Mm-Wave Beam-Sscanning Focal Plane Arrays with Microfluidically Switched Feed Networks

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A microfluidically switched feed network is introduced to realize mm-wave beam-scanning focal plane arrays. To achieve the switching functionality, a selectively metallized plate (SMP) within a microfluidic channel is brought in close proximity of the microstrip line feed network of a focal plane array by utilizing thin film fabrication techniques. The microstrip feed line network is strategically designed to exhibit gap discontinuities that are sequentially overlapped by the SMP metallizations as it is microfluidically repositioned within the channel. The capacitive coupling between the SMP metallization and the gap discontinuity is designed to achieve a low insertion loss (< 0.2 dB) and wideband (~20 GHz) performance. Transmission line theory is utilized to demonstrate that the feed network offers ~40% fractional bandwidth (FBW) with ≤ 12 dB insertion loss (IL) for linear arrays up to 64 elements.

This performance constitutes a significant improvement over the recently reported resonant feed network based realization of microfluidic beam-scanning focal plane arrays (A. A. Gheethan and G. Mumcu, "Passive Feed Network Designs for Microfluidic Beam-Scanning Focal Plane Arrays and Their Performance Evaluation," IEEE Transactions on Antennas and Propagation, vol. 63, no. 8, pp. 3452 – 3464, Aug. 2015). For experimental verification, a 30 GHz 8-element 1D focal plane array consisting of aperture coupled patch antennas with 8% FBW is designed. The array exhibits a 47° field of view with measured gains ranging between 20.32 – 22.54 dBi. The loss budget breakdown confirms the low-loss performance of the introduced microfluidically switched feed network as being ≤ 2 dB for an 8-element array. An integrated sensing approach for detecting the SMP position is also presented for the first time to facilitate the use of presented MFPAs with closed-loop position controllers. prior work, which relied on resonance mechanisms. The presented feed network allows for a highly efficient beam-scanning high gain antenna that is free from the costs and design complexities associated with the need of including active RF devices. In addition to the design details, experimental verifications of the proposed microfluidically actuated switch, feed network, and MFPA are presented. Furthermore, a technique for providing closed-loop control of the switching mechanism is proposed and experimentally verified as final discussion point.