Engineering ElectroMagnetism
Experiment - 7

To Simulate and Analyze a Monopole and Dipole antenna in HFSS.

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Aim

To simulate, and analyze a monopole and dipole antenna

Components

HFSS

THEORY

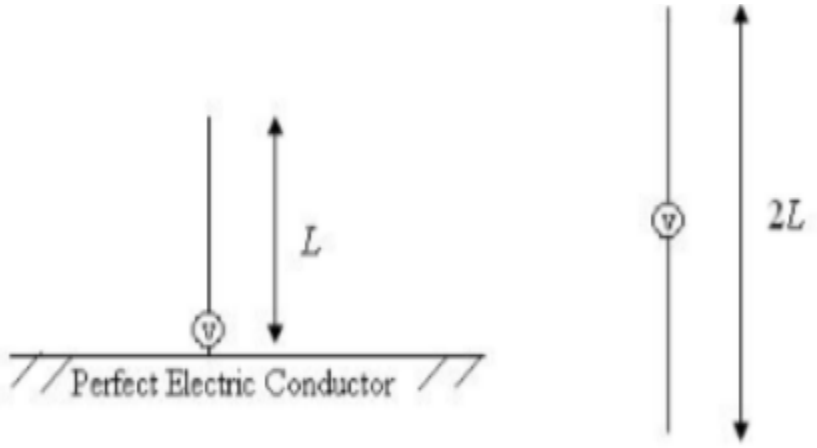
EM radiation occurs when electric charges undergo acceleration or deceleration or in other words current (time-varying) is the source of radiation. If the charge is not moving then there is no radiation as I=0. But when a charge moves with uniform velocity then radiation occurs when the wire is curved, bent, discontinuous, terminated or truncated as there will be an acceleration or deceleration. If the current is time-varying then there will be radiation even if the wire is infinitely straight. The radiation is produced by current distribution on the antennas and this distribution is usually excited by transmission lines and waveguides.

Consider the case where we keep two parallel conductors such that a time-varying current flows through them. Now, due to the open circuit at one end for both, there will be reflections at the end and this will cause the standing waves. However, the radiation is not efficient for an application. The current flows in the opposite direction in each wire and this causes a net cancelling of radiation at a point. To make it useful we can flare it at the ends, which makes the direction of current appear to be in the same direction such that the effects of both the bent parts cause appreciable radiation due to constructive interference at a point away. This structure is called a **dipole antenna.**

The dipole antenna or dipole aerial is one of the most important forms of RF antenna. The dipole can be used on its own, or it can form part of a more complicated antenna array. The dipole aerial or antenna is widely used for a variety of types of radio communication, on its own, or incorporated into many other RF antenna designs where it forms the radiating or driven element for the overall antenna.

A monopole antenna is one half of a dipole antenna, almost always mounted above some sort of ground plane. The case of a monopole antenna of length L mounted above an infinite ground plane is shown in Figure below.

The radiation pattern of monopole antennas above a ground plane is also known from the dipole result.The only change that needs to be noted is that the impedance of a monopole antenna is one half of that of a full dipole antenna.



The directivity of a monopole antenna is directly related to that of a dipole antenna. If the directivity of a dipole of length 2L has a directivity of D1 dB, then the directivity of a monopole antenna of length L will have a directivity of D1+3 dB.

Electric field of dipole

$E\theta = (j\eta Im * e^{-jkr} * \cos(\pi/2 \cos\theta)) / 2 \pi * r * \sin\theta$

Directivity : $Dm = 4\pi Um / Wrad$

$Rrad = 2Wrad / I^2$

Procedure:

1) Use a cylinder to model the wire as shown in the figure. In a project variable, we can set the variable- their value or equation and units.

2)The gap between the 2 will be very low and so to create a source we'll use a lumped port. Keep a rectangular section in between the 2 wires. Assign excitation - lumped port- assign the new line.

3) Assign the material for wires as pec.

4) To create a radiation boundary use another cylinder with the equations as mentioned and assign the boundary.

5) Enter the solution frequency as 29.9GHz

6) To view the frequency response go to setup and add sweep.

7) After entering the values and sweep type as fast, we can analyze the structure and display the resonant frequency and radiation reports from the results -> create reports part.
8) We can obtain the required plots and patterns accordingly.

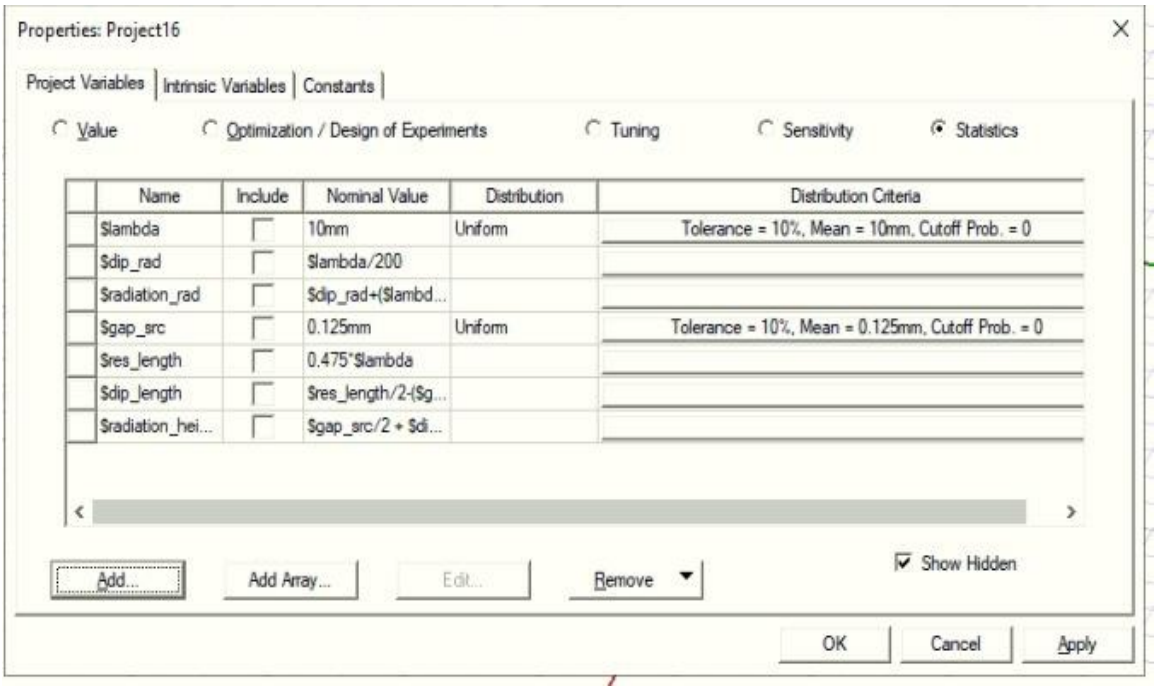
9) In the case of a monopole we have to follow a similar procedure to a dipole but use a cylinder and a ground plane with a rectangular radiation boundary.

10) Given the setup frequency of 10GHz. Right-click on radiation and give it an infinite sphere and follow the above procedure to obtain the result.

11) We then obtained the results for monopole with a bigger ground plane.

Observations:

The local variables been set in the HFSS



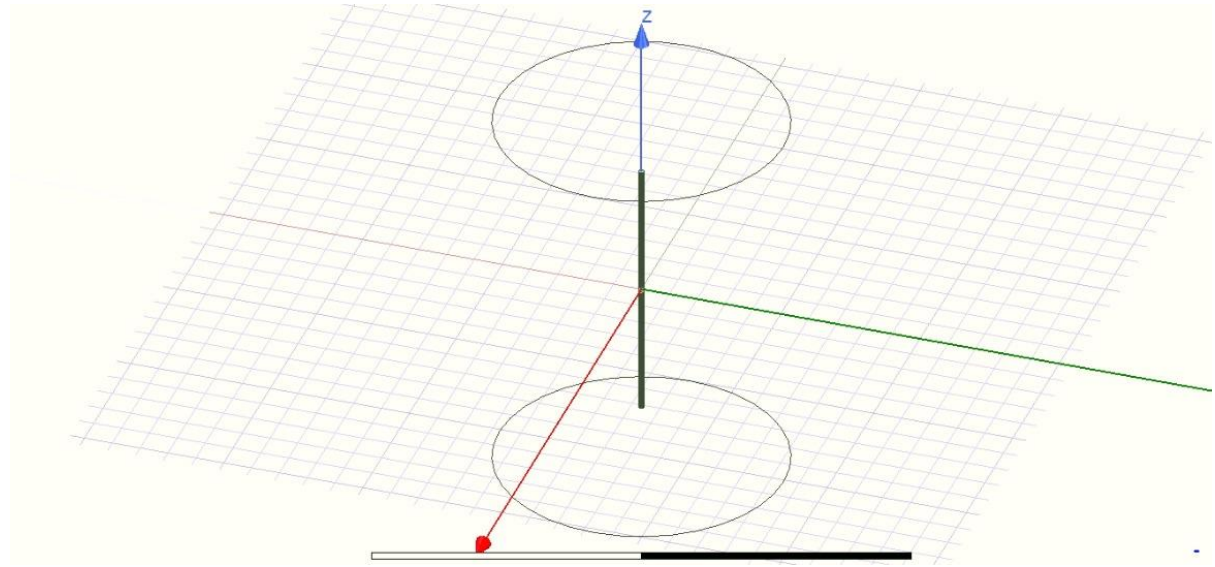
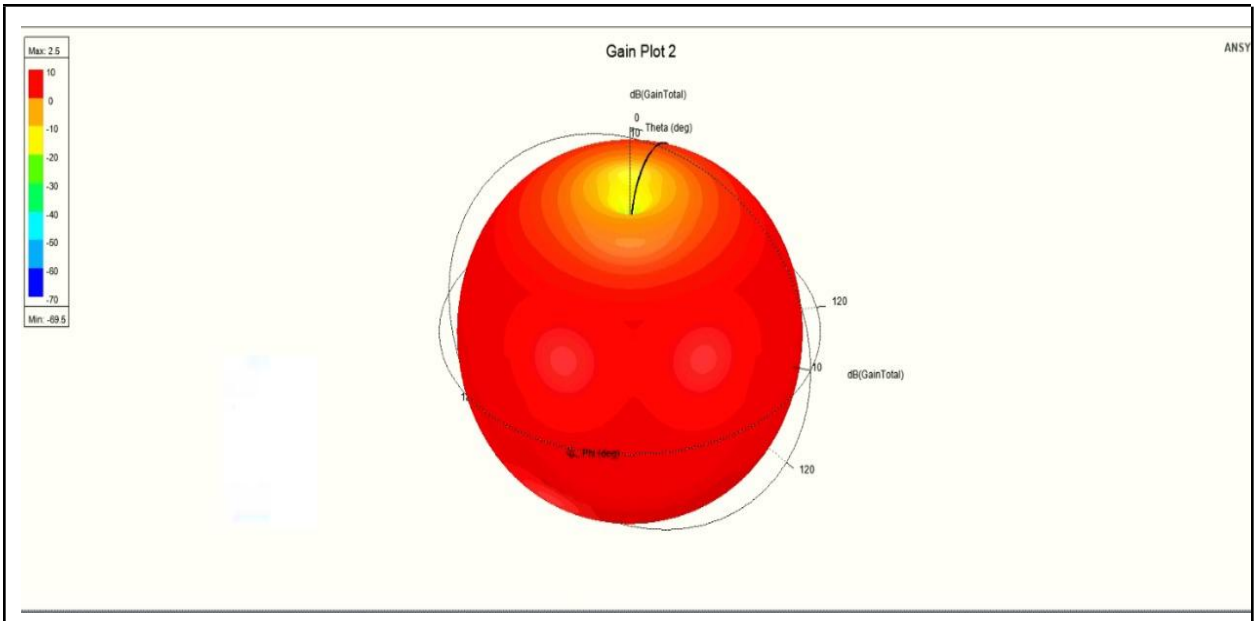
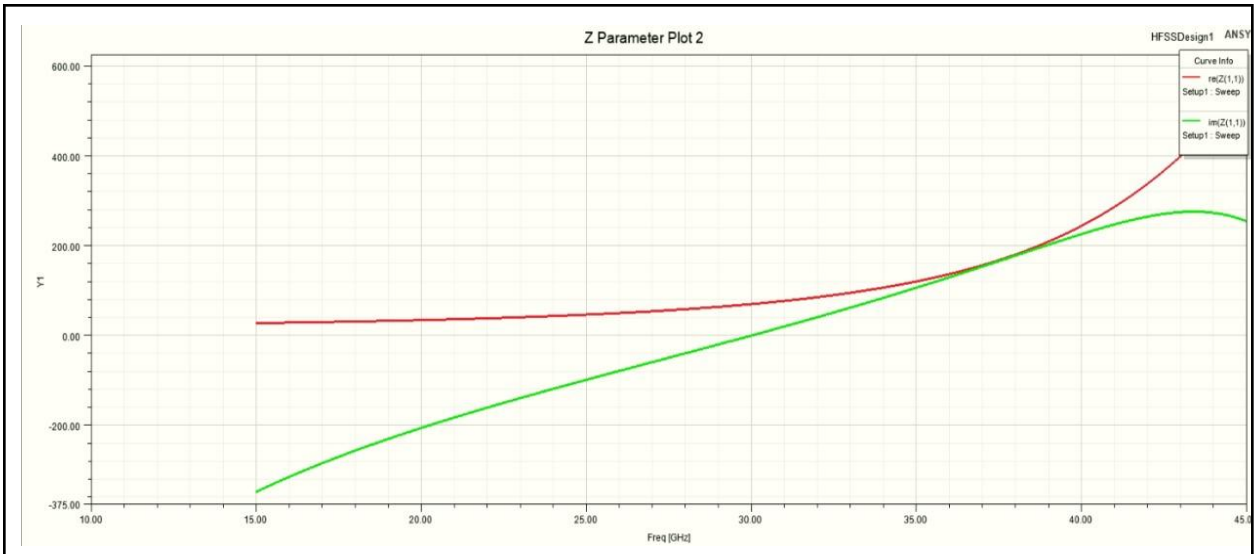


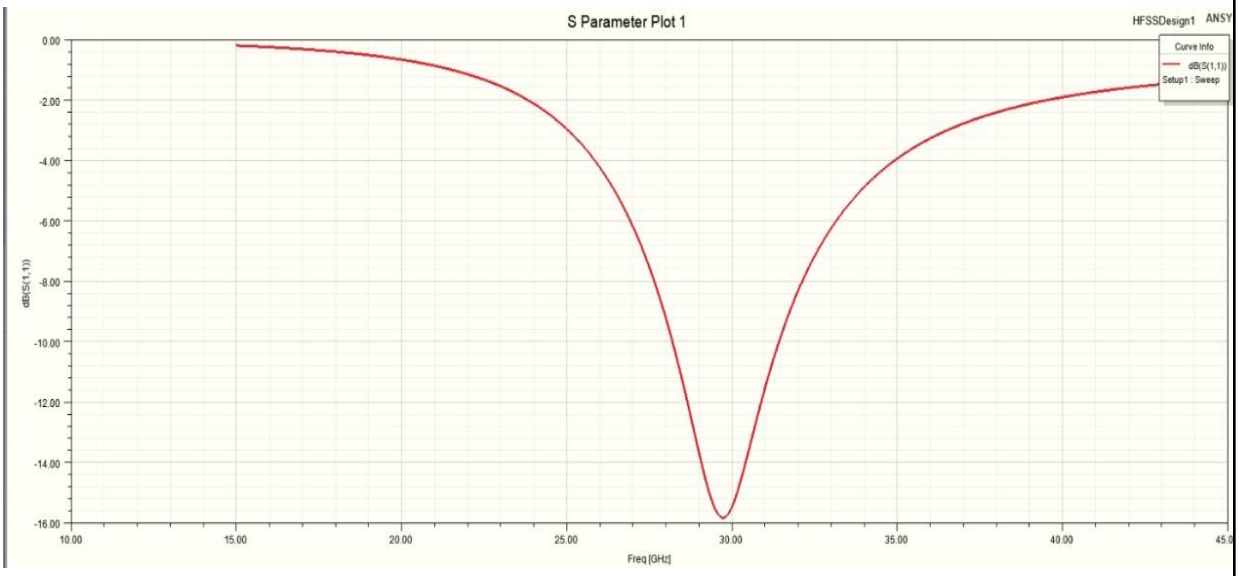
Figure of Dipole with radiation boundary



The radiation pattern of a dipole is as observed. As we have seen the maximum is in the direction of theta=90degrees. (sin 90 =1). Clearly, it has an omnidirectional radiation pattern in the xz plane and 0 isotropic radiation pattern in yz plane.



This is the Z parameter Plot. We have plotted both the real(red) and imaginary(green) values of Z in the plot. Moreover, the value of Z at 30GHz frequency came around 71.25Ω



The S parameter plot of the dipole is seen above. A sharper curve with minima at around 30GHz would have been observed if the source was matched.

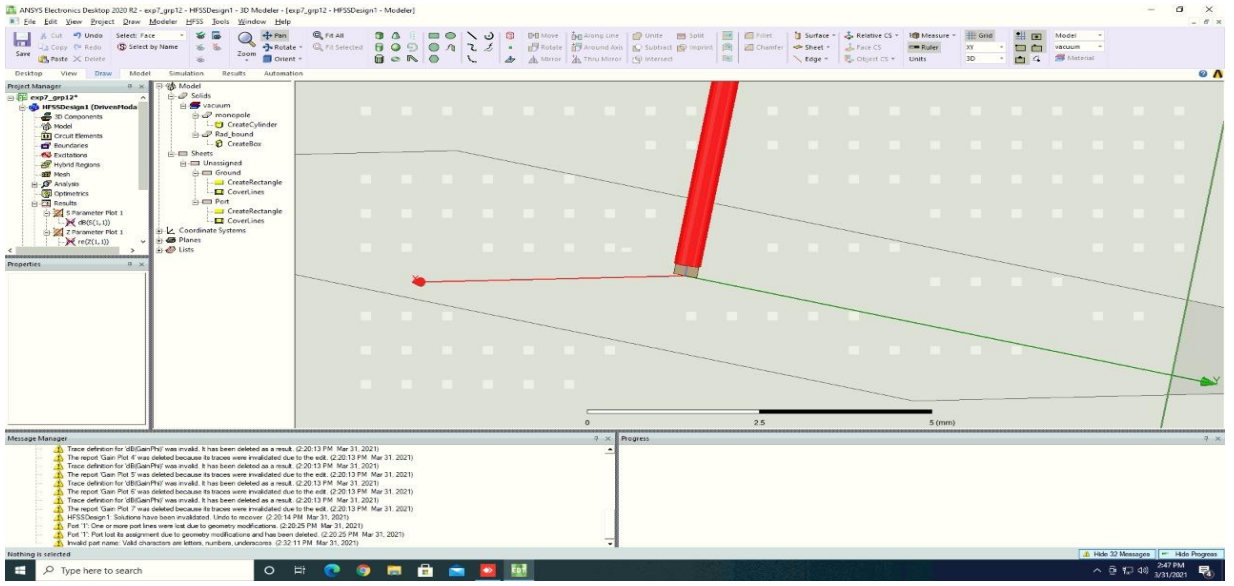
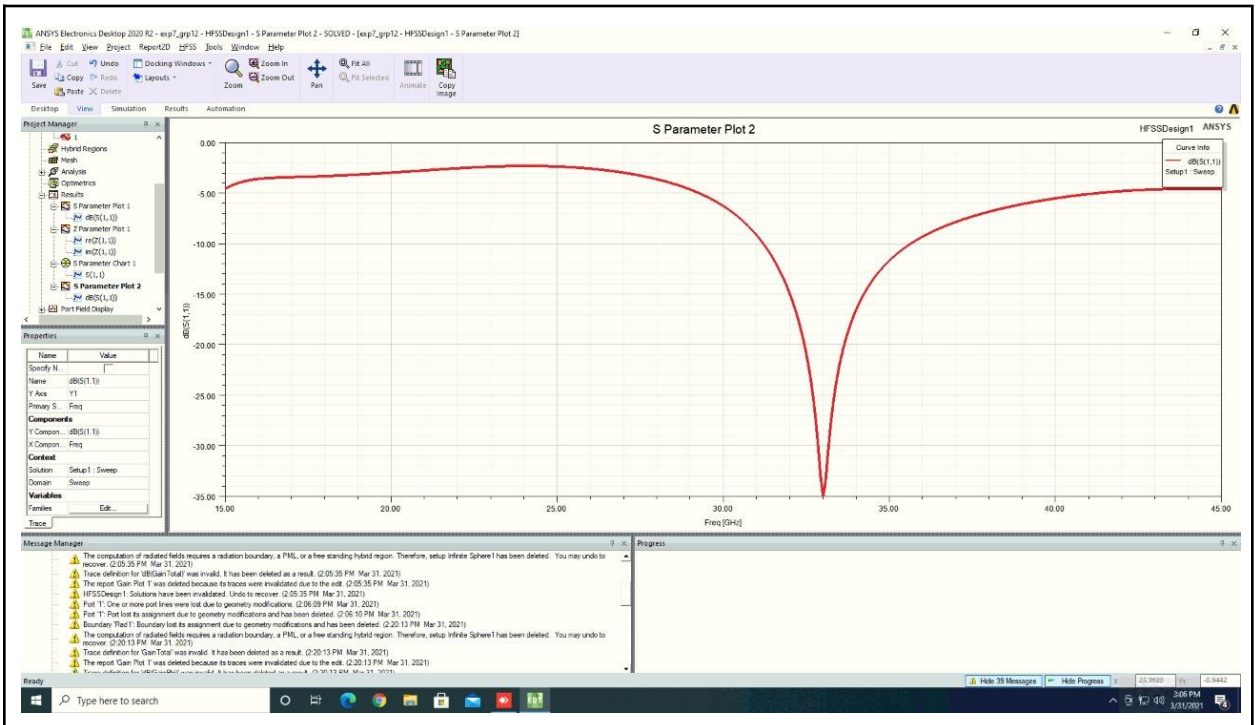
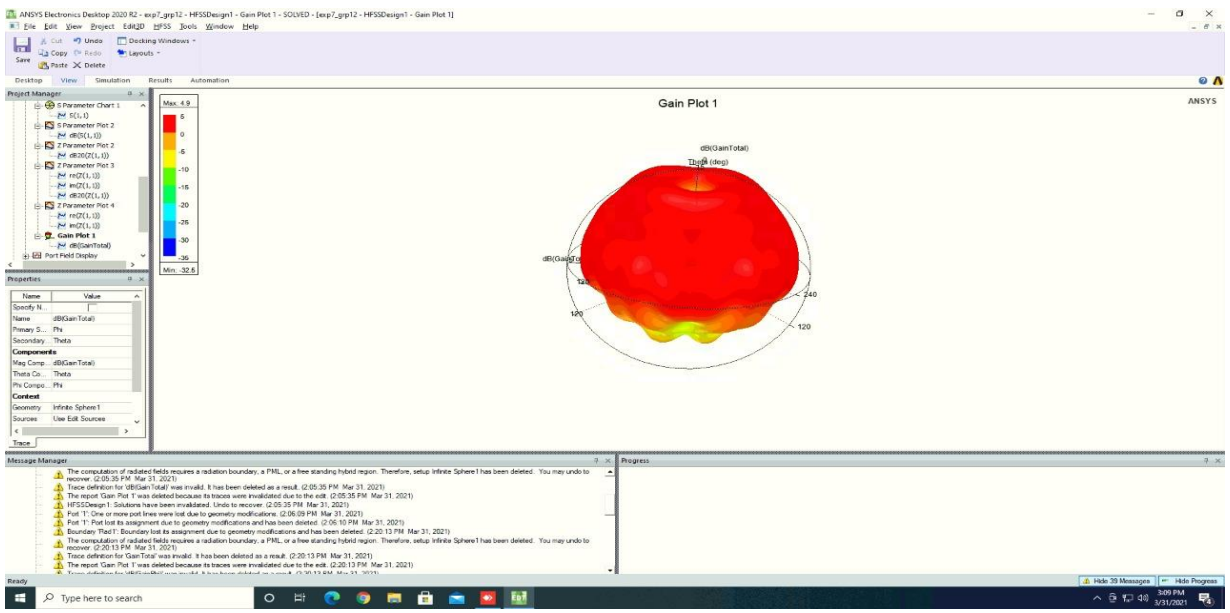


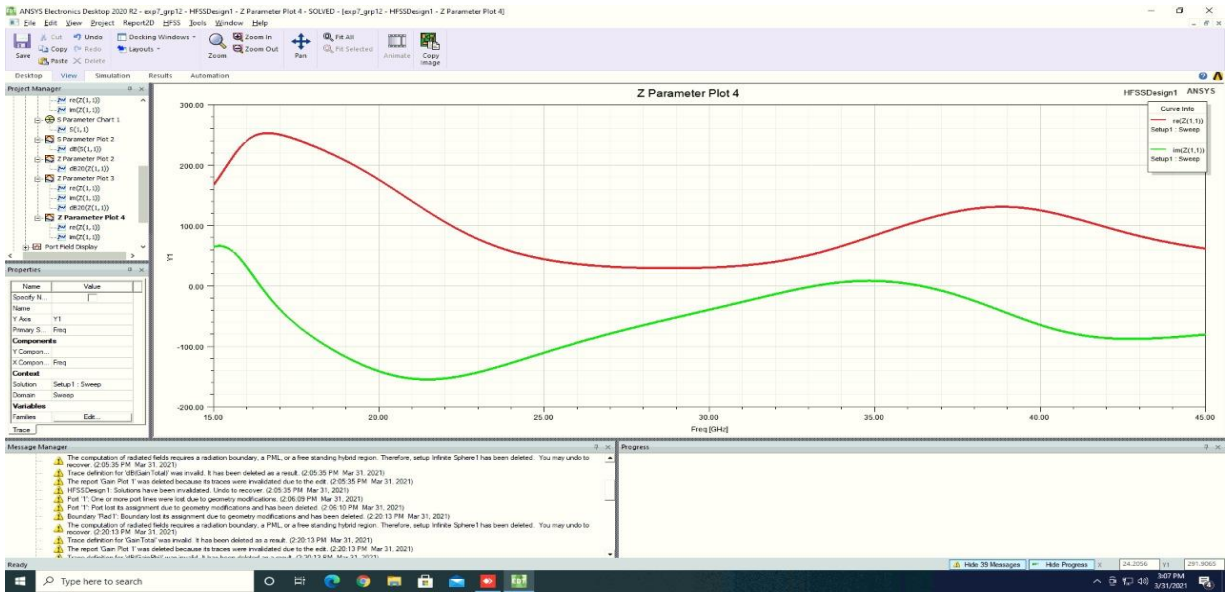
Figure of Monopole with radiation boundary



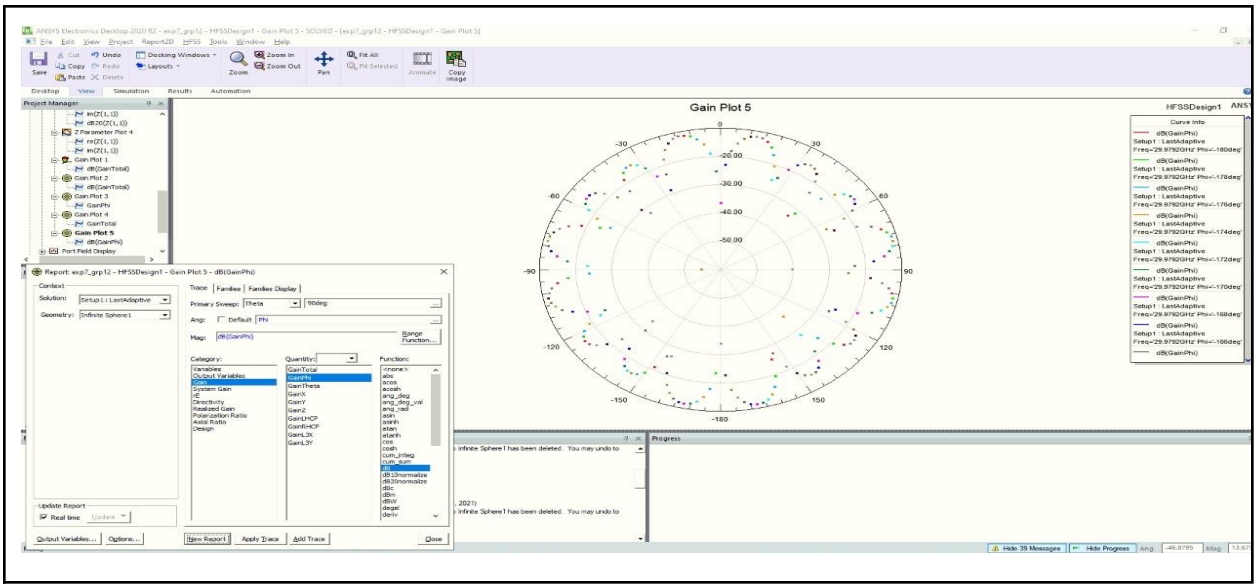
The S parameter plot of a monopole is as seen above

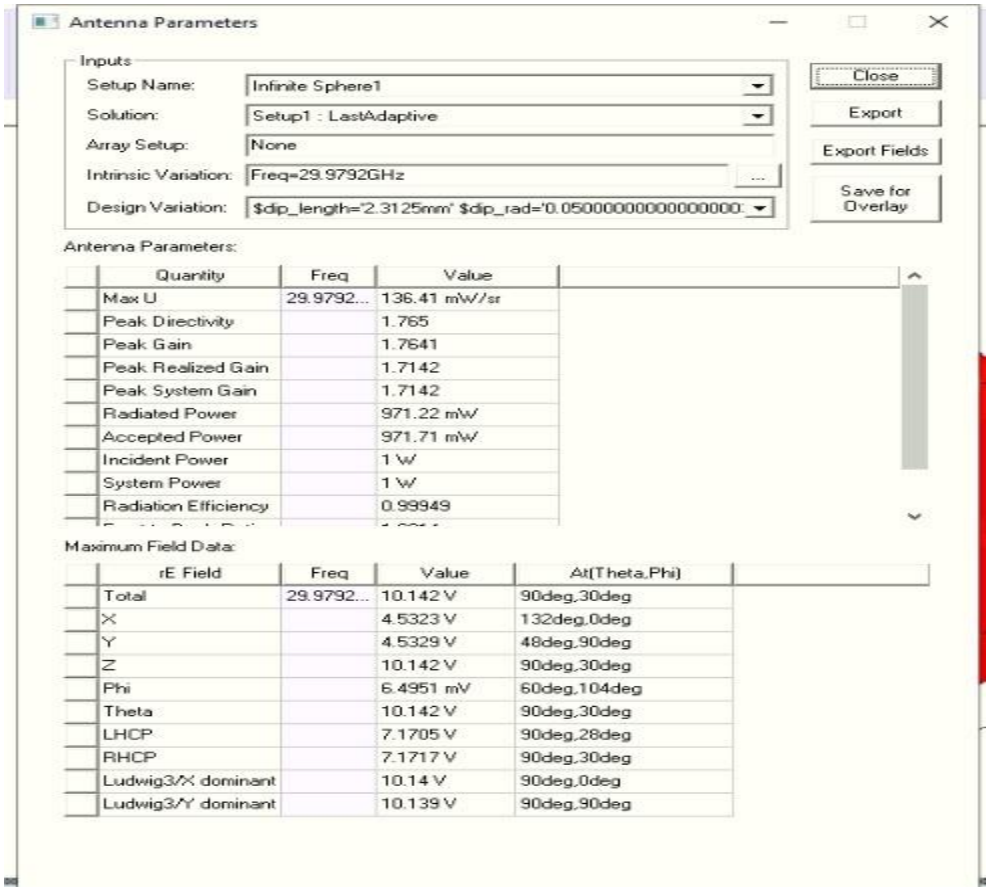


The radiation pattern of a monopole is as seen above. The radiation pattern is similar to a dipole as expected but the value changes accordingly

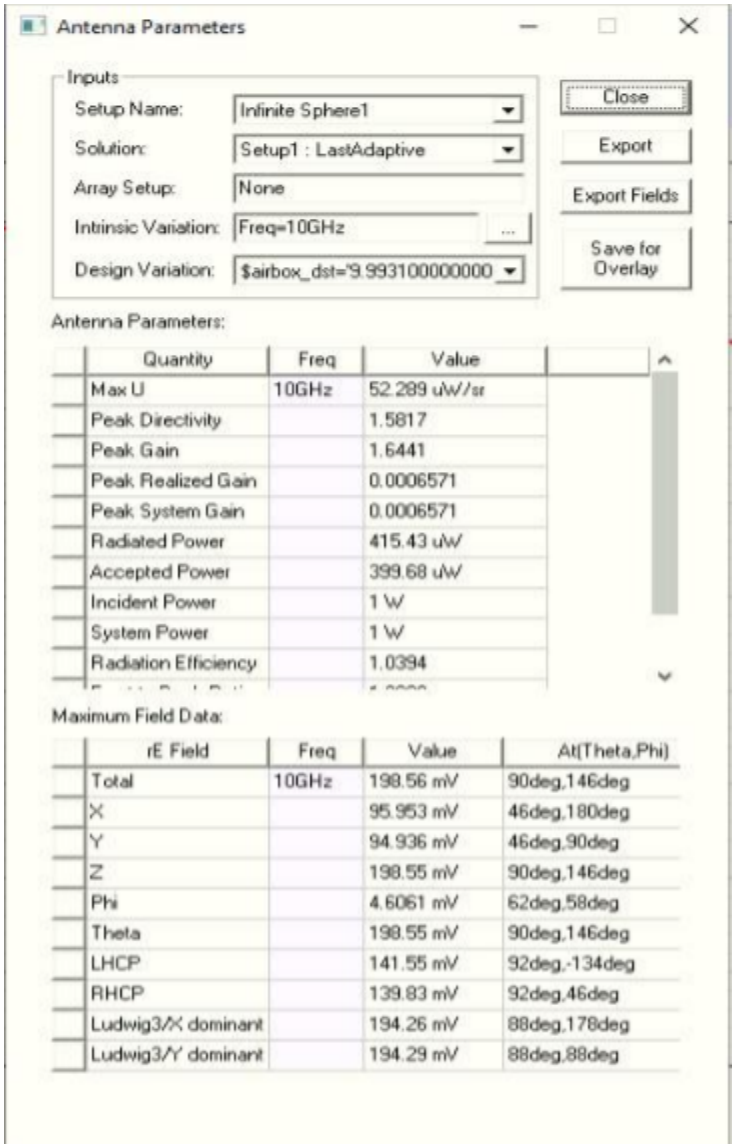


This is the Z parameter Plot. We have plotted both the real(red) and imaginary(green) values of Z in the plot. Moreover, the value of Z at 10GHz frequency came around 68.5Ω





Results for Dipole



Result for monopole

Peak directivity for monopole antenna = 1.5817
Peak directivity for dipole antenna = 1.765
Peak gain for monopole antenna = 1.6441
Peak gain for dipole antenna = 1.7641
Radiation Efficiency for dipole antenna = 0.99949
Radiation Efficiency for monopole antenna = 1.0394
Impedance comes out to be 50 ohms.
Dip in the graph of S11 parameter is at 29.5 GHz and the value at this point is -15.9 dB.

Result:

We have successfully implemented a dipole and monopole in hfss software and have observed the characteristics and the variations to be in accordance with our theoretical understanding.