# P14254: Underwater Thermoelectric Power Generation with Maximum Power Point Tracker

MULTIDISCIPLINARY ENGINEERING AT RIT
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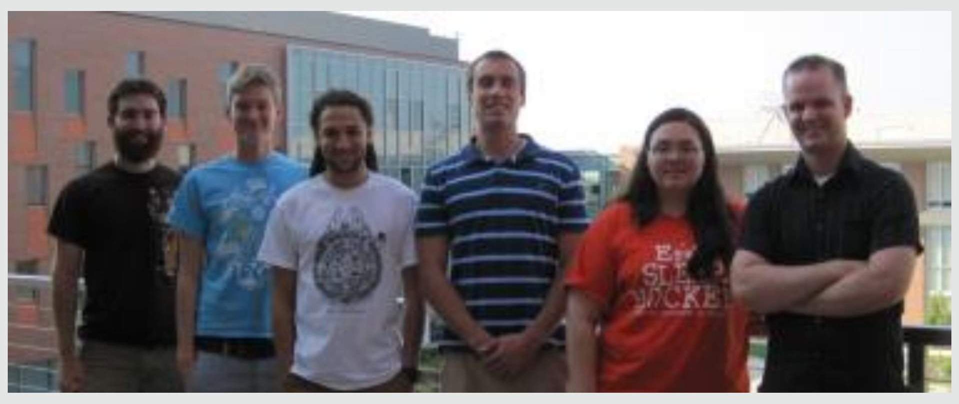
Senior Design



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Faculty: Rick Lux (Guide), Dr. Robert J. Stevens

## Abstract

Boeing has developed a unmanned underwater vehicle (UUV) with a standard mission time of 28 hours. To investigate the feasibility of thermoelectrics as a range extending generator, a proof-of-concept power generation system was developed leveraging expertise at RIT. Thermoelectrics are used to convert available heat into electricity, which is then used to charge a Li-ion battery. The system developed uses free convection over a heat sink to reject heat to the surrounding water.

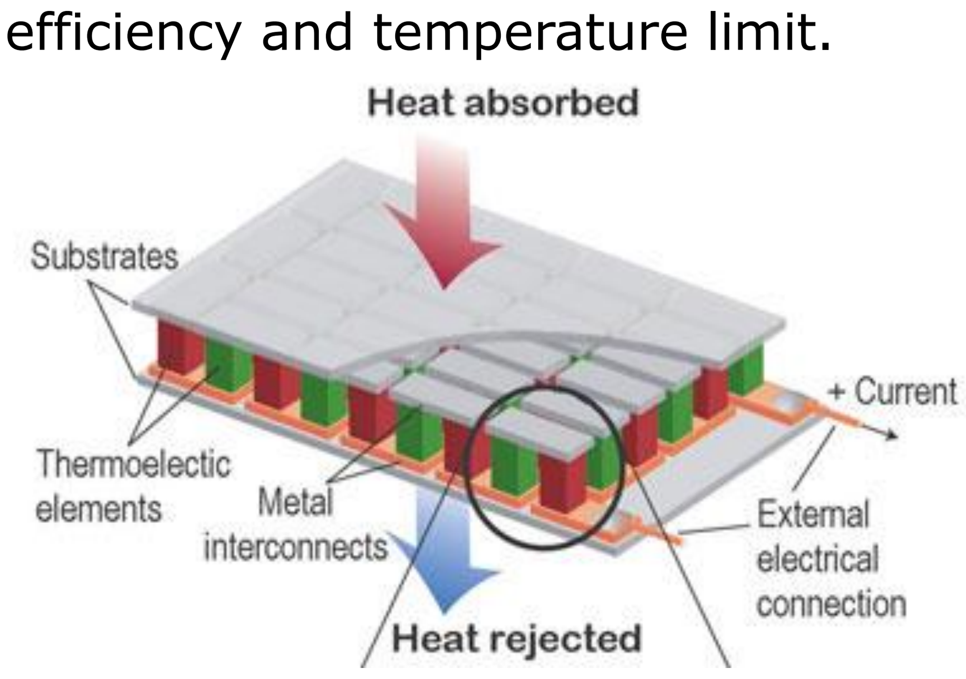
Hambling, *AUVUC*, 2012

## Objectives

- Continuously generate power
- Operate efficiently
- Charge a battery
- Operate underwater
- Heat source provides constant source of heat
- System can withstand interior enclosure temperature

## Thermoelectrics

- Converts heat directly to electricity
- Single 40x40mm module can produce 4-8W of power at an efficiency of 2-4%
- Thermonamic TEHP1-1264-0.8 modules were selected for their high efficiency and temperature limit.

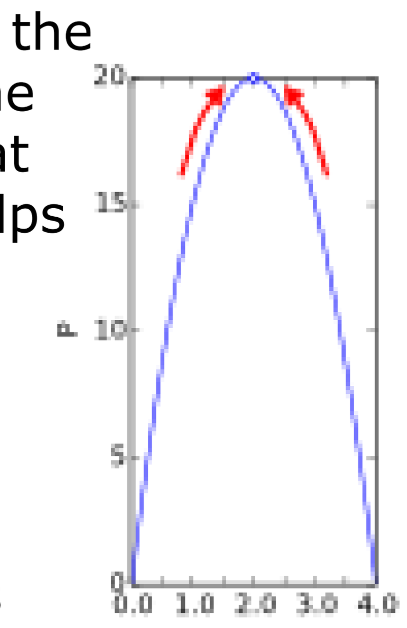



Snyder, *Nature Materials*, 2008

## MPPT

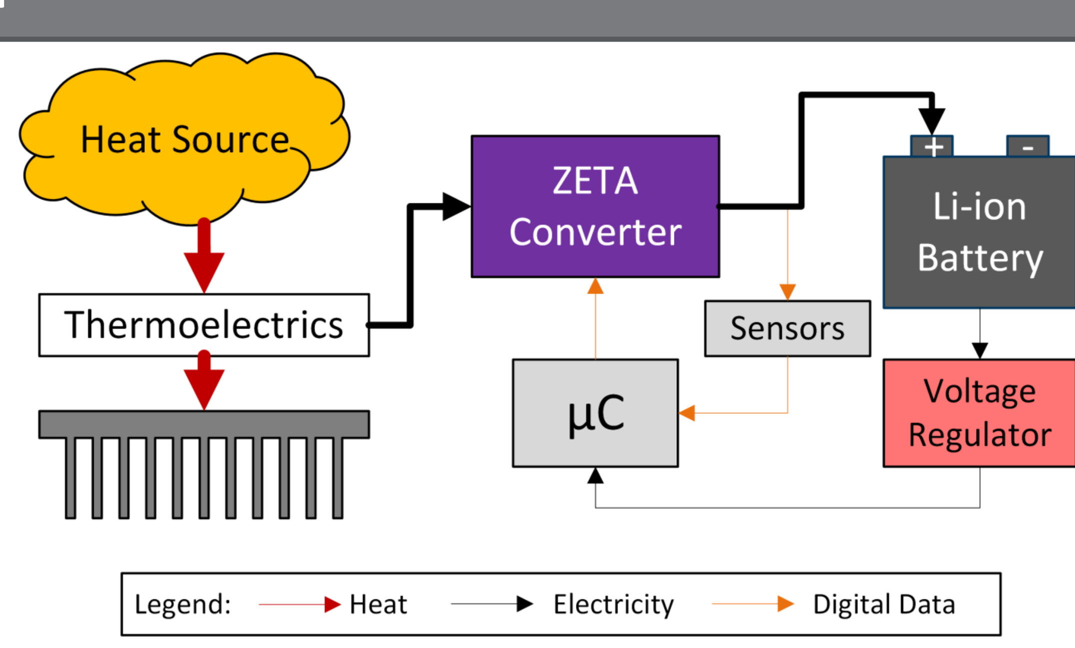
A maximum power point tracker (MPPT) controls the impedance seen by a generator to ensure that the load receives the maximum amount of power that the generator can provide. In this case, MPPT helps optimize the power transfer from the thermoelectrics.

The Perturb and Observe algorithm repeatedly adjusts the DC-DC converter and measures the output power response. If power decreases, the adjustment direction is reversed. This process is repeated continuously.



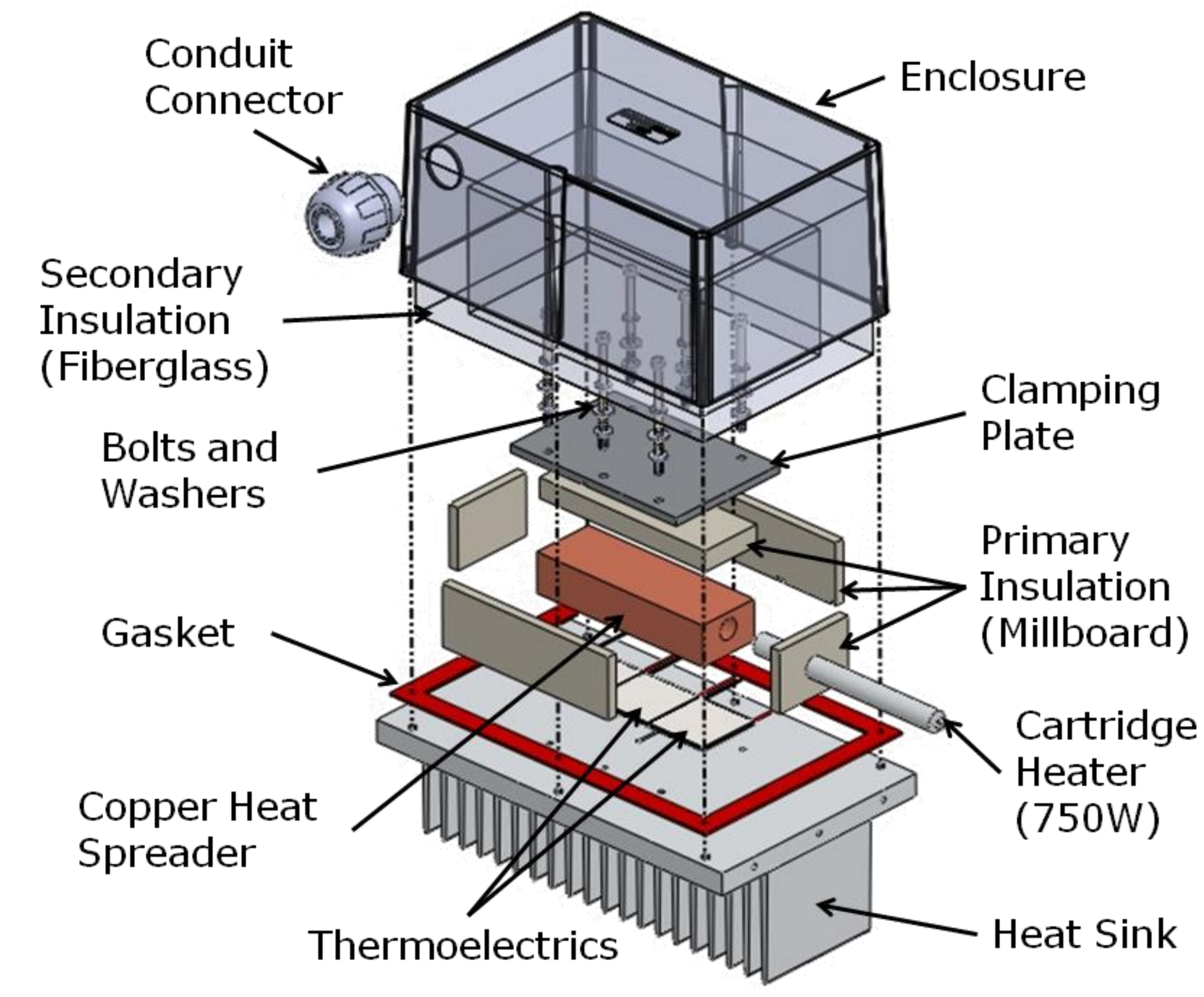

## System Diagram

- Heat source, thermoelectrics, and heat sink in an enclosure underwater.
- All other parts (electrical system) are located out of the water.



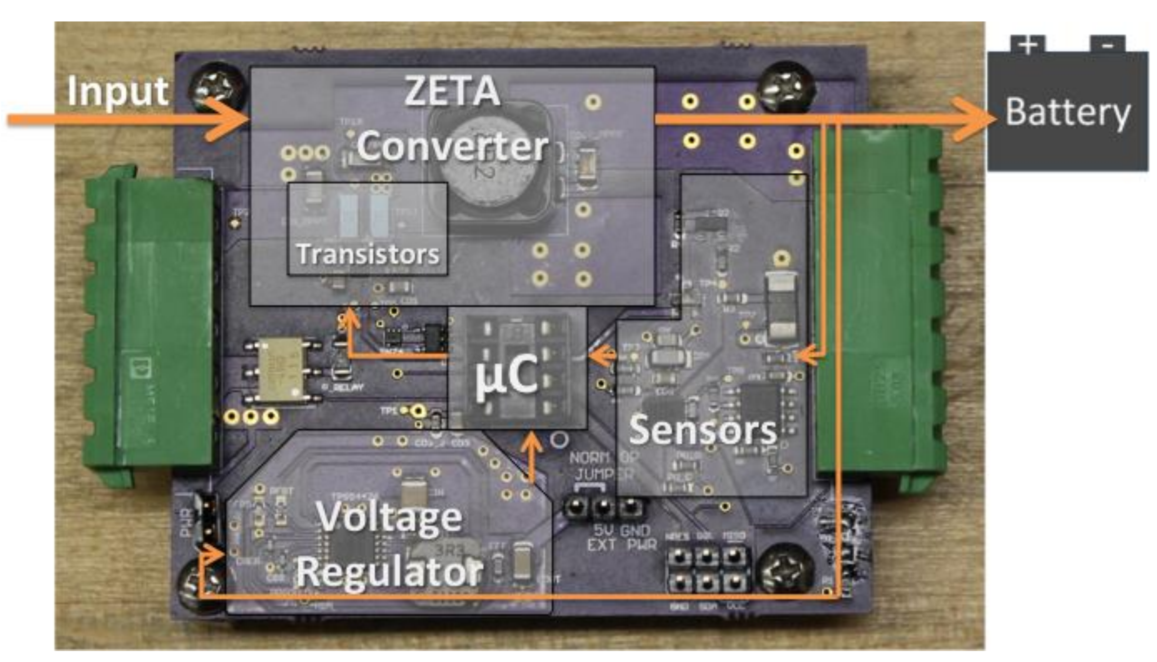

## Mechanical System

A heat source is used to create a temperature differential across the thermoelectrics. Output power is measured so that efficiency may be calculated. Two layers of insulation direct 96% of the heat through the thermoelectrics.




## Electrical System

- Microcontroller (μC) reads from the sensors and controls the ZETA DC-DC converter to implement MPPT.
- Voltage regulator supplies sensors and μC with power.




## Results

- High efficiency GaN FET transistors proved too fragile to use.
  - Replaced with ordinary MOSFET transistors
- Final product was hybrid of custom PCB and prototype board.
- Thermoelectric conversion efficiency of 3.5% is better than most thermoelectric systems in academic literature.

| Description | Design Value | Actual Value |
|---|---|---|
| Heat Input | 563W | 630W |
| Thermoelectric Power Output | 20W | 20.19W |
| MPPT Efficiency | >90% | 50% |
| Heat Sink Resistance | 0.1°C/W | 0.06°C/W |

## Conclusion

The electrical system performance was significantly less than a typical converter system. We believe that this could be vastly improved with another iteration of the electrical design.

We do not feel that a thermoelectric power generation system makes sense for a UUV. The low overall efficiency inherent in thermoelectrics mandates a large source of heat, which could be impractical. It may, however, be useful for other low-power underwater applications.

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## Acknowledgements

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For additional information visit: https://edge.rit.edu/edge/P14254/public/Home

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