Laboratory Report

Tag Antenna

Course: RFID Technologies

2020-2021

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Abstract

In this report, we cover the design, fabrication and response of a UHF tag antenna that contains of tag antenna place in far field which the tag can able to transmit the data within range of >1m , so here we are going to see how to design and response of the antenna tag by using the CST simulator.

Contents

Notation

- RFID = Radio Frequency Identification
- HF = High Frequency
- UHF = Ultra High Frequency
- Zin = Input Impedance
- Z = load Impedance
- R = Resistance
- C = Capacitance
- L = Inductance
- S = Scattering Parameters
- l = Length , b = Breadth
- cm = centimeters
- m = meters
- mm = mille meters
- kHz = Kilo Hertz
- ω0 = Angular frequency
- Hz = Hertz
- M = Mega
- m = Micro
- f0 = frequency
- H = Henry
- F = Farads
- pF = Pico Farads
- V = Volts

1

Introduction

RFID (Radio-Frequency Identification) is the use of radio communications to identify a physical object. RFID is really not one but a suite of identification technologies because of the differing characteristics of the radio waves of varying frequency used, and because of the differing approaches to operating the sensors that serve to identify individual objects. For that we use RFID tag and reader antenna for identification. I general Tags store the information and Reader reads information that stored in the tags by sending radio waves. RFID is an example of automatic ID (auto-ID) technology. RFID technology widely used in many fields, such as transportation, supermarkets, animal tracking and manufacturing. RFID systems are generally distinguished through four common bands; table 1.1 we can see the four frequency range ,And we have different operating frequency for UHF in region wise, here in the report we used Europe operating frequency range (865 - 868MHz). Each operating frequency has its own characteristics. Comparing to the all RFID frequency bands UHF has many applications because it provides long range reading, and large information storage capability. In this paper, a UHF tag antenna with the operating frequency is designed and simulated by using computer simulation CST STUDIO SUITE. Using MW & RF & OPTICAL by design the 3D view of the tag and the electromagnetic (EM) field simulator useful in designing the antenna. It provides features such as optimization, sweeping, and some calculations that are helpful during the simulation. Some features of this simulation tool will be shown in this paper.

Table 1.1 Radio Frequency spectrum

Frequency	**Range**	**Wavelength in free space**
Low frequency	30-300 kHz	104 -103 m
High frequency	3-30 MHz	102-10 m
Very high frequency	30-300MHz	10-1m
Ultra-high frequency	300-3000MHz	100-10cm

Cst studio suite 2018

The design began by working with the software simulation engineered for RFID purposes which is called CST studio suite 2018. Fig 1 The main interface of the program is captured via screenshot. within the program by pressing #1 we face the xy plane orthogonally. Then by using the tool “define brick’ in modelling menu we began to construct the design layout which was given to us at the first session.

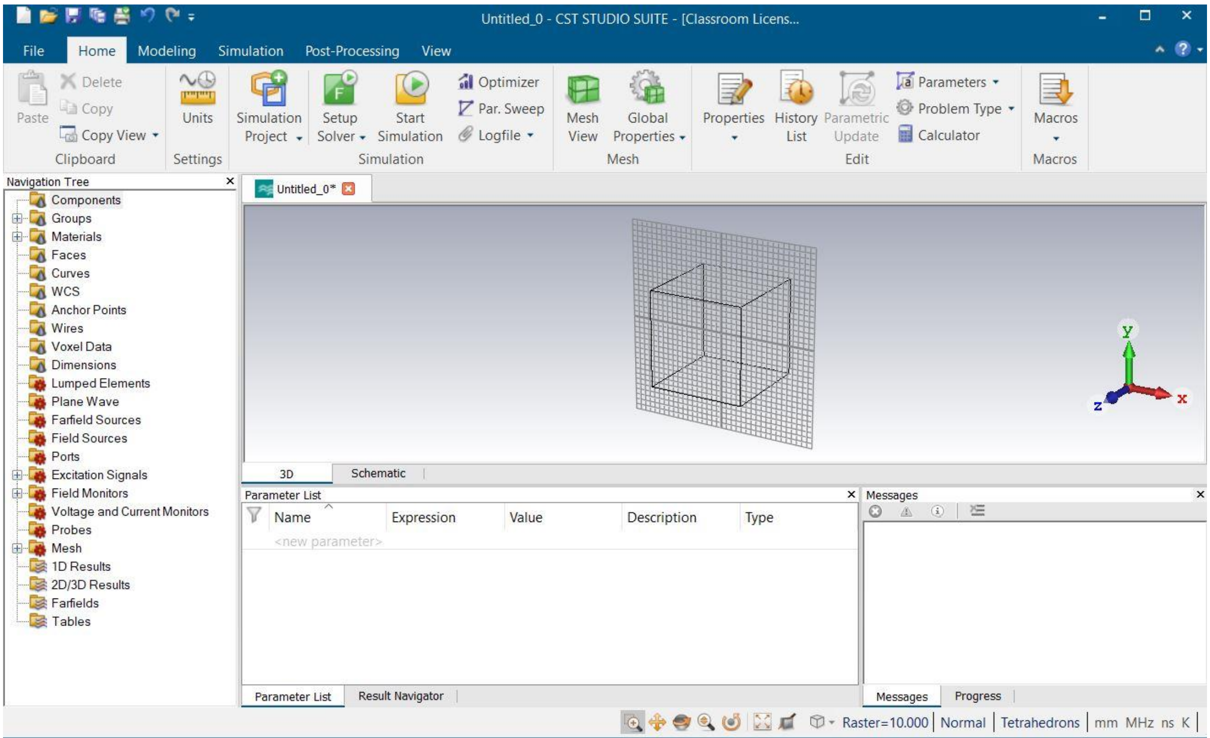


Fig.1 illustrates the basic working interface and design framework of the software

The layout has only two measurement provided with it, maximum height and maximum length. By measuring its dimensions with a ruler, we get another set of numbers for maximum length and height. By dividing the given length to the measured one, we get a scale coefficient which we name ‘K’ and will be used to convert all the real lengths that we measure in future to convert to the layout’s scale.

2

Antenna Tag Chip Design

2.1 UHF Frequency range of Tag antenna

The RFID tag antenna which works in the Ultra High Frequency (UHF) band. In general a UHF system is designed to work in the 800MHz-900MHz frequency range. Read range can be estimated. Our system is intended to work at 867 MHz since it is considered.

2.2 CST Frequency range settings

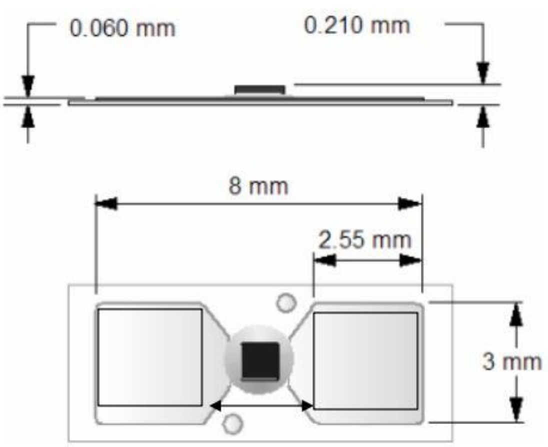
We configure the simulation settings of CST with the following values:

• The frequency range varies from 366.6 MHz to 1366.6 MHz with a step of 2 kHz in order to have a margin around the working frequency of 867MHz

• The expected inductance is 64 henrys and resistive is 9 ohms.

2.3 UHF tag chip and dimensions

Tag is a device which can be attached to an item with the purpose of identifying the item with the RFID reader. All tags are composed of the same basic components because they offer same basic functionality, which helps to identify and track an item. Chip is used to generate and process a signal.



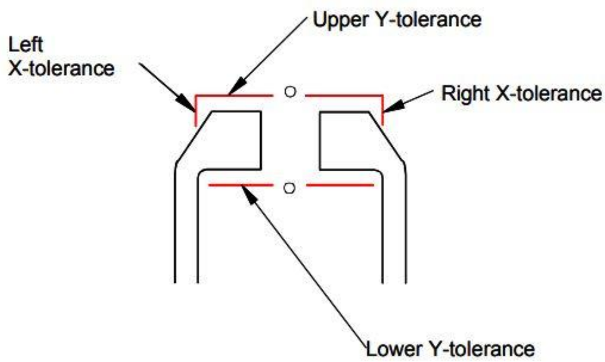


FIG.*3 UHF tag chip*

FIG.4 Tag chip attached in between the two right and left x-tolerance

2.4 Functional Components of a UHF Tag Chip

• Logical unit- implements the communication protocol used for tag-reader communication

• Memory- used to store data

• Modulator- used for modulating the outgoing signals and demodulating incoming signals

• Power controller- responsible for supplying power needed for operating the chip

2.5 Testing the tags:

This is how the real tag chip looks, When the day arrived for comparison to be made for our tag prototypes, we were presented in the lab for the feeding session and our layouts has been printed and cut out from the cupper sheet and we want to attach this chip in antenna. For that we used a conductive adhesive glue to establish a connection between the chip and the antenna and not to use too much of that glue in order to avoid excessive residue capable of causing short circuit to other joints which could lead to not energizing the chip at all.

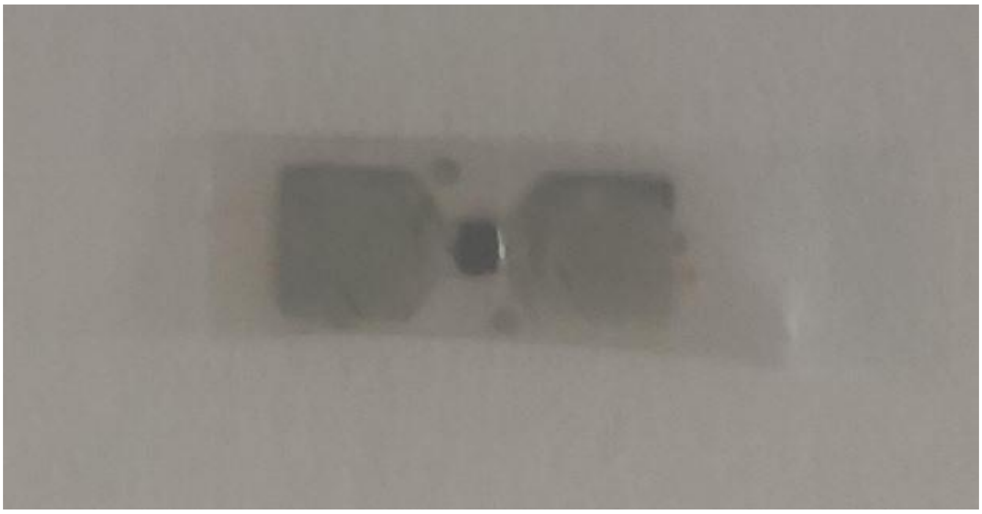


Fig 5. RFID chip (Texas RI-UHF-STRAP-08)

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Dimensions of an Antenna

The total length of the antenna taken by the value of the λ (Lambda), where the lambda value can be calculated by λ = c/f from that we take the total length of the antenna as λ/2, then total length of antenna L = "2*(lsb+lsep+wd+lsep+wd+lsep+wd+lsep+ld/2)" mm, and Want = 19mm(width of the antenna),the lgap=2.9(distance between two pads of the chip), and the wd = 2(width of the trace), lsep=1.5,lsb=7, the lt2=2, the lf =19,the ld = lgap+lt+lt3+wd ,the lt =lgap+lt2+wd, the height of first two left and right ht =9, and the hm=8, initially we will take this dimensions. According to this dimensions it is not possible to get required matching values then by observing the simulation operation and output operating frequency range the operator will change the dimensions to get desire output. **Fig.6** old tag antenna. So we made lot of changes in between by increasing the height and decreasing the length, vice versa. **Fig.7** new tag antenna. By this we can obtain our output. Let see briefly about this process in impedance matching. **Fig.8** which all the parameter mentioned.

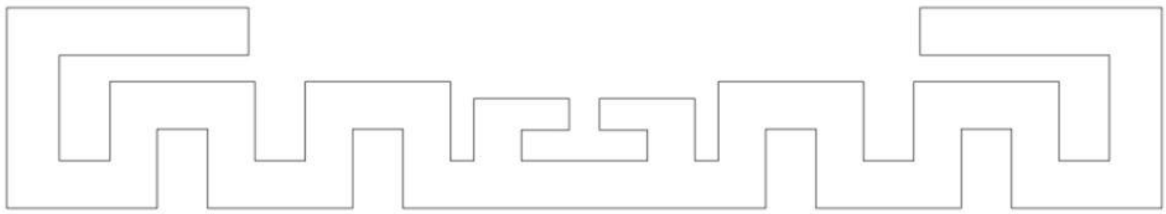


Fig.6 old tag antenna design

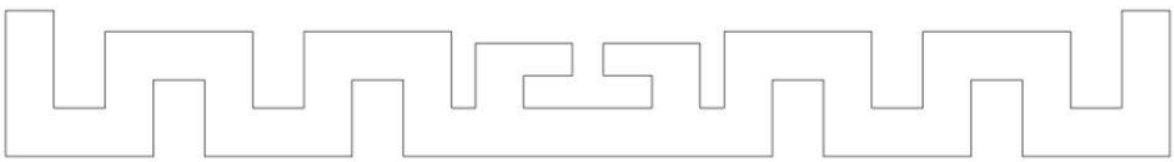


Fig.7 new tag antenna design

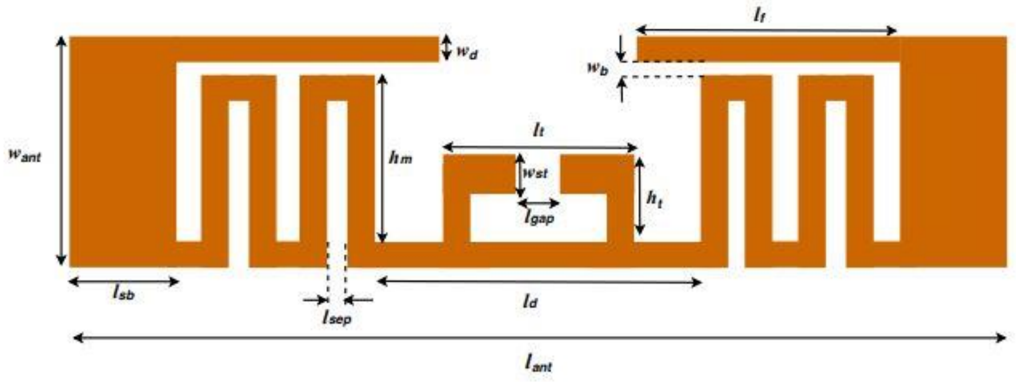


Fig.8 reference antenna

3.1 Parameter set:

First challenge was to come up with a method to name each parameter uniquely such that it's easy to remember and possibly can represent itself without need to look it up in the dictionary sheet. One simple but smart way is to use initial letters of the words that are addressing each part of the tag antenna. This are the parameters that which I used for **Fig.6** old tag antenna.

```
lgap=2.9
yc6=-wd/2+want/2
yc5=yc7
yc4=hm
yc3=wd/2+hm/2
yc2=wd/2+ht1-wpad/2
yc1=wd/2+ht1/2
xc6=-wd/2-lsep/2+xc5
xc5=-lsep/2-wd/2+xc4
xc4=xc3-wd/2-lsep/2
xc3=-ld/2+wd/2
xc2=-lgap/2-lpad-lt1/2
xc1=-lgap/2-lpad-lt1-wd/2
wst=5
want=19
lsep=4.8
lsb=5
ld=2*(lgap/2+lpad+lt1+2*wd+2.
hm1=hm+wd
hm=7.1
wb=1
xc7=-wd/2-lsep/2+xc6
lf=18
yc7=-wd/2+hm1/2
lpad=2.55
wpad=3
x8=-lgap/2-lpad/2
y8=wd/2+ht1-wpad/2
xc8=-wd/2-lsep/2+xc7
yc8=hm
xc9=-lsep/2-wd/2+xc8
yc9=-wd/2+hm1/2
xc10=-wd/2-lsep/2+xc9
xc11=-lsb/2-lsep/2+xc10
yc11=-wd/2+want/2
xc12=lsb/2+lf/2+xc11
yc12=want/2+yc11-wd/2
ht1=ht+wpad
```

4

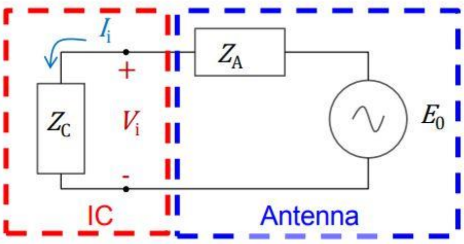
Impedance Matching

Matching circuit

The first goal of the tag antenna must be to deliver power to the tag IC to turn it on; The communication performance between an interrogator (reader) and one or more transponders (tags) in passive UHF RFID applications is strongly depends to the matching or the mismatching between transponder chip and transponder antenna. In the match, the power is absorbed by the tag, while in the mismatch the power is reflected by the tag.

The antenna used in RFID system are the type dipole right or meander, their input impedance are very resistive and less reactive, against by the impedance of the integrated circuit (IC) is very reactive and less resistive. So to get a good adaptation allowing maximum power transfer between the chip and the antenna and to assure power optimization in the forward link, the input impedance of the antenna must be the complex conjugate of the chip input impedance. Several impedance matching methods can be employed in order to achieve the match.

They model by an equivalent circuit in order to obtain an analytical expression of the antenna input impedance from the geometric parameters of the antenna which will be adjusted to achieve the impedance of RFID chip and equivalent circuit showed below.



$$Z_A = R_A + jX_A$$

- Complex reflection coefficient $\Gamma = \dfrac{Z_c - Z_A^*}{Z_c + Z_A}$
- Active power available $P_a = \dfrac{1}{2}\dfrac{|E_0|^2}{4R_A}$
- Active power delivered to the IC $P_d = P_a\left(1 - |\Gamma|^2\right)$
- Conjugate matching $Z_A = Z_c^*$

The chip has two main sections, die and sidelobes. The die has a parallel impedance to it which at the work frequency 866.6MHz based on the data sheet we read 440Ω for the resistive part and 2.8pF for the capacitive part (these numbers are corresponding to the Europe region, for other regions , there are other numbers)

DIE PARALLEL IMPEDANCE			EUROPE 866.5 MHz	USA 915 MHz	JAPAN 953 MHz	UNIT
READ	–13 dBm nominal	Resistance	440	380	340	Ω
		Capacitance	2.8	2.8	2.9	pF
	–9 dBm minimum.	Resistance	360	330	300	Ω
		Capacitance	2.7	2.8	2.9	pF
WRITE	–9 dBm nominal	Resistance	380	340	320	Ω
		Capacitance	2.8	2.8	2.9	pF
	–6 dBm minimum	Resistance	250	240	230	Ω
		Capacitance	2.7	2.7	2.8	pF

Table 1 European Standards for RFID read and write

In this paper, we were asked to compute the impedance that is seen from the chip stand view which by calculations resulted to Z=9.0- j64. The total impedance seen from the port view point is R=9.0Ω and the total reactance is X=-64.

$F = 866.9 \times 10^6 \, Hz$

$\omega = 2 \times \pi \times F = 5442248000$

$R_1 = R_p = 440\Omega$

$C = 2.8\, pF = 2.8 \times 10^{-12}$

$Z_c = (j \text{ x } C \text{ x } \omega)^{-1} = 1/j0.01523 = -j65.62 = R_2$

$R_T = \frac{R_1 \times R_2}{R_1 + R_2} = \frac{440 \times -j \times 64}{440 - j \times 64} = 9.05 - j63.07$

4.1 CST DESIGN

After doing the design in CST simulator. For the operating frequency range by changing the antenna dimensions finally we got the proper antenna. All the measurements are taken in mm. First we made reference base which is ld x wd. Then we want model the brick according to the mentioned dimension. fig. window of the brick. This is how the base brick was created.

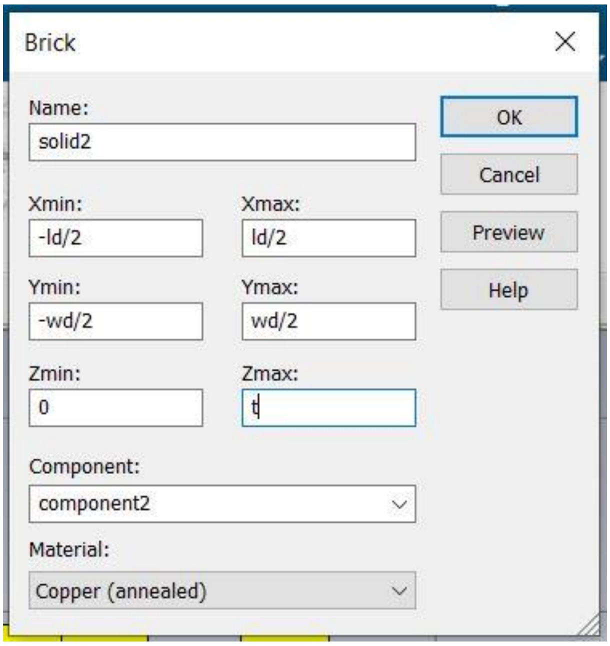


Fig 9. Brick definition window

According to the antenna design the first loop of ht1 is created. For that we need to shift the coordinate point of the centre that mentioned as x1,y1. To shift the centre we go to local wcs tab then we define the centre as x and y coordinate. This way, by shifting the centre we defined the position of the rest of the brick to be created.

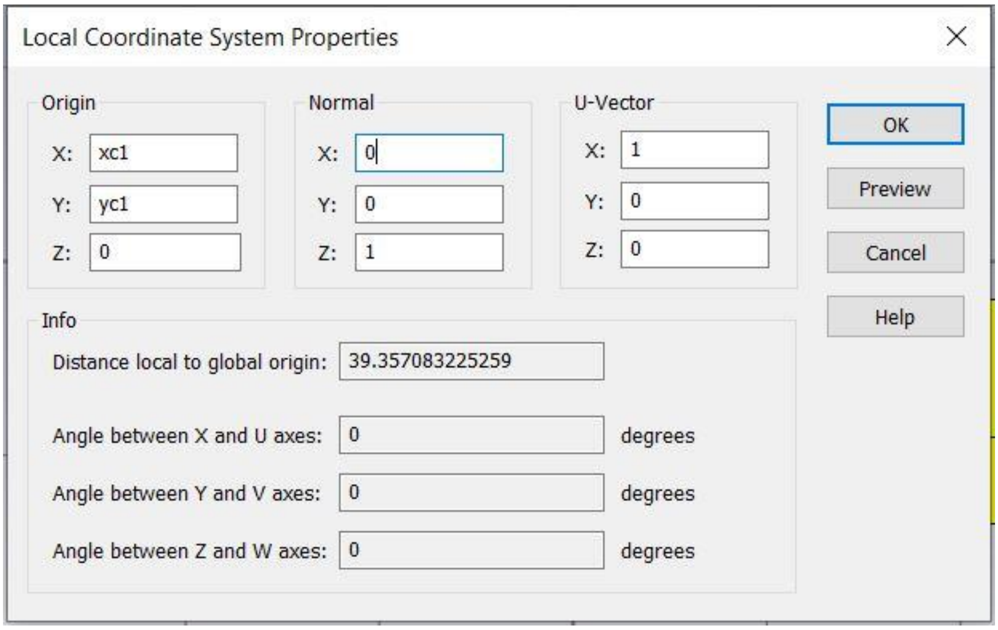


Fig 10. Local Coordinate System Properties window

Lsep is the distance between two vertical bricks we need it because if it is not wide enough then it will create more resistance. lsep needs to be greater or equal than wd(width of the antenna).

First we need to created one side of the component of antenna either it is left or right. Then we select them in components list and by right click we select transformed selected objects. There opens a new window in which we pick operation mirror repetition factor to be 1 and since we want to mirror along X axis we give X 's mirror plane normal 1 instead of zero and we let the other two to remain zero.

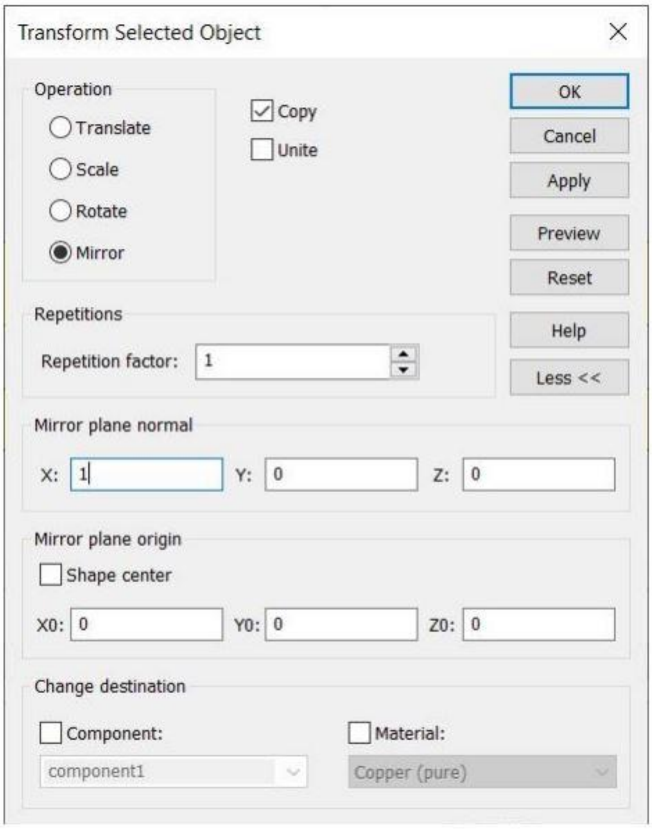


Fig 11. Transform the bricks and mirror it

After that we want to simulate our tag antenna. Go to simulation and do step up solver then the processing will start. Go to the adaptive tetrahedral mesh properties. Fig 12. adaptive tetrahedral mesh properties.

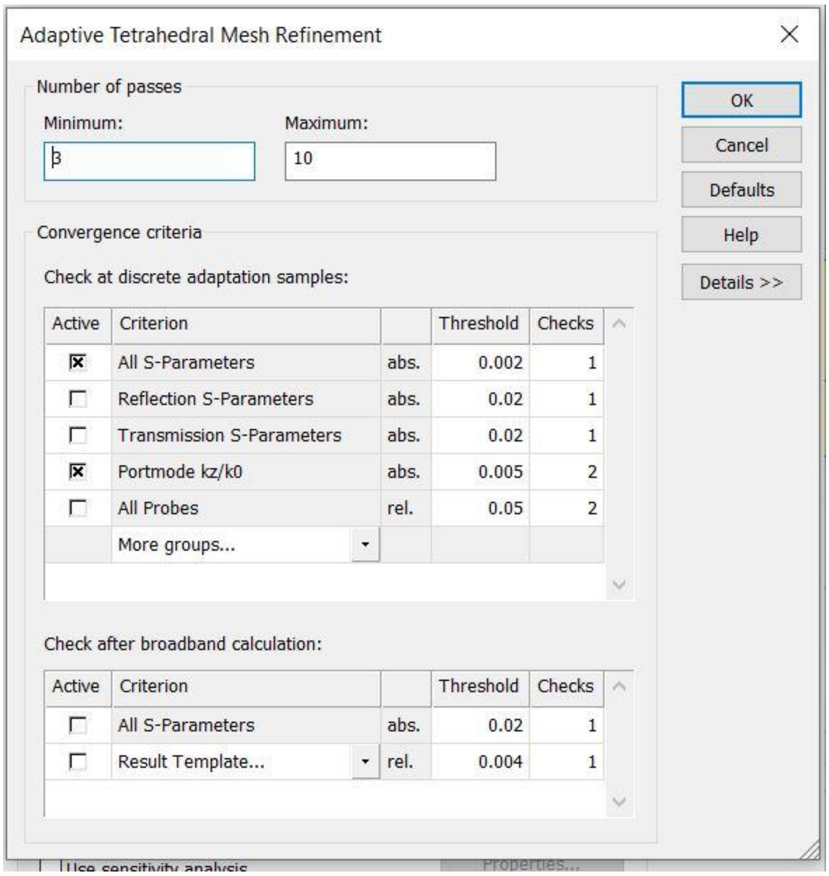


Fig 12. Adaptive Tetrahedral Mesh Properties

Then change the threshold of the values of all s parameters from 0.02 to 0.002. press OK. Then click on the START. Then we want to generate the z parameter shown in Z(1,1). It is described at section 4.2. The front view of antenna mentioned in **fig.6**.

4.2 Output graphs

4.2.1 Real part of antenna

The real part of the antenna measured at frequency of 867 MHz we got 9.05 ohms.

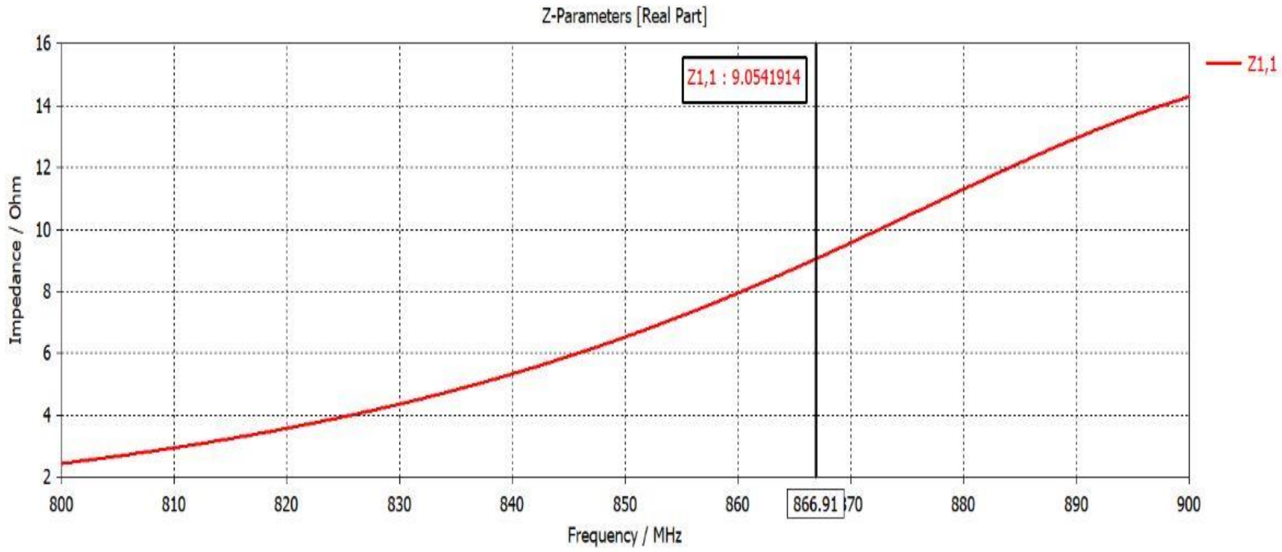


Fig 13. Real part of Z-parameters

4.2.2 Imaginary part

The imaginary part of the antenna measured at frequency 866.6 MHz we got 63.07 H.

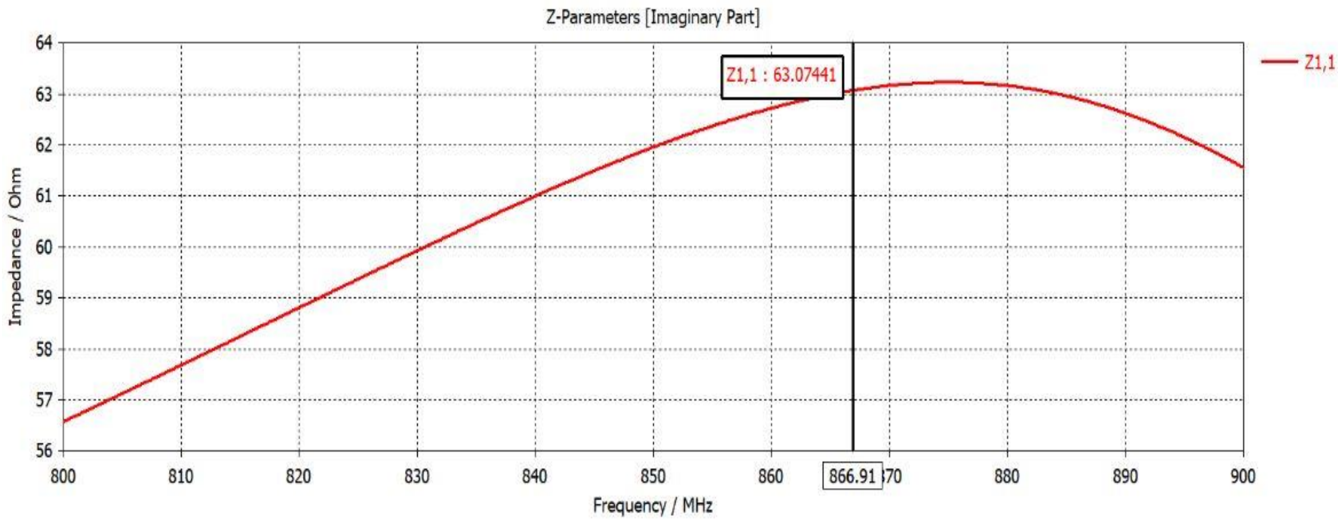


Fig 14. Imaginary part of Z-parameters

after getting the real and imaginary results we want to go to post processing tab and select result templates.

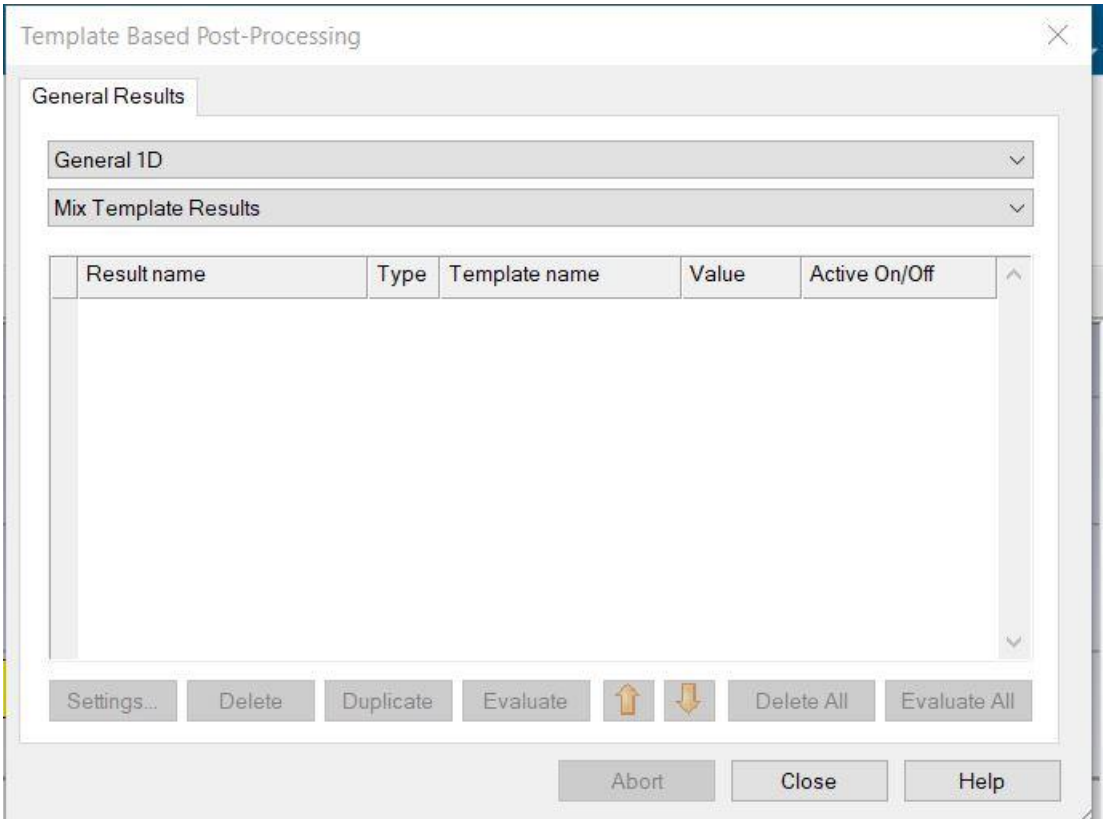


Fig 13. Result Templates Window

Then select the mix template result, new window will open where we select A to z matrix Z(1,1).we enter the given formula ((9+64*j)-A')/((9+64*j)+A), to find the reflection cooeffecient. Press OK. Click evaluate, the reflection cooeffecient graph will be generated. Intially the graph will be in linear readings we have to change it to db. Put the axes marker 867 to get readings.

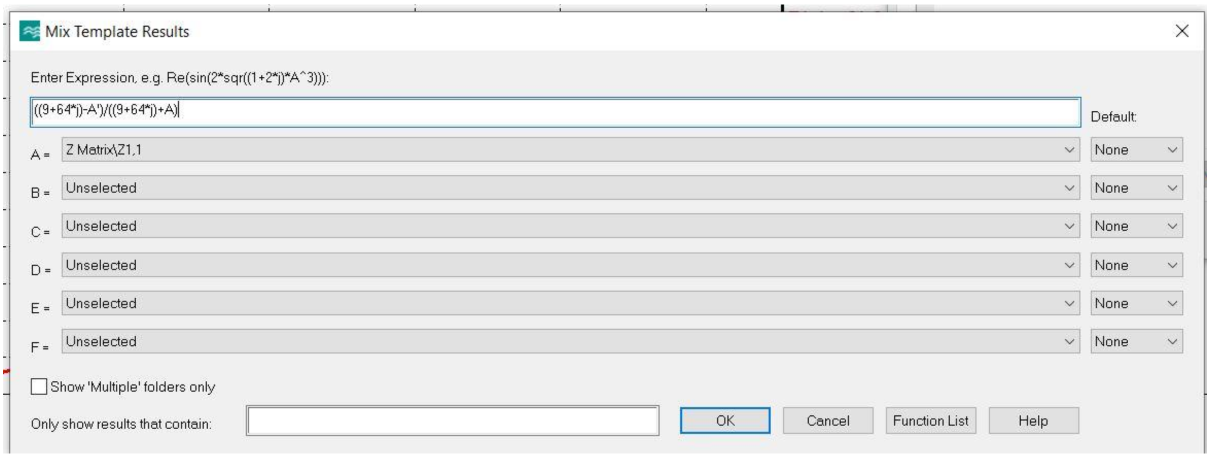


Fig 14. Mix template results

4.2.3 mix template results in dB measurements

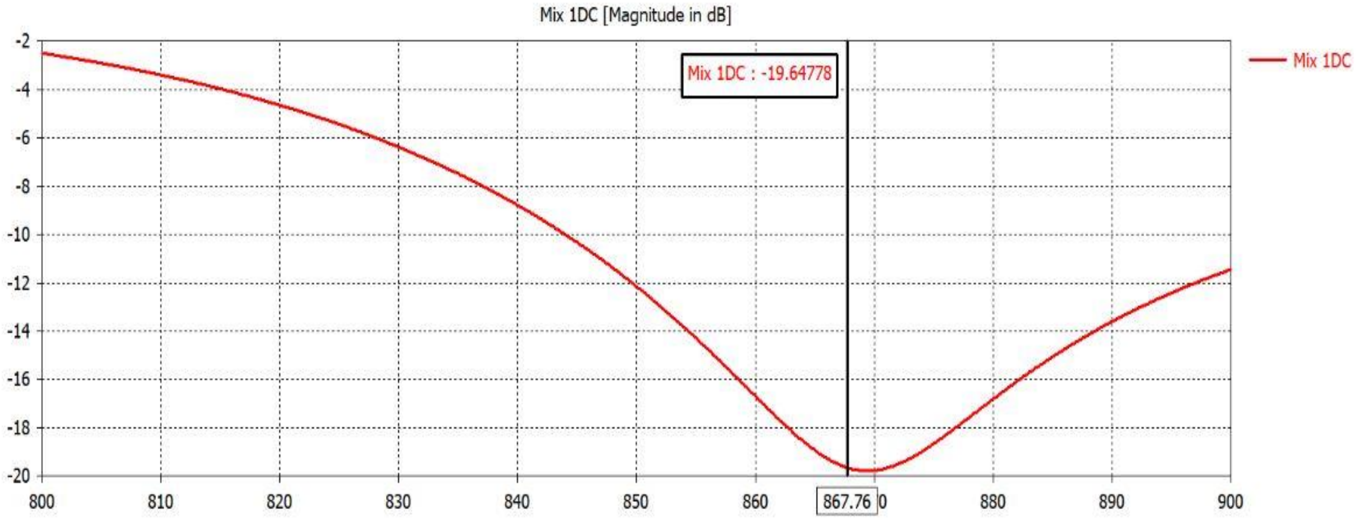


Fig 15. mix template results in dB measurments. At frequency 867MHz we results are -19.64 the desired value for this outcome.

5

RESULTS

After getting the proper values for the matching circuit by changing the dimensions of the antenna by using CST simulator. And the fabrication of the antenna is done by the cutting printer, copper 0.2mm sheet is taken as the conductive part, and placing the overall fabricated antenna plastic cover sheet. And finally placing the tag chip in between the two arms, by keeping the layout at a distance to reader, by moving away from the reader, the maximum read distance is taken

EXAMPLE- in my case, the measurements of our antennas are 31cm, 70cm, and 150cm for myself, Eduardo and Ernest respectively. Far from competition with commercial tags, But better than no competition at all. for the case of my antenna the first range was around 31cm, and I assumed by cutting 1mm from each loop width from each side, when the loop increase the distance is good, the results would be better, but I was surprised yet another time. Range become 70cm so I decided to cut another 1mm from the loop width. Then I again cut 1mm from the loop length then the range changed as 150cm and I couldn't cut anymore further though I've reached the optimal layout design, so I settled for this result. Fig 19 shows more details. **fig.a** is the final antenna after testing

Fig.b is the tag antenna that we designed.

fig.a is the final tag antenna after testing

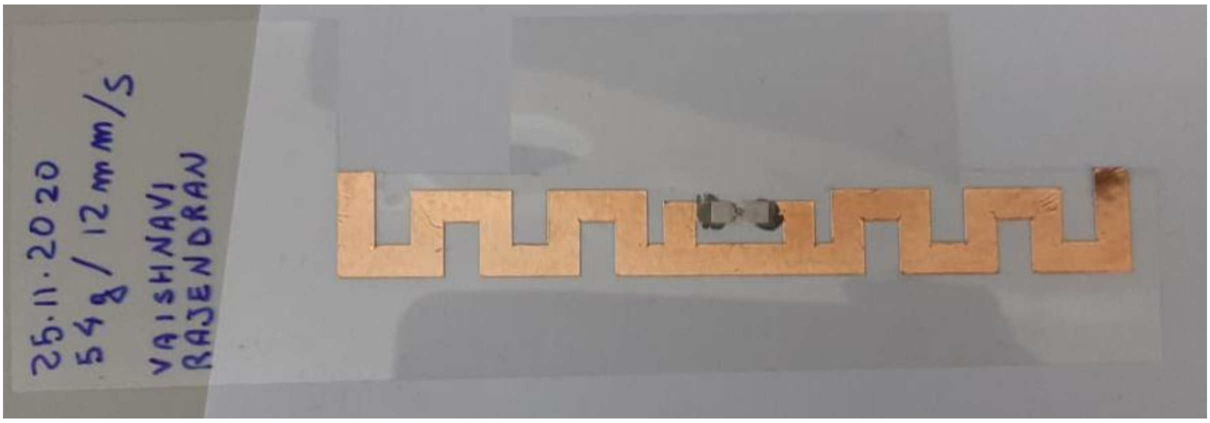


Fig.b is the tag antenna that we designed.

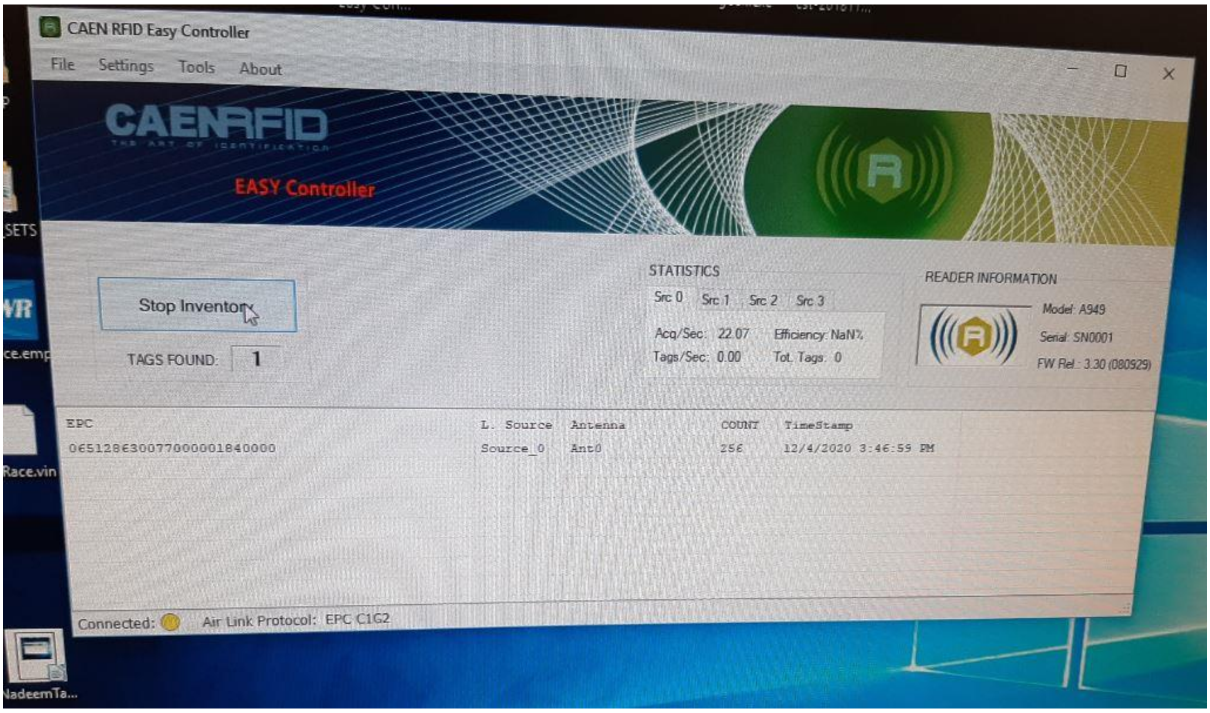


Fig.c caen RFID easy controller, the program that we used to read tag at their ranges.

6

Conclusion

Finally by using the RFID is the best way for the indentation in the lost cost and effective way, the design make as to understand that less cost material is used, simple structural design and small size, by the help of CST simulator.