Abstract

Analog beamforming networks at microwave frequencies have been in existence over several decades. They are widely used in applications such as wireless communications, surveillance, different type radars, and etc. Analog beam-former has its own advantages of being less complex and less costly over digital counterpart and is preferred where coverage in fixed directions are required. Most of the analog beam-formers like Butler matrix, Nolen matrix, Rotman lens, etc. provide beam steering to some fixed predefined beam positions i.e. continuous beam steering is not possible. Circuit size is also a major concern as the PCB area required for higher order beam-formers increases.

To solve this problem, the original Butler matrix is modified by introducing time delay elements for continuous beam steering using frequency sweep. Next, the delay elements are replaced by tunable phase shifters for beam steering at a fixed frequency. Also, compact designs of Nolen and Butler matrices are presented. Implementation of these modified beam-formers require some high-performance passive components. Five different components, namely, arbitrary coupling arbitrary phase coupler, wideband cruciform coupler, RF switch with high isolation, ultra-wideband compact CB-CPW crossover, and reflection type phase shifter with wide tuning range are presented in the first contributory chapter. Then, the modified matrices are presented in the following four chapters. For the passive components as well as beam forming networks, transmission line based analysis is first carried out to obtain design equations. Then, the full-wave electromagnetic simulator is used to obtain the physical layout for implementation in printed circuit board technology. Finally, all the components and networks are fabricated and experimentally verified.

Keywords: Butler matrix, crossover, hybrid couplers, Nolen matrix, Phase shifters, PIN diode, planar transmission lines, RF switch, varactor diode.