Numerical and experimental assessment of a phase retrieval technique applied to planar near field distribution for wide band application

Nicolas Ribi`ere-Tharaud, Aronne Casagranda, Marc Lambert, Fran¸cois Jouvie

To cite this version:

HAL Id: hal-01107471
https://hal-supelec.archives-ouvertes.fr/hal-01107471
Submitted on 20 Jan 2015
NUMERICAL AND EXPERIMENTAL ASSESSMENT OF A PHASE RETRIEVAL TECHNIQUE APPLIED TO PLANAR NEAR FIELD DISTRIBUTIONS FOR WIDE BAND APPLICATIONS

Nicolas Ribiére-Tharaud, A. Caugande, M. Lambert, F. Jouvie

Saint-Louis - USA

THE PHASE RETRIEVAL TECHNIQUE

• HISTORICAL BACKGROUND
  ✓ Gerschberg-Saxton [1972] : electron microscopy (1 plane)
  ✓ Misell variant [1973] : electron microscopy (2 defocused planes)
  ✓ Anderson & All [1984] : microwave applications

• PRINCIPLE
  ✓ Algorithm initialization
    ✓ Electric field magnitude known in two planes P1 & P2 in front of the source

NUMERICAL ASSESSMENTS (1/4)

• Models
  ✓ MoM (Feko)
  ✓ Classical horn antenna (same used for experimental approach)
  ✓ Frequency: 8 GHz

• Purposes
  ✓ Validation tool
    ✓ Agreement Models/Measurements
    ✓ Exact phase calculation
    ✓ Exact far field calculation
  ✓ Sets of data for parametric study
    ✓ dplane-source and dplane-plane
    ✓ Planes sampling
    ✓ Planes sizes

• APPROACH
  ✓ Implementation of a phase retrieval algorithm
  ✓ Assumptions on sources
    ✓ CW
    ✓ High directivity

• CONTEXT
  ✓ Final purpose
    ✓ Experimental antenna far field pattern characterization
    ✓ Wide frequency range
    ✓ Pulsed sources
  ✓ Measurement constraints
    ✓ Planar near field test setup
    ✓ Magnitude only measurements

• CONTEXT
  ✓ Final purpose
    ✓ Experimental antenna far field pattern characterization
    ✓ Wide frequency range
    ✓ Pulsed sources
  ✓ Measurement constraints
    ✓ Planar near field test setup
    ✓ Magnitude only measurements
**NUMERICAL ASSESSMENTS (2/8)**

- **Parametric Study**
  - **Criterion**
    \[
    \Delta_{\text{complex}} = \sqrt{\frac{\sum_{j=1}^{N} \sum_{i=1}^{N} \left| E_j(x_i, y_i, z_i) - \hat{E}_j(x_i, y_i, z_i) \right|^2}{\sum_{j=1}^{N} \sum_{i=1}^{N} \left| \hat{E}_j(x_i, y_i, z_i) \right|^2}}
    \]
  - **planes positions**
    - Fields calculated in magnitude and phase using Feko
    - distances: 11 values \[x_1 = 2\lambda, \ldots, x_{11} = 1\text{ m}]\n    - 55 phase reconstructions

**NUMERICAL ASSESSMENTS (3/8)**

- **Planes positions parameter: \(x_j\) and \(x_2\)**
  - Far field from using the reconstructed phase
    - Worst case: \(\Delta_{\text{complex}} = 222.54\%\)
    - Best case: \(\Delta_{\text{complex}} = 7.94\%\)

**NUMERICAL ASSESSMENTS (4/8)**

- **Sampling parameter: \(\delta_x\)**
  - Far field from using the reconstructed phase
    - \(\delta_x = \frac{\lambda_0}{6}\) \(\Delta_{\text{complex}} = 7.94\%\)
    - \(\delta_x = \frac{\lambda_0}{3}\) \(\Delta_{\text{complex}} = 6.07\%\)
    - \(\delta_x = \frac{\lambda_0}{2}\) \(\Delta_{\text{complex}} = 29.53\%\)

**NUMERICAL ASSESSMENTS (5/8)**

- **Planes dimensions parameter: \(L\)**
  - \(L_{\text{min}} = 20\lambda_0\)

- **Planes positions parameter:**
  - \(x_j\) and \(x_2\)
  - Far field from using the reconstructed phase
    - Worst case: \(\Delta_{\text{complex}} = 222.54\%\)
    - Best case: \(\Delta_{\text{complex}} = 7.94\%\)
Phase reconstructions

- Approx. 1000 to 10000 iterations
- Less than 1 or 2 hours on a standard PC

Results at 8 GHz: reconstructed far field

Experimental validation: planar near field measurement setup

- AUT = Horn, Probe = Dipole, open end waveguide
- Frequencies = 2 GHz, 8 GHz and 18 GHz
- Distance AUT/Probe: $2\lambda, 3\lambda, \ldots, 1\text{m}$
**EXPERIMENTAL VALIDATION : f = 8 GHz**

- Validation of reconstructed far field

![Graphs showing reconstructed and measured magnitudes](image)

**EXPERIMENTAL VALIDATION : f = 2 & 18 GHz**

- Validation of reconstructed far field

![Graphs showing reconstructed and measured magnitudes](image)

**CONCLUSION & FUTURE WORKS**

- Conclusions on the phase reconstruction algorithm
  - Validation on numerical and experimental data
  - Parametric study for optimal use
  - Wide band validation

- Future tasks
  - Adding information to increase performances
  - Expanding the parametric study
  - Towards pulsed sources …