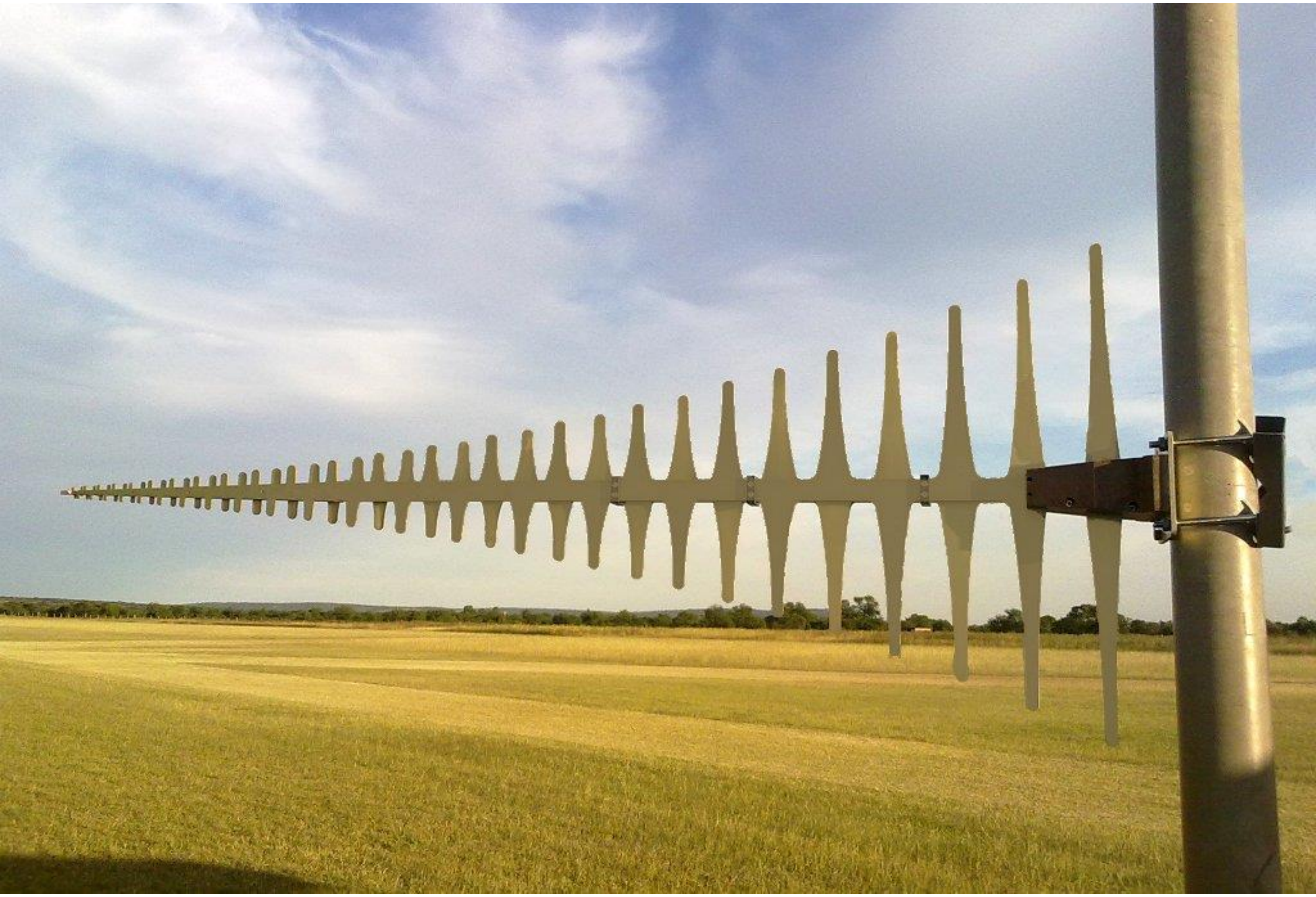

Spacing of multiple LPDAs on a mast

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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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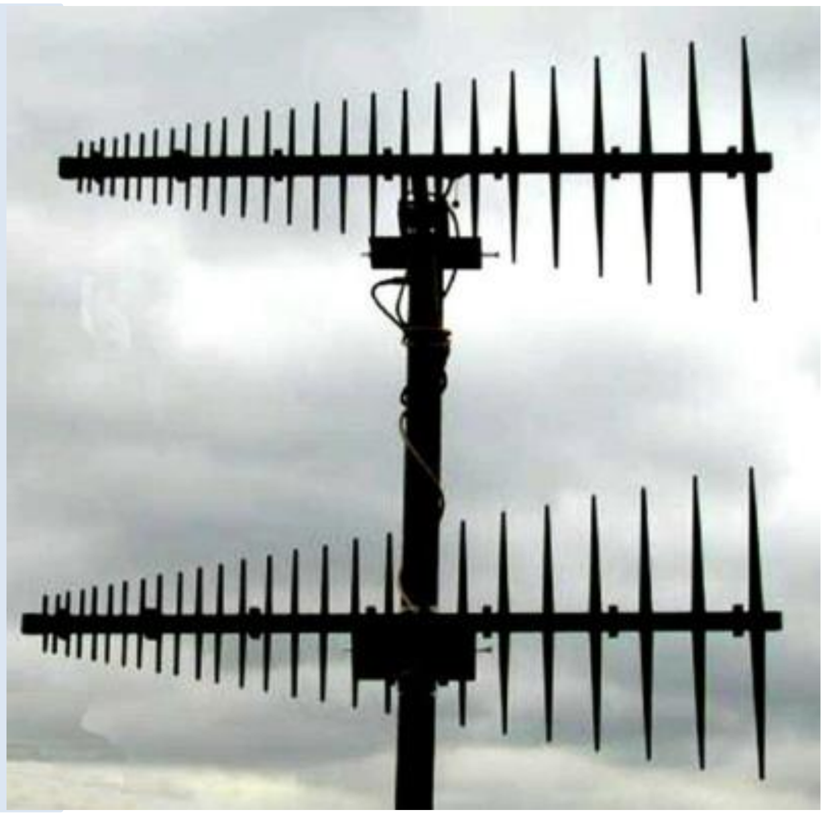

Introduction

One of the questions we often get asked at Alaris Antennas, is the question of spacing between multiple antennas on the same mast. Often, this question is related to situations where the space on the mast is limited (mobile or tactical application) and where high-power transmitters are involved.

Unfortunately, there are no easy formulas that will work in all circumstances, so the answer typically starts off with something along the lines of “it depends”. In addition to distance, there are also several other parameters that complicate the discussion. This answer, obviously, is not all that useful to most clients, so this article will attempt to discuss some guiding principles that Systems Engineers can use to address this problem of spacing antennas on a mast

CHAPTER 01

What is the worst that could happen?

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When two antennas are placed close to each other, they will inevitably couple to each other to some degree. ‘Coupling to each other’ is just a fancy way of saying that whenever one antenna transmits, some of that signal will be received by the other antenna. This stray signal may or may not be a problem, depending on the specific hardware, power of the signal being transmitted, gain of the two antennas, orientation, spacing and many other factors.

A typical example may be where a high power transmit system is on the same mast or shelter as a monitoring system, or where multiple high power transmit antennas (with their associated transmitters) are co-located on the same mast. Typically, any receiver (or transmitter) can only handle so much power coming in from the antenna before being permanently damaged. When dealing with kilowatt-capable amplifiers somewhere in the system, other transmitters or receivers could easily be damaged if the design of the system does not specifically make provision to prevent this.

The first and most important question is thus to determine how much isolation (the inverse of coupling) is really required between the various devices in the system. This will determine, in turn, how much isolation is required between the antennas.

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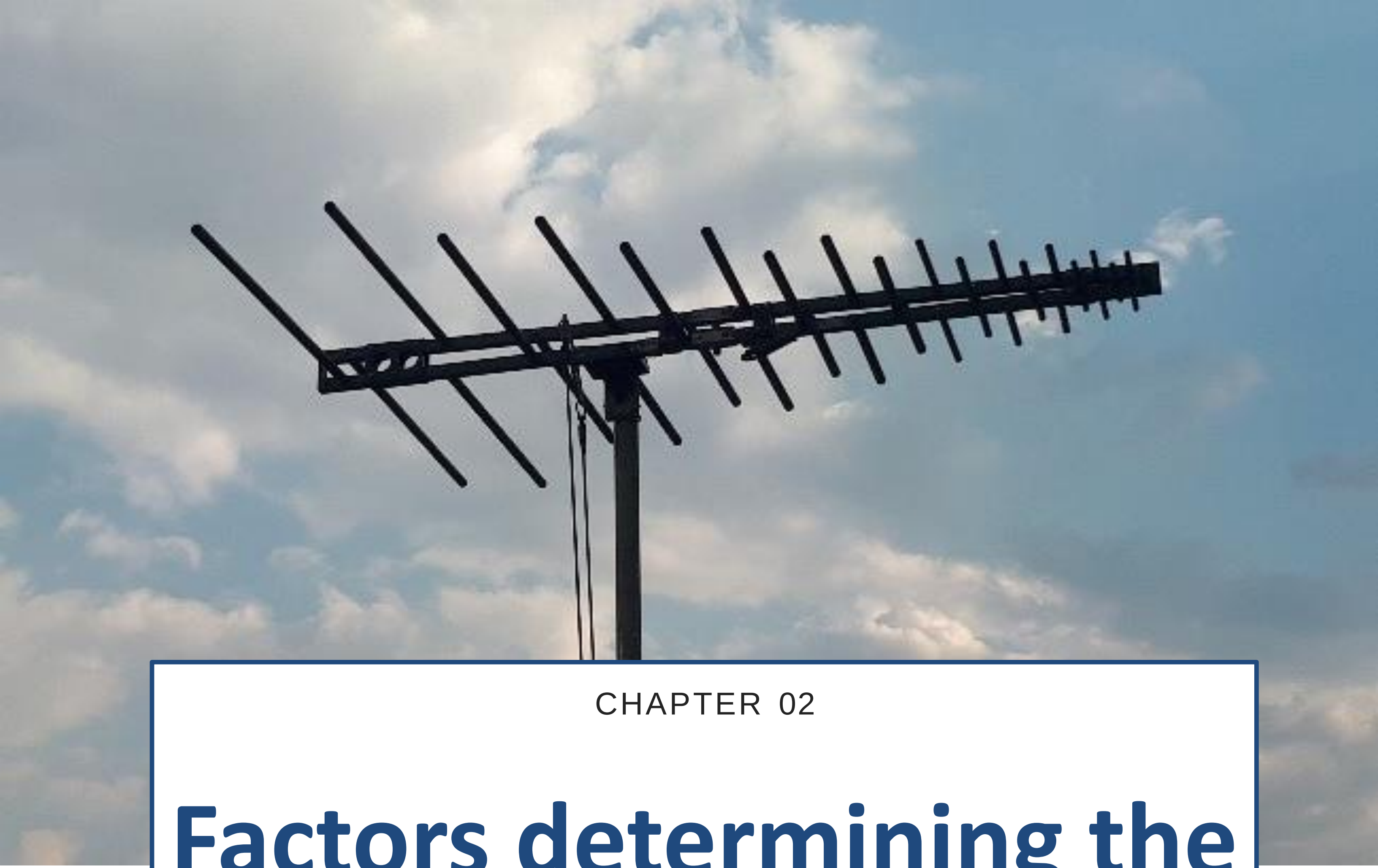

CHAPTER 02

Factors determining the isolation between co-located antennas

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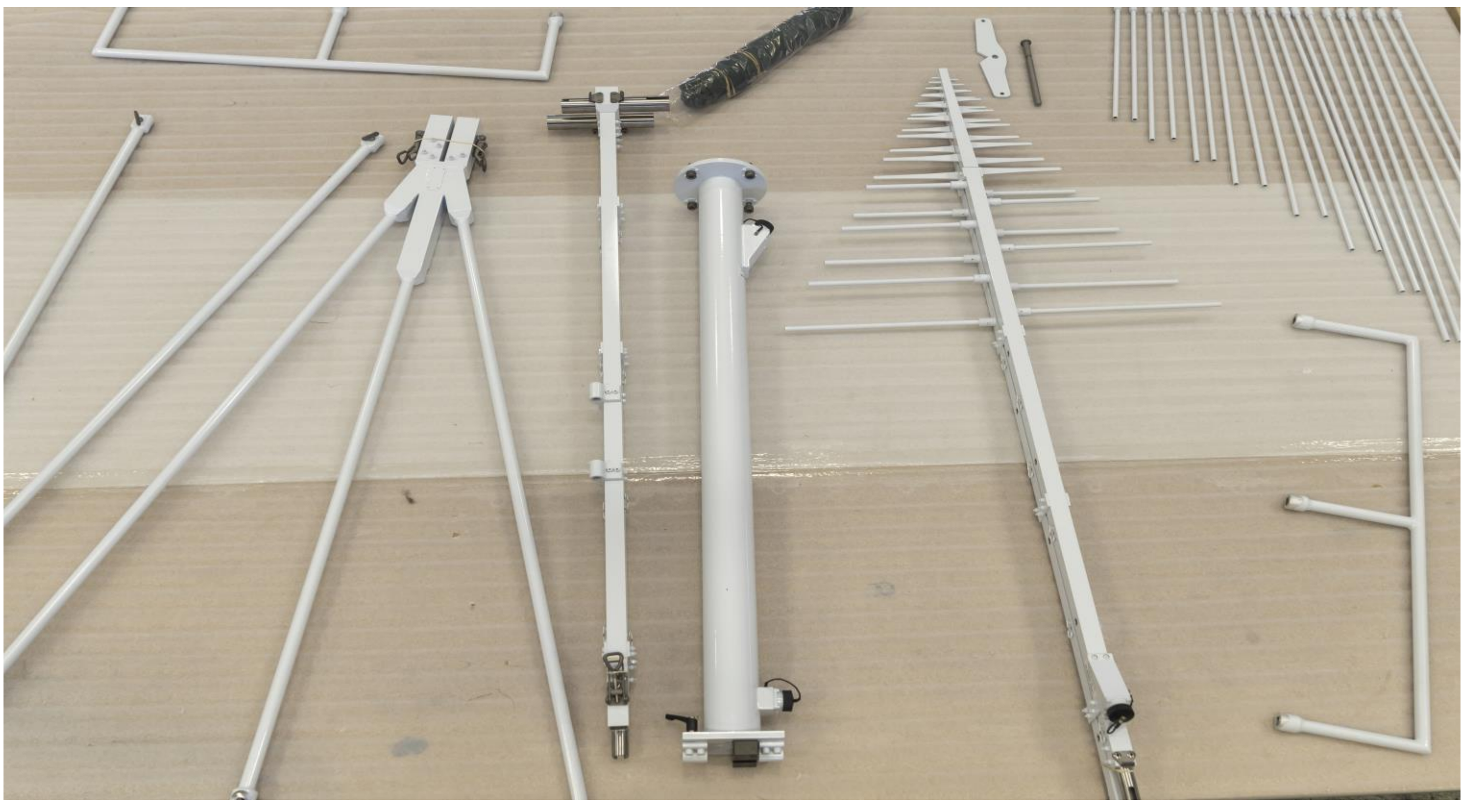
Let us consider some of the factors that will improve or deteriorate the isolation between two antennas. Since LPDAs are often used in wideband high power transmit systems, we will specifically use them to illustrate the principles, but they equally apply to most other types of antennas as well.



Polarisation

The one parameter that has a much larger impact on isolation than spacing, is the polarization of the two antennas. As the name suggests, Log-Periodic Dipole Antennas consist of several dipoles that are fed in specific way to create forward gain. Dipole elements, or any sort of "skinny" element, always have a null directly above or below the element when mounted vertically. When they are mounted horizontally, there is no longer a null in the radiation pattern aiming up or down where the other antenna may be located.

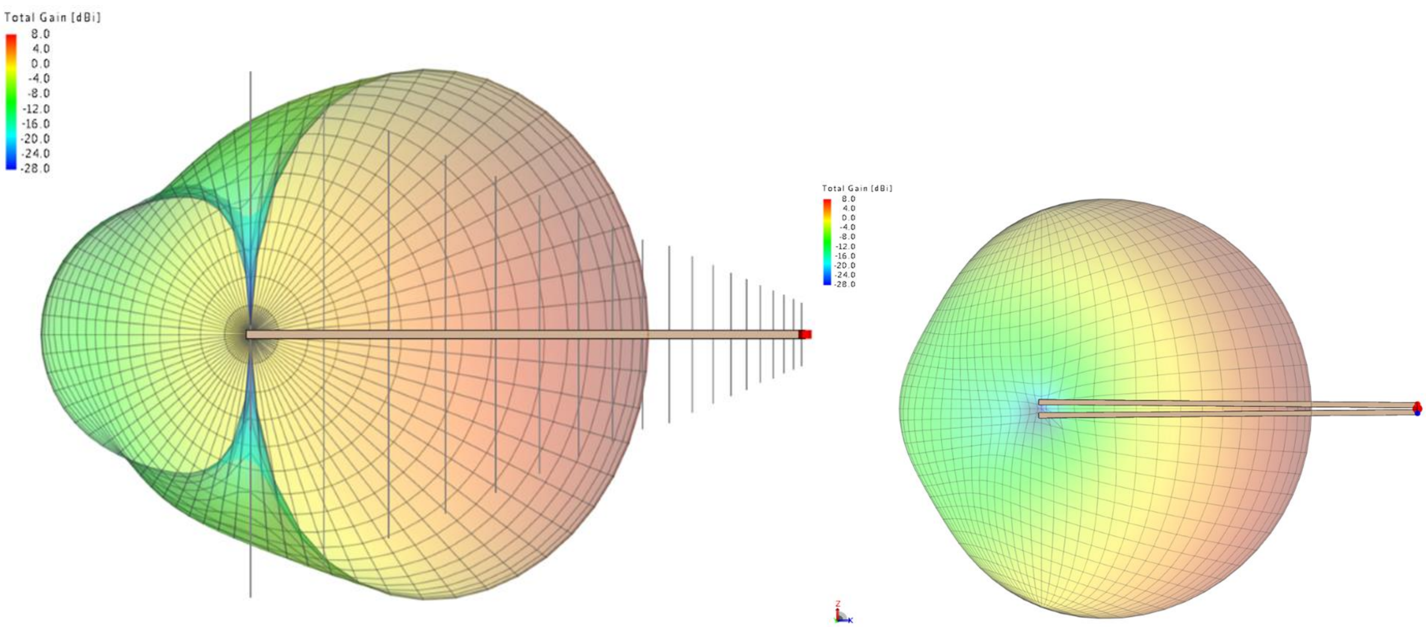


Figure 1: All LPDA antennas have a null in the radiation pattern above and below the antenna when mounted vertically (image at top), but still have significant gain towards the sides (image at bottom).

If two LPDAs are mounted on a mast, one on top of the other, the coupling between them will be much higher when they are both horizontally polarised (HP) compared to when they are vertically polarized (VP). In a simulation of the LPDA-A0102 using the same spacing between the two antennas, we can see that the isolation between the two VP antennas at 100MHz is about 40.7dB, whereas the isolation between the two HP antennas is only 22.5dB.
To put this into perspective, a 5kW (67dBm) signal transmitted from one of the antennas will induce only about 0.43W (26.3dBm) of power into the other antenna when both are VP. When both antennas are HP, a massive 28.2W (44.5dBm) signal is picked up by the second antenna.

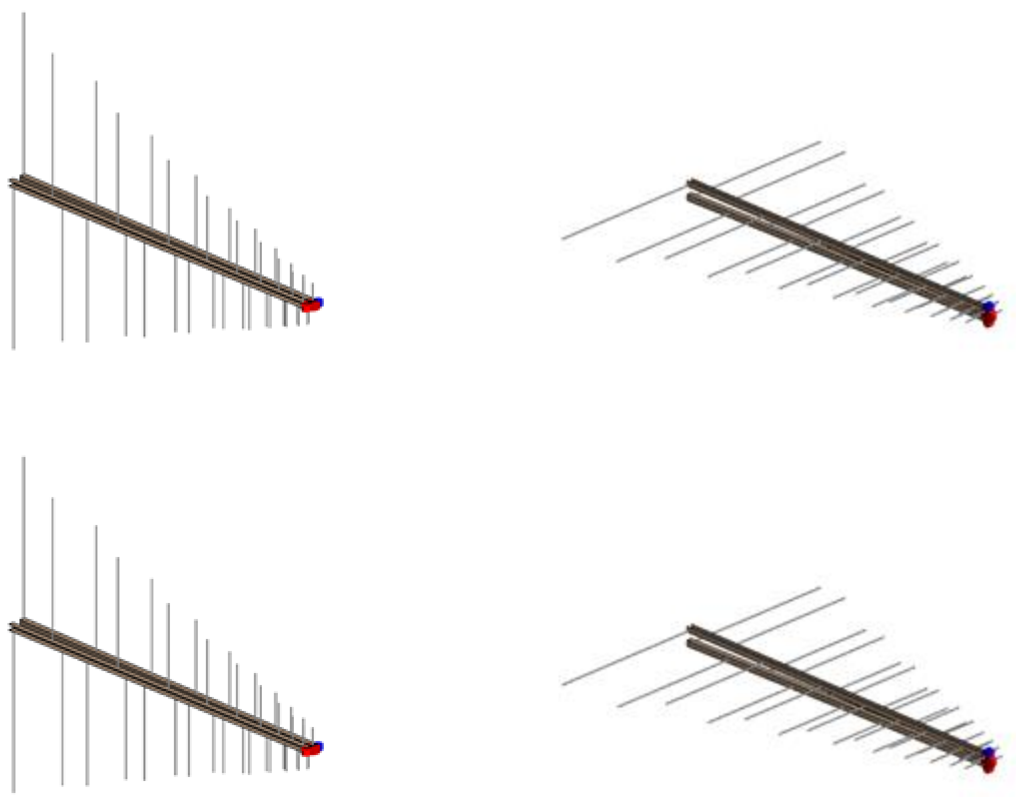


Figure 2: Two antennas mounted in vertical polarisation (left) vs horizontal polarisation (right).

The worst isolation will (almost) always be at the lowest frequency

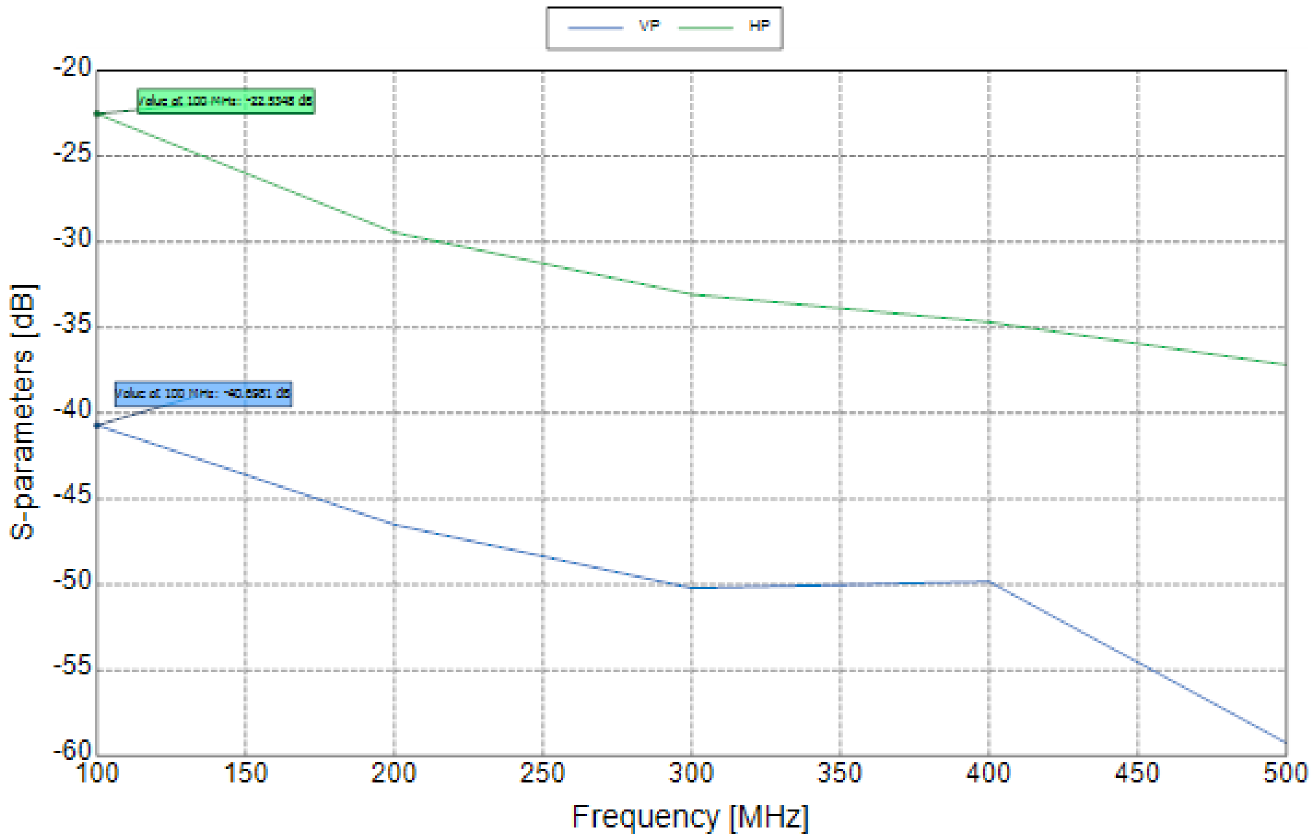


Figure 3: The coupling (S21) between the two VP antennas (blue) is much lower (-40.7dB) compared to that of the two HP antennas (green) (-22.5dB).

From Figure 3 it can be seen that the highest coupling (lowest isolation) occurs at the lowest frequency point of the plot. This will almost always be the case, with a few notable exceptions (like LPDAs with less efficient reduced length elements at the rear).

It is important to keep in mind that many antennas are designed to be wide-band and LPDA's are no exception. The isolation will be determined by both the distance between antennas and the frequency the of the signal. For a given spacing, a higher frequency does not transfer as much power as a lower frequency signal, with the reduction in power proportional to the frequency squared! Hence with all other things equal (e.g. antenna gain), the lower frequencies will typically be where the problems lie.

In addition to the propagation effect, it is also worth noting that all the other structures on the shelter, mast or building will be much closer (in terms of wavelengths) and is more likely to cause secondary effects that may (or may not) influence the isolation between the two antennas. System Engineers will do well to tread carefully when trying to estimate the isolation between two antennas in the HF and even VHF frequency bands.

Physical spacing between antennas

Thus far we have seen that the spacing between the two antennas is only one of the many factors that determine the isolation between two antennas. Unfortunately, it is also one of the parameters that turns out to have a relatively small influence compared to things like polarisation.

To illustrate, let us consider three scenarios where two identical antennas (LPDA-A0102) are horizontally polarised and spaced 2m, 4m and 8m apart. While we are using them both in HP, the same principle and relative difference will apply for the VP case.

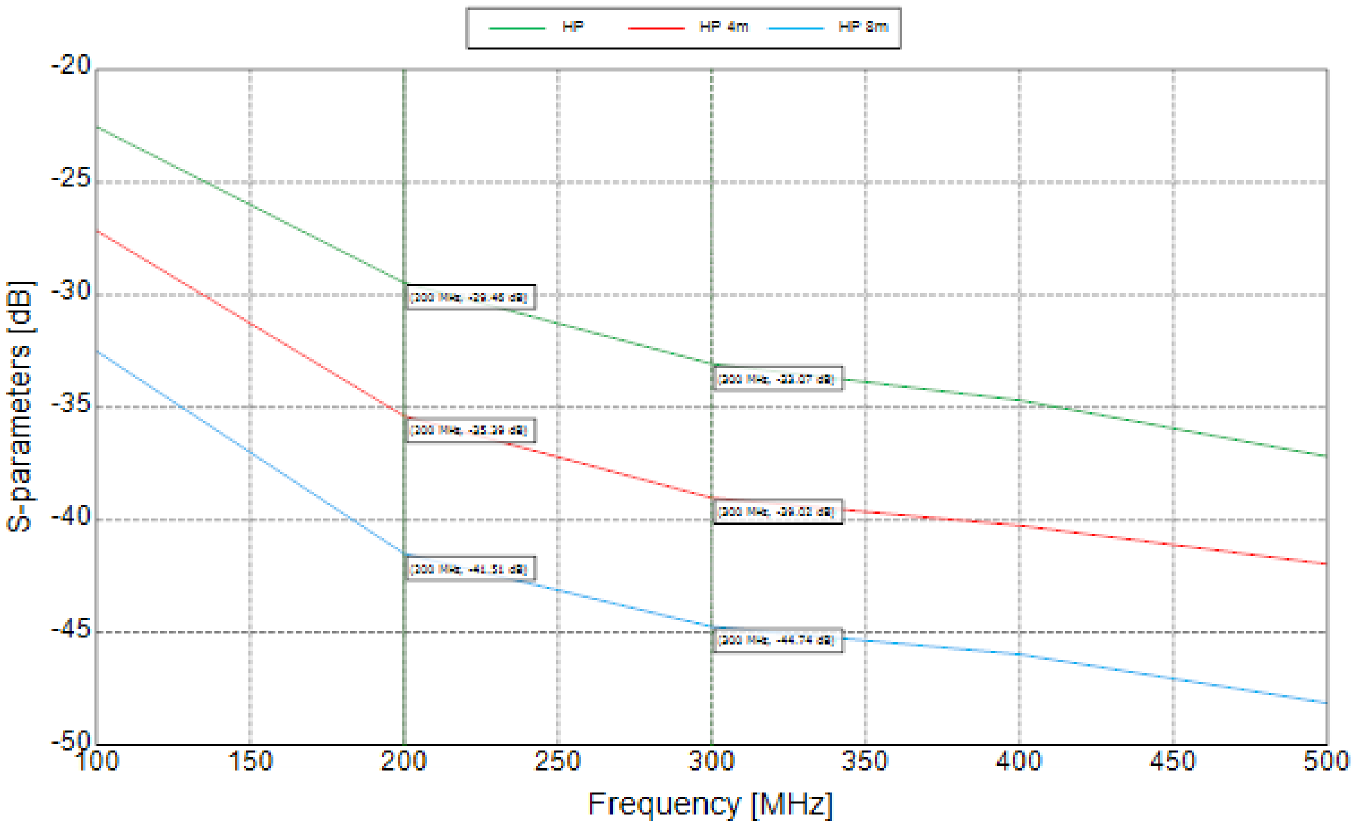


Figure 4: Coupling (S21) between antennas that are spaced 2m, 4m and 8m apart. Every time the spacing doubles, another 6dB of isolation is achieved.

Doubling the distance from 2m to 4m only increases the isolation by 6dB (and even less at 100MHz), which is not all that much since an additional 2m spacing on a mast is a practical impossibility under most situations. As a rule of thumb, every time the spacing between two antennas is doubled (or halved), the isolation between them increases (or decreases) by about 6dB. This is true unless the antennas are really close to each other (in terms of wavelengths) and is true for both the VP and HP scenarios.

It is thus clear that an increase in spacing between antennas is unlikely to be the magic bullet that will solve isolation issues in most practical scenarios!

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Different types/models of antennas

While we have used two identical antennas to illustrate the various parameters that influence isolation between two antennas, we should not forget that most of these also apply to antennas that are not identical. It would be easy to assume that antennas that are not working in the same frequency bands will not couple to each other, and we would be very wrong. To make matters even worse, because of the physical smaller size, one would typically be tempted to space them closer to each other.

Typically, antennas are designed to work well over a specific target bandwidth. Often the performance of the antenna at other frequencies is considered not to be important but some antennas could have unintended resonant frequencies way outside of their specified bands of operation.

For antennas like LPDAs (and many other wideband antennas), the performance outside of the specified bands of operation may roll off relatively slowly. When two LPDAs of different bands are mounted near each other, there may still be significant coupling between them, especially if they have partly overlapping frequency bands.

To illustrate the potential pitfall, consider the scenario where an LPDA-A0102 (100-500MHz) is mounted close (2m) to another LPDA designed to work from 200-1000MHz.

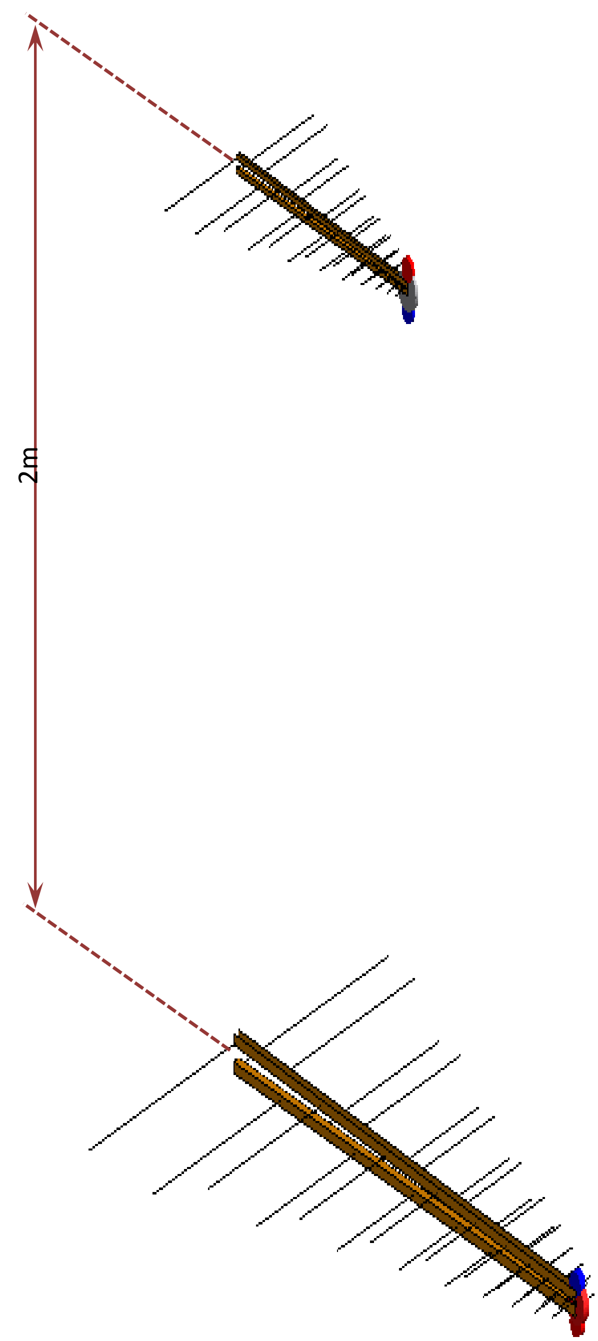

Figure 5: A small LPDA (200-1000MHz) antenna mounted 2m above an LPDA-A0102 (100-500MHz).

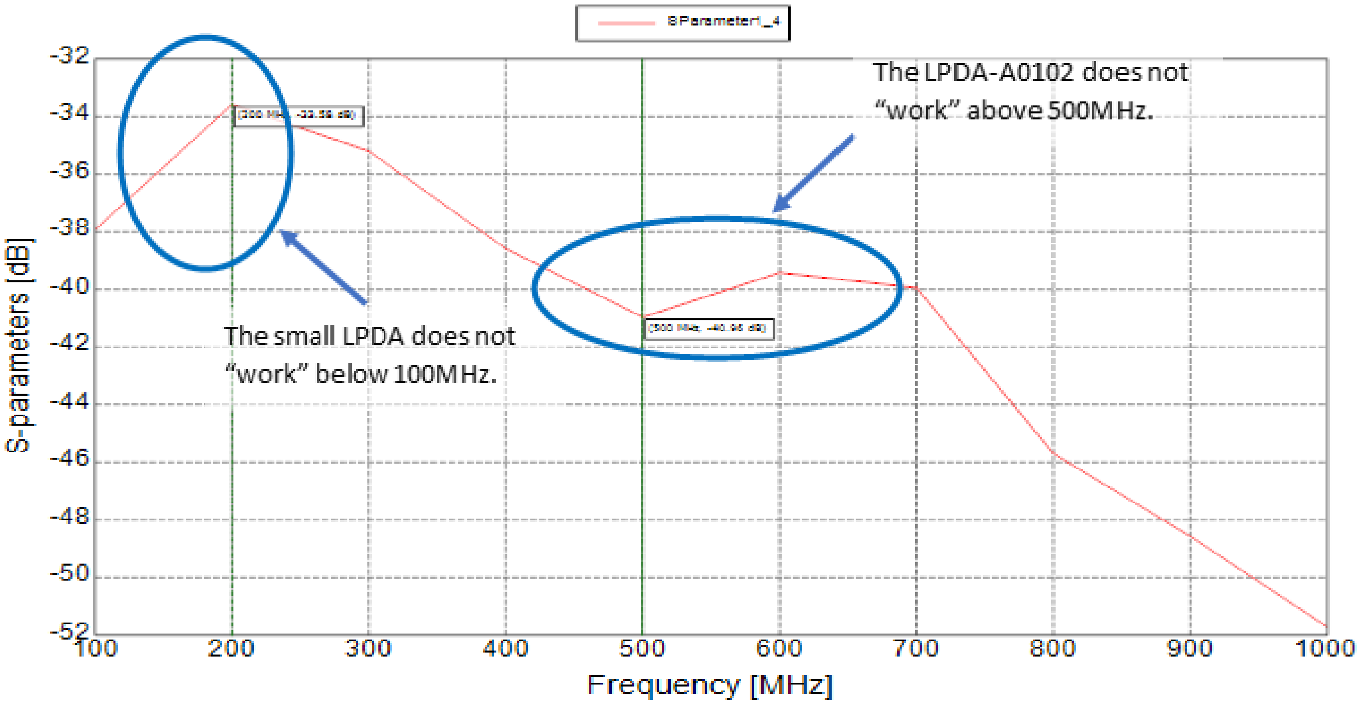

Figure 6: There is significant coupling between the two antennas outside of the overlapping frequency bands of the two antennas.

It can be seen that there is significant coupling between the two antennas from 500-750MHz, which is well outside of the frequency band where the LPDA-A0102 is designed to work. The same is true for the frequencies below 200MHz, which is below the designed operating frequency of the smaller LPDA.

Thus, just because two antennas do not have overlapping frequencies of operation, do not assume that the coupling will be negligible.

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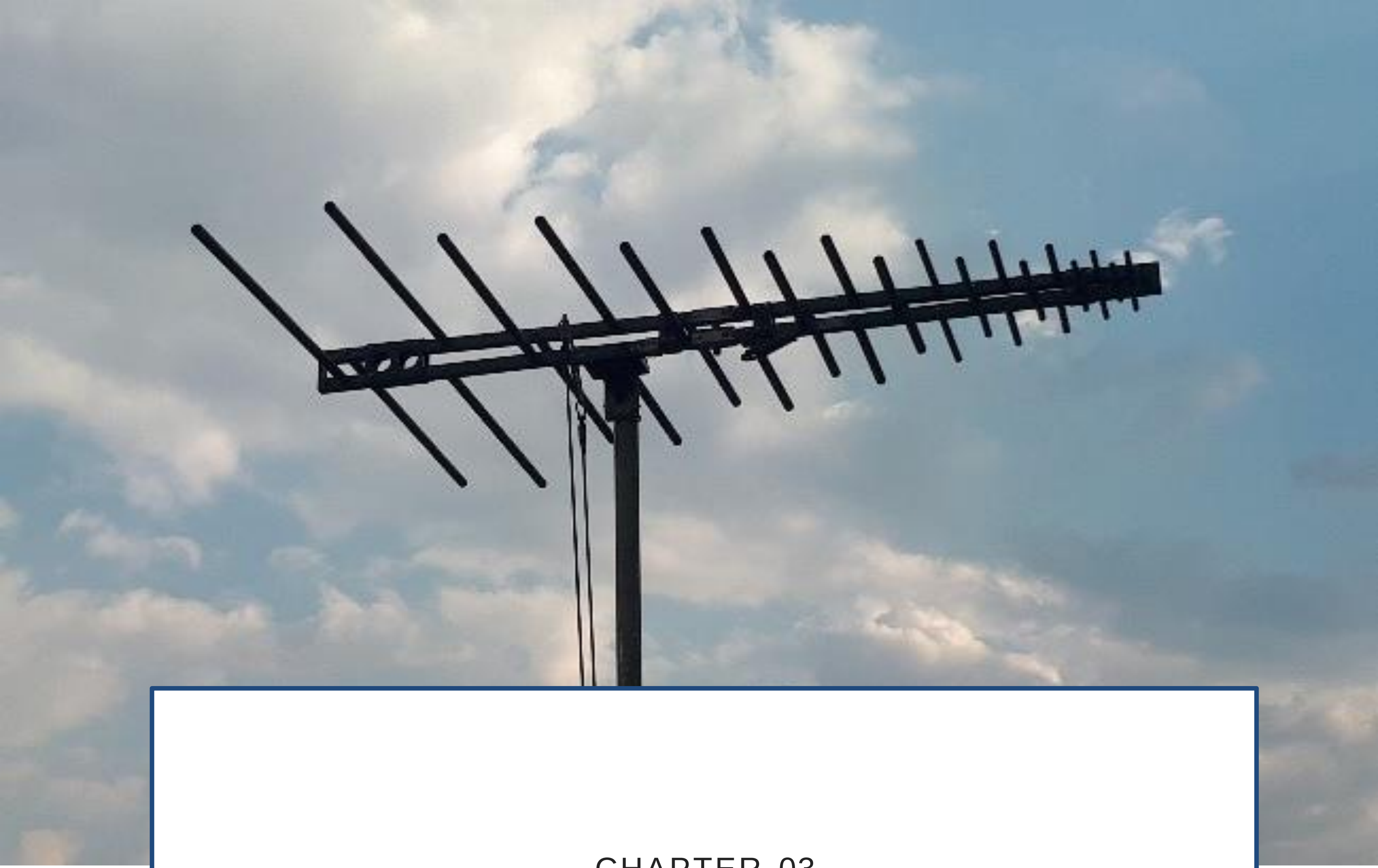

CHAPTER 03

If you must know…

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In some scenarios it might not be good enough to simply “do your best”, and a relatively accurate estimate of the isolation between antennas on a structure may be required. Unfortunately this cannot easily be done on the back of an envelope but there are ways of getting a better estimate.

...measure the isolation

There is simply no better way of knowing than doing an actual measurement. One should still be careful in setting up the measurement as it is quite easy to get wrong answers if one is not careful. It is important to recreate the final setup as closely as possible and remove as many objects that may cause reflections (thereby falsely reducing isolation) or direct paths between the antennas.

In many scenarios, measurements may not be practical or possible.

...simulate the system

With the advancement in computing power over the past decades it has become possible to simulate relatively complex and sophisticated systems involving multiple antennas and structures. Such simulation studies are extremely useful to point out unexpected problems and allow System Engineers to rapidly explore multiple configuration options while getting relatively accurate, or at least indicative isolation values for the various combinations. All this can be done without the investment in hardware and equipment that comes with measurements.

But, as is the case with measurements, simulation studies have their own potential pitfalls and it is important to have a good understanding of the potential inaccuracies that may arise from assuming a ‘perfect’ world on a computer so as to avoid disappointment with the results. As is often the case, a combination of simulation-based studies and measurements are generally the best approach

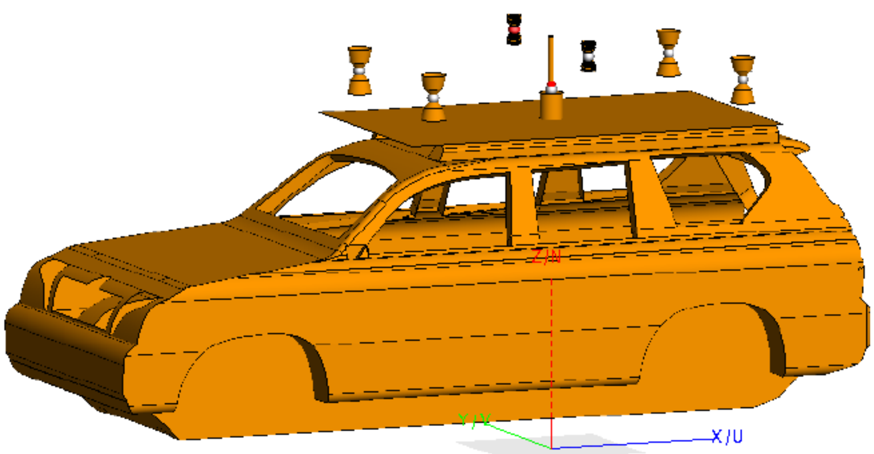
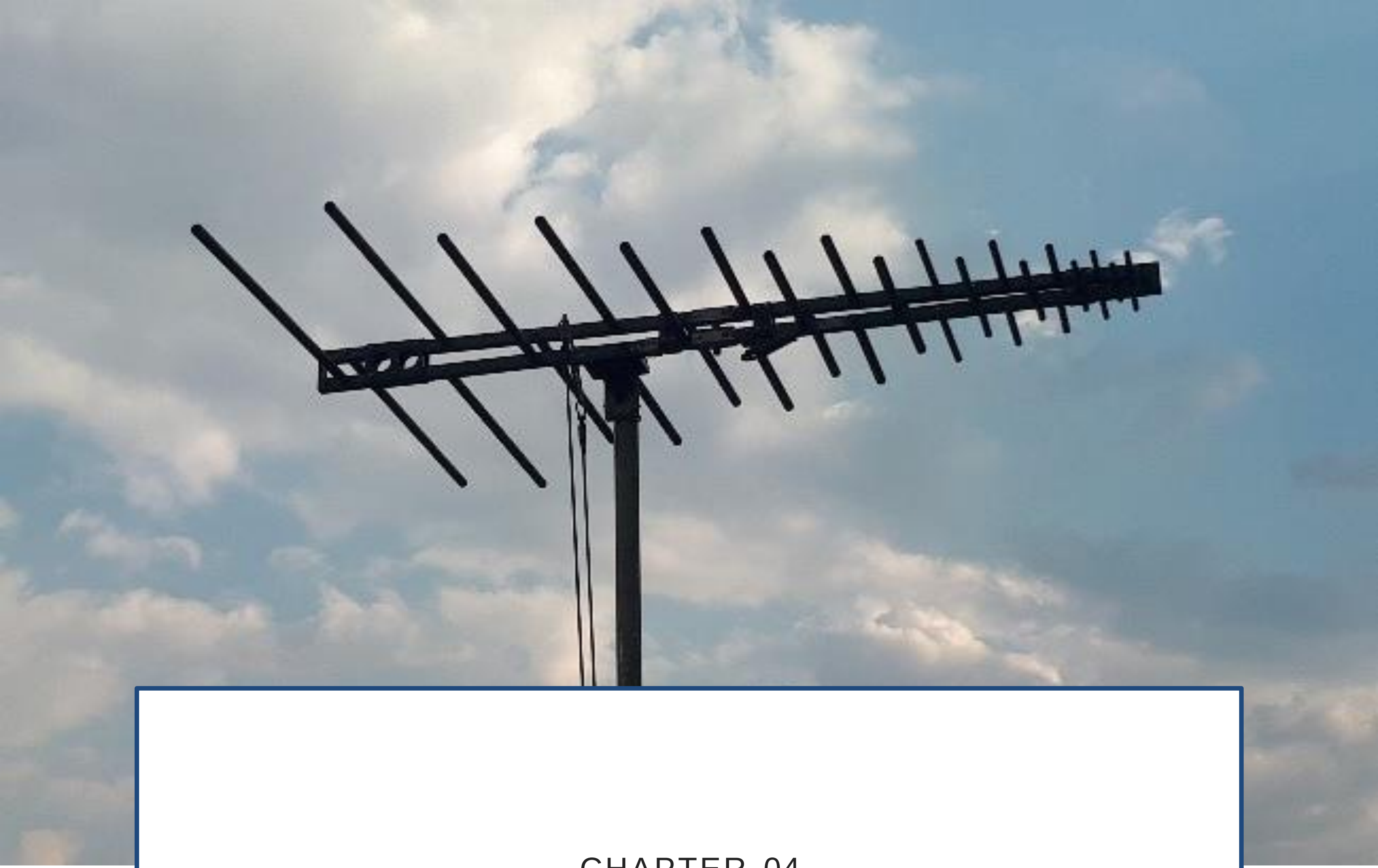


Figure 7: Simulations offer a relatively inexpensive option to investigate the coupling between antennas that are co-located on structures like vehicles or masts. An added advantage is that the effect of the structure itself can also be investigated.



CHAPTER 04

Conclusion

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When considering the placement of multiple antennas on a mast or some other structure, it is important to understand the principles that contribute to the isolation between various antennas. While physical spacing between antennas is often the first and obvious parameter that is considered, it is by no means the only one, or even most significant contributor to the isolation between two antennas.

Understanding the underlying principles will allow System Engineers to make educated decisions on how to co-locate antennas on a structure.

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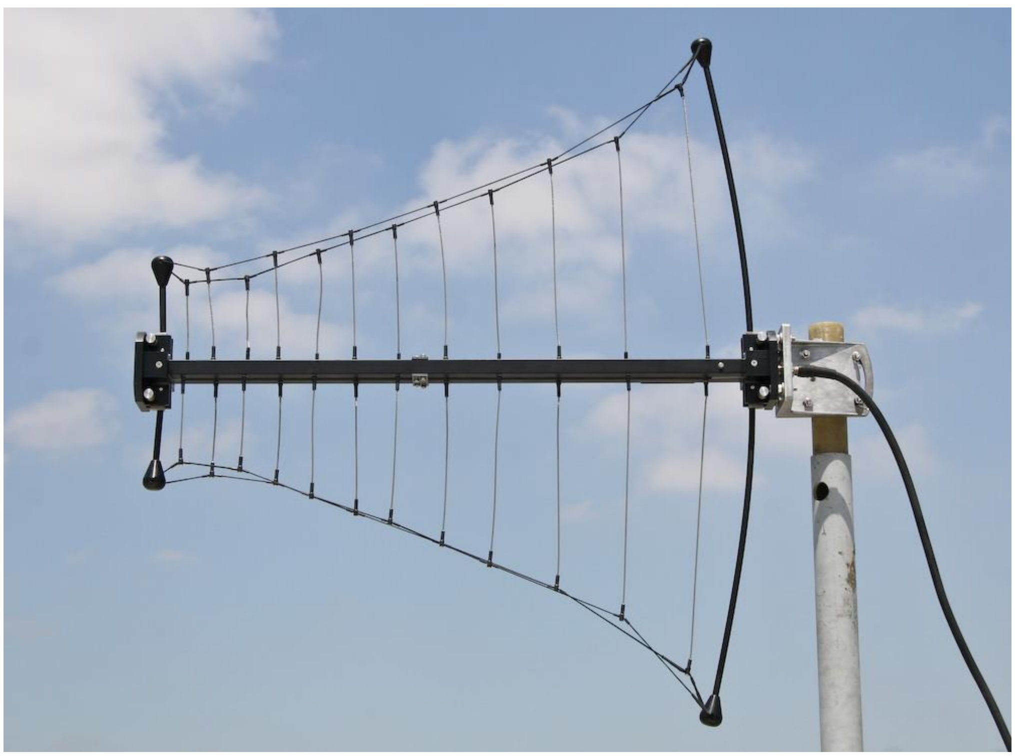

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