Regular Dense Dipole Arrays

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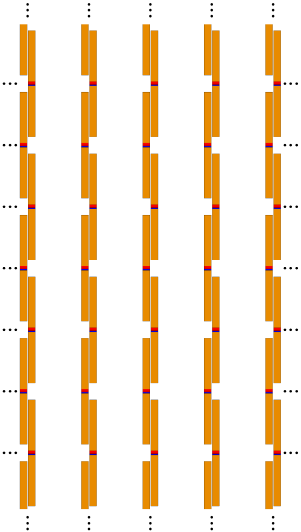
Outline

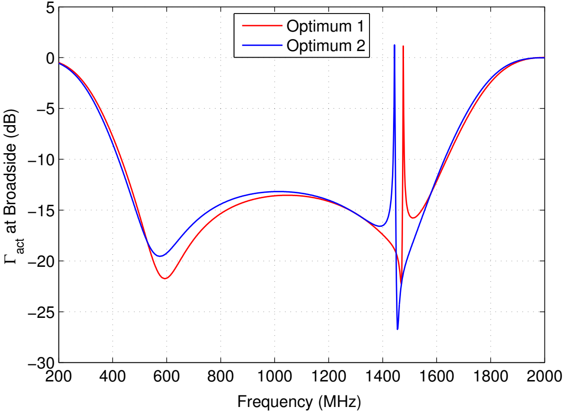
Introduction and Design Overview I

- Array of overlapping dipole elements placed above a ground plane
- Elements spaced $< \frac{\lambda}{2}$ apart at *all* in-band frequencies.
  - Grating lobes are avoided at all in-band frequencies
  - Not a lot of room for stored energy around elements
    $\rightarrow$ impedance is stabilized over wider bandwidth
- Capacitive coupling between elements
  - Compensates for the inductance in ground plane and elements themselves
    $\rightarrow$ reduces reactive part of Z_0 over wider bandwidth



Introduction and Design Overview II

Active reflection coefficient at broadside for 2 parameter sets

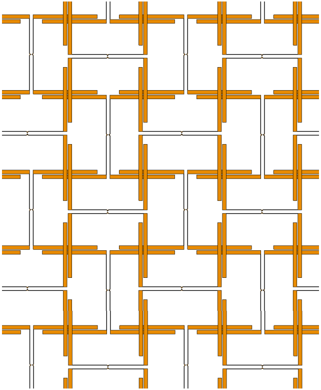


(Resonances are due to common-mode currents. Path length between elements determine the frequency at which they occur.)

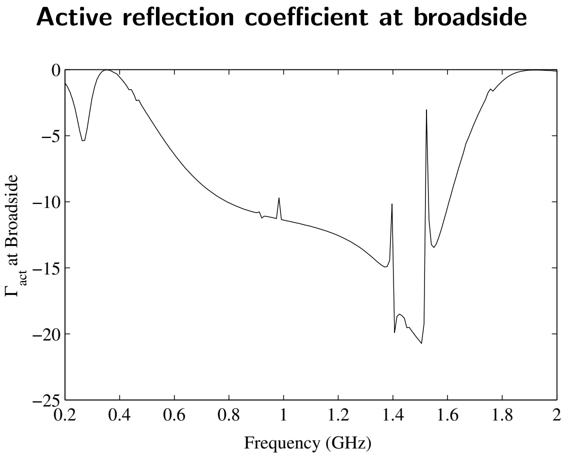
Outline

Dual Polarization Overview I

- We want a dual-polarized system...
- A second, orthogonal layer was added
- Elements are placed in parallel pairs
  - Lowers the 300 Ω characteristic impedance to 150 Ω
  - Halves required number of receiver chains (Huge cost saving...)
  - Trade-off - effectively beamforming element pair to zenith
    → Single element beamwidth is wide enough that this isn't really a problem.



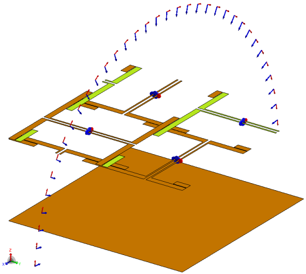
Dual Polarization Simulation Results I

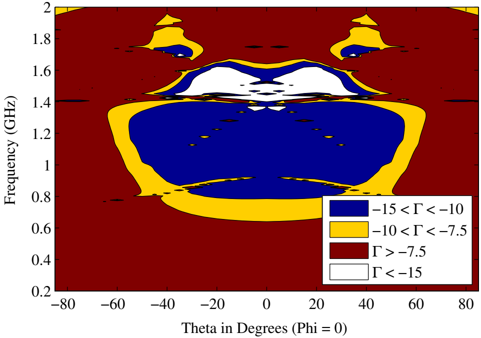


More path lengths between elements → more resonances

Dual Polarization Simulation Results II

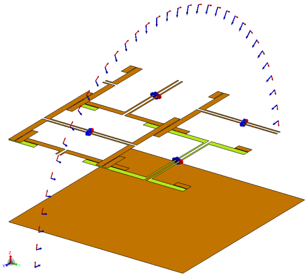
Active reflection coefficient for various scan angles along *E*-plane, with a co-polarized incoming wave-front.

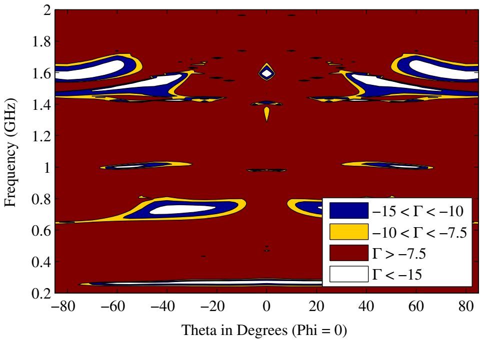




Dual Polarization Simulation Results III

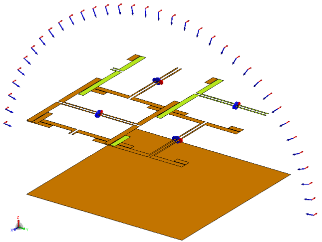
Active reflection coefficient for various scan angles along *E*-plane, with a <u>cross</u>-polarized incoming wave-front.

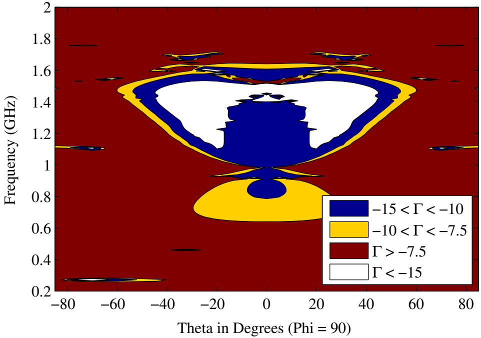




Dual Polarization Simulation Results IV

Active reflection coefficient for various scan angles along *H*-plane, with a co-polarized incoming wave-front.





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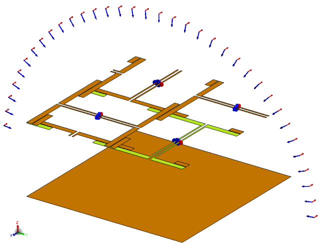
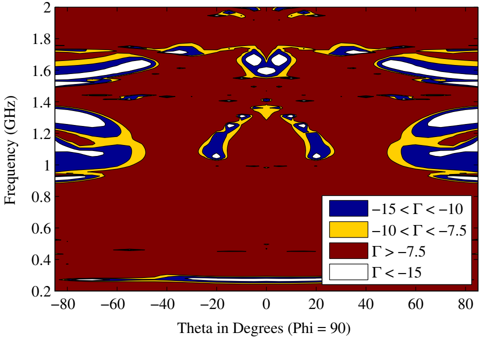
Dual Polarization Simulation Results V

Active reflection coefficient for various scan angles along *H*-plane, with a cross-polarized incoming wave-front.

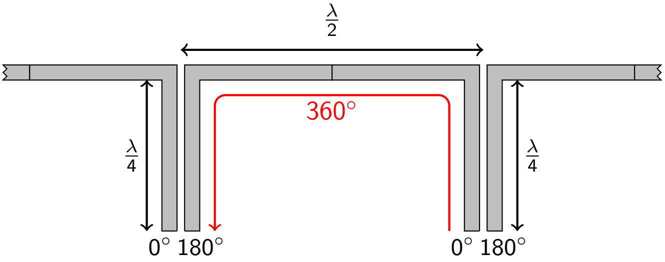




Outline

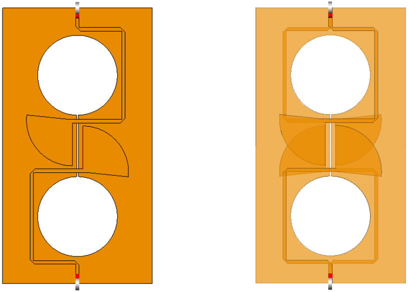
Feed Design I

- 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

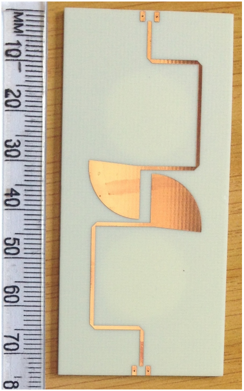
- We designed a feed to suppress the common-mode currents
- Design consists of 2× wide-band microstrip-slotline transitions on either side of a PCB



- 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.

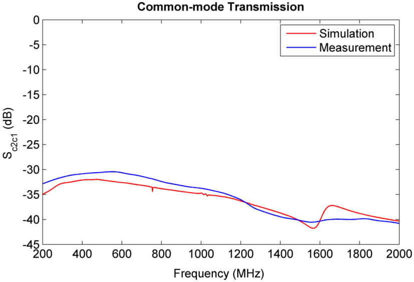
Feed Design III

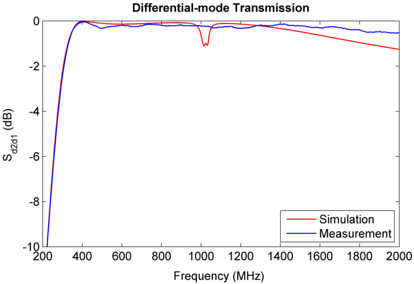
Manufactured PCB:

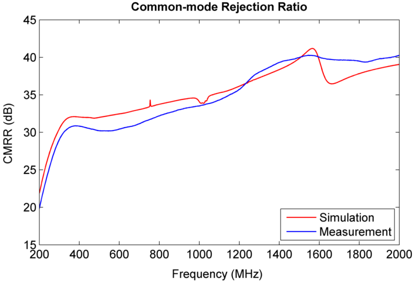


- Board has a height of 75mm ($\frac{\lambda_0}{4}$) and a width of 35mm
- Will be able to provide structural support between array and ground plane.

Feed Design IV



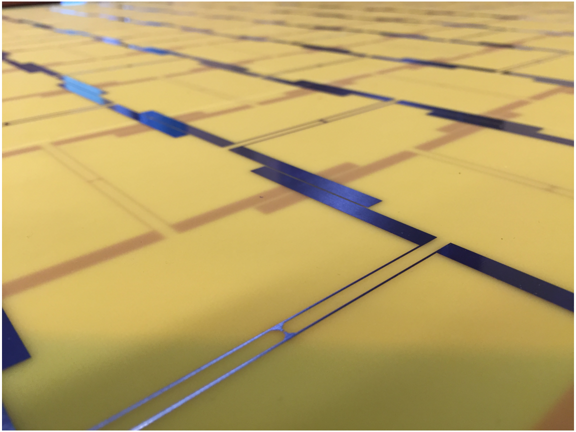




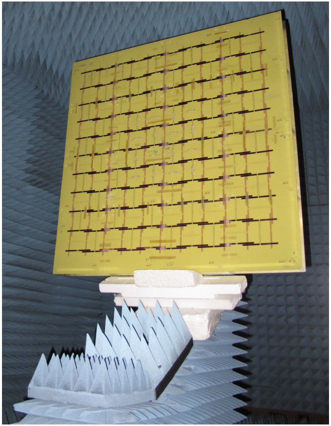
Outline

Implementation Overview I

$10 \times 10 \times 2$ Prototype DDA was built and measured

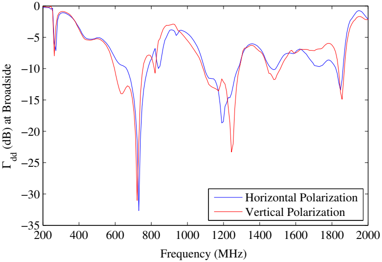


Implementation Overview II

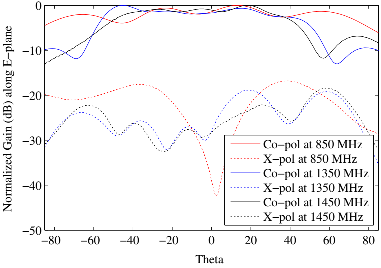


Measurement Results I

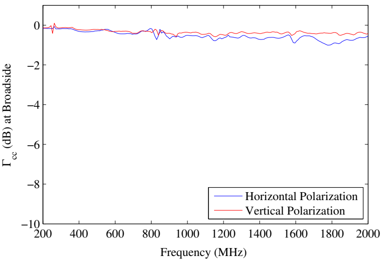
Differential-mode Γ_{act}



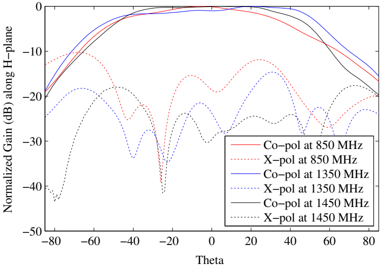
Embedded gain pattern (E-plane)



Common-mode Γ_{act}



Embedded gain pattern (H-plane)



Outline

Conclusion

- A dual-polarized DDA was designed, and a $1m^2$ prototype built and tested
  - A wide bandwidth over a wide scan-angle
  - Smooth embedded gain pattern $\rightarrow$ digital beamforming will be much simpler
  - Good cross-polarization performance was shown
- A feed that suppresses the common-mode resonances associated with connected antenna arrays were designed, built and tested
  - A CMRR of > 30 dB across all in-band frequencies were demonstrated.

Future Work

- Optimization of dual-polarized DDA parameter set
- Second prototype tile using optimized parameter set and more fed elements.
- 1-bit beamformer implementation on second prototype.
- Integration with LNA and LNA placement study
- Noise measurements with integrated LNA.

Acknowledgements

Thank you to our sponsors!

NRF

SEVENTH FRAMEWORK PROGRAMME

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