Abstract: A passive power splitter-combiner has been designed in-between two metallic ground plates using gap waveguide technology. The measured insertion loss is smaller than 2.3 dB and the return loss is larger than 10 dB over the entire W-band (75-110 GHz). The design procedure has been detailed and the simulated and measured results for the proposed structure are shown. The designed structure can be used as a passive power splitter or combiner, as a grid amplifier in a back-to-back RF chain, or as a quasi-optical beamforming component in beam steering antenna arrays.

Keywords: Gap waveguide technology, spatial power combiner, grid amplifiers.

References:


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*W-band Spatial Power Combiner and Splitter in Gap Waveguide Technology*

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Brief Overview of the Presentation

1. Background and Motivation
2. Design and Simulation of a Feed Horn and Offset Reflector Wall
3. Design of Transition between Reflector Wall and Array of Ridge Waveguides
4. Simulation of Back-to-Back structure
5. Prototyping, Manufacturing, and Testing Results
   Conclusion
1- Background

• Previously Spatial Power Combining has been done by use of [1]
  • Conventional Corporate Feeding Networks
  • Dielectric Lenses
  • Bulky Horn Antennas

• Issues [1]
  • Low radiation efficiency and power losses
  • Diffraction losses in the lenses
  • Compensation for phase imbalance
  • Narrower frequency bandwidth at W-band

Examples (1 / 2) [1]

36 W, V-band (60-65GHz) amplifier

120-W, X-band (8–11 GHz) amplifier

5-W, 37.2-GHz (1.3GHz bandwidth) amplifier

Examples (2 / 2) [1]

A 25/50 W Ka-band (30-40GHz) amplifier

A 600 W C-band amplifier with 6GHz (Bandwidth)

1-Motivation (1 / 2)

• The proposed spatial power combining technique consists of:
  • Offset reflector wall
  • Offset feed wall
  • Array of waveguides
1-Motivation (2 / 2)

• Benefits:
  • Power is divided or combined at the first stage over the air with minimal losses
  • Wide bandwidth
  • Suppresses cavity resonances at high frequencies (Gap Waveguide)
  • Less affected in case of few malfunctioning components (Amplifiers)

• Future Usage
  • Base for the grid amplifiers
  • Slot antenna arrays
2- Design and Simulation of a Feed Horn and Offset Reflector Wall
• **Reflector Designing:** An offset cylindrical reflector has been designed using parameters (in mm): \( D = 55; \Theta/2 = 36.3 \) degree ; \( h_1 = 10 \), and; \( F = 32.5 \). Hence, \( F/D = 0.59 \).

Where
- \( F \) is the focal length along z-axis
- \( h \) is the height of the center of the reflector along the y-axis
- \( D \) is diameter of parent paraboloid
- \( D_1 \) is diameter of the cylinder
- \( h_1 \) is offset height
- \( \Theta \) is the angle from the focal axis to the center of the offset reflector

\[
z = \frac{y^2}{4F} - F
\]
• E-Field and phase plots with offset reflector Wall
3-Design of Transition between Reflector Wall and Array of Ridge Waveguides

To solve this problem, fork shaped ridges have been implemented after several different configurations and finalized with the following parameters:

\[ L_1 = 0.782 \text{ mm}, \quad L_2 = 0.68 \text{ mm}, \quad L_3 = 1.25 \text{ mm}, \quad h_1 = 0.15 \text{ mm}, \quad h_2 = 0.52 \text{ mm}, \quad h_3 = 0.89 \text{ mm}, \quad W_1 = 0.537 \text{ mm}, \quad W_2 = 0.774 \text{ mm}, \quad \text{and} \quad S_1 = 0.744 \text{ mm}. \]
• **E-Field and phase plots of the transitions**
4-Simulation of Back-to-Back structure
• E-Field and phase plots of the back-to-back structure
5- Prototyping, Manufacturing, and Testing

Results
• S-Parameter Results
• E-Field PEC and phase plots of the back-to-back with structure
• Manufacturing and test setup of the prototype
• Testing setup and measurement results
• Result Comparison of PEC material, Al. Metal + 5um surface roughness (Simulated) and measured result
Conclusion

• The milled Aluminum 16-channel back-to-back gap waveguide spatial power splitter and combiner has an overall return loss better than 10 dB and an insertion loss smaller than 2.28 dB over the entire W-band (75–110 GHz).

• The offset feed for the offset reflector is designed. A fork-type transition is needed to transfer the planar wavefront originating from the reflector aperture to the array of ridge gap wave-guides.

• The simulated and manufactured prototype results as were well-matched as expected and covers the required band of interest.

• The novel dielectric-free structure can be used as a standalone power splitter and/or combiner, a beamformer to excite an array of slot antennas in the top ground plane by ridge gap waveguides, or as a back-to-back structure for the design of planar grid amplifiers.