Comparison of Multi-Beam Radiations by Metallic Waveguide Lens Antenna for 5G applications Using Different Phase Creation Mechanisms

Hsi-Tseng Chou, Zong-Chen Tsai and Siddhartha Panigrahi
Graduate Institute of Communication Engineering, National Taiwan University, Taipei, Taiwan
E-mail: chouht@ntu.edu.tw

The next generation of mobile communications will employ millimeter wave (mmW) frequencies for broadband access. The drawback of high energy loss in wave propagations in air or dielectric materials drives the need of developing high gain antennas with sufficiently low energy loss in the antenna materials. In this case, the metallic waveguide lens antennas provide the advantages of high radiation gains, where the multi-beam radiations are particularly attractive to simultaneously provide the sufficient gains and wide area coverage. It is particularly worth mentioning that at mmW frequencies waveguide-type antenna arrays may retain a very low profile for practical applications.

In this paper, we presented the waveguide lens antennas by using the concepts of multi-focal feeds to determine the lens's external profile. In particular, we employ different mechanisms to create the required phases for the aperture field distribution, where the effectiveness in the radiation beamforming is investigated and compared. These phase creation mechanisms will affect the freedom of placing feeds to estimate the lens's profiles. These mechanisms include changing the lengths of waveguides, varying the phase velocity and shaping the lens's profiles. Here the phase velocity can be altered by using dielectric loading or varying the cross-section of waveguides. These mechanisms result in the possibility of using different number of feeds in excitation for wide-angle beam scan and the lens's profile for minimum radiation blockage since curved surface profile on the radiation side can happen.

In this paper, we first derive the lens's surface profiles based on the multiple focal points for feeds' placement. The waveguide's phase variation mechanisms in terms of propagation distances within the waveguides and phase velocities are then incorporated to examine the effect on the external surface profile and wide angle radiation patterns. The derivation of theoretical solutions to implement these mechanisms and obtain the surface profiles will be presented. Comparisons in terms of radiation pattern, gain and bandwidth will also be presented to demonstrate their characteristics, where the exampled design at 38GHz for 5G applications will be presented to demonstrate the application and implementation. Full-wave simulations will be presented to validate the mechanisms, where some implementation observations will be shown.