A Compact 1-Bit Reconfigurable Folded Reflectarray Antenna

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Scanning antennas are a very important kind of antennas and can be found in many applications, such as radars, wireless communications, sensing systems, etc.. Conventional scanning antennas include mechanically and electronically scanning antennas. The former needs a rotation servo system and the agility and scanning range of antenna beams are limited. The latter is more widespread and a famous example is the phased array. However, phased arrays require a large amount of phase shifters or T/R modules, resulting in complicated structures and a high cost that are the big challenge for many applications, especially in millimeter-wave applications.

Recently, the study on reconfigurable reflectarray and transmitarray antennas attracts much attention of antenna researchers. These antennas normally provide 1-bit compensation phase and are able to perform wide-angle beam scanning, with a simple structure and a low cost. However, reflectarray and transmitarray antennas mostly use horns and non-planar antennas with an appropriate gain as the source feeders and usually have a longer focusing length, in order to improve the gain and the aperture efficiency. Therefore, the antenna volume is large, losing the portability and the possibility of integration with the associated systems, which are the important requirements of modern and future wireless communications. These properties are also reflected in current reconfigurable reflectarray and transmitarray antennas. To reduce the antenna volume while maintain the high-gain performance, full-planar folded reflectarray and transmitarray antennas are developed. However, the realization of scanning beams in folded reflectarray and transmitarray antennas is a big challenge.

Thanks to the recently appeared metasurfaces and the generalized Snell's law, lots of thin planar wavefront-manipulation devices at frequencies from ultrasound to optical band have been developed. In this paper, a 14×14 1-bit reconfigurable folded reflectarray antenna (RFRA) operating at Ku band is presented, which consists of a planar feed, a 1-bit reconfigurable reflectarray, a planar polarizing grating and a beam-control circuitry board. Each element of the reflectarray, which is composed of a dielectric layer, a metallic patch, two PIN diodes and a bias line, is able to provide the incoming electromagnetic waves of 1-bit compensation phase and 90º polarization rotation. A probe-fed 2×2 microstrip antenna array, which is integrated with the same dielectric layer of the reflectarray, is applied to feed the RFRA. Simulations and experiments are carried to validate the novel RFRA design. Experimental results show that the RFRA beam is able to perform 2D electronically beam scanning, with a scanning range of ±60º, a peak gain of 17.5 dBi, an aperture efficiency of about 14%, and a 3-dB gain bandwidth of over 10%. Further development of the RFRA is conducting to improve the aperture efficiency.