Dual-Band Transmit-Array Antennas Exploiting Polarization-Rotating Elements

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In recent years, frequency selective surfaces (FSSs) have been used to obtain a variety of different functionalities in manipulating the electromagnetic (EM) wavefront. The ability to manipulate the amplitude and phase of the incident EM wave at the sub-wavelength scale gave rise to innovative devices such as reflectarrays, transmitarrays, spatial filters, polarization converters, and more. Apart from the amplitude and phase another important property of the EM waves is the polarization state. FSSs have also been engineered to manipulate the polarization of the wave by converting a linearly-polarized incident wave to a circularly polarized transmitted or reflected wave, or rotate the polarization of an incident wave by a specific angle. The rotation of polarization has also been successfully used for phase compensation in designing transmitarrays and lenses in microwave frequencies. However, to date, a transmitarray which uses the rotation of polarization, in order to provide phase compensation, capable of operating in two different frequency bands have not been reported.

We present a polarization-converting FSS that offers the ability to rotate the polarization of an illuminating, linearly polarized, EM wave by 90^o and -90^o. The unit cell of the device comprises three metal and two dielectric layers, and the dual band polarization-rotation functionality is achieved with a combination of resonant and non-resonant elements. The second and third metal layers are rotated 45^o and 90^o, respectively, with respect to the first metal layer in order to facilitate the rotation of polarization. For the lower operating band, with center frequency at 8.5 GHz, the first and third metal layers exhibit capacitive behavior and they coupled together with a resonant dipole in the second metal layer. For the higher band, with center frequency at 14.5 GHz, the first and the third layers of the unit cell act as shunt parallel LC resonators coupled with a resonant dipole in the middle layer. The unit cell can achieve independent rotation of polarization by $\pm 90^o$ in each of the operating bands by rotating the corresponding coupling dipole in the middle metallic layer. The rotation of polarization by $\pm 90^o$ is offering a phase discretization of 180^o in each frequency band. The unit cell is used as a building block for a dual band polarization-rotation transmitarray, which exhibit phase discretization of 180^o in two different frequency bands. The transmitarray is designed to collimate the impinging EM wave, originate from an illuminating horn antenna, to the broadside. The spatial phase profile of the incident E-field is calculated on the surface of the array for the center frequencies of the two bands. Subsequently the unit cells are positioned in order to correct the incoming phase in 180^o increments. Using the previously mentioned design, one transmitarray were fabricated and experimentally characterized in a near field system.