Characterization of Metamaterials for Broadband and Reduced-Size Antennas

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Metamaterials – A Definition (one of many):

A class of engineered materials that exhibit highly beneficial electromagnetic properties, which are not naturally occurring or common synthetic materials, exhibit structure-dependent properties, and are not constrained by a rule of mixtures

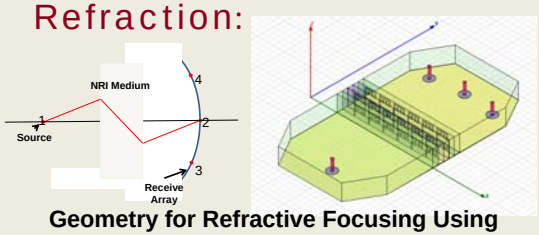
Objective:

Investigate metamaterials for antenna size reduction, embedded impedance matching and mutual coupling reduction

Key Advantages:

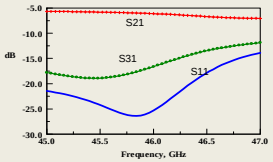
Negative Refraction, if realized at broad band, and Artificial Magnetic Conductors (AMC) introduce new optics paradigm that leads to new designs and size reductions

Initial Proof of Negative Refraction:

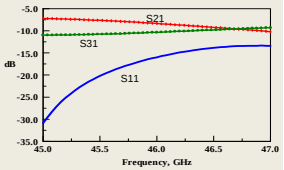


Geometry for Refractive Focusing Using Negative-Refractive-Index in Parallel Slab

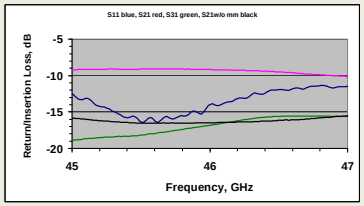
Metamaterial Pieces and Oversized Connectors



Simulated S-Parameters with Metamaterial



Simulated S-Parameters without Metamaterial

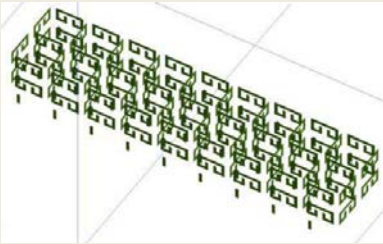


Measured S-Parameters

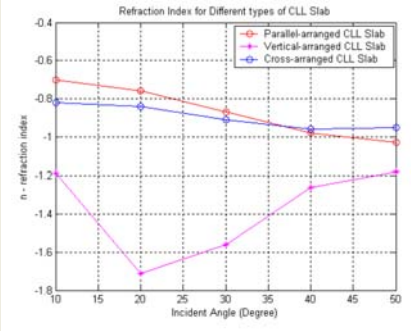
- S11 with metamaterial
- S21 with metamaterial
- S31 with metamaterial
- S21 without metamaterial

Isotropic Material:

Unit cell is a Capacitively Loaded Loop + Probe (CLL-P)



Cross-Plane Arrangement for 2-D isotropic Refraction



Refractive Index vs. Angle For Different CLL-P Slabs Cross-Plane Shows Isotropic Behavior

Summary:

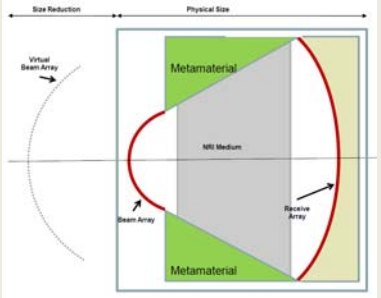
- **Isotropic negative refraction is realized**
- **Fabrication and broadbanding are underway**

Impact:

- **New designs for vehicle-mounted antennas with low profiles are possible**
- **Software tools facilitate in-situ modeling based on detailed material structure**

Deliverable:

A reduced-size Rotman lens for Army platforms



Metamaterial-Loaded Rotman Lens
- **Reduced size**
- **Single-ray path**
- **New optics pattern**

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