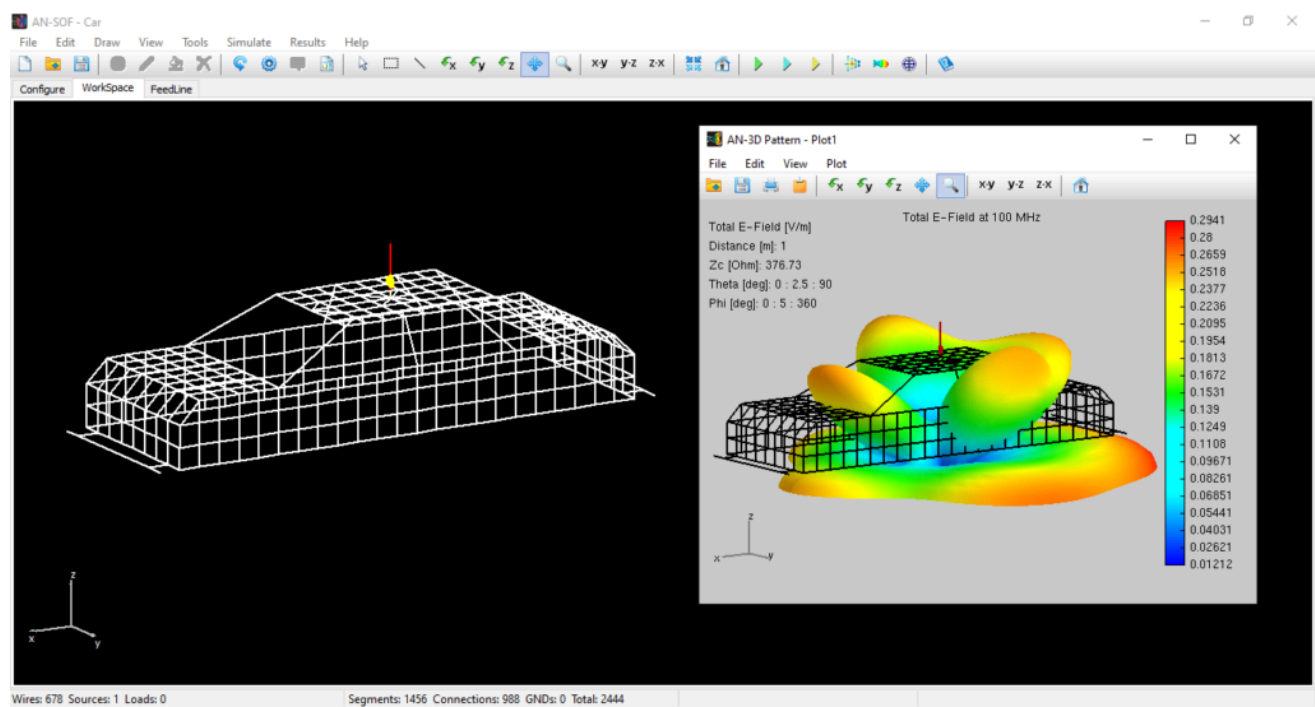


Automotive Antenna Placement: How Vehicle Geometry Reshapes FM Reception

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Is your car antenna truly omnidirectional? Discover how vehicle geometry reshapes FM signals in this AN-SOF study of a 100 MHz monopole. We compare roof-mount and trunk-mount placements, revealing how induced surface currents and body diffraction create unexpected directional gain and reception bias.



Introduction: The Vehicle as a Radiator

In automotive engineering, the location of an antenna is often a compromise between aesthetics, aerodynamics, and RF performance. However, at FM frequencies (88–108 MHz), a vehicle is not just a mounting bracket; it is a complex electromagnetic scatterer. When a vertical monopole is mounted on a car, the metallic body supports induced surface currents that contribute significantly to the total far-field radiation pattern.

This article analyzes a 19.6-inch vertical monopole integrated into an average sedan (184" x 64" x 40") modeled at **100 MHz**. Using [AN-SOF's wire-grid modeling](#), we demonstrate how the physical "ground plane" of the car body tilts, focuses, and diffracts the signal, leading to surprisingly directional results.

Simulation Methodology & Setup

To isolate the interaction between the antenna and the vehicle body, the following parameters were used:

- **Platform:** A wire-grid representation of a sedan’s external metallic surface.
- **Ground Environment:** A **Perfect Electrical Conductor (PEC)** ground plane situated 16 inches below the vehicle.
- **The “Near-Far” Perspective:** By using a PEC ground, we eliminate ground-wave attenuation variables, allowing the far-field pattern to represent the **Transverse Electromagnetic (TEM) field distribution** in the intermediate zone, far enough to be beyond reactive near-fields, but close enough to visualize how the car’s shape “sculpts” the signal.
- **Excitation:** A **1-volt source** at the base of the monopole.

Case 1: The Roof-Mounted Monopole

The center of the roof is often considered the “ideal” location due to its height and relative symmetry. However, our AN-SOF simulation reveals a more complex reality.

Observations:

- **Peak Gain:** 8.2 dBi.
- **Directivity:** The pattern is predominantly **rearward-facing (Fig. 1)**.
- **Physics of the Pattern:** At 100 MHz, the roof acts as a finite ground plane. The currents induced on the roof and the sloping rear window (C-pillar area) create a directive effect. The “tilt” of the car’s profile from the roof down to the trunk acts as a quasi-tapered transition, reinforcing the radiation toward the back of the vehicle.

By the **Principle of Reciprocity**, this means a car with a center-roof antenna will inherently exhibit better reception sensitivity to FM stations located behind the vehicle.

Figure 1 shows the car model with the roof monopole antenna in the AN-SOF workspace, along with the 3D gain pattern. The model can be downloaded via the button below the figure.

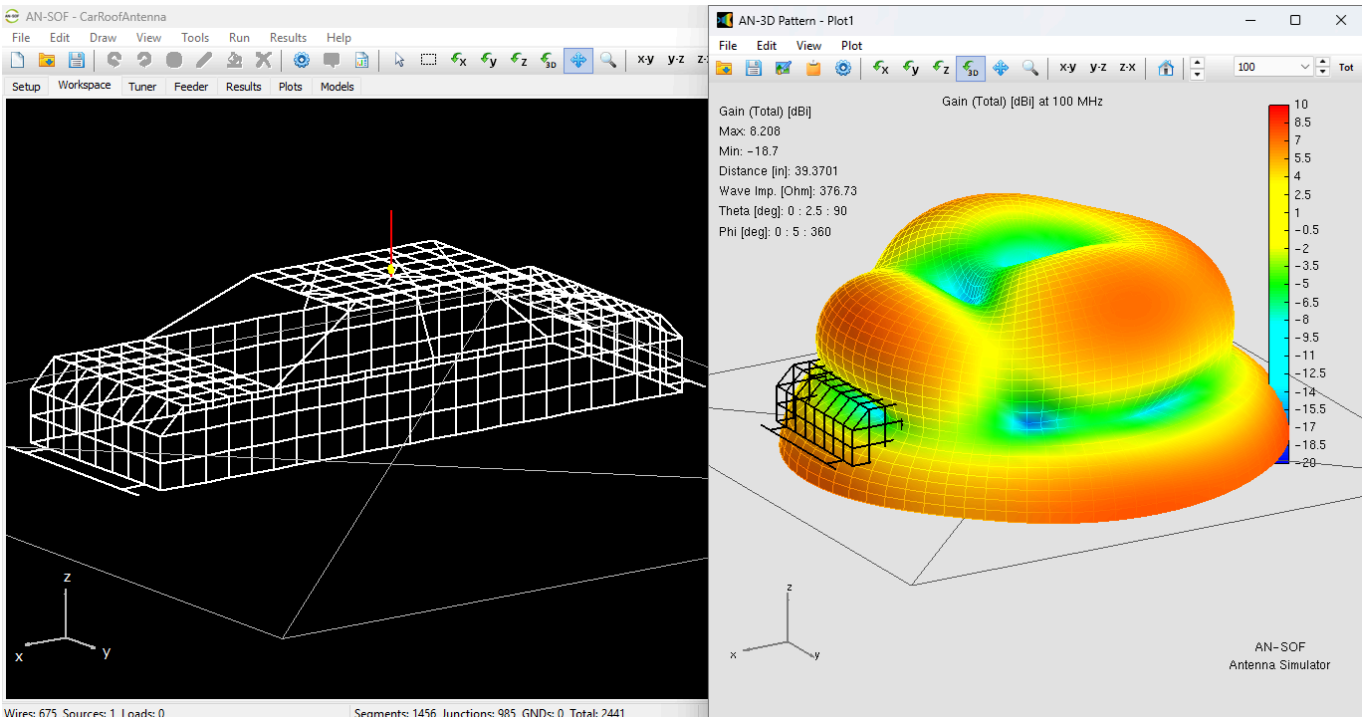


Fig. 1: Calculated gain pattern of an FM antenna (vertical monopole) mounted on the roof of a car, modeled in AN-SOF.

[Download Model](#)

Case 2: The Trunk-Mounted Monopole

Moving the antenna to the center of the trunk yields a surprising reversal of the radiation characteristics.

Observations:

- **Peak Gain:** 6.6 dBi.
- **Directivity:** The pattern points preferentially **toward the front** of the vehicle (**Fig. 2**).
- **Physics of the Pattern:** When placed on the trunk, the most significant “obstacle” is the rest of the car’s body (the cabin and engine block). The vertical bulk of the cabin acts similarly to a parasitic ‘director’ element in a **Yagi-Uda array**, diffracting energy over the roof and toward the front. The lower gain (6.6 dBi vs 8.2 dBi) is due to the increased shadowing and multi-path interaction with the car’s pillars.

The car model, featuring the trunk-mounted monopole antenna, is displayed in the AN-SOF workspace in **Figure 2**, which also includes the 3D gain pattern. A download button for the model is located below the figure.

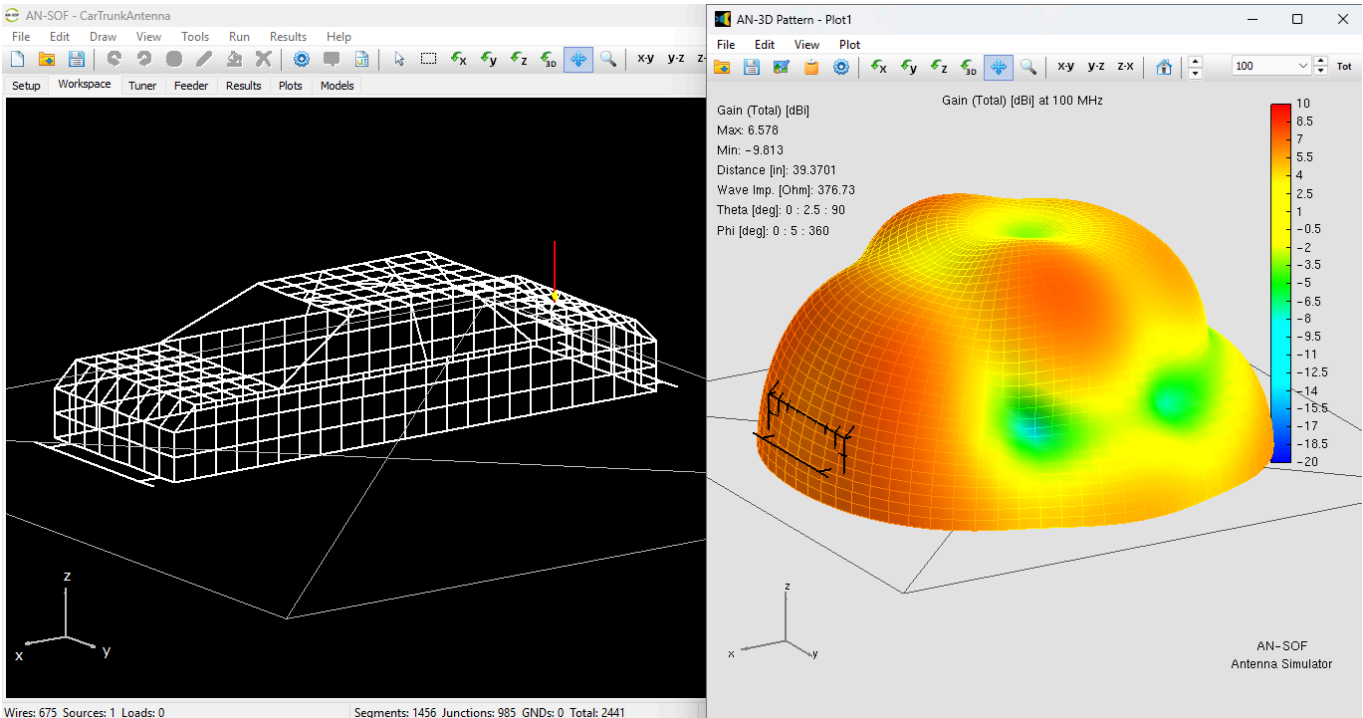


Fig. 2: Calculated gain pattern of an FM antenna (vertical monopole) mounted on the trunk of a car, modeled in AN-SOF.

[Download Model](#)

Comparative Analysis: The Shadowing Effect

Both simulations showed significant **lateral lobes**. These are caused by the width of the vehicle (64 inches $\approx 0.54\lambda$). At this width, the car body supports transverse resonances that “leak” energy to the sides.

The contrast between the two placements highlights a critical rule in automotive CEM: **The bulk of the vehicle mass opposite the antenna often acts as the primary “director” or “reflector” for the signal.**

- **Roof Mount:** Higher gain, better rearward coverage.
- **Trunk Mount:** Lower gain, better forward coverage.

Conclusions

This study proves that “omnidirectional” monopoles become directional the moment they are integrated into a vehicle platform. At FM frequencies, the car body behaves as a resonant cavity and a parasitic radiator.

For the RF designer, these results suggest that:

1. **Diversity is Key:** To achieve true 360-degree FM coverage, modern vehicles often require diversity systems (multiple antennas) to fill the “nulls” created by the vehicle’s body.
2. **Platform Awareness:** Simulation in **AN-SOF** is essential before final hardware placement, as the “geometric center” of a surface rarely correlates to the “electromagnetic center” of the radiation pattern.

See Also:

- [Monopole Antennas Over Imperfect Ground: Modeling and Analysis with AN-SOF](#)
- [Step-by-Step: Modeling Basic Yagi-Uda Arrays for Beginners](#)

Technical Keywords: Automotive CEM, Monopole Antenna, Platform Integration, Wire-Grid Modeling, 100 MHz FM, Far-Field Pattern, Reciprocity.



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