A Microfluidically-Controlled, Polarization & Frequency Reconfigurable Antenna on a Hexagonal Substrate Tile

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As the number and type of communications systems multiplies, the need for antenna systems capable of operation over a wide range of frequencies–often with the ability to reconfigure for optimal link performance–increases. Similarly, antenna systems for mobile or portable use need to be capable of both land-mobile and satellite-mobile communication. In this paper, a design for a reconfigurable antenna is presented which demonstrates polarization reconfigurability, tunable impedance bandwidth, integrated thermal management, and a modular hexagonal topology for array tiling. A set of fluid channels with alternating plugs of Eutectic Gallium-Indium alloy immersed in a low-loss perfluorocarbon heat transfer fluid provide variable control of the coupling between a central driven patch element and four sectional, tapered parasitic arms. These are used in combination with an orthogonally- offset dual probe feed to obtain polarization diversity. Impedance tuning of the antenna structure is achieved via reactive loading of the parasitic arm segments. The reactive loading is accomplished via two complementary methods. In one design, Coaxial Stub Microfluidic Impedance Transformers (COSMIXs) connected to the arms enable frequency agility. By varying the electromagnetic properties of the dielectric fluid flowing through the COSMIX elements, a varying reactance can be presented to the antenna structure, tuning the impedance bandwidth. In an alternate design, electrically-biased phase shifting MMICs, with their second ports terminated in either a short- or open- circuit load, are attached to the arm segments. By varying the DC control voltage applied to the MMICs, a variable phase shift can be applied to the reactive termination, achieving similar results to the COSMIX design. Both simulated and experimental results are presented which verify the performance of the antenna designs and demonstrate the aforementioned impedance tuning.