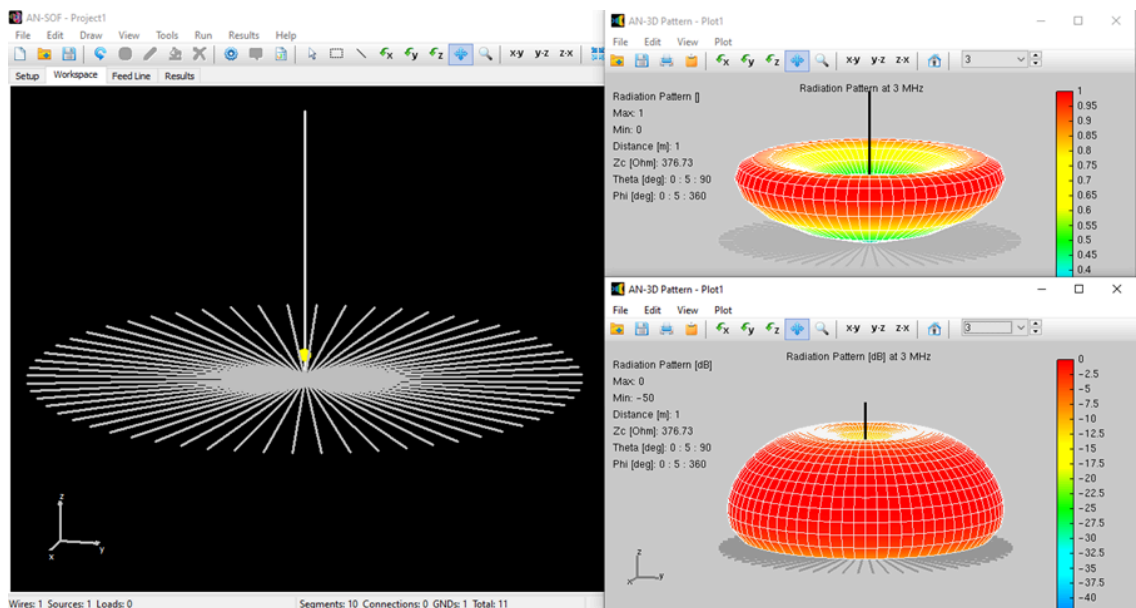


Monopole Antennas Over Imperfect Ground: Modeling and Analysis with AN-SOF

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Explore the design and simulation of monopole antennas over imperfect ground using AN-SOF. Learn how ground conditions impact performance and optimize efficiency for LF/MF broadcasting applications.



Introduction

A **monopole antenna** is a class of radio antenna consisting of **a single radiating element**, typically mounted vertically over **a conductive ground plane**. It is one of the simplest and most widely used antenna designs, particularly in applications where space and simplicity are critical. The monopole can be thought of as **half of a dipole antenna**: by introducing a ground plane, one of the dipole's two radiating elements is effectively replaced by the ground plane's mirror image, creating a virtual "second leg." This results in a structure that is electrically equivalent to a dipole but requires only half the physical height, making monopoles particularly advantageous for low-frequency and compact installations.

Monopole antennas are commonly used in a variety of applications, including AM/FM broadcasting, LF (Low Frequency) and MF (Medium Frequency) communication systems, mobile and base station antennas, and amateur radio setups. Their omnidirectional radiation pattern in the horizontal plane makes them ideal for broadcasting and communication over wide areas. However, their performance is highly dependent on the quality of the ground plane, as losses in the

ground can significantly reduce efficiency and gain. In this article, we will simulate a monopole antenna in the form of a **radio mast operating over imperfect ground**, typical of LF and MF broadcasting scenarios. We will explore the impact of ground conditions on antenna performance and demonstrate how to optimize the design for improved efficiency.

Step 1 | Setup

Navigate to the **Setup** tab and set the operating frequency to **3 MHz** in the **Frequency panel**. Next, go to the **Environment** panel > **Ground Plane** box and select the **Real** option, as shown in **Fig. 1**. Choose the **Radial wire ground screen** and **Poor ground** options. Note that the soil conductivity will automatically be set to **0.001 S/m** and the relative permittivity (dielectric constant) to **5**.

Finally, configure the number of radials, their length, and their radius as illustrated in **Fig. 1**. For radio masts, it is common practice to use a constant input power as a reference, such as **1 kW**. Proceed to the **Excitation panel**, select **Discrete Sources**, then choose **Set Input Power** and enter **1,000 W**, as shown in **Fig. 2**.

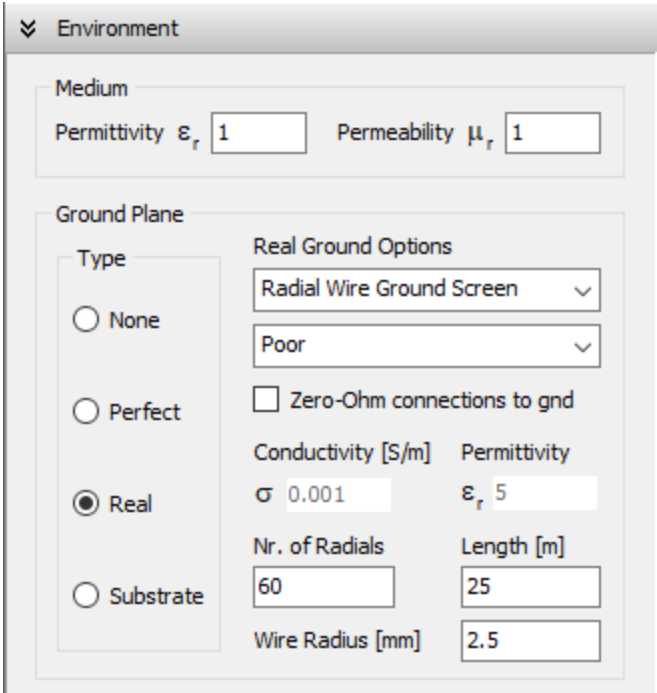


Fig. 1: Configuring a radial wire ground screen in the Environment panel of AN-SOF.

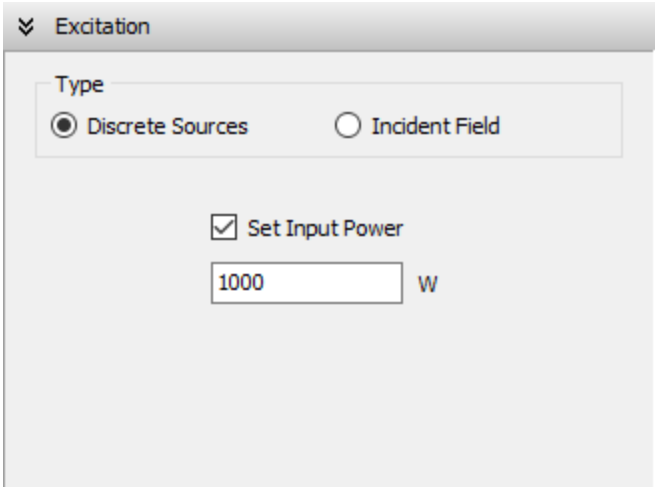


Fig. 2: Configuring discrete sources in the Excitation panel with an input power of 1,000 W.

Step 2 | Draw

Right-click on the workspace and select **Line** from the **pop-up menu**. Specify a vertical wire with a height of **25 meters** (equivalent to 1/4 wavelength at 3 MHz) and a triangular cross-section, as illustrated in **Fig. 3**. Although the recommended minimum number of segments is **3**, we will divide the wire into **10 segments** to achieve higher resolution in the current distribution. Note that the wire will automatically be connected to the ground at the origin **(0, 0, 0)**.

Next, right-click on the wire and select the **Source/Load** command from the pop-up menu. Place a voltage source on the first segment to ensure the source is connected to the base of the mast. For further details, refer to the **Adding Sources** section.

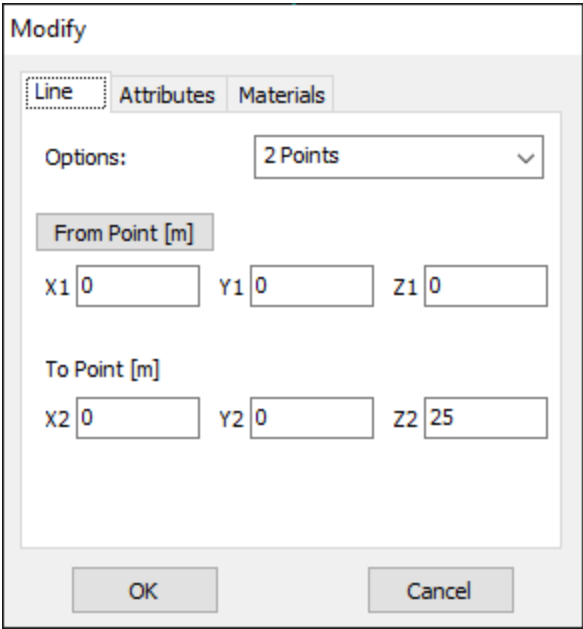


Fig. 3(a): Defining a vertical wire in the Line configuration page.

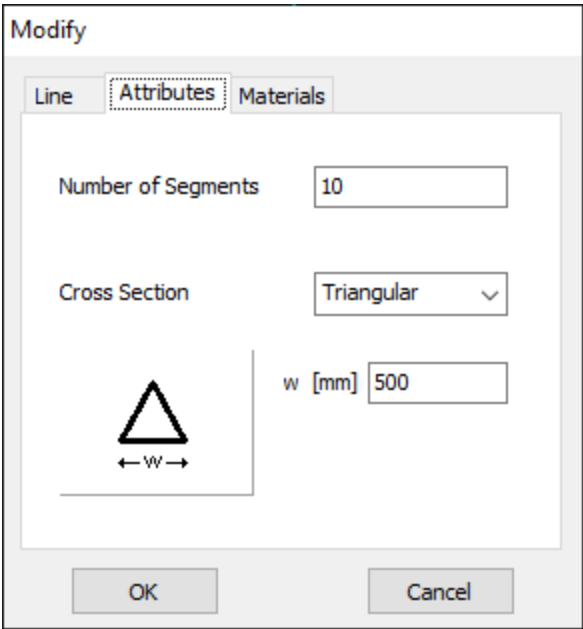


Fig. 3(b): Configuring a triangular cross-section in the Attributes page.

Step 3 | Run

Click on the **Run Currents and Far-Field (F11)** button located on the toolbar. Once the calculations are complete, click on the **Far-Field 3D Plot** button on the toolbar to display the radiation pattern. In the **AN-3D Pattern** window, select **Radiation Pattern** from the **Plot** menu to generate the normalized radiation pattern (dimensionless). Then, choose the **Radiation Pattern [dB]** option to view the pattern in decibel scale. Note that the far field exhibits a null on the **xy-plane** due to losses in the ground plane, as shown in **Fig. 4**.

The antenna efficiency is defined as the ratio of radiated power to input power. Navigate to the **Results tab** to view key parameters such as input impedance, VSWR, directivity, gain, and efficiency, as illustrated in **Fig. 5**. You will observe that the efficiency is relatively low, which consequently results in low gain, as a significant portion of the input power is dissipated in the ground. In this example, we have intentionally chosen a **Poor soil** condition. To improve antenna efficiency, experiment with different soil types, increase the number of radial wires, and adjust their lengths.

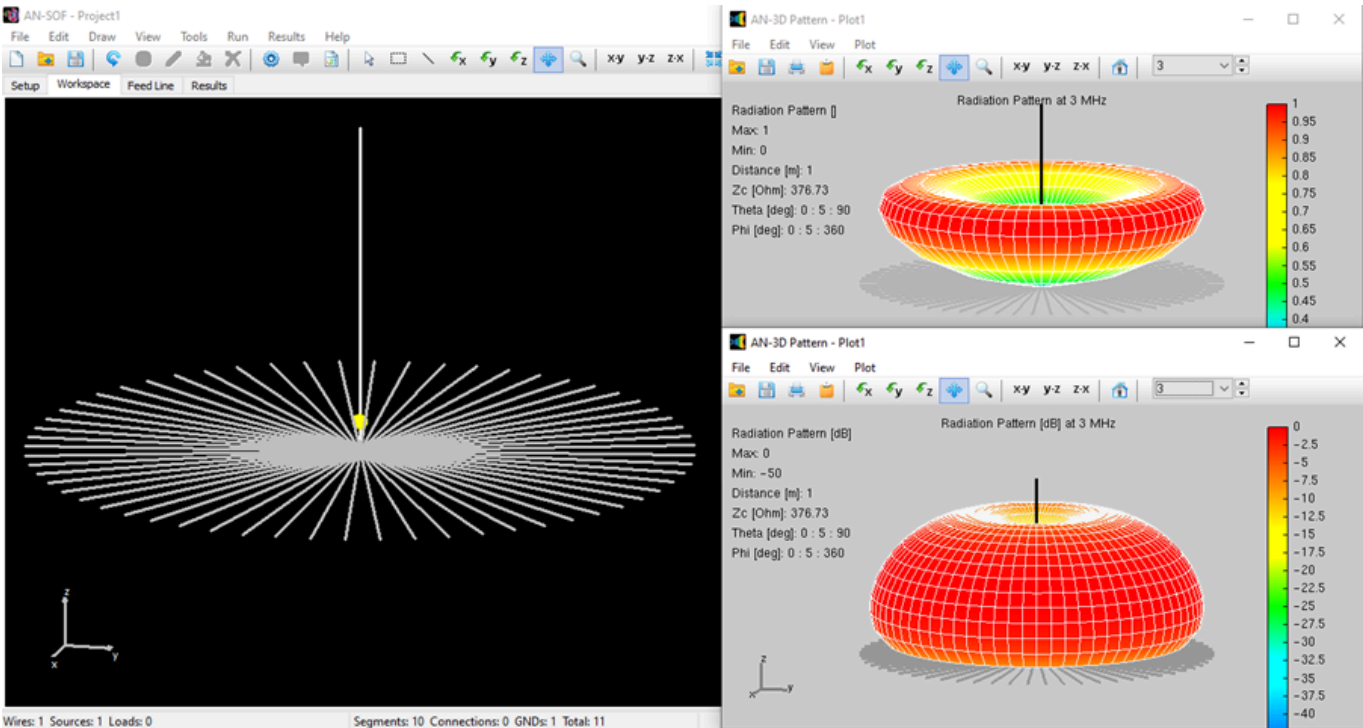


Fig. 4: Quarter-wave monopole antenna model (left) with its 3D radiation pattern: linear scale (top right) and decibel scale (bottom right), simulated using AN-SOF.

Download Model

Setup	Workspace	Tuner	Feeder	Results	Plots	Models			
No.	Freq.	Rin	Xin	VSWR	S11	Dir.	Gain	Eff.	
---	MHz	Ohm	Ohm	---	dB	dBi	dBi	%	
1	3	52.2053	30.0022	1.78716	-10.982	5.19411	-2.71064	16.2004	

Fig. 5: Results tab displaying input impedance and radiation parameters for the quarter-wave monopole antenna over a radial wire ground screen.

Conclusion

Simulating monopole antennas using the **AN-SOF Antenna Simulator** offers significant advantages for engineers and designers. By leveraging its advanced modeling capabilities, users can accurately predict antenna performance, optimize

designs, and evaluate the impact of various ground conditions without the need for costly and time-consuming physical prototypes.

The ability to analyze parameters such as radiation patterns, input impedance, gain, and efficiency provides invaluable insights, enabling the development of high-performance monopole antennas tailored to specific applications.

Whether you’re designing for LF/MF broadcasting, mobile communications, or amateur radio, AN-SOF empowers you to explore design trade-offs and achieve optimal results with precision and efficiency.

See Also:

- [Modeling a Center-Fed Cylindrical Antenna with AN-SOF](#)
- [An Efficient Approach to Simulating Radiating Towers for Broadcasting Applications](#)

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About the Author
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ANTENNA SIMULATION ENGINEER & PHYSICS PH.D. With over 25 years of experience in Computational Electromagnetics, I’m a dedicated researcher specializing in antenna modeling and design. As the founder of Golden Engineering LLC, I develop intuitive yet powerful simulation tools to help RF engineers optimize designs, educators demonstrate concepts, and hobbyists bring antenna projects to life.

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