RF MEMS Actuated Reconfigurable Reflectarray: A Novel Patch-Slot Element Design

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Microstrip reflectarrays combine some of the best features of the conventional printed phased array and parabolic reflector antennas. The concept of reconfigurable reflectarray element is beneficial for reflectarray design as it allows for dynamic phase control of a single radiating element. Each radiating element can have a similar physical structure and the desired phase response can be achieved by electronically manipulating the element. Some of the applications of this reconfigurable reflectarray are – surface distortion compensation (alternative to adjustable subreflector), electronic beam steering and tunable frequency selective surfaces.

The reconfigurable reflectarray with MEMS technology can be used as a subreflector to compensate for both static and dynamic distortions in real time, for on-orbit distortions of a main reflector antenna in this dual reflector system. A critical feature in the design of reflectarray is the choice of the shape and size of the elements. In this work, the reflectarray element with patch on the top surface and variable slot on the ground plane was best suited for this particular application by taking into consideration the eventual implementation of MEMS technology. The primary advantage of such a reflectarray is that the MEMS switches, DC biasing wires and the control circuitry will be on the backside of the reflectarray and there will be no electronics on the top surface (the re-radiating surface) of the reflectarray design.

RF MEMS switches were mounted on the slot to electronically vary the slot length by actuating the switches and thus get the desired phase response. Waveguide measurements have been performed at S-band to characterize this patch-slot element. The element is placed inside the waveguide and the reflection characteristics (S11 magnitude and phase) are studied. As a representative case, 4 MEMS switches element were mounted on the slot which gives 10 states with a phase swing of 150° and a maximum loss of 1.5 dB at 2 GHz. A bigger phase swing (~300°) is expected with more MEMS switches. The loss is mainly attributed to the dielectric loss and conductor loss which occur due the strong electric fields in the substrate region below the patch and the large currents on top surface of the patch respectively, close to the patch resonance. It was observed that for thicker substrates the loss was significantly lower (60 mil – 1.5dB) than compared to thin substrates (30mil – 4.5dB). Detailed analysis is performed to characterize the effect of the switches by taking into consideration the switch model and wire bonding effects.