A Mechanically Tunable Multi-split-ring-slot Wavguide Directional Coupler for High-power Microwave Applications

Xuyuan Pan*, Georgios Atmatzakis, and Christos G. Christodoulou
Dept. of Electrical & Computer Eng., The University of New Mexico,
Albuquerque, NM 87131-0001, USA

Waveguide directional couplers have been seen in high-power microwave applications due to their good directivity, low loss, high-power handling capability and low cost. Multi-hole waveguide couplers have been designed for wider bandwidth, better directivity, by applying Bethe′s small sized coupling hole theory. Other structures such as cross apertures, T-slots, longitudinal apertures are also used in waveguide coupler designs. Similar to longitudinal apertures, split-ring-slots can be introduced to waveguide couplers for high-power applications.

This work mainly seeks a mechanically tunable waveguide directional coupler applying the split-ring-slot structure. Split-ring-slots on the narrow-wall of the rectangular waveguide can be analyzed through equivalent circuits. The slots are equivalent to two-port networks in parallel or in series between two waveguides which have mutual coupling. By mechanically rotating the split-ring-slot, the characteristics of the equivalent two-port network change, resulting in variable coupling ratios at the output port and the coupled port. Another reason the split-ring-slot structure is used is that the split-ring-slots can achieve stronger coupling such as 6dB or even 3dB with minimal number of aperture, compared to Bethe holes. Since waveguide directional couplers are generally achieved by having small holes separated by $\lambda_g/4$, the fewer apertures applied, the smaller the couplers are.

The multi split-ring-slot waveguide directional coupler is analyzed as a lossless microwave network. Full-wave analysis is then conducted in HFSS to include mutual coupling. The dimension of the split-ring-slot is optimized to achieve better coupling and directivity. To further improve the directivity, optimization of the dimensions of the split-ring-slots can be done by applying binominal or Chebyshev coefficients as the voltage distribution at each split-ring-slot.

By varying the positions of the slits of the split-ring-slots in HFSS, which is equivalent to mechanically rotating the split-ring-slots, different coupling ratios can be achieved between the output port and the coupled port.

Power handling capability of the mechanically tunable multi-split-ring-slot waveguide directional coupler is mainly limited by air breakdown at the sharpe corners of the apertures. Due to the rotating mechanism, air-filled waveguide directional couplers will be used instead of vacuum. However, simulation results show that up to 100 MV of input power can be sustained inside the waveguide directional coupler. The output of such coupler can be controlled to feed different HPM antennas based on the power handling capabilities of the antennas.