Variable Waveguide Power Dividers for High-Power Applications

Uwe Rosenberg
ANT Nachrichtentechnik GmbH
Gerberstr. 33, D-7150 Backnang, Germany (West)

Jens Bornemann
University of Victoria, Dept. of Electr. and Computer Eng.
P.O. Box 3055, Victoria B.C., Canada V8W 3P6

Since World War II, high-power microwave sources (magnetrons, klystron, and TWTAs) have been developed and applied in several technical areas ranging from communications systems (especially troposcatter and satellite systems) and advanced radar systems to high-energy physics. The enormous progress in the development of new passive waveguide components and CAD tools for their design support until now have made possible substantial advancements in all these areas. The various passive waveguide components are classified in several groups. An essential one of those covers couplers and power dividers that are widely used for a variety of applications. Many different designs have been established since the introduction of the waveguide technology in the 1930's, e.g., Magic Tee, multihole coupler, branch guide coupler, septum divider, etc. Some recent applications aim at variable power splitting, i.e., the coupling value is changed during operation to vary, for example, the pointing direction of a multifeed antenna.

This paper presents the main principles for the design of variable power divider equipment for high-power applications. The design of the required components, or combinations thereof, as well as several design variants of each principle are discussed in view of special demands, e.g., phase stability at the respective ports, bandwidth, etc. Experimental results are provided for two different designs.

The first principle is based on a bisection of microwave power and a recombination of the signal portions with a variable differential phase. This method can be realized by two Magic Tees or 3-dB hybrid couplers that are interconnected with two phase shifters at two corresponding semi power ports. The microwave energy fed to the input port of the first Magic Tee (coupler) is bisected and supplied to the interconnected phase shifters. If the phase shifters exhibit identical phase relations, the semi signal portions passing the phase shifters are recombined by the second Magic Tee (coupler) and provided at the respective (Σ) output port of this component. In case of different phasing, the recombination within the second Magic Tee yields signals at both ports (Σ and Δ), depending on the phase difference. Hence, the signal can be divided arbitrarily between the two output ports of the equipment. Phase stability versus change of coupling value is obtained by the correlation of the phase-shifting functions, i.e., $\phi_1 = \phi + \Delta\phi$ for the first phase shifter and $\phi_2 = \phi - \Delta\phi$ for the second one. Another design variant of this principle uses only one coupler (Magic Tee, hybrid), two short-circuited phase shifters and a circulator.

The second method builds on the spatial superposition principle, i.e., an electromagnetic field can be regarded as the superposition of two independent orthogonal polarized waves. Realization of this method can be achieved by the spatial rotation of the electromagnetic field within a dual-polarized waveguide that is terminated by an orthomode transducer (OMT). The variable coupling of the signal energy between the OMT ports is determined by the alignment of the ports with respect to the electromagnetic field in the dual-polarized waveguide part. The field rotation can, for example, be performed by a 180° polarizer within the dual-polarized waveguide or by a preceding step twist. The application of a proper OMT design allows an axial combination of several such units to form a multiport variable power divider.