

Simulation of Antenna Arrays: Part 4 - Simulation of An Array of Antennas

In this blog, the approaches used in Part 3 will be extended to allow prediction of the performance of an array of half-wavelength dipole antennas using array.

Use of array factors

In COMSOL Multiphysics 5.3a and earlier versions, the user had to define the array factor manually to calculate radiation pattern of an array of antennas. In COMSOL Multiphysics Version 5.4, calculation of the antenna array factor function is available in the RF Module. The array factor is defined under **Definitions > Functions** in the postprocessing context menu when the Far-field Calculation feature is present in the physics interface:

```
Component 1
  Definitions
    Component couplings
    Functions
      emw.af3(nx, ny, nz, dx, dy, dz, alphax, alphay, alphaz) - Uniform three-dimensional array factor
```

The arguments of the function `af3()` are defined as follows:

- n_x , n_y , and n_z are the number of elements along the x -, y -, and z -axis, respectively
- dx , dy , and dz are the distances between array elements in terms of wavelength
- α_x , α_y , and α_z are the phase progression in radians

This function evaluates the radiation pattern of an antenna array from a single antenna radiation pattern. By using an asymptotic approach, the far-field of a single antenna is multiplied by a uniform array factor; the function `af3()` is not normalized by the total number of array elements.

Arrays can be designed to radiate in either *broadside*, radiation perpendicular to array orientation (the y -axis in Figure 9), or *end-fire*, radiation in the same direction as the array orientation (the x -axis in Figure 9).

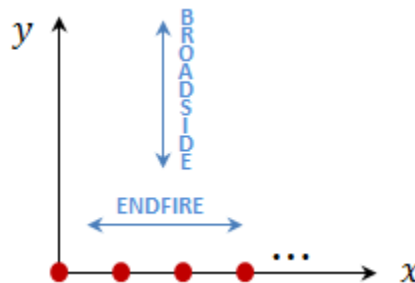


Figure 9: Design radiation patterns of linear array

For an idealized multi-element isotropic array along the x -axis a 2D polar plot can be used to visualize the radiation pattern. The evaluation plane for the radiation pattern is defined by the reference and normal directions. The **Reference direction** specifies the direction from which the plot angle is measured. In our case, we want to evaluate the radiation pattern in the xy -plane and use the

azimuth angle as an argument. We can use **Preview Evaluation Plane** option to make sure that evaluation plane is set as intended (Figure 10):

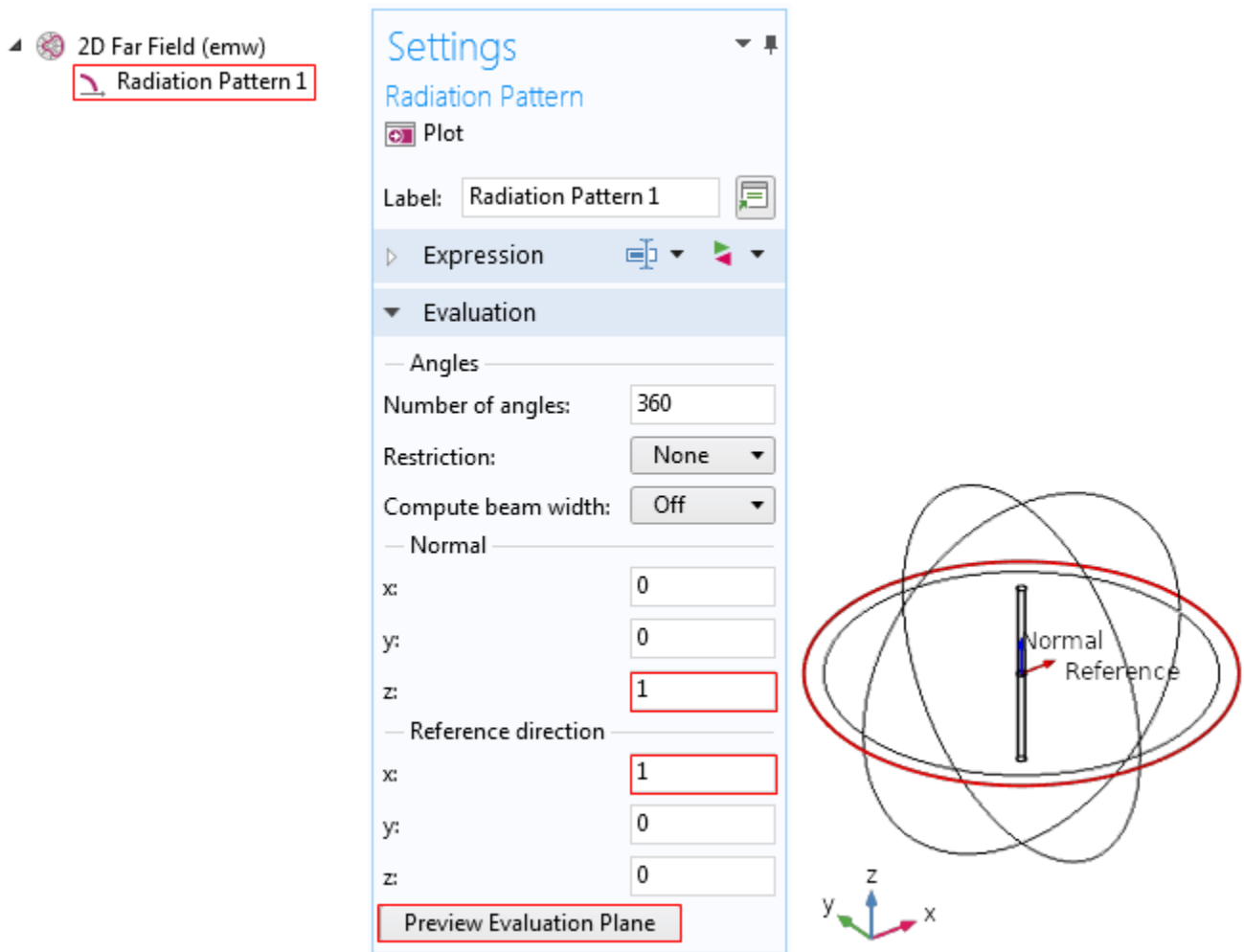


Figure 10: Evaluation plane setup for visualization of the radiation pattern

Once the evaluation plane is defined, the next step is to define the arguments of the function `af3()`. In this example we will visualize the angular pattern of the normalized gain of the of 8-element isotropic x –axis linear array. The array spacing $d_x = 0.25 \lambda$ with no excitation phase progression $\alpha_x = 0$. The normalized power gain of the isotropic array is defined as:

$$g(\theta, \varphi) = |A(\theta, \varphi)|^2$$

The expression to plot is shown in Figure 11:

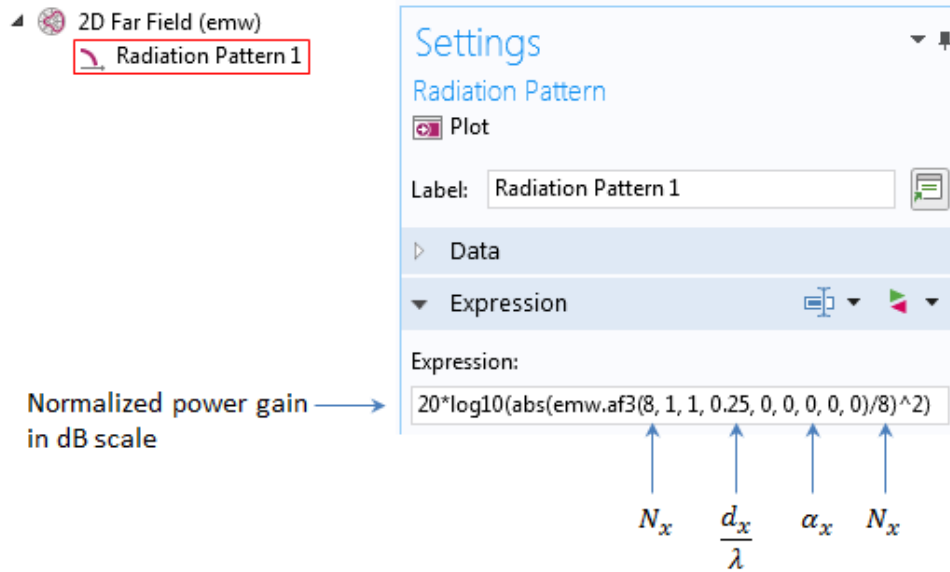


Figure 11: Settings window for the normalized power gain of 8-element x –axis linear array

Plots of the normalized power gain of the linear arrays are shown in Figure 12. The radiation pattern depends on the spacing between the elements; the broadside radiation pattern is plotted for a quarter-wavelength spacing between the array elements, left side of Figure 12; the end-fire radiation pattern is plotted for the full wavelength spacing, right side of Figure 12.

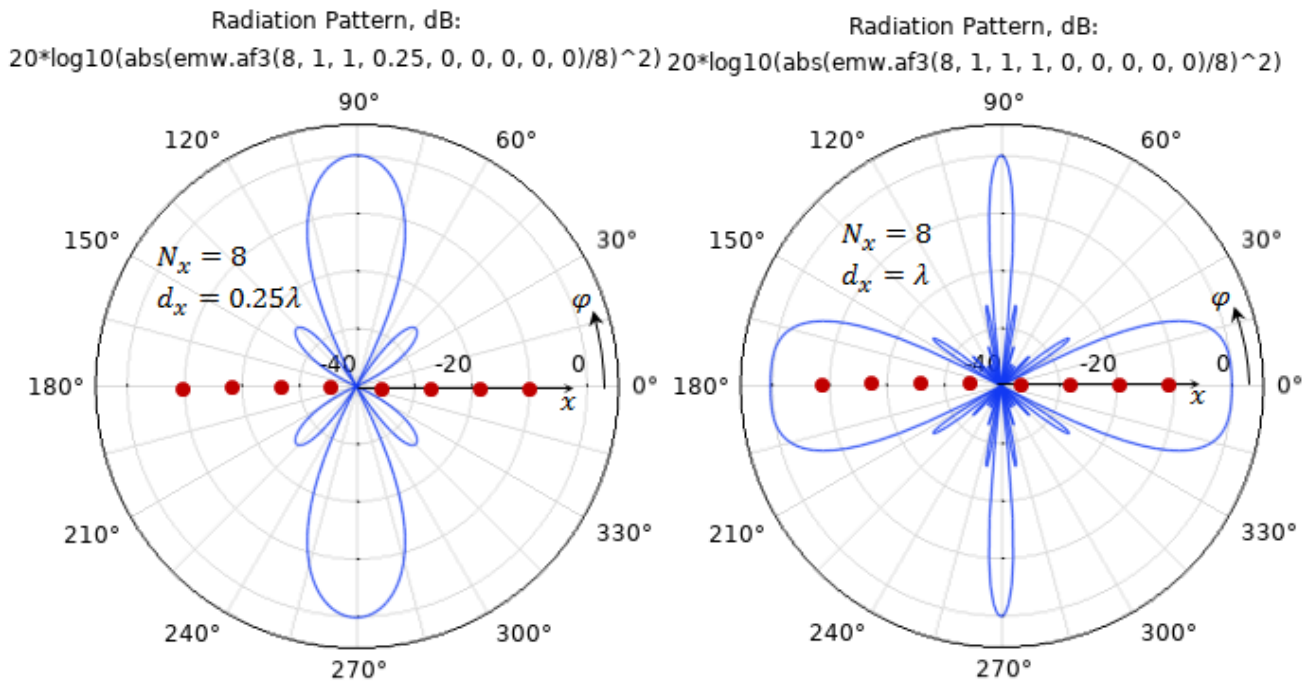


Figure 12: Normalized power gain of 8-element isotropic array

So far, we were concentrated on the arrays of isotropic elements, now we can apply the array factor to the half-wavelength dipole. Because of the array pattern multiplication property, the input for the array of the half-wavelength dipoles is straight-forward and is shown in Figure 13:

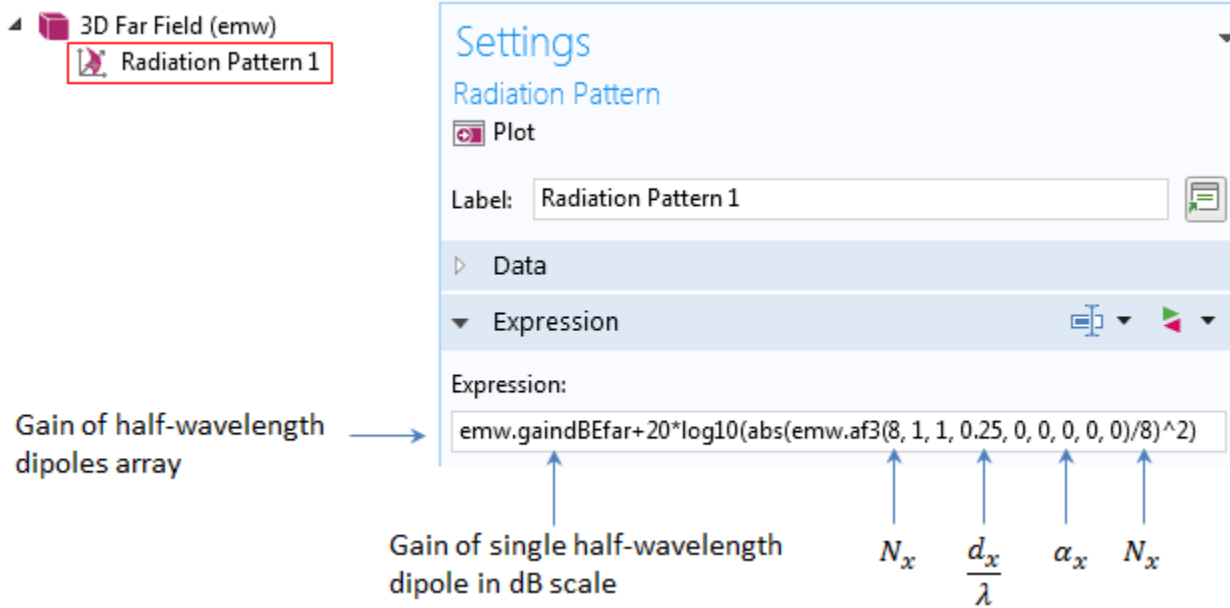


Figure 13: Settings window for the linear array gain of 8 half-wavelength dipoles

The radiation patterns of the half-wavelength dipole arrays are shown in Figure 14.

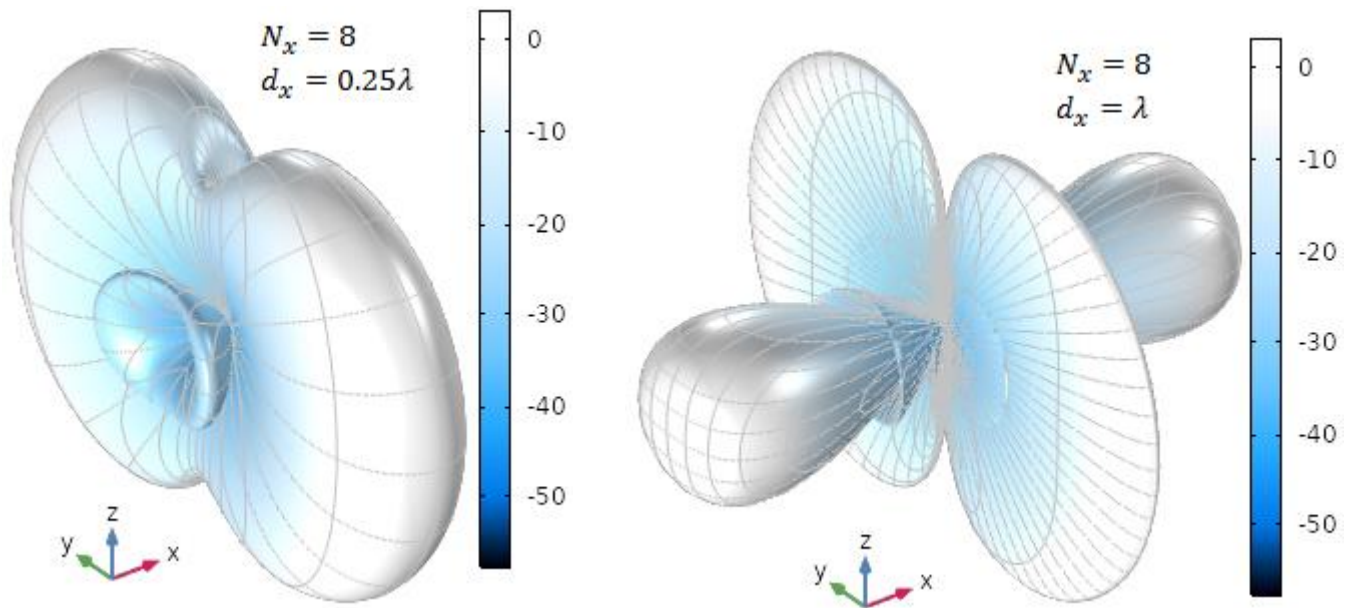


Figure 14: Radiation patterns of the half-wavelength dipoles x –axis arrays in two configurations: broadside (left) and end-fire (right)