Horn-Fed Reflector Antenna

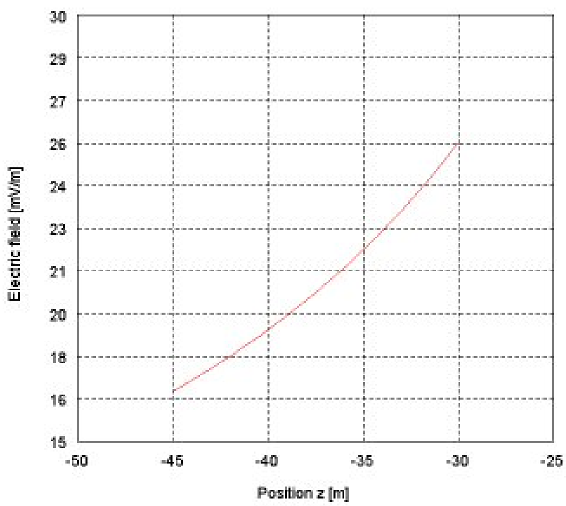
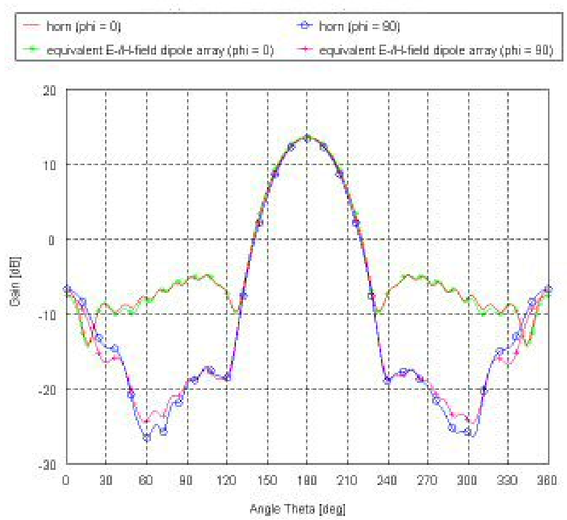
A horn-fed parabolic reflector is modeled in FEKO to determine its radiation pattern

Horn antennas are known for their high gain characteristics and are a popular choice for feeding reflectors in high gain applications such as satellite communications. In designing an antenna-reflector system there are many degrees of freedom and a genetic algorithm optimized design for a horn-fed parabolic reflector is given in [1]. As reflector antennas are electrically very large, simulating directly with the method of moments (MoM) becomes inefficient and hybrid simulations (e.g. method of moments / physical optics, MoM/PO) are used as shown in [2]. Here the horn antenna of [1] is used to illuminate a parabolic reflector and the radiation pattern is calculated.

The reflector system is shown in Figure 1. As the electrical size of the problem is very large a hybrid MoM/PO is applied to the complete system as shown in Figure 1. Another way of increasing computational efficiency is by separating the complete system into a horn feed and a reflector. Following this approach, the horn antenna is modeled on its own and the near-field is determined on a surface enclosing the horn. This near-field data is then used to construct an equivalent array of magnetic and electric dipoles which is then used to illuminate the reflector. It is also possible to create an equivalent point source from the horn antenna far-field pattern and use this source to illuminate the reflector. However, since the reflector is not in the far-field region of the horn antenna this method would deliver inaccurate results.

The placement of the horn is such that its phase center is at the focal point of the parabolic reflector. To determine the phase center of the horn the electric field is calculated in the far-field region of the horn on an axis passing through the center of the horn. As the electric field is known to decay as 1/r in the far-field region, extrapolating from the calculated field to the point where the singularity occurs gives the phase center. The electric field is shown in Figure 2a (calculated roughly 100~150 wavelengths from the horn aperture). Near-field data on a closed surface around the horn is also used to create an equivalent array of magnetic and electric dipoles. A sample resolution of 5 near-field points per wavelength is used and the radiation patterns of the horn antenna and the equivalent array are compared in Figure 2b.

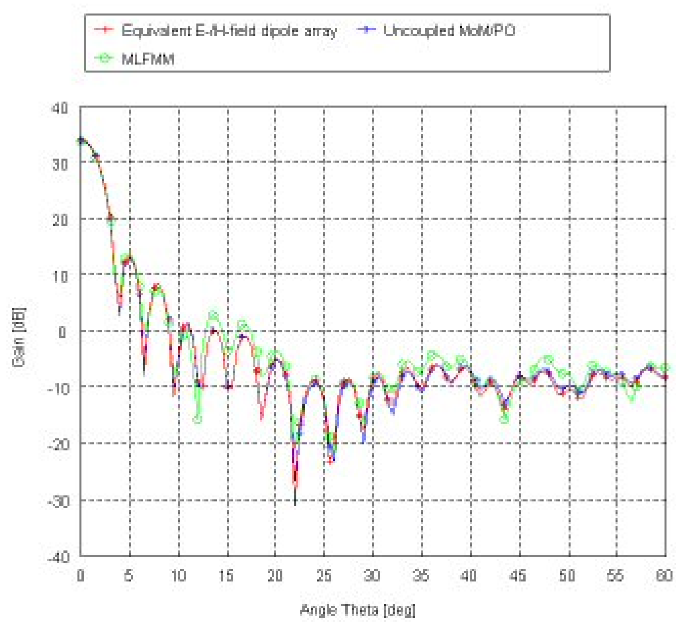
Figure 2: Horn antenna simulation results reflector

(a) Electric field in far-field region of horn	(b) Radiation pattern of horn and equivalent source
	

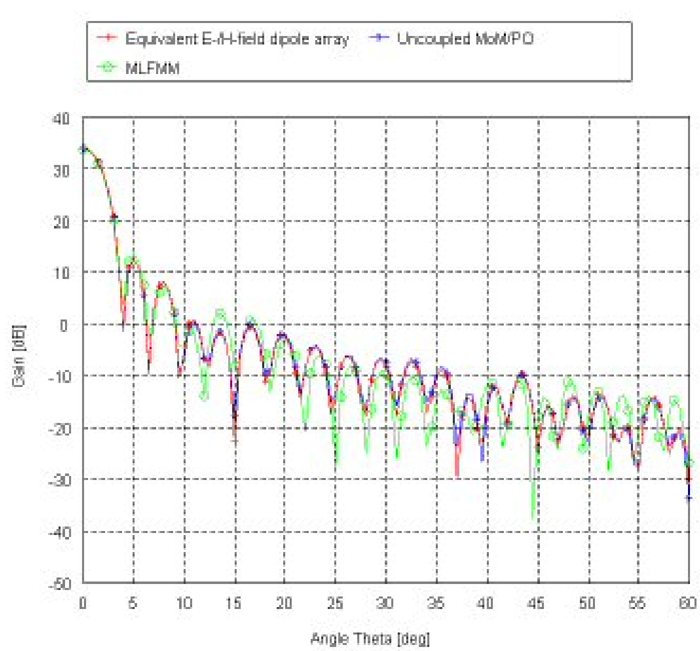
Using the equivalent array, the parabolic reflector is illuminated and the gain pattern is calculated. As the problem is still electrically large the hybrid MoM/PO method is used. For comparison, the horn antenna and reflector are also simulated with the MoM/PO method and also using the multi-level fast multi-pole method (MLFMM). Gain patterns for the three simulations are compared in Figure 3. The angle phi is measured in the xy-plane from the x-axis and the angle theta is measured from the z-axis.

Figure 3: Gain patterns of illuminated reflector

(a) phi = 0



(b) phi = 90



The difference in accuracy resulting from substituting the horn antenna with an equivalent array of electric and magnetic dipoles is negligible while the computational efficiency is improved considerably. Using the equivalent source results in a 35.8% decrease in computational time and a 94.9% decrease in memory requirements for the reflector simulation.

References

[1] R.L. Haupt, "A Horn-Fed Reflector Optimized with a Genetic Algorithm", IEEE/ACES International Conference on Wireless Communications and Applied Computational Electromagnetics, April 2005, pp. 517-520.

[2] S.J. Franson, "Invited Paper - Hybrid Simulation of Electrically Large Millimeter-Wave Antennas", IEEE/ACES International Conference on Wireless Communications and Applied Computational Electromagnetics, April 2005, pp. 505-508.