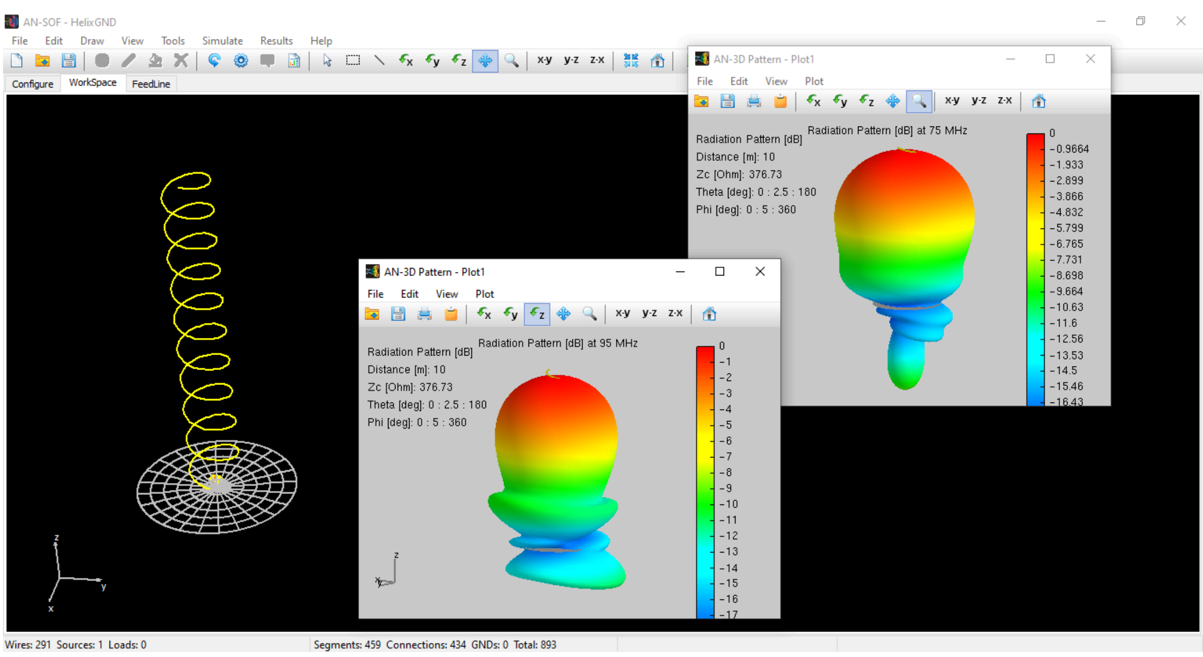
Simulating Helical Antennas over Finite Wire-Grid Ground Planes

Learn how to simulate axial-mode helical antennas using AN-SOF. This study analyzes LHCP gain, impedance, and axial ratio over a finite wire-grid ground plane from 75 to 95 MHz.



Introduction

The axial-mode helical antenna is a premier choice for applications requiring circular polarization and high directivity, such as satellite tracking and long-range VHF/UHF communications. Unlike the **normal-mode helix**, which radiates omnidirectionally, the **axial-mode helix** acts as a high-gain end-fire radiator. In this article, we analyze a **Left-Handed (LH)** helix design simulated in **AN-SOF**, focusing on the broadband stability of gain and the impact of a finite wire-grid ground plane.

Design Parameters & Geometry

The antenna was modeled to operate across the 75–95 MHz band. A critical aspect of helical simulation is the discretization of the curved conductor. By using AN-SOF's **Conformal Method of Moments (CMoM)**, we achieve superior numerical convergence compared to standard piecewise-linear approximations.

Helix Specifications:

- **Handedness:** Left-Handed (LH)

- **Radius:** $0.477\ \mathrm{m}$ (Diameter: $D = 0.954\ \mathrm{m}$)
- **Pitch:** $S = 0.692\ \mathrm{m}$
- **Number of Turns:** $N = 10$
- **Pitch Angle:** $\alpha = \tan^{-1}(S/(\pi D)) \approx 13^\circ$
- **Total Height:** $H = N \cdot S = 6.92\ \mathrm{m}$ (**Fig. 1**)

The helix is discretized into 120 segments (12 per turn), ensuring that segment length is significantly smaller than $\lambda/10$ even at the highest frequency (95 MHz), satisfying the CMoM requirements.

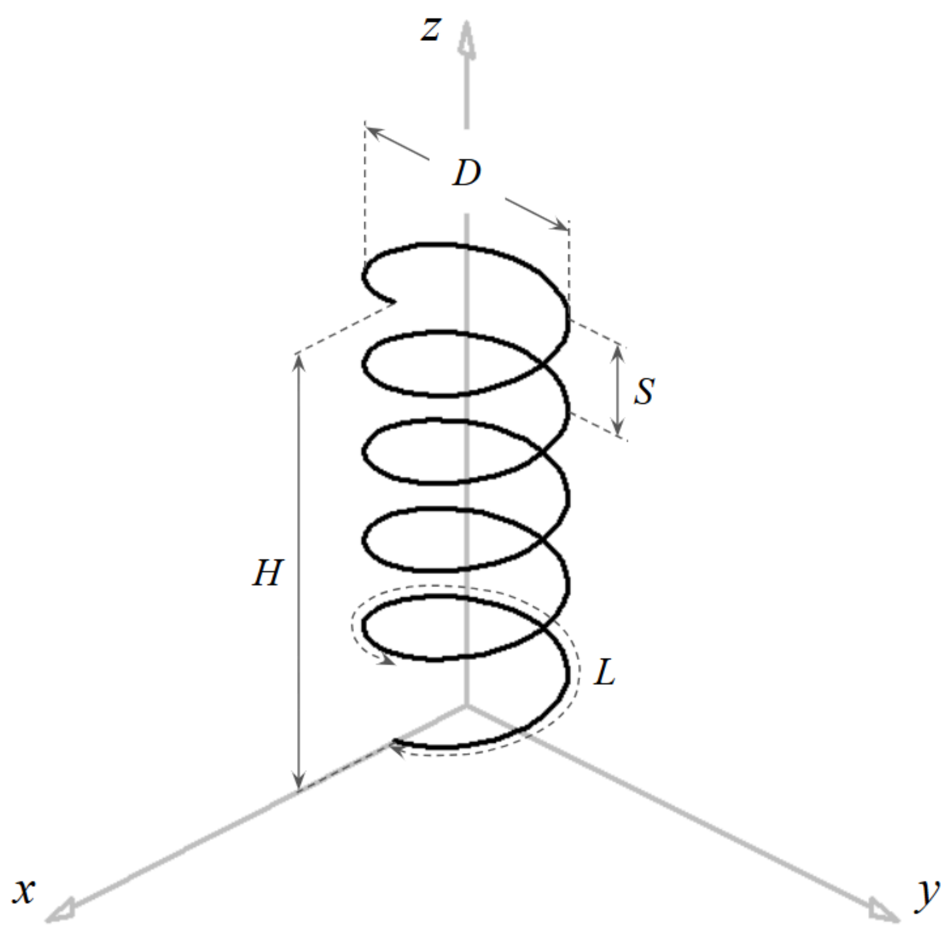


Fig. 1: A helix indicating key geometric parameters.

Ground Plane Modeling: The Wire Grid Approach

To simulate a realistic finite environment, a **circular ground plane** with a radius of $1.5\ \mathrm{m}$ was implemented (**Fig. 2**). In Method of Moments (MoM) solvers, solid surfaces are effectively modeled as a mesh of wires. We utilized a circular grid divided into:

- **Radial Divisions:** 6
- **Circumferential Divisions:** 24

This 6×24 facet configuration provides a robust reflective surface that correctly captures the edge diffraction effects that a simple infinite-plane mathematical model would ignore.

To download the complete helix model, click the button located beneath **Fig. 2**.

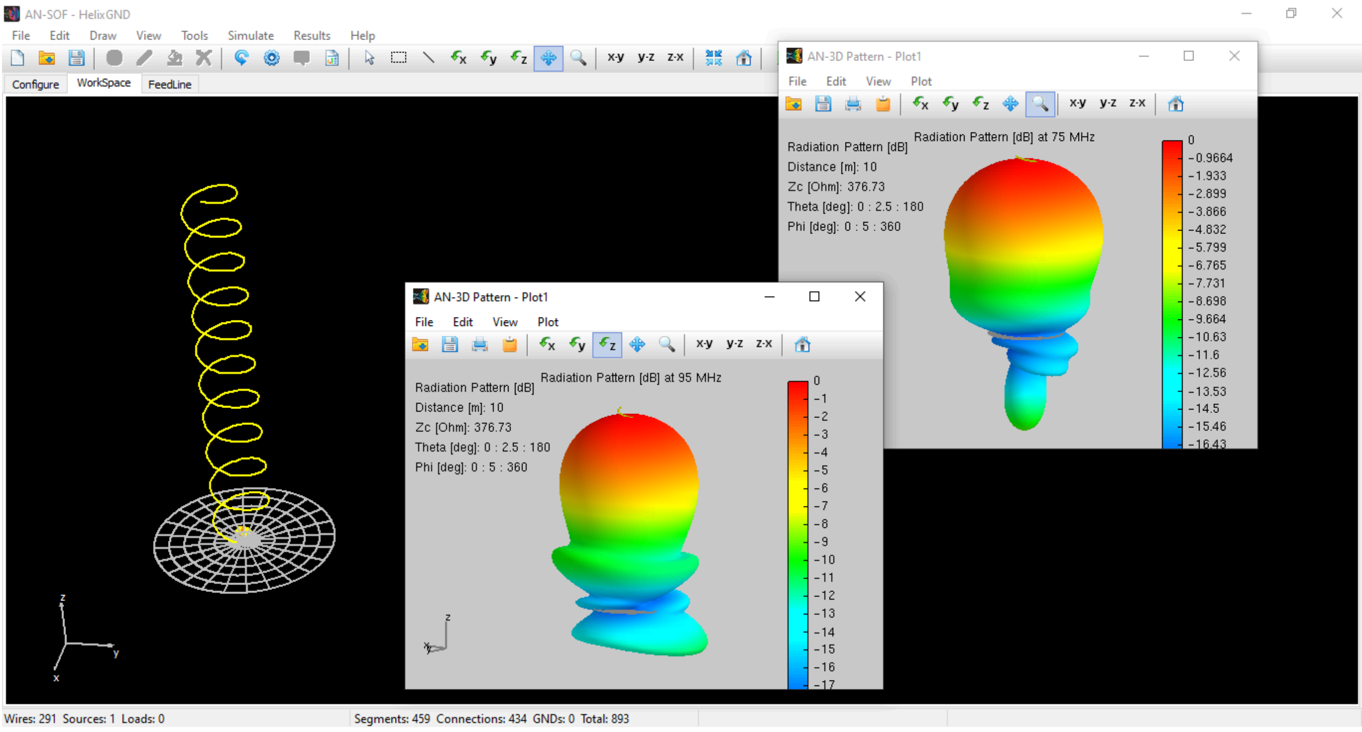


Fig. 2: *AN-SOF model of the Left-Hand Circularly Polarized (LHCP) axial mode helix antenna and its corresponding radiation patterns.*

Download Model

Simulation Results & Analysis

1. Radiation Pattern and Gain

The simulation confirms a stable, directional main lobe pointing along the helix axis (opposite the ground plane, **Fig. 3**). The gain remains remarkably constant at approximately 10 dBi across the entire 20 MHz bandwidth.

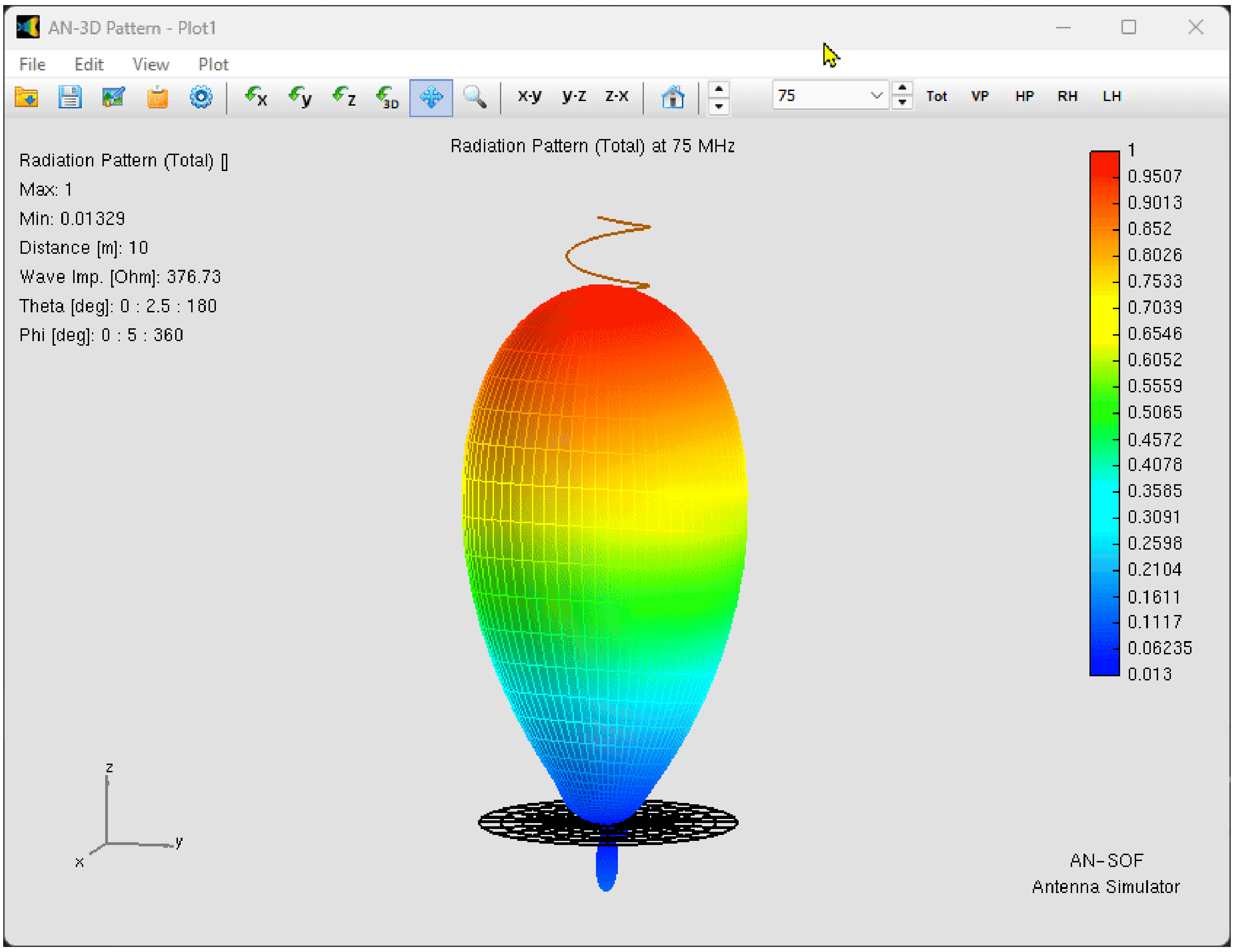


***Fig. 3**: Variation of the radiation pattern (linear scale) with changing frequency for the LHCP helix antenna. The buttons located at the top right of the window enable switching between the LH and RH components for detailed polarization analysis.*

The **Front-to-Back (F/B) ratio** varies between 10 and $16\ \mathrm{dB}$ (**Fig. 4**). This variation is primarily due to the finite size of the ground plane; at $75\ \mathrm{MHz}$, the $1.5\ \mathrm{m}$ radius ground plane is roughly 0.37λ, meaning surface currents reaching the edges contribute to back-lobe radiation.

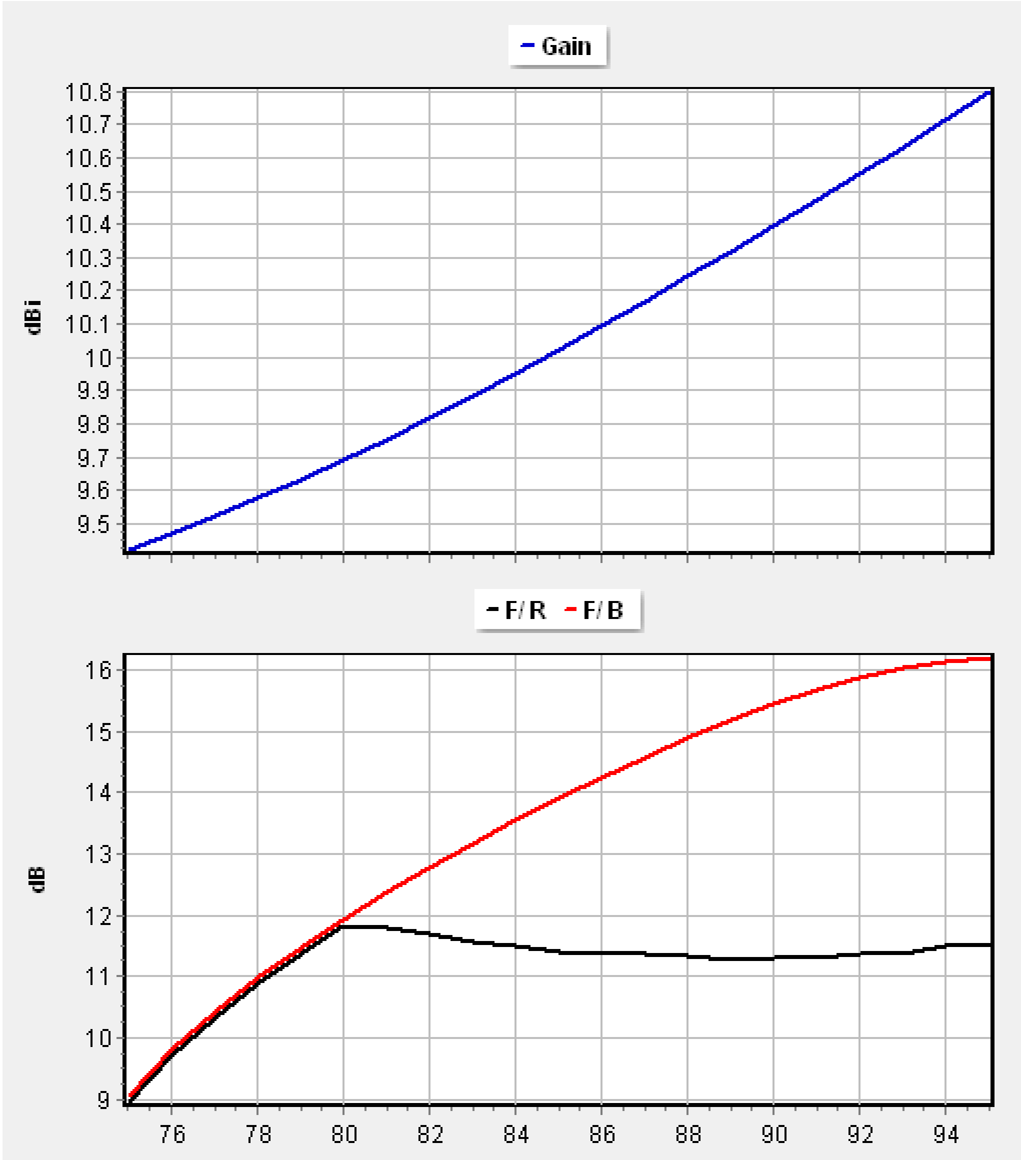


Fig. 4: Gain in dBi (top) and the Front-to-Rear (F/R, black line) and Front-to-Back (F/B, red line) ratio of the helix antenna plotted as a function of frequency in MHz.

2. Polarization Purity

As a left-handed helix, the antenna produces **Left-Hand Circular Polarization (LHCP)**. The Axial Ratio $(|AR|)$ is a critical metric for polarization purity, where 1.0 represents a perfect circle.

- **Observed $|AR|$:** 0.9 to 0.95 (**Fig. 5**)

This high purity indicates that the phase quadrature between the horizontal and vertical components of the radiated field is well-maintained, a direct result of the optimized 13° pitch angle.

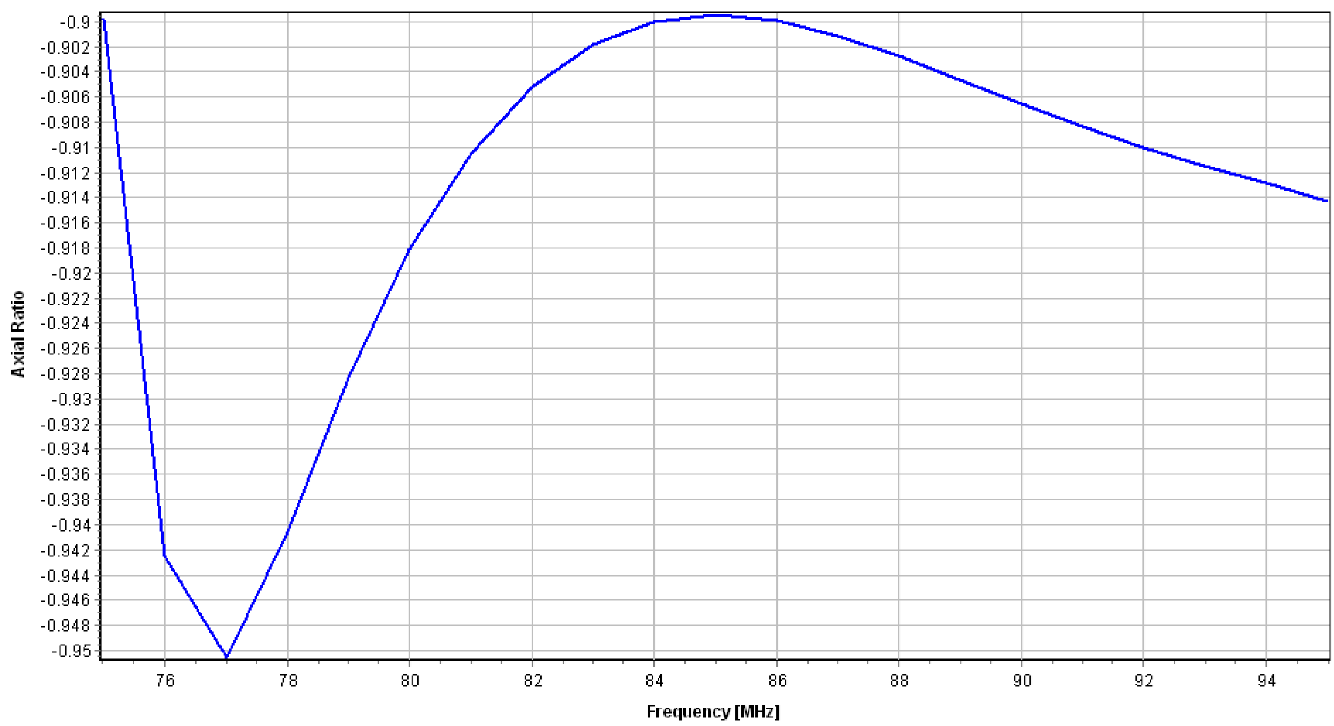


Fig. 5: Axial ratio of the LHCP helix antenna along its axis, showing LH polarization (indicated by the negative sign).

3. Input Impedance

The input impedance of an axial-mode helix is typically high and primarily resistive. For this model, AN-SOF calculated:

$$Z_{in} = (200 \text{ to } 280) + j(50 \text{ to } 80)\,\Omega$$

The significant real part ($> 200\,\Omega$) is characteristic of the axial mode (**Fig. 6**). To interface this with standard $50\,\Omega$ coaxial systems, a matching network is required, such as a $\lambda/4$ transformer or a tapered microstrip transition at the feed point.

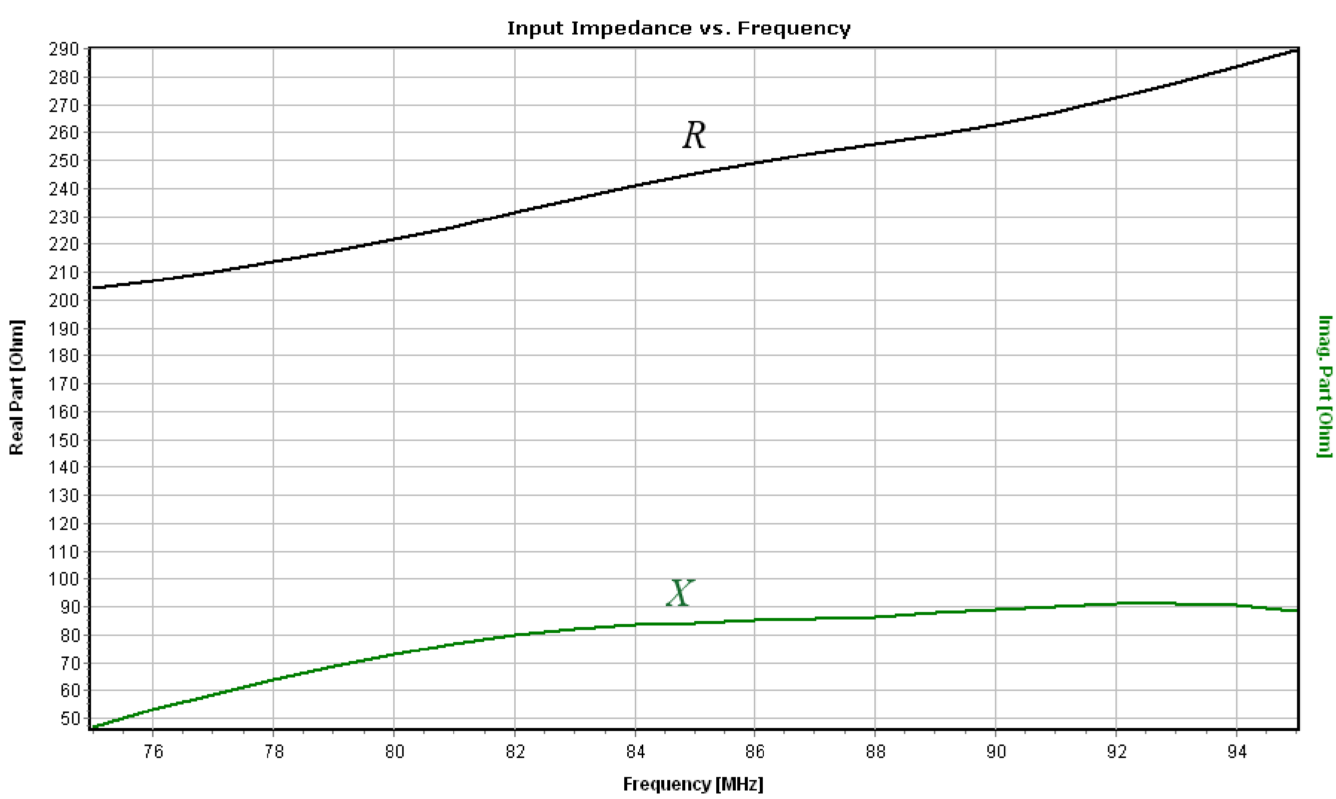


Fig. 6: Input impedance versus frequency for the Left-Hand Circularly Polarized (LHCP) helix antenna.

Conclusion

This AN-SOF model demonstrates the classic broadband characteristics of the axial-mode helical antenna. The stability of the gain and the axial ratio across the 75–95 MHz range highlights the antenna's relative immunity to minor frequency shifts. For engineers, the high input impedance remains the primary design challenge, requiring careful attention to the feedpoint geometry to ensure maximum power transfer.

See Also:

- **Modeling Helix Antennas in Axial Radiation Mode Using AN-SOF**
- **Efficient NOAA Satellite Signal Reception with the Quadrifilar Helix Antenna**

Technical Keywords: LHCP (Left-Hand Circular Polarization), Axial Ratio (AR), Finite Ground Plane Modeling, Method of Moments (MoM), 85 MHz Helix Design.

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