A Study on Design Methodology for Flexible Beam Shaping Lens with Phased Array Antenna and its Application

Seungtae Ko, Yoongeon Kim, Seungku Han, Byungchul Kim, Jungyub Lee, and Yeongju Lee
Next Generation Communications Business Team, IT & Mobile Communications, Samsung Electronics, Suwon 16677, Korea

Until now, a lot of efficient antenna designs are presented in order to obtain electrically small size, broad bandwidth, high gain, and etc. Especially, the flat lenses such as a transmit-array, a reflectarray, and a meta-surface are well known as an efficient application to enhance the antenna gain. By utilizing these, the spherical wave from the antenna can be converted to a plane wave in a specific region, and then the gain will be dramatically enhanced. The beam converting is generated by the proper phase compensation in a specific region from an antenna source. Indeed, numerous beam shapes can be generated such as wide beamwidth, angular shifted beam and etc., as well as a high gain beam by using spatially phase compensation method. By using this, we can obtain the attractive properties in various applications. However, the actual design and realization are not easy because of several limitations as follows.

First, it is difficult to obtain an optimized compensated phase of the lens. To generate a required beam shape, the information of the input phase from the antenna source should be secured. Even though the Fermat's principle is well known a useful guidance for lens design, it is just available in ideal case. For example if the source antenna has an electrically large size, the accuracy of Fermat's principle is reduced. Second, it is well known that the flat lens is composed of a lot of unit-cells having subwavelength. Each unit-cell converts the input phase to a required output phase. In practical design, the deployment of the unit-cells spends a long time manually. Finally, it is not easy to predict the output gain and HPBW by the effect of lens. Especially, when the source is replaced by an array antenna, the effect of lens will be changed by the steered beam.

In this paper, practically a fast design method of lens is proposed to convert to the arbitrarily required beam shape from an array antenna source. The design of the lens can be performed automatically by using a common EM simulation and a simply calculation. Also, the beam shape by effect of lens is easily estimated before a full wave EM simulation or a measurement from basic near field to far field calculation even if the phase of source is changed.

We will present the total design procedure from the unit-cell design to the actual lens design by stages. Moreover, several valuable results for the effect of lens are compared among the calculated result, EM simulated result, and measured results.