Element Design Methodology for Printed Reflectarray Antennas

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The printed reflectarray antenna has recently been paid attention by many researchers. Its flat or slightly curved reflecting surface can be conformally mounted onto existing supporting structure with relatively small incremental mass and volume. With a proper phase design or phase changing device incorporated into each element of the reflectarray, the main beam can be tilted or scanned to large angles from the aperture broadside direction. Another significant advantage of the reflectarray is that it can perform as a high-gain phased array with thousands of elements but without any complicated beamforming network and expensive transmit/receive amplifier modules. Many researchers have developed reflectarrays with good pattern performance, such as side-lobe level and cross-pol level. However, to achieve reasonable aperture radiation efficiency (above 40%) remains to be a challenge for reflectarray designers.

The efficiency of a reflectarray is primarily governed by its element design. There are several element types for printed reflectarrays such as the ones that use variable element size to achieve the desired phase change, the ones that use identical element size but with different-length phase-delay lines attached, and those that use identical elements but variable rotational angles (circular polarization only). No matter what element type is used, in order to achieve good radiation efficiency, one must pay attention to the following three factors when designing reflectarray elements. First, one must characterize the phase change versus the element change (size change, phase delay line length change, or rotation angle change). In other words, a curve for the amount of phase change versus the amount of element change should be generated. Second, as element phase changes, its radiation amplitude should not be sacrificed. For an example, the input impedance of a patch element should be matched to its attached phase delay line. Third, as element phase changes, the change in element's resonant frequency should be minimized. Several mathematical methods can be used to predict theses three factors. These are element radar cross-section calculation, infinite array computation, or waveguide simulator calculation. A more detailed discussion on these element design methodologies will be given during the presentation.

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