University of Lille
Master 1 Nanosciences-Nanotechnologies (E-Tech)

AORC1 Theory of radiating elements

Realization of Patch Antenna
(Realization with CST and Network analyzer)

By
KHEROUS Louiz
SIDIBE Issa

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Introduction

An antenna functions as a tool for both transmitting and receiving information via the electromagnetic waves surrounding it. There exist numerous types of antennas, with our focus lying on the widely recognized micro-strip antenna in this instance.

The micro-strip antenna, commonly referred to as a patch antenna, falls under the category of printed antennas and finds extensive application in wireless communications, as well as various industrial, scientific, and medical domains. Its popularity stems from its cost-effectiveness and straightforward fabrication process.

This research introduce the distinct characteristics of the micro-strip antenna operating at 2GHz. The investigation commences with a simulation phase utilizing CST software, specifically designed for electromagnetic propagation studies. Subsequently, the study progresses to the practical realization of the antenna, involving the manipulation of various parameters to achieve the desired outcomes.

I. Simulation Part

I.1. Design of patch antenna on CST

Parameter	Value [mm]
L_{metal}	35
L_{metal}	30
$L_{Dilectric}$	100
$T_{Dilectric}$	1,52
T_{metal}	0,07

Table1. *Different dimensions of antenna (with given values).*

Using the software CST we design the patch antenna by taking into account the different parameters, with precise value given by the Data sheet, cite at Table1.

Firstly, we fix the range frequency from 1,5GHz till to 4,5 GHz, thus we design the ground plane (metal) with his specific parameters (Length, Width, Thickness and specific material(PEC)) is used to confine electromagnetic field, we will do the same for the dielectric except that we choose different material(FR4) than the ground plane. We constitute the radiating element by using the same material as the ground plane (PEC).

Secondly, before designing feeder line we have to computing the width and the length by using Thin Micro-strip parameter, measurements are used to set the impedance of the line at 50Ω, so that the feeder line would be 50Ω (in general power sources impedance).

For the width we have found the formula (1) in book.

$$w=\left(\frac{377}{Zmin\sqrt{\varepsilon r}}-2\right)Td \qquad (1) \qquad \text{with: } Z_{min}=50\Omega,\ \varepsilon_r=4.4,\ Td=1.52mm.$$

W_{line}= 2,42mm

For Length we have used, the impedance calculation command from CST:

L_{line}=20,53mm

After we get those measurements, we design our antenna, which shows in Figure1.

Finally we put the port the (wave-guide) centered to the feeder line to excite the line with electromagnetic field biasing by guiding the electromagnetic waves with lower losses.
At the end we obtain the final shape in the Figure1.

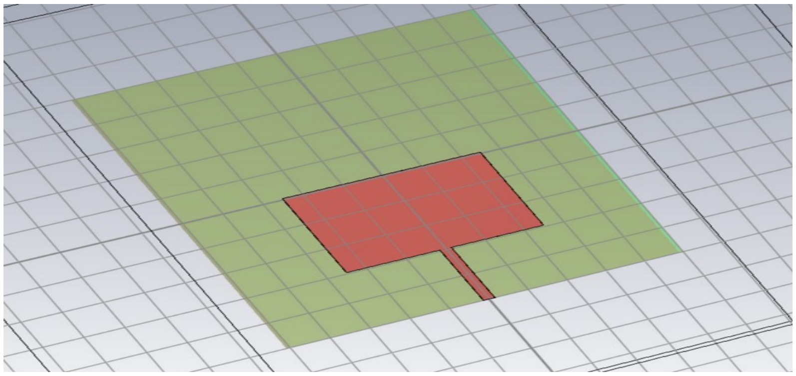
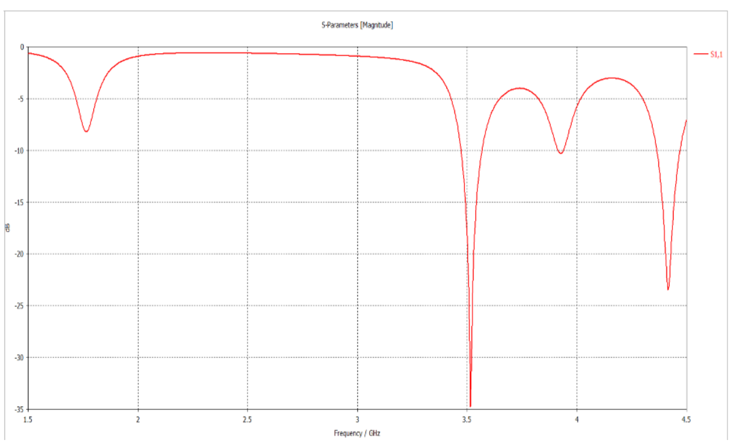


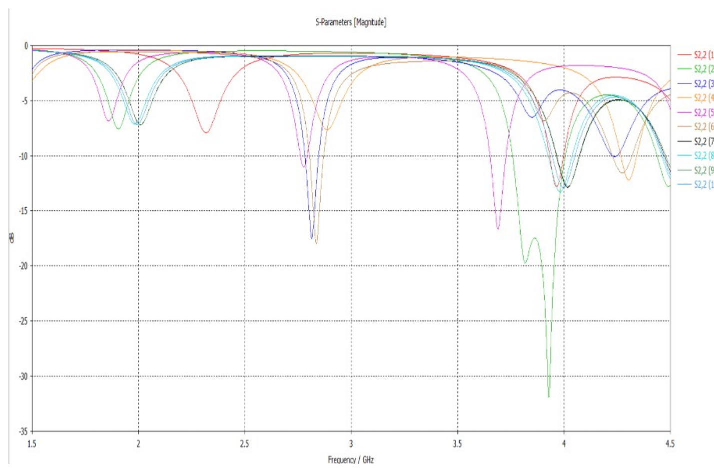
Figure1. *Design of patch antenna in CST.*

I.2. Simulation results on CST

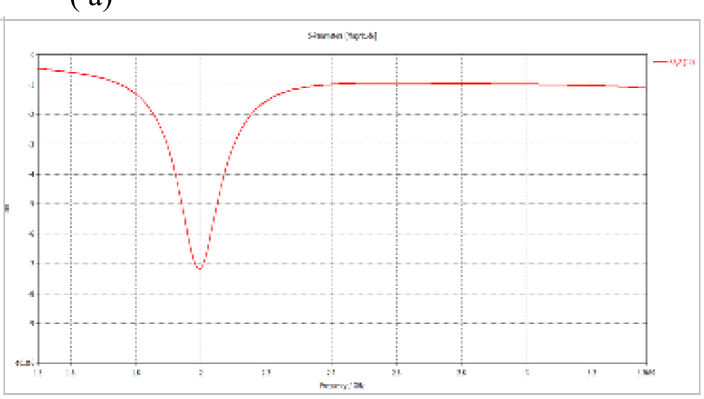
We evaluated The performances of designed antenna by S_{11} parameter which is the reflection coefficient (to get resonant frequency,matching and bandwidth) and the radiation pattern.



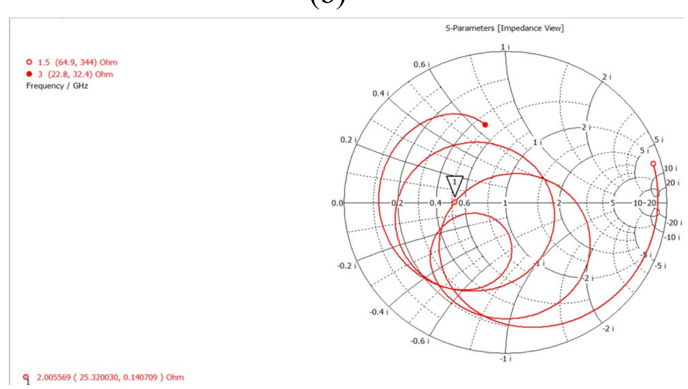
(a)



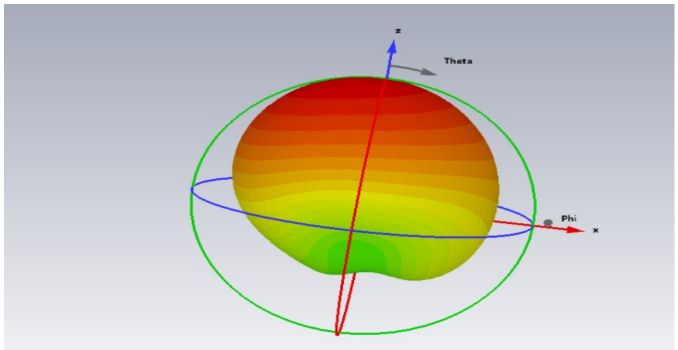
(b)



(c)



(d)



(e)

Figure2.*Simulation results.****(a)****. S_{11} parameter with default dimensions .* ***(b)****. S11 with variation of dimensions (L_{patch},L_{line}).****(c)****. S_{11} parameter for (70×60mm) at 2Ghz.* ***(d)****.Smith chart at 2GHz for (70×60mm) .****(e)****.Directivity of patch antenna at 2GHz for (70×60mm) .*

S_{11} represent how much feeding power that was reflected back at the port of patch antenna, we have some peaks which show the multi band properties in Figure2(a). And bandwidth is 250MHz, We observe that the feeder line length(20,53mm) doesn't really impact the emission frequency neither the emitter dimensions (35mm x 30mm).

Let us try to optimize the antenna to emit exactly at 2GHz, by dealing with length of the patch, as is shown in Figure2(b), we find, the shape of patch greater, regarding to the first.
By varying the width only we observe that when we increase to the width we increase the amplitude at resonance frequency

After carefully dimension the patch by increasing the longer more than the width (70×60 mm) we reach a resonant frequency of 2.02GHz in Figure2(c), with an amplitude of -7dB.

we have a look on the smith chart Figure.2.(d) to check the adaptation at (2.04GHz), we have almost no the imaginary part, on other hand the real part is at 25.32 Ω which is quite far to our matching impedance, so we can conclude that we are not matched so our antenna is not able to emit at 2GHz.

Radiation pattern, gives an image nature of the value and direction of radiation by which antenna emits and receives the electromagnetic waves, in Figure 2(e). We notice that we have one main lobe and no back lobe because the emitter is on top of the substrate.

Directivity is the ability of our antenna to focus energy in a particular direction as shown in Figure2(e), at the same frequency we have a directive radiation

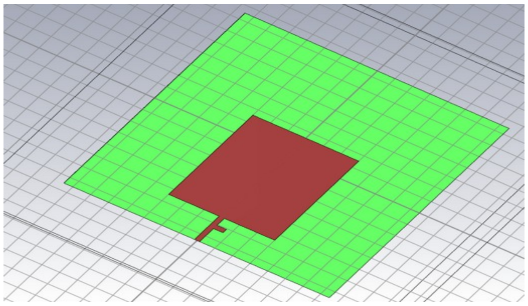
Minimum distance for far field study

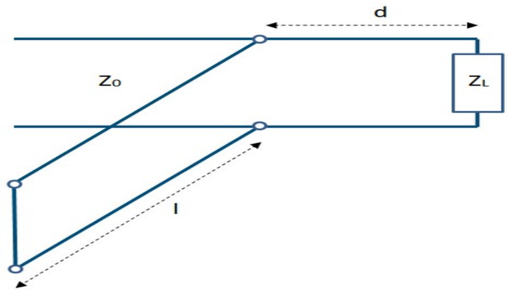
$R \gg \frac{2Lw}{\lambda}$;L= length of patch antenna , W= width of patch antenna.

R=29mm

I.3. Adaptation with single stub on CST

In order to get matched, there is numerous method we have choose, the single stub method. According to the of Microwave engineering we have study in the first semester, We need to well design the stub position (d) and length (l) by using the smith chart the width remain the same as the feeder line's width.


(a)

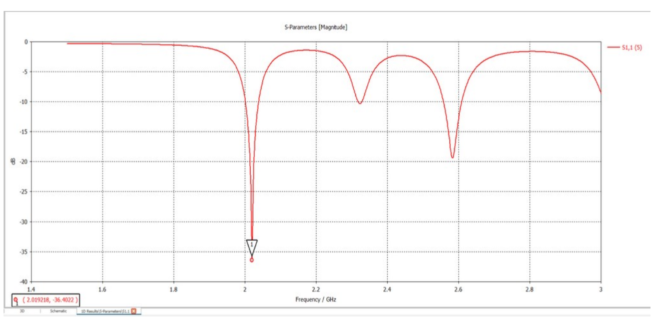


(b)

Figure3.(a).Design of patch antenna with single stub. (b).Transmission line with single stub.

By using the Smith chart we deal with the dimensions of transmission line like it shows in Figure3(b) in order to design antenna in Figure(a):
d (is choose to obtain local admittance) = 0,085 λ=5,36mm

l (is choose to remove the imaginary part) = 0,075 λ=6,077mm; with: $\lambda=\frac{c}{f\sqrt{\epsilon r}}$



(a)

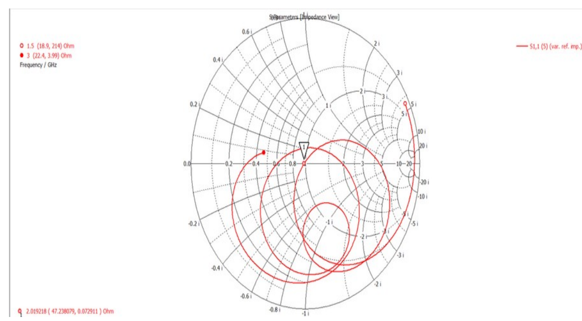

(b)

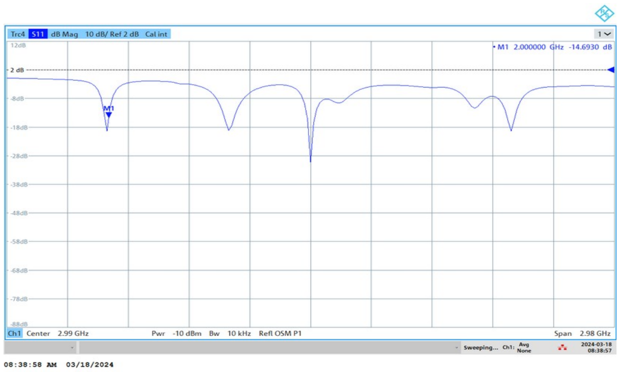
Figure4.*Simulation results after adaptation. (a).S_{11} parameter with peak of -37dB at 2,02Ghz. (b).Smith chart.*

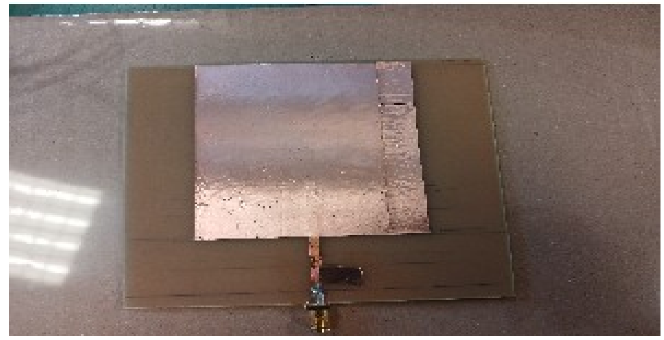
Eventually, after we add single stub, for S_{11} parameter in Figure4(a). We notice that the pick arrives at resonant frequency, and in other hand, we have reached the 0 imaginary part and 1 for real part at 2.02 GHz as we see it in Figure4(b).which is what we expected

II. Practical Part

II.1. Realization of antenna and characterization on Network Analyzer

After we have done with simulation part now we will move on to practical part, to compare between simulation and reality, first thing to do is to realize our antenna with thin film of copper on substrate by using the same dimensions as CST, and then we obtain the antenna in figure 4(b). and we do the characterization with network analyzer, is the calibration (In our we will do it just for the short and the adapted)and then we display results.



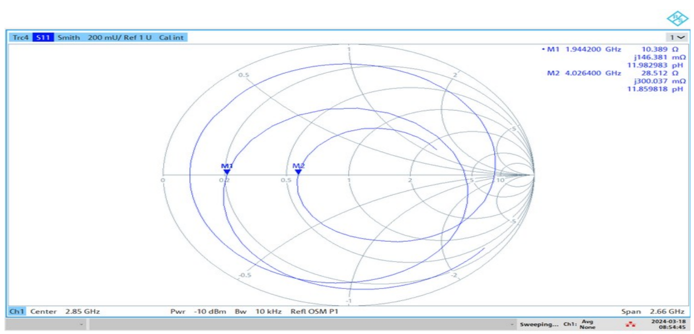


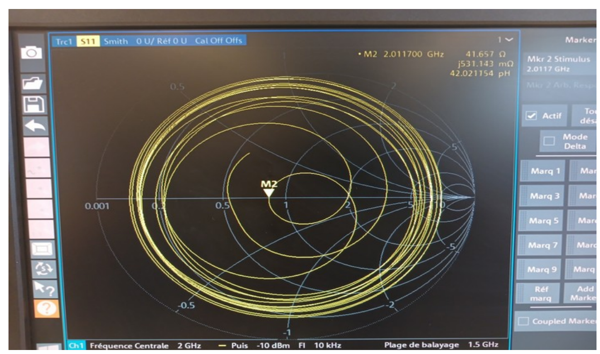
(a) (b)

Figure4. *S_{11} parameter. (a) peak S_{11} at 2GHz with amplitude -14,7dB. (b) patch antenna with single stub.*

From figure4(a) we can remark that we are near to the resonant frequency, so we are almost adapted, we calculate bandwidth at -10GHz, we find 90MHz.

II.2.Adaptation with single stub





(a) (b)

Figure5. *Results on network analyzer.(a).Smith chart before we add stub.(b). Smith chart after we add stub.*

From Smith chart shows Figure5(a). we can say that we are not adapted at resonant frequency, that's why we have added a single stub as in simulation part with the same dimension, and when we perform that we obtain the smith chart shows in Figure5(b), and in this case we obtain an imaginary part of 531.143mΩ its close to zeros, and impedance matching of 41.7Ω, then we can conclude that have almost reached the matching impedance.

Conclusion

finally we have exploit many way to adapt antenna, and one that worked best for us, is the single stub.

To finish, this study we can say that we have modeled our patch antenna to be able to emit at 2GHz and to be able to be matched to all to power source of 50 Ω (power source and antenna are well matched).

ARTICLES:

KHEROUS Louiz---→>>>5G microstrip patch antenna and microwave dielectric properties of 4 mol%LiF–MgO–*x*wt%$MTiO_3$ (M = Ca, Sr) composite ceramics

Link:

https://link-springer-com.ressources-electroniques.univ-lille.fr/article/10.1007/s10854-021-06826-1

SIDIBE Issa------>>>>Microstrip patch antenna design, simulation and fabrication for 5G applications

Link:

https://www-sciencedirect-com.ressources-electroniques.univ-lille.fr/science/article/pii/S1569190X22000090