MEMS Enabled Continuously Tunable Patch Antennas using Electrostatic Actuation: Design, Simulation, and Applications

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Introduction: The resonant frequency of a patch antenna can be controlled by adjusting the height of the patch. While the heights of most patch antennas are static due to a fixed substrate thickness, MEMS can be employed to design a patch antenna whose height can be adjusted to tune the resonant frequency. Furthermore, because the antenna does not rely on switches for its reconfigurability, the precision of possible tuning is limited to the precision which the height can be controlled.

Patch Antenna Design: The resonant frequency of the patch antenna changes as the height of the patch over the ground plane is changed due to the changing cavity size under the patch. A MEMS enabled patch that can achieve various heights can be fed with a microstrip feed through aperture coupling. Aperture coupling is chosen to minimize the metallic connections to the patch which could fracture after repeated actuations. The resonant frequency response has been determined using the Method of Moments (MoM) to simulate a patch antenna with varying heights over a ground plane. The resulting input impedance is shown on the left of Fig. 1. It can be seen how the resonant frequency shifts 2% by lowering the patch 33%. Over small ranges of height changes the bandwidth and far field patterns of the antenna remain stable.

MEMS Design: The patch antenna is suspended by a polysilicon membrane. A DC voltage applied to the patch electrostatically draws the patch closer to the ground plane. By balancing the forces between the applied DC electrostatic actuation force and the restoring forces of the polysilicon torsion beams, the patch antenna can be held at arbitrary fixed height. A 3D schematic concept drawing of the fabricated MEMS enabled patch is shown on the right of Fig.1.

Applications: Tunable patch antennas can be useful in the design of large antenna arrays. Reconfigurability can increase the versatility of these designs. A reconfigurability of 2% at 90GHz leads to potential tuning of 1.8GHz. Another potential application is in the design of phased arrays. Detuned elements have been shown to shift the radiated phase and eliminate the need for external phase shifters.

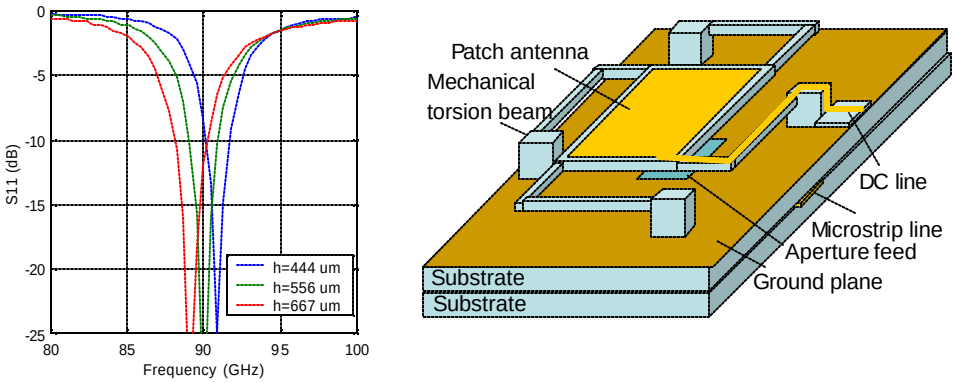

Figure 1: The simulated input match as calculated with MoM for a patch antenna of various heights showing the tunability is shown on the left. A 3D schematic of a potential MEMS design for the tunable patch antenna is shown on the right.