REMCOM®

Remcom, Inc.

315 South Allen Street
Suite 416
State College, PA 16801

www.remcom.com
sales@remcom.com

Toll free: 1-888-7-REMCOM
Tel: 1-814-861-1299
Fax: 1-814-861-1308

RLD

Rotman Lens Designer

$$\nabla \times E = -\frac{\partial B}{\partial t}$$

General Capabilities

- RLD is a special-purpose software tool for designing Rotman Lenses
- It is based on theoretical equations and Geometrical Optics
- Calculations are performed in real time with interactive redrawing of the design and output quantities
- It is intended for microstrip and stripline lenses at frequencies up to 45 GHz
- It is cross platform compatible for Windows and Linux

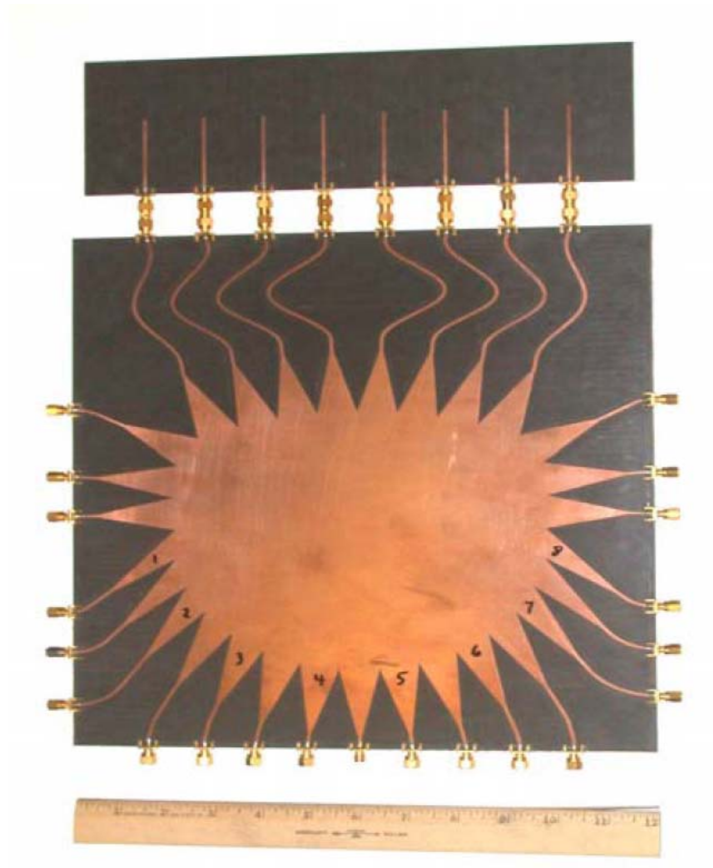
$B = \mu H$ $\nabla \cdot B = 0$ $\nabla \cdot D = \rho$ $D = \epsilon E$

Background

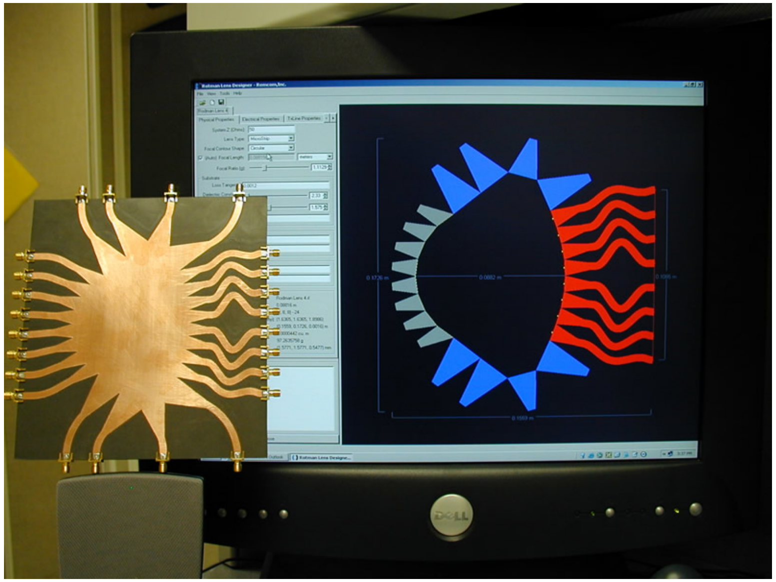
- RLD grew out of a US Army SBIR from the Army Research Laboratory
- Army needed a tool for designing low cost, true time delay beamformers
- Available as a commercial product since 2006
- Successfully used by both the US Army and academic researchers to design and fabricate Rotman Lenses
- Measured results of fabricated lenses have shown good agreement with RLD calculations (see references)

REMCOM

Lenses Built with RLD



4.6 GHz, 8 beam lens
Courtesy Dr. Steven Weiss
US Army Research Laboratory



10 GHz, 8 beam lens shown with RLD design
Courtesy Dr. Erik Lenzing
Penn State Applied Research Laboratory

$B = \mu H$ $\nabla \cdot B = 0$ $\nabla \cdot D = \rho$ $D = \epsilon E$

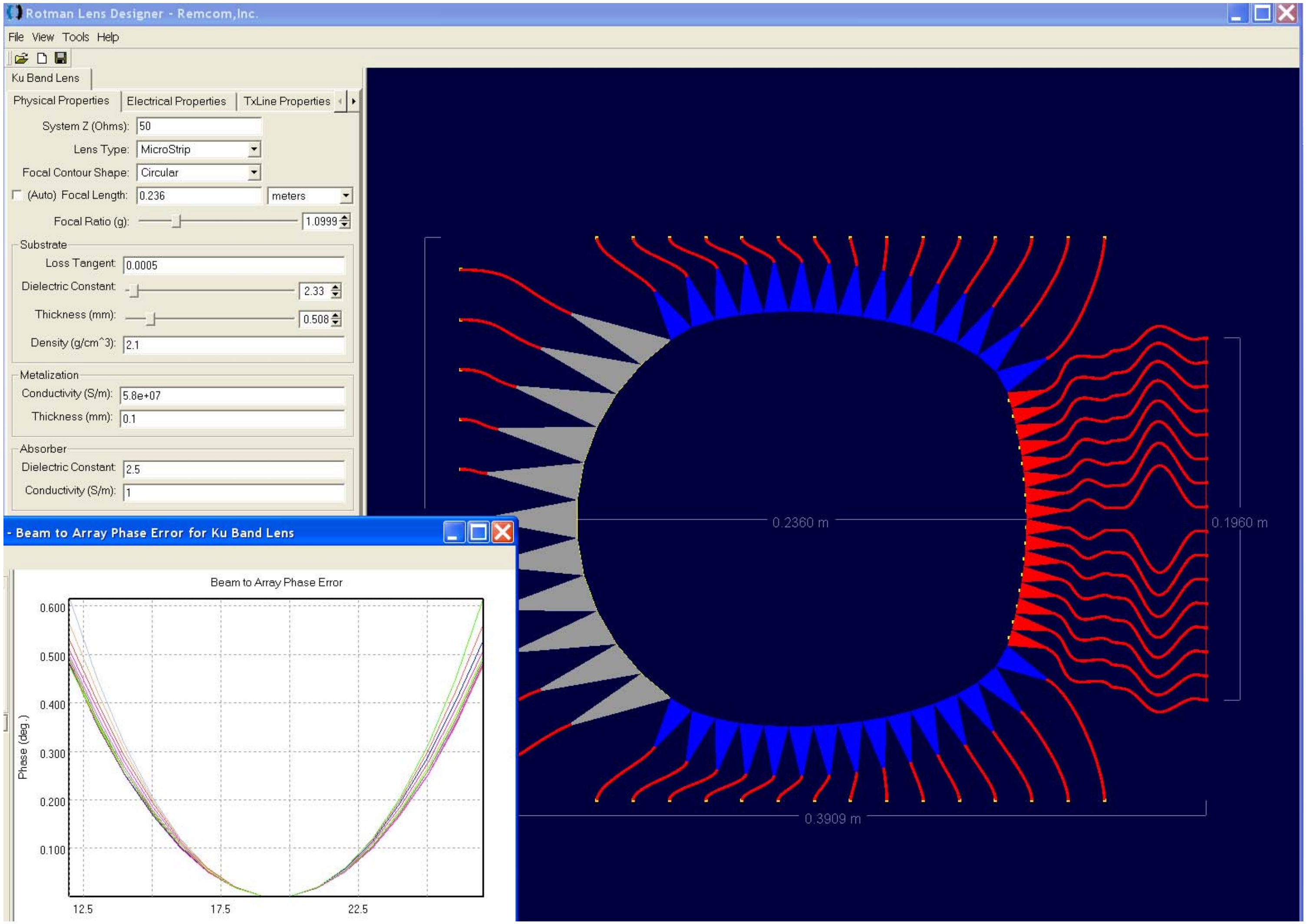
REMCOM®

Using RLD

- Typical lens design parameters are available as inputs to the software
- The Lens design is interactively redrawn as parameters are adjusted
- Several performance criteria may be plotted and interactively updated while input parameters are adjusted
- Feed lines to all ports may be added and routed
- Lens design may be exported to a full wave solver for further analysis or into a CAD format for fabrication

$B = \mu H$ $\nabla \cdot B = 0$ $\nabla \cdot D = \rho$ $D = \epsilon E$

The RLD Interface



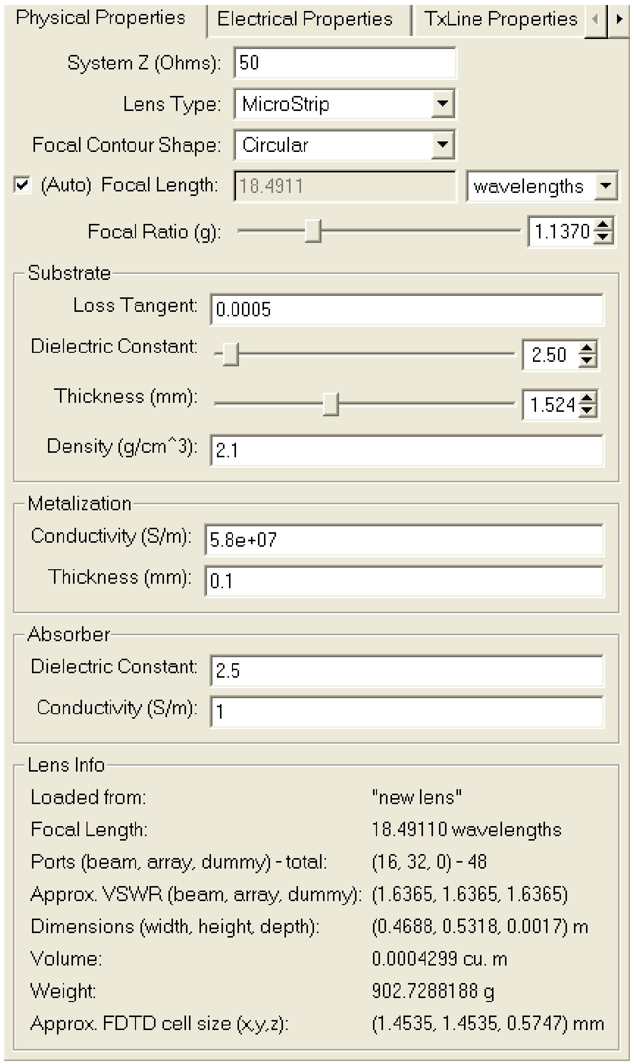
Input Parameters

- Inputs are divided into categories of physical properties and electrical properties
- Separate tabs list the available parameters
- Most inputs are controlled by both text screens and slider bars
- Lens design is redrawn as the parameters are changed

$B = \mu H$ $\nabla \cdot B = 0$ $\nabla \cdot D = \rho$ $D = \epsilon E$

Physical Properties

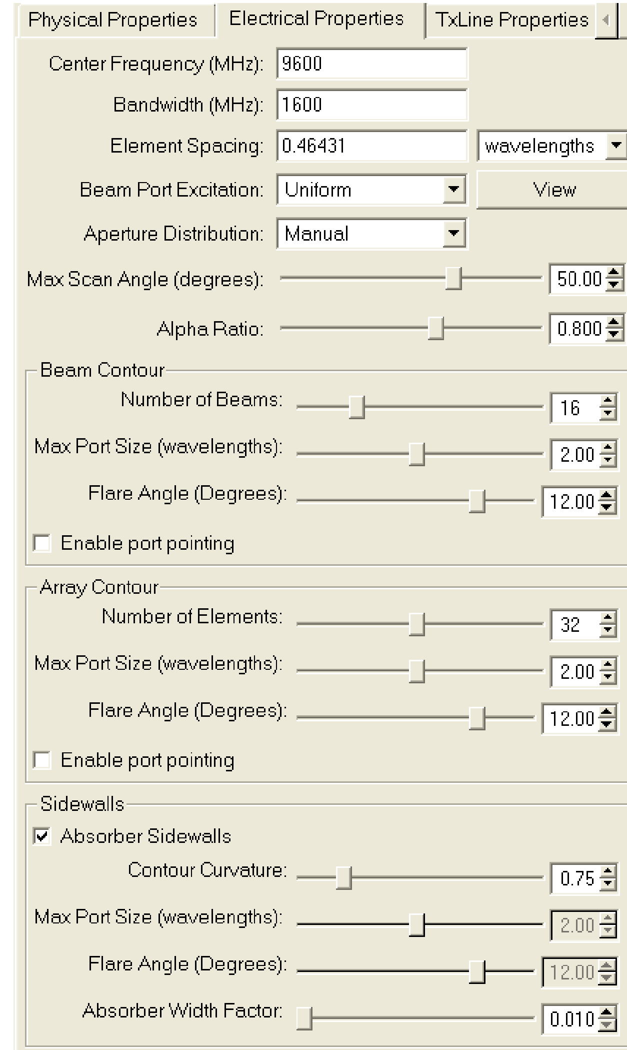
- Physical properties are quantities such as the system impedance, the focal length and the focal ratio
- Values for the substrate, metallization layer, and any absorber dielectric are included
- A summary screen lists details about the design



$B = \mu H$ $\nabla \cdot B = 0$ $\nabla \cdot D = \rho$ $D = \in E$

Electrical Properties

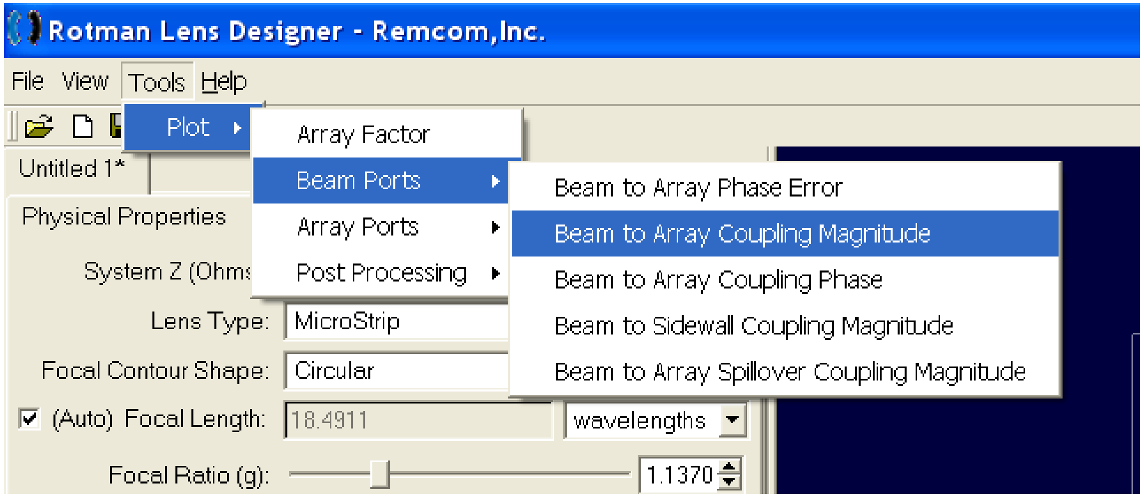
- Electrical properties include the center frequency, bandwidth, element spacing, and scan angle
- Details about the Beam and Array contours are set
- Control of the sidewall absorption through material or dummies



$B = \mu H$ $\nabla \cdot B = 0$ $\nabla \cdot D = \rho$ $D = \epsilon E$

Design Criteria

- A number of lens performance criteria may be plotted as the design is tuned
- Array factor displays the beam pattern produced at the output elements of the lens
- Beam and Array Coupling and phase error may be plotted



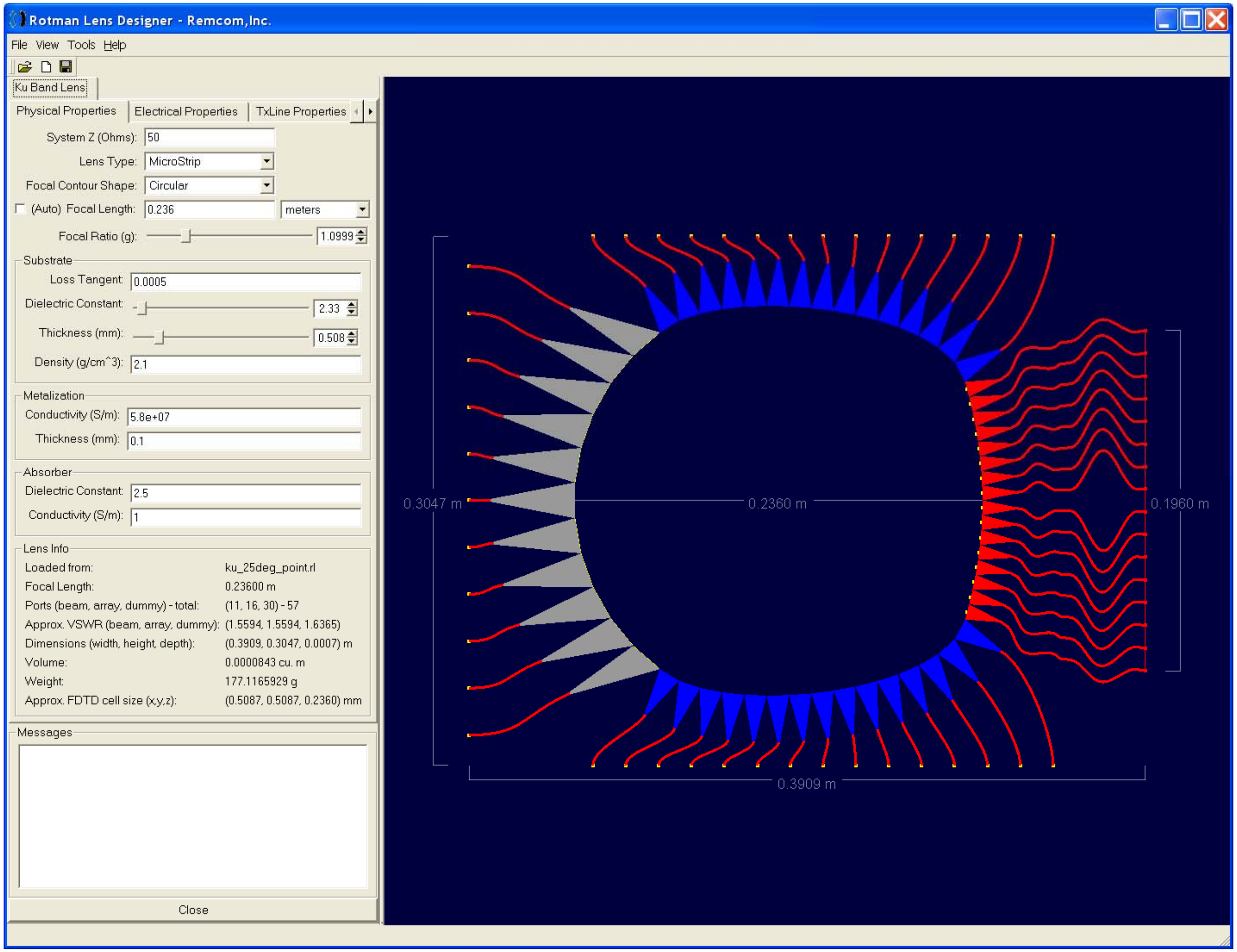
Output Quantities

- After a lens design is tuned several output values may be computed
- S-parameters and insertion loss are available for every port
- The lens design may be exported in several formats for further analysis or fabrication
- Original intended use of the software was for export of the design to a full wave solver for fine tuning
- Actual use has shown the RLD results are often sufficiently accurate

Example Design

- A microstrip lens with a center frequency of 16 GHz will be designed and compared to results from a full wave solver (XFDTD)
- The lens will produce 11 beams for a 16 element linear array with a scan angle of 25 degrees
- Beam patterns and S-parameter results will be compared to XFDTD

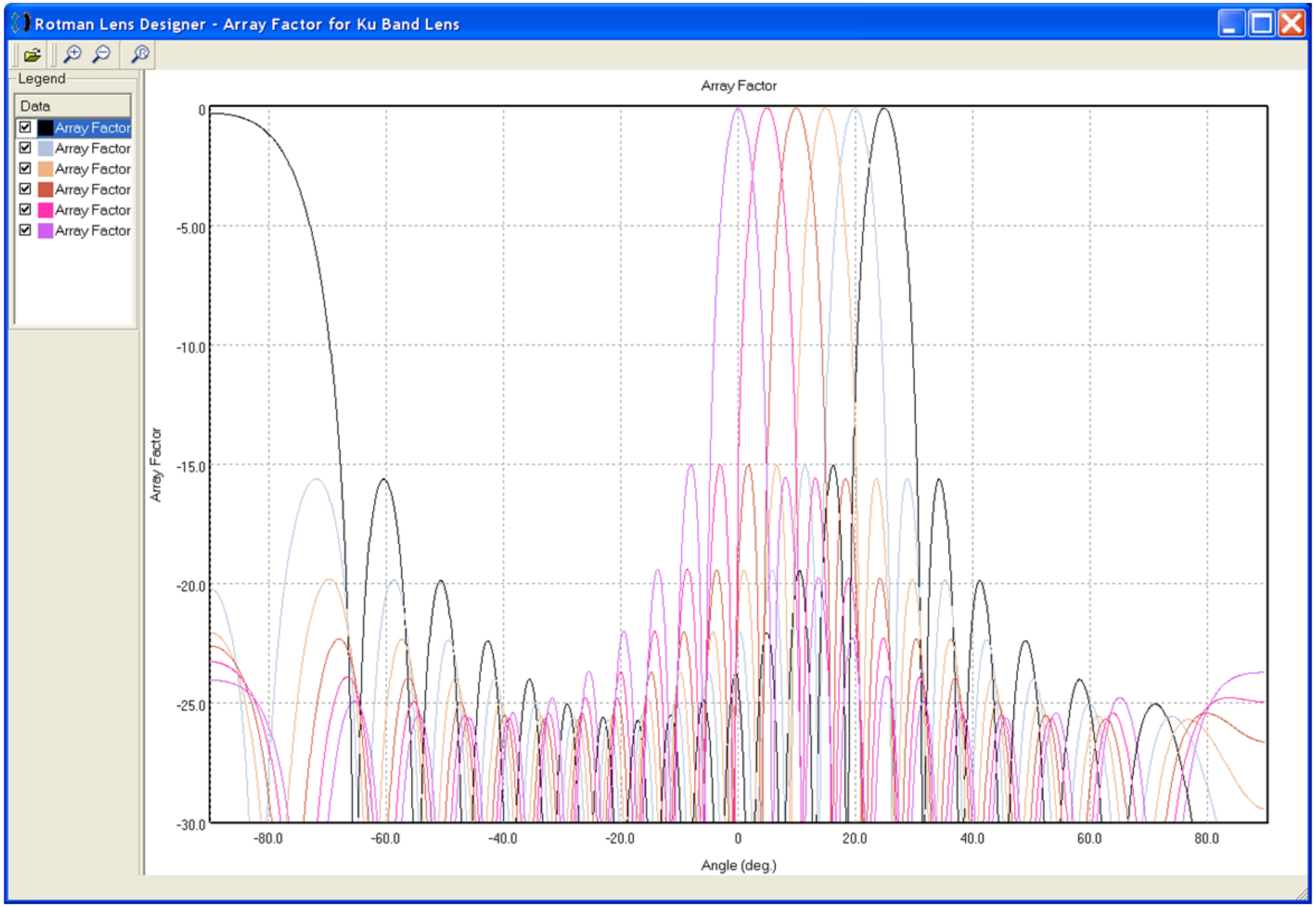
Example Lens Design



Ku band Lens after tuning

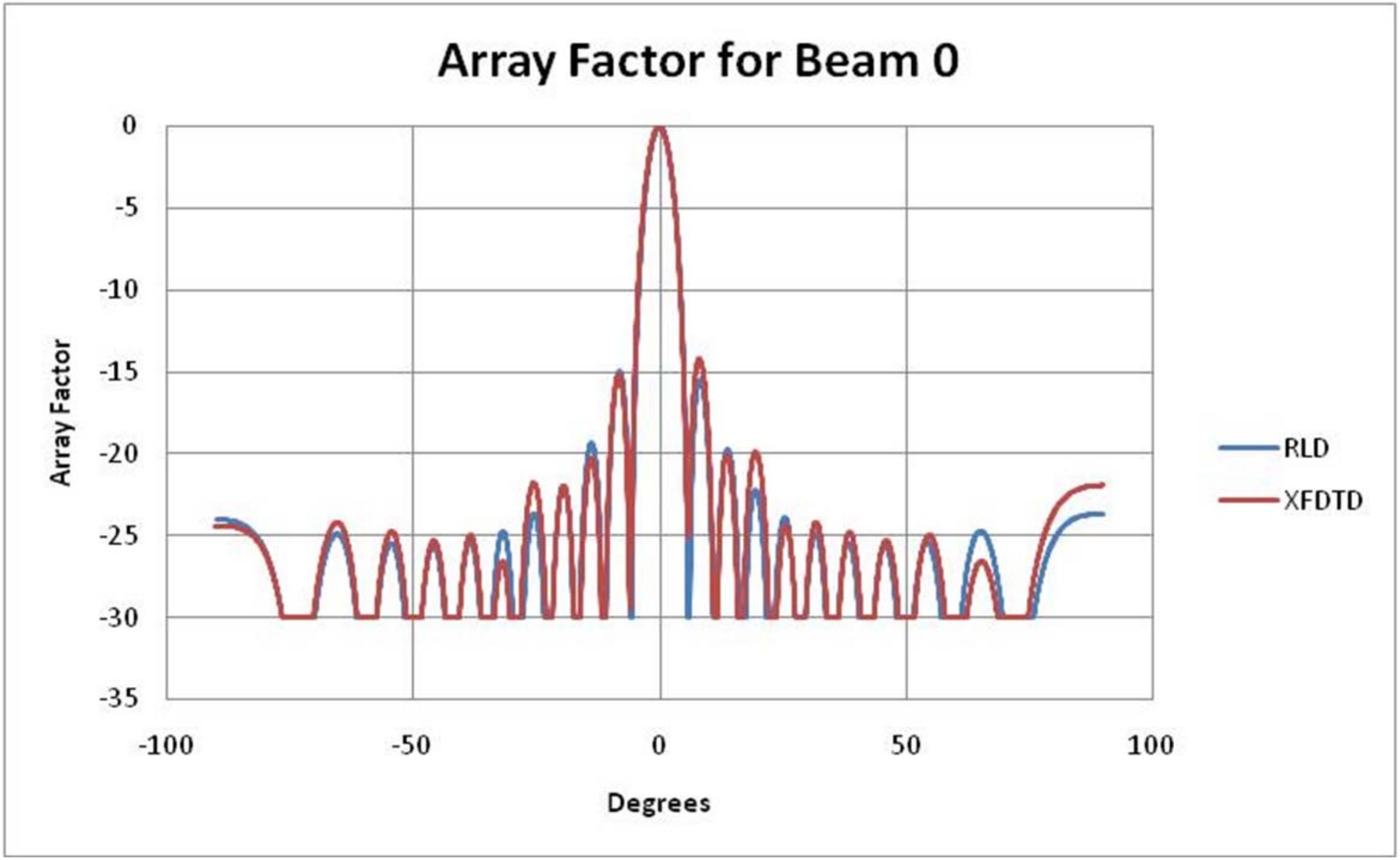
$B = \mu H$ $\nabla \cdot B = 0$ $\nabla \cdot D = \rho$ $D = \epsilon E$

Beam Patterns



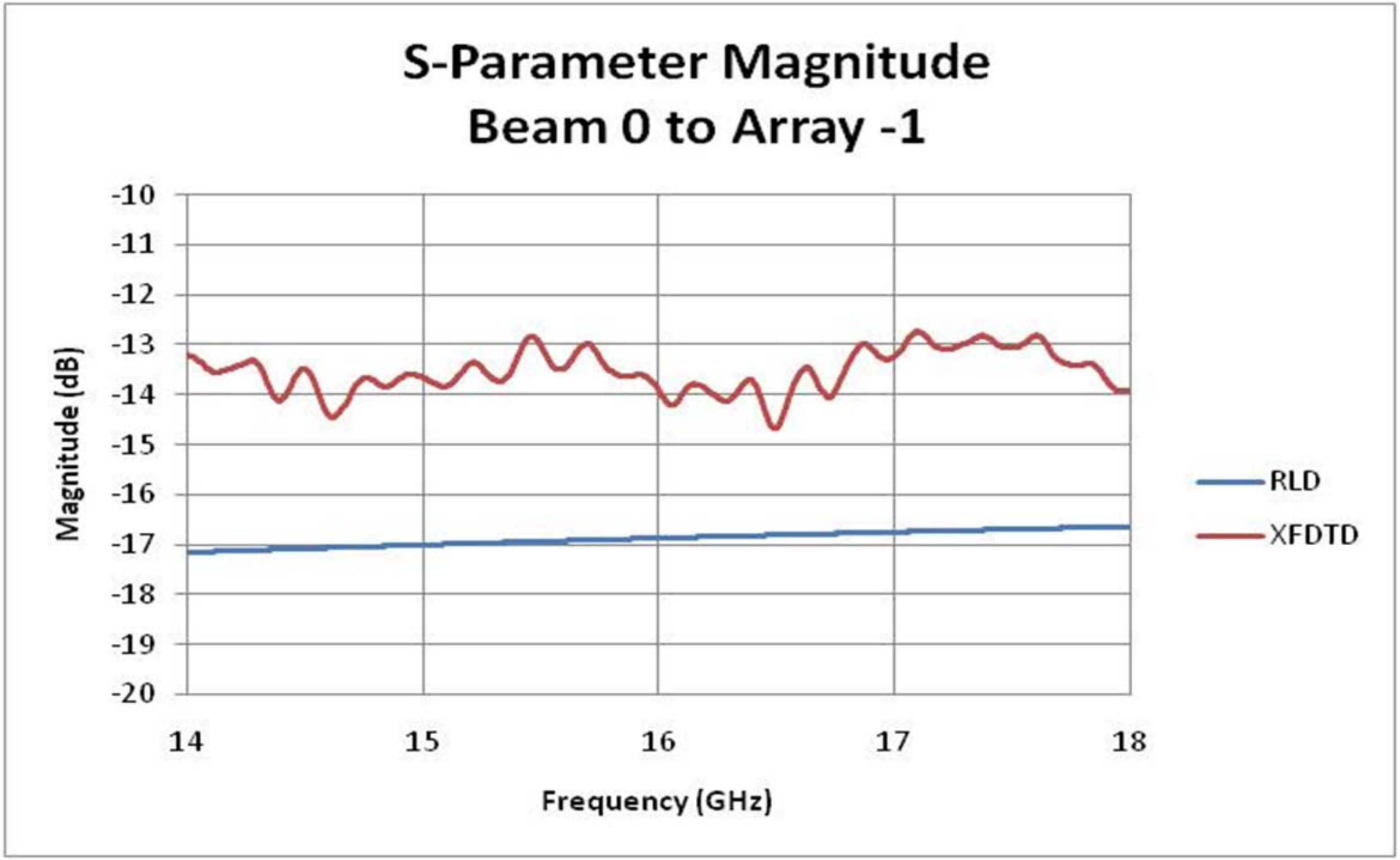
Half of the beams formed by the lens are shown

Beam Pattern vs. XFDTD



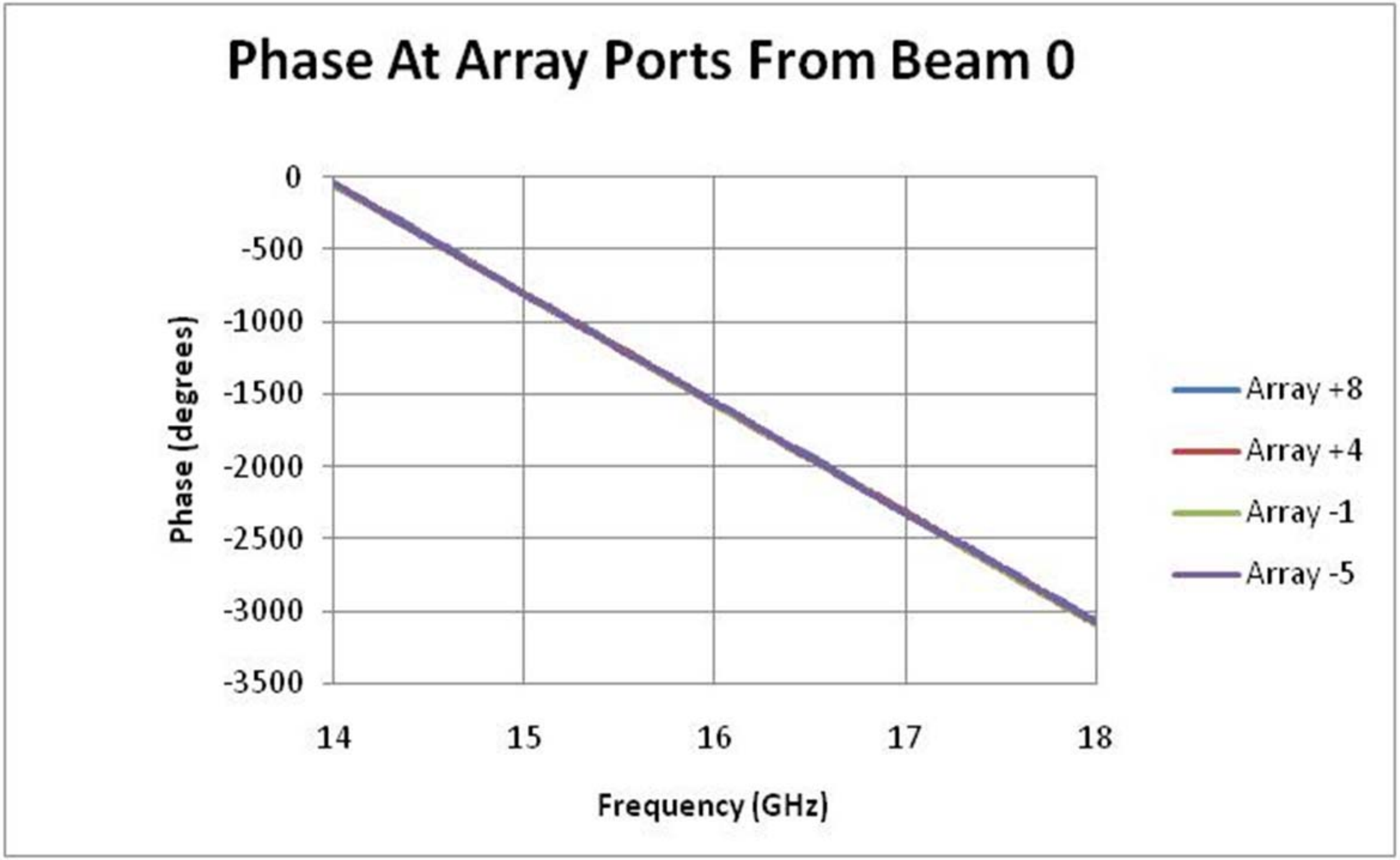
Good agreement is found for the center beam

S-Parameter Magnitude vs. Frequency



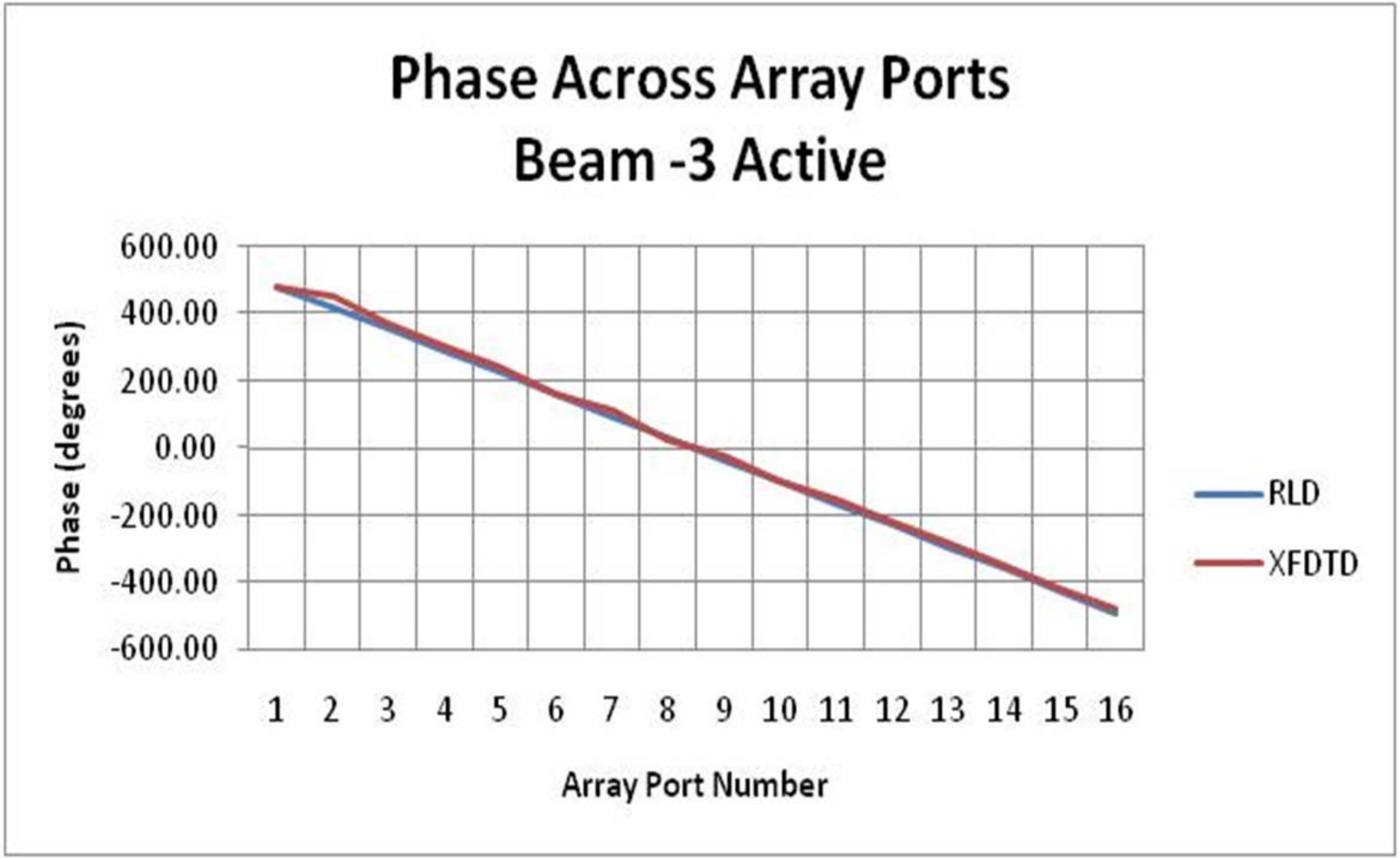
RLD S-parameter computation is conservative compared to full wave result

S-Parameter Phase vs. Frequency



Phase remains linear as a function of frequency

S-Parameter Phase across Output Ports



Phase across output (array) ports is in good agreement with XFDTD

Summary

- RLD is an easy to use tool for initial design of Rotman Lenses
- Tuning process is intuitive as output criteria are updated in real time as lens parameters are changed
- Results have been shown to have good agreement with full wave and measured results

$B = \mu H$ $\nabla \cdot B = 0$ $\nabla \cdot D = \rho$ $D = \epsilon E$

References

For further reading on RLD results, including comparisons with measured results, see the following

S. Weiss, S. Keller, and C. Ly, "Development of Simple Affordable Beamformers for Army Platforms," presented at *2007 GOMACTech Conference*, Lake Buena Vista, FL, March 2007.

C. W. Penney, R. J. Luebbers, E. Lenzing, "Broad Band Rotman Lens Simulations in FDTD," in *Proc. 2005 IEEE AP-S International Symposium*, vol. 2B, pp. 51-54, July 2005.

S. Albarano III, E. H. Lenzing, C. W. Penney, and R. J. Luebbers. "Combined Analytical-FDTD Approach to Rotman Lens Design," presented at the *22th Annual Review of Progress in Applied Computational Electromagnetics*, Miami, FL, March 2006.