Application of FEKO for Rotman Lens

Introduction

Applications such as satellite and radar antennas require Beam Forming Networks (BFN) to produce correct feeding phases and amplitudes for their phased arrays. The Rotman lens is an example of a BFN with wide bandwidth and wide scan angle. Given the nature of the printed structure of Rotman Lens, method of moments (MoM) with Planar Green's Function is very suitable considering both accuracy and computation efficiency. In [1], simulations of Rotman lens are conducted with MoM in FEKO, and excellent agreement with measured data is observed.

Rotman Lens Model in FEKO

The Rotman Lens under consideration is 8x8 microstrip lens, with the layout shown in Fig. 1, whose beam ports 1 through 8 are marked as 1, receiving ports 9 through 16 are marked as 2, and dummy ports are marked as 0. Fig. 2 shows the Rotman lens prototype that was fabricated by the Army Research Lab in Adelphi, MD. This lens was designed at center frequency 4.6 GHz, and extensive S-parameter measurements were taken [2].

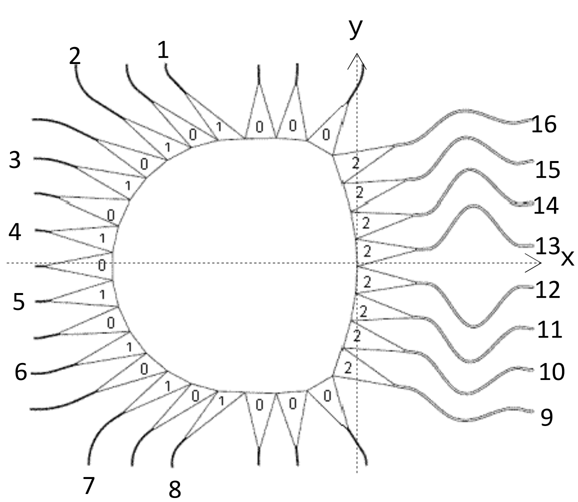

Fig.1. Rotman lens layout.

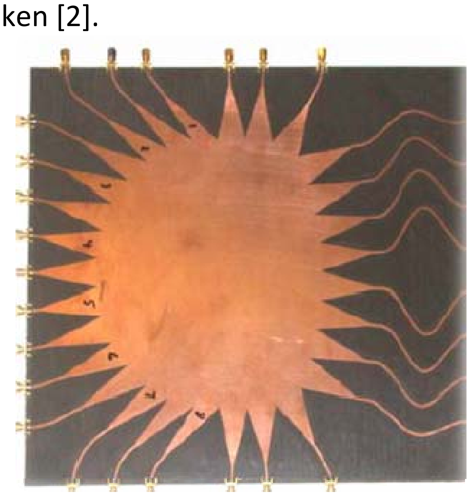

Fig. 2. Fabricated Rotman lens prototype.

Full wave analysis of this Rotman Lens is performed with the Planar Green's Function solver in FEKO. Each input/output is modeled as microstrip port. Each port is assigned 50-Ohm load so that when any beam port is excited, all others are terminated. The S-parameters between the beam ports and the receiving ports are registered. Eleven discrete frequency steps from 4 to 5 GHz were simulated.

For performance across the receiving aperture, the amplitude and phase couplings are studied when single ports are excited at a single frequency. For performance across the frequency band, the beam-port to receiving-port couplings with amplitude and phase are compared.

Couplings across Aperture at 4.6 GHz

In both simulations and measurements, the data achieved include the port-to-port S-parameters with amplitude and phase information. For Rotman lens design, a primary objective is for the single port excitation to produce the right amplitude taper and linear phase information across the receiving array aperture at the desired frequency. Fig. 3 shows the surface current distribution when a single port is excited at 4.6 GHz.

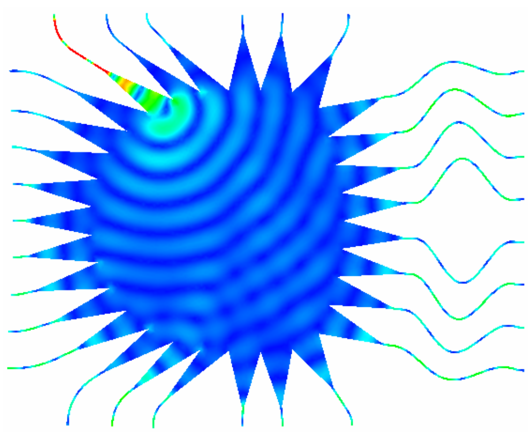

Fig. 3. Surface current distribution for a single port excitation.

In Fig. 4 and Fig. 5, the simulated amplitude coupling and phase shift between beam ports (1-4) and all receiving ports (9-16) at 4.6 GHz are compared with measured data in 3-D plots. Excellent agreement between the simulation and measurement is observed.

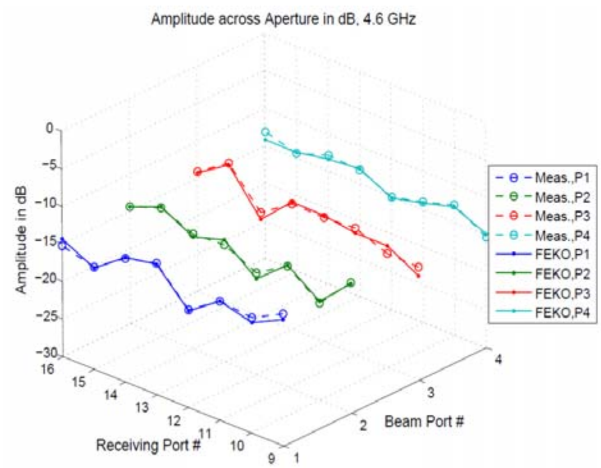

Fig. 4. Comparison between FEKO and measurements for amplitude taper across the aperture at 4.6 GHz.

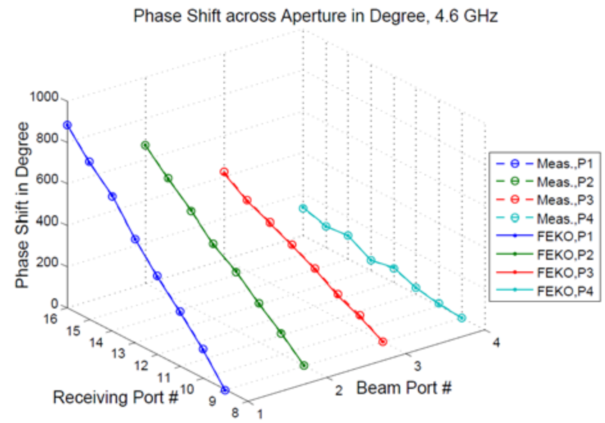

Fig. 5. Comparison between FEKO and measurements, for phase shift across the aperture at 4.6 GHz.

Couplings across Aperture for 4-5 GHz Band

The insertion loss across frequency band for single beam-port to receiving-port is another important factor from the communications system design point of view. This reflects how much of gain variation tolerance over the frequency the device possesses. Besides, the phase variations across the frequencies may be significant if the medium is dispersive. In Fig. 6 and Fig. 7, the amplitude and phase couplings between the chosen beam ports (5, 6, 7, 8) and chosen receiving ports (13, 14, 15, 16) are plotted across 4-5GHz. Again, it is observed that the simulation results agree very well with the measurements.

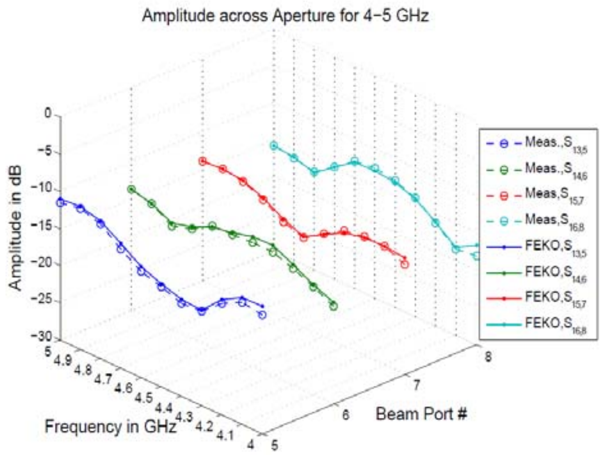

Fig. 6. Port to port amplitude coupling comparison between FEKO and measurements for 4-5 GHz.

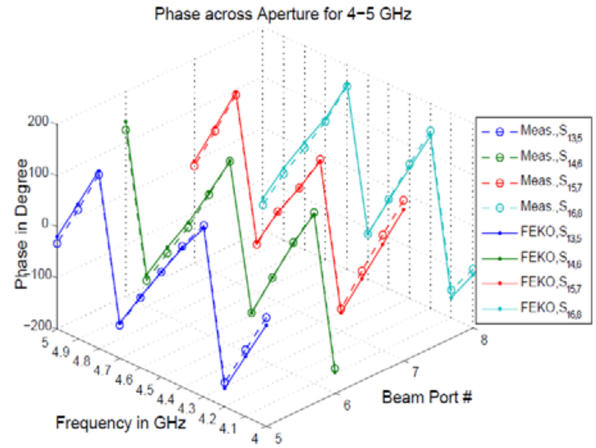

Fig. 7. Port to port phase coupling comparison between FEKO and measurements for 4-5 GHz.

[1] J. Dong, A. Zaghloul, R. Sun, C.J. Reddy, and S. Weiss, " Rotman Lens Amplitude, Phase, and Pattern Evaluations by Measurements and Full Wave Simulations," Applied Computational Electromagnetic Society (ACES) journal, vol. 24, no. 6, pp. 567-576, December 2009.

[2] S. Weiss, S. Keller, and C. Ly, "Development of Simple Affordable Beamformers for Army Platforms," in Proceedings of GOMACTech-07 Conference Lake Buena Vista, FL, 2006.