An Experimental Analysis of the Characteristic Behaviors of an Impedance Pump

Thesis by

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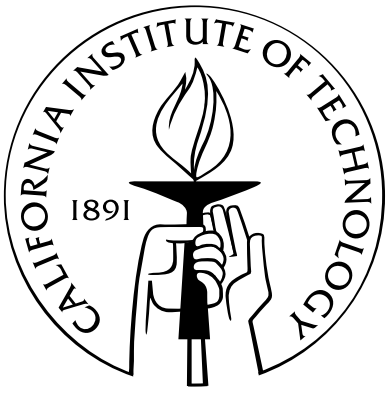

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For my hubby, Kevin, with all my love.

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Abstract

When a fluid-filled pliant tube is connected to tubing of a different impedance, a net flow in either direction can be induced by periodically compressing the pliant section asymmetrically from the ends. An experimental analysis of the characteristic behaviors of such a pump has been done demonstrating interesting results not predicted by prior analytical and computational results. Measurements show a complex non-linear behavior in response to the compression frequency, including distinct resonance peaks and reversals in flow direction. Ultrasound imaging provided a unique view of the tube wall and flow within, allowing us to visualize the wave propagation and reflection. Measurements include transient responses, resonant responses, and bulk flow behaviors for a variety of configurations. Net flow rates can exceed the volumetric displacement done by active compression demonstrating that, as a first approximation, this pump can have a higher efficiency than peristaltic pumping. Elasticity has been shown not to be a necessary factor in stimulating net forward flow.

Results from this study have helped show that a zebrafish (a model for human cardiac development) may utilize impedance pumping to drive circulation in early embryonic stages prior to valve formation as opposed to peristaltic pumping as was once thought. Additional research is being conducted to develop a micro-scaled version with applications in medicine, heat transfer, lab-on-chip technology, and micromixing.

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