

Simulation of Hairpin Monopole Antenna using High Frequency Structural Simulator Software

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ABSTRACT

A revolution in science of electronics and communication has emerged in the last few decades, with the potential to create a paradigm shift in thinking about simulation theories. The paper throws some light on the utility and simulation of hairpin monopole antenna. The main focus is to get the exact simulation and results that we obtain from analyzing a simple monopole antenna. Analysis of number of antenna elements and comparison of the practical characteristics of the antenna with the ideal one have been done. A traditional dipole antenna is used to begin things and from there research is carried forward with the analysis of antenna using the same software over its specified range of frequency. The name hairpin is so called because the antenna is in the form of hairpin which is a slender U-shaped piece of wire, shell, etc. Modern car radio, mobile communications, personal wireless devices, and medical instruments use the application of hairpin monopole antenna for better performance and efficiency.

Keywords: antenna, monopole, dipole, frequency, simulation

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I. INTRODUCTION

As the simulation of any system allows us to study the behavior of a system without building it, we can get the results that are accurate in general, compared to analytical model. This will also help to find un-expected phenomenon, behavior of the system. Hairpin monopole antenna is often used as an enhancer attached to the main antenna system which enhances the bandwidth as well as the directivity of the antenna. By simulation of this hairpin monopole antenna we can obtain desired results just by changing the antenna parameters which will help us to get the maximum output.

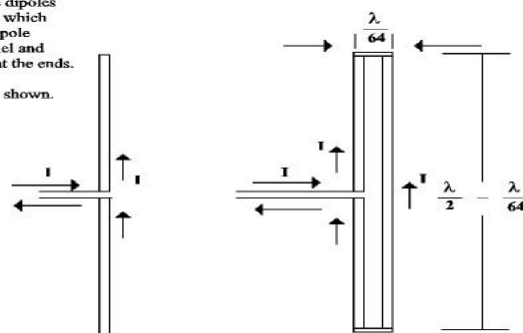
About The Antenna

The "hairpin" monopole antenna has been there for a long time. A center-fed half wave dipole with another half-wave element close to it, joined at

the ends is a folded dipole antenna, as shown in the figure below. The spacing between the elements is about $1/64$ wavelength and the overall length approximately one-half wavelength. A dipole antenna can be expressed electrically, expressed as a series resonant circuit consisting of a resistive component and two reactive components. The impedance which results from this combination becomes resistive at the resonant frequency because at resonance the reactive components are of equal and opposite characteristics and cancel each other. The resultant resistance is 73.16 ohms for a vanishingly thin dipole. Over the years, this particular type of antenna has been one of the most researched and widely used antennas due to its capabilities of being used as a single unit and also along with other antennas to boost their performance standards. The structure and the diagram have been explained overleaf.

Simple half-wave dipoles and folded dipole which consists of two dipole elements in parallel and shorted together at the ends.

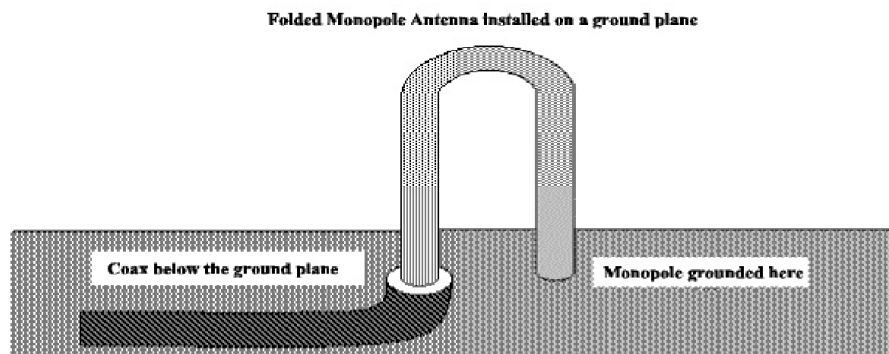
Current flow also shown.



The Basic Structure

One-half of a folded dipole antenna is made to operate above the ground plane so as to function as a folded monopole type of antenna. This is the basic structure of the hairpin monopole antenna. Under these conditions, the input impedance is one-half that of a half-wave folded dipole, about 150 ohms, for a perfectly conducting ground plane. Figure illustrates the basic folded monopole or hairpin antenna. The

difference between a basic folded monopole antenna and a hairpin is that the hairpin is considerably shorter. The radiation resistance is reduced by shortening an antenna. General Dynamics developed a 10(c) kW hairpin antenna only 14 feet high that tuned the 30-MHz range in two bands: 2 to 8 MHz and 8 to 30 MHz.



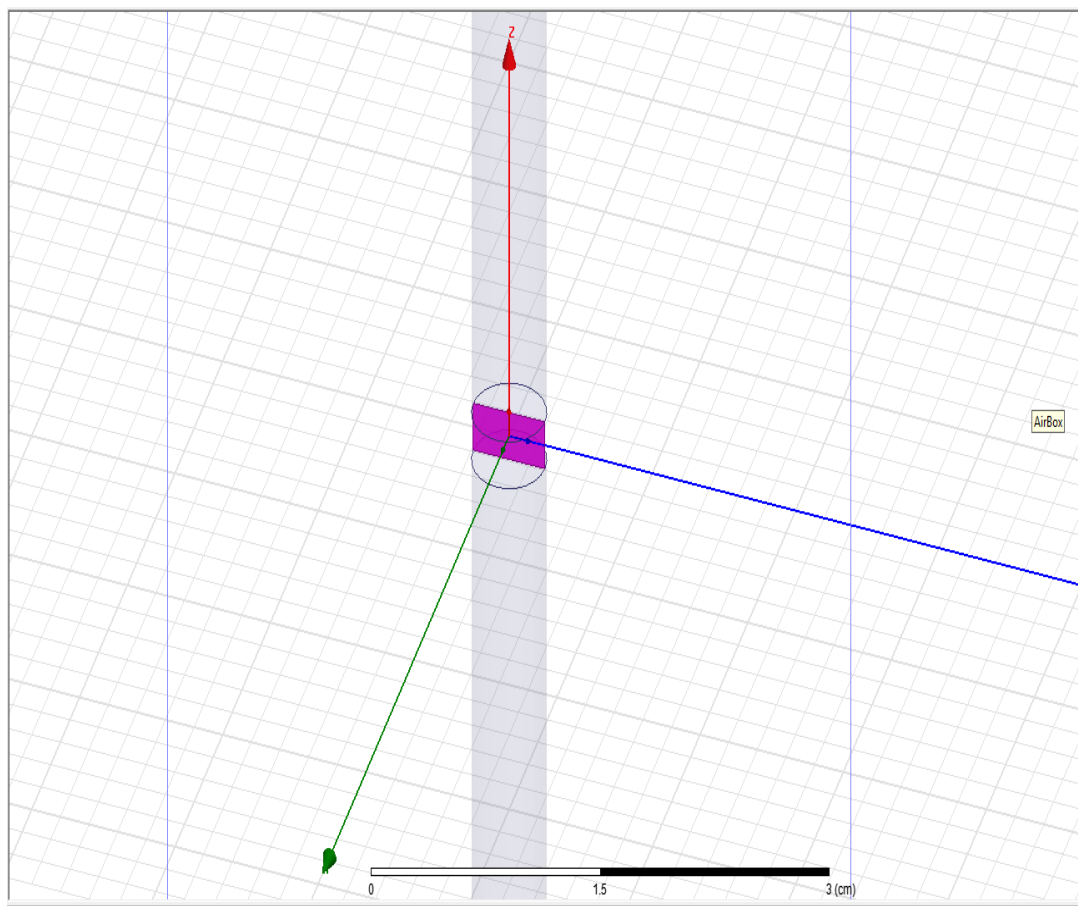
About The Software

The industry standard for simulating 3-D, full-wave, electromagnetic fields is the ANSYS HFSS software. Its gold-standard accuracy, advanced solvers, and high-performance computing technologies make it an essential tool for engineers tasked with executing the accurate and rapid design in high-frequency and high-speed electronic devices and platforms. A state-of-the-art solving technology is offered by HFSS based on the finite element, integral equation, asymptotic and advanced hybrid methods used to solve a wide range of microwave, high speed digital and RF applications.

It was developed by Professor Zoltan Cendes and his students at Carnegie Mellon University, Pittsburgh(PA). In 1889, under a marketing relationship with Hewlett-Packard, Prof. Cendes and his brother Nicholas Cendes, who founded Ansoft, sold HFSS stand-alone to the latter and bundled into Ansoft products. After various business relationships over the period 1996-2006, HP and Ansoft went their separate ways. Ansoft was later acquired by Ansys.

Implementation Of Hairpin Antenna On HFSS Implementation of Dipole Antenna -

1. Draw a cylinder of perfect conductor using the cylinder tool in the toolbar. Change color if necessary.
2. Adjust the dimensions of the cylinder as per your requirements.
3. This is one pole of the dipole.
4. To draw another pole, go to "Edit" menu after selecting the pole that we have already constructed and select "duplicate" around X-Axis.
5. After carefully checking the dimensions of both the cylinders we have to draw a conducting plate that will act as the supply port for the antenna.
6. To do this select "Draw Rectangle" from the toolbox and then draw a rectangle of suitable dimensions in the YZ plane. This plate lies between the 2 cylindrical poles.
7. Select the plate, right click on it and then go to the excitation section and select "Lumped Port".
8. To conclude the design of the dipole antenna, make another volumetric medium of any shape. this should be considerably larger than the dipole antenna.
9. The bigger volume is going to be the air medium in which the dipole will radiate. The analysis of this antenna will include the 3-d polar plot, rectangular polar plot and finally the return loss. The results have been displayed collectively in the next section.

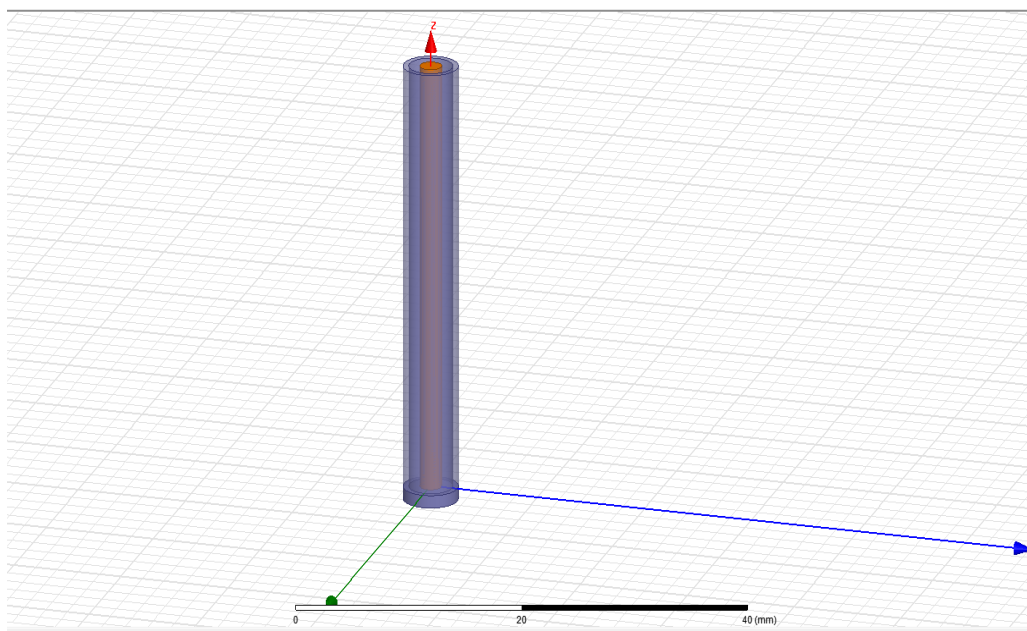


Implementation of Coaxial Cable -

1. To begin, draw a cylinder(1) anywhere on the screen using the 'Draw Cylinder" option in the toolbox.
2. After adjusting the dimensions, we change the material of this cable to "perfect conductor" and this completes our "Inner Conductor" layer. Change the color if necessary.
3. Draw a second cylinder(2) using the same options.
4. After adjusting the dimensions, set the transparency and we will call this the "Dielectric Layer".
5. To make the third and final layer, we draw another cylinder(3) keeping the origin as the centre point of construction. We change the material to "Perfect Conductor". Change the transparency if needed.
6. All the cylinders are concentric and constitute a coaxial cable.
7. The next step is eliminating the overlap between these cylinders taking 2 at a time.
8. To eliminate the overlap between cylinders 2 & 3, we select cylinder 3 and while holding down

Our main aim is to construct a general diagram of a coax cable and then get it's characteristic impedance. the control button, we go to "Modeler > Boolean>Subtract".

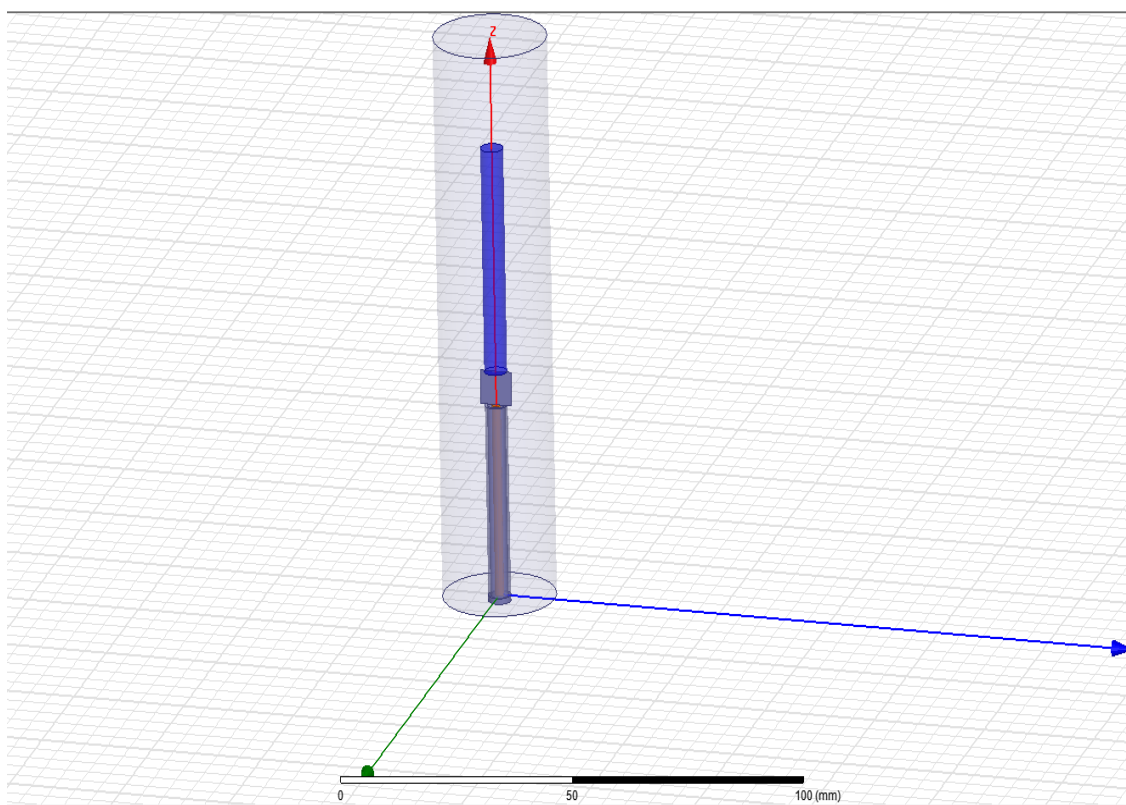
9. Similarly, to eliminate the overlap between cylinders 2 & 1, we select cylinder 2 and while holding down the control button, go to "Modeler>Boolean>Subtract".
10. After eliminating the overlap between all the cylinders it is now time to construct a conducting cap that closes down the coaxial cable from one end.
11. Navigate to the bottom of the figure then right click and go to "Select Faces'.
12. Select the face between the cylinders 2 & 3 and right click on it to "Assign Excitation" as a "Wave port" .
13. To add a cap, draw a cylindrical conductor with a small height value and assign the material as 'Perfect Conductor'. This cylinder will also be concentric with the other cylinder.
14. This completes the construction of "Coaxial Cable".



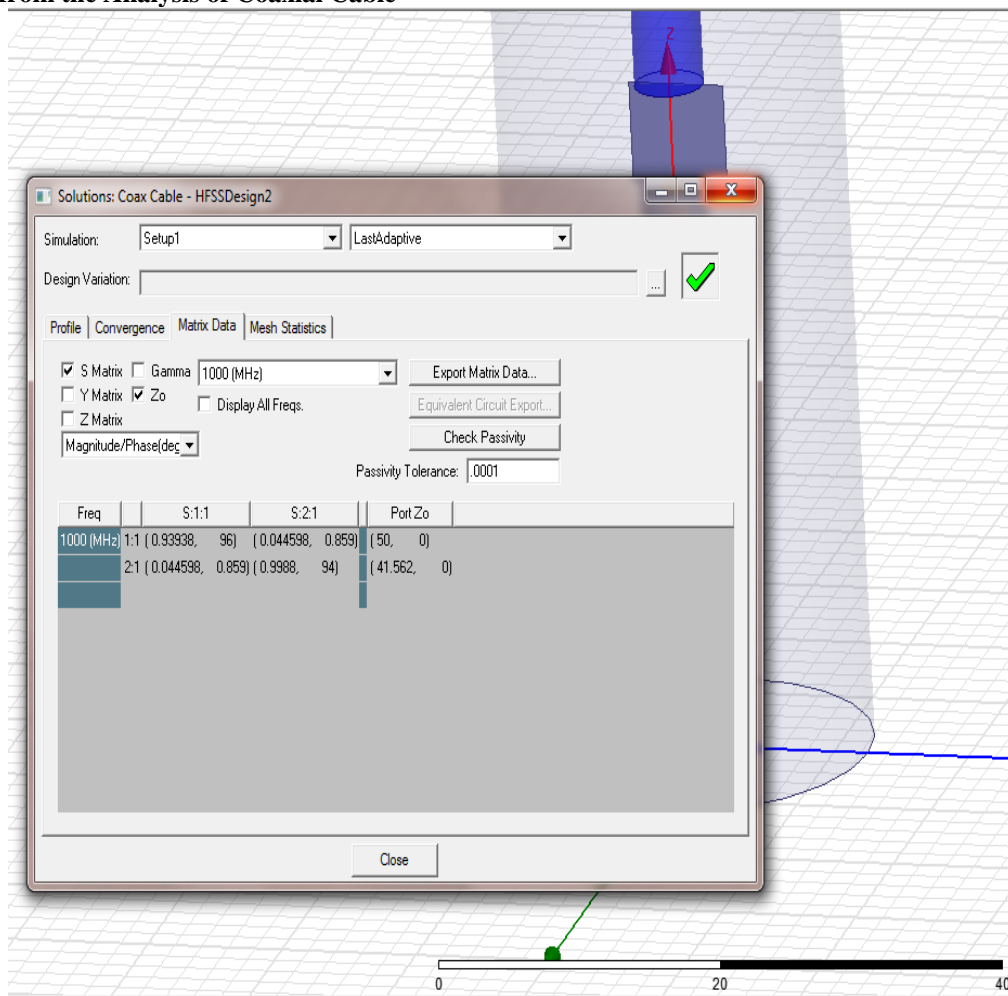
Implementation Of Hairpin Monopole Antenna -

1. Now to make the antenna, we take elements from the dipole antenna as well as the coaxial cable.
2. Create a new project file and cut out a monopole from the dipole antenna that we constructed earlier.
3. Similarly we use the coaxial cable to provide a supply to the monopole using a rectangular plate

4. Cover the entire setup with a cylindrical volume or any other volume that is considerably larger than our setup.
5. The antenna formulated as a result of this procedure is the "Hairpin Monopole Antenna".

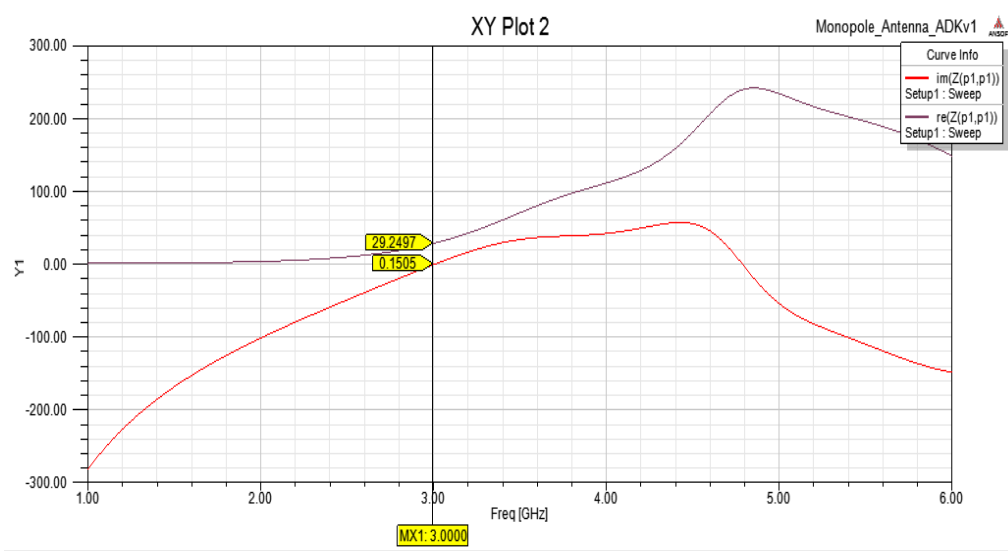


Results from the Analysis of Coaxial Cable –

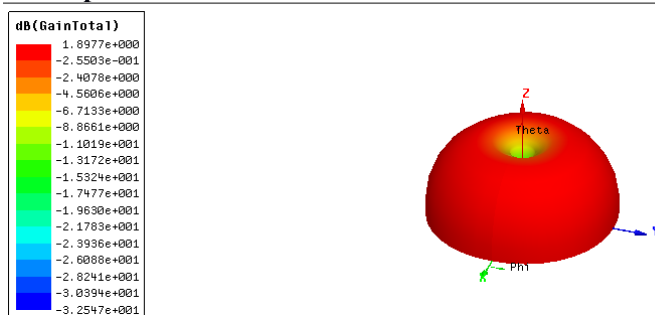


Results From The Analysis Of Hairpin Monopole Antenna

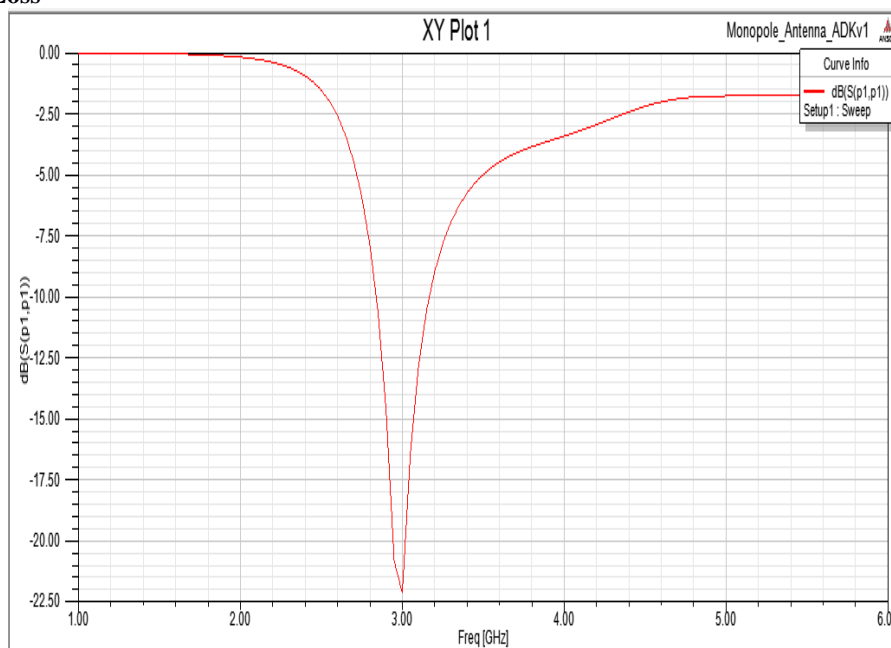
1. Impedance curve



2. 3-D Polar plot



3. Return Loss



II. CONCLUSION

From the visual representation and models developed in this paper, we can safely conclude that:

1. It is possible to analyze and design a hairpin monopole antenna on HFSS Software.
2. The results obtained for the hairpin monopole antenna are very similar to that of a traditional monopole antenna.
1. Balanis, Constantine A., "Antenna Theory Analysis and Design", John Wiley & Sons, 3rd Edition, USA (2005), pg.151.
2. Ramo, Simon, Whinnery, John R., Duzer, Theodore Van, "Fields and Waves in Communication Electronics", , John Wiley & Sons, 3rd Edition, Canada (1994).

3. The graph for return loss, radiation pattern and other results were obtained and analyzed.
4. The characteristic impedance of the coaxial cable is very similar to that of a normal coaxial cable. This implies that the result is correct.

REFERENCES

- [1]. Saunders, Simon R., Zavala, Alejandro Aragon, "Antennas and Propagation for Wireless Communication Systems", John Wiley & Sons, 2nd Edition, England (2007), pg. 73.
- [2]. Balanis, Constantine A., "Antenna Theory Analysis and Design", John Wiley & Sons, 3rd Edition, USA (2005), pg. 182 .

- [3]. Parminder Singh, Ankita Sharma, Neha Uniyal, Richa Kala, "Half-Wave Dipole Antenna for GSM Applications", *International Journal of Advanced Computer Research* (ISSN (print): 2249-7277 ISSN (online): 2277-7970), Volume-2 Number-4 Issue-6 December-2012 .
- [4]. Balanis, Constantine A., "Antenna Theory Analysis and Design", John Wiley & Sons, 3rd Edition, USA (2005), pg. 34-35.
- [5]. Saunders, Simon R., Zavala, Alejandro Aragon, "Antennas and Propagation for Wireless Communication Systems", John Wiley & Sons, 2nd Edition, England (2007), pg. 77.
- [6]. R. M. Black, *The History of Electric Wires and Cables*, Peter Pergrinus, London 1983 .
- [7]. BICC Cables Ltd, "Electric Cables Handbook", WileyBlackwell; London 3rd Edition 1997.
- [8]. Martin J. Van Der Burgt et al, "High-Definition Cabling and Return Loss", Belden Electronics Division, 2001.
- [9]. Yidong Xu, Lili Guo, Wei Xue, Korochentsev Vladimir, and Junwei Qi, "An Optimal Electric Dipole Antenna Model and Its Field Propagation", College of Information and Communication Engineering, Harbin Engineering University, Harbin, China, 2016.
- [10]. ANSOFT CORPORATION, "user's guide – High Frequency Structure Simulator", 2006.

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