Ministry of Higher Education
Egyptian Academy for Engineering & Advanced Technology (EAEAT)
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Department	Electrical engineering
Academic Year	3rd Year
Course name	Antennas Engineering
Course code	**ECO344**

Title: 5G Antenna

By:

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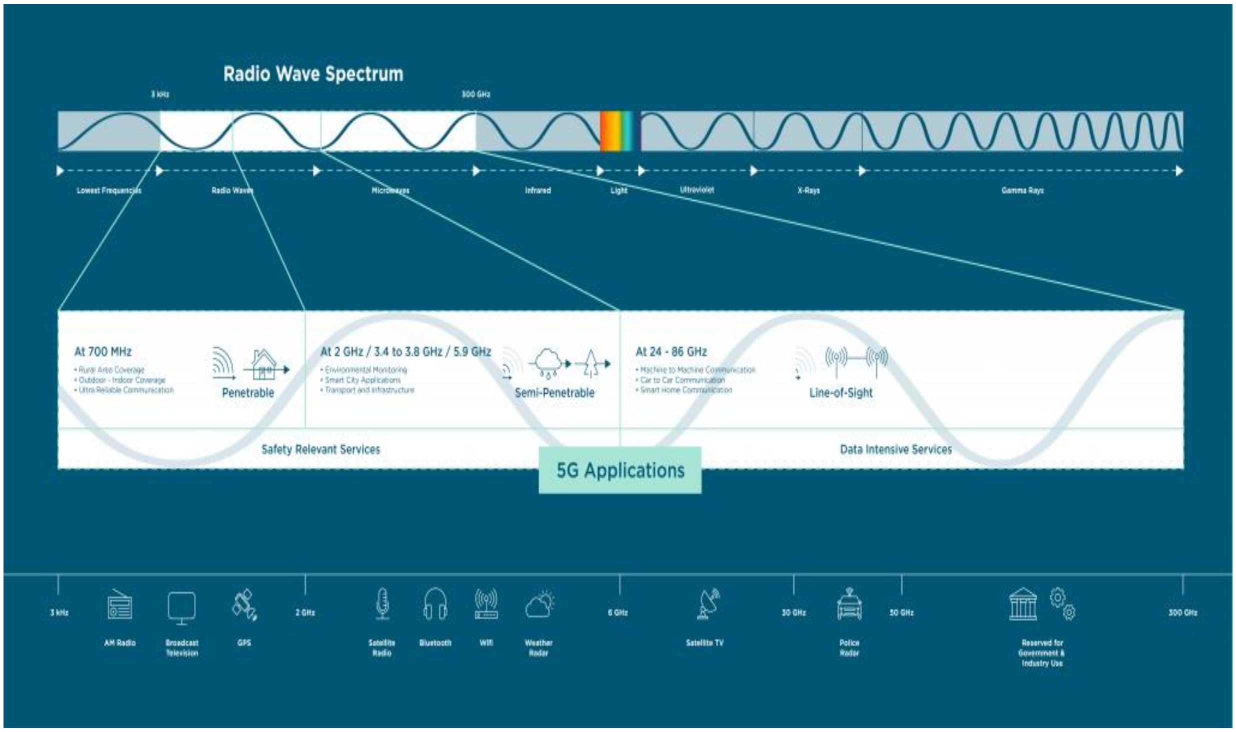
Introduction:

5G network consider a whole new set of networks for different applications, 5G promises Maximum speeds of up to 20 GB/s, minimizing signal propagation time (latency), it let all wireless experiences seem instantaneous that opens the door for new applications.

5G mobile network operates in various frequencies therefore there are different antennas for different frequency bands.



5G applications mainly consists of two types (Safety relevant services and data intensive services)

Safety relevant services: Coverage area:

1- below 2 GHz suitable for rural area coverage, Outdoor/Indoor coverage and Ultra reliable communication.

2 – 2 ~ 6 GHz suitable for environmental monitoring, smart city applications and transport/Infrastructure

Data intensive services: coverage area from 24 GHz provide a high bandwidth but require a direct line connection.

5G antennas are highly directional and can be used right next to other wireless signals without causing interference, these antennas use shorter wavelengths due to higher frequencies, which means that antennas can be much smaller than existing antennas while still providing precise directional control.

Important Advantages:

The main advantages of the 5G are a greater speed in the transmissions, a lower latency and therefore greater capacity of remote execution, a greater number of connected devices and the possibility of implementing virtual networks (network slicing), providing more adjusted connectivity to concrete needs.

Greater speed in transmissions:

Speed in transmissions can approach 15 or 20 Gbps. By being able to enjoy a higher speed we can access files, programs and remote applications in a totally direct and without waiting. By intensifying the use of the cloud, all devices (mobile phones, computers) will depend less on the internal memory and on the accumulation of data and it won't be necessary to install a large number of processors on some objects because computing can be done on the Cloud.

For example, being able to activate software remotely as if it were executed in personal devices, will allow not having installed the mobile applications in the terminal and executing them directly from the cloud. Just as it will no longer be necessary to store the information in the memory of the device (photos, videos)

Lower latency:

Latency is the time that elapses since we give an order on our device until the action occurs. In 5G the latency will be ten times less than in 4G, being able to perform remote actions in real time.

Thanks to this low latency and the increase of the sensors, it is possible to control the machinery of an industrial plant, control or remote transport, surgical operations in which the doctor can intervene a patient who is at another side of the world with the help of precision instrumentation managed remotely or the complete control of remote transport systems, automated and without driver

Greater number of connected devices:

With 5G the number of devices that can be connected to the network increases greatly, it will go to millionaire scale per square kilometre.

All connected devices will have access to instant connections to the internet, which in real time will exchange information with each other. This will favour the IOT (internet of things).

It is anticipated that a common home will have a hundred connected devices sending and receiving information in real time. If we think of industrial plants, we would speak of thousands of connected devices.

This greater number of connected devices will allow the smart cities and the autonomous car.

For example, by placing sensors in different points and objects in the city, a large part of it can be monitored. If you share the information of the sensors of the cars and those of the city, and these exchange data you can improve the quality of life of the cities, facilitate the navigation of the autonomous car (choose better routes, reduce the number of accidents, find available parking spaces)

Restrictions:

There will be several antennas on a 5G phone, and this poses difficulties in finding out proper techniques for measuring efficiency. Design teams need to make radio testing rooms considerably longer for better over-the-air measurements, so they can find out how far those mm Wave signals can actually go. Ultra-short distance networking often causes improvements that include physical changes in the design of the chip or device.

The problem of high-frequency and short-distance, which might restrict a 5G cell to a width not greater than the distance on a city street between poles, puts pressure on a system to track and manage all those connections

Furthermore, 5G gives near-zero latency a very high priority, implying the need to rely more on silicon for complex processing and less on software.

How we designed the 5g antenna?

We designed the antenna to operate at 28 Ghz

-First ground dimensions:

Xmin = -x/2	Xmax = x/2
Ymin = 0	Ymax = y
Zmin = -0.035-h	Zmax = -h

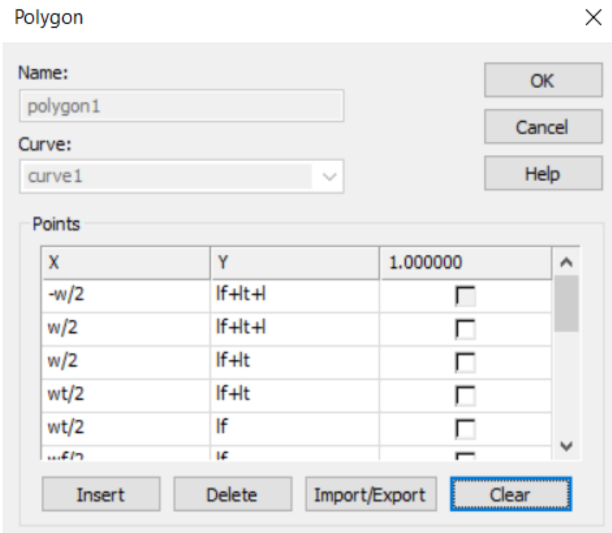
Where x =8.05mm, y = 6.96mm, h = 0.8mm, assigning PEC as material.

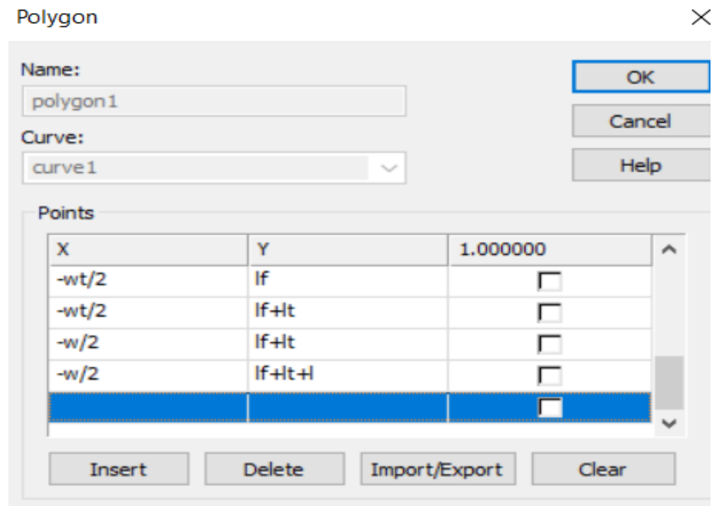
Second substrate dimensions:

Xmin = -x/2	Xmax = x/2
Ymin= 0	Ymax = y
Zmin = -h	Zmax = 0

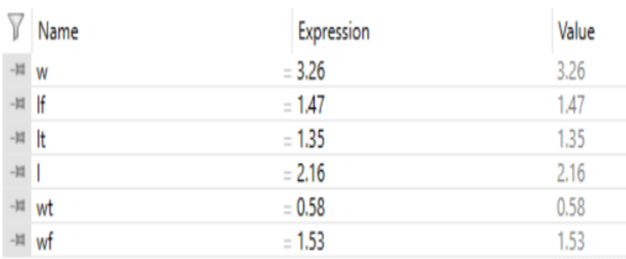
We assign our substrate with Fr-4(lossy) with epsilon of 4.3 and loss tangent of 0.02

Third designing the patch as polygon with the following points:

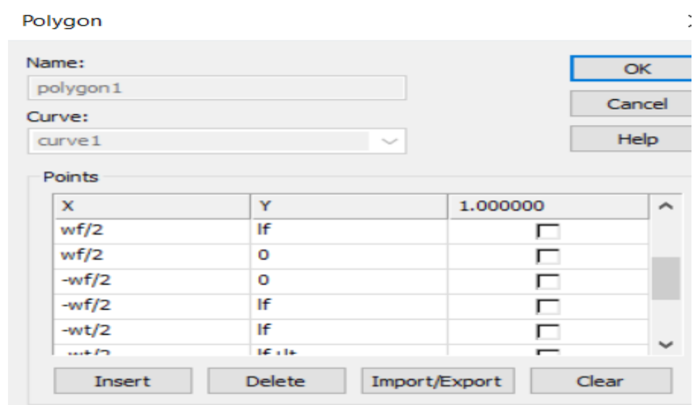




With a total of 13 points, where:



Name	Expression	Value
w	3.26	3.26
lf	1.47	1.47
lt	1.35	1.35
l	2.16	2.16
wt	0.58	0.58
wf	1.53	1.53

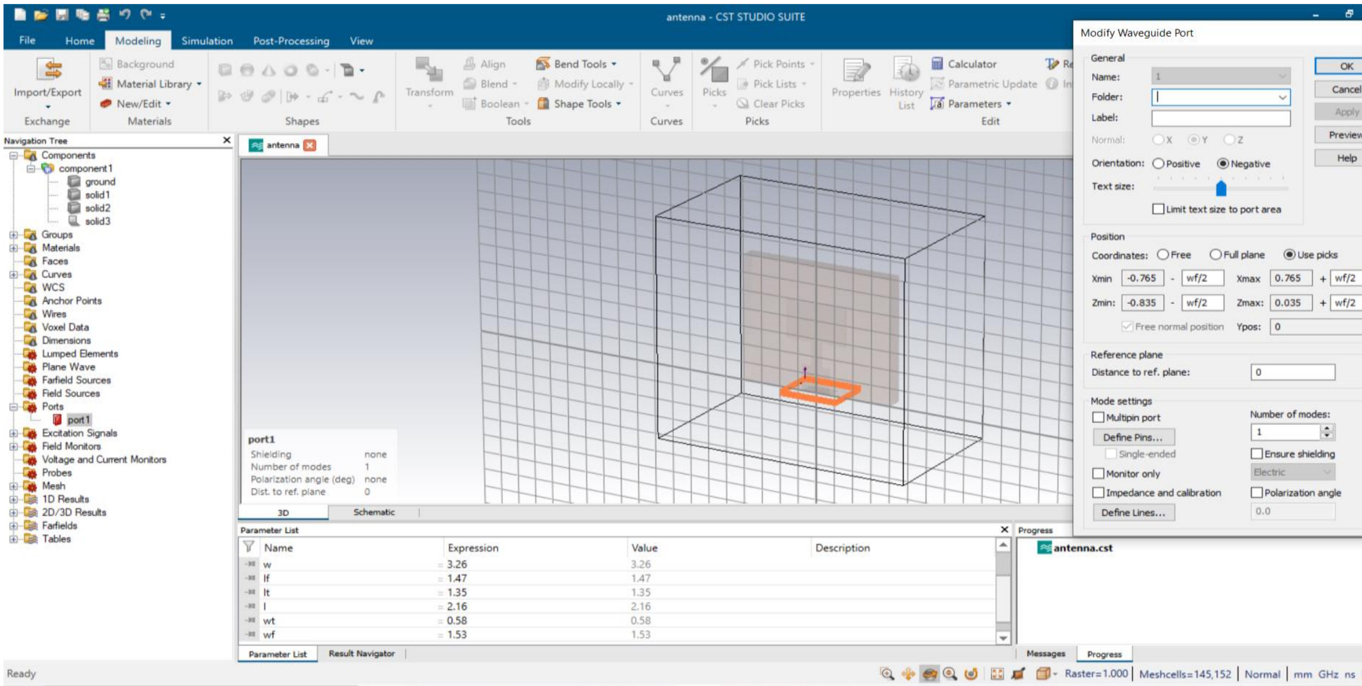


Then we extrude the polygon into a patch with thickness (zmax) of -0.035 so it got on top of our substrate

Lastly we design a rectangle where wave port will be with following dimensions:

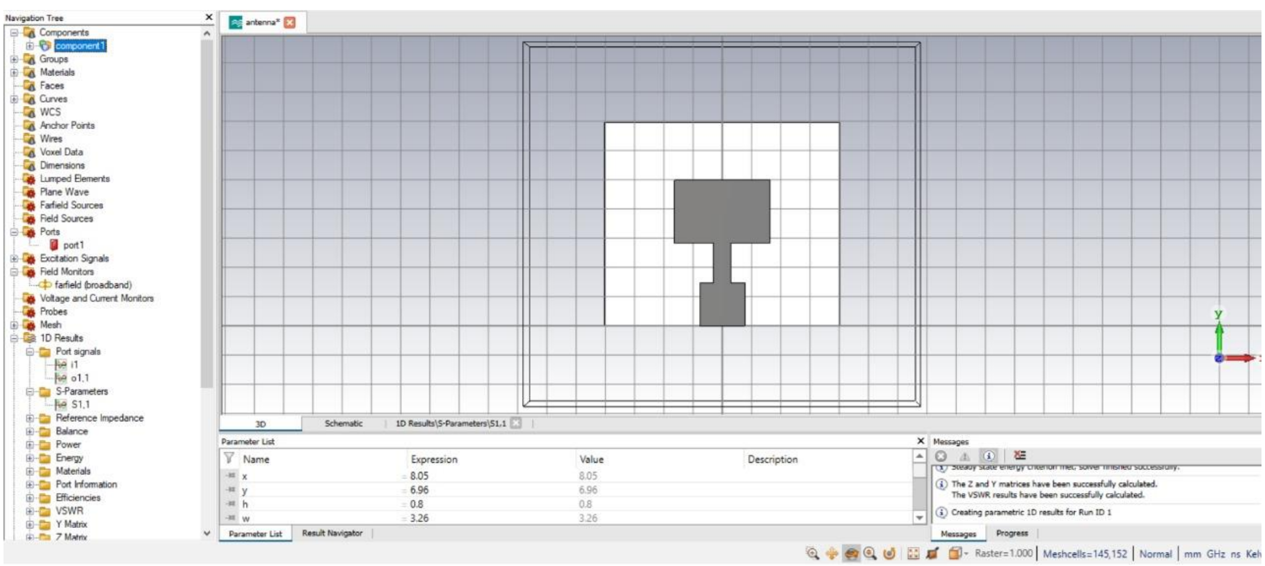
Xmin = -wf/2	Xmax = wf/2
Zmin = -0.035-h	Zmax = 0.035

Port configurations:

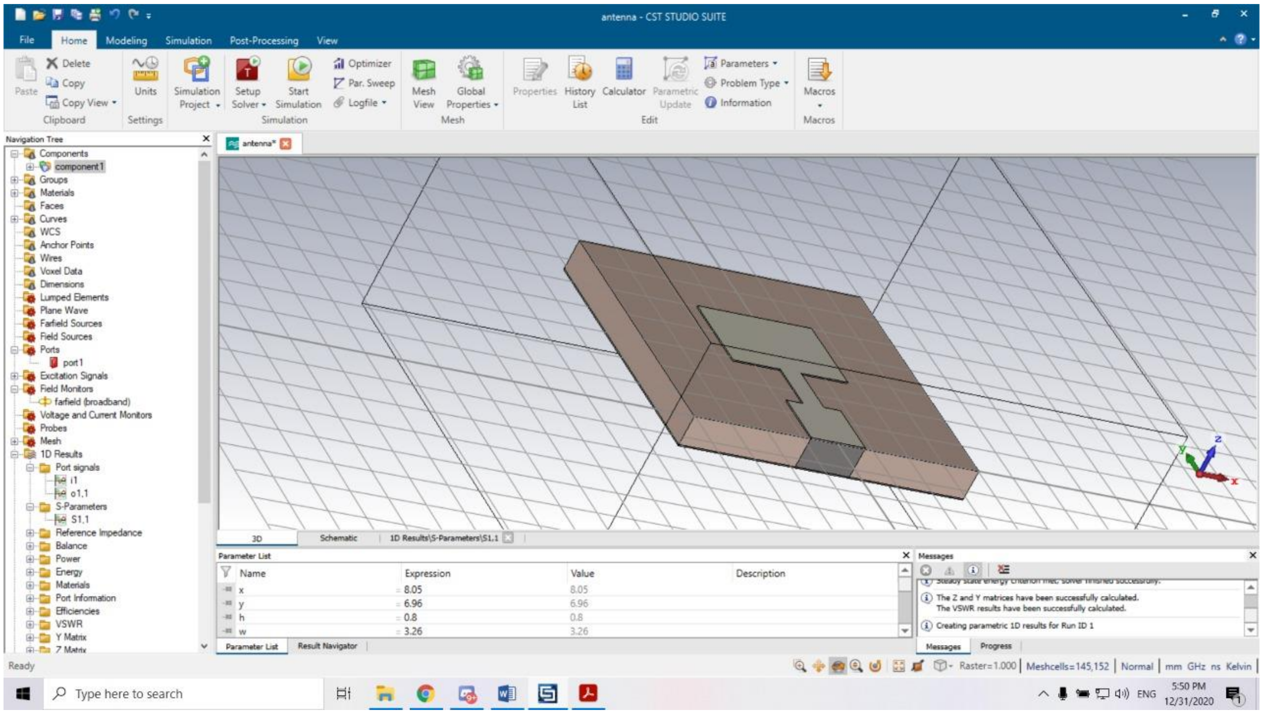


<u>Simulation Results from CST</u>:

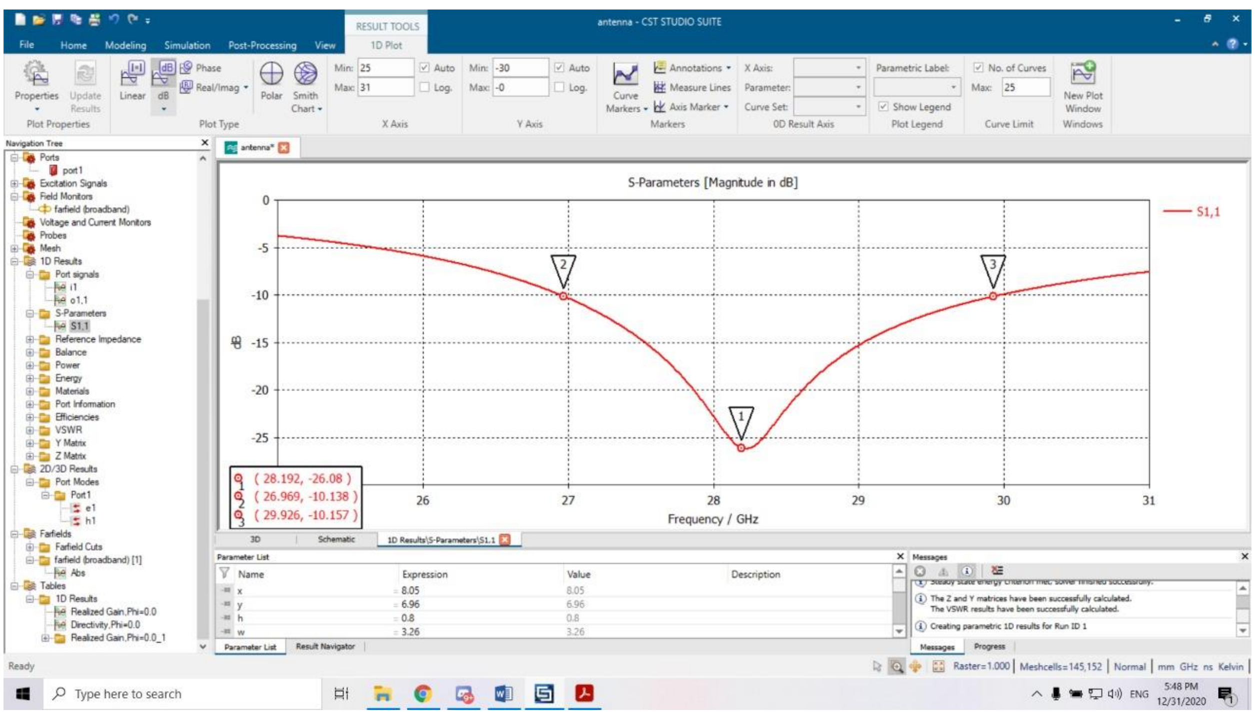
1- <u>Front view of the design:</u>



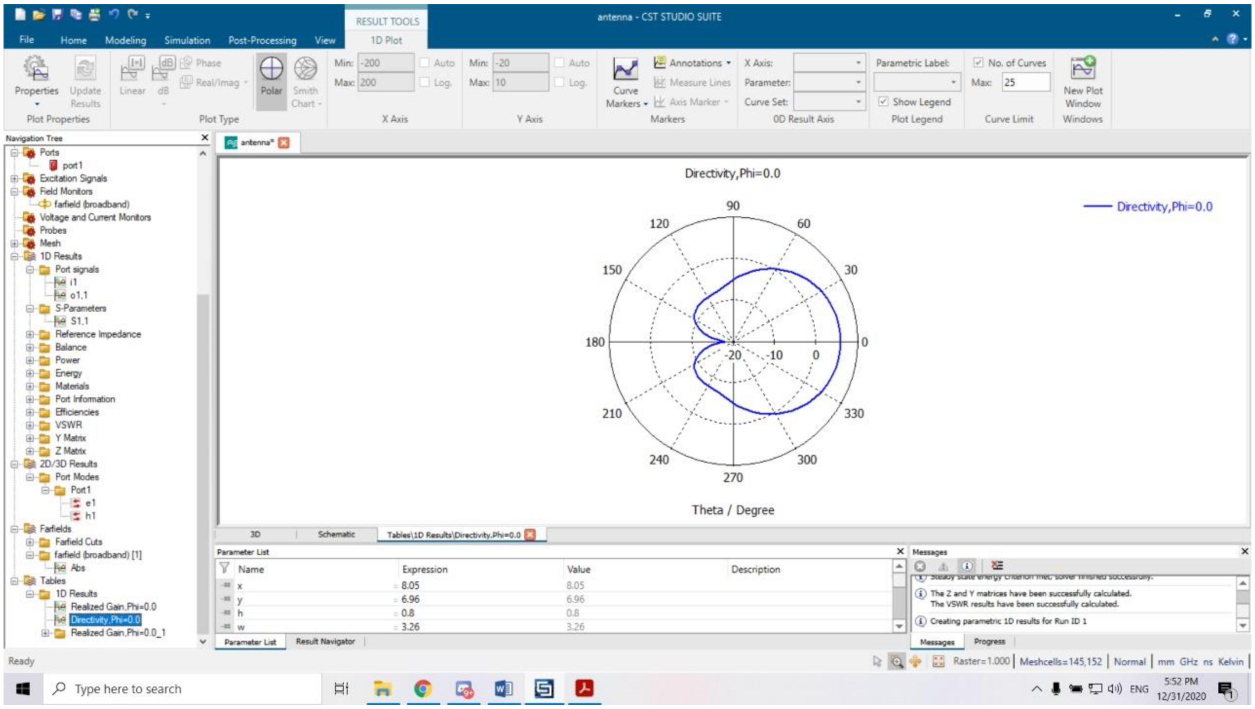
2- <u>Side view of the design:</u>



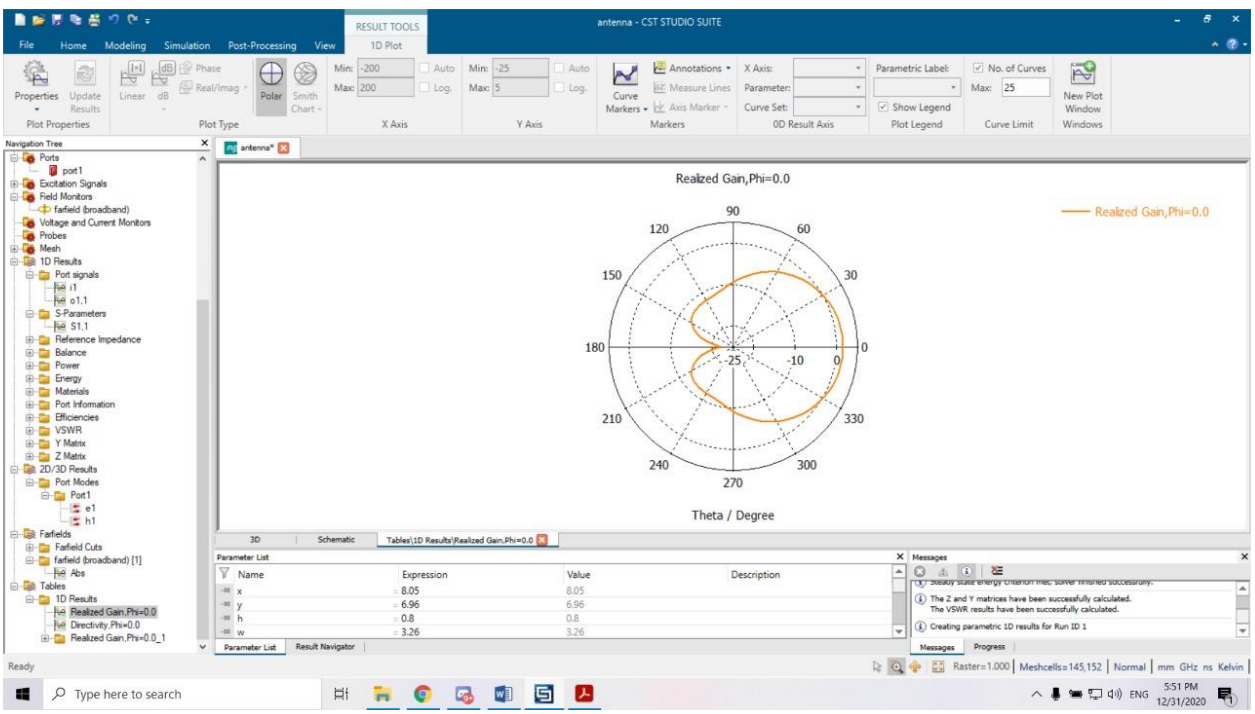
3- <u>S-parameters:</u>



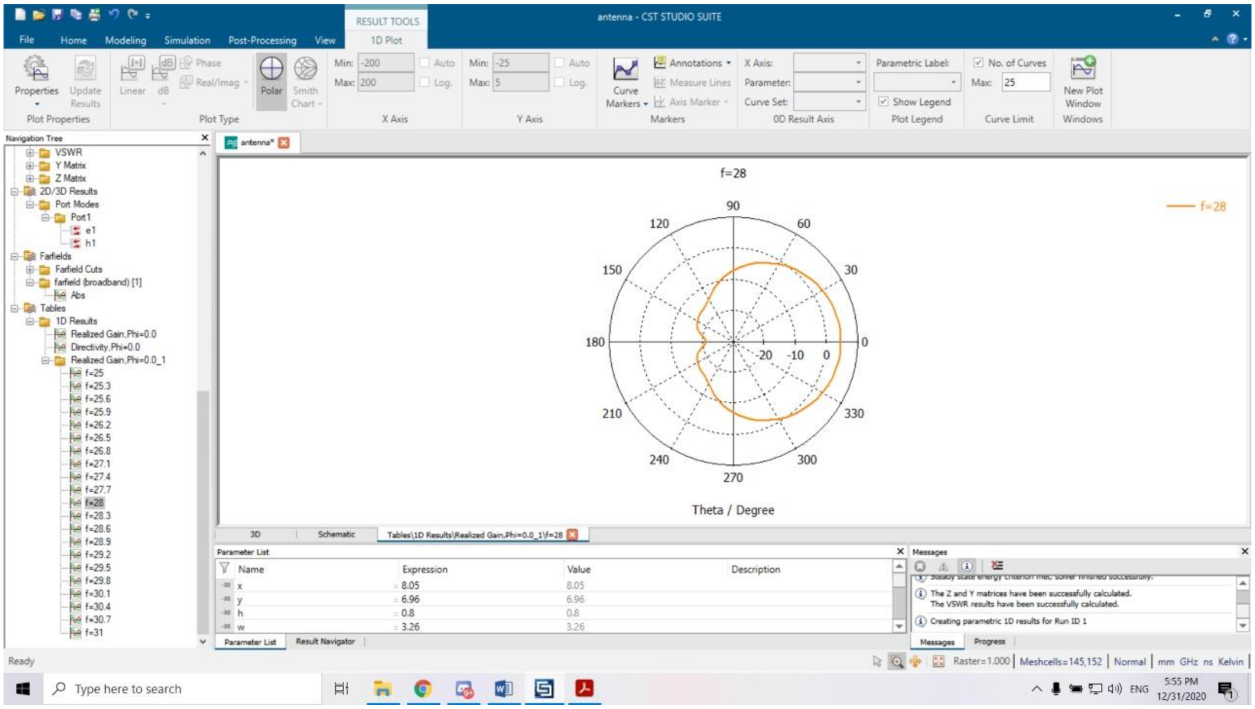
4- Directivity:



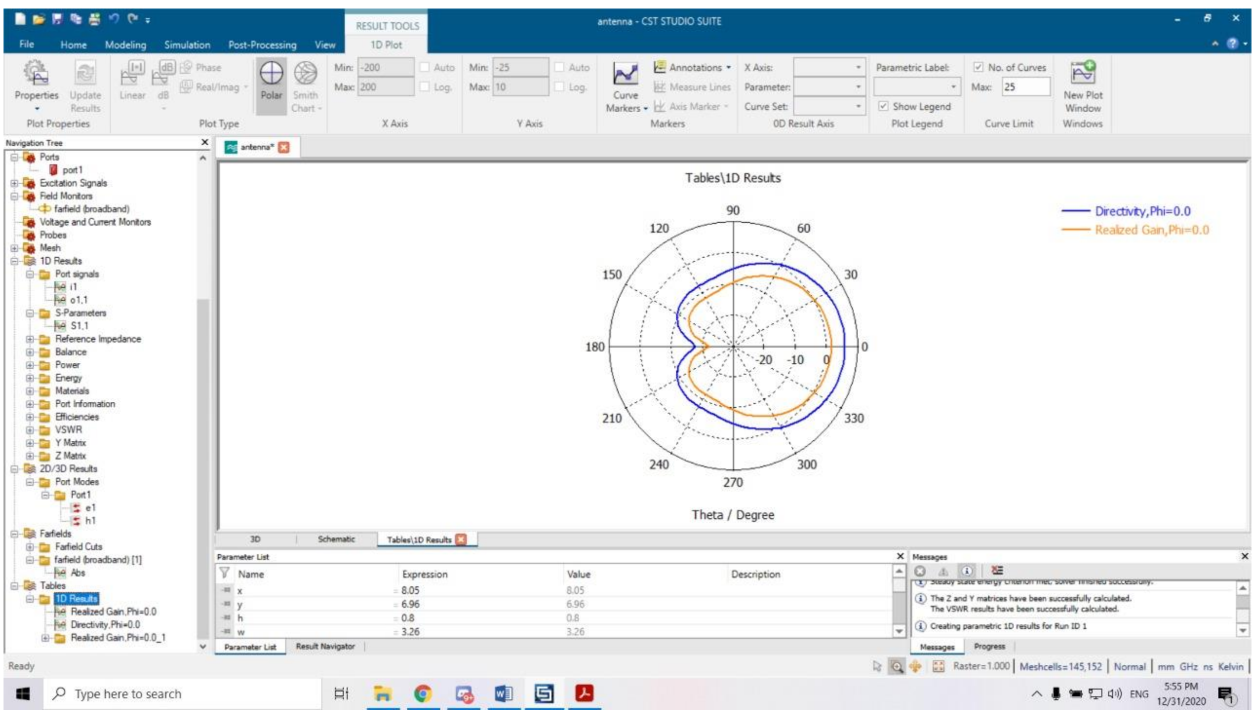
5- Gain:



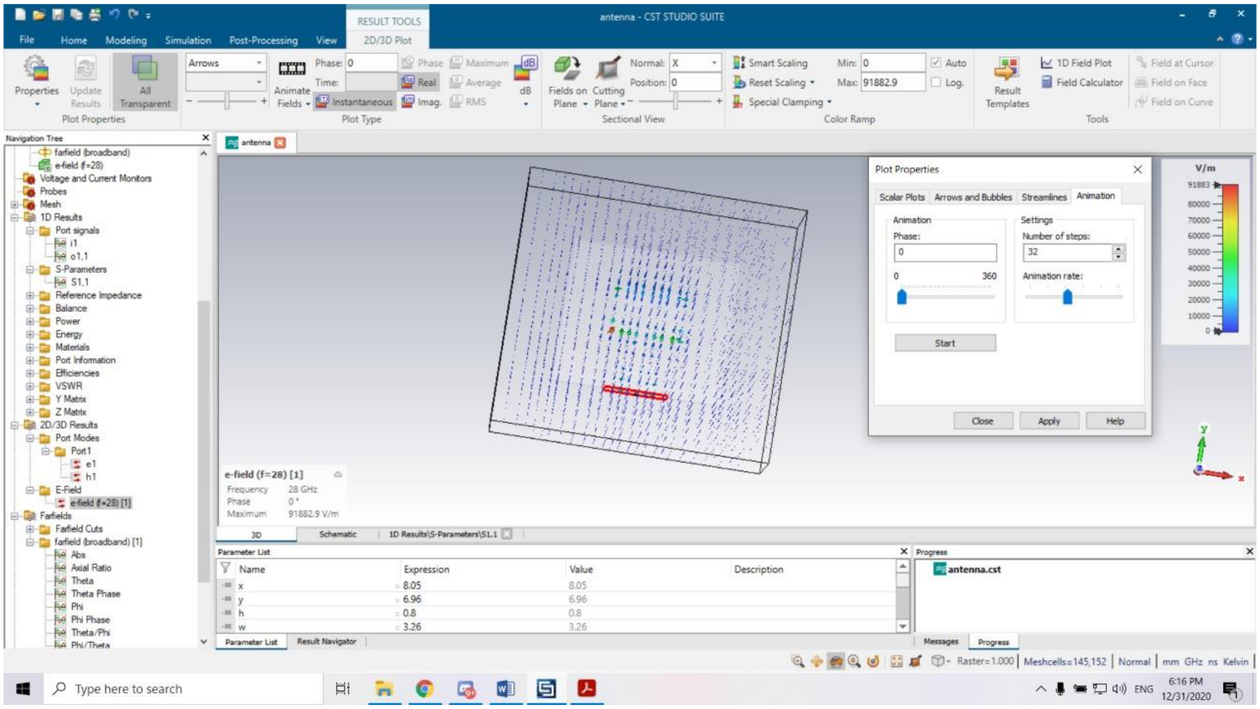
6- <u>Gain at frequency 28G:</u>

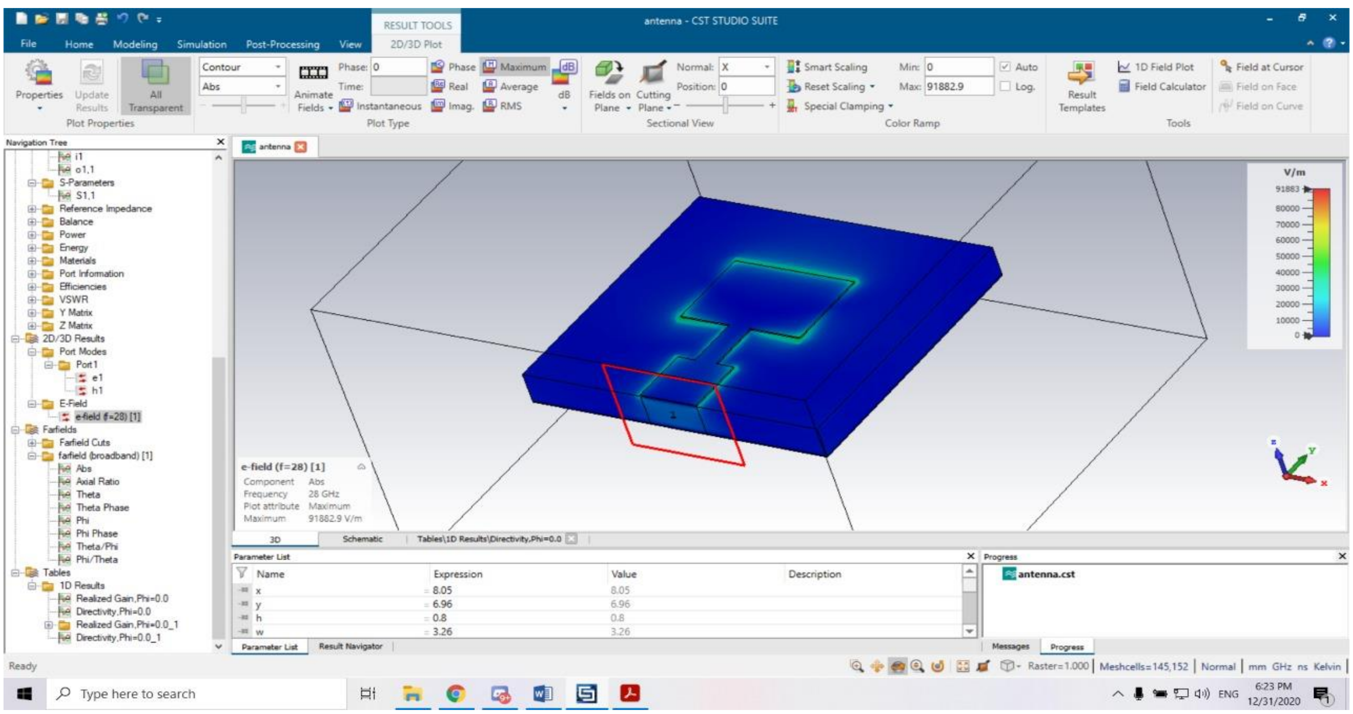


7- <u>Gain/Directivity vs frequency:</u>

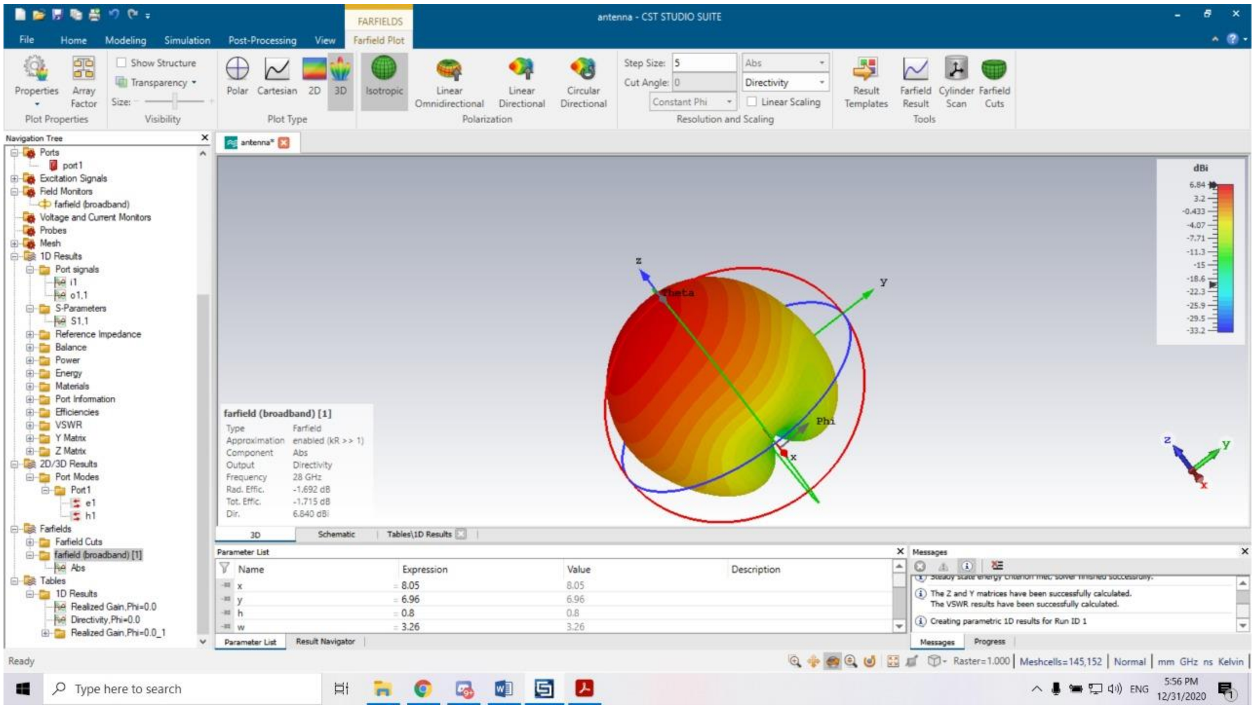


8- Electric Field distribution:

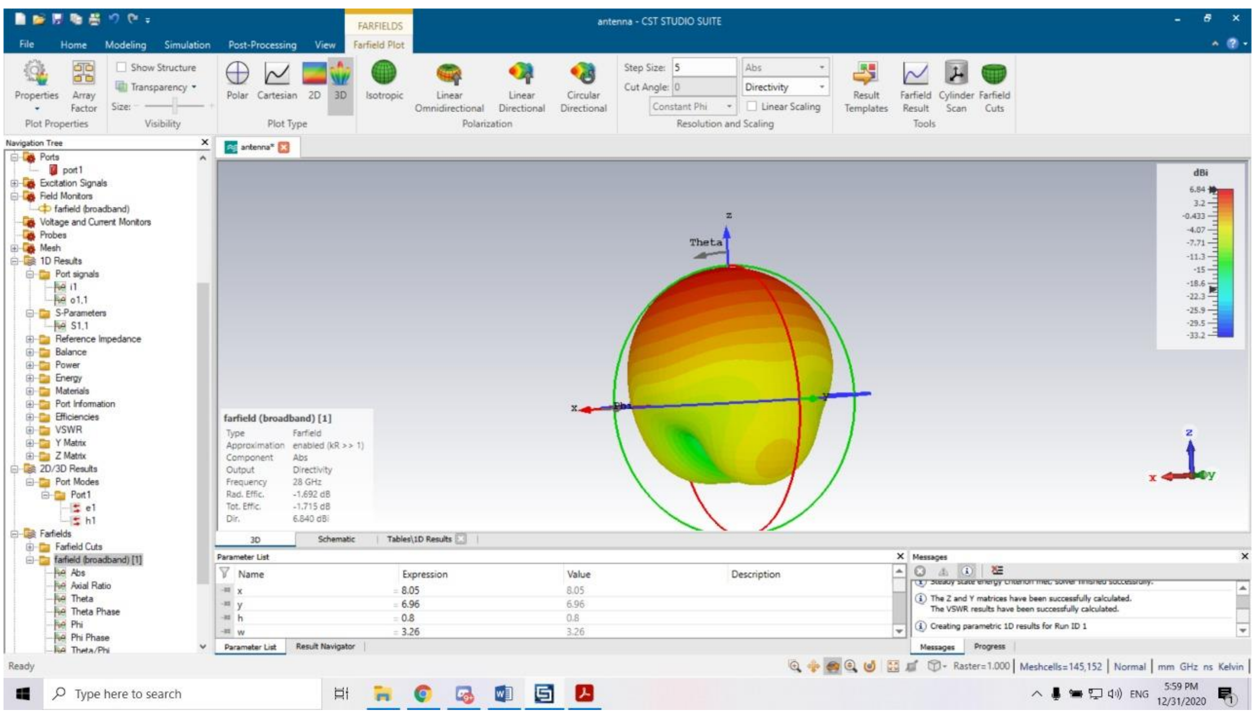




9- <u>Radiation Pattern:</u>



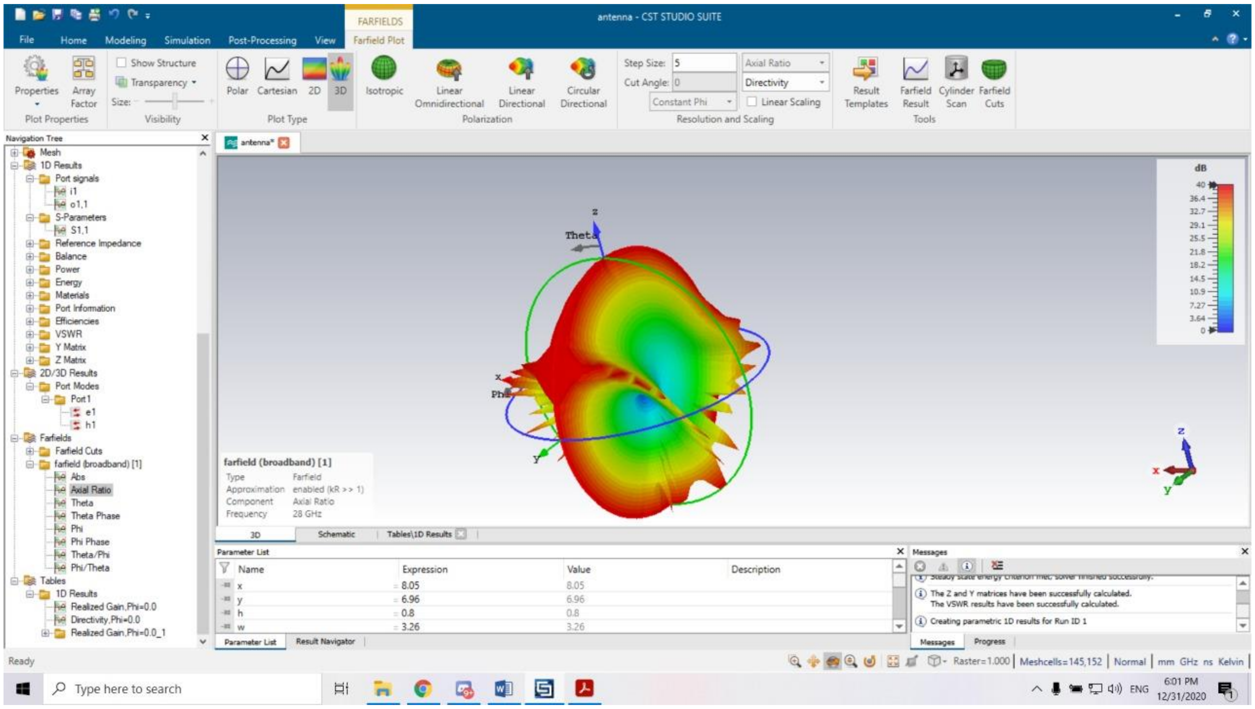
(1)



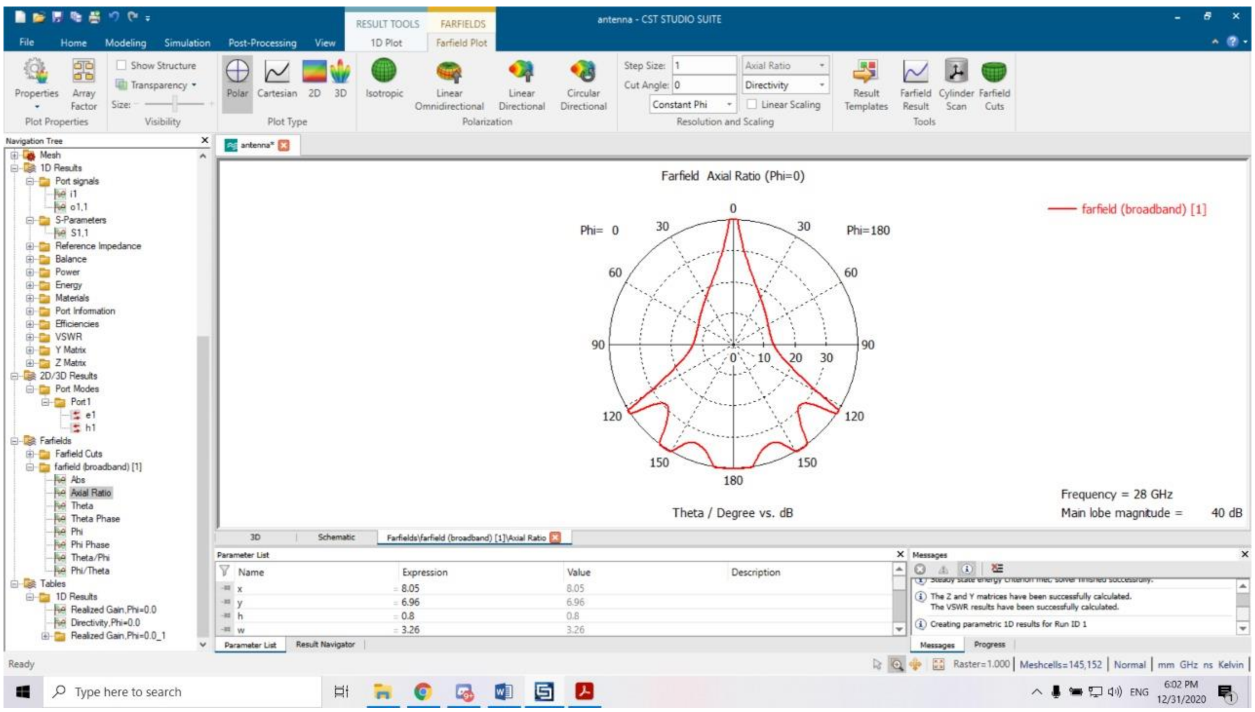
(2)

We noticed a small back radiation in the lower side of the radiation pattern.

10- Axial Ratio:



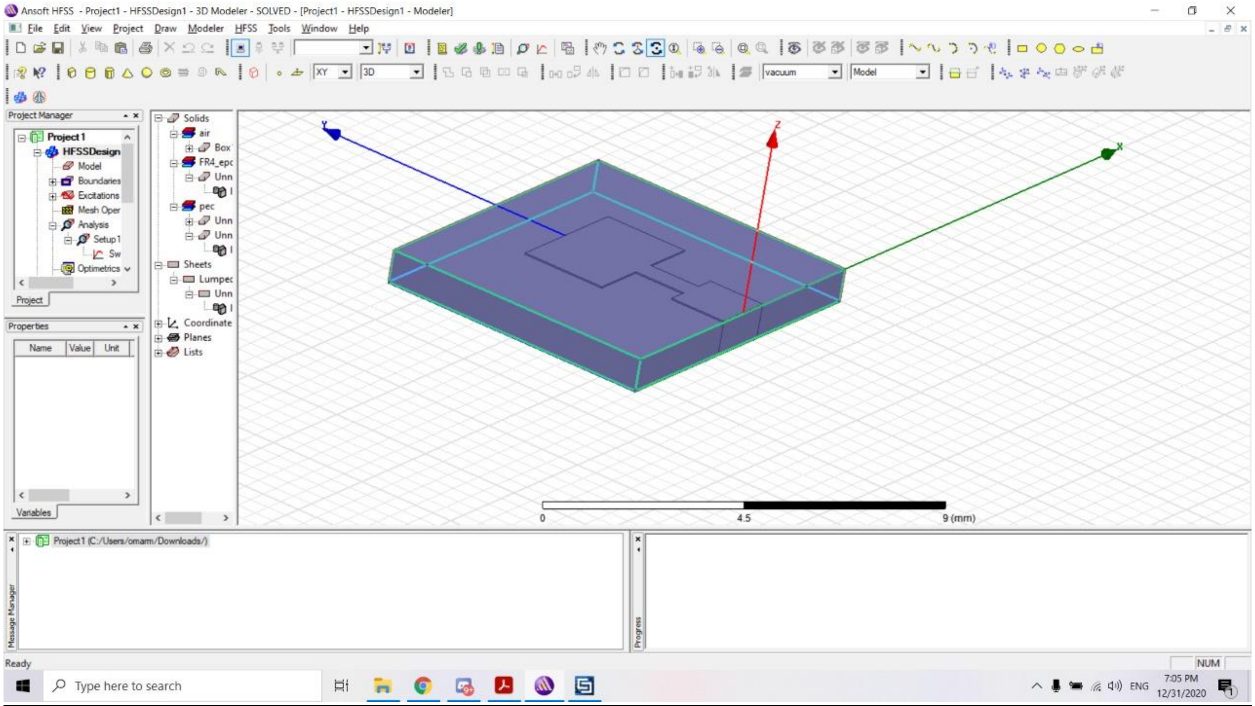
(1)



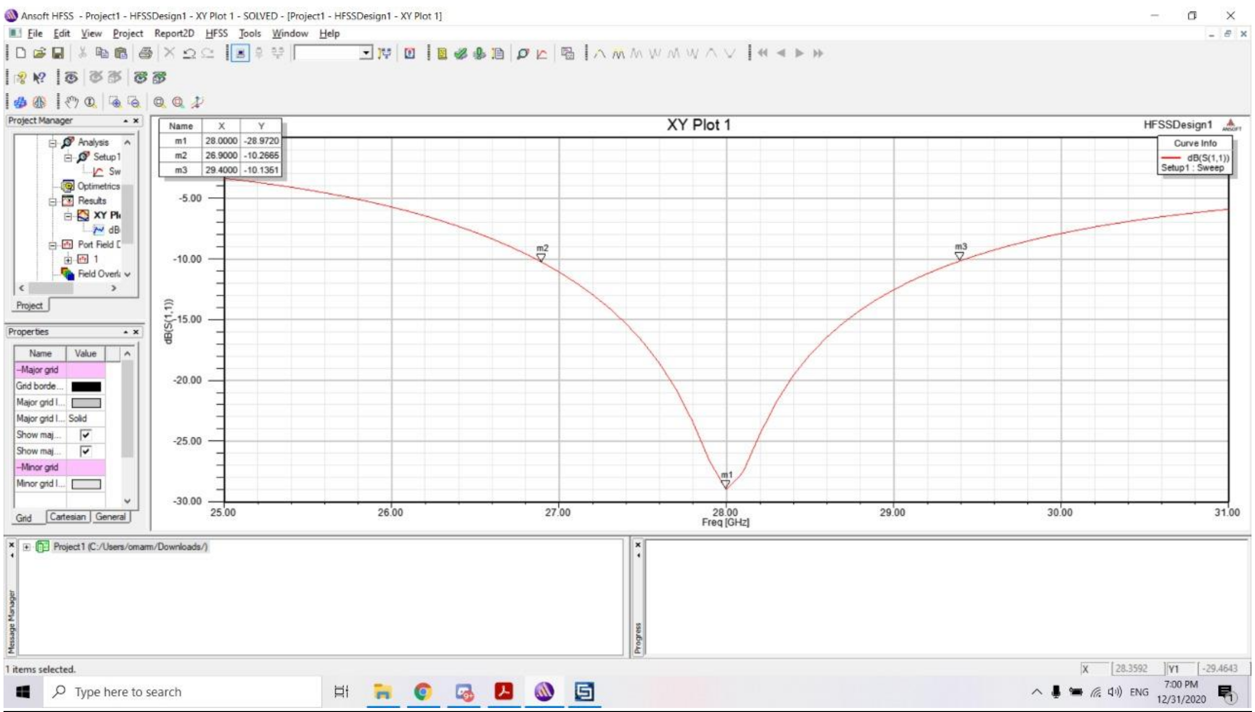
(2)

Simulation Results from HFSS:

1- Design:



2- S-parameters:



3- <u>Radiation Pattern:</u>