Patch_Array_Antenna

Where To Find This Example

Select Help > Open Examples... from the menus and type either the example name listed above or one of the keywords below.

Or in Version 14 or higher you can open the project directly from this page using this button. Make sure to select the Enable Guided Help before clicking this button.

Open Install Example

Design Notes

Patch Array Antenna Example

This example project illustrates the simulation of an array of microstrip patch antennas. The EM structure "Single_Element" models one element using AXIEM. The EM structure "16_Element_Array" is for calculation of the port properties and antenna pattern of the 4 by 4 patch array again using AXIEM.
The circuit schematic "Antenna_Array_Design" combines the array EM structure and the feed network "Full_Feed_Network" which adjusts the magnitude and phase of port excitations to steer the main lobe of the antenna. This direction is controlled by variables Phi & Theta found under Global Definitions in the Project browser. Variable Atten_Taper is used to adjust the level of the side lobes.
Graph "1_Far_Field_Pattern_Array" plots the far field pattern of the array as fed by the full feed network. It uses the in-situ measurement to account for the effect of feed network in the far field pattern. Please consult installed example "InSitu_Polarization_Diversity.emp" for more details of the in-situ antenna measurement.

Graph "2_Peak_TWP_vs_Freq" plots as a function of frequency the peak total radiation power of the array as fed by the circuit. This is again an "in-situ" measurement which accounts for the effect of circuit feed model.
Graph “3_Angle_Theta_of_Peak_TWP_vs_Freq” plots, as a function of frequency, the “theta” angle toward which the maximum power is radiated by the array as fed. It uses also in-situ measurement. The global definition has “Theta=30”, so we expect that the peak angle theta should be 30 degree at 2.6 GHz. The curve here shows a value of around 26.5 degree, which is shifted away from the desired goal of 30 degree. As shown in the far field pattern of graph 1, there is a very small difference between the power radiated toward the two angles. Mutual coupling between the patches is ignored in calculation of the feeding signals for steering but is accounted for in calculation of the in-situ far fields. This is the main cause for the difference.
Graph "4_Angle_Phi_of_Peak_TWP_vs_Freq" plots the "phi" angle of the maximum radiated power.
Graph "5_Active Impedance" shows the active reflection coefficients as seen at several ports of the antenna array when it is fed by the feed network. These correspond to the active impedances of the antenna elements. Active impedance is normally not directly output from EM simulation as it is dependent on the excitations at the ports. Here, the values are obtained by inserting a series of gamma probe GPOBE2 elements in the circuit schematic at the junctions between the feed network and the EM structure subcircuit. The "Active Impedance" graph will update slightly as each radiator couples to others. The isolation resistor in the Wilkinson feed networks helps mitigate the different impedances seen by each patch as the array is steered. If you change the "Global Definition" Riso to a large number, such as 1000, there is no longer isolation between each path of the Wilkinson and the impedances of the individual patches will vary much more.
Graphs "6_Feed_Phase" and "7_Feed_Magnitude" show the excitation signals generated by the feed network. Note that these are essentially calculated by the closed form formula inserted in the schematic "Module". Observe that in the array EM structure, the centers of the adjacent array elements are separated by 2000mils along both x and y. Global variables "XPos" and "YPos" are two linear arrays both with a step size of 2000. These are used to determine the magnitude and phase of port excitations so as to steer the main lobe. Exact origin of the coordinate system is not important. Shifting the origin would move the phases of all port signals uniformly by the same amount. The number C=11803 within schematic "Module" is simply the light speed in mils/second scaled by 10^-9 to account for the frequency unit in GHz.

Graph "8_Coupling_RawSP" examines the S-parameters calculated by AXIEM. Due to symmetry, coupling between ports 1 and 2 should be very close to that between ports 13 and 14. Likewise for the port pair doublets 1 & 5 and 13 & 9. There are some difference between the S-parameters as shown in this graph. Consequently, the active impedances shown in graph 5 also lack the expected symmetry. To obtain a better agreement, open the AXIEM option tab for the array EM structure, find the "Compression Accuracy" under "Iterative Solver Options" and set it to "Very High" (instead of the default value of "Medium"). Rerunning the simulation would cause the corresponding pair of curves to overlap with each other.

More Details of the Hierarchical Design in the Feed Network

The feed network is designed with an ideal version of a Wilkinson, in the "Power_Divider" schematic. The "Manifold" schematic then builds up the single divider into a 4 way divider. The "Full_Feed_Network" schematic then uses the "Manifold" 4 way divider to first split the signal to drive the different columns of the array and then 4 additional "Manifold" 4 way dividers finally create the 16 way power divider structure.

The phase/magnitude control is implemented with the core schematic named "Module". The "TR_Module_Array" schematic implements one row of the array (notice the ColIndex parameter is set and passed down to the lower level). Then each row is integrated into the "Full_Feed_Network" at the end of each power divider and the RowIndex in passed down from this level.
The "Module" schematic uses values defined in the "Global Definitions" document as well as patch position (row and column) passed into the schematic from the higher levels of hierarchy to calculate the phase and attenuation needed to feed each patch element. View the global definitions to see which values are defined there and then view the "Module" schematic to see the equations to calculate the phase and attenuation.