

In-band Interference from a Nearby Transmitter

A Technical Application Note from Doppler Systems

17 July 2006

1.0 Introduction

The direction finder contains a broad band front end which needs to be protected from very strong RF signals and should also 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 the mixing of multiple transmitters. In this application note, only the case of a single strong in-band transmitter is considered.

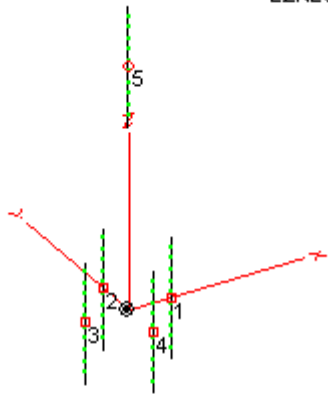
In Sections 2 and 3, the isolation is plotted between dipole transmit antennas in various orientations and a 4 or 8 element DF array. The log scale on the isolation plots can be interpolated by noting that the data points are shown at distances of 1, 2, 5, 10, 20, 50 and 100 wavelengths. Section 4 shows the isolation between yagi transmit antennas in various orientations and an 8 element DF array.

In Section 5, some examples are given for illustrating the use of these curves to prevent damage to the DF, and in Section 6 more examples are given to avoid desensitization.

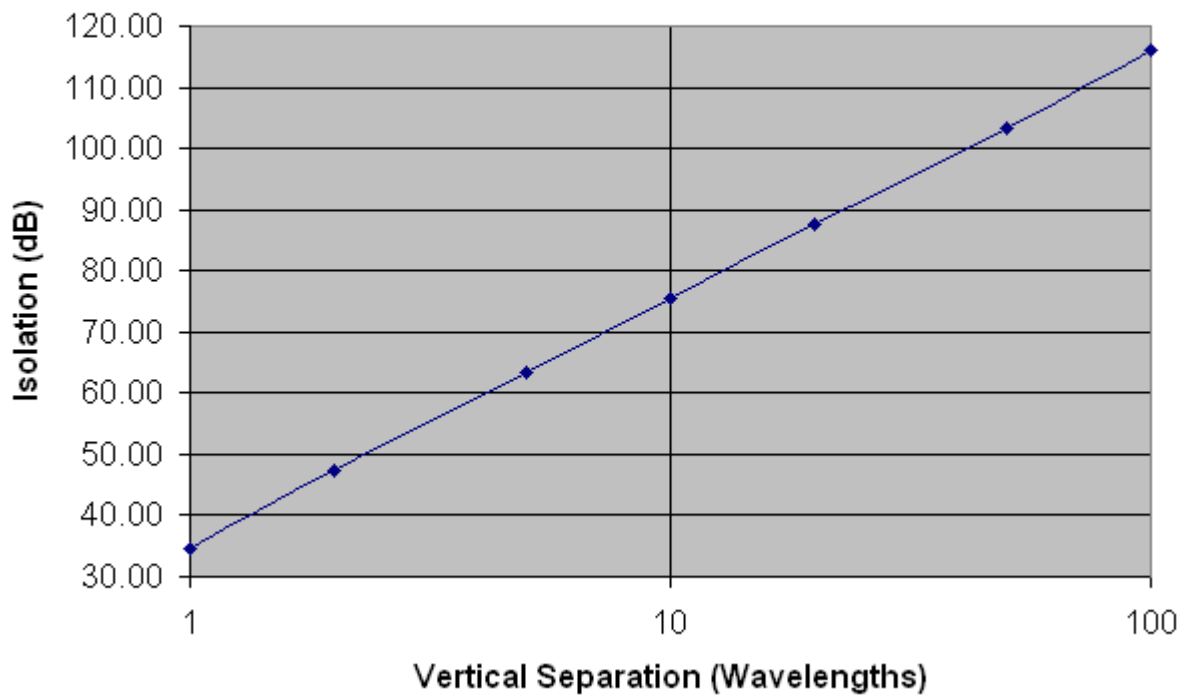
2.0 Isolation between Dipole Transmit Antenna and 4-Element DF

2.1 Transmit Antenna is Vertical Dipole Separated Vertically

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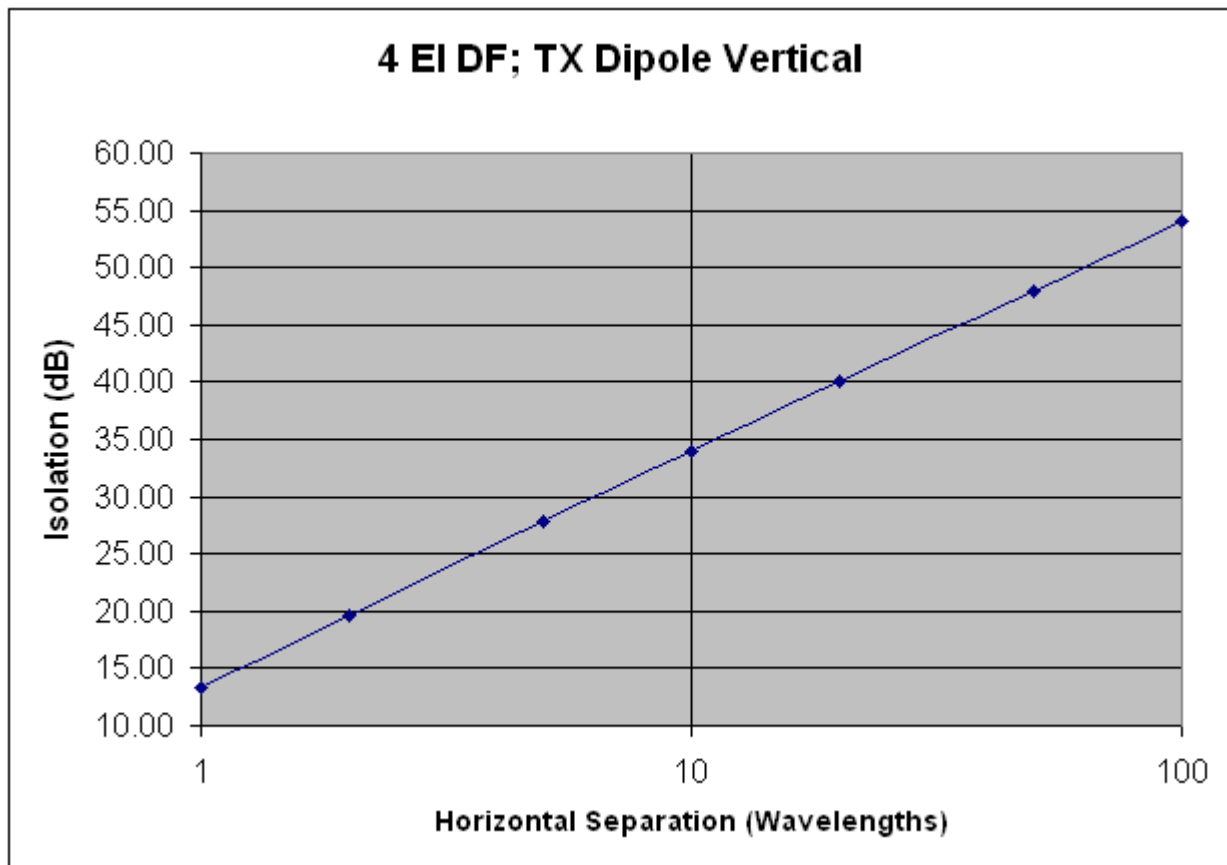
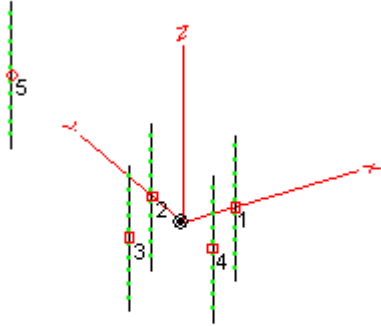


4 EI DF; TX Dipole Vertical

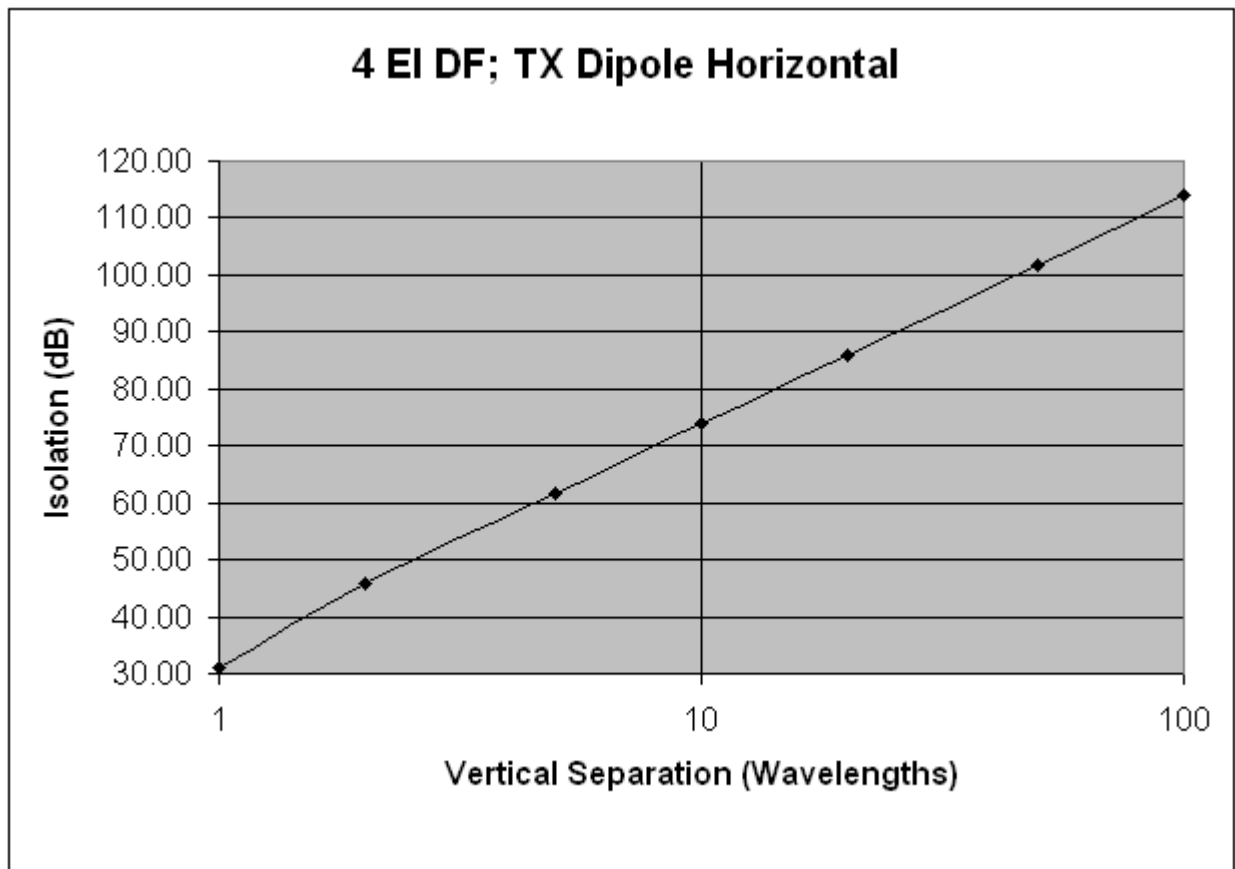
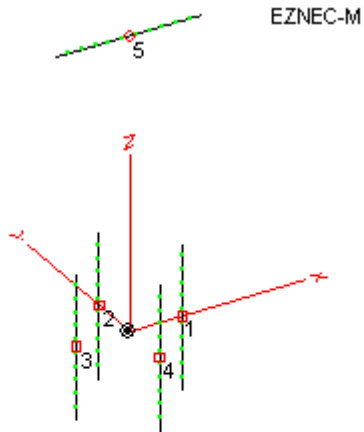


2.2 Transmit Antenna is Vertical Dipole Separated Horizontally

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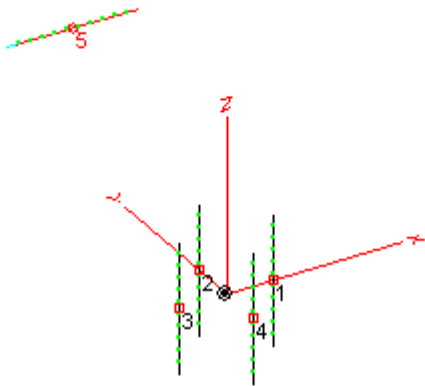
2.3 Transmit Antenna is Horizontal Dipole Separated Vertically



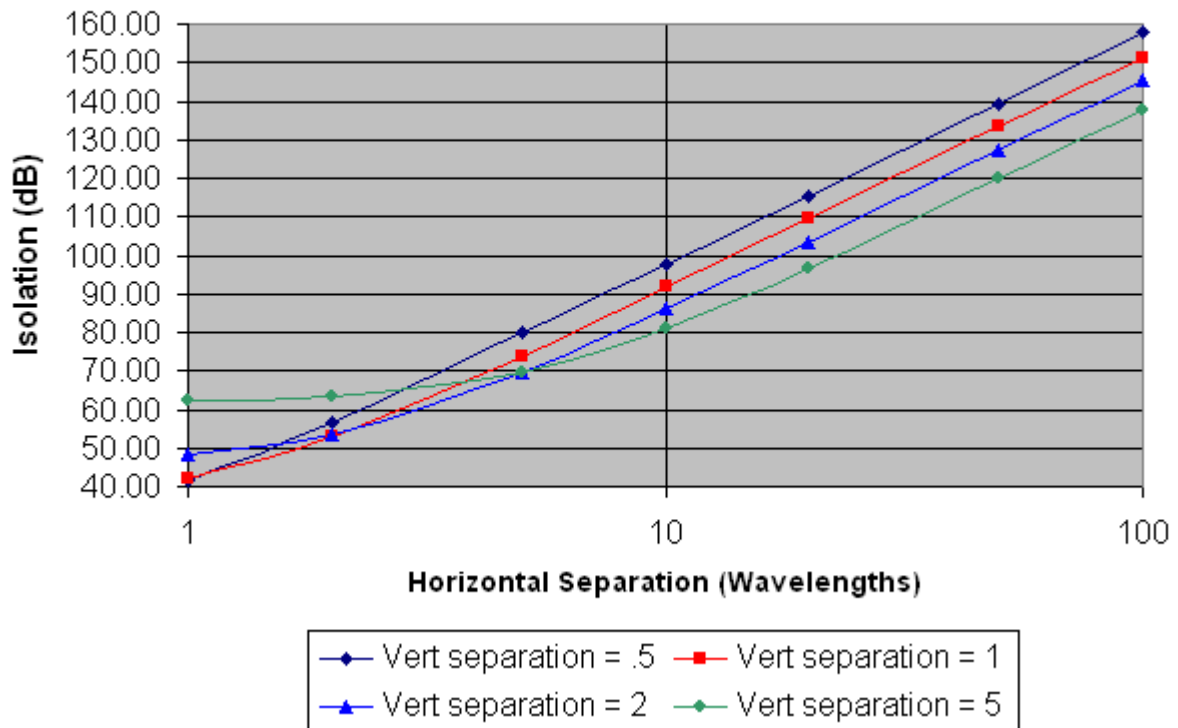
2.4 Transmit Antenna is Horizontal Dipole Separated Horizontally, Side to DF

If the vertical separation is exactly zero, there is no coupling (infinite isolation). Since this would be very difficult to achieve, curves are shown for several values of vertical separation.

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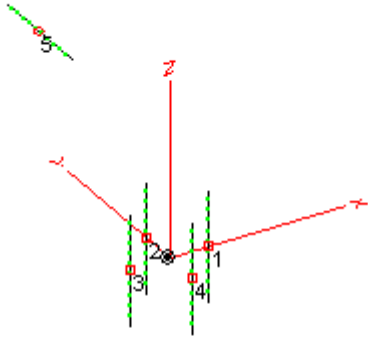
4 EI DF; TX Dipole Horizontal, Side To DF



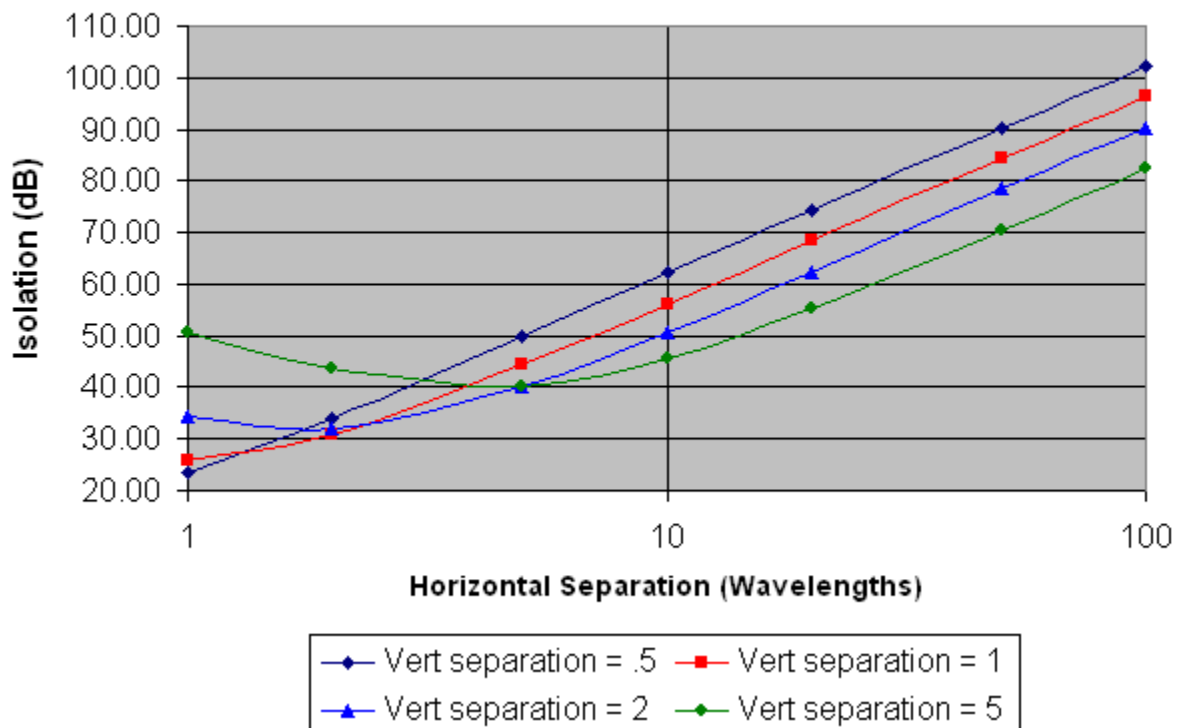
2.5 Transmit Antenna is Horizontal Dipole Separated Horizontally, End to DF

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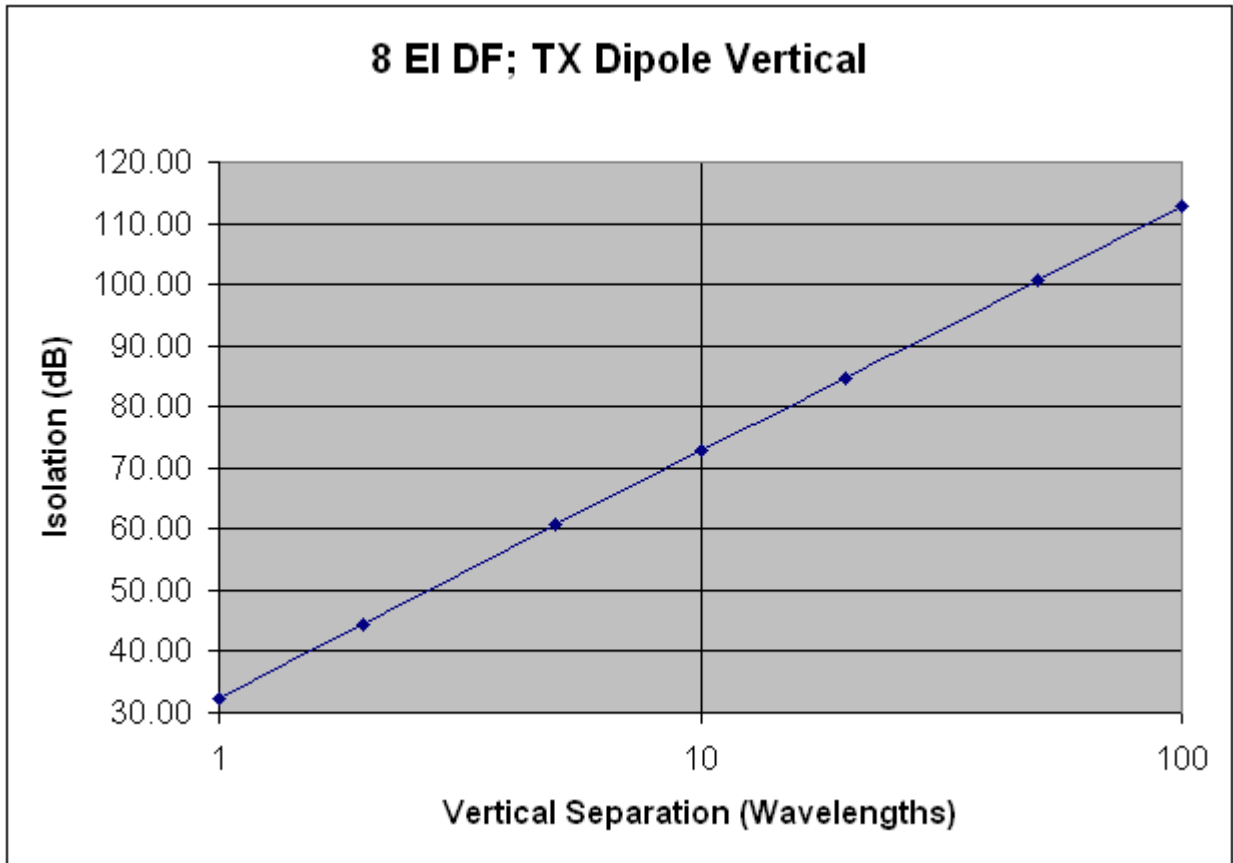
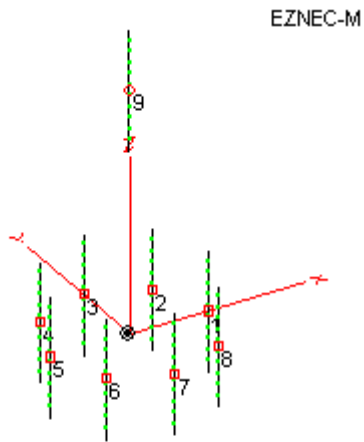


4 EI DF; TX Dipole Horizontal, End to DF



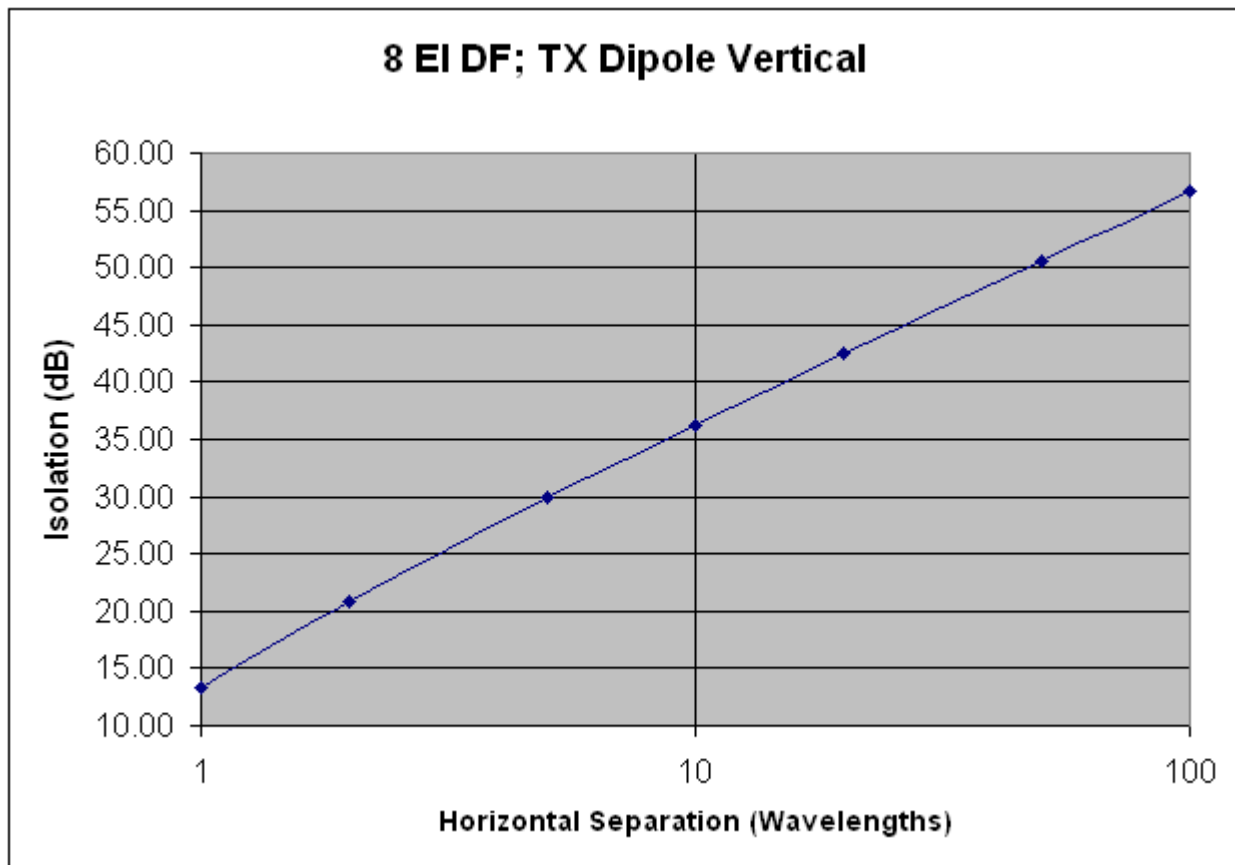
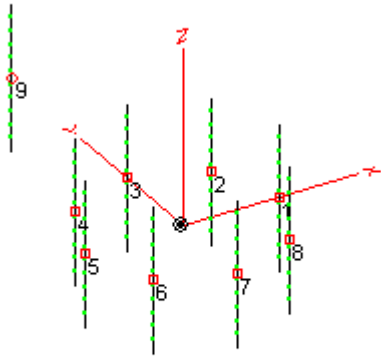
3.0 Isolation between Dipole Transmit Antenna and 8-Element DF

3.1 Transmit Antenna is Vertical Dipole Separated Vertically

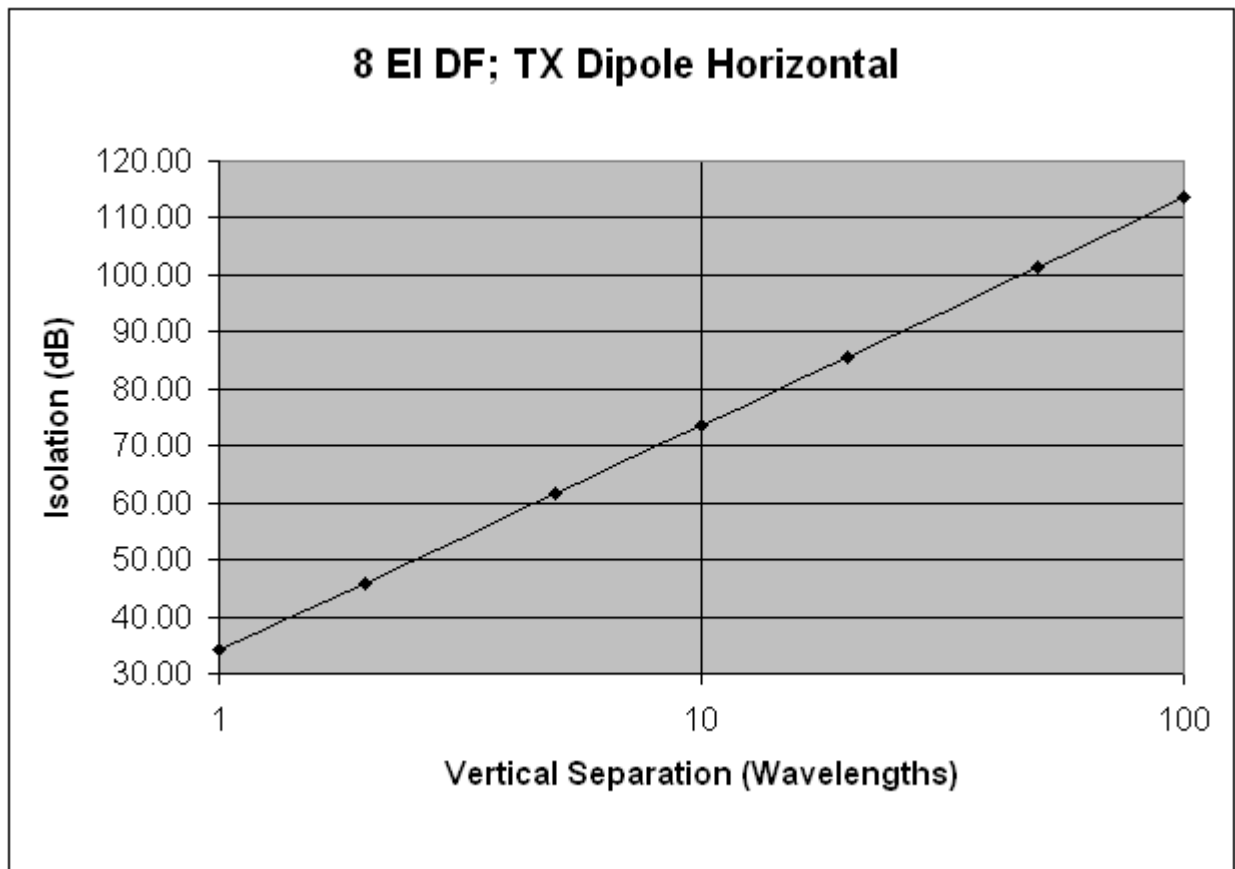
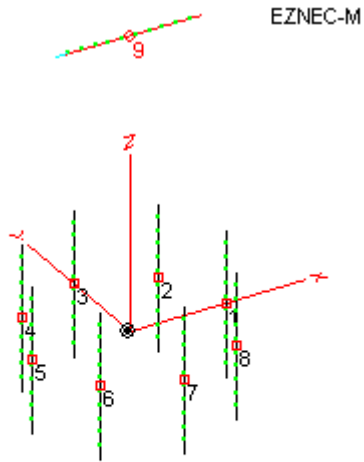


3.2 Transmit Antenna is Vertical Dipole Separated Horizontally

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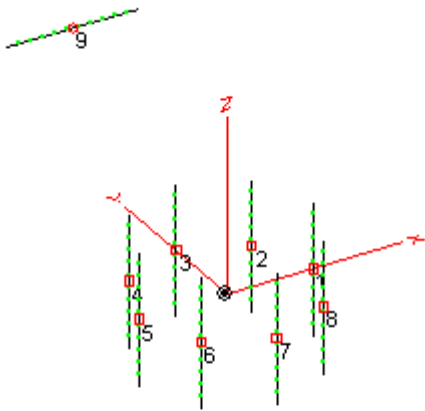
3.3 Transmit Antenna is Horizontal Dipole Separated Vertically



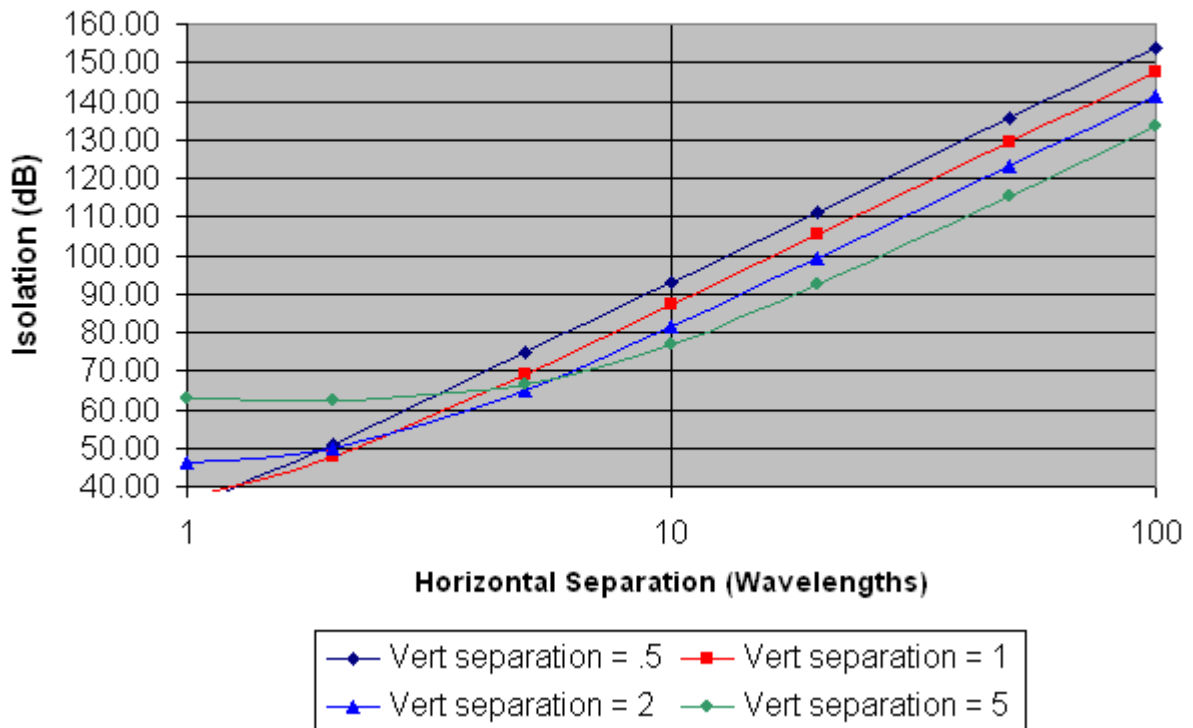
3.4 Transmit Antenna is Horizontal Dipole Separated Horizontally, Side to DF

If the vertical separation is exactly zero, there is no coupling (infinite isolation). Since this would be very difficult to achieve, curves are shown for several values of vertical separation.

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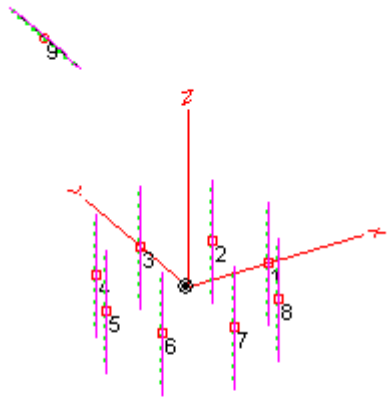
8 EI DF; TX Dipole Horizontal, Side to DF



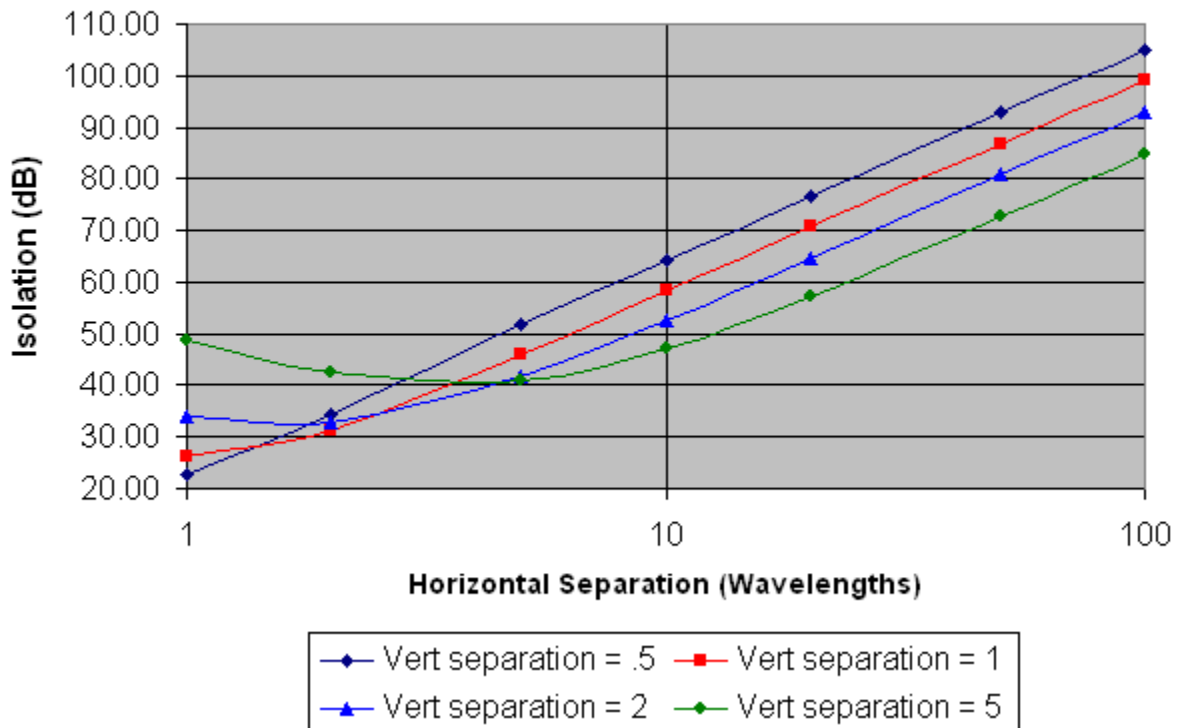
3.5 Transmit Antenna is Horizontal Dipole Separated Horizontally, End to DF

If the vertical separation is exactly zero, there is no coupling (infinite isolation). Since this would be very difficult to achieve, curves are shown for several values of vertical separation.

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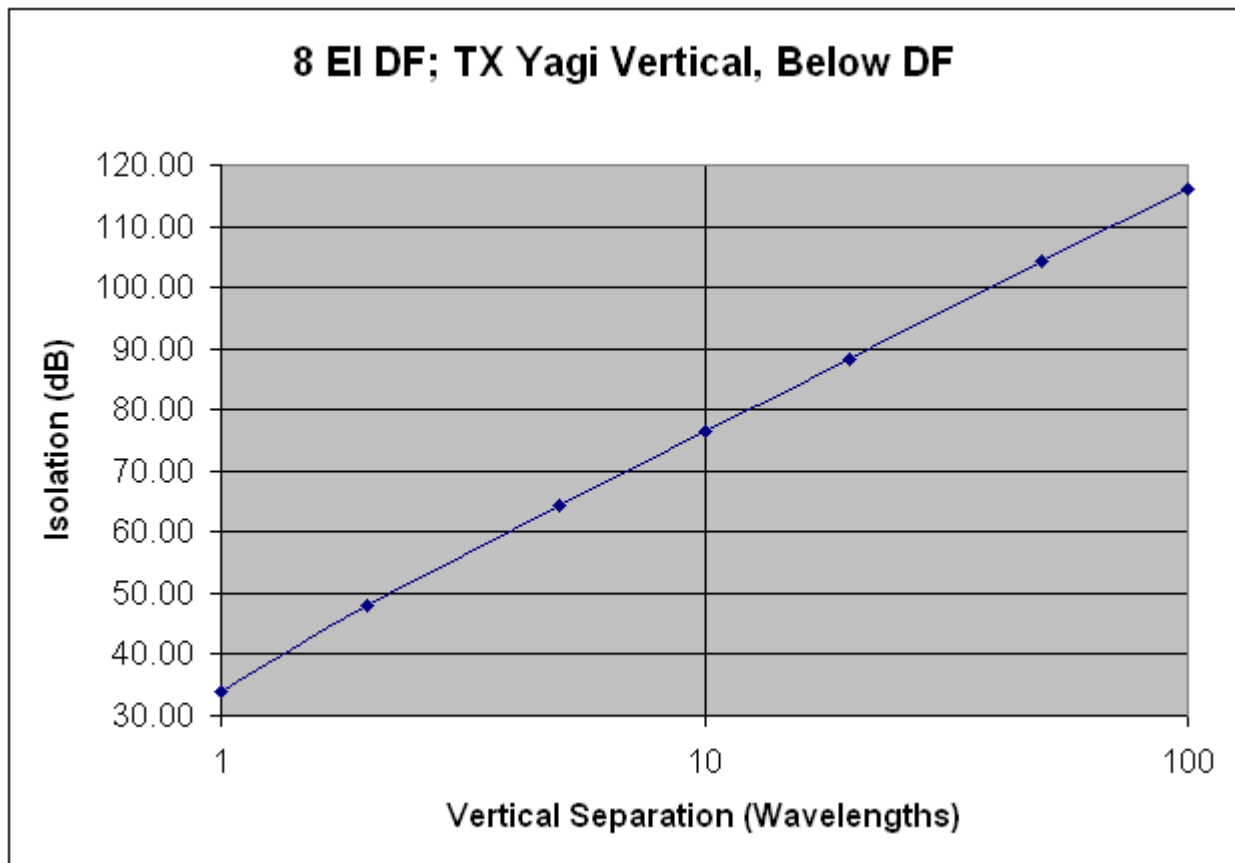
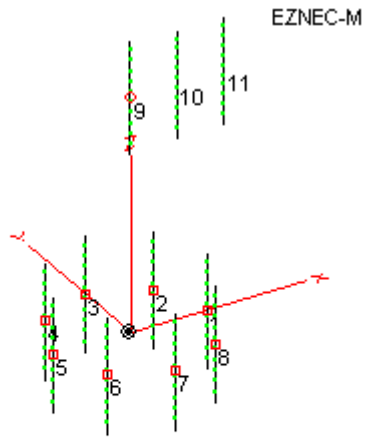


8 EI DF; TX Dipole Horizontal, End to DF



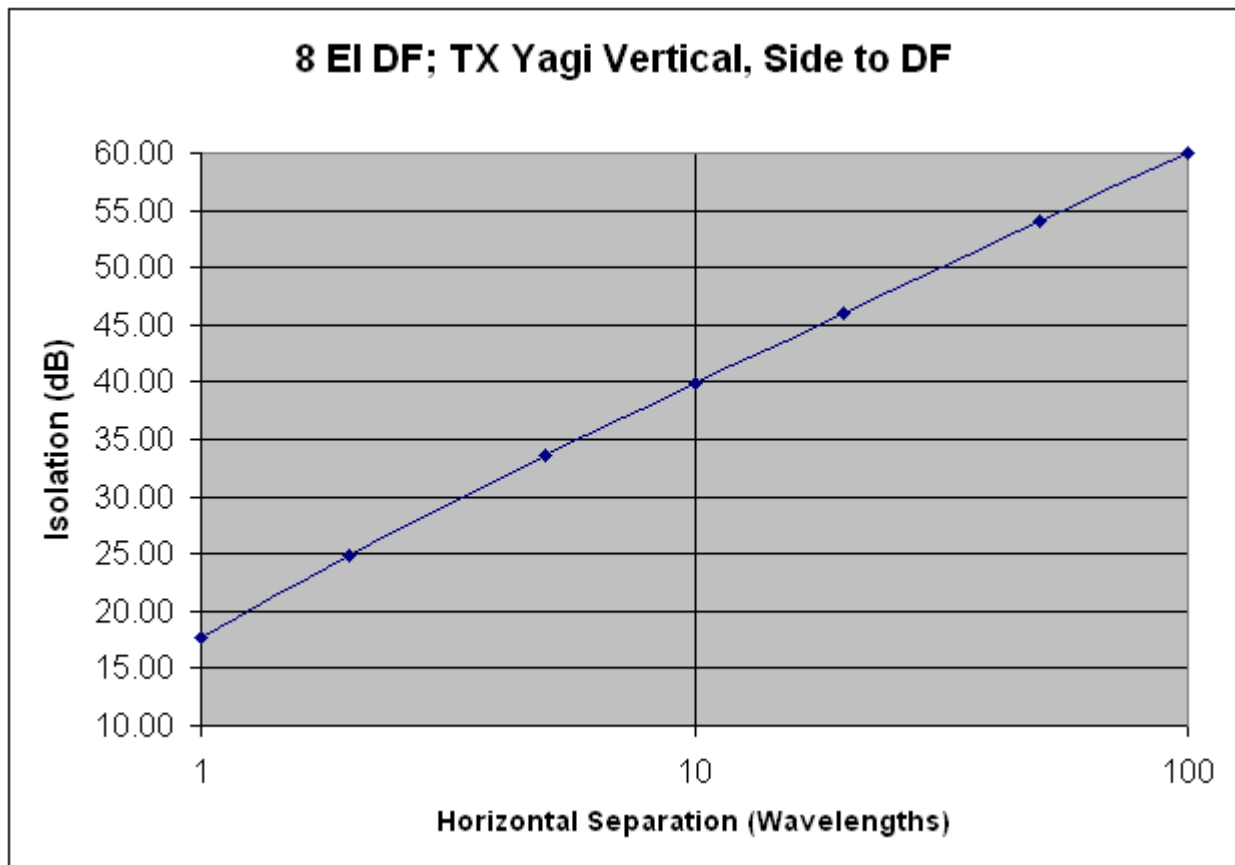
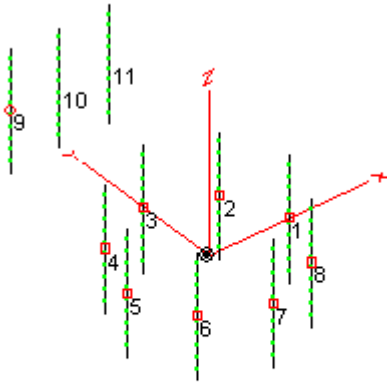
4.0 Isolation between Yagi Transmit Antenna and 8-Element DF

4.1 Transmit Antenna is Vertical Yagi Separated Vertically

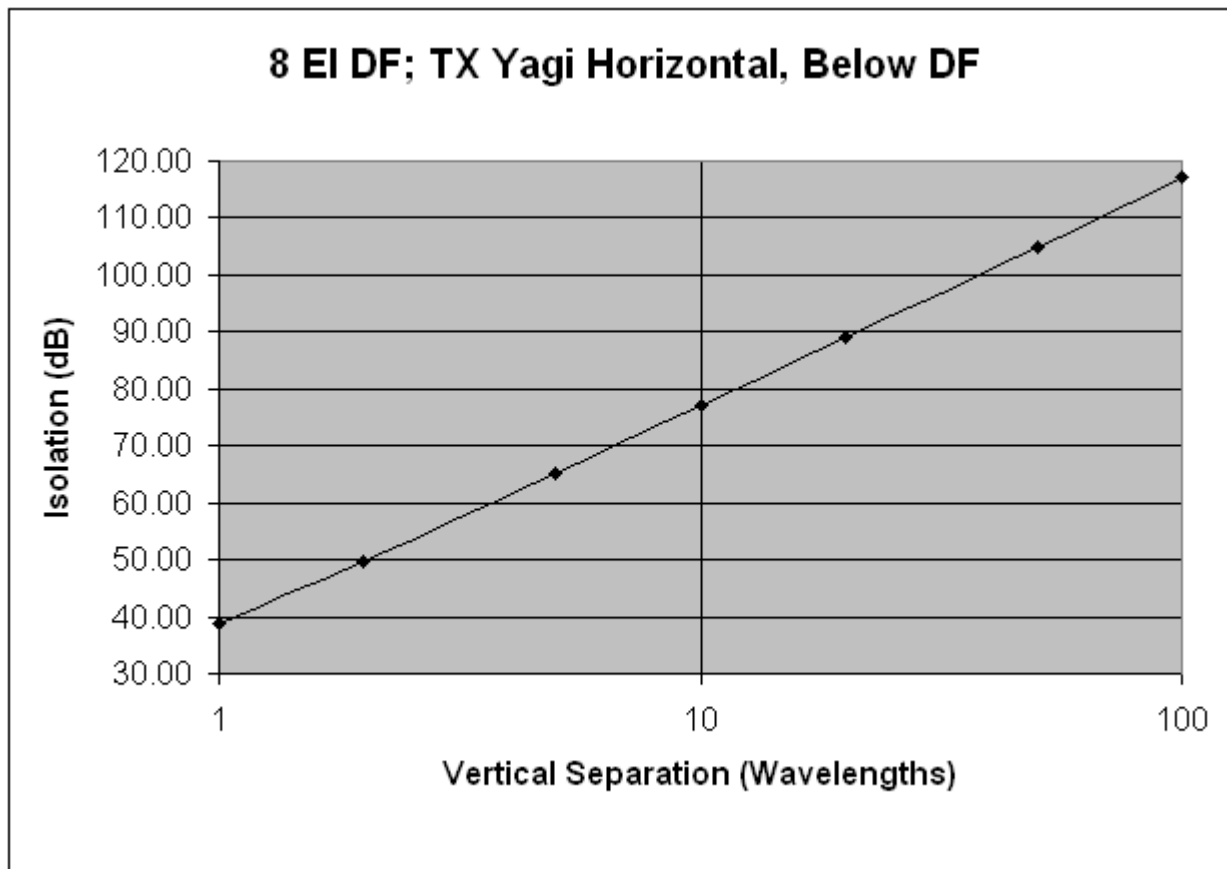
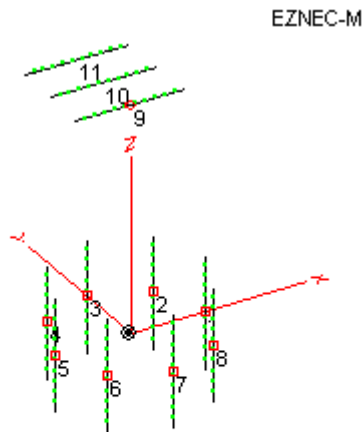


4.2 Transmit Antenna is Vertical Yagi Separated Horizontally

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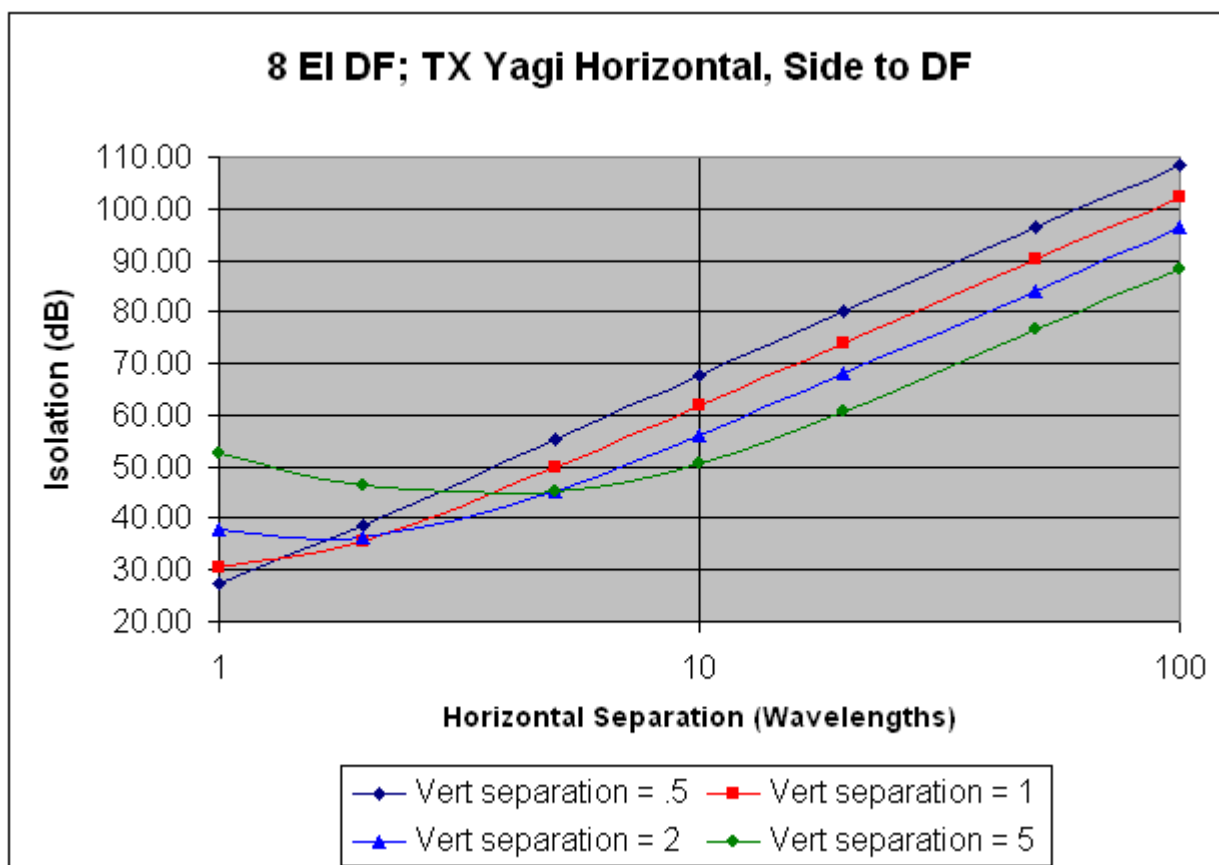
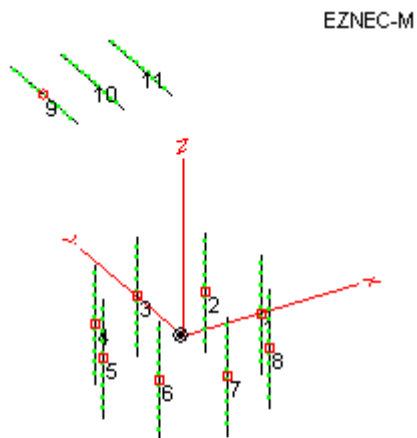


4.3 Transmit Antenna is Horizontal Yagi Separated Vertically



4.4 Transmit Antenna is Horizontal Yagi Separated Horizontally, Side to DF

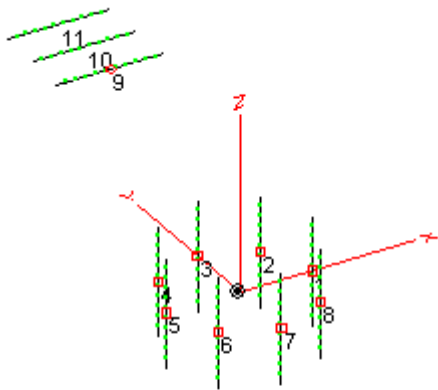
If the vertical separation is exactly zero, there is no coupling (infinite isolation). Since this would be very difficult to achieve, curves are shown for several values of vertical separation.



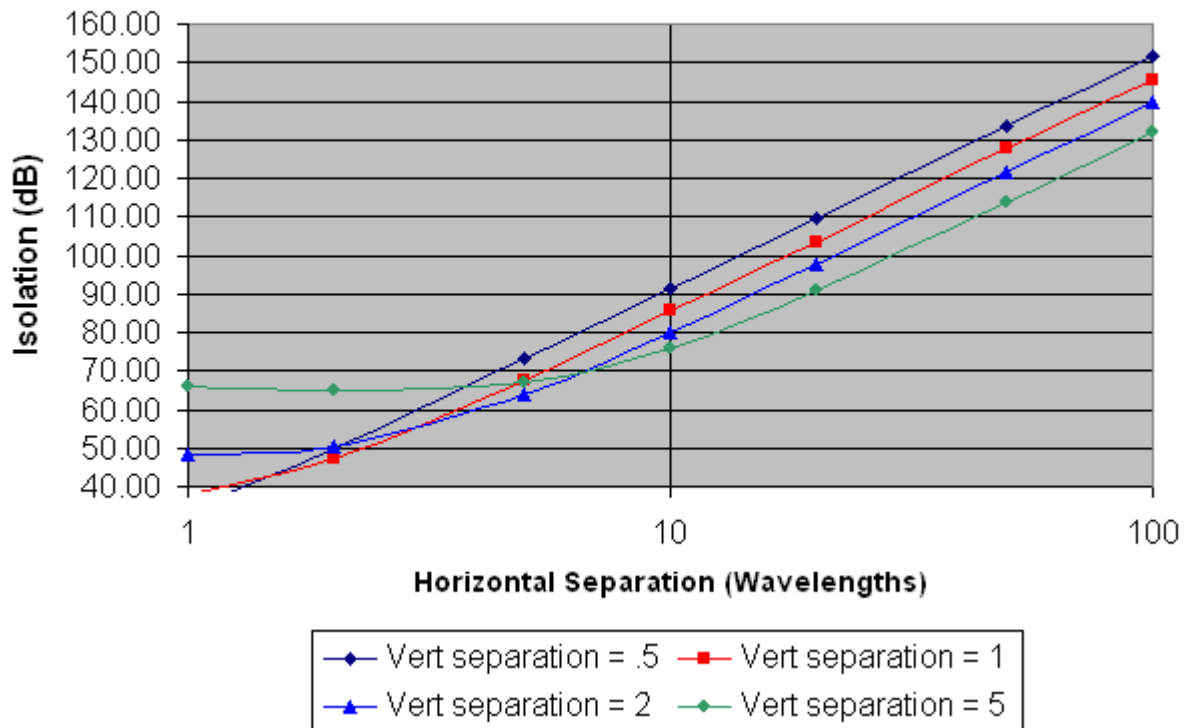
4.5 Transmit Antenna is Horizontal Yagi Separated Horizontally, Back to DF

If the vertical separation is exactly zero, there is no coupling (infinite isolation). Since this would be very difficult to achieve, curves are shown for several values of vertical separation.

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8 EI DF; TX Yagi Horizontal, Back to DF



5.0 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.

5.1 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 2.2, we need at least 1.5 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 3 meters behind the DF array. This assumes both antennas are on the same plane. Placing the transmit antenna on the trunk lid adds some vertical separation as well.

5.2 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 2.2, 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. Since this is impractical, this configuration should be avoided (at VHF).

6.0 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 dB.

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

6.1 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 5.5 wavelengths. If the yagi is horizontally polarized and mounted below the DF array, Section 4.3 indicates the vertical separation must be 5.0 wavelengths - only slightly less. At VHF, this corresponds to 10 meters, which may place the yagi too low on the tower.

An alternative solution is to place the yagi at the same height as the DF array on a separate tower. If the yagi is vertically polarized, it would have to be horizontally displaced by more than 100 wavelengths (Section 4.2). A better solution is to horizontally polarize the yagi. If the second tower is oriented such that the side of the yagi faces the DF array, and the heights are matched to within 0.5 wavelength, Section 4.4 indicates the horizontal separation should be at least 9 wavelengths. If the yagi faces away from the DF array, the horizontal separation should be at least 4 wavelengths (Section 4.5).

6.2 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 20 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 broadband. 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.