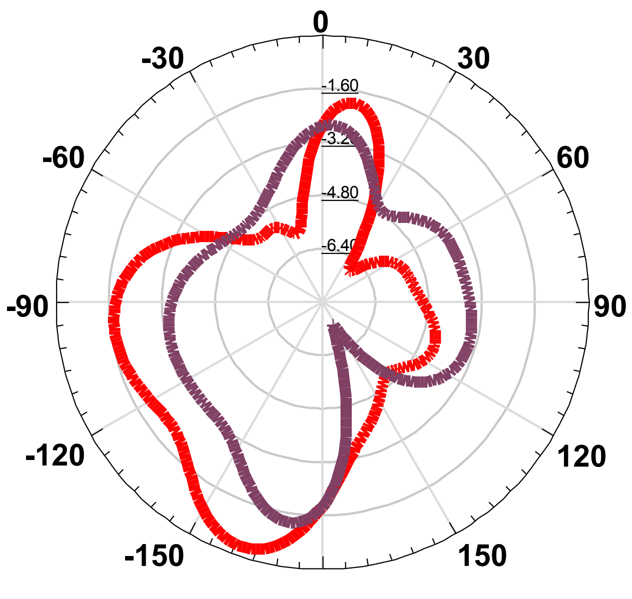

Figure-11. Radiation pattern of antenna with T-slot.

The radiation pattern in two dimensions in Plan E and Plan H which is illustrated in Figure-11 for the PIFA antenna and Figure-12 for the PIFA antenna with a T-slot which represent two main lobes.

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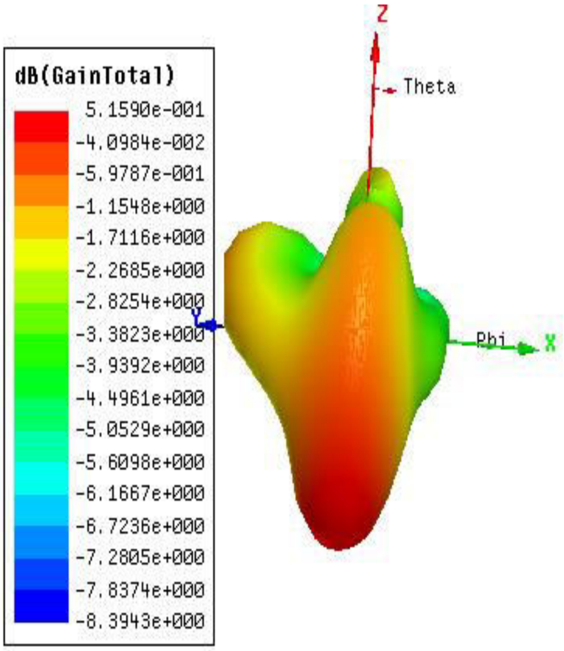

Figure-12. Radiation pattern 3D of antenna.

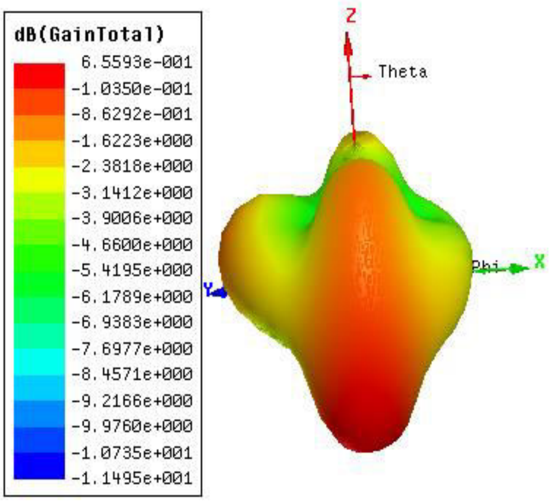

Figure-13. Radiation pattern 3D of antenna with T-slot.

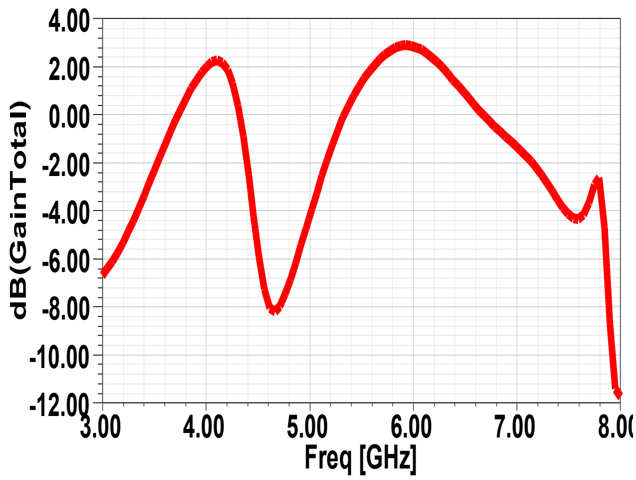

Figure-14. Gain of antenna.

The appearance of (Figure-15) shows that the gain of the PIFA antenna without slot is equal to 2.8 dB around the resonance frequency 5.8 GHz.

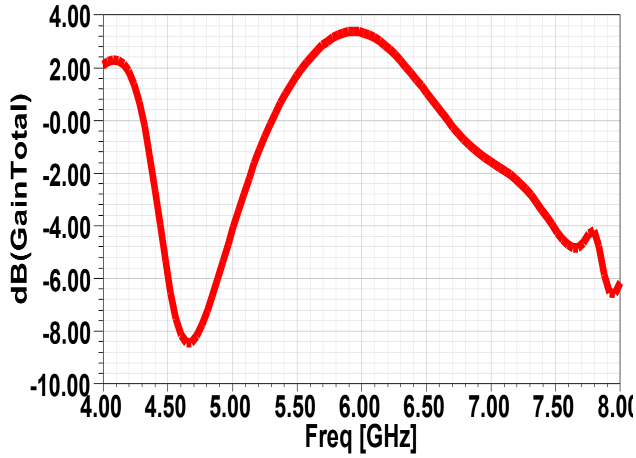

Figure-15. Gain of antenna with T-slot.

The appearance of (fig. 16) shows that the gain of our adapted antenna is equal to 3.8 dB.

3. COMPARISONS

From the results obtained, we deduce that our PIFA antenna has a return loss equal to -21 dB, a SWR less than 2 and a gain equal to 2.8 dB. For the PIFA antenna with slot, from the results we deduced a return loss equal to -34 dB, a SWR less than 2 and a gain equal to 3.8 dB.

We deduce that our PIFA antenna with T slot is well matched.

4. ARRAY PIFA ANTENNA

The geometric configuration of a PIFA antenna array with a T-slot on the Ansoft HFSS software is shown in Figure-17:

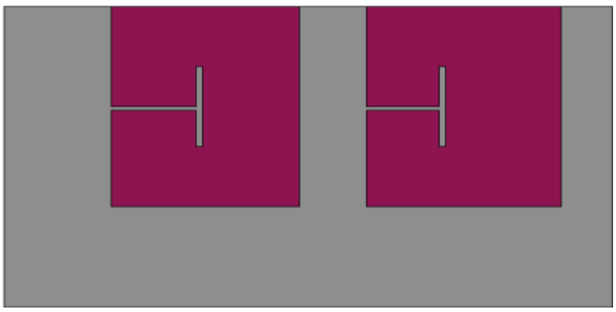

Figure-16. Structure of array PIFA antenna.

The simulation of the PIFA antenna array with T-slot resonating at the resonance frequency of 5.8 GHz gives the following results:
Return loss to -58 dB.

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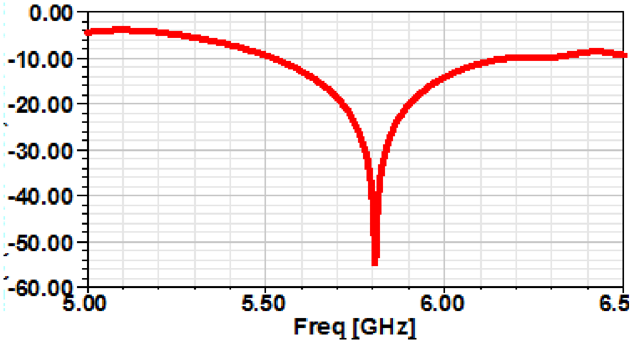

Figure-17. Return loss.

The SWR parameter of the matched antenna with T slots is less than 2.

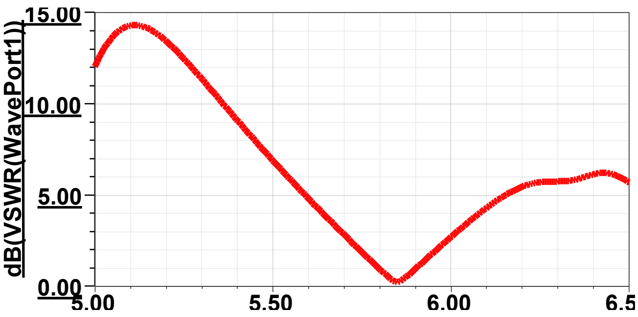

Figure-18. SWR.

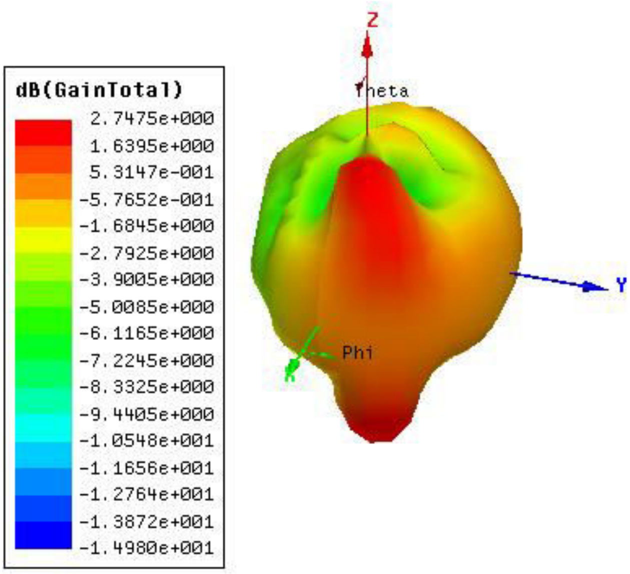

Figure-19. Radiation diagram.

Figure-19 shows that the 3D radiating diagram is directional.

5. CONCLUSIONS

In this article, we presented design and simulation of a PIFA antenna adapted by a T-slot and powered by a coaxial cable. Then we have compared the results of simulations obtained by the software Ansoft HFSS, with the results of a PIFA antenna without slot, to know the influence of the slot on our chosen antenna, at 5.8 GHz resonance frequency for RFID applications. To improve the results obtained, we have networked antennas two PIFA antennas with T-slots. The results obtained are in perfect harmony for RFID applications, either in terms of frequency or bandwidth. Similarly, we obtained important maxima for S11 parameters, gain, SWR, radiation pattern.

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