Miniaturized Power Electronic Interfaces for Mobile Microrobots

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THIRTY YEARS OF SYSTEMS RESEARCH EXCELLENCE

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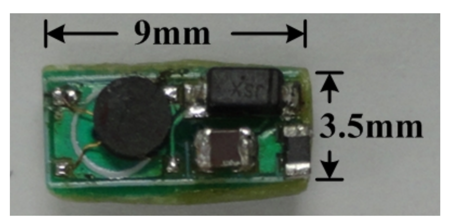
Challenges of Power Autonomy for μ-Robots

1) Miniaturization and lightweight of power supply
2) High step-up voltage-gain
3) Battery compatibility
4) High efficiency
5) Low cost
6) High driving speed

▪ **High-voltage Pulse Generator**

- ✔ High voltage
- ✘ Very bulky & heavy
- ✘ Battery incompatible
- ✘ Very expensive
- ✘ Very inefficient
- ✘ Low driving frequency

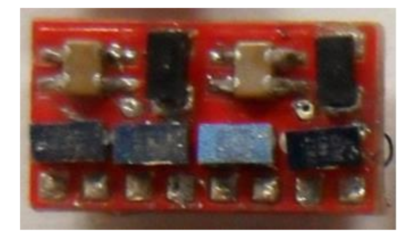
▪ **High-voltage Tiny PEI**



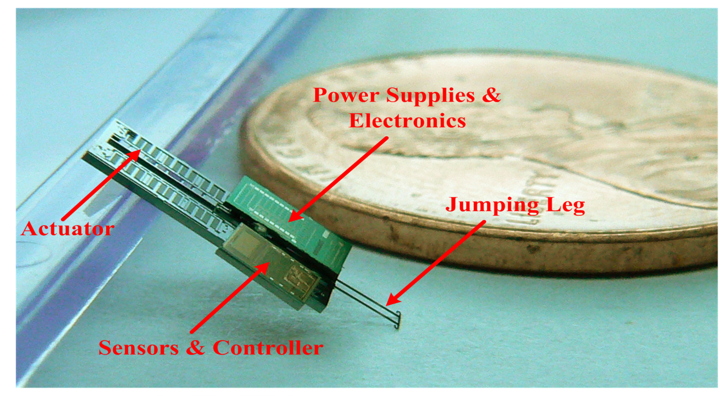
- ✔ High voltage
- ✔ Tiny & lightweight
- ✔ Battery compatible
- ✔ Low cost
- ✔ High efficiency
- ✔ High driving frequency

Current Achievements

1) Introduced a novel resonant dc-dc converter
2) Developed a 4mm×8mm, 1.5MHz PEI prototype
3) Capable of driving electrostatic inchworm motor
4) Retrieved unused energy of actuator



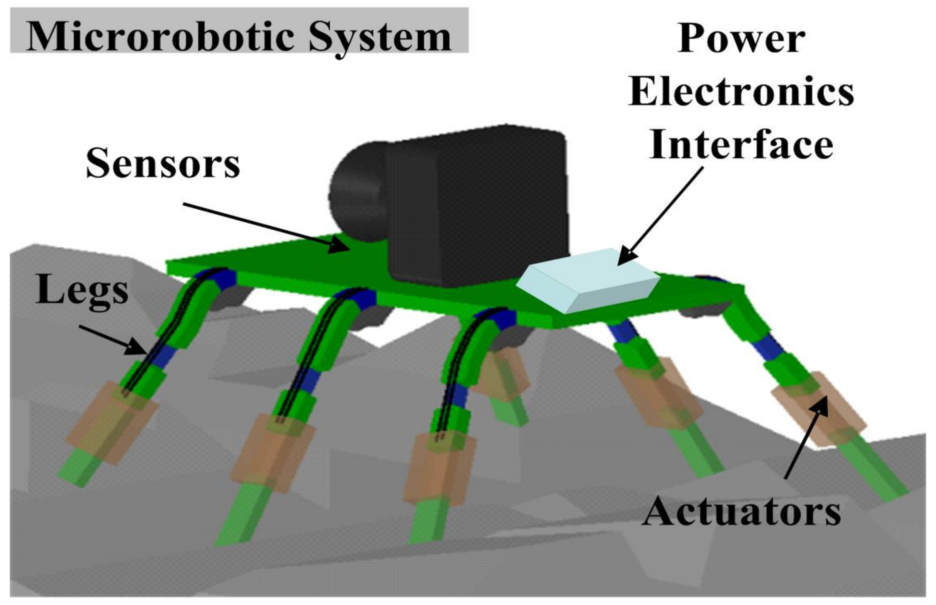
Future Goals



1) To develop on-chip integrated PEI
2) To investigate advanced driving strategy
3) To drive a real jumping μ-robot using on-board PEI

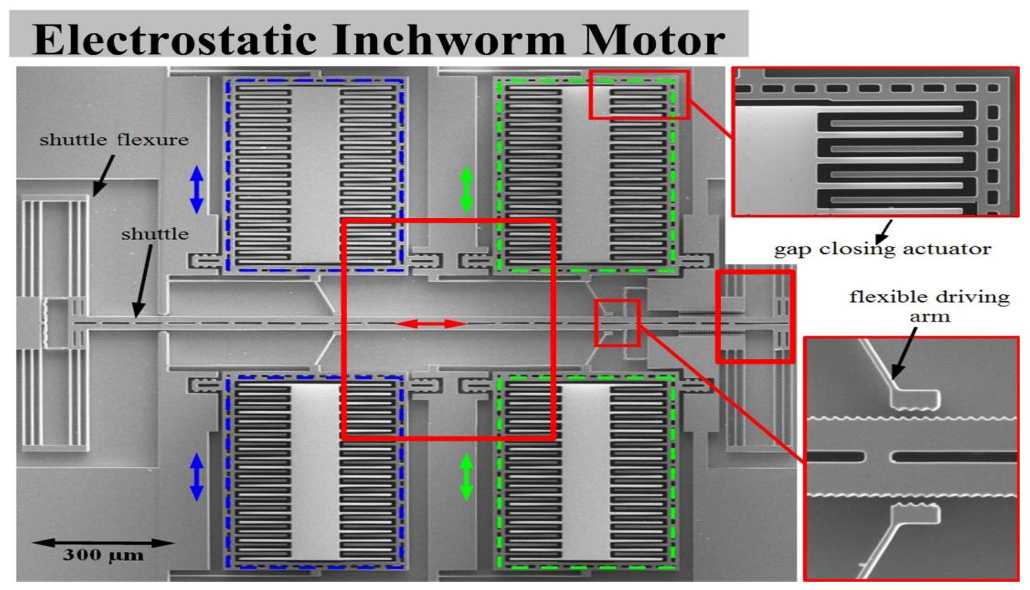
μ-Robotic System

- Electromechanical actuator
- Onboard battery
- Onboard power electronic interface (PEI)



Inchworm Motor

- Electrostatic actuator
- In-plane gap-closing
- High force density
- Large displacement

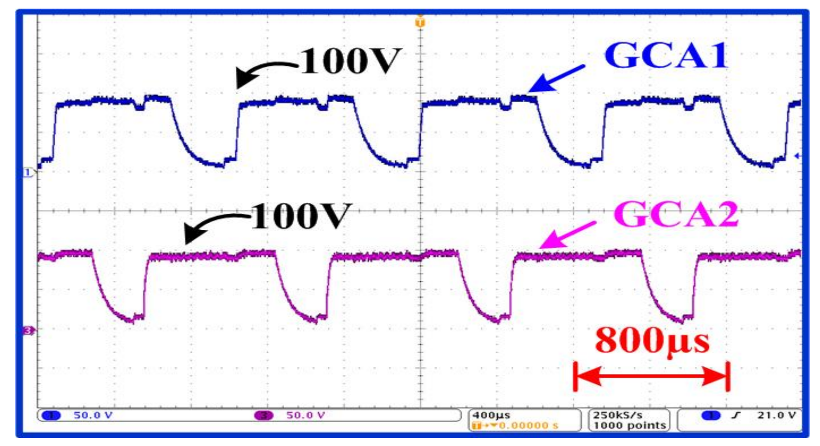


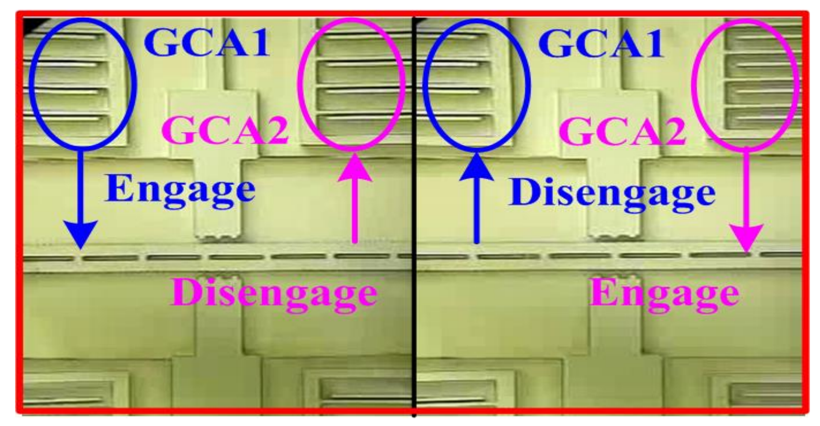
Power Converter

- High voltage boost
- High-frequency soft-switching
- Bidirectional operation
- High efficiency

Driving Strategy

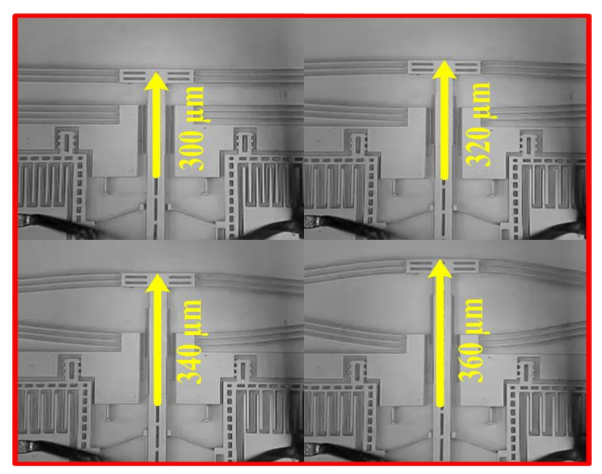
- Unipolar pulsatile signals
- Complementary drive
- Quasi-square waves
- Unused energy recovery

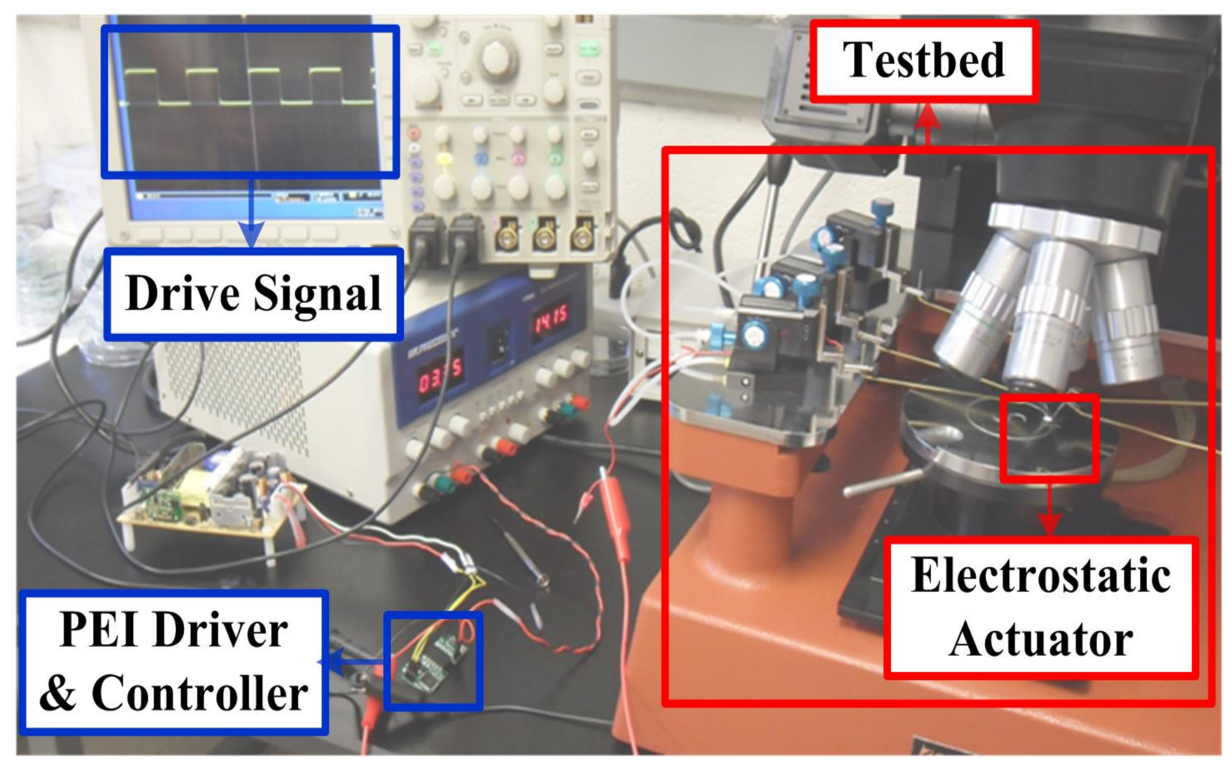




Experimental Results

- 2V to 100V boost
- 1kHz driving
- 60 μm displacement
- 75.2% efficiency at 200-mW





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