A Reconfigurable Frequency Selective Surface Using Addressable Metamaterials

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We present measurements of a tunable metamaterial surface composed of digitally addressable complementary electric resonators (CELCs). The CELC unit cell consists of a complementary ELC screen backed by a 5 mm layer of FR4 substrate on top of a copper ground plane. The CELCs are loaded with *Skyworks* SMV 1405-079 hyperabrupt junction varactor diodes, which are reversed biased using a network of digital potentiometers configured as voltage dividers. Each digital potentiometer can be addressed independently on a single bus wire, allowing for precise control of the bias across each diode. By changing the bias across the diodes to tune each CELC self-resonant frequency, the potentiometer states can be programmed to create an arbitrary spatial gradient in the reflection coefficient phase angle. This gradient can be configured to control the scattering of an incident plane wave.

The dielectric backed CELC particle was designed to be resonant from 2-3 GHz, due to ease of fabrication and free space measurements within this band. The metamaterial surface consists of a 5 x 5 array of unit cells (each 3 cm x 4 cm), each of which is connected to power sources and the one-wire control network. The goal of the experiment is to show that the reflected radiation can be controlled by tuning the CELC unit cells across the surface. From the phase distribution across the surface required to steer the peak radiated beam in the desired direction, we derive the required reflection coefficient phase at each unit cell across the metasurface. Full wave simulations of the CELC unit cell using *Ansoft* HFSS were used to determine the varactor capacitance necessary to achieve the necessary reflection coefficient phase angle. The diode capacitance versus the input reverse bias voltage was then used to determine the potentiometer setting needed on each unit cell to realize the desired capacitance value. Measurements of reflection angle from the fabricated sample show that the angle of peak reflected radiation can be steered more than 45 degrees away from the specular direction. Such a reconfigurable surface could be useful in antenna applications where precise control of reflected waves is needed, and in principle the concept can be extended to significantly higher frequencies.