1 Alignment and the ADP equation

A number of questions have come up regarding the plotting of the experimental data and the theoretical ADP expression.

In most (if not all) electromagnetics books, the half-wave dipole is discussed as being aligned with the legs vertical, and a spherical coordinate system is then defined with the angle theta sweeping from one leg to the other, and the angle phi going around the antenna. Unfortunately the test stand in the anechoic chamber only rotates in the horizontal plane, forcing us to align it that way. The angles used in the first set of measurements are the same as theta from the ADP equation given as equation 1.

\[ ADP(\theta) = \cos(\cos(\theta)\pi/2)/\sin(\theta) \]  

(1)

In the second set of measurements \( \theta \) (you can hopefully determine what value it has) is a constant and you are sweeping through \( \phi \). In the final set you are also sweeping through \( \phi \) but because the incoming signal is cross polarized you see a very different value for the received signal.

2 Normalization and Plotting

You can use any of the listed programs to normalize the experimental data but to the best of my knowledge it is not possible to display the data in a polar plot in Excel. When you normalize the data from the first set of measurements you should have data ranging from 0 dB to approximately \(-40 dB\).

If you then go and try to plot the normalized data in matlab you probably ended up with something like what is shown in Figure 1. Recalling that this is a plot of received signal vs angle, this should strike you as being very wrong. According to this plot the maximum signal was recorded at 0° and 180° while when you took the data the maximums were at 90° and 270°. The problem here is in the way that matlab handles polar plots. It expects that the data will range from 0 at the center to some Rmax at the edge and due to the primitive nature of the polar plot routine, you cannot change the axis range. You can get the shape to be correct by subtracting the smallest recorded value instead of the largest. The results of this can be seen in Figure 2.

This gives the proper shape but has the wrong values for the tick marks on the radial axis. You could then manually change the tick marks to display the data properly but the quickest and easiest solution is probably just to normalize the data as described in the lab handout and use the attached m-file "dirplot.m" to plot the data. The dirplot function accepts the angles in degrees from -180 to 180 and will plot with a negative value at the center. Figure 3 shows the results of the first set of measurements, plotted using dirplot, if they were sample every 15° for the entire circle. Figures 2 and 3 do not overlay because the dirplot function rotates the image 90° so that 0 is at the top of the plot.

In normalizing the theoretical expression shown in equation 2 there are also
a couple of other little things that may cause problems.

\[ ADP(\theta)_{dB} = 20 \log_{10}(ADP(\theta)) \]  \hspace{1cm} (2)

You may want to shift the angles at which you calculate the ADP slightly to avoid a couple numerical problems. First off, if you sample at 0 and 180 degrees, you will end up with divide by zero errors from the \( \sin(\theta) \) portion of equation 1. Secondly, \( \lim_{x \to 0} \log_{10}(x) = -\infty \), so you may want to avoid the angles which make the linear ADP shown in equation 1 equal to zero. Finally, the linear ADP goes negative and the \( \log_{10} \) of negative numbers is complex. The log of a complex number \( z = a + jb \) is defined as :

\[ \log_{10}(z) = \log_{10}(|z|) + j\arctan(b/a) \]  \hspace{1cm} (3)

So since in the lab we measured intensities which are real valued you can either just take the real component of \( 20 \log_{10}(ADP(\theta)) \) or equivalently take \( 20 \log_{10}(|ADP(\theta)|) \) for your theoretical \( ADP(\theta)_{dB} \).
Figure 1: Completely messed up
Figure 2: Matlab polar plot with incorrect radial tick mark values
Figure 3: Sample dirplot output