Design of one-body 64×64-way 2-D beam-switching Butler matrix

Dong-Hun Kim*[1)], Jiro Hirokawa[1)], and Kentaro Nishimori[2)]
[1)]Tokyo Institute of Technology, Tokyo, Japan
[2)]Niigata University, Niigata, Japan
{donghun.kim, jiro}@antenna.ee.titech.ac.jp; nishimori@ie.niigata-u.ac.jp

Along with the proliferation of 5G service and IoT, the requirement of data traffic will be drastically increased. To supply enough data traffic to a subscriber and a device, the operating frequency band should be moved upward. However it leads to increase the loss in the propagation path. One of solutions is the beam-switching technique what divides a coverage by corresponding inputs and connects orthogonally. There are many approaches to operate beam-switching network using active or passive circuits. Because the existing approaches are suffered high insertion loss, the authors propose the one-body 64×64-way 2-D beam-switching Butler matrix with 4×4-way short-slot 2-plane couplers.

The previous work introduced the basic configuration of the one-body 16×16-way 2-D beam-switching Butler matrix (D.-H. Kim, J. Hirokawa, and M. Ando, IEEE Trans. Microw. Theory Techn. vol. 64, no. 3, pp. 776-784, Mar. 2016). It consists of 2-plane hybrid couplers. E- and H- and 2-plane cross couplers, and phase shifters. The 2-plane hybrid and cross couplers work as a quartering power divider (-6 dB) and a 2-D cross junction, respectively, as shown in Fig. 1(a). Those couplers are introduced to the 64×64-way 2-D beam-switching Butler matrix. These components are grouped and arranged to units as shown in Fig. 1(a). Three hybrid coupler units divides an inserted power to one sixty-fourth (-18 dB). The cross coupler units shuffle the propagation paths of the divided orthogonal signals. Preceding two phase shifter units delay given values and compensate the phase differences caused by the propagation modes of the cross couplers. The last phase shifter unit compensates the phase differences only. The main body size of one-body 64×64-way 2-D beam-switching Butler matrix is 5.6 λ_0×4.8 λ_0×25.8 λ_0. The operation frequency band covers from 19.39 GHz to 19.88 GHz (f_0=19.63 GHz, Δf=0.25 GHz). It generates 64 beams and covers 39.5% of the hemisphere in the frequency band as shown in Fig. 1(b) by simulations. Un-overlapped 3.9 dB gain contours indicate the orthogonality of beams corresponded to the input ports. The insertion loss is less than 2.17 dB including the conducting loss (0.37 dB) from the hollow waveguide walls (aluminum alloy, A6061, $\sigma=2.56\times10^{7}$ S/m).

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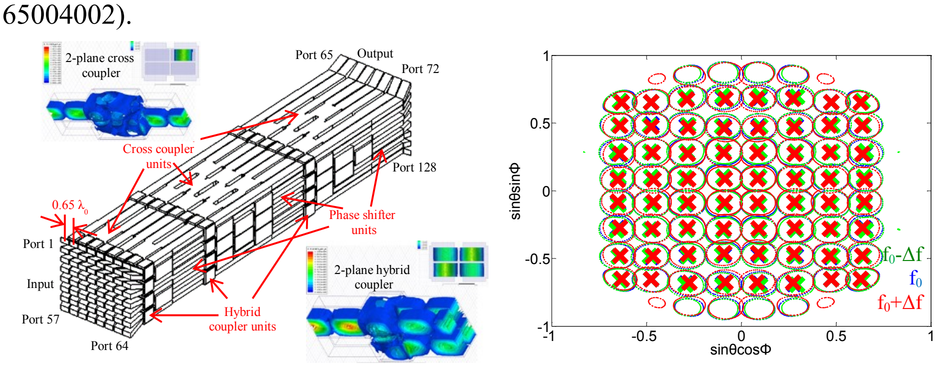

(a) (b)

Fig 1. One-body 64×64-way 2-D beam-switching Butler matrix (a) Configurations (b) 3.9 dB gain patterns and beam directions ('×' symbols).