In-band Interference from a Nearby Transmitter

A Technical Application Note from Doppler Systems

17 July 2006

REVISED 29 June 2018

1.0 Introduction

The direction finder contains a broad band front end which needs to be protected from very strong RF signals and should therefore be located away from interfering transmitters - especially those in the same band as the DF antenna - to avoid desensitization. Interference can result from a single in-band transmitter, or from multiple transmitters. In this application note, only the case of a single strong transmitter is considered.

In Sections 2 and 3, isolation is plotted between dipole transmit antennas in various orientations and a 4 or 8 element DF array. The log scale on the isolation plots can be interpolated by noting that the data points are shown at distances of 1, 2, 5, 10, 20, 50 and 100 wavelengths. Section 4 shows the isolation between Yagi transmit antennas in various orientations and an 8 element DF array. (Yagi antennas are frequently used to control and link data to/from remote DF sites). Section 5 shows the isolation between a UHF antenna and a VHF DF.

In Section 6, some examples are given illustrating the use of these curves to prevent damage to the DF, and in Section 7 more examples are given to avoid desensitization.

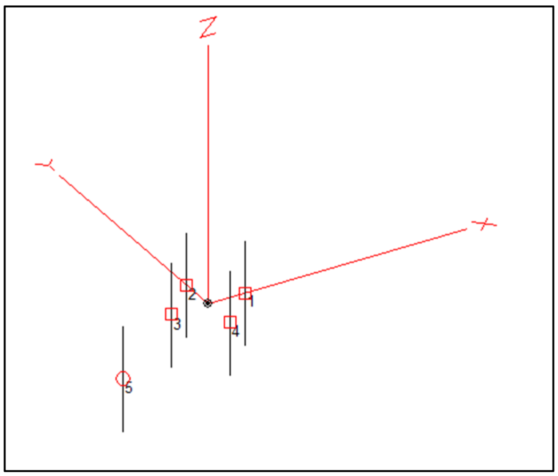
Both the transmit antenna and the elements of the receive (DF) antenna are modeled as dipoles in free space (no ground plane). The isolation shown is the ratio between the power applied to the transmit antenna and the maximum power developed in any one of the DF antenna elements.

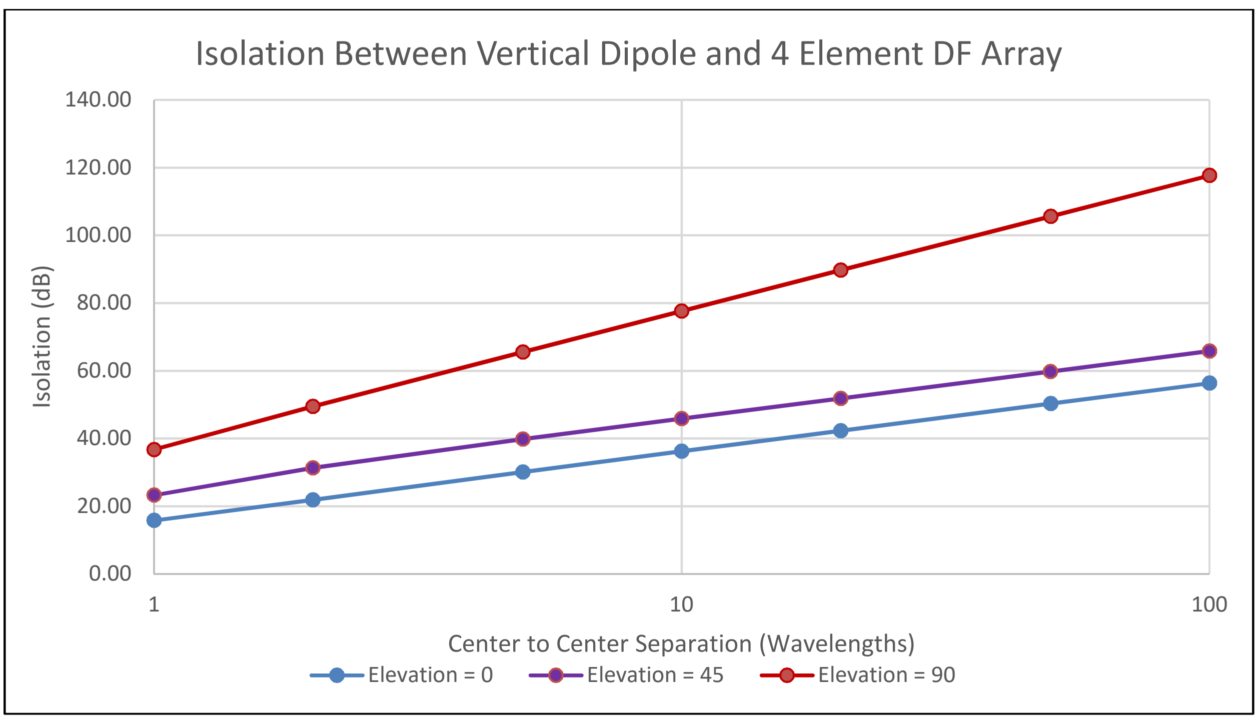
Three cases are considered for each transmit/DF antenna pair. Elevation = 0 is where the center of the transmitting antenna is in the same plane as the DF antenna. Elevation = 90 is where the transmitting antenna is directly above or below the DF antenna. And elevation = 45 is where the center of the transmitting antenna is at an angle of 45 degrees above or below the plane of the DF antenna.

2.0 Isolation between Dipole Transmit Antenna and 4-Element DF

2.1 Transmit Antenna is Vertical Dipole

In the figure below, the transmit antenna (#5) is in the YZ plane and its center is 45 degrees below the Y axis.

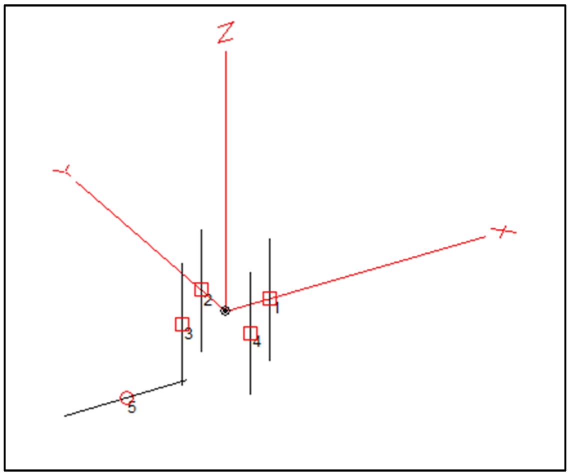


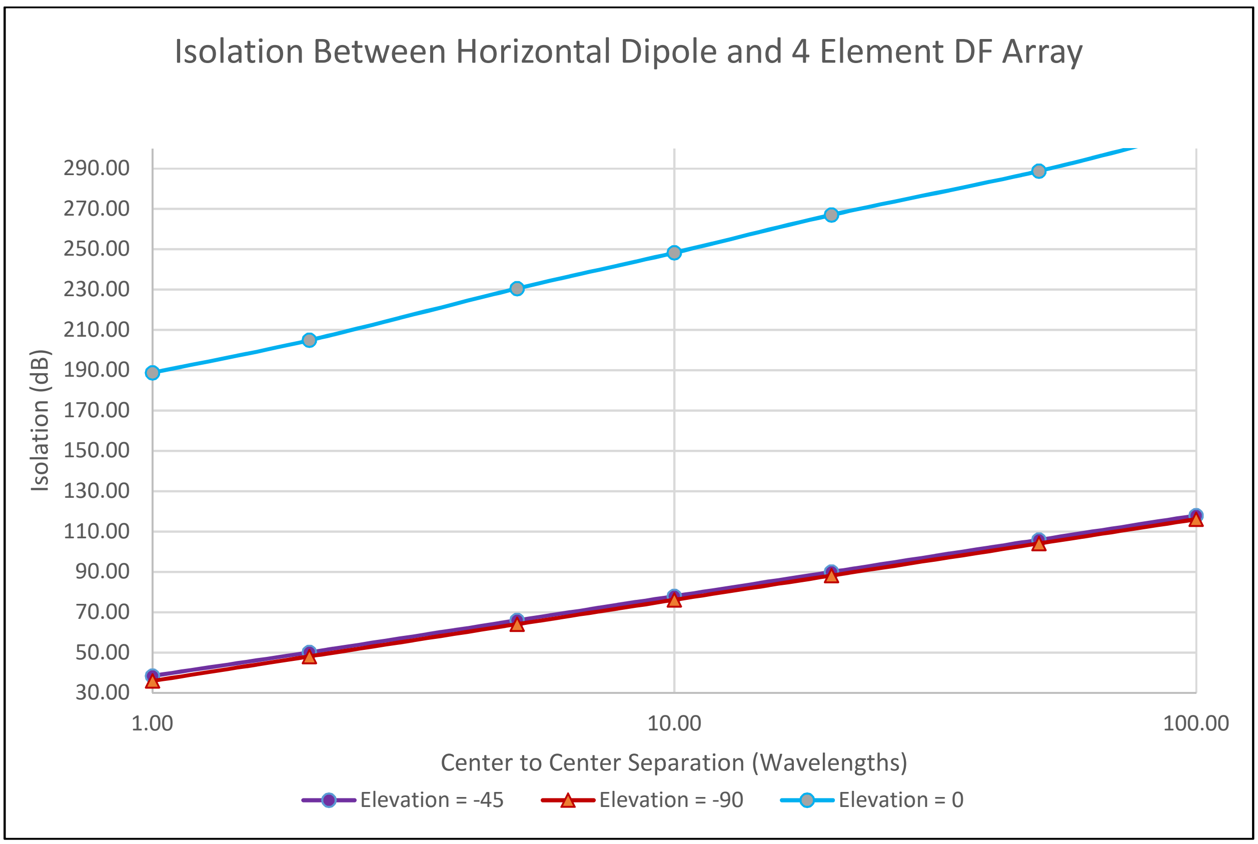


Note that placing the transmit antenna below rather than in the plane of the DF antenna is equivalent to increasing the separation by a factor of 20!

2.2 Transmit Antenna is Horizontal Dipole

In the figure below the center of the transmit antenna is in the YZ plane and is 45 degrees below the Y axis. The transmit dipole is parallel to the X axis.



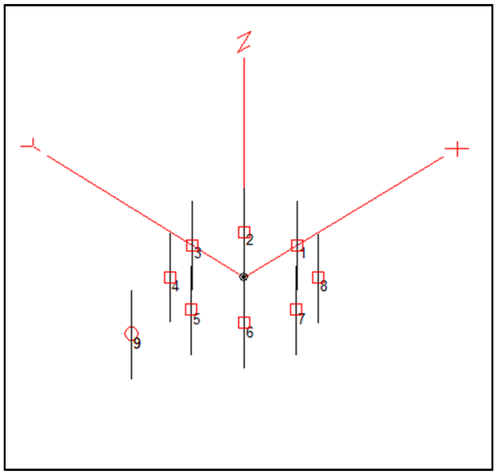


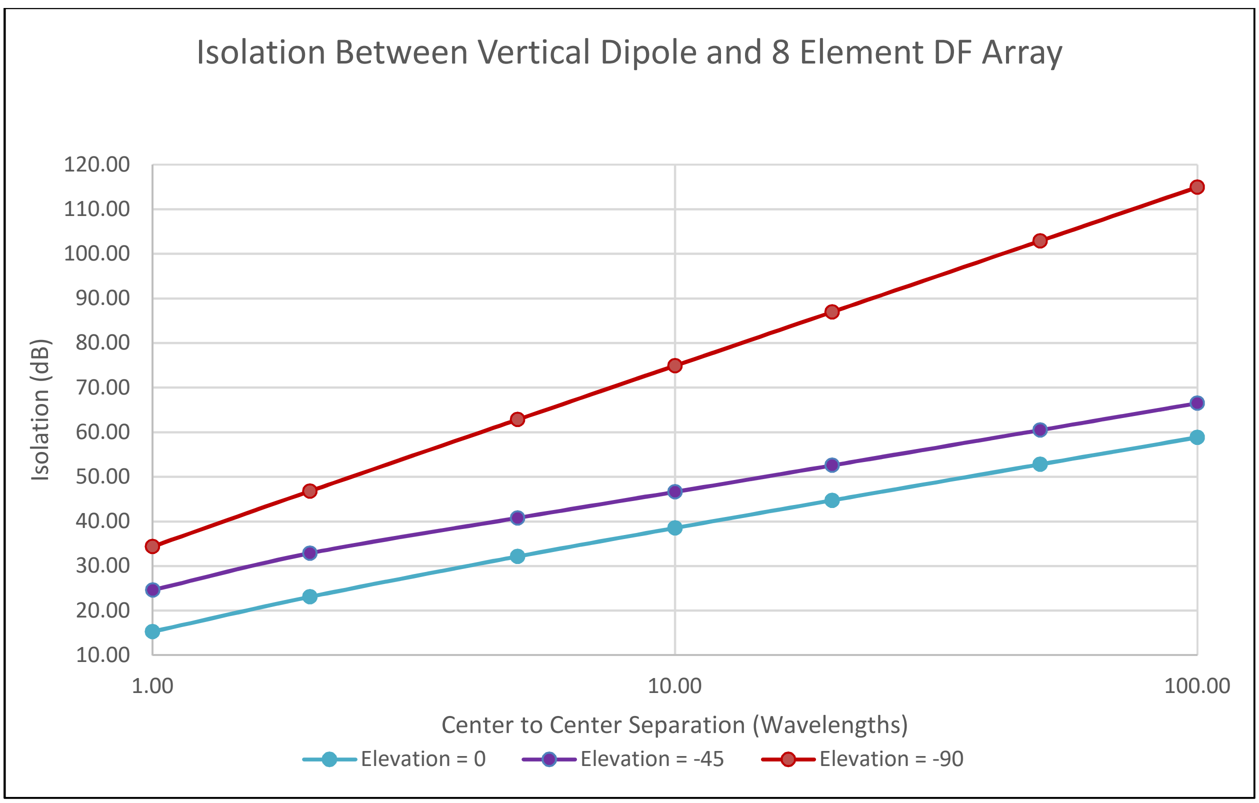
The isolation at 0 degrees is extremely high, but errors in the alignment will likely not provide the degree of isolation shown.

3.0 Isolation between Dipole Transmit Antenna and 8-Element DF

3.1 Transmit Antenna is Vertical Dipole

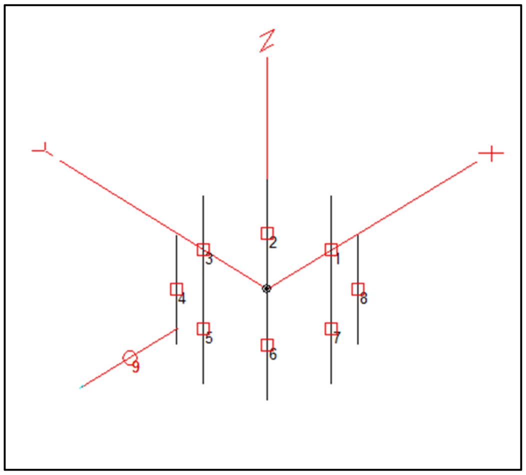
In the figure below, the transmit antenna (#9) is in the YZ plane and its center is 45 degrees below the Y axis.

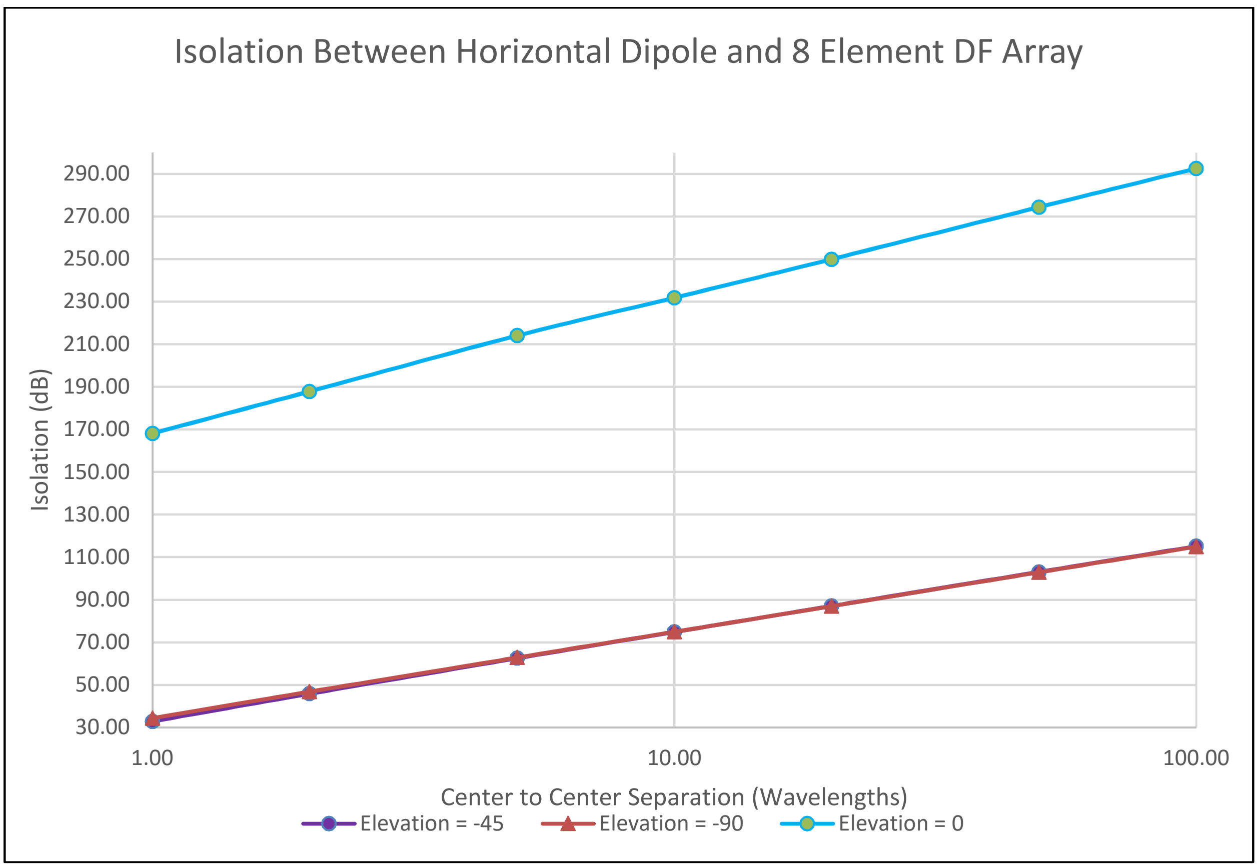




3.2 Transmit Antenna is Horizontal Dipole

In the figure below the center of the transmit antenna (#9) is in the YZ plane and is 45 degrees below the Y axis. The transmit dipole is parallel to the X axis.

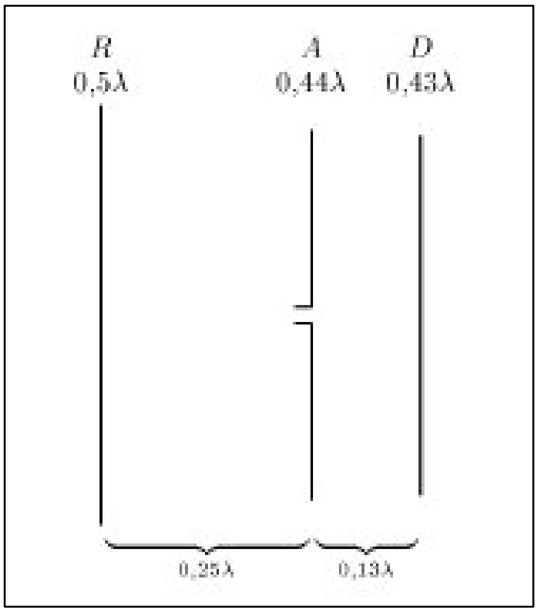




The isolation at 0 degrees is extremely high, but errors in the alignment will likely not provide the degree of isolation shown.

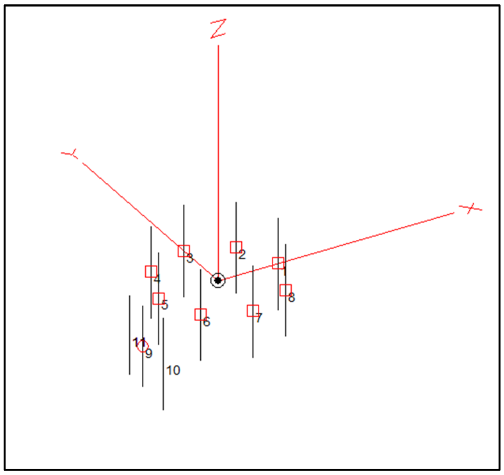
4.0 Isolation between Yagi Transmit Antenna and 8-Element DF

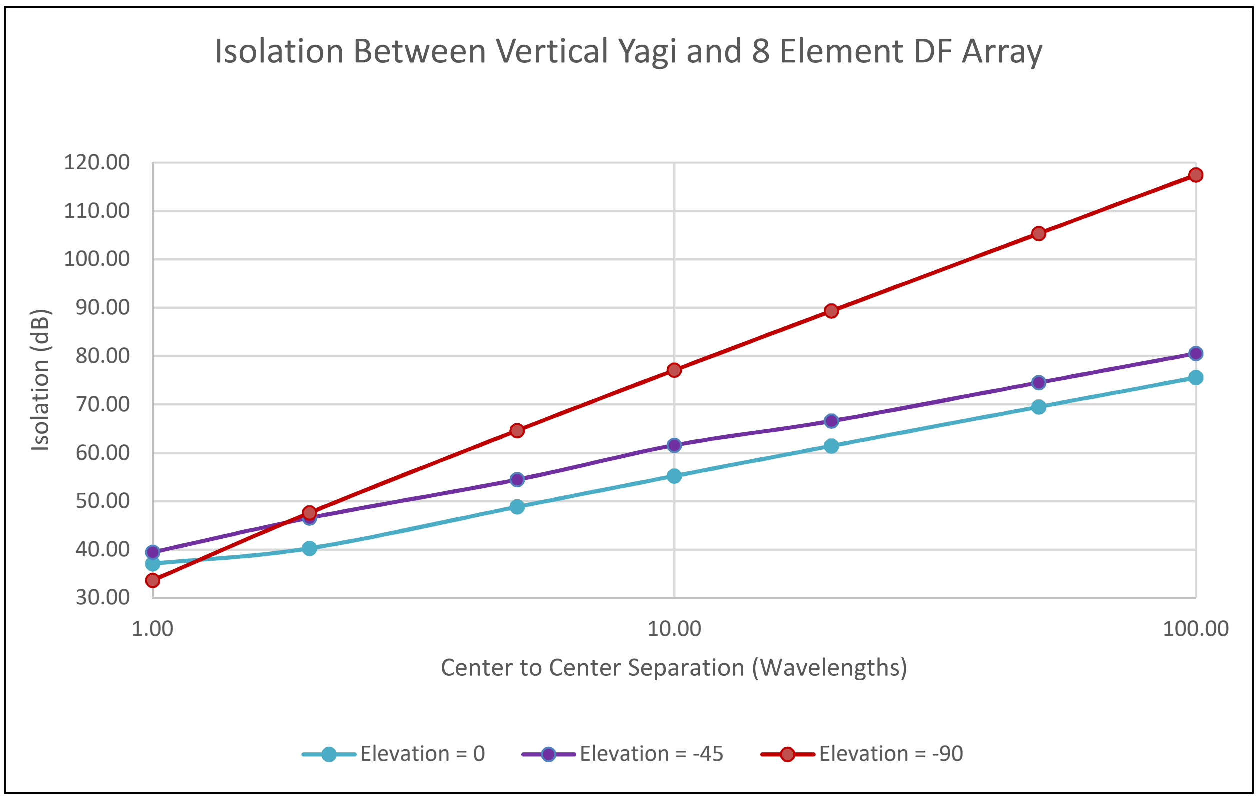
A three element Yagi antenna is modeled for the transmit antenna. The dimensions of the Yagi are shown below. (Courtesy of Wiki).



4.1 Transmit Antenna is Vertical Yagi

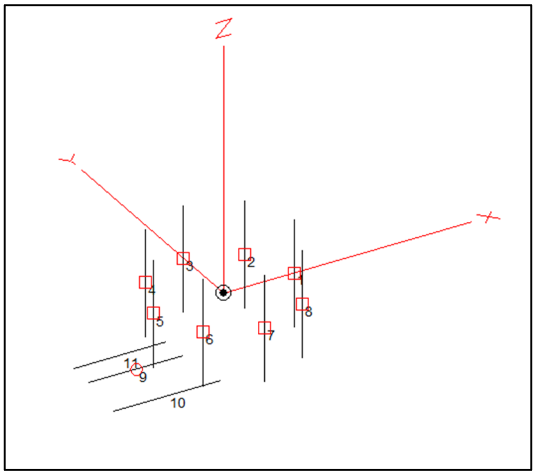
In the figure below, the driven element of the Yagi transmit antenna (#9) is in the YZ plane and its center is 45 degrees below the Y axis.

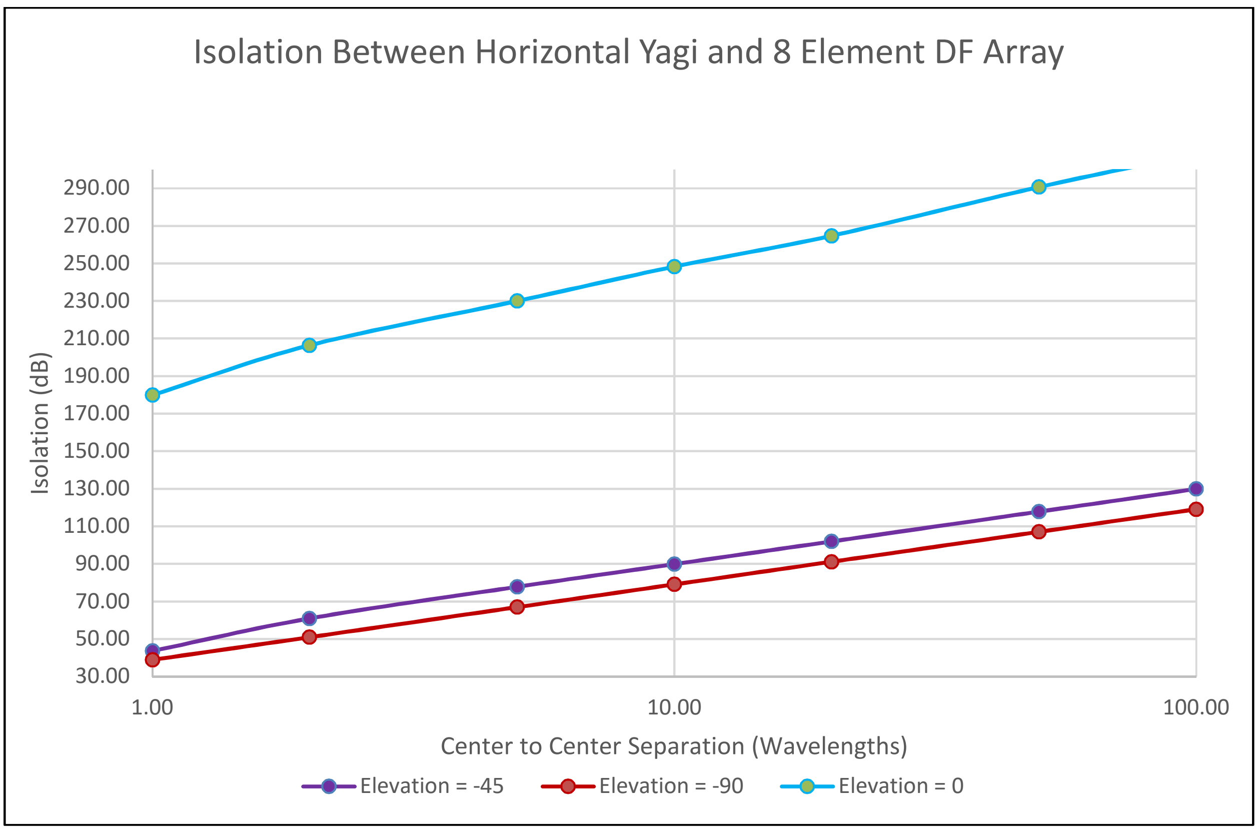




4.2 Transmit Antenna is Horizontal Yagi

In the figure below the center of the driven element of the Yagi transmit antenna (#9) is in the YZ plane and its center is 45 degrees below the Y axis.

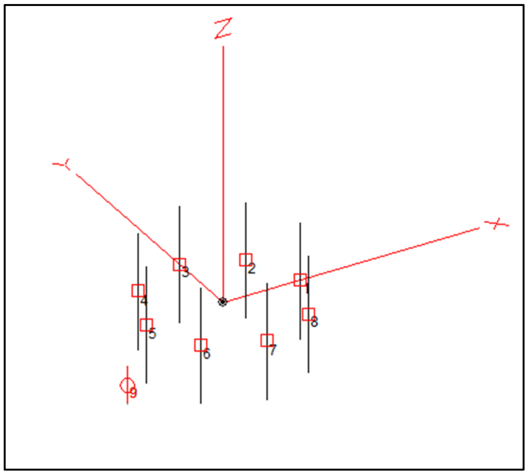


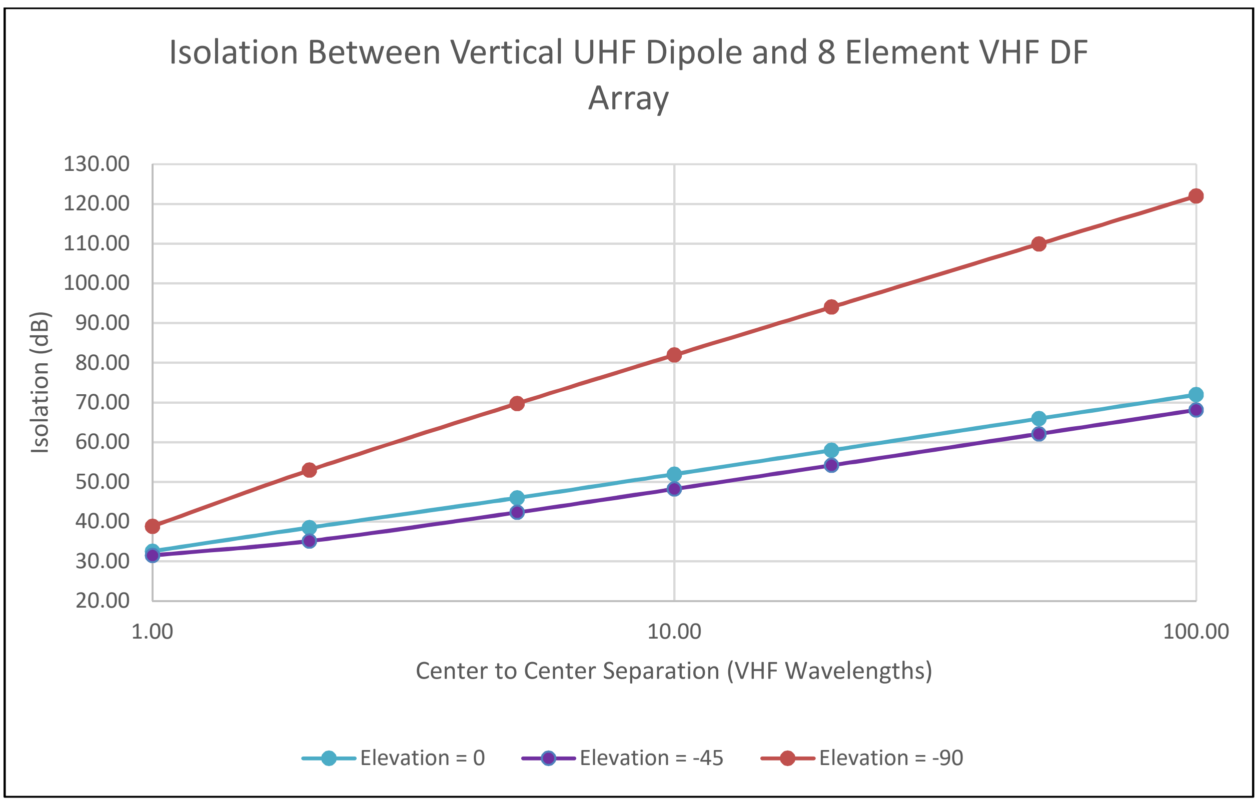


The isolation at 0 degrees is extremely high but errors in the alignment will likely limit the isolation to less than that shown.

5.0 Isolation Between Vertical UHF Dipole Transmit Antenna and VHF 8-Element DF

In this figure, the transmit dipole antenna is in the YZ plane and its center is 45 degrees below the Y axis.





The above isolation can be compared directly with that shown in Section 2.1 to see the effect of transmitting on a different band.

6.0 Separation to Avoid Damage

The DF input preamplifiers are rated at 100 milliwatts maximum. There is an input limiter circuit, but the input should still be kept to below 100 mW (+20 dBm) to be safe.

6.1 Protection from a 5 Watt (+37 dBm) Transmitter in a Mobile Installation

To avoid damage, the isolation must be more than (+37) - (+20) = 17 dB. From the graph in section 2.1, we need at least 1.1 wavelength of horizontal separation. So, for example, if a 5 watt VHF transmitter is used on a car along with the DF antenna, it should be located at least 2.2 meters behind the DF array. This assumes both antennas are on the same plane. Placing the transmit antenna on the trunk lid brings the minimum separation distance down to less than 1 wavelength.

6.2 Protection from a 25 Watt (+44 dBm) Transmitter in a Mobile Installation

To avoid damage, the isolation must be more than (+44) - (+20) = 24 dB. From the graph in section 2.1, we need more than 3 wavelengths of horizontal separation. A mobile VHF 25 watt transmit antenna would therefore have to be located at least 6 meters behind the DF array to avoid damage. Even placed on the trunk lid, the minimum separation is over 1 wavelength (2 meters). Since this is not practical, this configuration should be avoided (at VHF).

7.0 Separation to Avoid Desensitization

The sensitivity of the DF is very high (typically -130 dBm) under noise and interference free conditions. We can measure the magnitude of input interference at various frequency separations that would degrade this by some factor, for example, 3 dB. However, atmospheric and power line noise, in addition to RF interference, will typically limit the minimum signal to a higher value. The following table lists the interference that limits the DF sensitivity to -120 dBm.

Frequency Offset of Interfering Signal	Interference Magnitude that Limits Sensitivity to -120 dBm
60 KHz	-59 dBm
600 KHz	-39 dBm
6 MHz	-29 dBm

7.1 Avoiding Desense from a 5 Watt (+37 dBm) Telemetry Transmitter at a Fixed DF Site

When planning to remotely connect a DF site using a telemetry transmitter, we recommend using one in a different band from the DF antenna. However, this is not always possible. The required isolation is (+37) - (-29) = 66 dB assuming that the telemetry transmitter will be at least 6 MHz away from the receive frequency. Assume that a Yagi antenna is used for the TLM transmitter.

If the Yagi is vertically polarized and mounted below the DF array, from Section 4.1 we see that the vertical separation required is 5 wavelengths. An even better solution would be to use a horizontally polarized Yagi at the same height as the DF antenna and mounted 5 wavelengths or more away.

7.2 Avoiding Desense from a 25 Watt (+44 dBm) Repeater Transmitter at a Fixed DF Site

The required isolation is (+44) - (-39) = 83 dB assuming a 600 KHz offset. From section 3.1, we would need the repeater transmit antenna to be mounted 15 wavelengths below the DF antenna which is clearly impractical at VHF. This illustrates the fact that repeater sites are generally not the best place to locate DF antennas. The reason is that unlike repeater receivers which use duplexers and cavities at their inputs, the DF is relatively broad-banded. There are applications where we have added helical filters to the DF to reject out of band signals, but even then, helical filters do not provide rejection of frequencies that are only 600 KHz offset from the receive frequency.