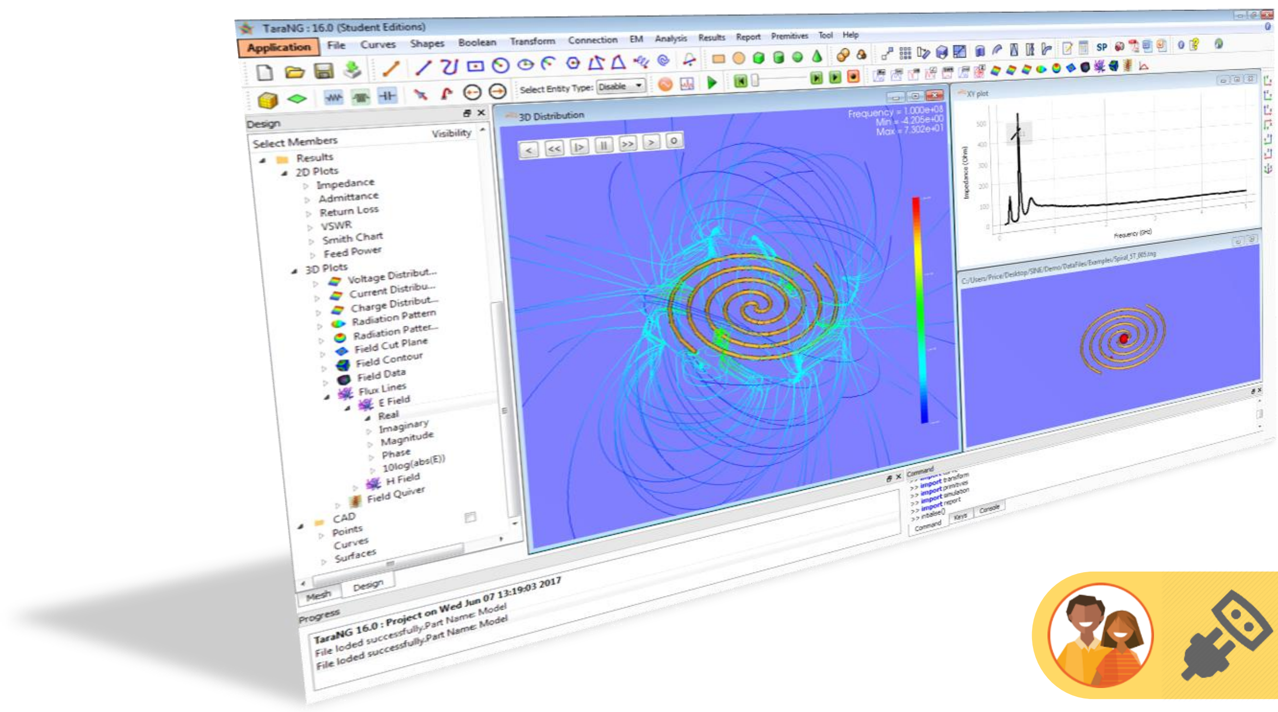
NUMEREGION's TaraNG

TaraNG – EMF

Electromagnetics Simulations



User Manual

TaraNG is indigenously developed simulation software tool in the domain of electromagnetics. TaraNG offers simulation based hands-on experience which is best suitable for interactive pedagogical learning

MADE IN INDIA

NUMEREGION is a DIPP recognized start-up working in field of simulation and mathematical modelling. We have got initial fund support incubation from Department of Science and Technology (DST) Government of India.

For more details visit our website: **www.numeregion.com**

Introduction:

This user manual provided step by step detail for using the TaraNG simulation platform to learn and practice different concepts of Electromagnetics subject. The software also enables the user to learn near and far field applications, modelling and simulation of sets of EM problems. Students shall get hand-on problem solving experiences and knowledge.

At the end of course students will be able to learn how computers are solving the RF & microwave problems and helping us in entire product life-cycle at industries. Each student will perform all modules on the TaraNG platform.

Software Requirements:

- 4 GB of RAM recommended.
  - Memory requirement could vary depending on model size. Normally 2 GB RAM is good enough for 10000 elements/cell models.
- 2.6 GHz Xeon or i3-i7 equivalent CPU.
- Hardware accelerated graphics (preferably NVdia or AMD) equivalent of Quodro 2000 or above
- 2 GB disk (free) for complete installation.
- Super VGA monitor with following settings:
  - Screen resolution set to at least 1280 x 1024.
  - Small fonts selected.
- Three button mouse (middle button is used to switch the control mode between pan/rotate)

Windows:

- Visual 32/64 bit version:
  - Windows 10 version 1607
  - Windows 8.1 with Update
  - Windows server 2012 R2 with Update
  - Windows 7 SP1
  - Windows Server 2008 R2 SP1
- All the essential system files and DLL's essentially mscvcr100.dll installed properly in system folder for Windows operating system.

List of Experiments using TaraNG simulation tool

1. **Coordinate System:** To understand Rectangular, Cylindrical and spherical coordinate system and the conversion from one system to another
2. **Vector Algebra:** Performing different manipulation on vectors like addition, subtraction and cross product using interactive simulations
3. **Electrostatics - Coulomb's Law:** To demonstrates how the lines of electric forces (flux) gets established when we have different charges located within a simulation domain. Students can change the location of charges, the charge and the polarity to observe the effects and changes in flux lines.
4. **Magnetostatics Biot-Servet's Law:** To demonstrates how the lines of magnetic forces (flux) gets established when different current carrying conductors located within a simulation domain.
5. **Moving charges inside Electric and Magnetic Field:** This simulation demonstrates the behavior of static charge in a magnetic field. The trajectory path of the charges can explain the behavior in animated format which can be controlled by students by changing the value of charge.
6. **Wave Polarization:** This simulation explains polarization concept of EM waves in which students can change the levels of signals and the orientation of vectors to observe Linear and Circular Polarization (LHCP, RHCP) of EM waves.
7. **Rectangular Waveguide:** To observe various modes inside the waveguide (TE10, TE20, TM11, TE11 etc.). Plot propagation constant, attenuation loss, characteristics impedance and guided wavelength.
8. **Dipole Antenna:** Design and simulation of dipole antennas to study different 2D and 3D results which includes Input impedance, Scattering parameters, VSWR, Smithchart and Radiation Patters.

1. Coordinate System

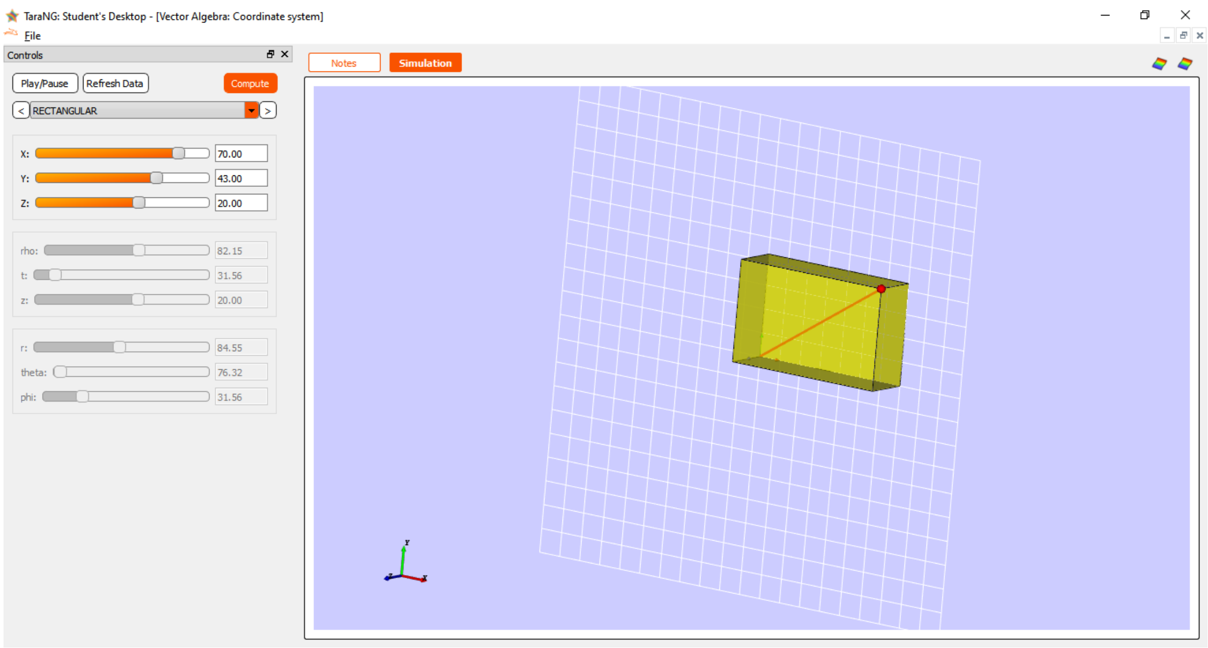
A coordinate system is a method for identifying the location of a point in space. Points are designated by their distance along a x, y and z axis from a reference point or the origin. A polar coordinate system locates a point by its direction relative to a reference direction and its distance from a given point, it leads to cylindrical and spherical coordinates. Such a system is used in radar or other navigation systems.

Goal

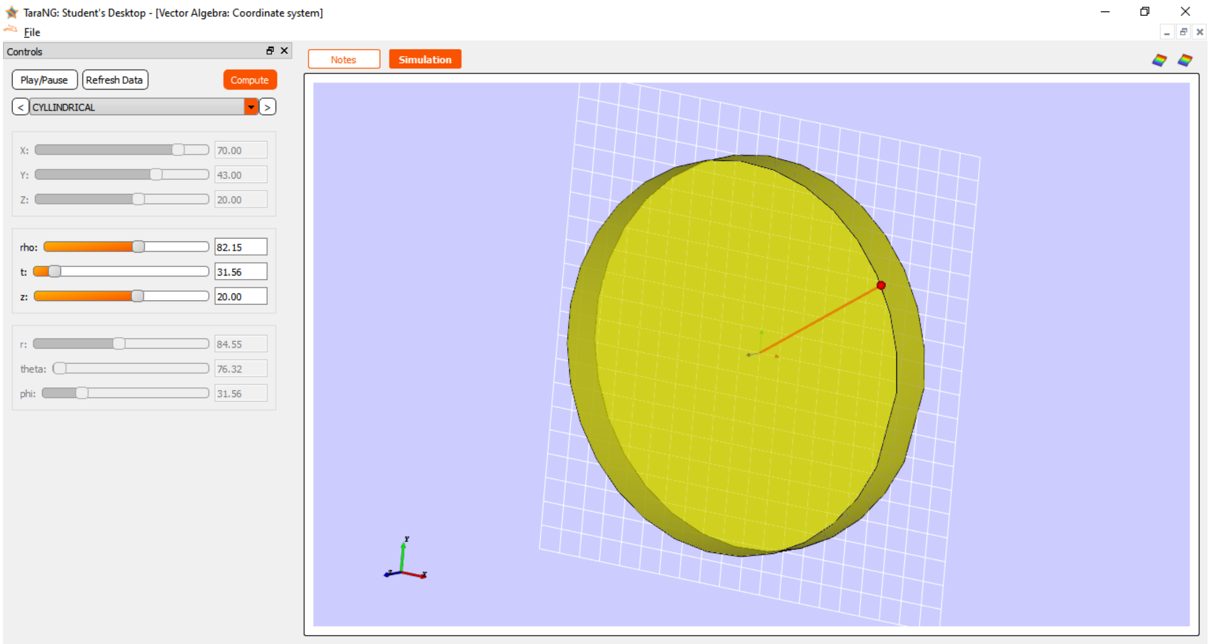
- To move a point in different coordinate systems using sliders
- To understand coordinate system conversion

Design Procedure

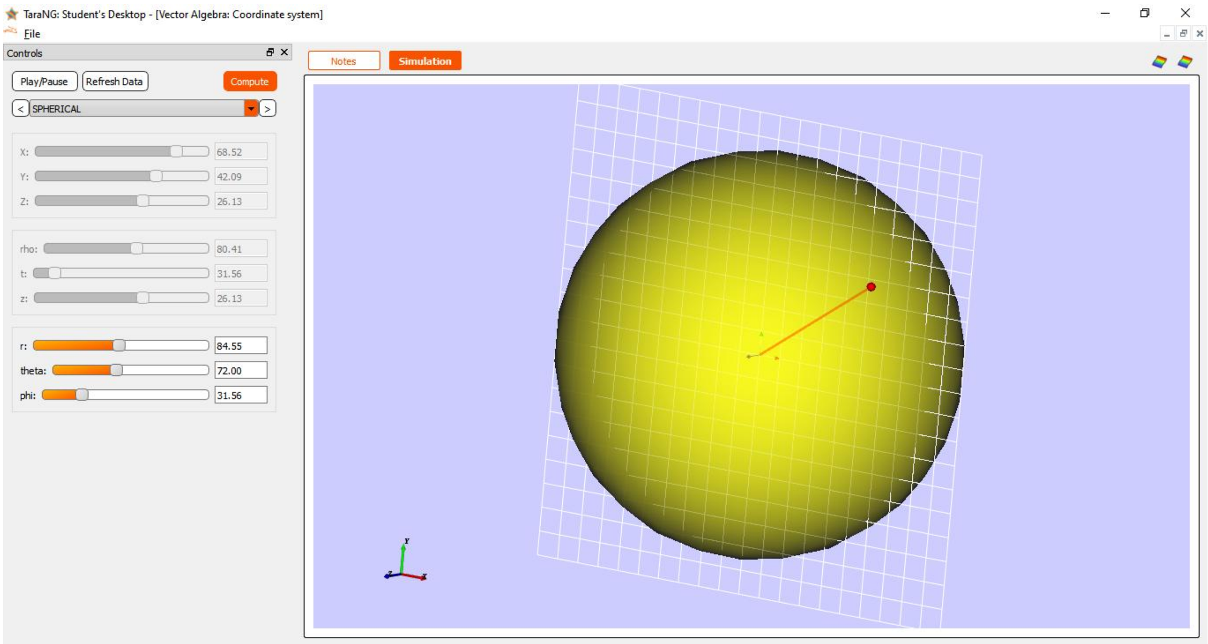
1. **Initiating Project:** Open the project it will show below window,
2. **Rectangular Coordinate System:** Adjust the X, Y, Z sliders it will show coordinate space values being changed, the changes will be reflected in the design window. Note down the changes in other coordinate systems



3. **Cylindrical Coordinate System:** To get into Cylindrical Coordinate System choose CYLINDRICAL option from the options. Adjust the sliders and note down the conversions



4. **Spherical Coordinate System:** To get into Spherical Coordinate System choose SPHERICAL option from the options. Adjust the sliders and note down the conversions



2. Vector Algebra

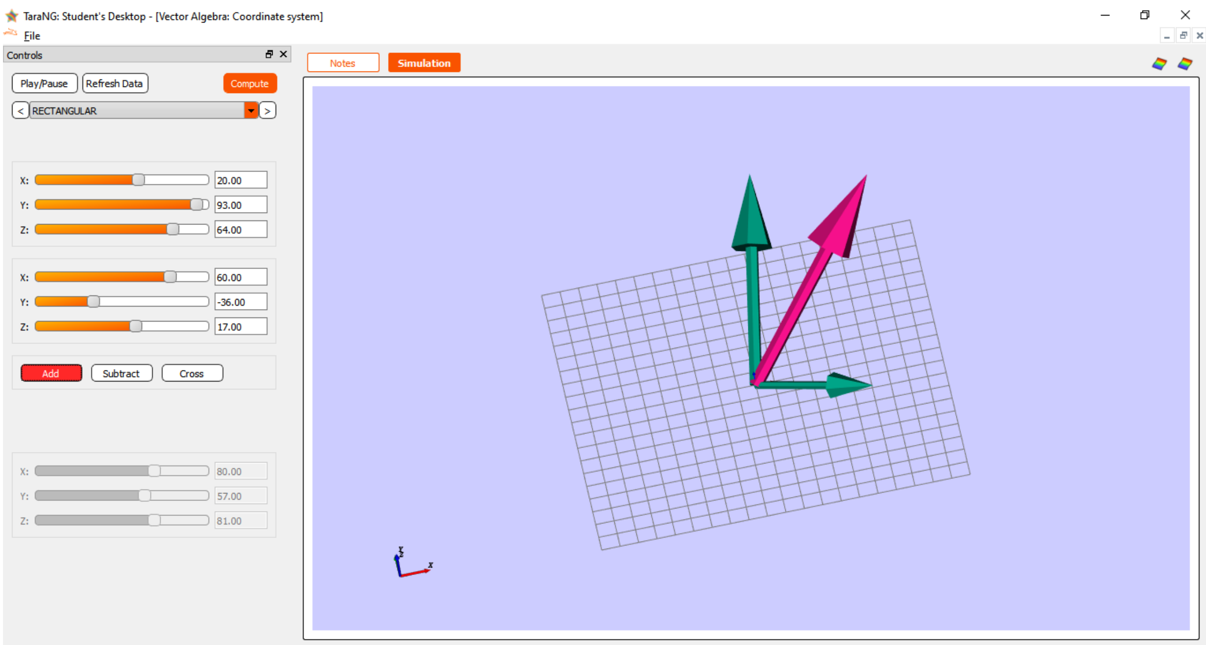
In last experiment we studied coordinate system where the point is examined under different coordinate systems. Vectors are objects which have magnitude and direction, but they do not have any specific location in space. On the other hand, a point has a certain position in space, and the only characteristic that distinguishes one point from another is its position. Points cannot be “added” together like vectors. On the other hand, vectors can be added to a point p together. The operations of addition, subtraction and multiplication familiar in the algebra of numbers (or scalars) can be extended to an algebra of vectors.

Goal

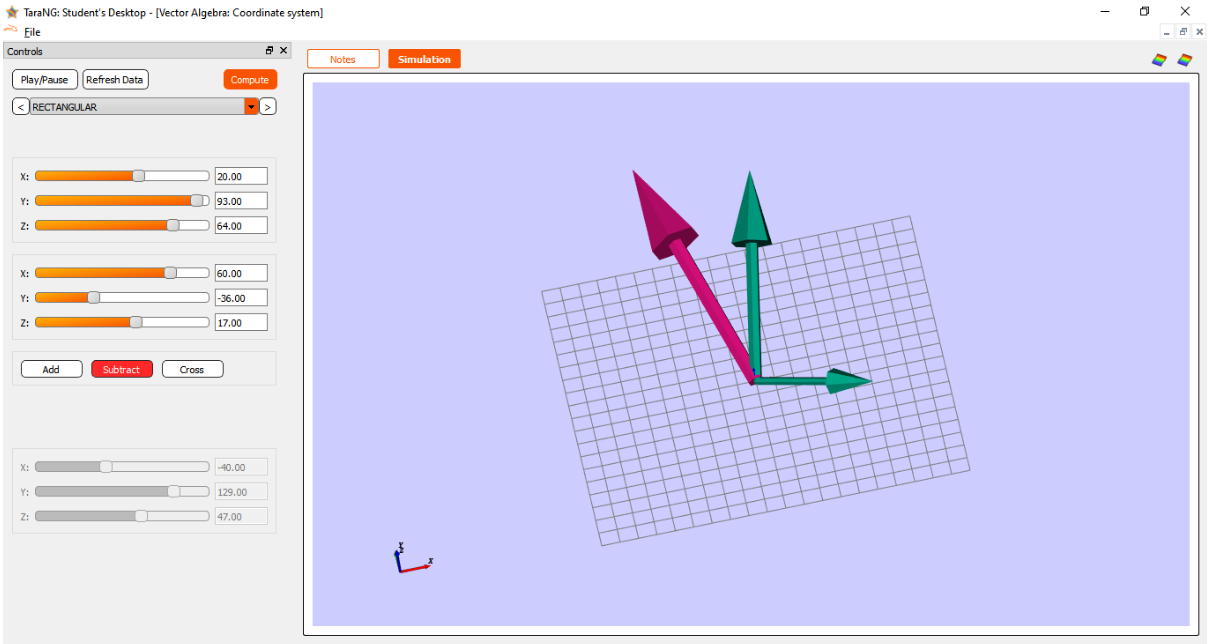
- To Add, Subtract to Vectors
- To perform Cross product operation on two vectors
- Make 3D vector plot for given equation & understand different plot types like contour plot, quiver plot, cut-planes etc.
- Observe Curl function of any function in 3D

Design Procedure

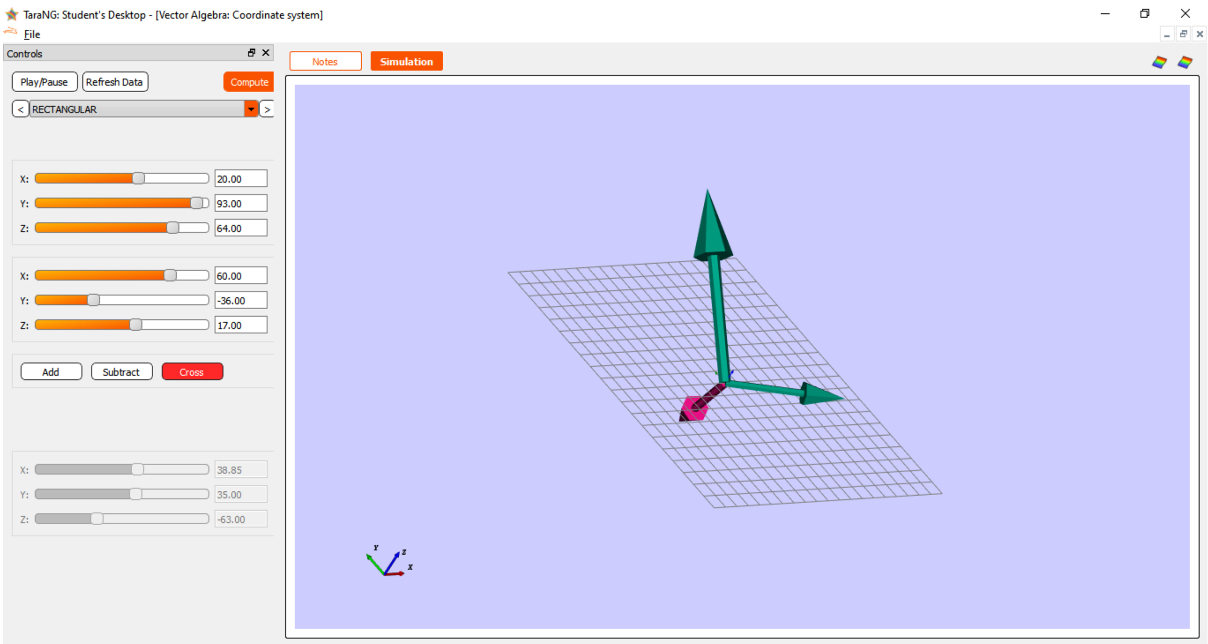
5. **Initiating Project:** Open the project it will show below window,
6. **Addition of two vectors:** Adjust the X, Y, Z sliders of both the vectors as seen in below UI. It will show two input vectors (in green) along with the resultant addition vector (in pink),
7. Click on Compute the changes will be reflected in the design window.



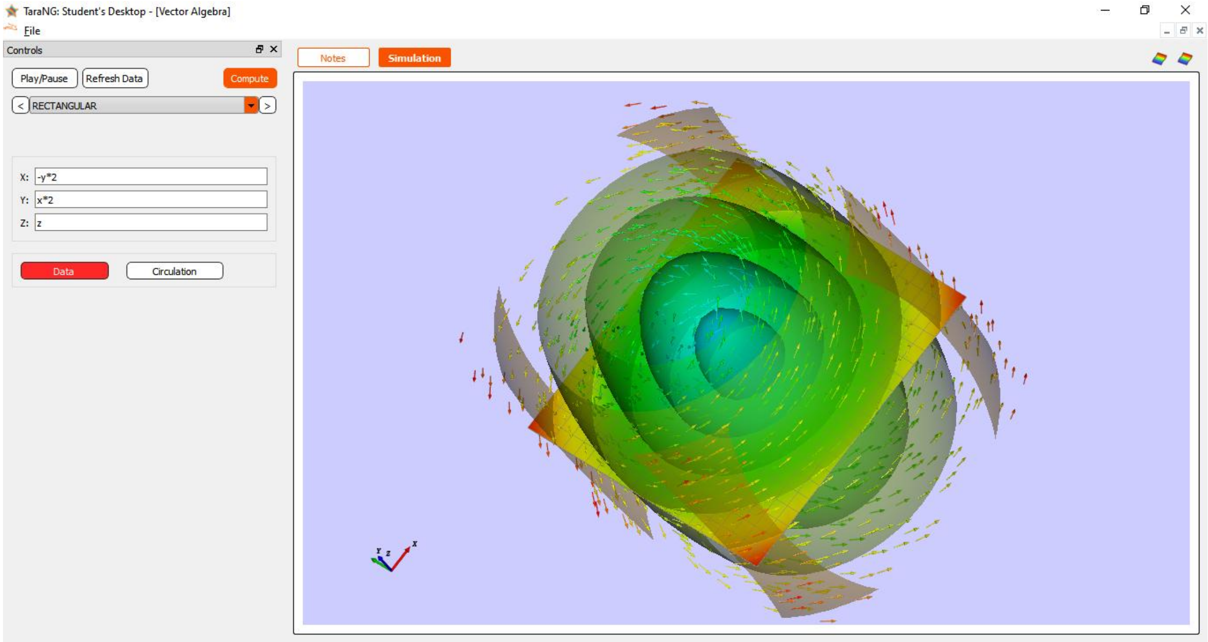
8. **Subtraction of two vectors:** Click on the Subtract button
9. Now click on 'Compute' the changes will be reflected in the design window the subtraction of two vectors will be illustrated. We can adjust the sliders for calculating the subtraction of vectors.



10. **Cross product of two vectors:** Click on the Cross button and repeat the process as in step 5



11. **Vector Plots for 3D Equations:** In this tool we can enter the equations to generate 3D data over a particular space. In below image the equation -y*2.ax+x2.ay+z.az is plotted



12. In this way several other equations can be visualized easily

3. Coulomb's Law

In 1785 Augustin de Coulomb investigated the attractive and repulsive forces between charged objects, experimentally formulating what is now referred to as Coulomb's Law: "The magnitude of the electric force that a particle exerts on another is directly proportional to the product of their charges and inversely proportional to the square of the distance between them."

Mathematically, the magnitude of this electrostatic force F acting on two charged particles (q1, q2) is expressed as:

F = k q1q2/ r^2

where r is the separation distance between the objects and k is a constant of proportionality, called the Coulomb constant, k = 9.0 × 109 Nm^2/C^2 . This formula gives us the magnitude of the force and we can get the direction by noting a positive force as repulsive and a negative force as attractive. Noting that like charges repel each other and opposite charges attracting each other.

However, it is not so easy to measure such a force in the laboratory. Reason, the very magnitude of the force itself and secondly the tiny charge carriers as well as extremely mobile nature of the electrons. To study such force and electric field intensity at a particular point we will use the simulation-based approach.

Goal

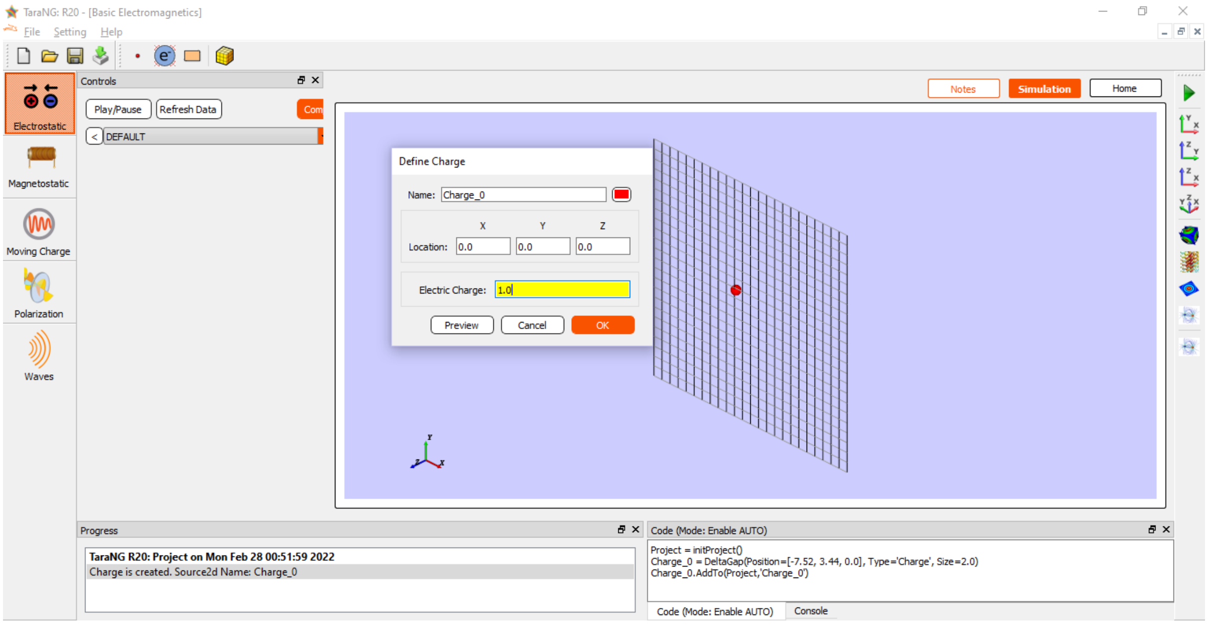
(i) To find electric field at a particular point due to a charges

(ii) Visualize Contour Field, Streamlines and Arrows for the electric field vectors in 3D Space

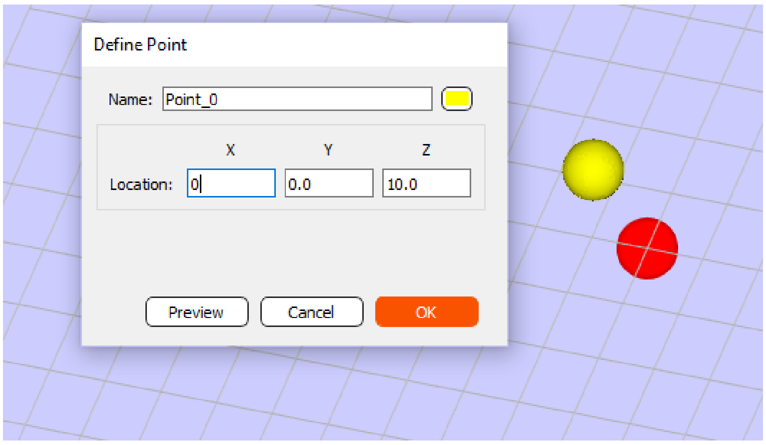
(iii) To observe field interactions due to multiple charges of different values

Design Procedure

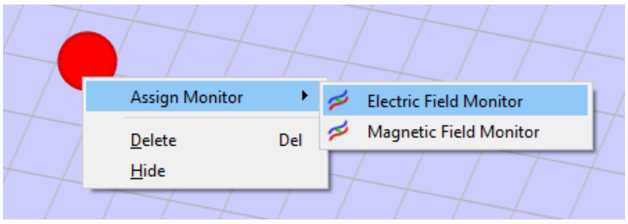
1. **Initiating Project:** Make sure you have started Magnetostatic Tool by clicking Magnetostatic icon at the left side bar.
2. **Design:** Initially, click on the 'Electron' icon in the toolbar.
3. Click at almost center point of the design grid the location where we want to add the charge
4. Doble click on the charge and modify the charge location to X=0, Y=0, and Z=0
5. Enter Charge value as 1 as shown in image
6. Click Okay button. This will add 1C charge at the center/origin



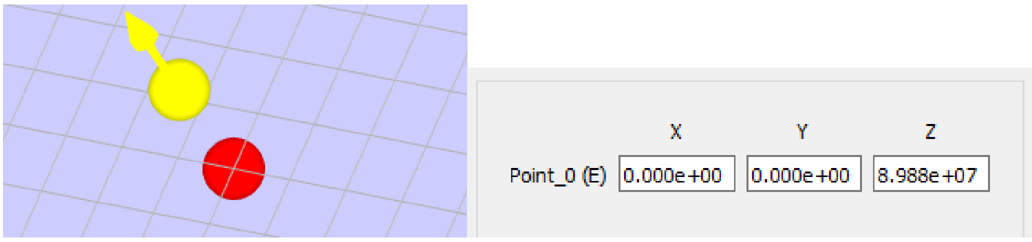
7. **Adding Observation Point:** To add the observation, click on the 'Point' icon in the taskbar click anywhere on the screen, the point will be placed. Now press Escape (Esc).
8. To update point location doble click on point and set it to (0,0,10) as shown below, click 'Okay' to update.



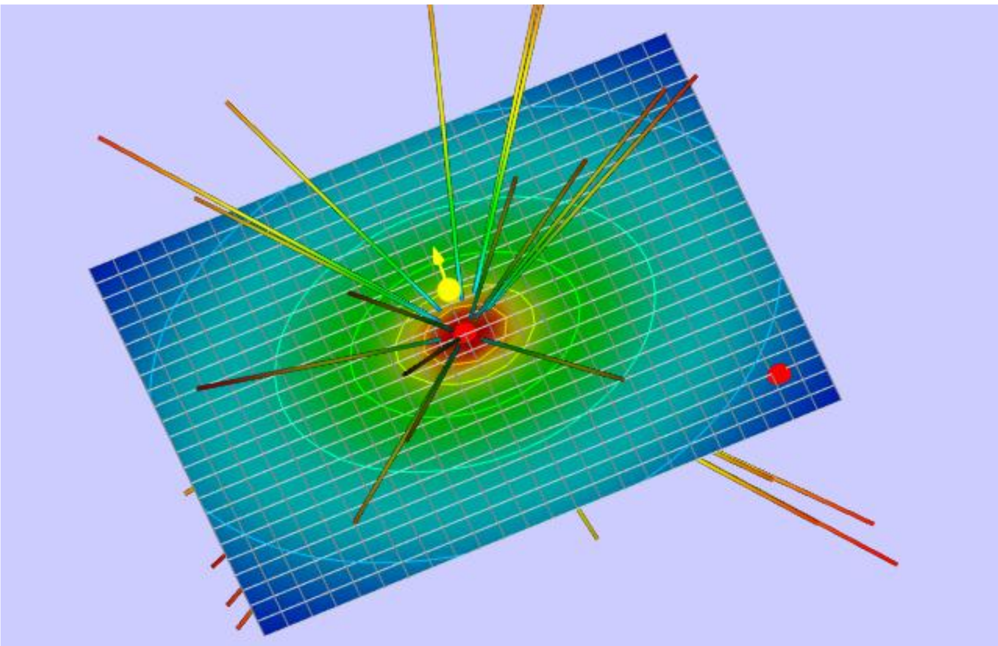
9. Now right click on the point and select option as 'Assign Electric Field Monitor' to keep track of values.

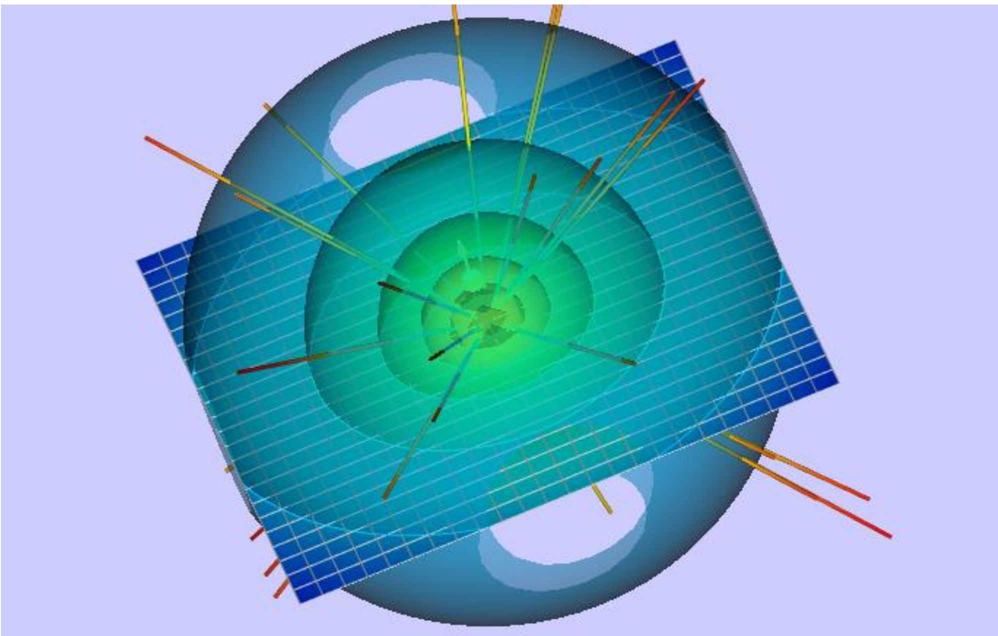


10. Click on ‘Compute’ Button in Control window located at the left side of GUI



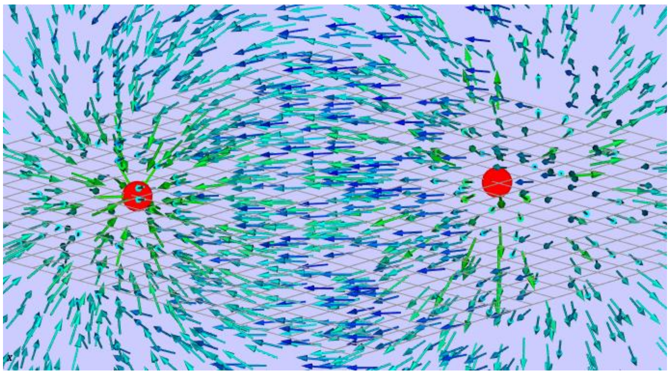
11. Plot the vector field contour and quiver maps. User can turn ON or turn OFF the plots using after right clicking on the plots or clicking options at right side of toolbar,

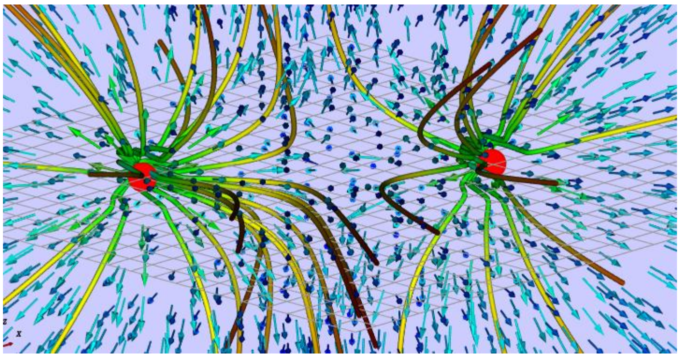


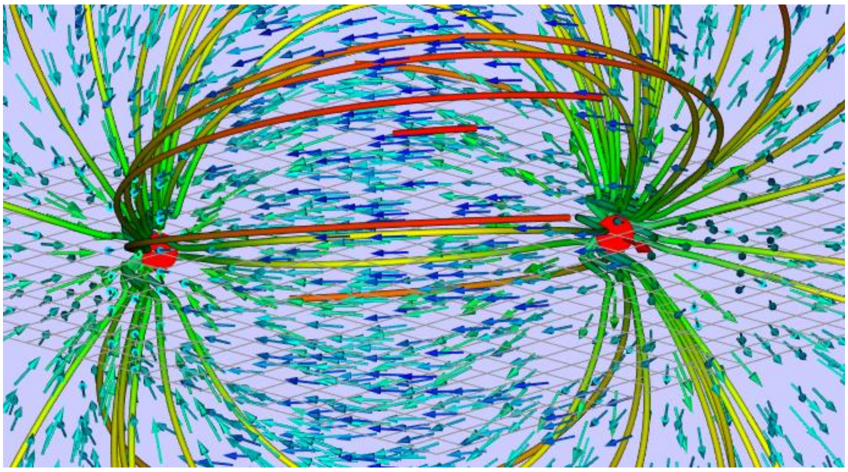


Assignment:

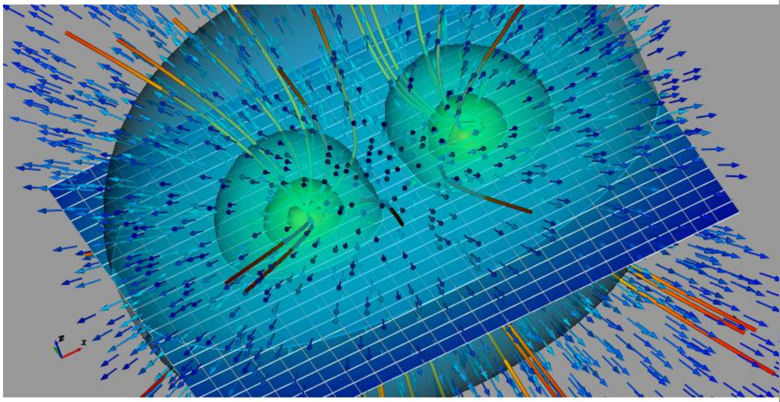
A) Try different values of two charges and plot vector lines

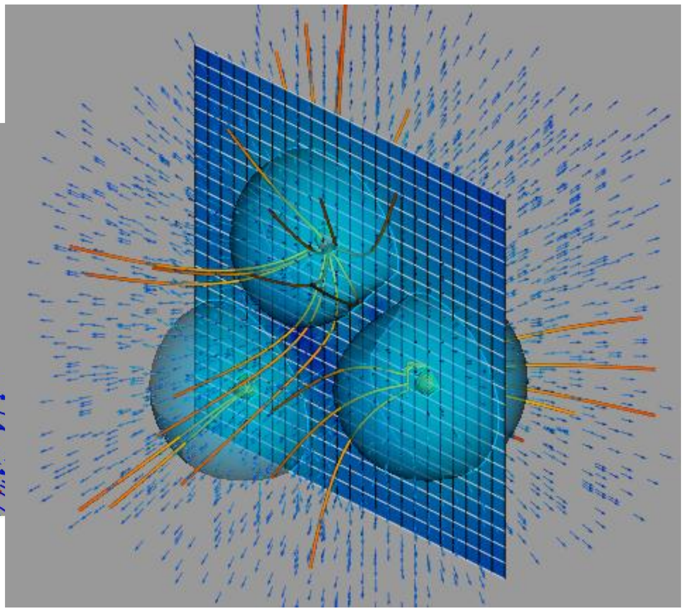






B) Multiple Charges Combination





4. Magnetic field due to a current element,

BIOT-SAVART LAW

All magnetic fields that we know are due to currents (or moving charges) and due to intrinsic magnetic moments of particles. Here, we shall study the relation between current and the magnetic field it produces. It is given by the Biot-Savart's law.

A finite conductor carrying current I. Consider an infinitesimal element dl of the conductor. The magnetic field dB due to this element is to be determined at a point P which is at a distance r from it. Let θ be the angle between dl and the displacement vector r. According to Biot-Savart's law, the magnitude of the magnetic field dB is proportional to the current I, the element length |dl|, and inversely proportional to the square of the distance r. Its direction is perpendicular to the plane containing dl and r .

The Biot-Savart law for the magnetic field has certain similarities as well as differences with the Coulomb's law for the electrostatic field. Some of these are:

(i) Both are long range, since both depend inversely on the square of distance from the source to the point of interest. The principle of superposition applies to both fields. [In this connection, note that the magnetic field is linear in the source I dl just as the electrostatic field is linear in its source: the electric charge.]

(ii) The electrostatic field is produced by a scalar source, namely, the electric charge. The magnetic field is produced by a vector source I dl.

(iii) The electrostatic field is along the displacement vector joining the source and the field point. The magnetic field is perpendicular to the plane containing the displacement vector r and the current element I dl.

(iv) There is an angle dependence in the Biot-Savart law which is not present in the electrostatic case.

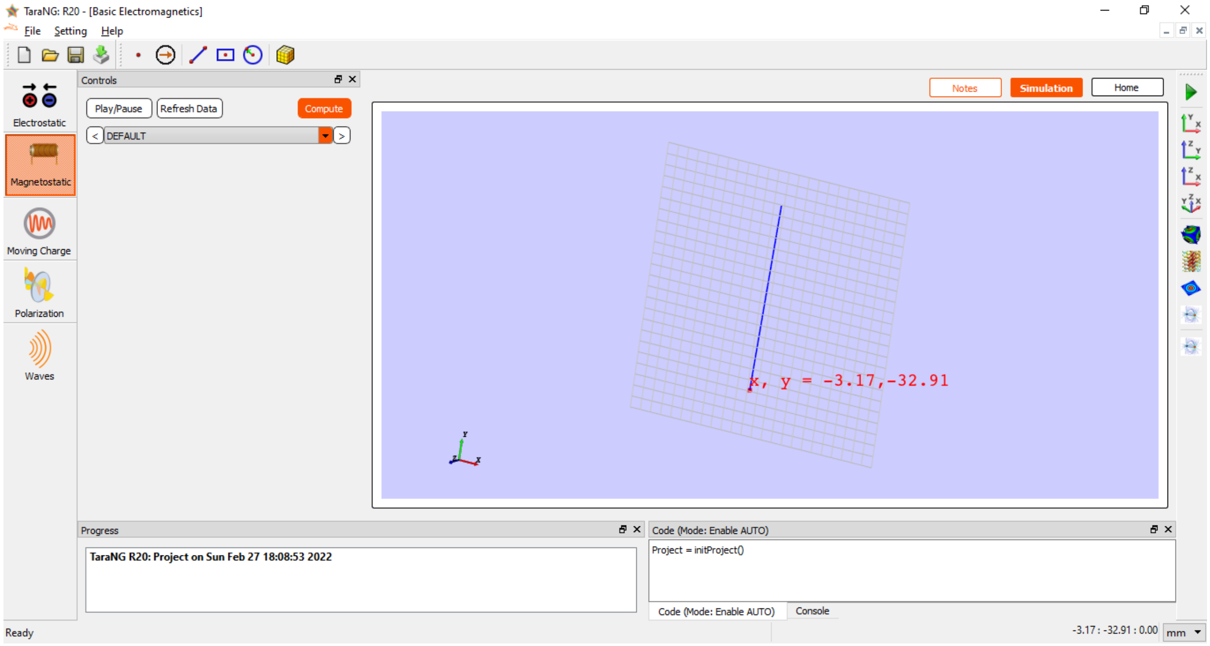
Goal

A current carrying conductor having length 10.0 centimeter (cm) is placed at the origin and carries a large current I = 10 A. Design a simulation model to,

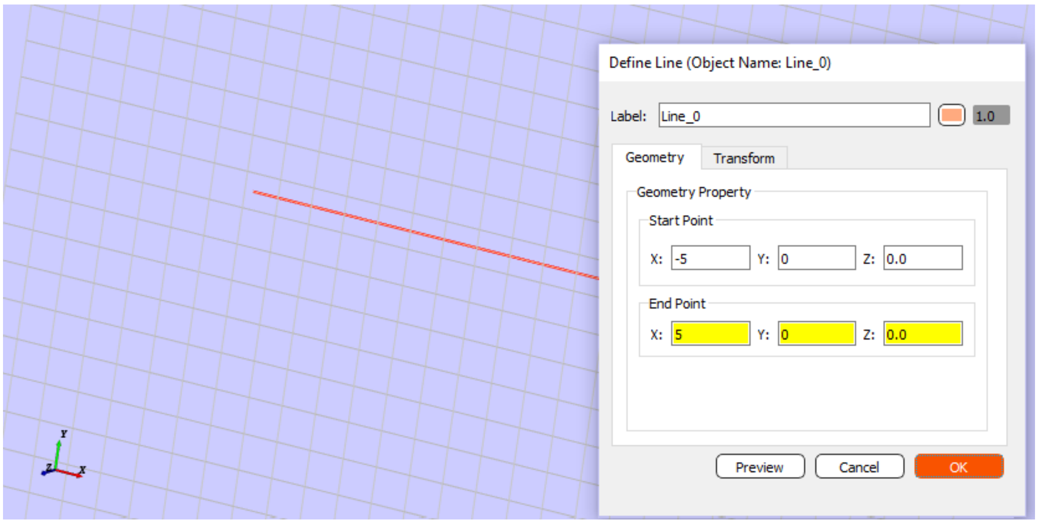
A. Find is magnetic field on the z-axis at a distance of 10 cm.
B. Plot the magnetic field vectors and contours

Design Procedure

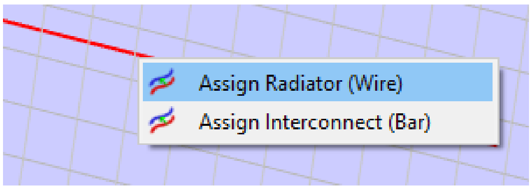
12. **Initiating Project:** Make sure you have started Magnetostatic Tool by clicking Magnetostatic icon at the left side bar.



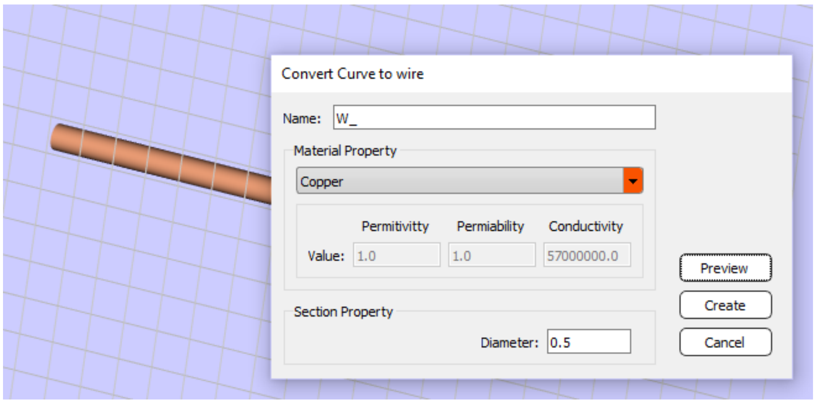
13. **Design:** Initially, click on the 'Line Segment'  icon in the toolbar.
14. Pick up the points on the design grid where we want to draw the line
15. Once the line is drawn press Escape (Esc) button on keyboard to leave the 'Insert Object' Mode.
16. Make sure the unit is set to centimeter by choosing 'cm' at bottom right corner
17. For the length 10 cm along x direction, we will use two points P1 = (-5,0, 0) and P2 = (5,0,0) respectively.
18. Click on 'Preview' to verify the design and then 'Okay' to apply the changes.
19. User can press 'R' button on screen to reset the view and view the complete design.

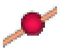


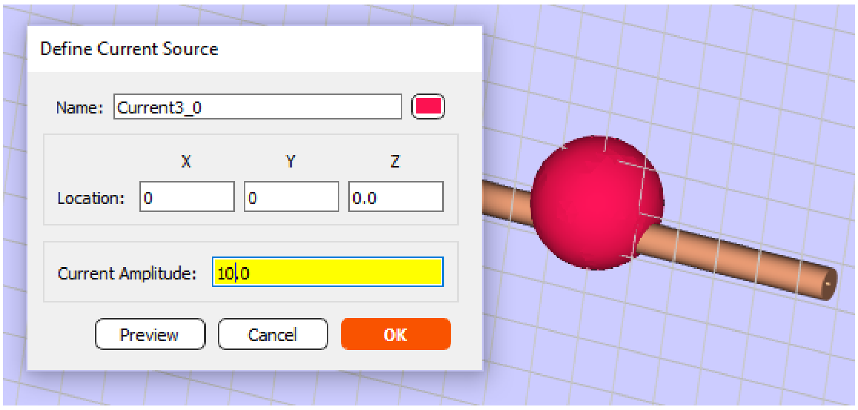
20. After defining start and end coordinates of line we will define the material properties to wire.
21. Right click on the line choose option ‘Assign Radiator (Wire)’ to make it wire



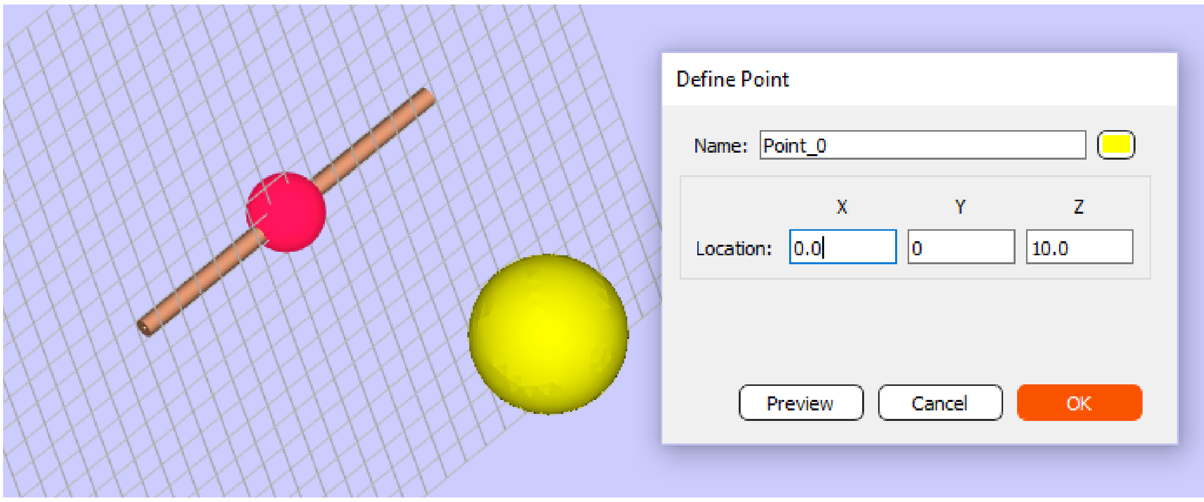
22. We will set Diameter as 0.5 cm and set the Material Property as copper for this example. In this experiment, we have used copper as the material however these properties can be changed per the requirement of the user.



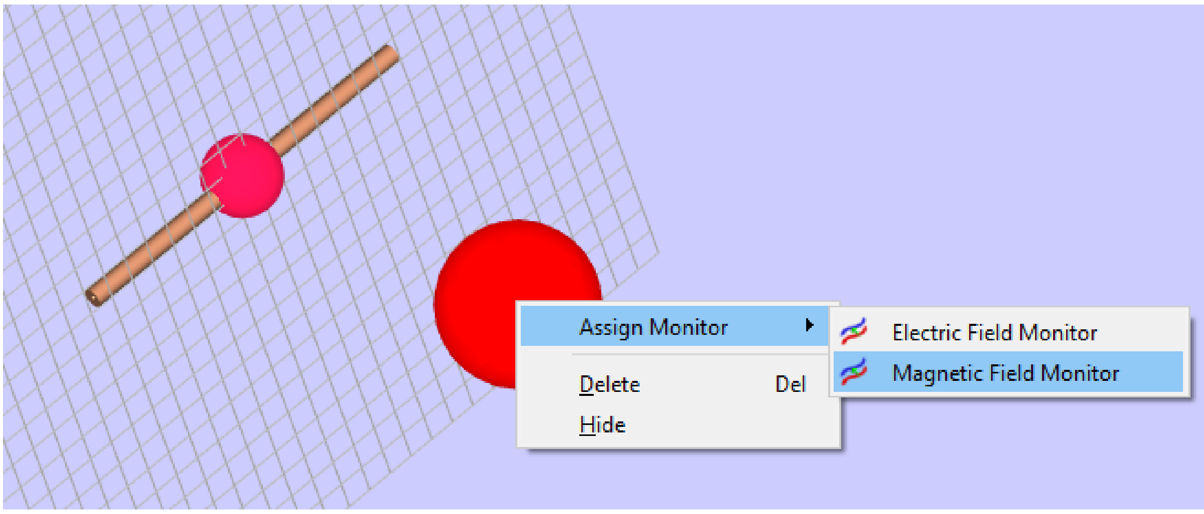
23. After the details are entered, clicking Create will show the wire. In the main 3D Design window of the software.
24. **Applying the excitation:** The next step is to add the current source in the center of the wire.
25. To add the feed, click on the ‘Current  icon in the taskbar and slide the cursor near the wire to get the visuals. By clicking anywhere on the wire, the feed will be placed.
26. To make sure the current source is exactly at the center of the wire, double click on the source  and make X, Y and Z as 0.0, 0.0 and 0.0 respectively
27. Set Current Source Amplitude as 10.0 Ampere in the window
28. Click OK to complete the step. The dipole antenna with these easy steps has been created using TaraNG Software.



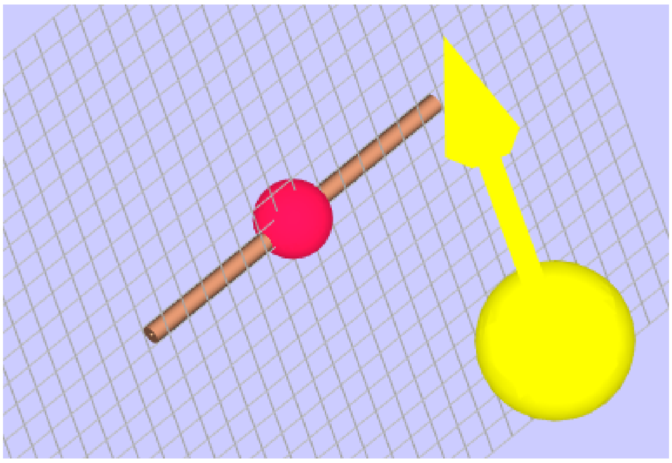
29. **Adding Observation Point:** To add the observation, click on the 'Point' icon in the taskbar click anywhere on the screen, the point will be placed. Now press Escape (Esc).
30. To update point location doble click on point and set it to (0,0,10) as shown below, click 'Okay' to update.



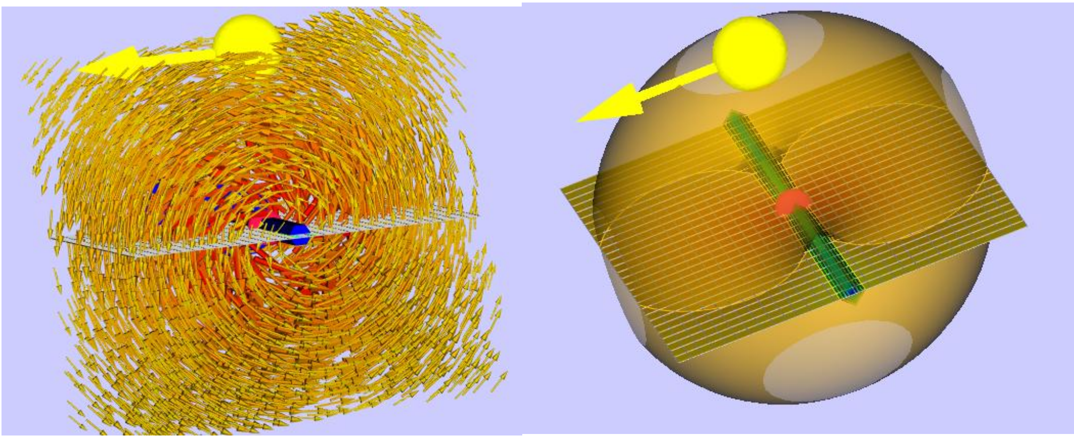
31. Now right click on the point and select option as 'Assign Magnetic Field Monitor' to keep track of values.



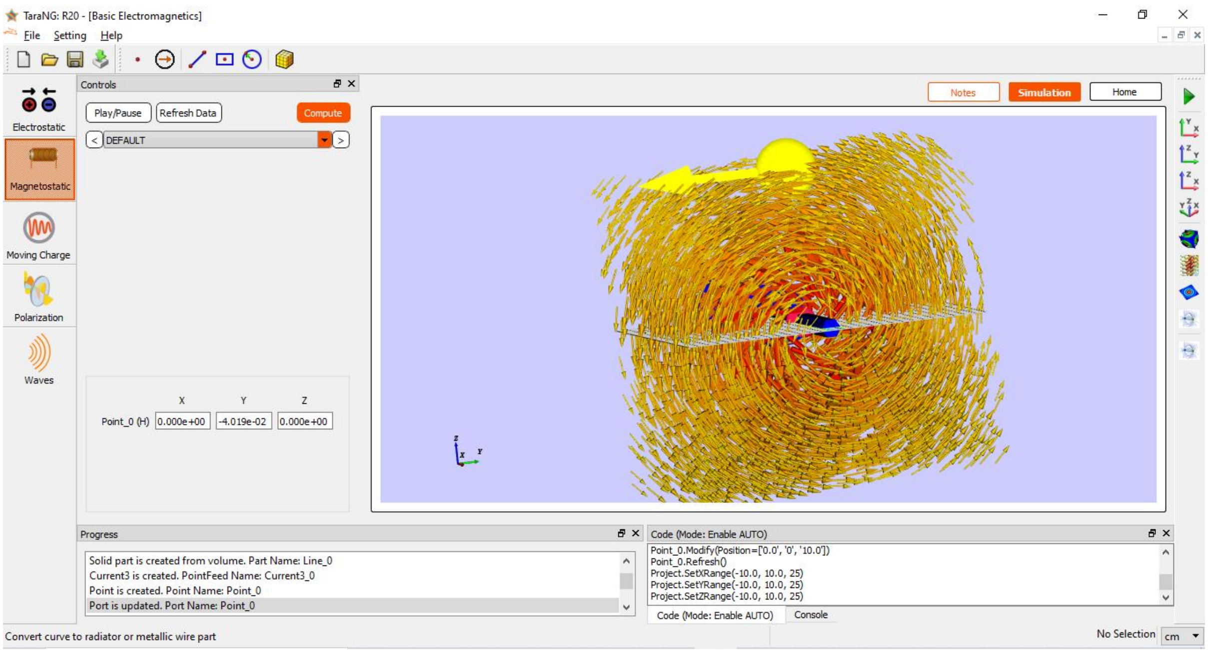
32. Click on Compute Button in Control window located at the left side of GUI



33. We can note down the values of Magnetic Field (H) as
34. Plotting Contour & Quiver plots



35. Furthermore, we can plot streamlines and change the values of current source amplitude and do the experimentations.



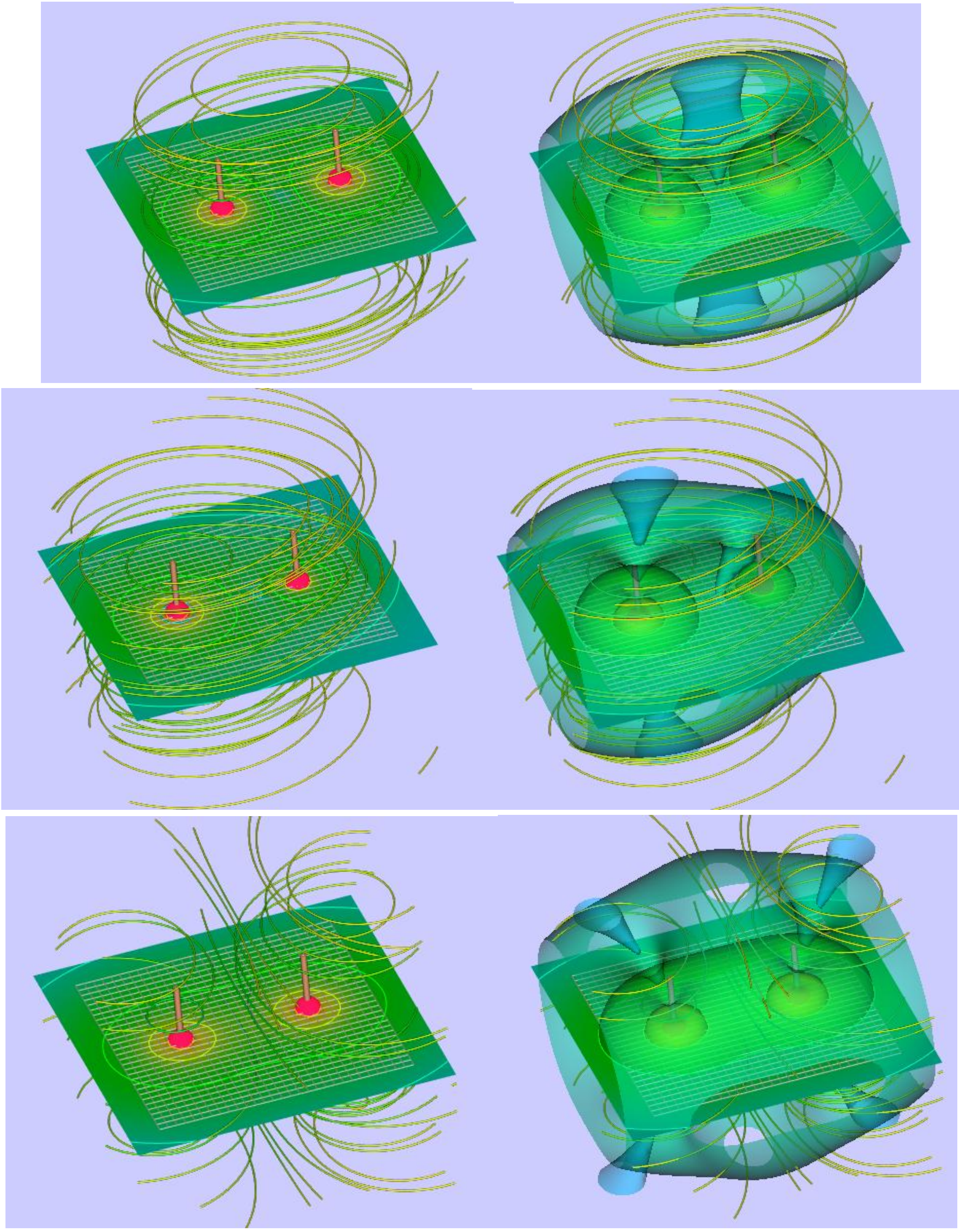
36.

Assignment 1. Two current carrying straight conductors with different amplitude

A. Both of 10 Ampere

B. One 20 Ampere another 5 Ampere

C. One 20 Ampere another -20 Ampere

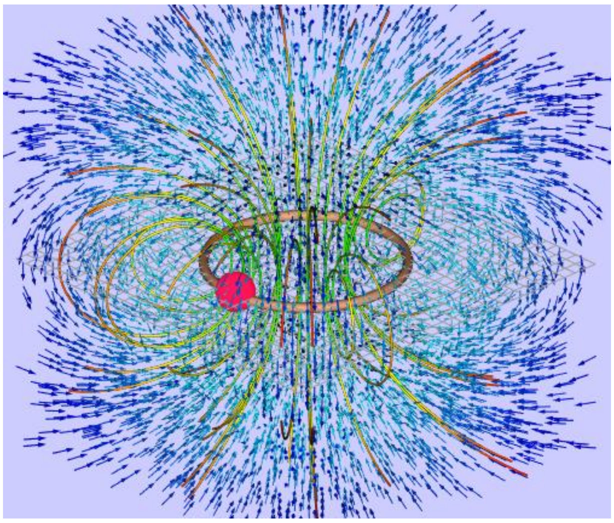


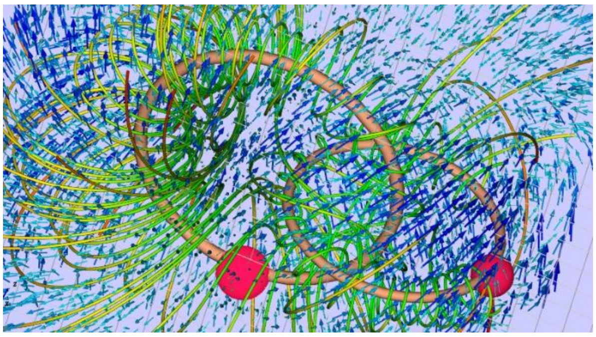
Assignment 2. Circular loop and combination

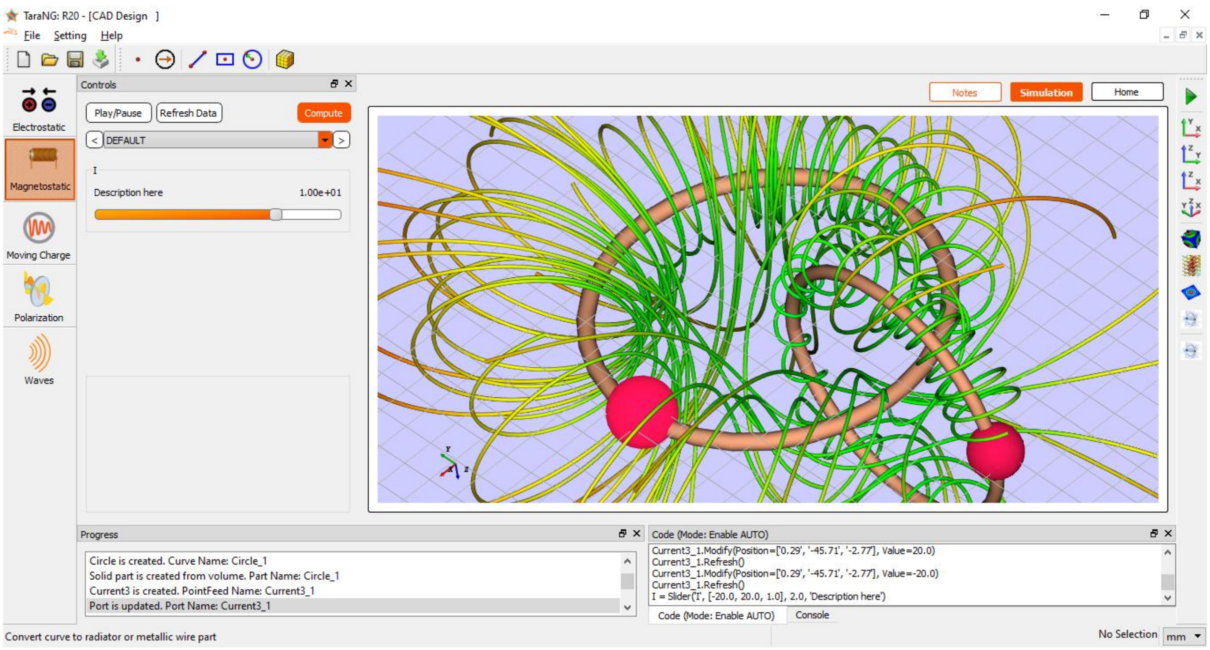
A. Single Circular loop of 25 cm diameter and 10 Ampere current source.

B. Combination

C. Create sliders to perform the behavior study







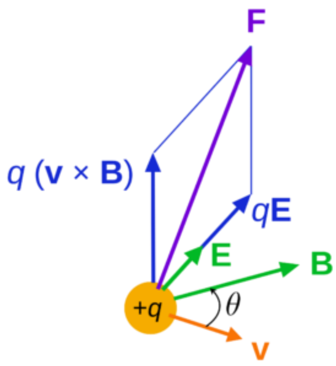
5. Moving Charges in Electric & Magnetic Field

In this experiment, we will see how magnetic field exerts forces on moving charged particles, like electrons, protons. Before we introduce the concept of a magnetic field, we shall recapitulate what we have learnt in earlier experiment about the electric field. We have seen that the interaction between two charges can be considered in two stages. The charge Q, the source of the field, produces an electric field. Just as static charges produce an electric field, the currents or moving charges produce (in addition) a magnetic field, denoted by B (r), again a vector field

Lorentz Force: Let us suppose that there is a point charge q (moving with a velocity v and, located at r at a given time t) in presence of both the electric field and the magnetic field. The force on an electric charge q due to both of them can be written as

$$F = qE + qv \times B$$

where,
F is Lorentz Force,
q is Charge on the Particle,
E is Electric Field,
B is Magnetic Field,
v is Velocity of the Particle



A particle with charge q, mass m, and velocity v perpendicular to a uniform magnetic field B moves in a circular path with the radius $r = mv / qB$

If there is a component of the velocity parallel to the magnetic field (denoted by v2), it will make the particle move along both the field and the path of the particle would be a helical one. The distance moved along the magnetic field in one rotation is called pitch $p = v2T = 2\pi mv2 / qB$

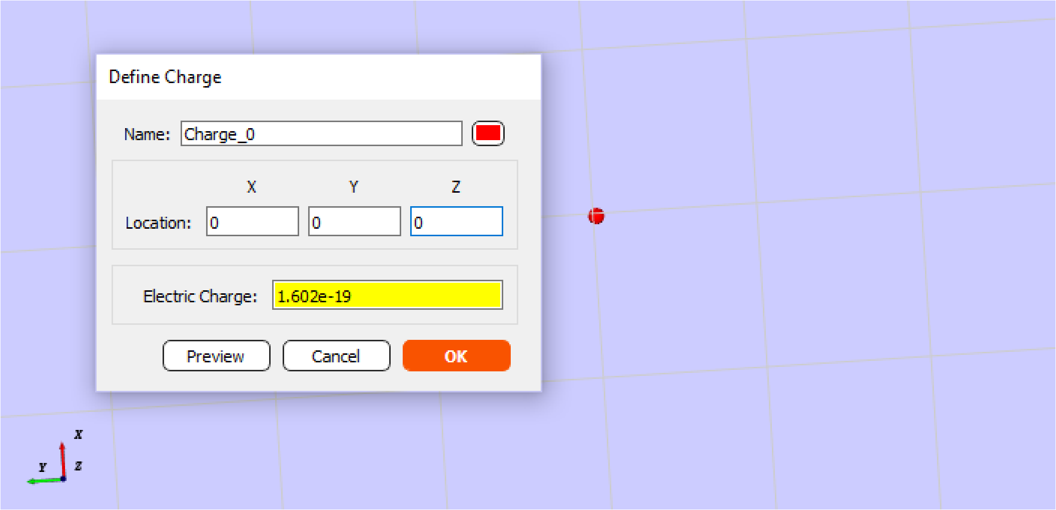
One can also deflect the trajectory of a charged particle with an electric field, although not into a circular path.

Goal

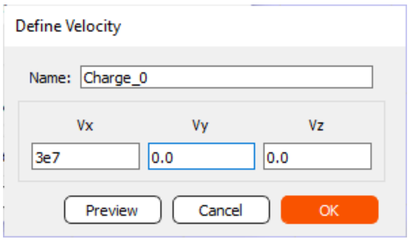
To observe the circular motion of an electron (having mass m= 1.67e-27kg and charge Q=1.6e-19C) moving with speed 3e7 m/s towards x direction in magnetic field of 1.0 Tesla perpendicular to it.

Design Procedure

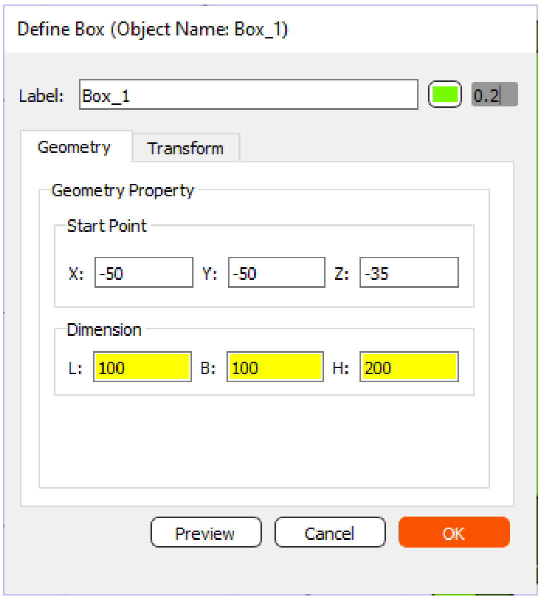
1. **Initiating Project:** Make sure you have started Moving Charges Tool by clicking Moving Charges icon at the left side bar.
2. **Design:** Initially, click on the 'Electron' icon in the toolbar.
3. Click at almost center point of the design grid the location where we want to add the charge
4. Doble click on the charge and modify the charge location to X=0, Y=0, and Z=0



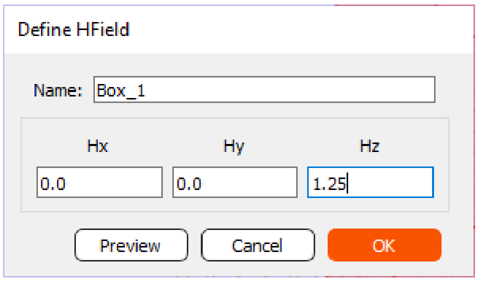
5. Keep the Electric Charge as 1.602e-19 C and click 'Okay'
6. To move the charge, right click on it and click on 'Assign velocity'
7. Enter Vx = 3e7, Vy = 0.0, and Vz = 0.0



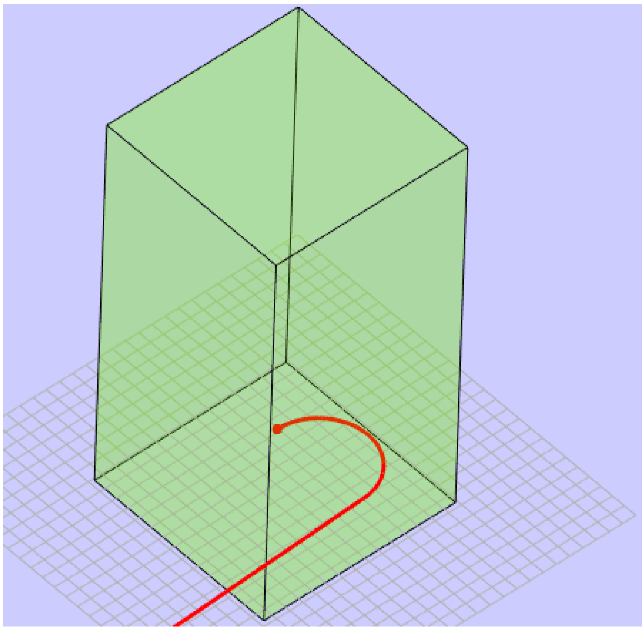
8. Now draw a Box by clicking Box icon in toolbar by doing three clicks it will appear in the design window
9. Doble click on the box to update the dimension and modify it



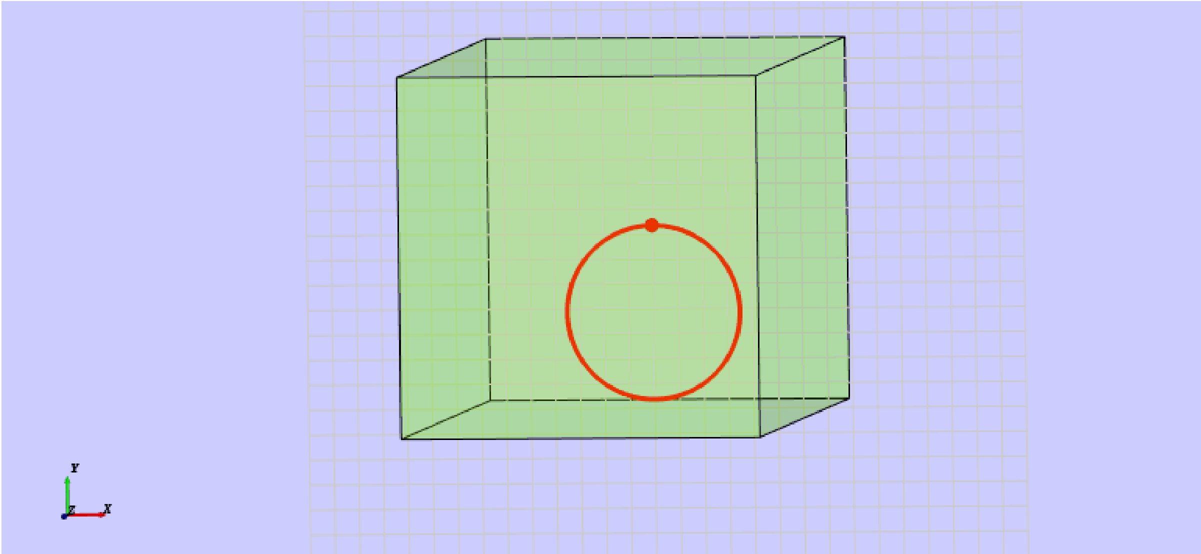
10. Assign the magnetic field to the box by right click on it, make Hz=1.25



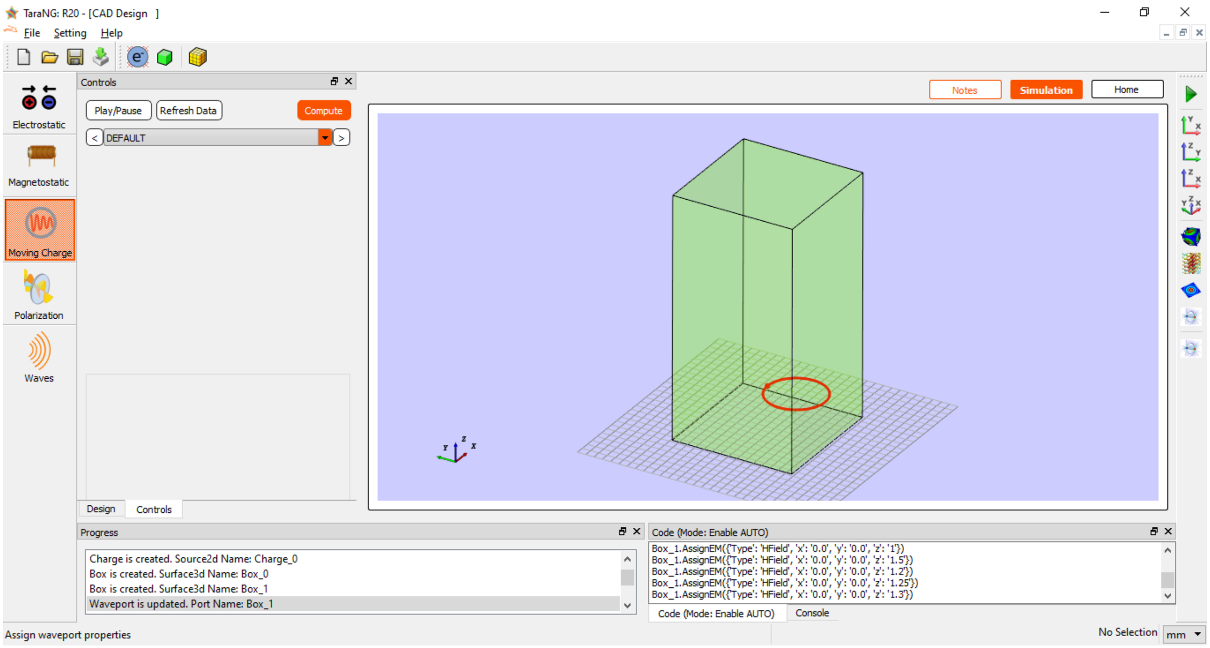
11. Now click on ‘Compute’ to visualize the trajectory, it will show a semi-circle



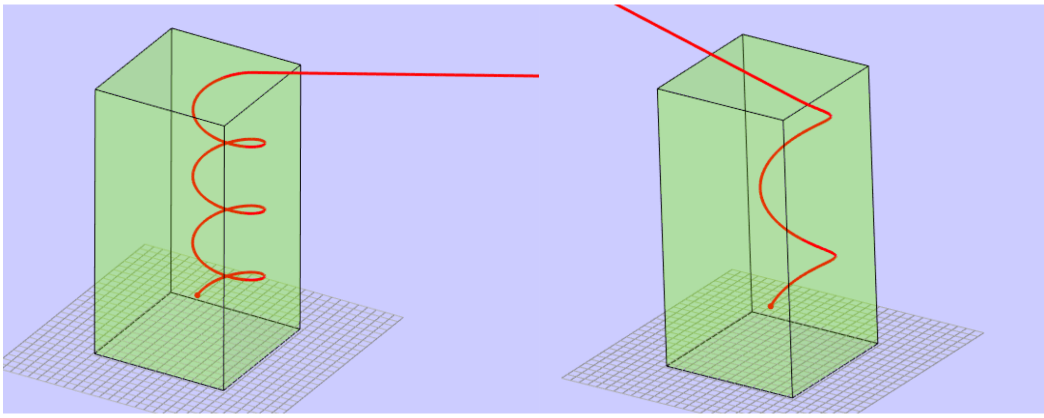
12. Change the magnetic field to Hz=1.3 T which will show a circular trajectory with radius almost 25m



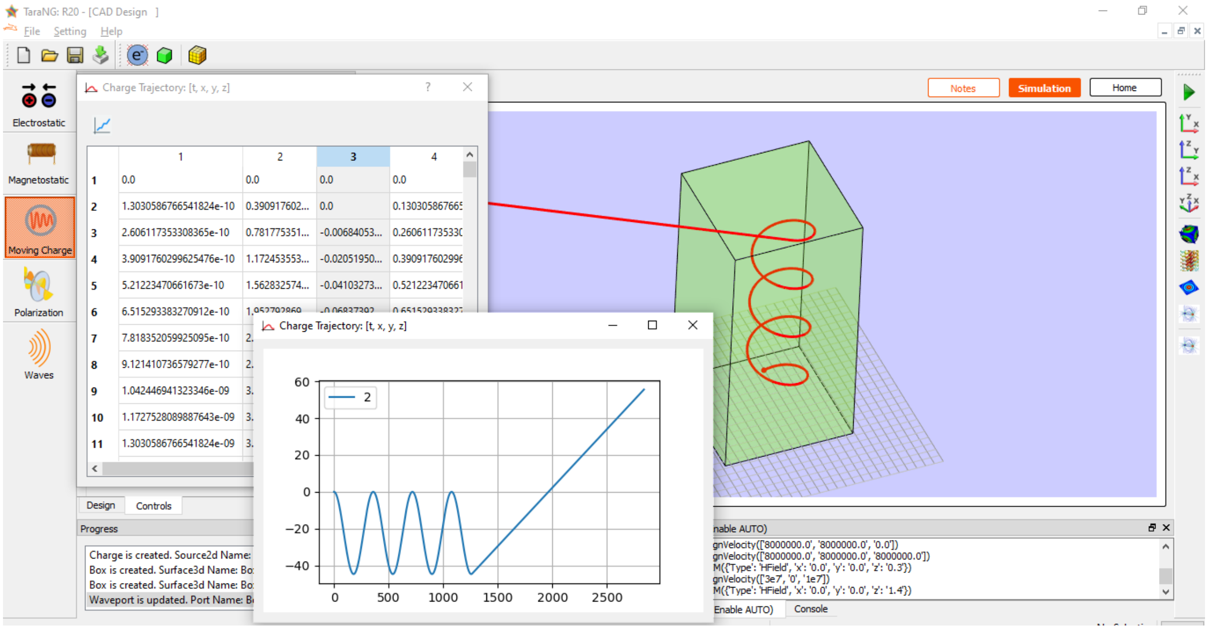
13. The circular trajectory can be observed as



14. In next example, we will assign movement of charge in z direction by making Vz = 1e7, 2e7 to observe change in pitch of helical path



15. **Visualizing the trajectory data:** To get the data of the trajectory right click on the path and select View Trajectory option.



Assignment 1: Moving Charge in Electric Field

Assignment 2: Combination of different charges and different electric and magnetic field regions to understand the charge movements.

In polar regions like Alaska and Northern Canada, a splendid display of colors is seen in the sky. The appearance of dancing green pink lights is fascinating, and equally puzzling. An explanation of this natural phenomenon is, During a solar flare, a large number of electrons and protons are ejected from the sun. Some of them get trapped in the earth's magnetic field and move in helical paths along the field lines. The field lines come closer to each other near the magnetic poles. Hence the density of charges increases near the poles. These particles collide with atoms and molecules of the atmosphere. Excited oxygen atoms emit green light and excited nitrogen atoms emits pink light. This phenomenon is called Aurora Borealis.

6. Wave Polarization

Electromagnetic waves are periodic changes of electric and magnetic fields in space and time. They propagate at the speed of light. The electric and magnetic fields oscillate in a plane perpendicular to the direction of propagation of the light beam. In this experiment we will observe the linear and elliptical and circular polarized waveforms.

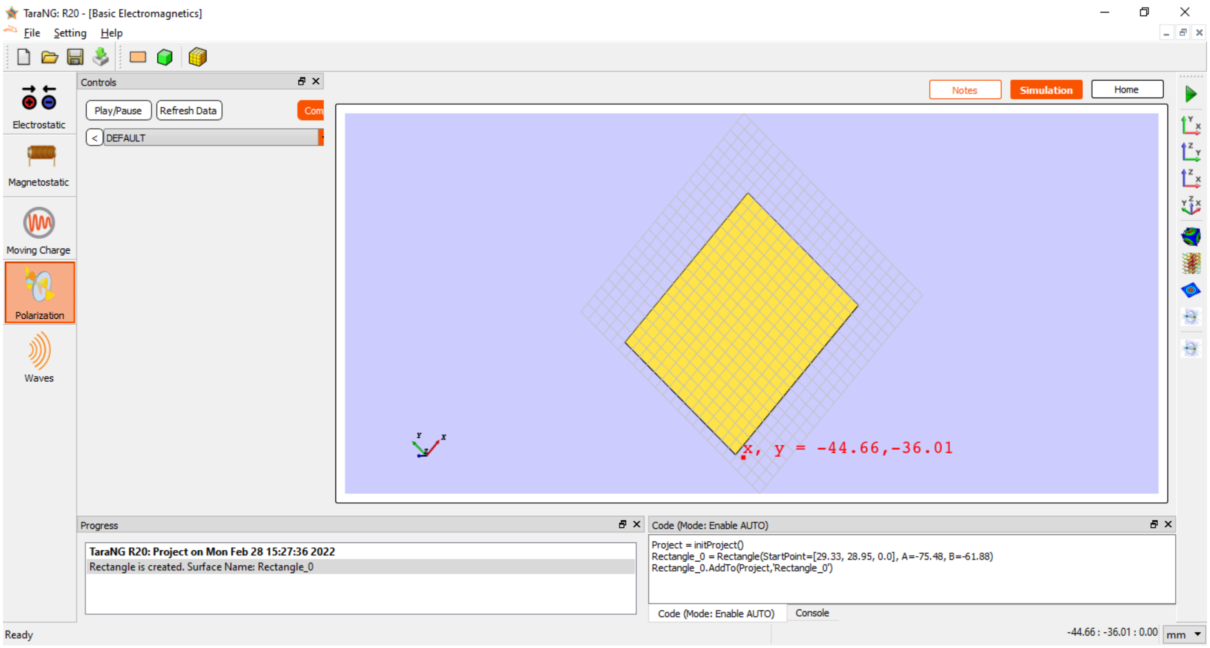
When two electromagnetic waves plane-polarized in two perpendicular planes are present simultaneously then the electric fields are added according to the rules of vector addition, superposition. The properties of the resulting electromagnetic wave depend on the intensities and phase difference of the component waves.

Goal:

A) To simulate & understand linear polarized waveform
B) To simulate elliptical and circular polarization
C) Design polarizer to achieve circular polarization

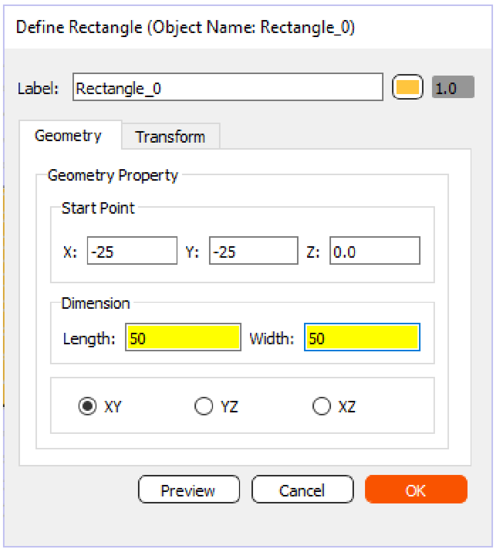
Design Procedure

1. **Initiating Project:** Make sure you have started Polarization Tool by clicking Magnetostatic icon at the left side bar

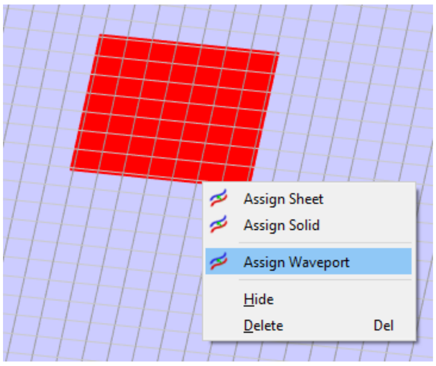


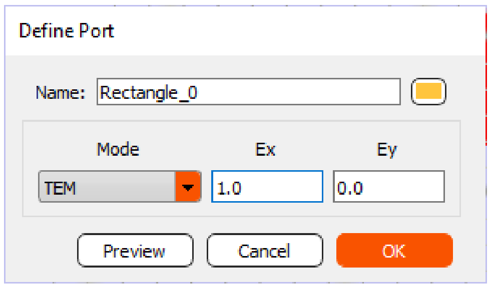
2. **Design:** Initially, click on the ‘Rectangle’ icon in the toolbar.
3. Pick up the points on the design grid where we want to draw the rectangle
4. Once the line is drawn press Escape (Esc) button on keyboard to leave the ‘Insert Object’ Mode.

5. Make sure the unit is set to centimeter by choosing 'cm' at bottom right corner
6. For the length 10 cm along x direction, we will use two points P1 = (-25,-25, 0) and Length = 50, and Width = 50 respectively.

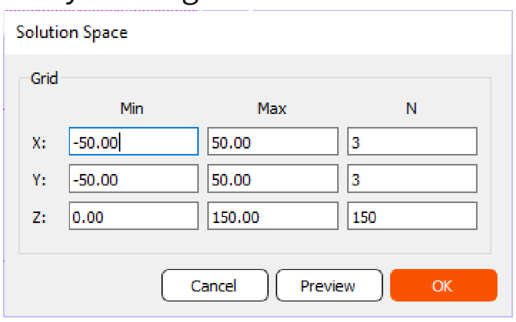


7. Click on 'Preview' to verify the design and then 'Okay' to apply the changes.
8. User can press 'R' button on screen to reset the view and view the complete design.
9. Right click the rectangle and 'Assign Waveport' and Select TEM wave and set as Ex=1.0 and Ey=0.0

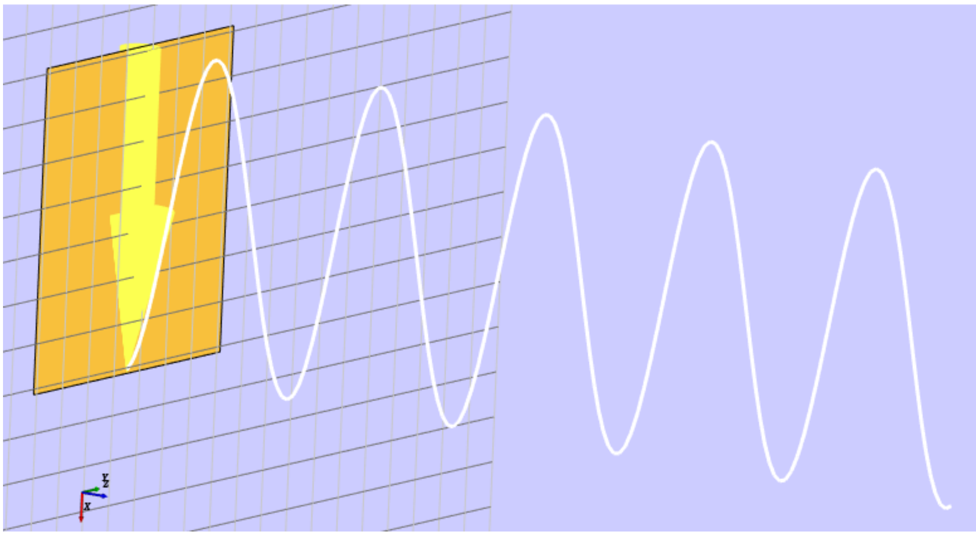




10. The signal frequency we are using, default is **100MHz**, resulting wavelength 30 meters
11. Define the solution box by clicking in toolbar and Z= 150 that means 5 cycles

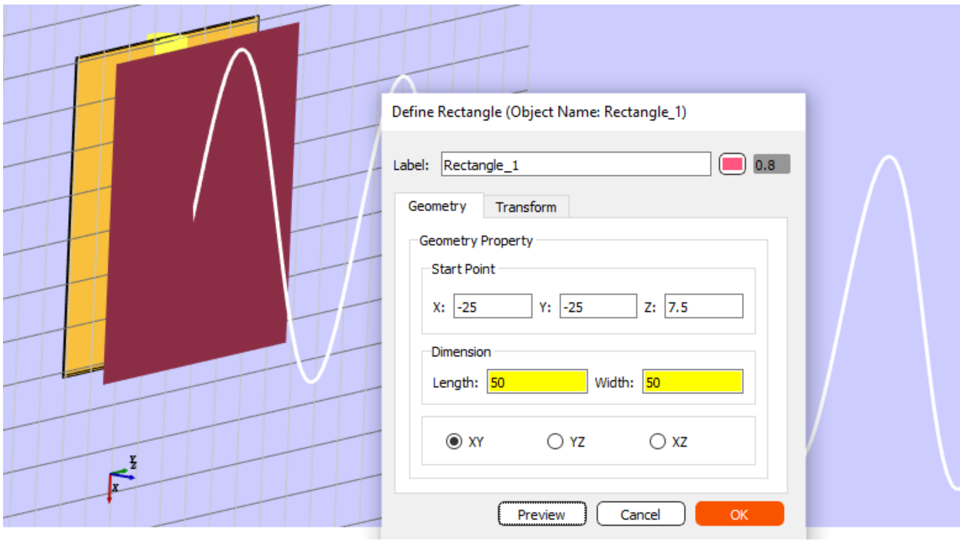


12. Now press Compute button it will show a waveform like below, we can start and stop the animation by clicking on Play/Pause button in Controls

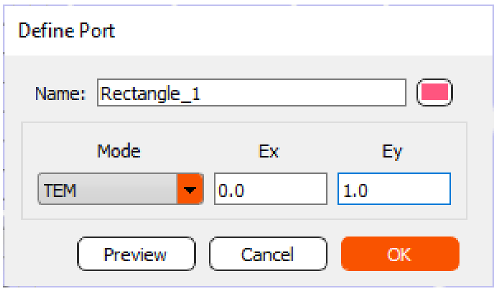


Part A: Superposition

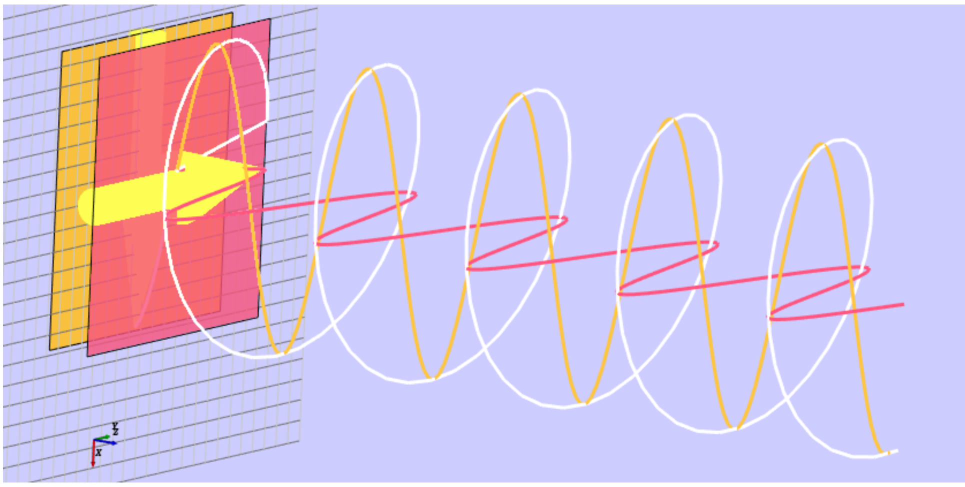
13. Now we will add one more rectangle at distance lambda/4 = 7.5



14. Now draw Rectangle in same way shifted at Z=7.5 with different color
15. ‘Assign Waveport’ to second Rectangle by right-clicking make Ey=1.0



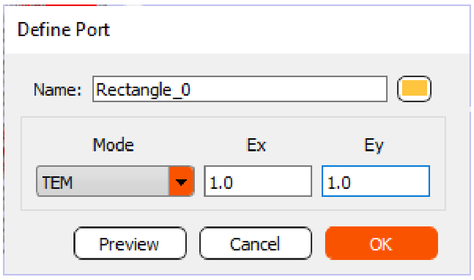
16. Click on Compute to see the superposition of waveforms



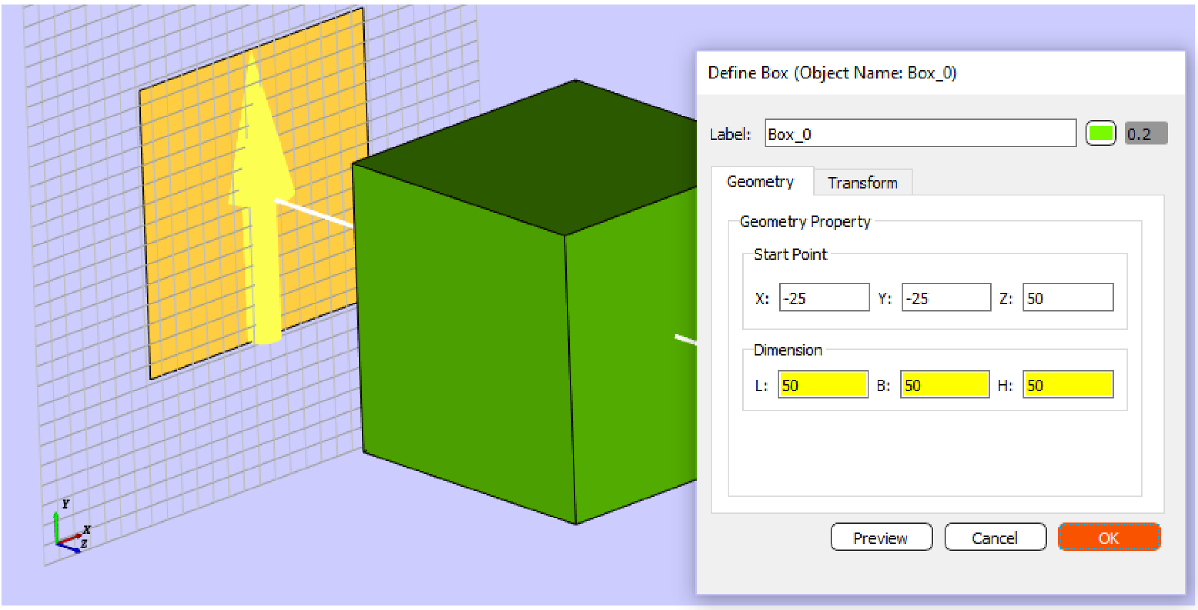
17. We can observe the circular polarized waveform, as the two sources have orthogonal components and phase delay of 90 degree
18. Now adjust the separation distance and Ex, Ey components to observe the changes.

Part B: Polarizer

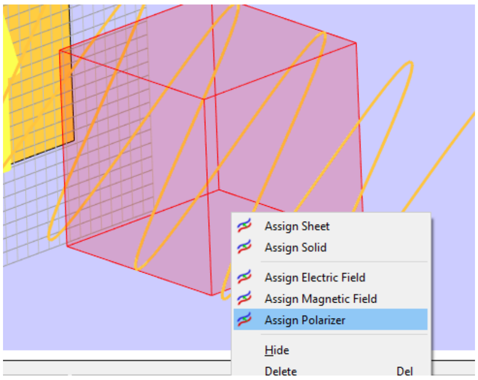
19. Start ‘New Project’ and repeat first 12 steps
20. Make waveport as Ex=1 and Ey = 1

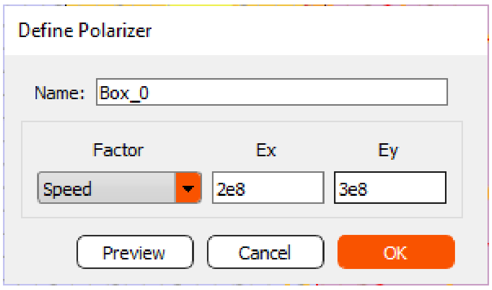


21. Draw the box with dimension 50*50*50 at Z=50 and opacity 0.2

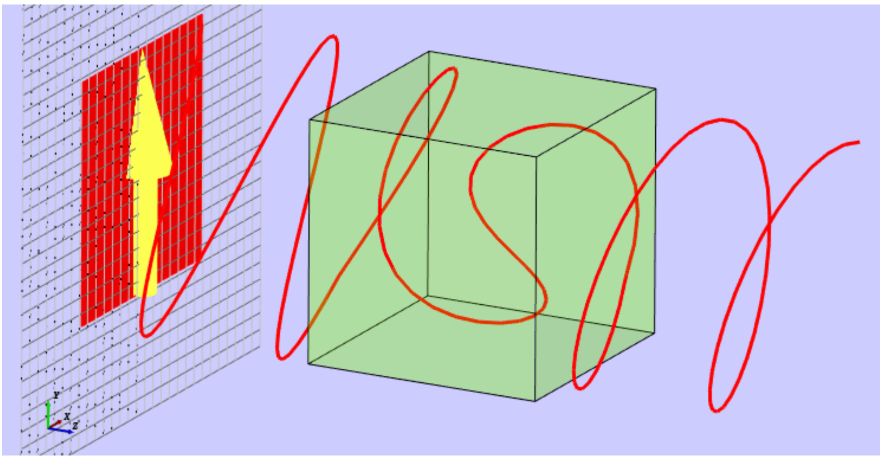


22.
23. Now click Okay





24. Assign the material as Polarizer and set different velocities for Ex and Ey Components
25. Click Compute to start calculations and see animations
26. Run animations to visualize linear to circular polarization



Assignment:

A) Add multiple wave sources with different amplitude and plot their superposition.
B) Change the values of Speed factors or length of polarizer to achieve perfect circular polarization (hint: length=60 to 2*lambda, to achieve 90 degree phase shift, signal should advance 1/8 lambda and travel 2.25*lambda; 60=2.25*lambda;)

7. Rectangular Waveguide

In electromagnetics, a waveguide confines electromagnetic signals within the structure, preventing spreading, losses, and signal transmission from one point to another. When electromagnetic waves are transmitted longitudinally through a rectangular waveguide, they are reflected from the conducting walls. The total reflection inside the rectangular waveguide results in either an electric field or magnetic field component in the direction of the propagation. There is no TEM mode in rectangular waveguides. The modes of propagation in a hollow rectangular waveguide with only one conductor are either TE or TM modes.

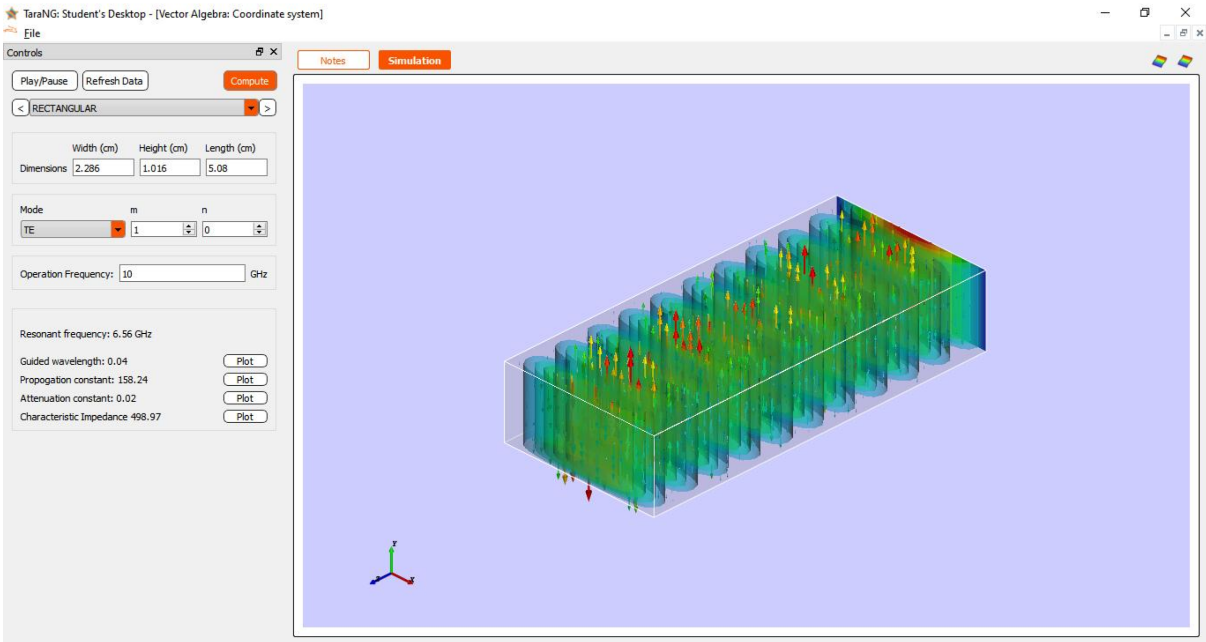
For this experiment we will consider an air-filled WR-90 waveguide which has dimensions Width of 2.286cm and Height of 1.016cm

Goal

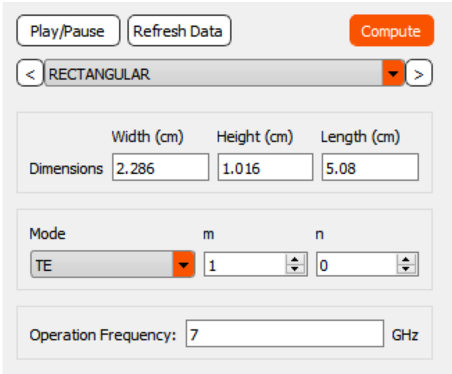
- To obtain the intrinsic Impedance and wavelength for various modes
- To visualize the electric field and magnetic field animations of different modes ex. TE10, TE20, TM11 using TaraNG
- Observe different types of plots which are arrows, quivers and contours
- Change the waveguide dimension and understand the changes in resonant frequency

Design Procedure

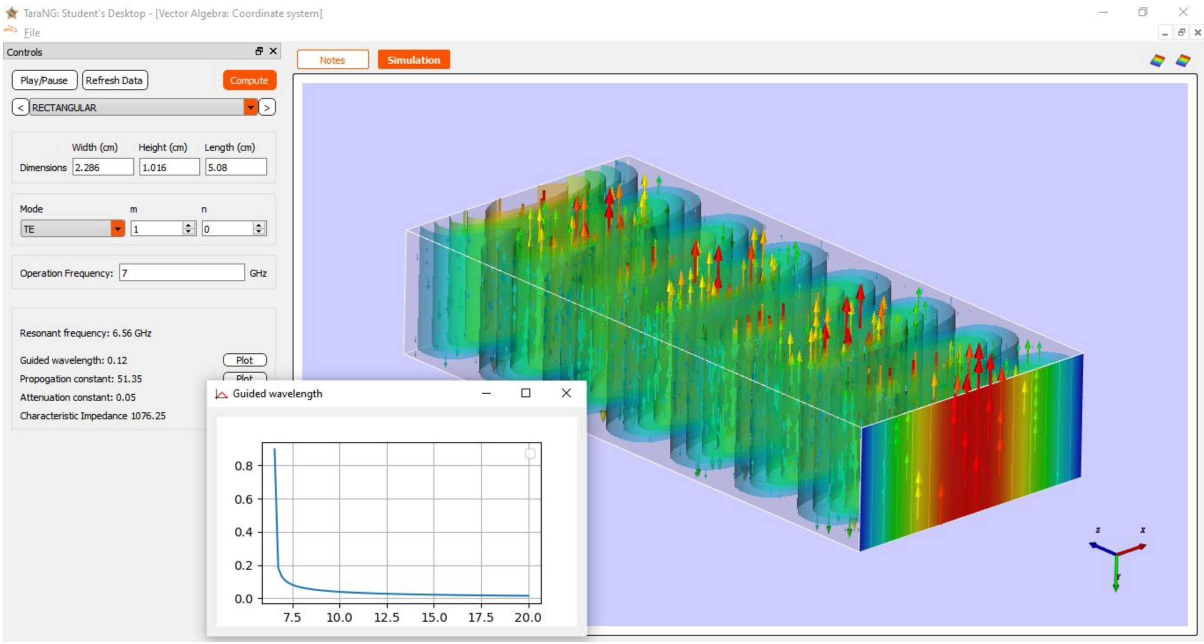
13. **Initiating Project:** Open the project it will show below window,



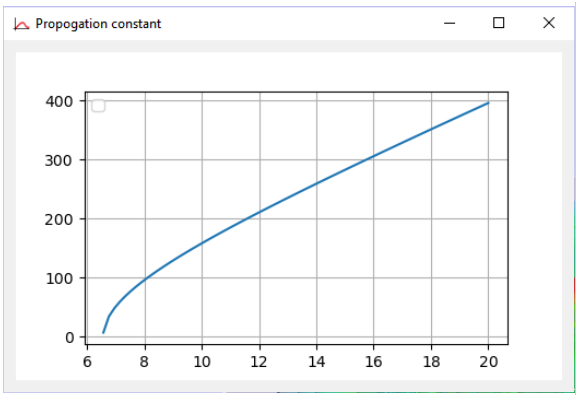
14. Now enter the desired dimensions for WR-90 waveguide Width(cm) = 2.286, Height(cm) = 1.016 and Length(cm) = 5.08
15. The mode we want to observe first is TE with m=1 and n=0
16. The operation frequency is fo = 7 GHz
17. Now Click on Compute button
18. After clicking Compute the fields will be updated and the desired data will be computed for the waveguide

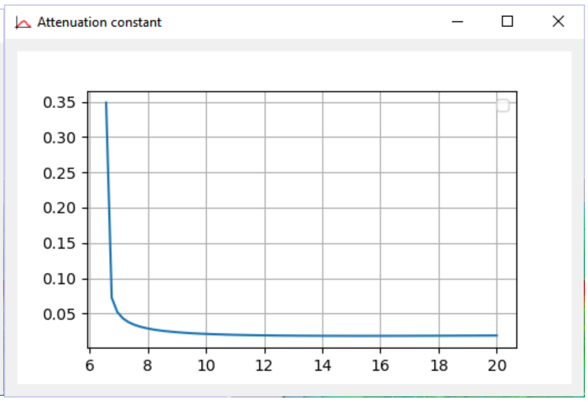


19. We can notice that the resonant frequency is 6.56 GHz for TE10 mode
20. The Guided wavelength for the waveguide is 0.12. We can click on plot button to plot the data

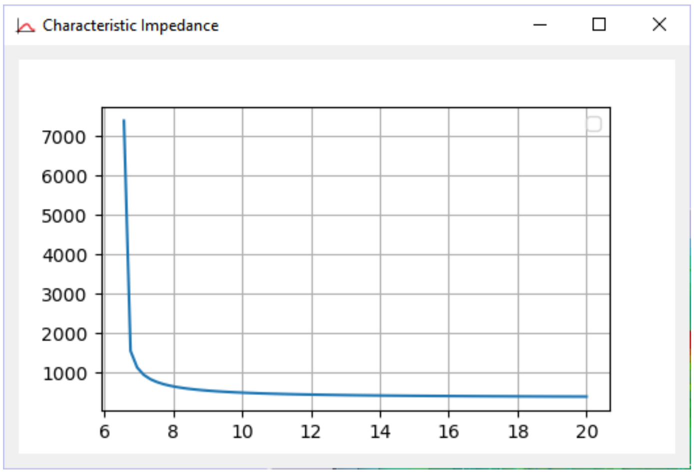


21. Plotting Propagation constant and Attenuation constant click on the respective Plot buttons

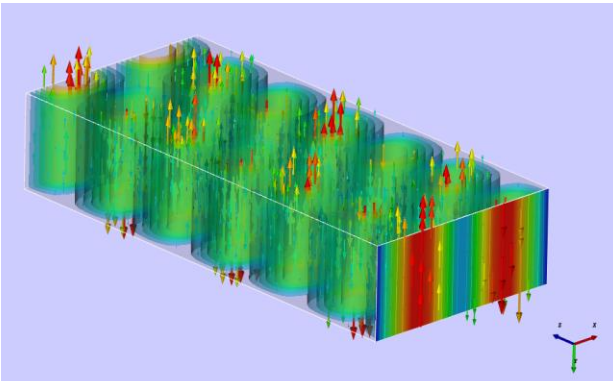


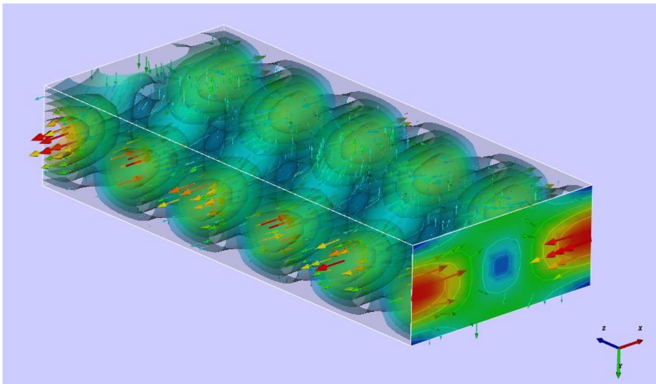


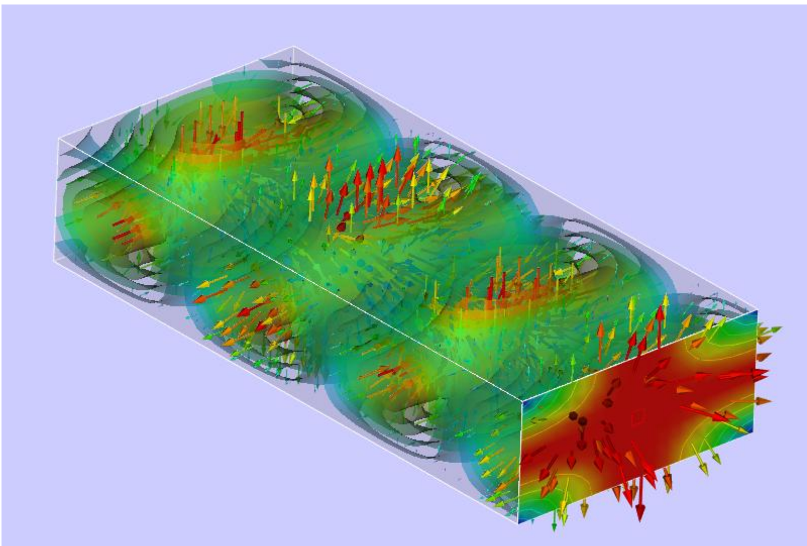
22. The characteristic impedance of the waveguide can be plotted. It can be seen that at very high frequency the Z0 approaches to intrinsic impedance



23. The fields can be animated by clicking on ‘Play/Pause’ button
24. Furthermore, we can plot the fields for other modes at different frequencies which are shown as below
25. TE20 Mode, TE11 Mode and TM11 Mode are as plotted below







Assignment: Study various modes of waveguide for different frequencies

8. Half-wavelength Dipole Antenna

This example demonstrates how to compute the input impedance and radiation pattern (Directivity and Gain) for a lossless half wavelength dipole antenna. The length of the dipole is 200 cm and it is a half wavelength long at 75 MHz. The dipole is located along the z-axis and has a radius of 1 cm. The excitation used in the analysis is a voltage source with a voltage applied at the midpoint of the dipole. The analysis is done for a linear frequency interval of 101 frequencies from 25 MHz to 500MHz.

Starting TaraNG Software

Design steps for the starting a new project in TaraNG :

1. Click on the third option (figure showing radian pattern symbol) and enter the User ID Password in the given box.
2. API Key will be provided in your dashboard on the TaraNG website after the registration on myTaraNG web-portal.
3. Click on the start button to run TaraNG Software for Antenna simulation.

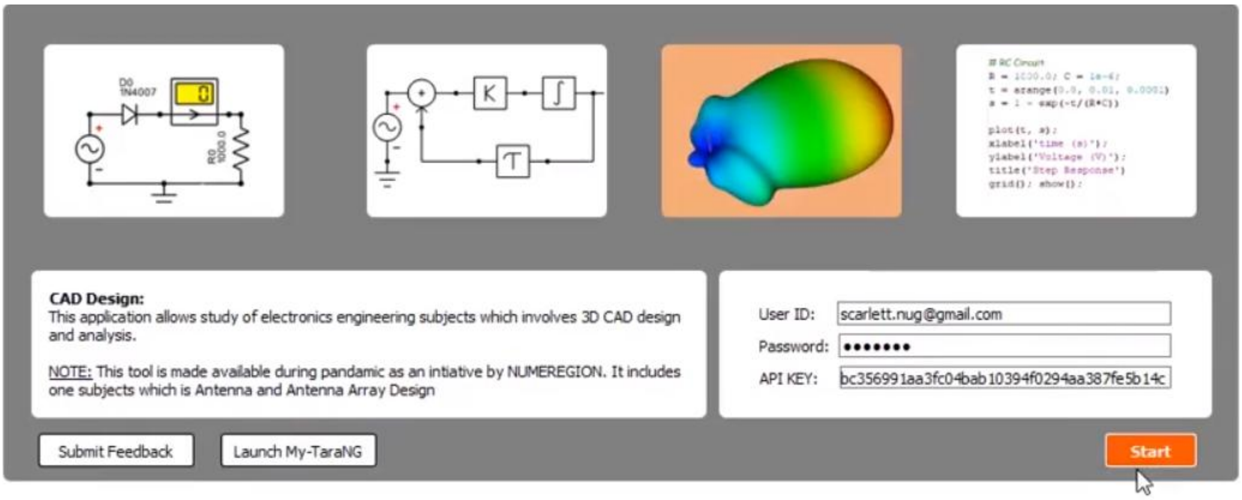


Fig 1.1 TaraNG Launcher Window

Geometry Design

Dipole length plays an important role while designing an antenna. The length of this antenna is equal to half of its wavelength ($l = \lambda/2$ or $\beta l = \pi$). According to the formula,

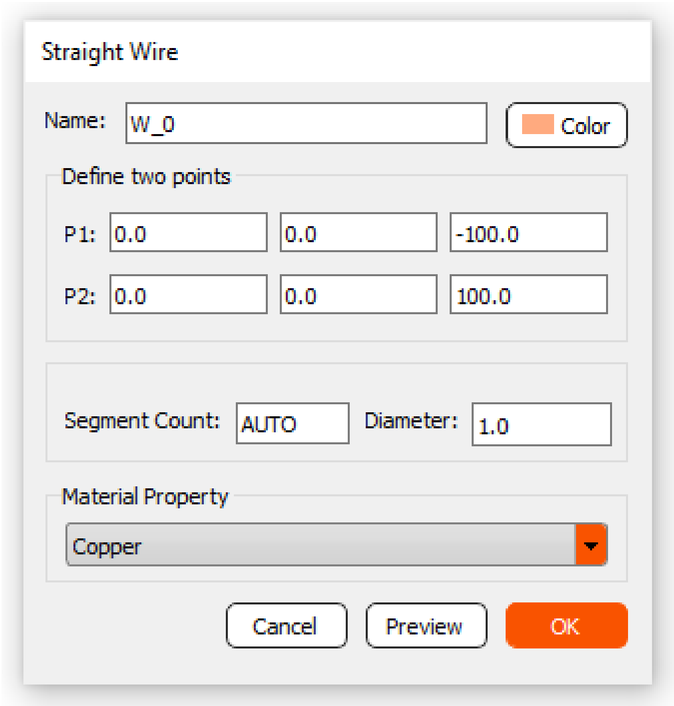
$$f = c / \lambda$$

Where, f is frequency in Hz, c is speed of light (3×10^8 m/s) and λ is wavelength

To find the length of the half-wavelength dipole antenna at frequency 75MHz

Length = $\lambda/2$ = (c/f)/2 = 3e8/75e6/2 = 300/75/2 = 2 meter = 200 cm

37. Initially, click on the 'Wire Segment'  icon in the toolbar. A wire appears on the screen with a dialogue box shown in figure 1.3



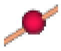
For the length 200 cm along z direction, we will use two points P1 = (0,0, -100) and P2 = (0,0,100) respectively.

38. After defining start and end coordinates of wire we will define Diameter as 1.0 cm and set the Material Property as copper for this example. In this experiment, we have used copper as the material however these properties can be changed per the requirement of the user.

39. After the details are entered, clicking OK will show the dipole antenna wire. In the main 3D Design window of the software.

Setting up the Excitation

The dipole is a balanced antenna, that is, neither of the two parts or sides of the antenna is connected to the ground. The next step is to add the antenna feed in the center of the dipole wire.

1. To add the feed, click on the ‘Port’  icon in the taskbar and slide the cursor near the dipole to get the visuals. By clicking anywhere on the dipole, the feed will be placed.
2. To make sure the port is exactly at the center of the dipole, double click on the port  and make X, Y and Z as 0.0, 0.0 and 0.0 respectively
3. Click OK to complete the step. The dipole antenna with these easy steps has been created using TaraNG Software.

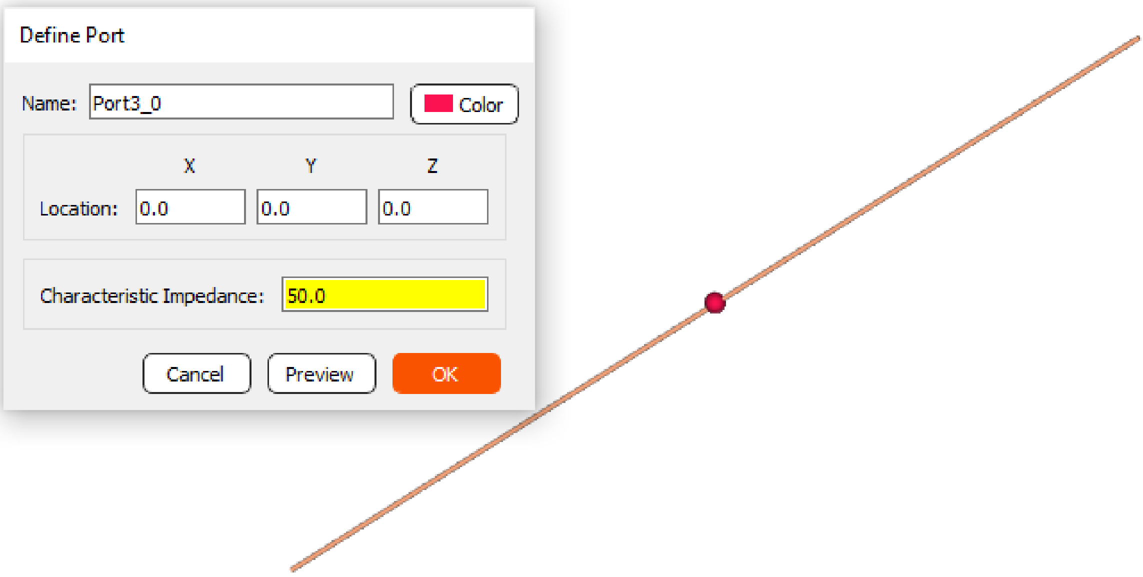
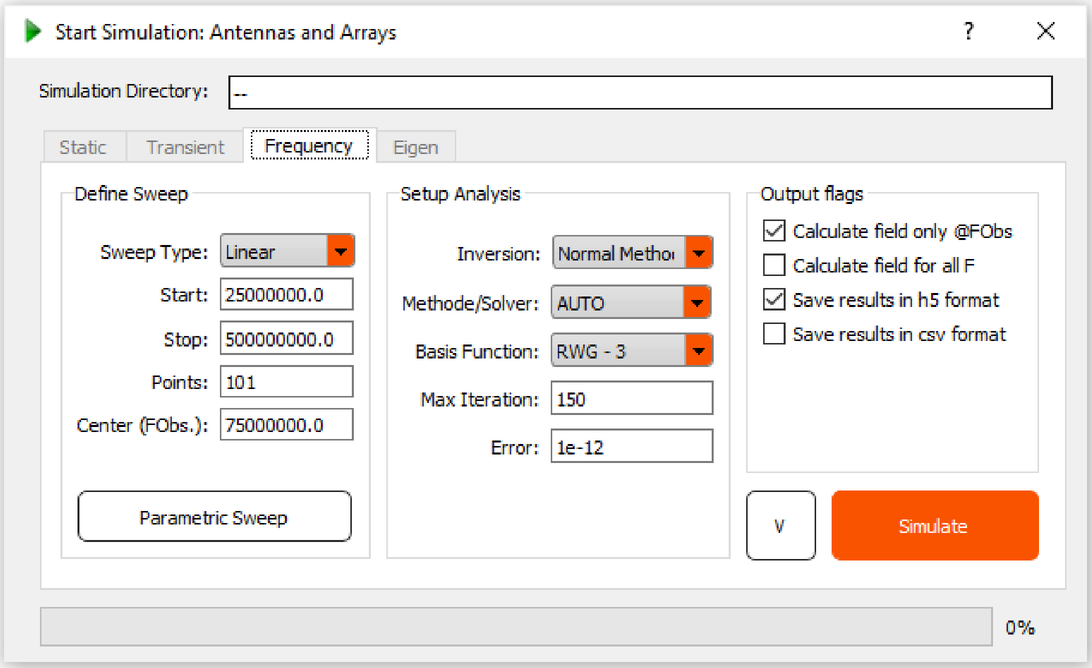


Fig. Feeding the Dipole Antenna:

40. After the successful creation of the dipole antenna and applying excitation, the next step is to run the simulation to perform the computations or analyses.

Running the Simulation

1. To run the simulation, click on the Run button  in the taskbar. The box appears where the user has to enter the start, stop, center frequency and the number of simulation points.



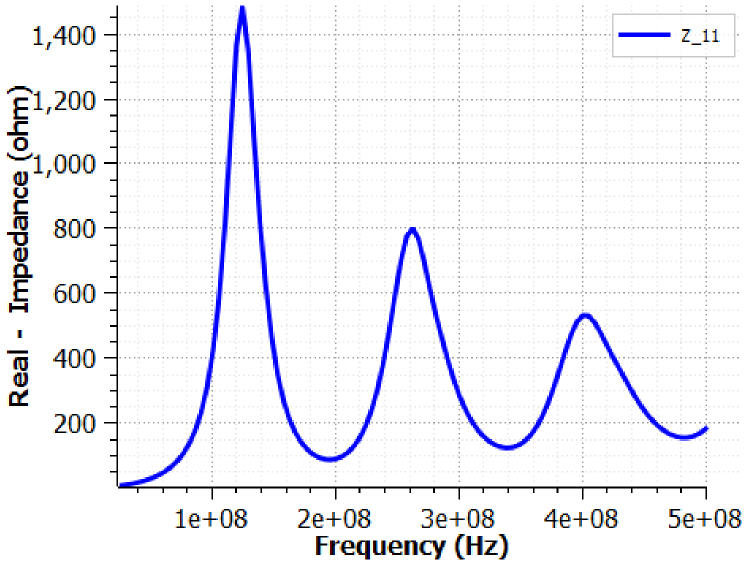
2. Setup Analysis settings are useful for setting up solver method and inversion methods. We will keep these parameters as default.
3. Further click on the simulate button. The software solves the problem in a few seconds the progress bar will reach to 100% once the simulation is complete.

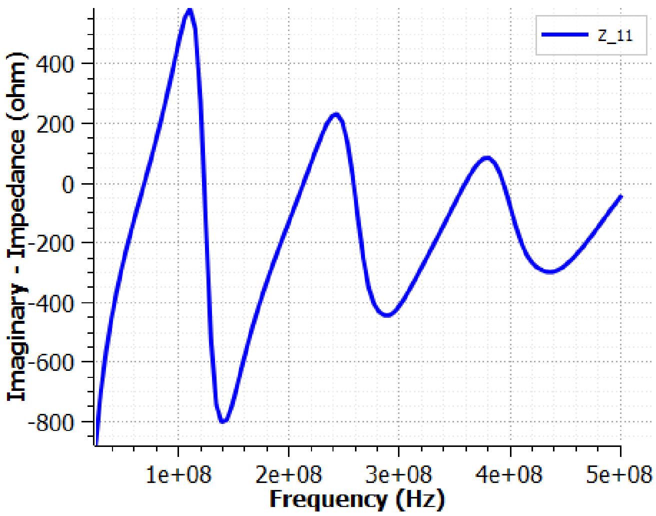
Visualize the Results

Clicking on the bar to the right shows the required plots.

A) Port Parameters

Plotting Input Impedance: Clicking on the right bar shows the real part of the input impedance  The very next tab shows the result of the imaginary part of the input impedance 

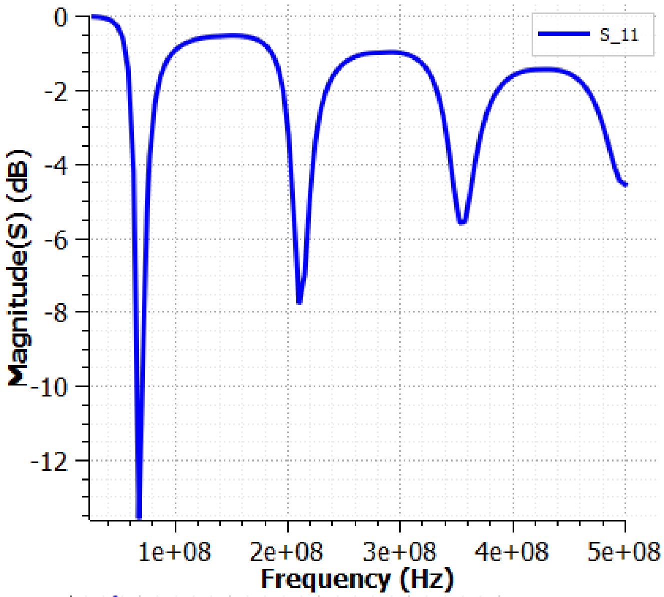


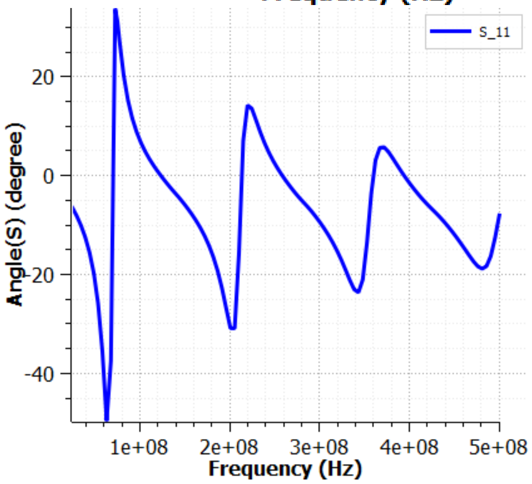


Here we can see that the antenna shows capacitive behavior at the lower frequencies. At a particular frequency, it changes from capacitive to inductive. This is the resonant frequency when the reactance is zero. This behavior changes between capacitive to inductive and so on.

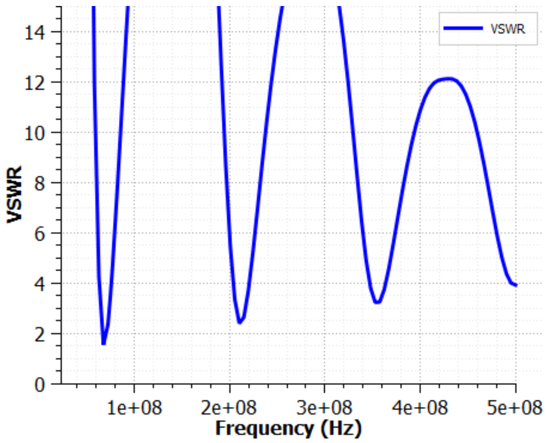
Plotting Scattering Parameters:

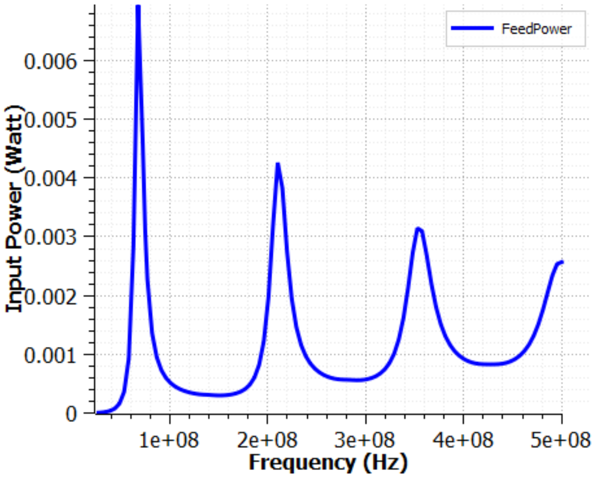
1. In the S parameter, dip can be seen close to the resonant frequency (in this case, 75MHz). For the proper operation, S11 should be less than -10dB.
2. In the phase angle of the S parameter, we can see 0-degree phase resonance.





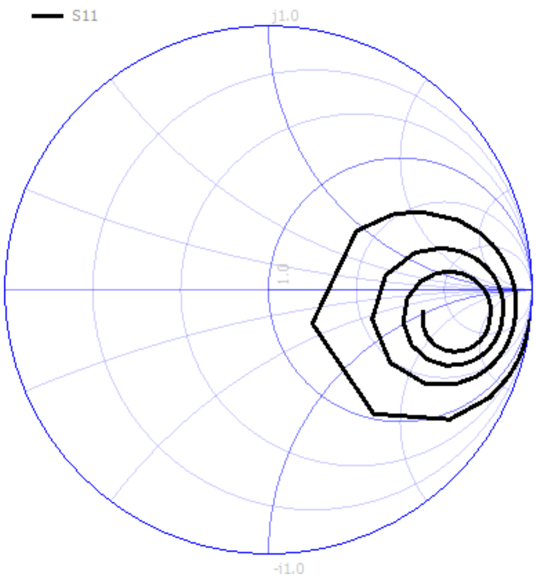
Plotting VSWR and Input Power: Next, we will plot the SWR (Standing Wave Ratio), the value of the SWR will be less than 2 in the operation range. The plot can be viewed by zooming in on the graph in the software.





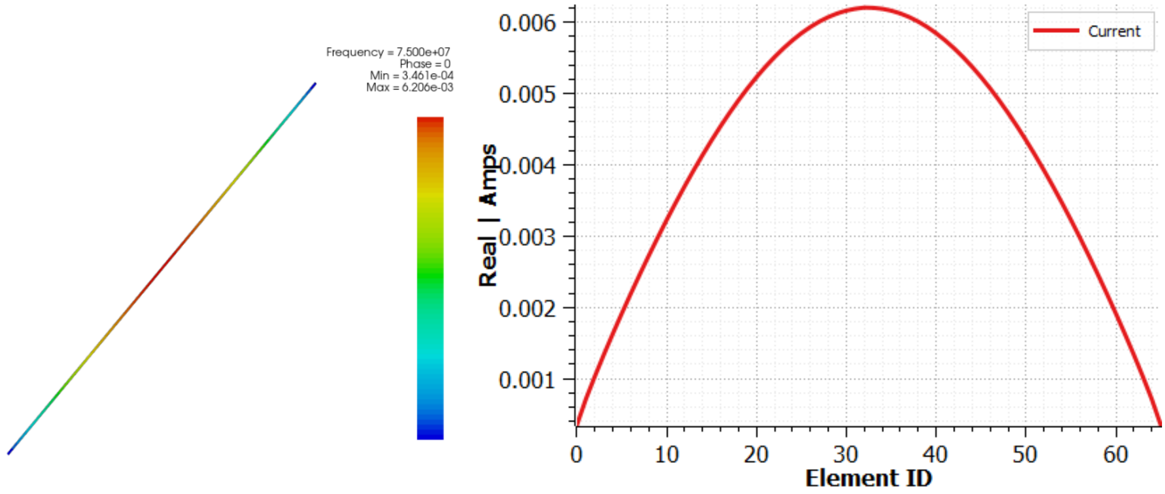
The next plot shows the fed power to the antenna. The fed power will be maximum at the resonant frequencies.

Plotting Smith Chart: TaraNG also has the Smith chart feature. We can see that the lower side depict the capacitive type of behavior and the upper side depict the inductive behavior.

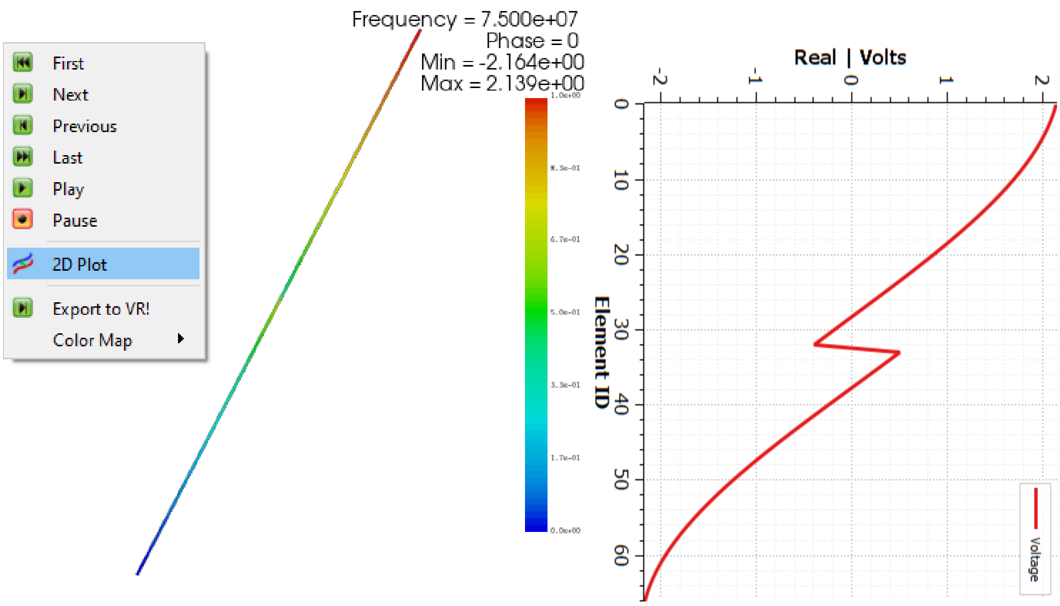


B) Near and Far Fields:

Visualizing Current Distribution: The current distribution can also be view as the 3D and as the 2D plot. At the center, the current will be maximum and at the ends, the current will be zero. It looks more like the half sinusoidal.

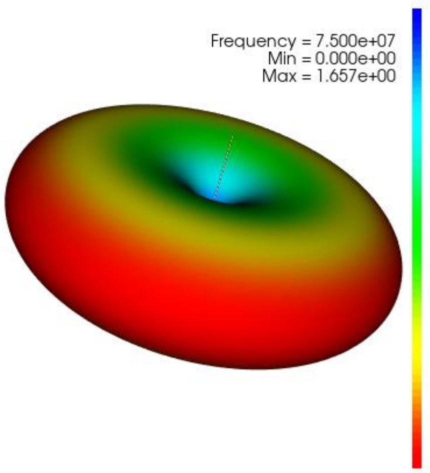


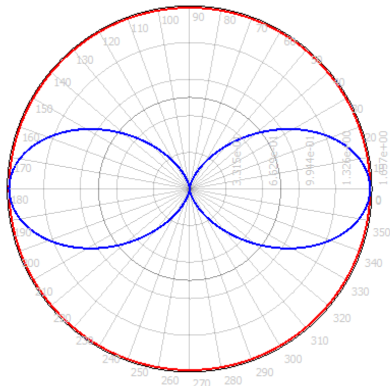
Visualizing Voltage Distribution: The first plot in the near-far field is the voltage distribution antenna where one side has a positive voltage and on the other end the negative voltage. The 2D plot of the same can also be viewed.



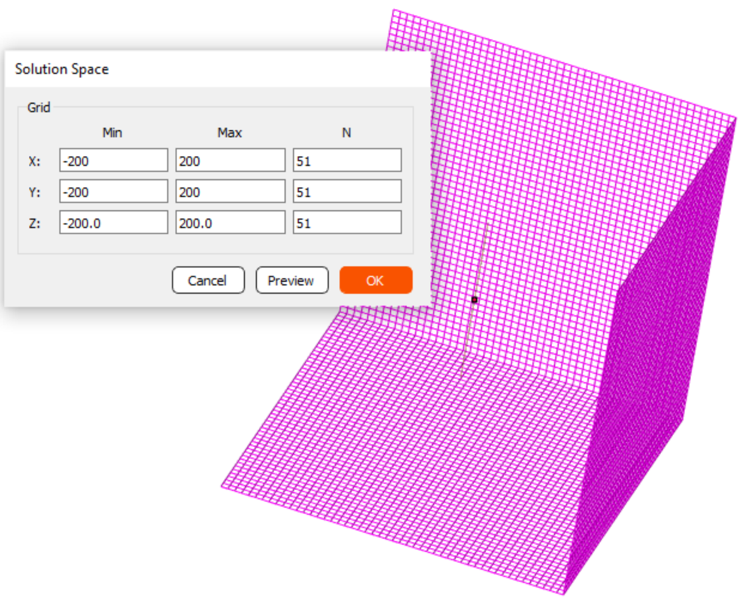
1. We can observe positive and negative charges at the opposite sides of the dipole in the charge distribution plot. In a 2D plot, we can see these changes at the end that's why it is called a dipole.

Visualizing Radiation Patterns: The 3D radiation pattern can be viewed in the TaraNG software by clicking on button with  icon. Dipole antenna's radiation pattern looks like a Doughnut shape with a gain of around 1.6. The polar plot can be viewed which looks like the shape of '8'.

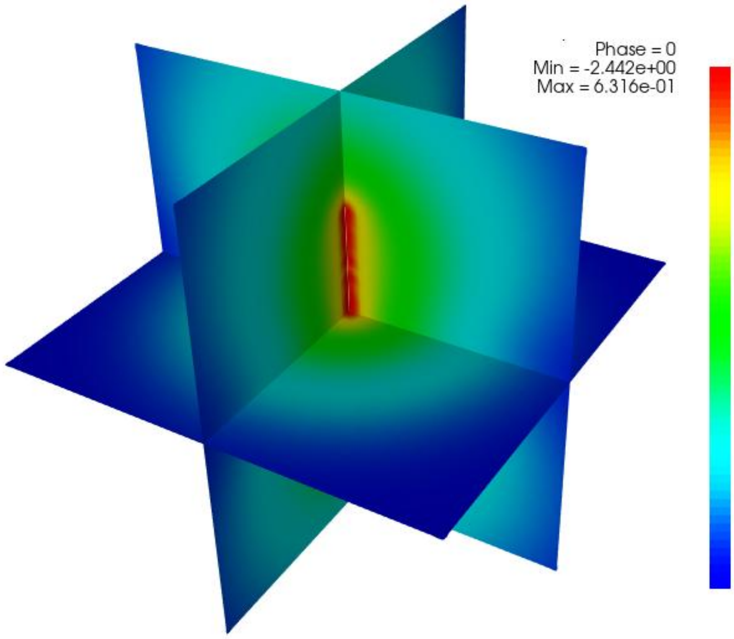




Creating Near-field Region: We can create the near field region in order to observe the near field in close proximity antenna. To view the region in the software, grid  icon in task bar can be clicked. The box appears to enter the required values. Further, the rectangular shaped grid appears on the viewing area near the dipole. By modifying the grid, visual region can be viewed on the viewing area



Visualizing Near-fields over Cut-planes: Next plot is of the field cut plane pattern of the electric field. Unique feature of the software is that the animation can be played simply by right clicking and playing the same.



Visualizing Near-fields Contours: 3D near field contour plane is the next icon on the left bar in the software. By clicking on the run button, the animation can by played for visualization. With this graph, one can view, how the waves propagate out from the antenna. (if the plot gets too zoomed/shrinked, 'R' button on the keyboard can be pressed to reset the view)