Expecting the Unexpected

Jamming antennas on vehicles

About Alaris Antennas

From its roots in 1990, Alaris Antennas has grown to become a substantial supplier of advanced Electronic Warfare (EW) antennas.

For the global defense and security markets, Alaris Antennas' mission is to deliver high quality antenna Solutions, on time, through technical and service excellence.

We specialize in supplying innovative, customized antennas and related RF product solutions to global RF system integrators.

Alaris Antennas continues to be the trusted and innovative partner to its clients for over two decades.

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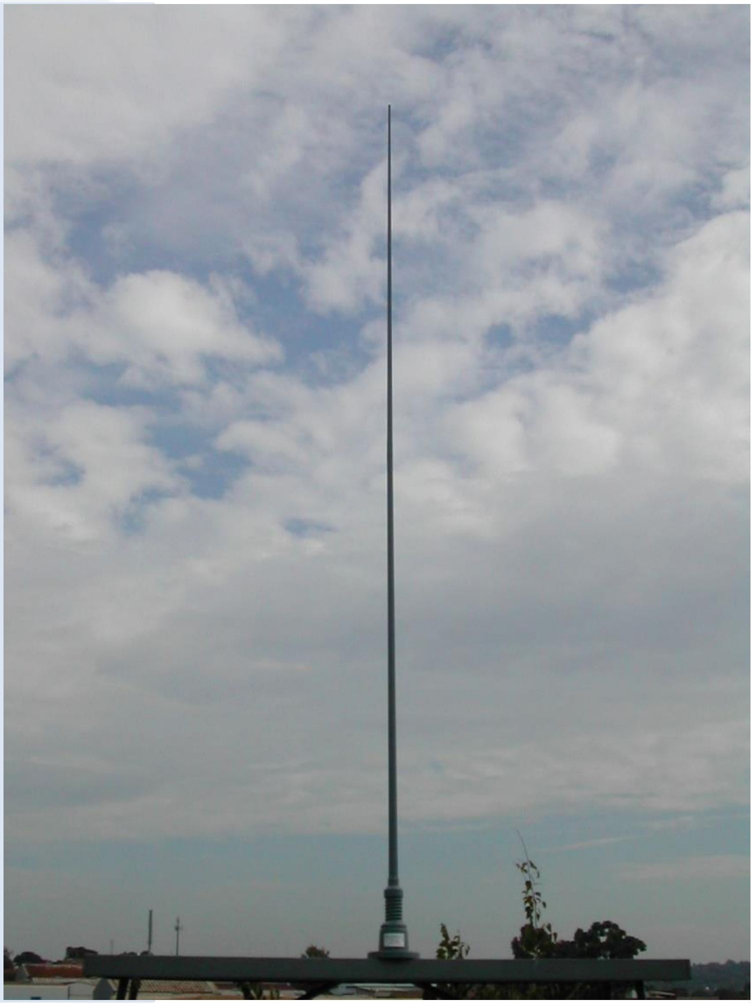


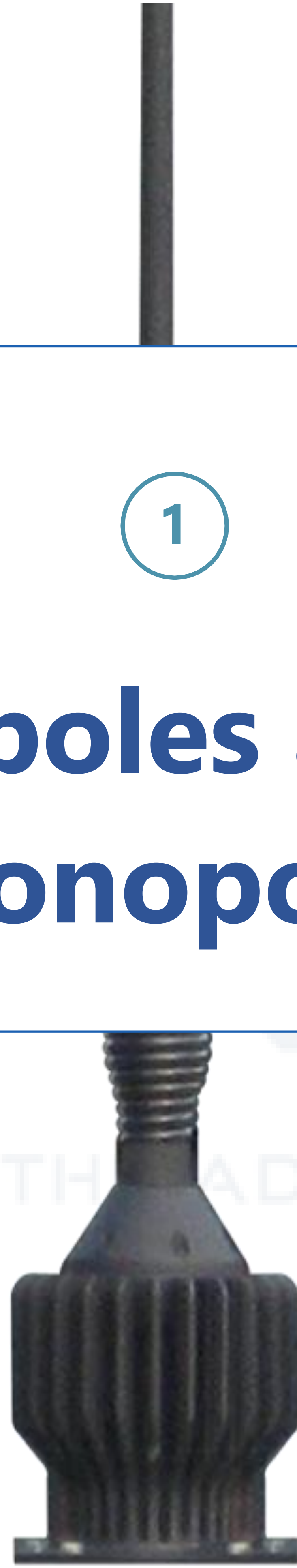
Introduction

Many of the Alaris Antennas products are used in vehicle-based jamming systems, a typical application being the protection of convoys or VIP transport vehicles against remotely triggered improvised explosive devices (IED)s.

Since the performance of the antenna will directly influence the effectivity of the jamming system, choosing the correct antenna and placing it in the correct position is vital.

Unfortunately, antennas tend to be heavily influenced by their environment, and vehicles are especially antenna-unfriendly installation locations.

Let’s discuss a couple of issues that a Systems Engineer might unexpectedly stumble into when placing antennas on a vehicle.



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Dipoles and Monopoles

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There are two major types of antennas that are commonly used on vehicles. The first is a dipole-type antenna that consists of two similar elements which are fed by connecting the “positive” and “negative” terminals to the two respective elements. These antennas do not require a ground plane to work, and they are often said to be “ground-plane independent”, since the ability of the antenna to radiate energy into space is generally unaffected by the presence (or lack thereof) metallic or conducting surfaces below it.

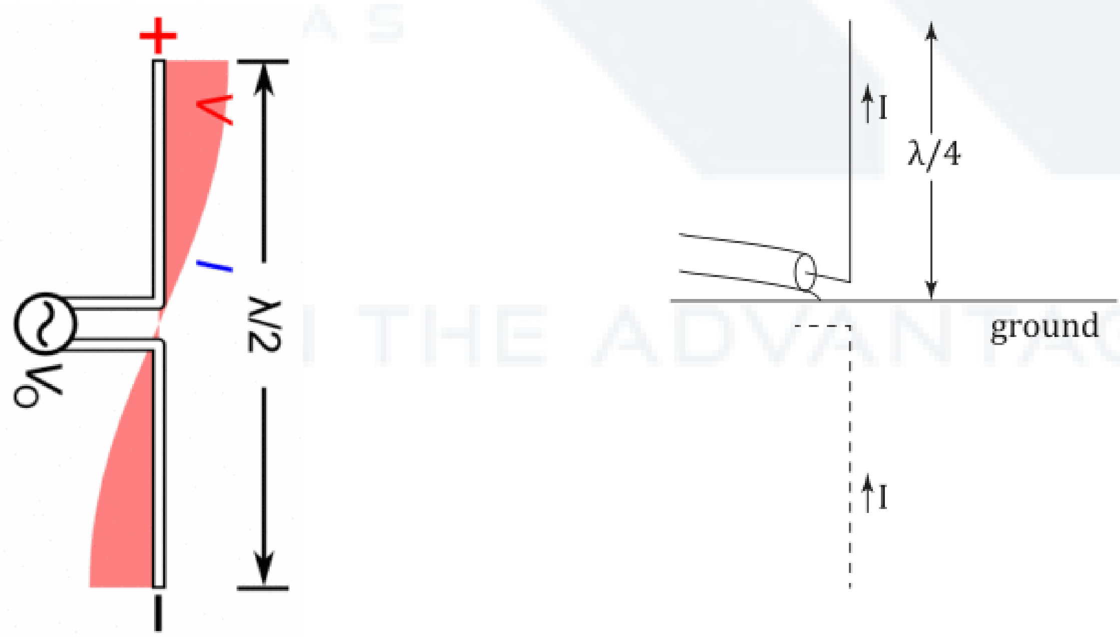

Figure 1. The dipole antenna, on the left, consists of two symmetrical conductors attached to the radio, whereas the monopole antenna (right) has only one conductor over a ground plane that acts as a "mirror".

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The second antenna type used in jamming systems is the monopole antenna. These are highly ground plane dependent, as they are effectively half a dipole with the conducting mounting surface acting like a "mirror" of sorts.

These antennas are mostly used at low frequencies where it is not practical to use full sized dipole antennas.

Monopole-type antennas on a vehicle

Monopole antennas, like the MONO-A0062, are often used at HF frequencies where the wavelengths are 10m or longer, making the vehicle electrically small. By electrically small, we imply that the metallic parts and panels of the vehicle are much smaller compared to the wavelength of the signal, and they can no longer act as a proper ground plane "mirror" for the monopole antenna.

While the too-small ground plane issue is problematic, most System Engineers will already be aware of this and will already consider the higher than advertised VSWR that comes with using a monopole antenna on a small ground plane.

The VSWR, however, is only one part of the equation. Hidden beyond our ability to easily measure, lurks a potentially problematic change to the shape of the radiation pattern.

Monopole antennas will typically have an omni-directional radiation pattern under ideal conditions, and a vehicle installation by no means qualifies as an ideal environment.

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Figure 2. A vehicle with two whip antennas (MONO-A0062) on the front corners of a vehicle being measured. The other antennas on the roof (OMNI-A0281, OMNI-A0266) are all dipole-type antennas.

Above is an example of a monopole antenna that was mounted on the front corner of a large vehicle, and the radiation pattern measured. Instead of the beautiful circular pattern you would expect to measure, there are certain directions that have gain holes as deep as -18dB.

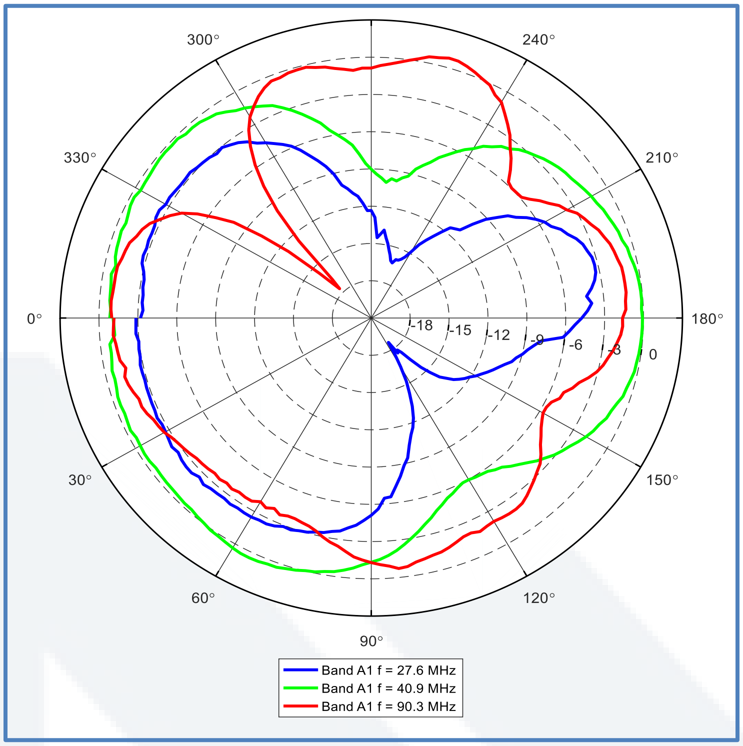

Figure 3. Measured radiation patterns of the MONO-A0062 mounted on the front corner of a large passenger vehicle. Notice the deep gain holes.

To make things even worse, moving the antenna by even a small amount will significantly change the resulting radiation pattern. Even mounting two antennas exactly symmetrical on two sides of the vehicle will not guarantee symmetrical radiation patterns, as it turns out that the quality of the electrical continuity between the metallic panels of the vehicle (among other things) will also influence the final radiation pattern.

This leaves the System Engineer with a major problem in practical applications regarding predicting the range and, consequently, the effectivity of a jamming system. Unfortunately, short of installing and measuring the performance of the system, predicting real-life performance is dubious at best for monopole antennas in the HF band.

Dipole-type antennas on a vehicle

Fortunately, the ability to predict performance improves drastically as the frequency of operation increases. Above roughly 100MHz we can start making use of dipole antennas, such as the OMNI-A0266 or OMNI-A0281, which are not as dependent on the vehicle.

This does not, however, imply that the vehicle has no influence on the radiation pattern. Below, is an example of the measured radiation pattern of an OMNI-A0281 antenna installed on a roof-rack of a Toyota Land-Cruiser (see Figure 2).

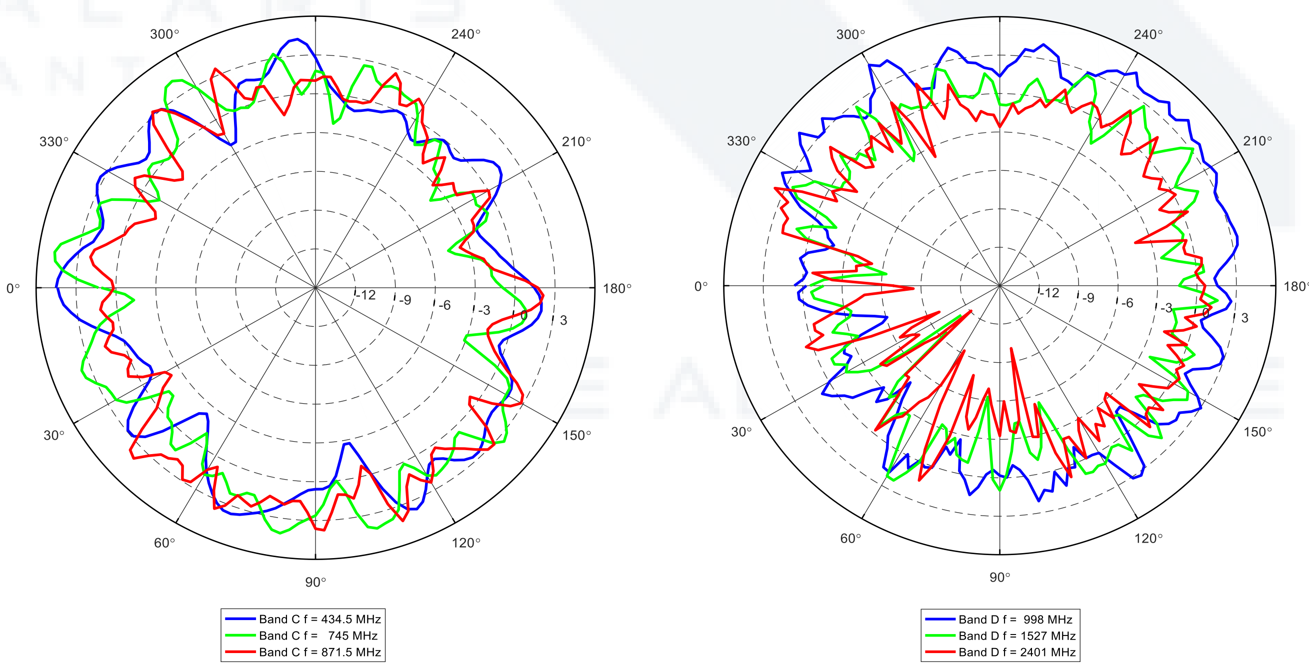

Figure 4. Measured radiation pattern of an OMNI-A0281 antenna on the roof-rack of a Land-Cruiser vehicle.

The radiation pattern is significantly more omni-directional than when compared to the monopole antennas discussed in the previous section, but there can still be significant variations. At higher frequencies, the gain holes can be as deep as -12 dBi or more and change rapidly as you move around the vehicle. It is important to note that this fast-changing pattern is purely due to the signal interacting with the edges of the roof-rack. Other physically large objects on the roof (e.g. gun turrets on military vehicles) will also have a significant influence on the radiation pattern. On a moving vehicle, a rapidly changing radiation pattern will present itself as a rapidly changing E-field at a particular position around the vehicle, for instance, the target to be jammed. The System Engineers will need to take this into account in the design of the system.

On a more positive note, it was found that simulations of complete systems (antennas on the vehicle) tend to agree relatively well with real-life measurements, and simulation studies could assist in identifying major potential problems with antenna placement before building expensive prototypes.

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Conclusion

When placing antennas on a vehicle, keep in mind that the physics and mechanics of the vehicle/antenna system could present you with nasty surprises in the shape of deep nulls and dead zones in the radiation patterns. In many situations, a simulation study could assist in identifying potential problem areas and give insight into the performance of the system.

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