A Novel Spatial High Power X- Band RF Power Combiner

Vinay Ravindra
University of Tokyo

Hirobumi Saito
Institute of Space and Astronautical Science
Japan Aerospace eXploration Agency

Jiro Hirokawa, Zhang Miao
Tokyo Institue of Technology

1. Background

We plan to launch a small satellite carrying Synthetic Aperture Radar (SAR) instrument to provide for day/night earth observation cabability. SAR is an active imaging sensor based on principles of ranging and doppler. It is a massive power hungry device which makes the incorporation of the satellite onto a small satellite bus challenging. Traditional power amplifiers for big SAR satellites have been TWTAs or magnetrons. Our satellite shall use compact Solid State Power Amplifiers (SSPAs) which allow for smaller size and a RF power combiner to combine the RF output from these amplifiers.

2. Research Objective

To realize a X-Band radio frequency (RF) power combining technique to combine the RF power output from several SSPAs coherently and hence produce a high power RADAR pulse.

3. System Requirements

Selection of the power combining technique depends on the SAR system requirements. This is tabulated in following Table 1.

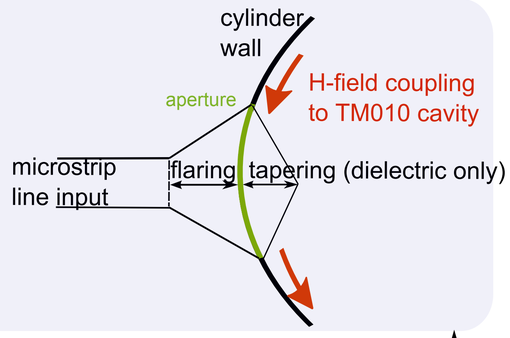
Table 1

Parameter	Value
Peak Power	>600 W
Duty Cycle	20%
Frequency	9.55 GHz – 9.75 GHz

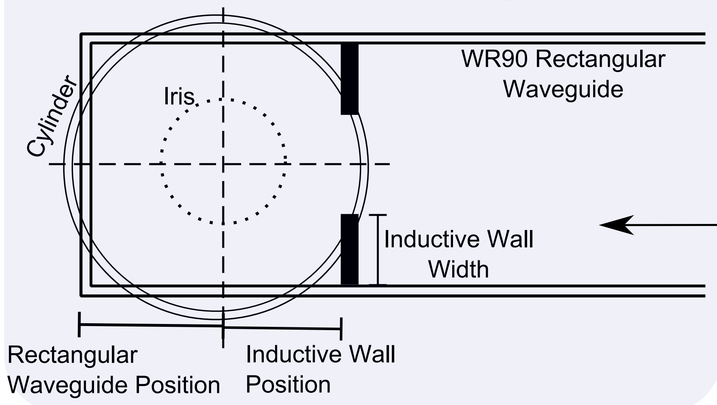
4. Design

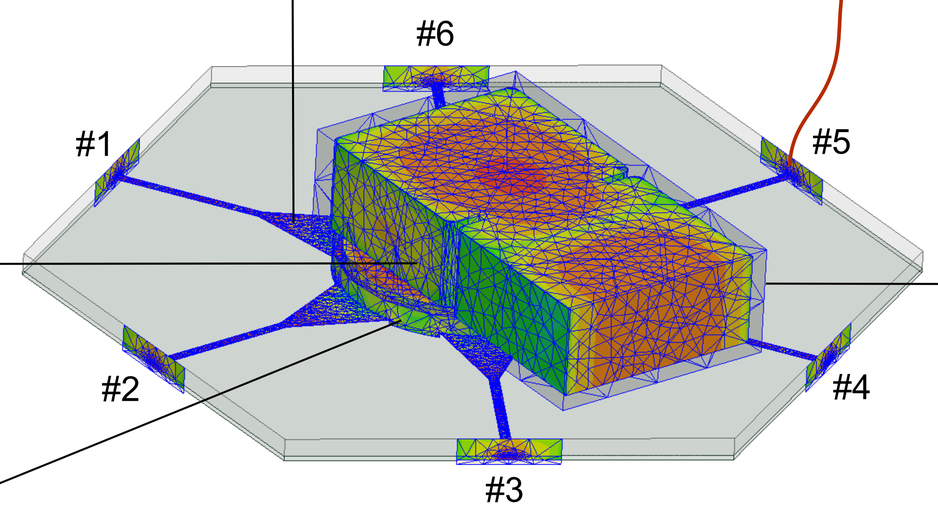
Microstrip Line Interface

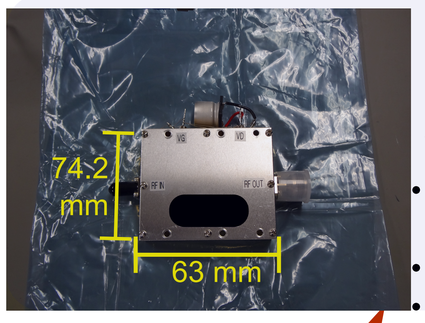
- Rogers HTC 6035 laminate
- High Thermal Conductivity
- Low loss tangent



Iris coupling to rectangular waveguide







GaN Solid State High Power Amplifier Inputs

- 120 W GaN X-Band power amplifier
- Efficiency: 35%
- Compact Structure

Standard WR90 rectangular waveguide output

- TE10 modal propagation
- Easy coupling to Antenna Feeder network

Cylindrical Cavity Resonator

- TM010 excitation mode
- Silver plating on inside to reduce conductor loss and hence increase cavity unloaded Q
- Almost flat structure
  cylinder height ~ 3.0 mm
  cylinder radius ~ 13.5 mm

Optimization

- *Optimization Objective:*
  -> Low insertion loss within frequency bandwidth of interest
  -> Low return loss to input SSPA aperture width
- *Optimization variables:*
  - aperture width
  - flaring length
  - tapering length
  - cylinder radius
  - iris radius
  - cylinder height
  - rectangular waveguide position
  - inductive wall position
  - inductive wall width

Computer Aided Electromagnetic Simulation using ANSYS HFSS

- Finite Element Method
- Automatic Adaptive Meshing technique
- Multicore processing to improve solver speed

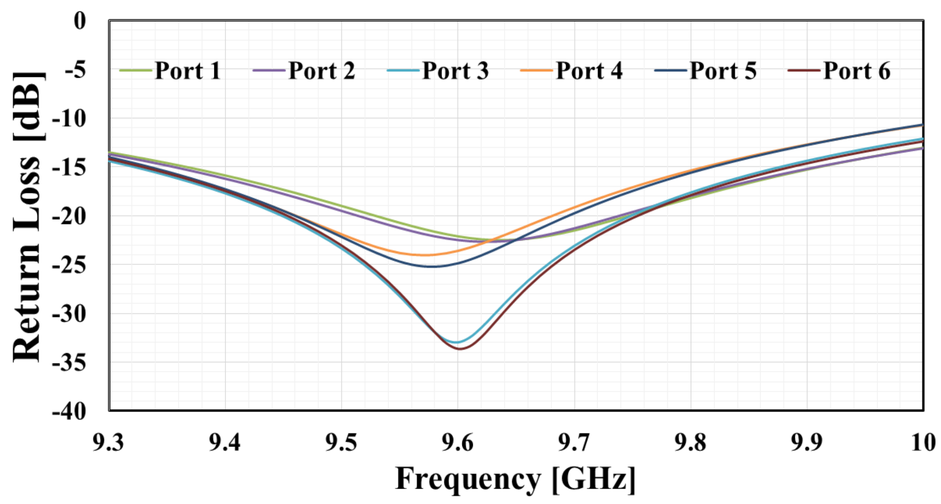
5. Results and Future Work

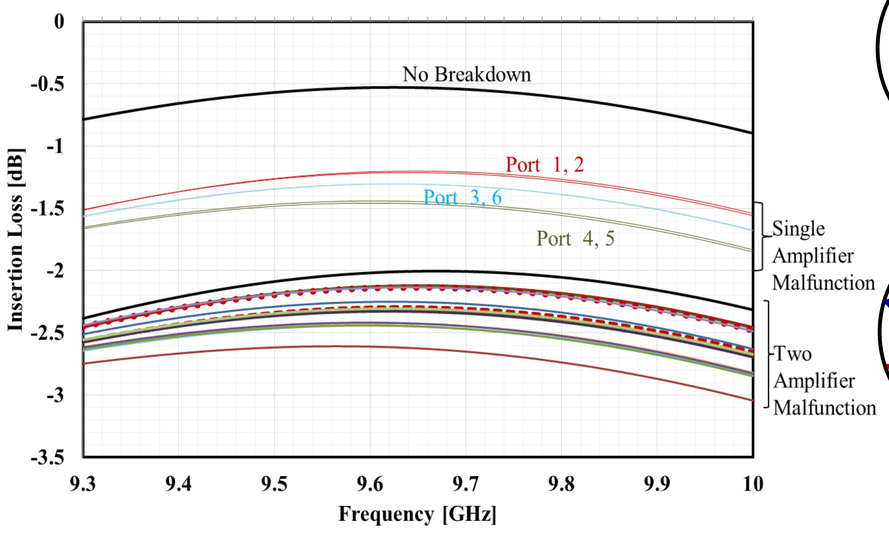
- Simulation results show the power combiner exhibits low insertion loss (< - 0.5 dB) and low low return loss (< -20 dB) within our bandwidth of interest (200 MHz).

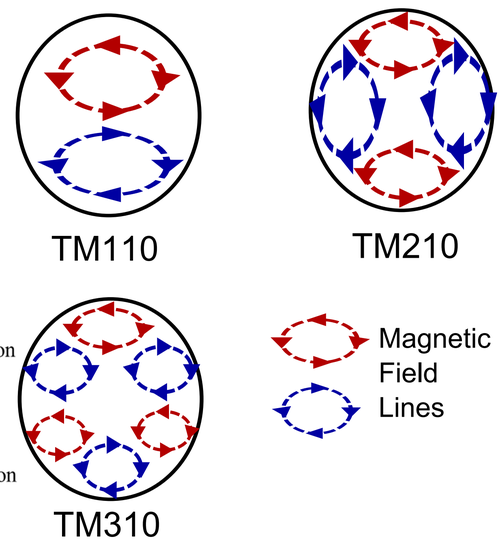
- In case of malfunction of any one of the power amplifiers,we see a degradation in insertion loss by 1 dB.

- Two power amplifier failure results in 2.5 dB degradation in insertion loss.

- Future work includes study of techniques to improve insertion loss of the power combiner in case of single power amplifier malfunction.







Spurious mode excitation in 6-input magnetic field coupled cylindrical cavity