Wideband Design of a Waveguide Short-slot Two-plane Coupler

Jiro Hirokawa*, Masahiro Wakasa, Dong-Hun Kim, and Takashi Tomura
Tokyo Institute of Technology, Tokyo 152-8552, Japan

The authors proposed a waveguide short-slot two-plane coupler as a key component of two-dimensional beam-switching Butler matrix as shown in Fig.1 (D.-H. Kim et al., IEEE Trans. Microw. Theory Techn., 64(3), 776-784, 2016). It has 2x2 ports at each end of the coupled region. The cross section shape of the coupled region is changed from a rectangular. It has concaves at the center of the top and the bottom sides and at the corners to keep the symmetry in both the horizontal and the vertical directions. The ideal operation of the hybrid is explained as follows. For an incidence from Port 1 as an example, Ports 1-4 have no outputs and Ports 5-8 have equal division in amplitude. Ports 6 and 7 have 90-degree delay and Port 8 has 180-degree delay in comparison with Port 5. The ideal operation of the cross coupler is described as follows. For an incidence from Port 1 as an example, only Port 8 have output and Ports 1-7 have no output in amplitude.

The coupler is analyzed by a hybrid of mode matching and finite element methods (M. Wakasa et al., Intl. Symp. Antennas Propag., POS3-R5, 2017). The structure is reduced to a one-eighth model as shown in yellow in Fig.1 by considering the three-dimensional structural symmetry. In the coupling region, a PEC or PMC is placed on each of the symmetrical planes in the consideration of the symmetry of the electromagnetic field modes. Genetic algorithm is introduced for the wide band design. The population is 44 and the generation is 550. Parallel computing is done using 44-core CPU. The computation time is 46.0 seconds for 200 frequency points from $20 - 24\text{GHz}$ using CPU core i7 3.4GHz and 16GB memory. The bandwidth for the hybrid is defined as follows: $|S_{51}|, |S_{61}|, |S_{71}|, |S_{81}| = -6.02 \pm 0.5\text{dB}$, $\angle S_{61} - \angle S_{51}, \angle S_{71} - \angle S_{51} = -90 \pm 10\,\text{deg}.$, $\angle S_{81} - \angle S_{51} = -180 \pm 10\,\text{deg}.$ The bandwidth is improved from 2.3% to 6.9%. The hybrid is under fabrication. The measured results will be shown in the conference.
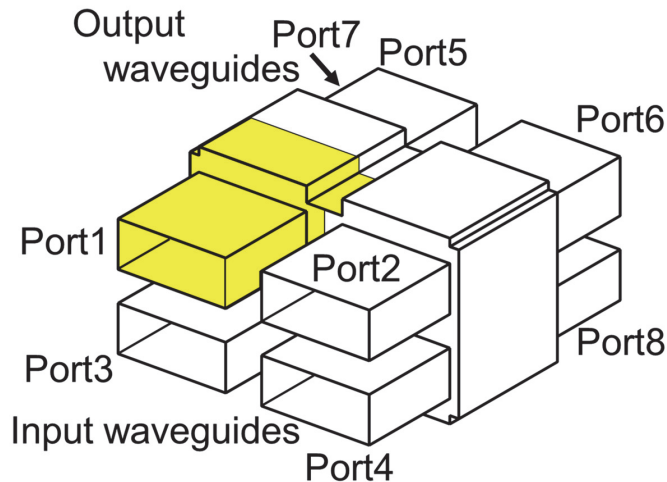

Figure 1. Waveguide Short-slot Two-plane Coupler.