Large Array Modeling - A Microstrip Case Study

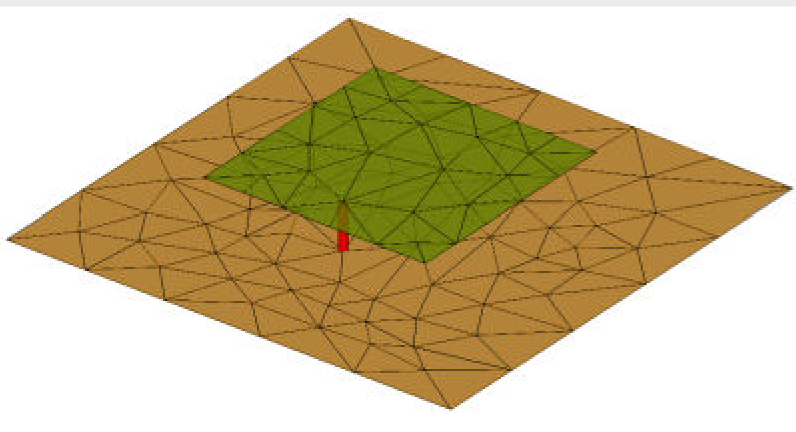
A 25 x 40 element microstrip array is used as a case study of how large antenna arrays may be modeled with the ideal transmitting antenna feature in FEKO.

Introduction: This case study aims to illustrate how large arrays may be modeled with FEKO. It considers a 25 x 40 microstrip patch array as example. The array consists of microstrip elements, depicted in Figure 1, with the following dimensions:

- λ/4 edge length square patch.
- λ/2 edge length square ground plane.
- λ/20 spacing between the patch and the ground plane.
- Feed pin λ/12 (patch edge length/3) in the x-direction from the centre of the patch.

The spacing from any element's centre to the centre of an adjacent element is always λ in the x and/or y direction, as applicable.

Figure 1: Array elements



Simulation steps

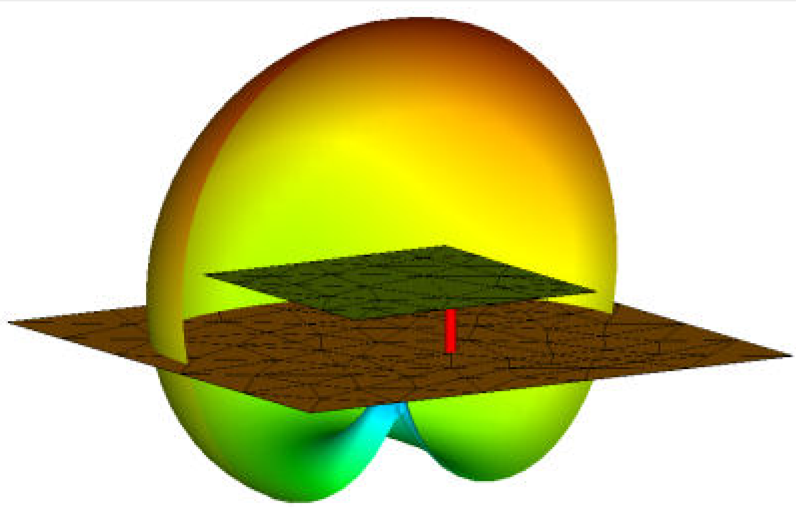
The simulation of this array will be conducted in the following logical steps:

- Construct a single element simulation model.
- Characterisation of nearest neighbour radiation coupling influence on array element radiation patterns.
- Decomposed 25 x 40 element array construction, using nearest neighbour radiation pattern data.
- Validation of 25 x 40 element array simulation results.

Single element simulation model

The 3D far-field simulation of the single patch model is depicted in Figure 2. It is noticeable that radiation is mainly vertical, with a zero directly below the patch. The maximum gain is approximately 5dBi.

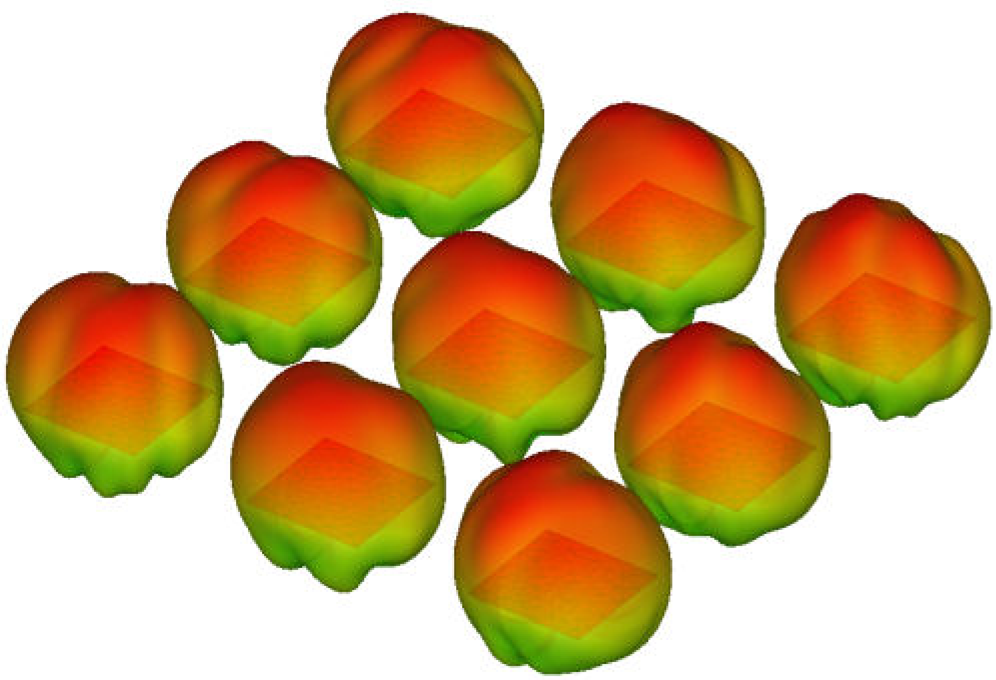
Figure 2: Single patch 3D far fields



Characterization of nearest neighbor radiation coupling influence on array element radiation patterns

The key to the use of the ideal transmitting antenna for the simulation of the large array is to state that adjacent elements will influence the radiation pattern of individual elements in the array. This influence is characterized with a simple 3 x 3 array. Each element is driven in turn, with all the other elements passive and terminated in 50 Ω, to derive the far-field pattern for each element in the presence of its neighbors. The resulting far-field patterns will be used as sources for each element in the eventual 25 x 40 array, each element in this array being replaced with an ideal transmitting antenna with the radiation pattern of the element with comparable geometry in the 3 x 3 characterization array. The 3 x 3 characterization array with element far-field patterns indicated is presented in Figure 3.

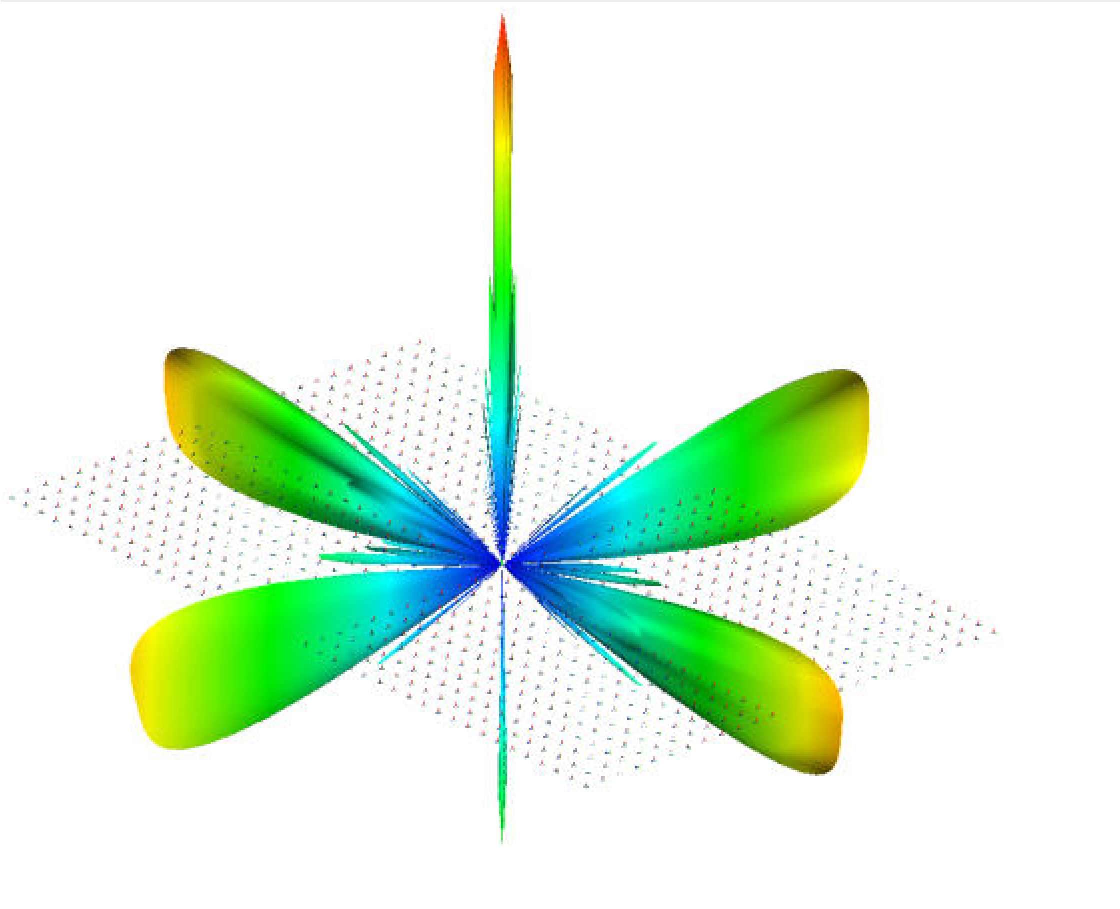
Figure 3: 3 x 3 array with far-fields for each element



Decomposed 25 x 40 element array construction

Once the characterization has been done, the 25 x 40 array can be simulated by selectively importing one of the nine radiation patterns which has the same relative position in the characterization solution. FEKO is ideally suited to this solution technique as it features the ideal transmitting antenna which can be used to import pre-calculated radiation patterns. The advantage to this method of large array simulation is that no mesh is created and no currents are computed, resulting in significant savings in simulation time and computational resource requirements. Figure 4 depicts the decomposed 25 x 40 element array simulation with far-field radiation pattern shown.

Figure 4: 25 x 40 array with decomposed solution far-fields computed at 1° resolution



Validation of 25 x 40 element array simulation results

The approach to the simulation of large arrays that is described here is applicable to much larger arrays. A "modest" 25 x 40 element array was chosen to enable an MLFMM solution of the entire structure for comparison with the decomposed solution. Figure 5 (a), (b) and (c) present comparisons between horizontal and vertical far-field cuts as computed with the decomposed array and MLFMM techniques. From these figures it is evident that the comparison is satisfactory, validating the decomposition technique for simulation of large arrays, e.g. 1000 x 1000. The small offset that is visible in the absolute gain/directivity value can be attributed to the presence/absence of losses (loads) in the reference/decomposed solution.

Figure 5: Comparison of MLFMM and decomposed solutions for a 25 x 40 element array

(a) Horizontal plane

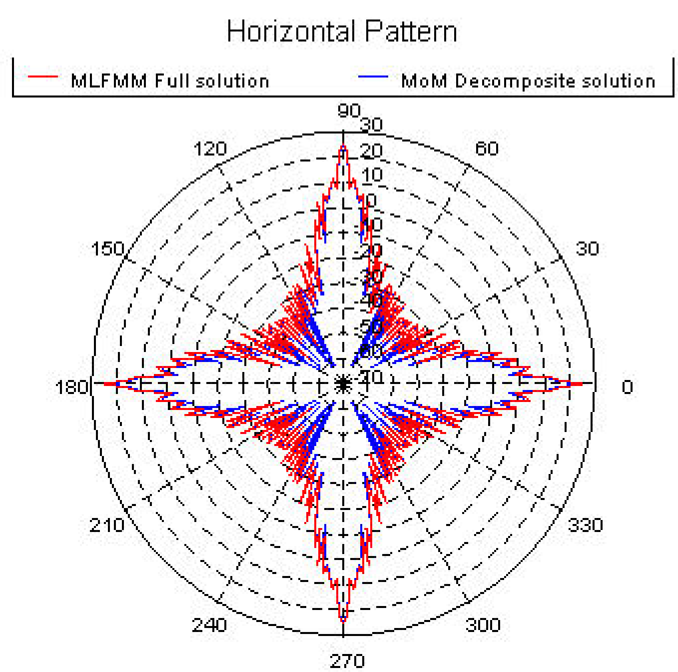
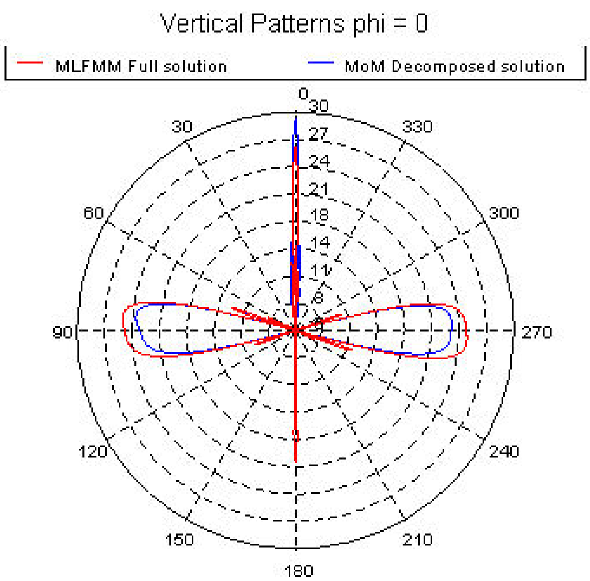


Figure 5: Comparison of MLFMM and decomposed solutions for a 25 x 40 element array

(b) Vertical plane (ϕ = 0)



(c) Vertical plane (ϕ = 90)