Millimeter Wave Frequency Selective Surface Design Based on Large-Scale Full-wave Simulation

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Frequency selective surfaces (FSSs) are widely used in microwave and millimeter wave system, either as a radome to prevent out-of-band transmission, or a duplexer to allow transmitting and receiving electromagnetic wave on different frequencies simultaneously.

Usually, FSS is periodically structured on 2-dimensional or 3-dimensional surface. Periodic Method of Moment (PMM) is a conventional approach to design and analyze FSS (Ben A. Munk. Frequency Selective Surfaces: Theory and Design. New York: Wiley, 2000). PMM assumes that FSS is infinitely periodically structured and illuminated by plane wave. Thus the periodic boundary conditions can be applied to isolate one unit from the periodic structure, on which the incident wave is expanded into Floquet modes. However, when the FSS is not illuminated by plane wave, PMM calculation would be inaccurate.

In our case, an FSS is placed at the near field region of feed horn as a duplexer. According to antenna theory, the electromagnetic wave in near field region cannot be assumed as plane wave. The result of original design simulated by PMM shows good performance with 0.1dB insert loss, while the experiment result indicates insert loss of 4dB, which accords with the above analysis.

To redesign this FSS, 3-dimensional full-wave simulation is necessary. This electric large millimeter wave FSS demands huge computational resources, thus a parallel code JEMS-FDTD (J ElectroMagnetic Solver-Finite Difference Time Domain) is used. JEMS-FDTD is a universal massively parallel electromagnetic field simulation program developed by IAPCM since 2008, which is designed and structured oriented to thousands of processors on high performance computer with MPI and OPENMP hybrid-parallel techniques. The simulation result of redesigned FSS indicates insert loss below 0.4dB, which agrees with the experiment result very well.

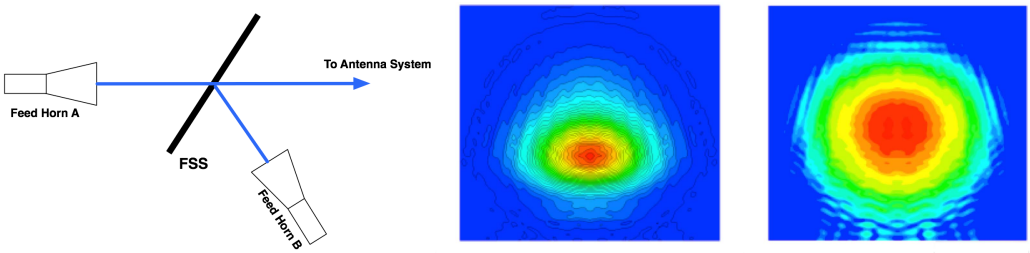

Fig. 1 (a) FSS used as duplexer
(b) Electric field distribution behind FSS of original design simulated by JEMS-FDTD
(c) Electric field distribution behind FSS of new design simulated by JEMS-FDTD