Reconfigurable Planar Dipole Using Liquid-Metal Nodes for Frequency-Tuning Applications

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Reconfigurable antennas offer dynamic performance capabilities which may be desired in various applications where an operating requirement is unknown or must be satisfied over multiple domains. Such antennas are typically implemented using MEMS or PIN-diode switches.

In this work, a novel approach using reconfigurable liquid-metal nodes, which may be merged and split in any combination, is applied to the case of a planar dipole antenna for frequency-tuning applications. The dipole antenna consists of 16 liquid-metal nodes, eight nodes per arm, corresponding to eight discrete operating states which range from 1.59 GHz to 4.34 GHz.

The design is based on a microfluidics approach, using glass to provide the antenna's structural stability while using a flexible silicone elastomer to allow for the reconfiguration of the liquid-metal nodes. The liquid metal is a non-toxic, gallium-based alloy which is immersed in an electrolytic solution necessary for the removal of an oxide layer inherent to such alloys. Reconfiguration is achieved by physically pressing the silicone elastomer to merge and split the liquid-metal nodes, which are connected by channels, to alter the physical length of the dipole antenna and thus its resonant frequency.

Each channel connecting two adjacent nodes serves a dual purpose: electrically shorting the nodes when merged, or electrically isolating the nodes when split. When two nodes are merged, the surface tension separating the two volumes of liquid metal is overcome, combining them to form a singular, multi-node element. As pressure is removed, the nodes remain in their merged condition due to surface tension. When two merged nodes are split, the surrounding electrolytic solution re-enters the connecting channel, electrically isolating the nodes from one another. In this manner, unused nodes are physically and electrically isolated by the electrolyte-filled channels between them and the merged, radiating elements.