Octave-Band Three-Beam Scalable Antenna Array Fed by Broadband 4 × 4 Butler Matrix

Andrzej Dudek, Piotr Kanios, Krzysztof Wincza and Slawomir Gruszczynski
AGH University of Science and Technology
30-059 Krakow, Poland

Abstract

A novel concept of a three-beam antenna array operating over a one-octave frequency range is proposed in this paper. The antenna array allows stable beams' direction and beamwidths. To achieve constant radiation patterns, the antenna elements are appropriately spaced and fed by a network consisting of a broadband Butler matrix to which outputs directional filters are connected. The radiating elements are placed in such a way that two similar subarrays can be distinguished, one for the lower and another for the higher end of the desired frequency range. Signal switching between the subarrays and differential phase between pairs of radiating elements is ensured by directional filters and Butler matrix, respectively. The concept has been verified by measurements of the antenna array operating in a 2–4 GHz frequency range.

Introduction

In this paper, we propose a novel concept of a broadband three-beam antenna array with stable radiation characteristics over an octave-frequency range. The radiating elements are appropriately spaced and fed by a feeding network composed of a Butler matrix and four directional filters. The broadband 4 × 4 Butler matrix consists of 3.3-dB 0°/180° couplers and a 3-dB quadrature coupler, and therefore, ensures 0°, ±90°, and 180° phase shifts between its outputs. The input of the Butler matrix which provides a 180° phase shift is terminated, since such a phase shift results in a radiation pattern with two end-fire beams. The directional filters are connected to the outputs of the Butler matrix. These filters realize the signal switching between the radiating elements in order to achieve a stable radiation pattern over one frequency octave. The proposed concept was verified by measurements of the manufactured antenna array operating in a 2–4 GHz frequency band.

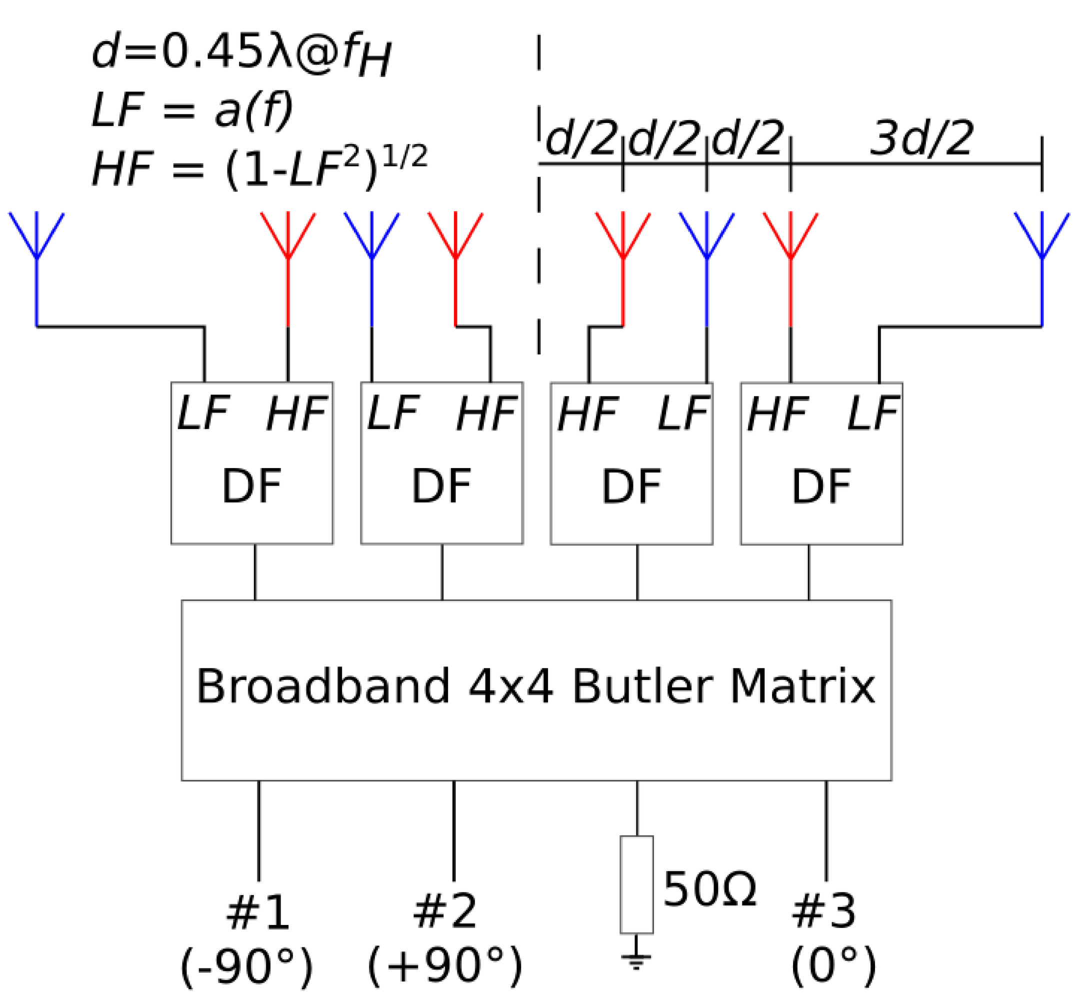

Fig. 1. Concept of three-beam scalable antenna array composed of eight radiating elements and fed through directional filters (DF) by a broadband Butler matrix.

Experimental Results

The radiation patterns of the multibeam scalable antenna array were calculated in the one frequency octave with the use of the simulated radiation characteristics of the linearly tapered slot antenna presented in [13] and are shown in Fig. 3. As it is observed the calculated radiation patterns are very promising. For the broadside beam, in calculation results, variation of the beam direction is not observed, whereas, for the 1L&1R beams, variations of beam directions are not greater than ±1.5°. Moreover, the HPBWs were calculated and their variations are not greater than ±1° for the broadside beam and ±5° for 1L&1R beams.

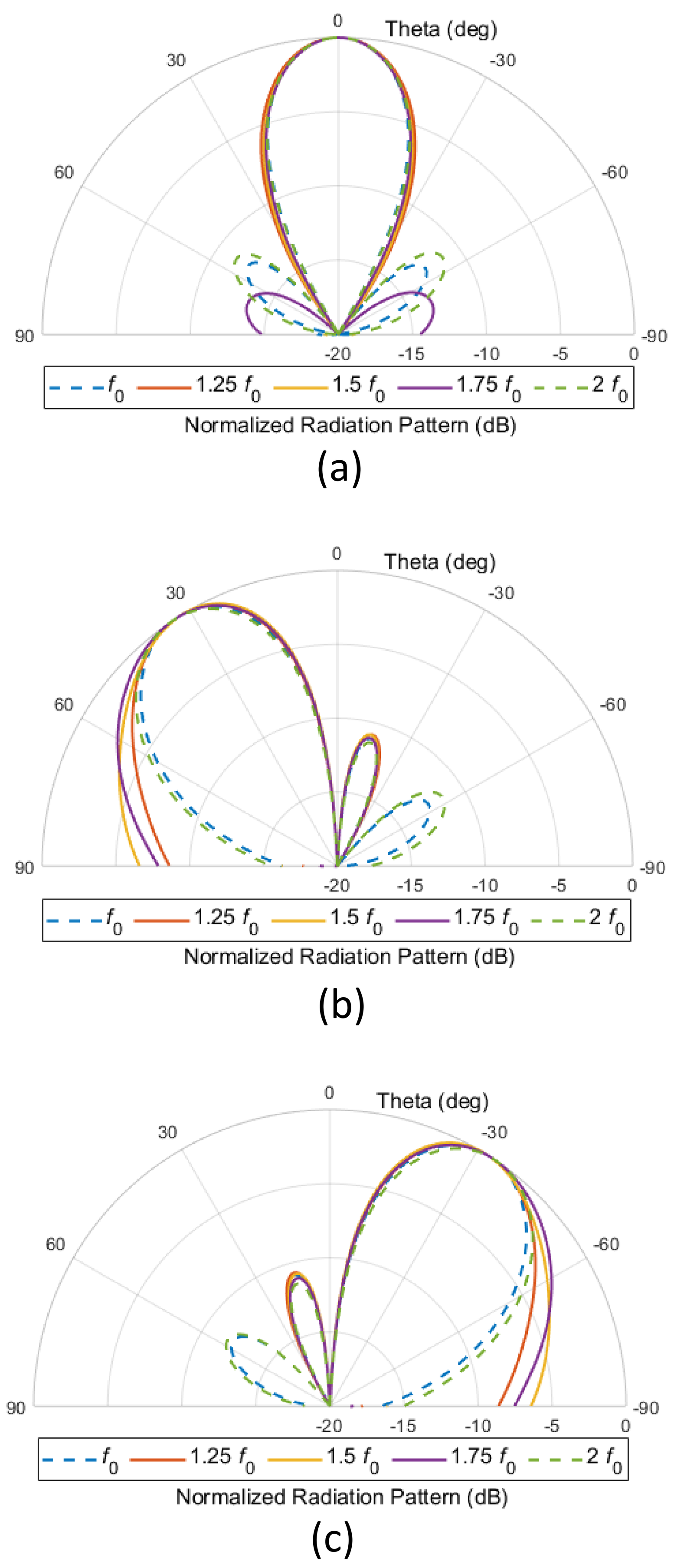

Fig. 3. Calculated broadside (a), 1L (b), and 1R (c) radiation patterns of the scalable antenna array. The radiation pattern of linearly tapered slot antenna presented in [13] was assumed for calculation purposes.

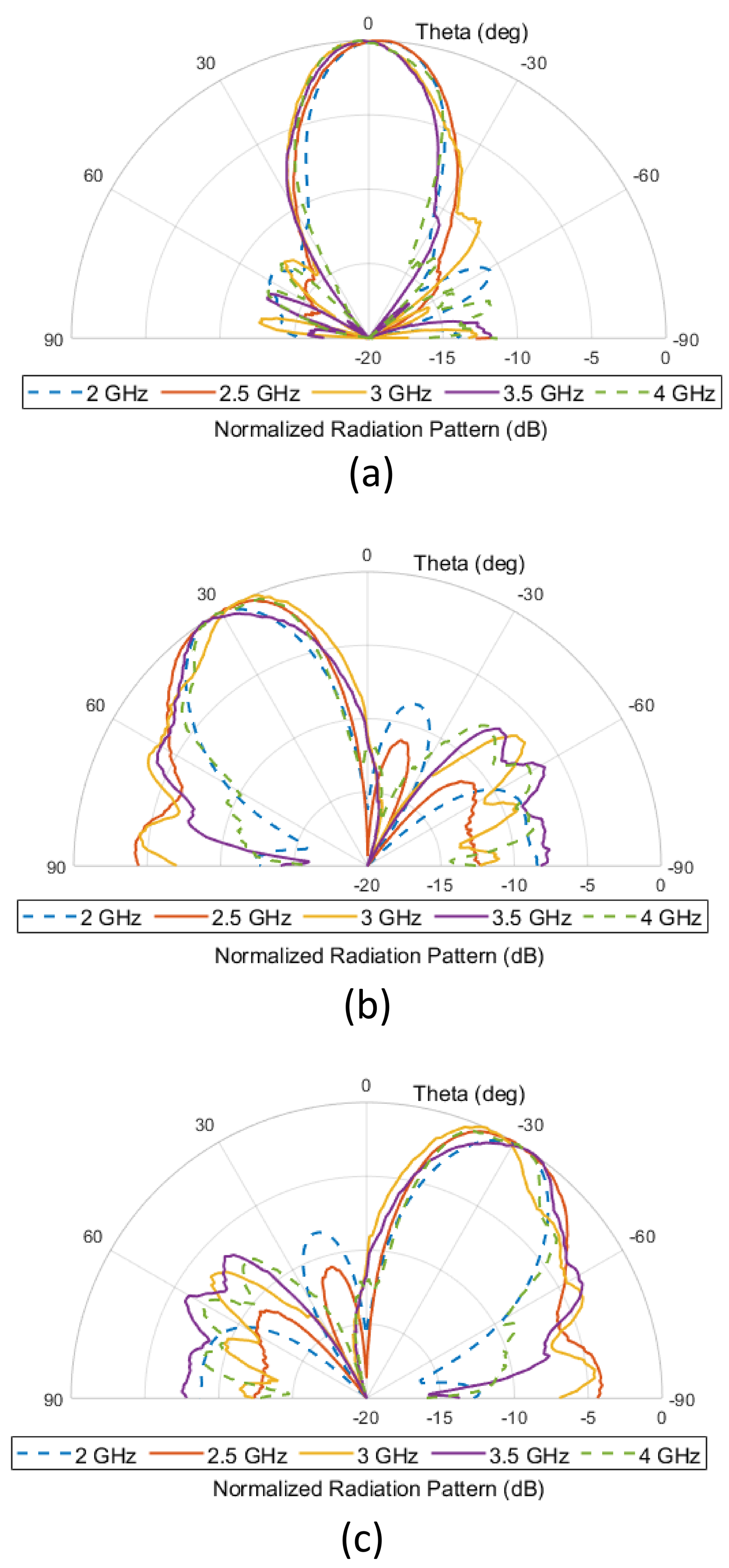

Fig. 4. Measured broadside (a), 1L (b), and 1R (c) radiation patterns of the developed multibeam scalable antenna array.

Measured radiation patterns are shown in Fig. 4. As it is seen the beam variation does not exceed ±3° and ±4° for broadside beam and 1L&1R beams, respectively. Similarly, the HPBWs variation is not greater than ±2° for the broadside beam and ±4.5° for 1L&1R beams.

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