WE3H-5

N-Way Spatial Power Combiner Using Tapered Antipodal Slotline Feed Array in a Radial Waveguide

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Outline

- Motivation
  - High-power Amplifiers
  - Binary-tree vs parallel RF power combiners
  - Spatial RF power combiners
- Proposed RF Power Combiner
  - Antipodal slot-line impedance transformer
  - Conical TL to co-axial TL transition
  - Coaxial TL impedance transformer
- Simulation Results
- Measurement Results
- Conclusion

PA: Power Amplifier
TL: Transmission Line

High Power Amplifiers

- Vacuum-tube Power Amplifiers
  - Travelling tube amplifiers, klystrons, magnetrons…
  - High power with single device

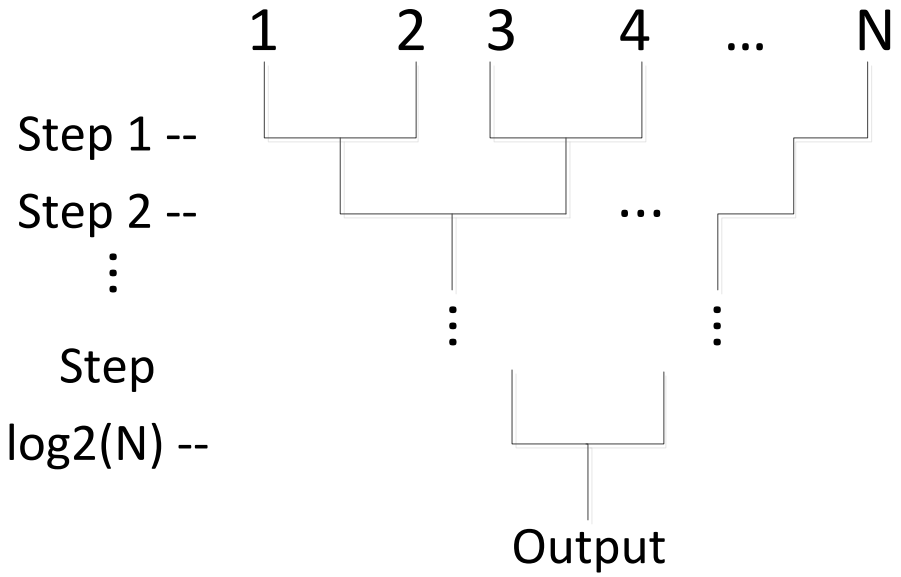
- Solid-state High Power Amplifiers
  - Output combination of parallel solid-state amplifiers

Spatial Power Combiners

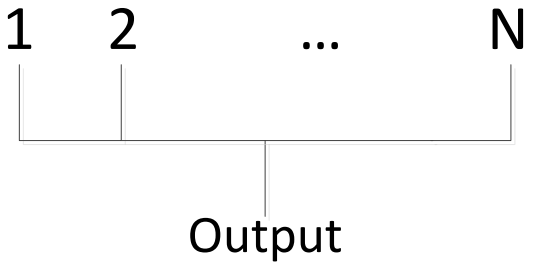
- Several different combination medium
  - Rectangular Waveguide
  - Coaxial Waveguide
  - Radial Waveguide
  - Conical Waveguide
- Waves combined in air and transformed to a coaxial structure

Binary-tree vs Parallel Combiners

Binary-tree Combination



Parallel Combination

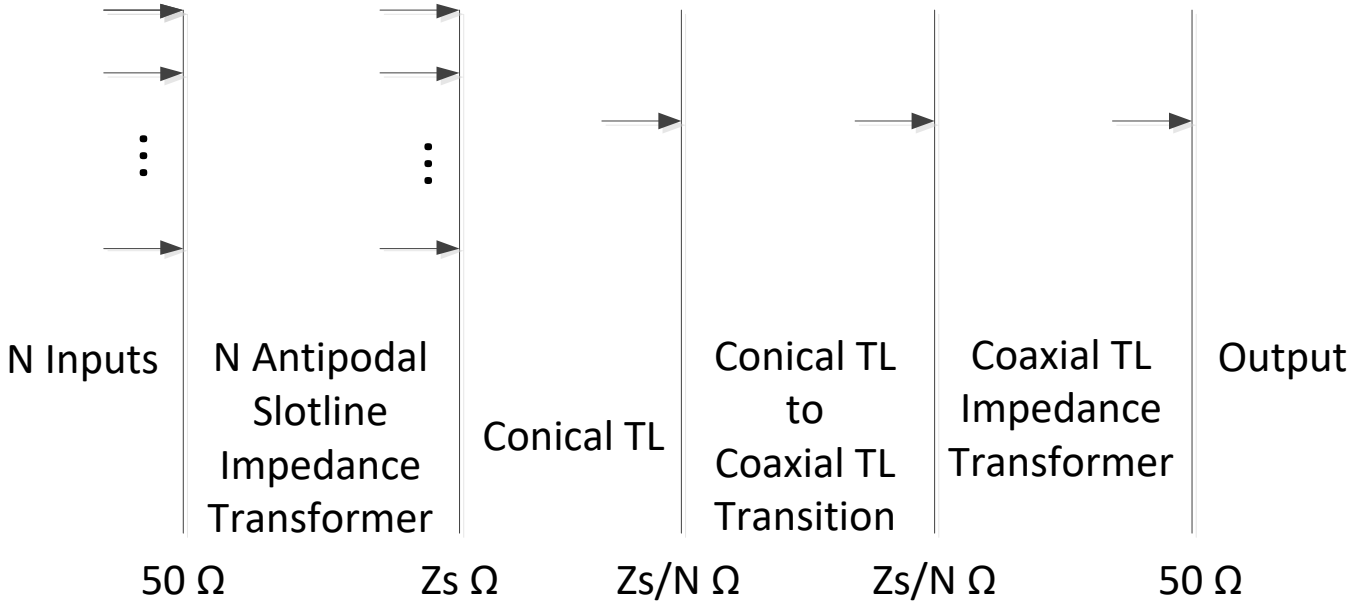


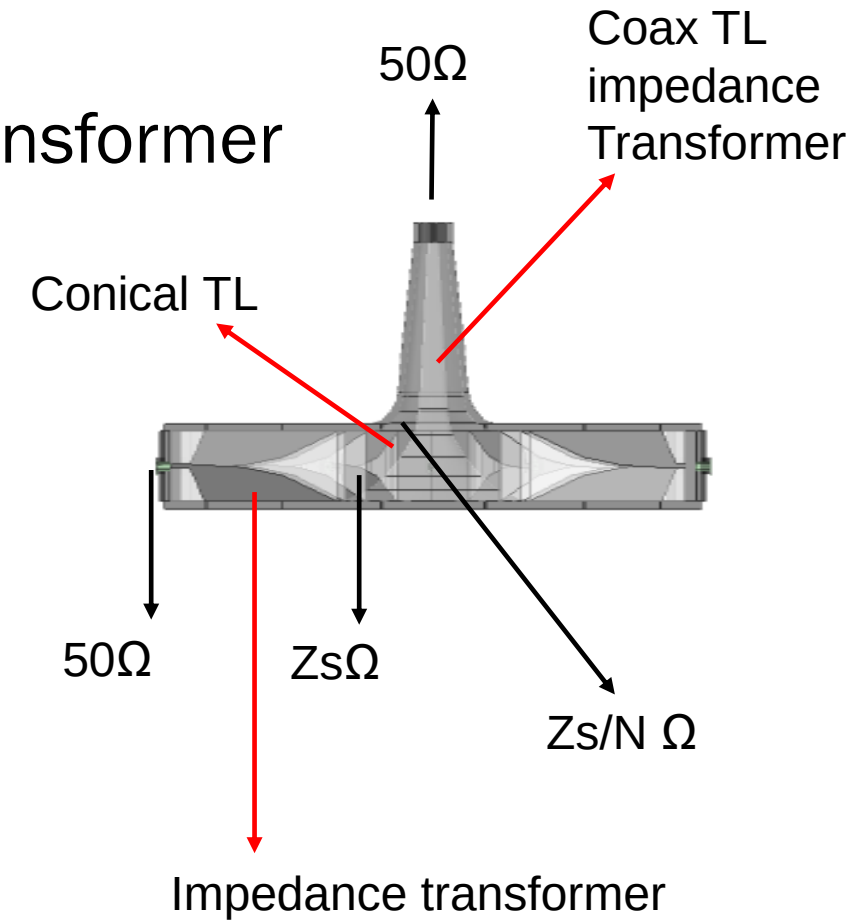
- Paths are longer (in multiple steps)
- Path loss is high
- Low combining efficiency

- Paths are shorther (one step)
- Path loss is low
- High combining efficiency

Proposed RF Power Combiner

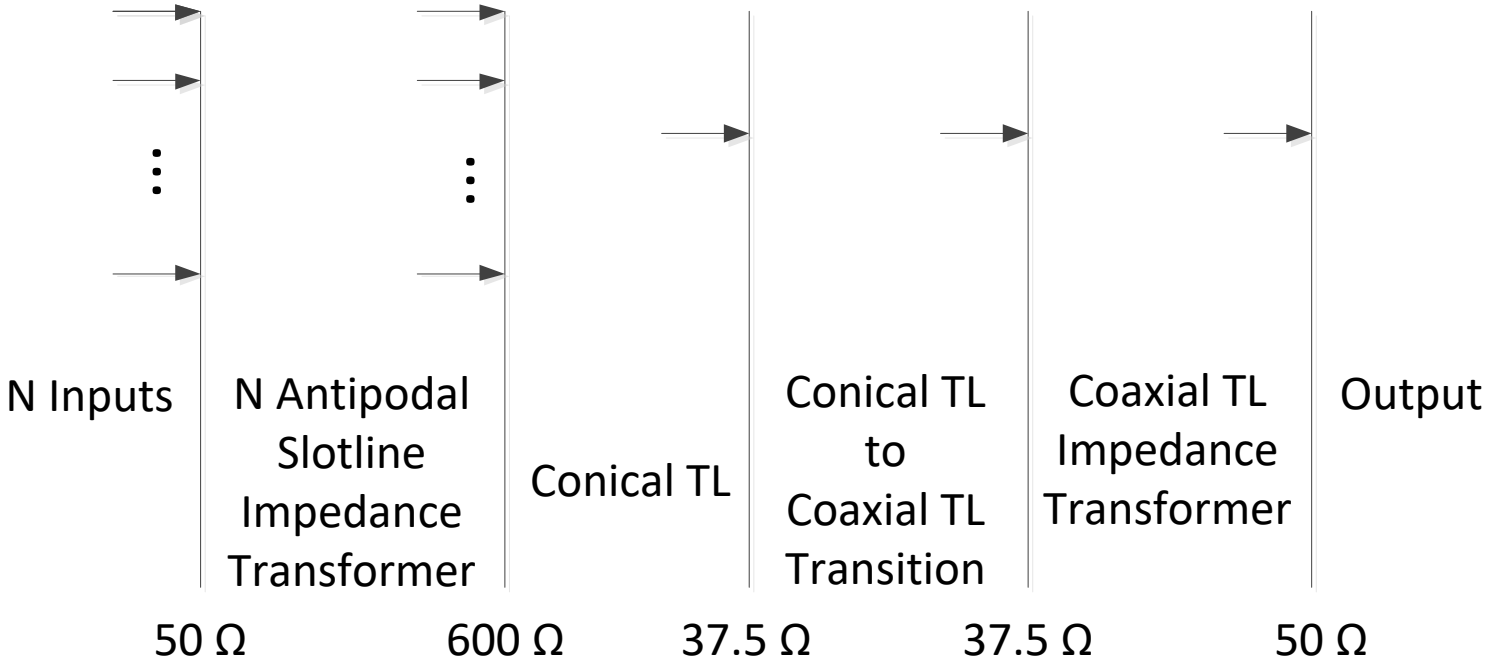
- Has 3 main design stages;
  - Antipodal slot-line impedance transformers
  - Conical TL to coaxial TL transition
  - Coaxial transmission line impedance transformer

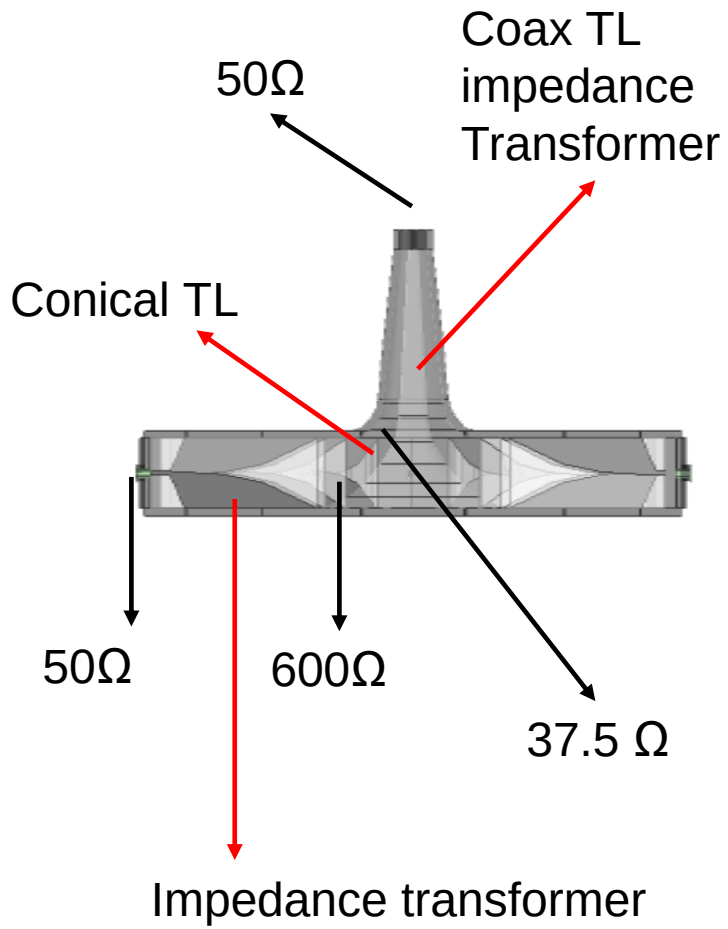




Proposed RF Power Combiner

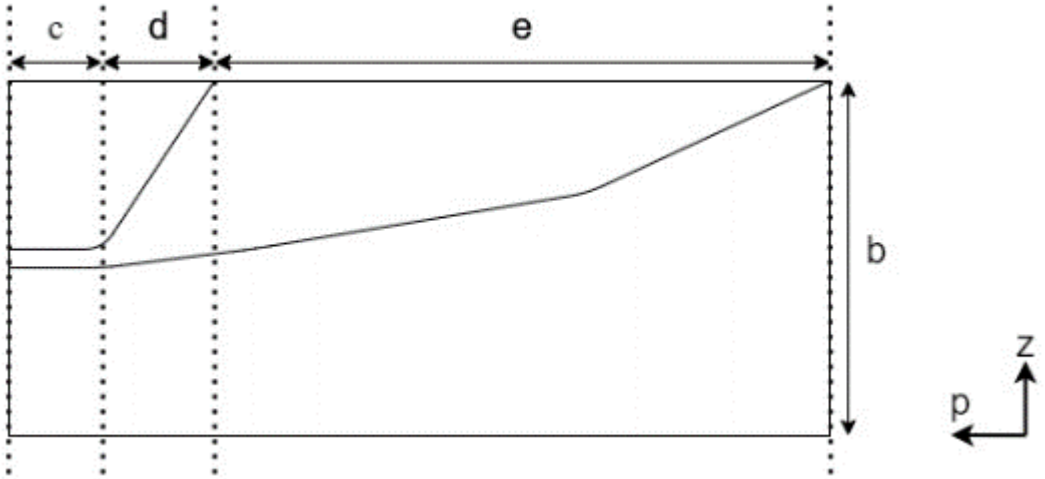
- For the 16-way power combiner design
- Z_s is chosen as 600 Ω
- Z_s/N is found to be 37.5 Ω



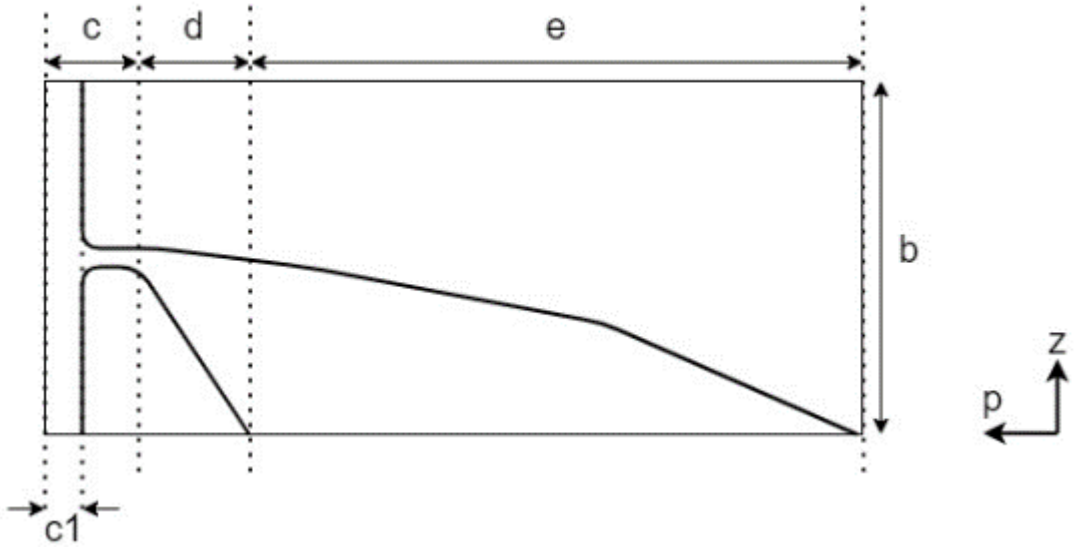


Antipodal Slot-line Transformer

- It transforms 50 Ω input port impedance to Zs Ω.
- In our example it transforms 50 Ω to 600 Ω.



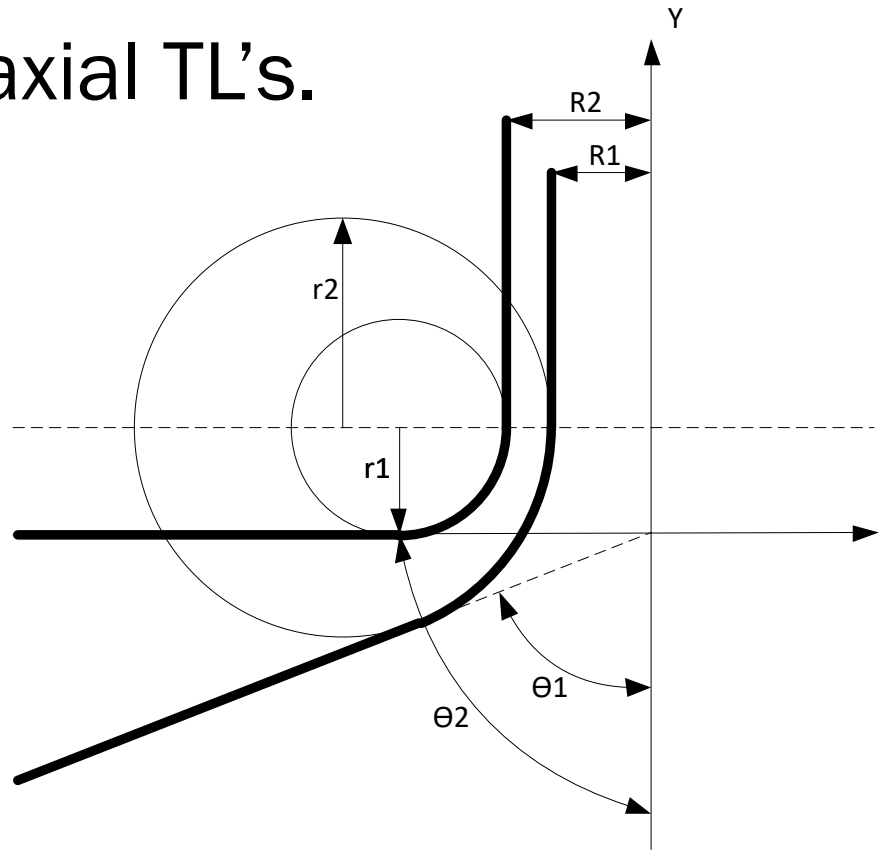
Top layer of slot-line transformer



Bottom layer of slot-line transformer

Conical TL to Coaxial TL Transition

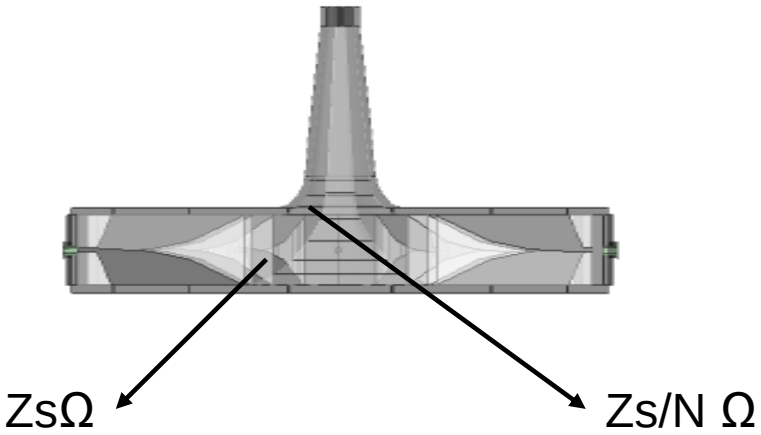
- It aims a smooth transition between coaxial and conical transmission line mediums.
- Z_0 is the impedance of conical and coaxial TL's.
- Z_s should be equal to Z_0.
- Z_0 = 600 Ω in our case.
- θ_1= 56.3°

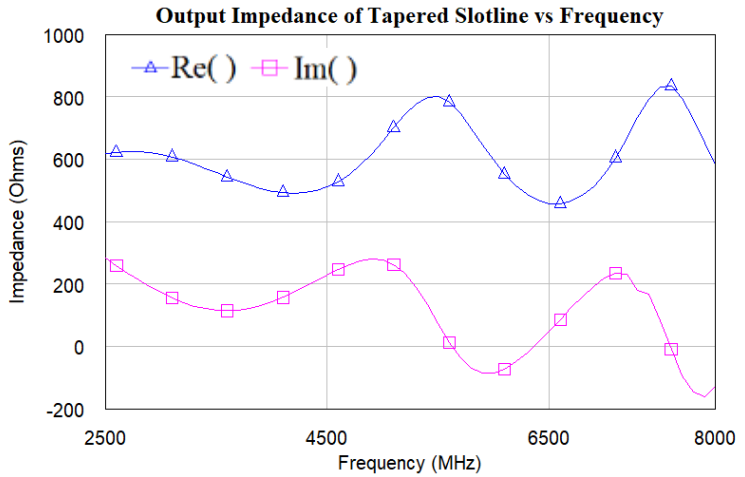


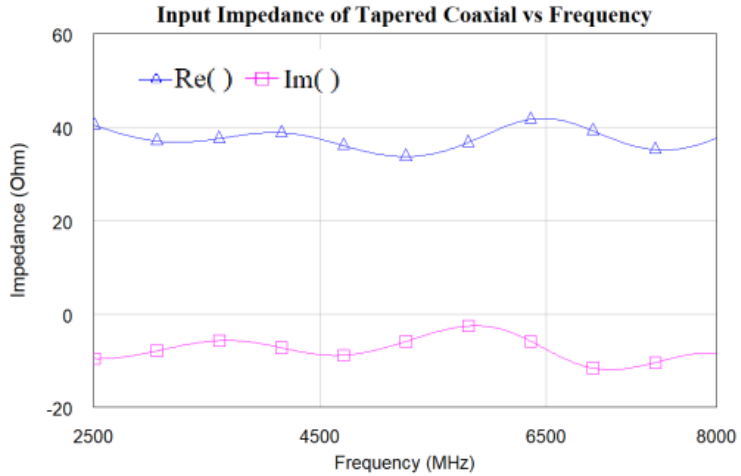
$$Z_0 = 60\ln\frac{\tan(\theta_2/2)}{\tan(\theta_1/2)}$$

Simulation Results

- Designed combiner was optimized using HFSS
  - Simulated impedance at the end of the slot-line transformer is shown in the upper Figure
  - 16 slot-line transformer combined in parallel and resulted in 37.5 Ω as shown in the Figure below

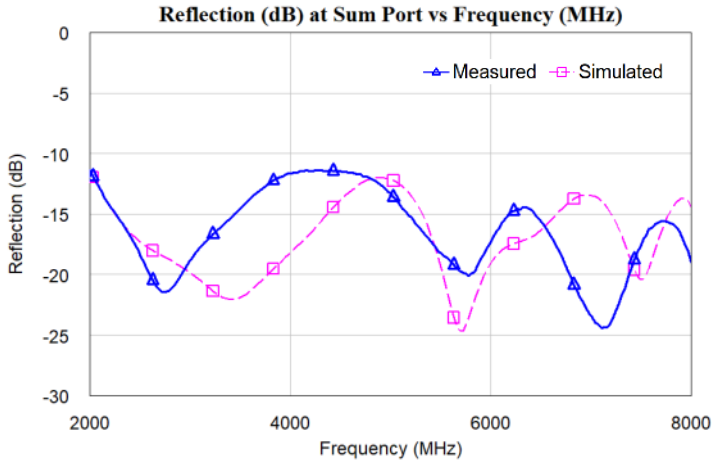


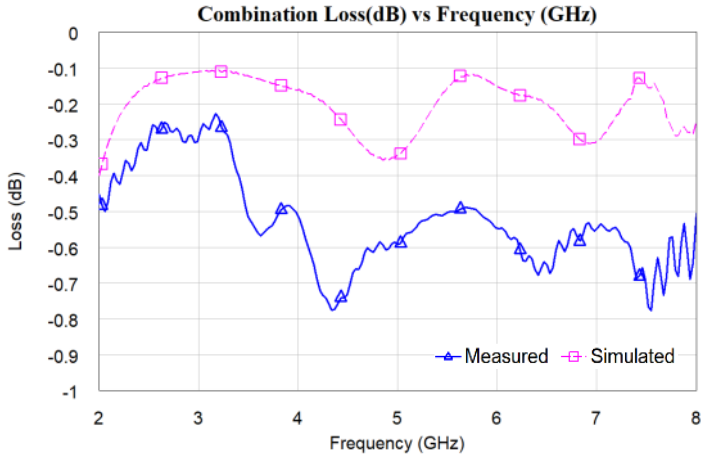


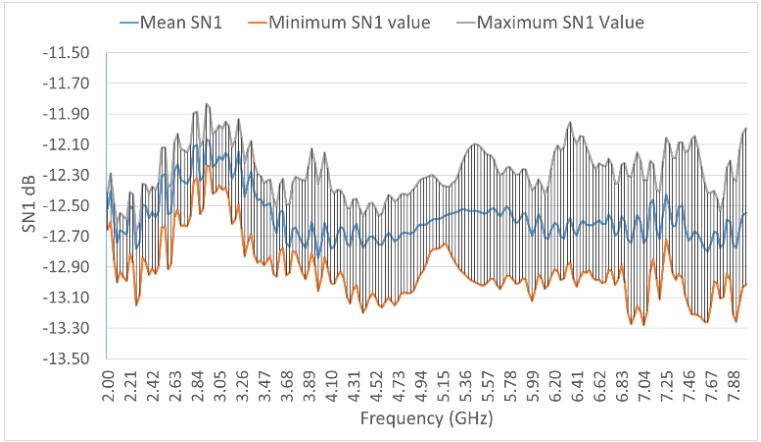


Simulation and Measurement Results

- Measured and simulated reflections at the sum port is given in the left most Figure
- Measured and simulated combination loss is given in the middle Figure
- Measured amplitude imbalance is given in the right most Figure







Conclusion

- Power handling
  - 500W @ 8GHz - Limited by the power handling of N-type female connector
- Remarkable amplitude imbalance performance
  - Maximum ±0.6dB (1.2dB peak)
- Remarkable loss performance
- Advantage of displacing power amplifiers on a large cooling plate.