Dense Dipole Array for Mid-Frequency Aperture Arrays

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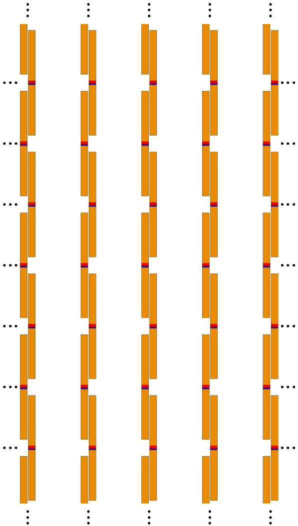
Outline

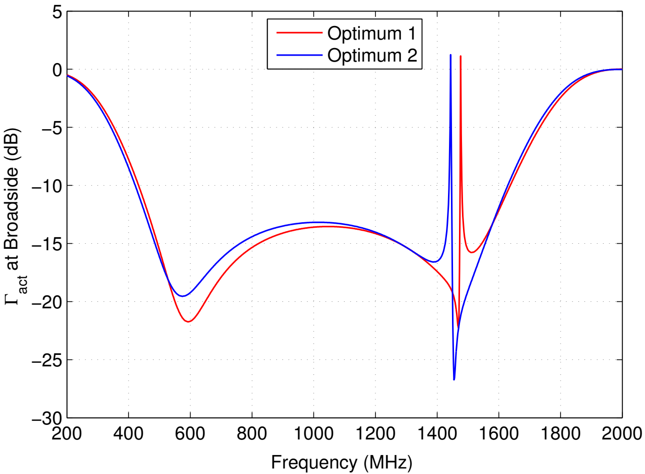
Introduction and Design Overview I

- Starting point was Jan Noordam's "Bathmat Antenna"
- Version of Wheeler's current sheet array
- Array of dipoles placed above a ground plane
- Overlapping dipole elements:
  - Elements spaced $< \frac{\lambda}{2}$ apart at *all* in-band frequencies.
- Bandwidth improved by:
  - Capacitive coupling between elements
  - Close proximity of elements



Introduction and Design Overview II

Results of 2 Optimizations with different goals:



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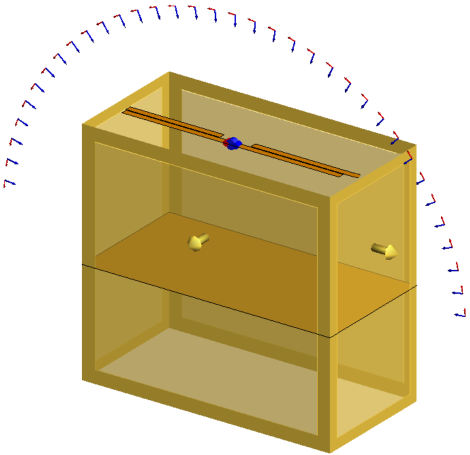
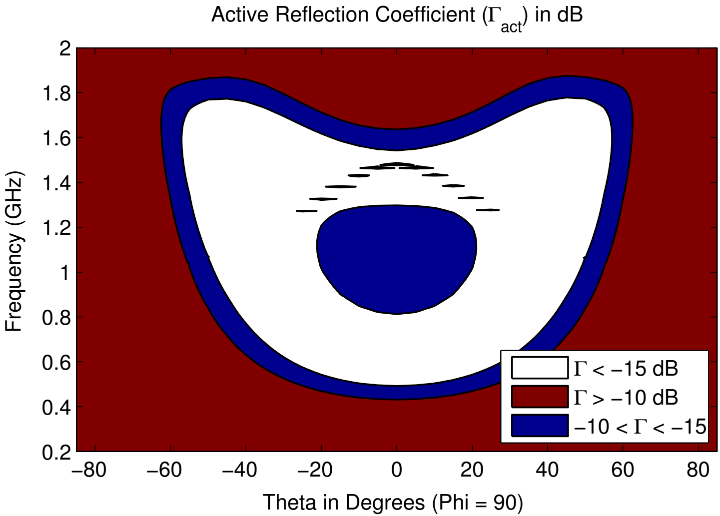
Scanning I

Scan 1:
Scan along θ with $\phi = 90^{\circ}$



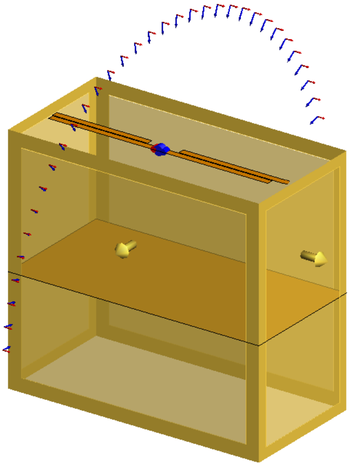
Scanning II


Active Reflection Coefficient (Γ_{act}) in dB
Frequency (GHz)
2
1.8
1.6
1.4
1.2
1
0.8
0.6
0.4
0.2
−80
−60
−40
−20
0
20
40
60
80
Theta in Degrees (Phi = 90)
$\Gamma < -15$ dB
$\Gamma > -10$ dB
$-10 < \Gamma < -15$

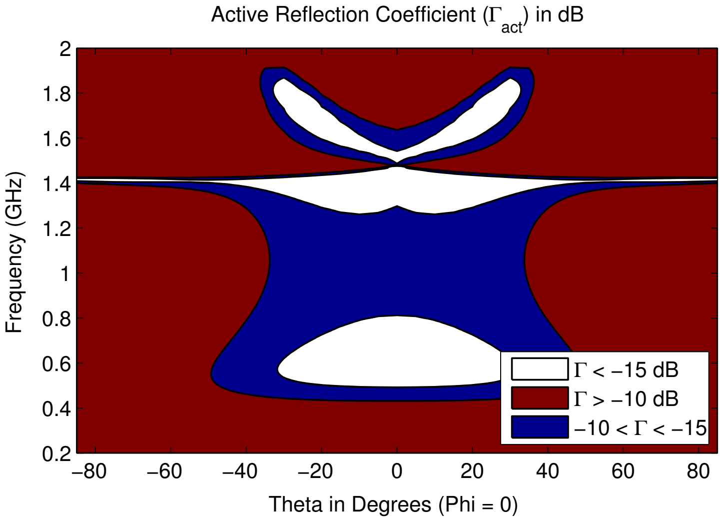
Scanning III

Scan 2:

Scan along θ with $\phi = 0°$



Scanning IV



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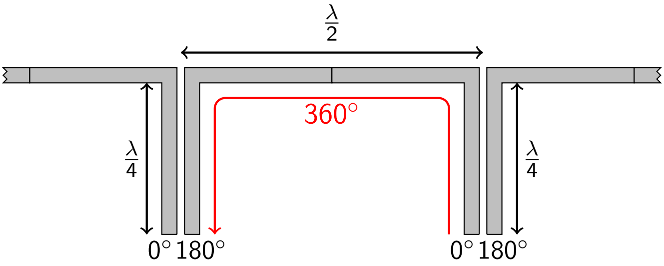
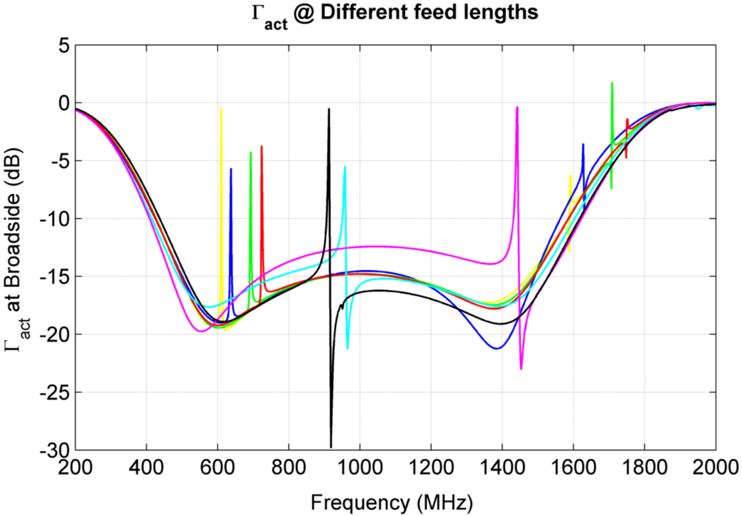
Outline

Feed Design I

- Preliminary results look encouraging...but...there is an in-band resonance
- Caused by 360° current loops between neighbouring differential ports
- Frequency at which resonance occur will change with scan angle and length of feed line



Feed Design II



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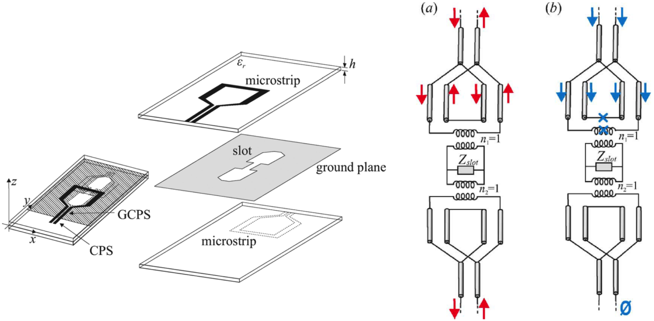
Feed Design III

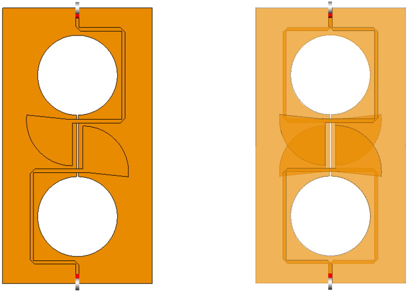
- Solution is to try and cancel out the common-mode currents in the feed
- Feed design by Cavallo et al. employs $2 \times 180°$ microstrip loops on either side of a slot to cancel out common-mode currents



- However, a "hard-wired" 180° is only 180° at a specific frequency

Feed Design IV

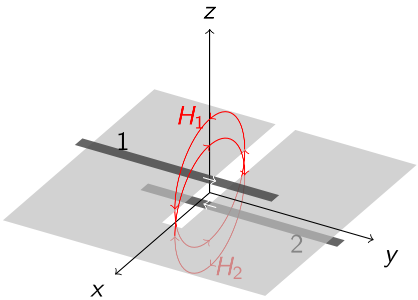
- We redesigned the feed to improve the bandwidth
- The current-loop is replaced with 2× wide-band microstrip-slotline transitions on either side of a PCB

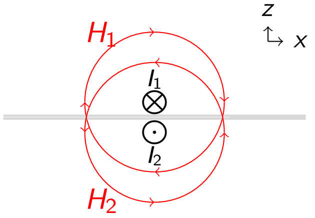


- Instead of directly cancelling out common-mode currents, the EM-fields induced by the common-mode currents are cancelled out, and the EM-fields induced by the differential-mode currents are still allowed to propagate.

Feed Design V

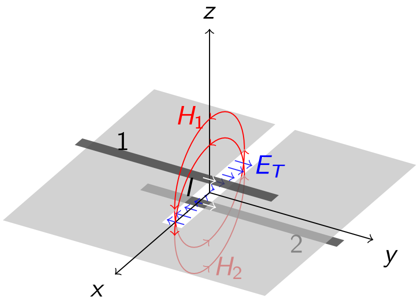
Common-mode Fields:

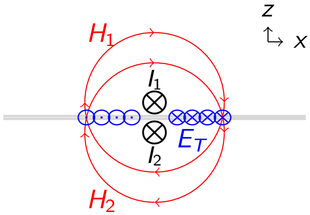




Feed Design VI

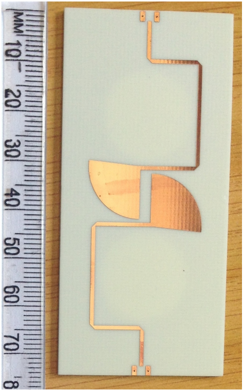
Differential-mode Fields:





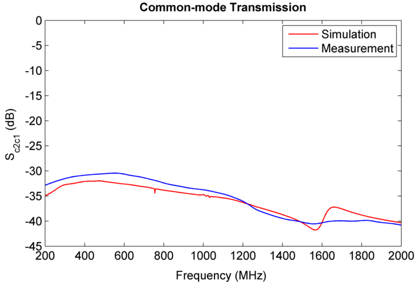
Feed Design VII

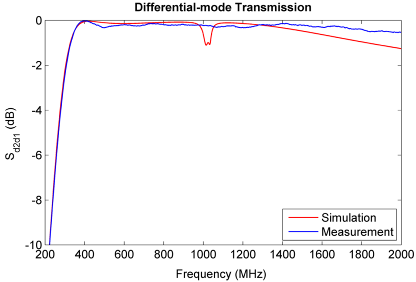
Manufactured PCB:

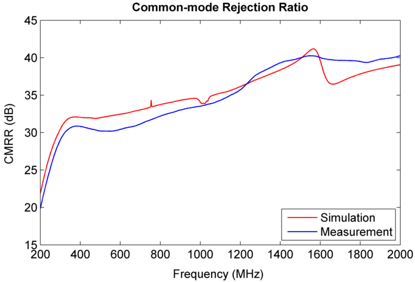


- Board has a height of 75mm ($\frac{\lambda_0}{4}$) and a width of 35mm
- Will be able to provide structural support between array and ground plane.

Feed Design VIII



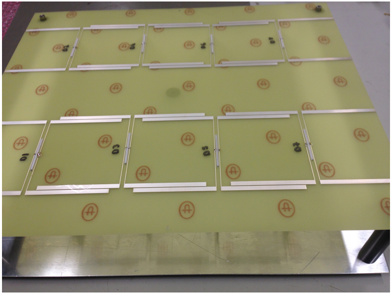


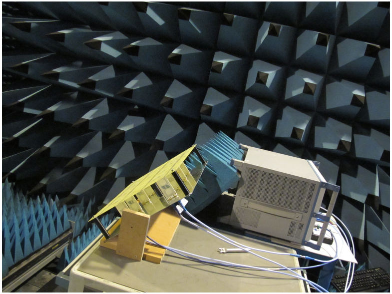


Outline

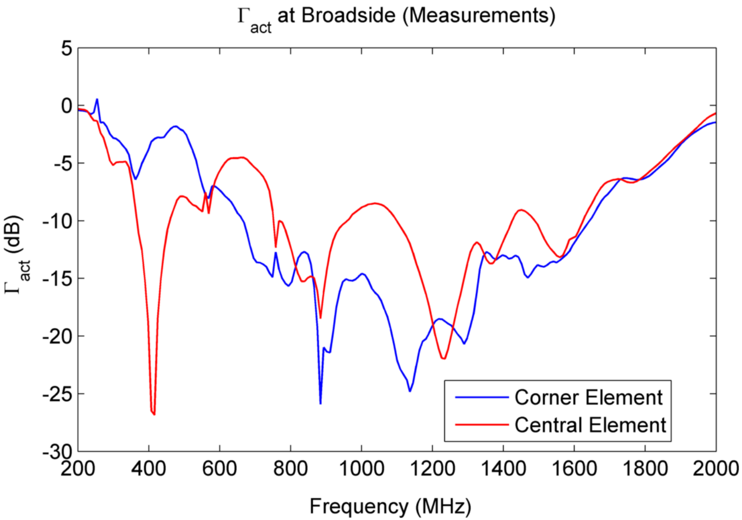
Implementation I

- A 4X4 Prototype DDA (Single Pol) has been manufactured at ASTRON
- S-parameters were measured





Implementation II



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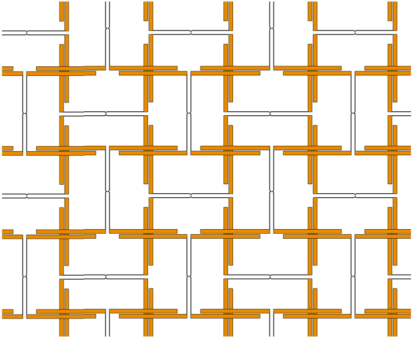
Outline

Dual Polarization I

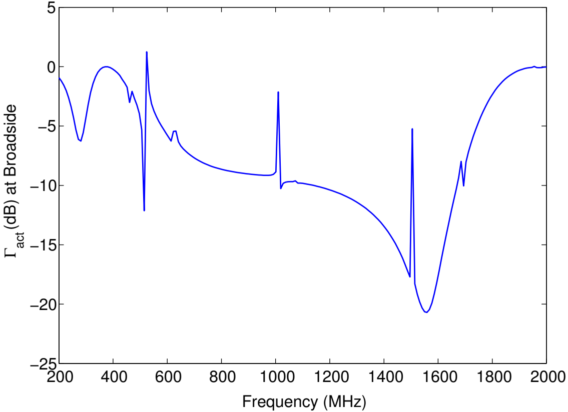
- Optimization of the Dual Polarized DDA is currently underway



Top View

Dual Polarization II

- "Taster Results"... No optimization and no feedboard!!
- The same rough shape as that of the single-pol is observed.



Outline

Conclusion I

- Design of a Dense Dipole Array (DDA) is well under way
- Bandwidth $> 3:1$ has been achieved over wide scan angle
- Wide-band common-mode suppressing feed has been designed and manufactured
- A 4x4 Prototype Array has been manufactured and testing is under way.
- Initial results are encouraging, but there is still quite a lot of work left!
  - Radiation Pattern Measurement of prototype array
  - Optimization of Dual-Polarized design
  - Rigorous Finite Array Investigation
  - ...

Acknowledgements

Thank you to our sponsors!

NRF

SEVENTH FRAMEWORK PROGRAMME

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