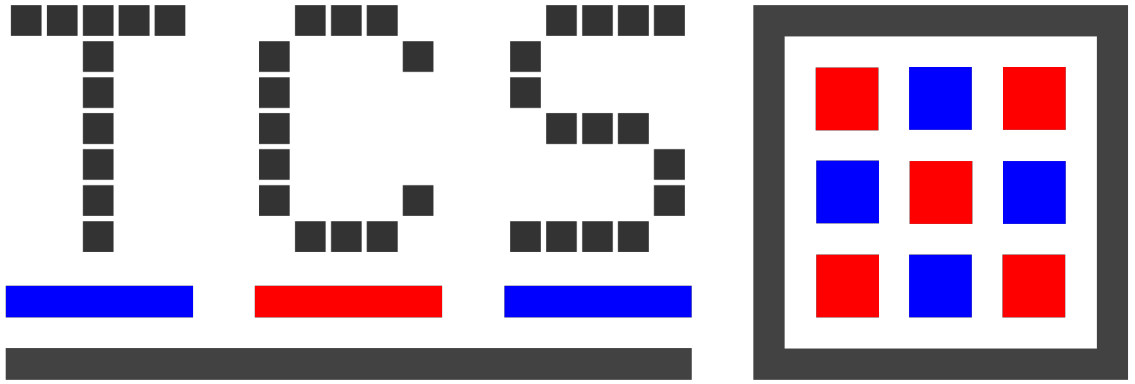

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THERMOELECTRIC CONVERSION SYSTEMS

EPSRC TE Network Meeting

Glasgow

18th October 2016

Contents

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- Constant Heat Converter
- Comparison of MPPT algorithms
- Monitoring TE Device
- Test and Characterisation
- Power Converters and Energy Harvesting

Variable Thermal Conductance of a TEG

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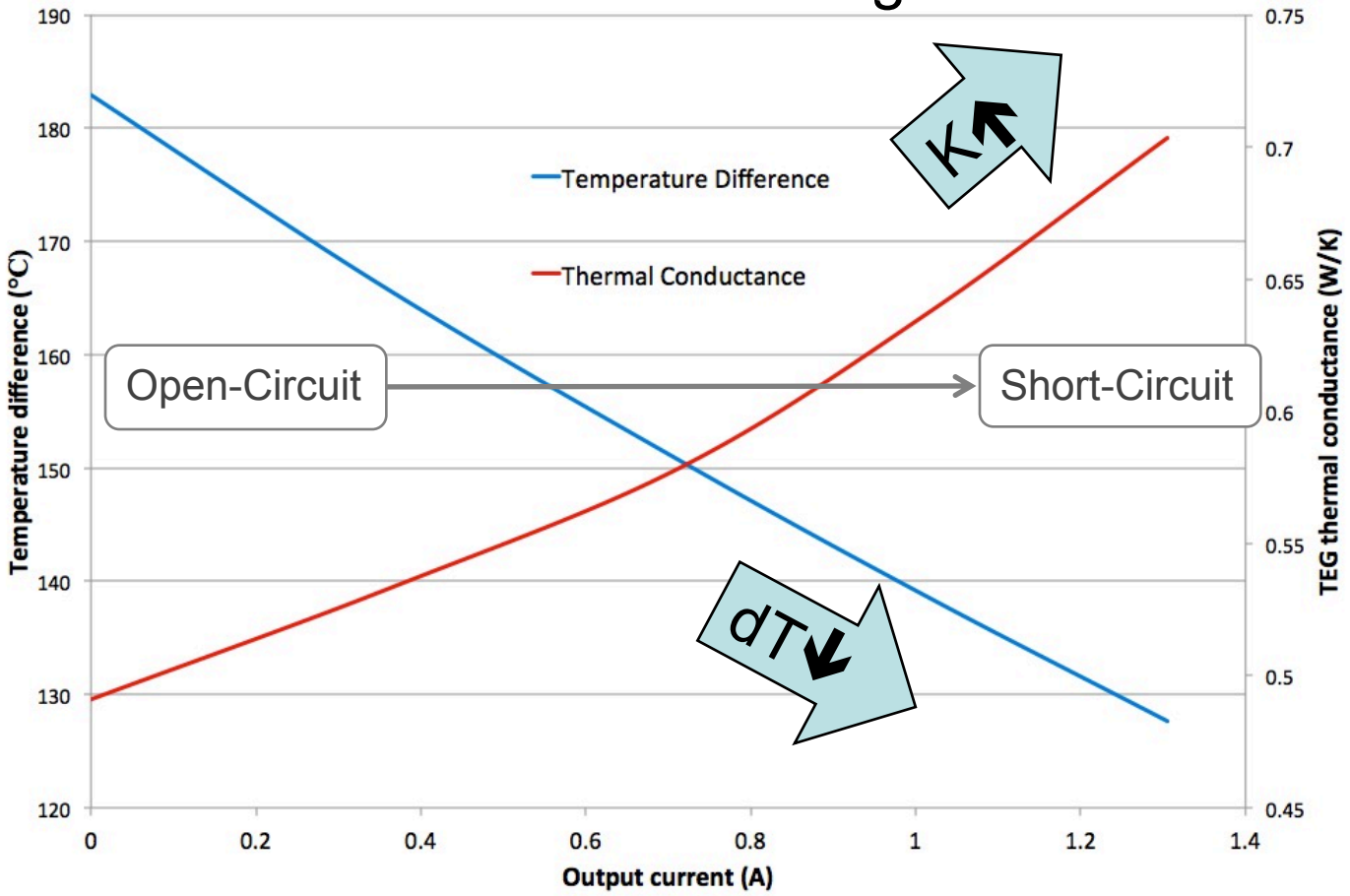
with Constant Heat flow through the TEG



- P_{OUT} is greater for $V_{OUT}>V_{OC}/2$.
- Continuously adjusting V_{OUT} to $V_{OC}/2$ results in almost 3% less power generation.

Constant Heat Converter

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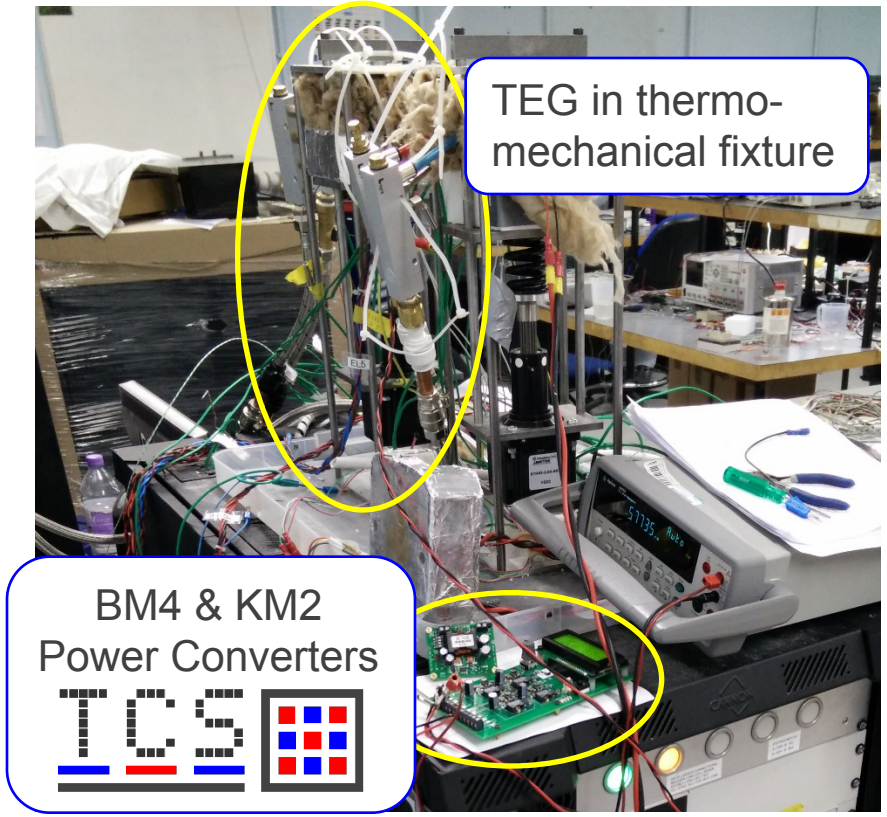
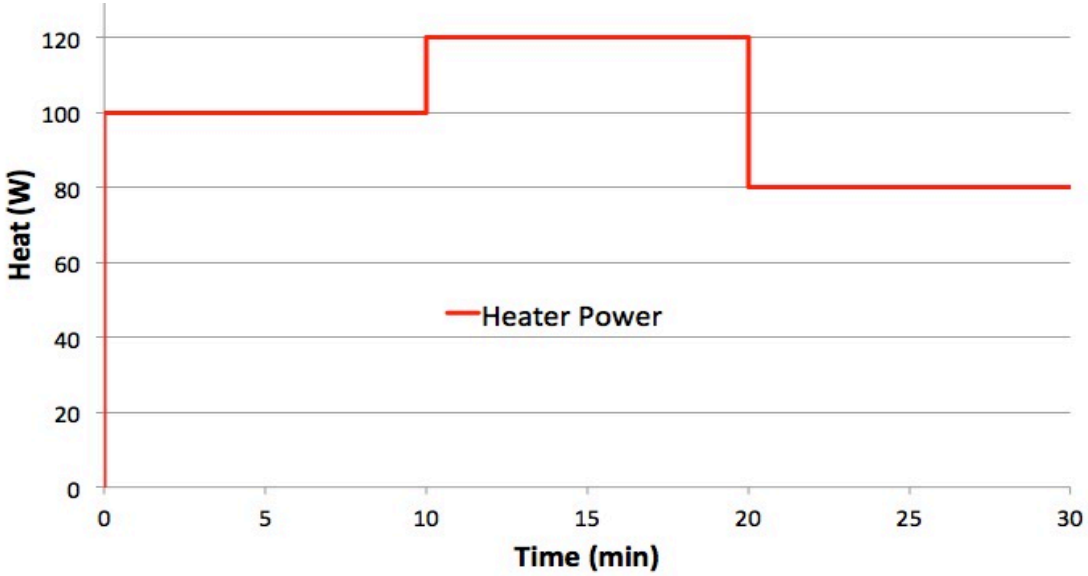
- Fully Automated Control by PC
- Thermal Losses Compensation to guarantee application of constant heat



- Constant Mechanical Pressure Compensation
- Precise Measurements by Multimeters and Data Logger



Fractional Open Circuit (FOC) MPPT

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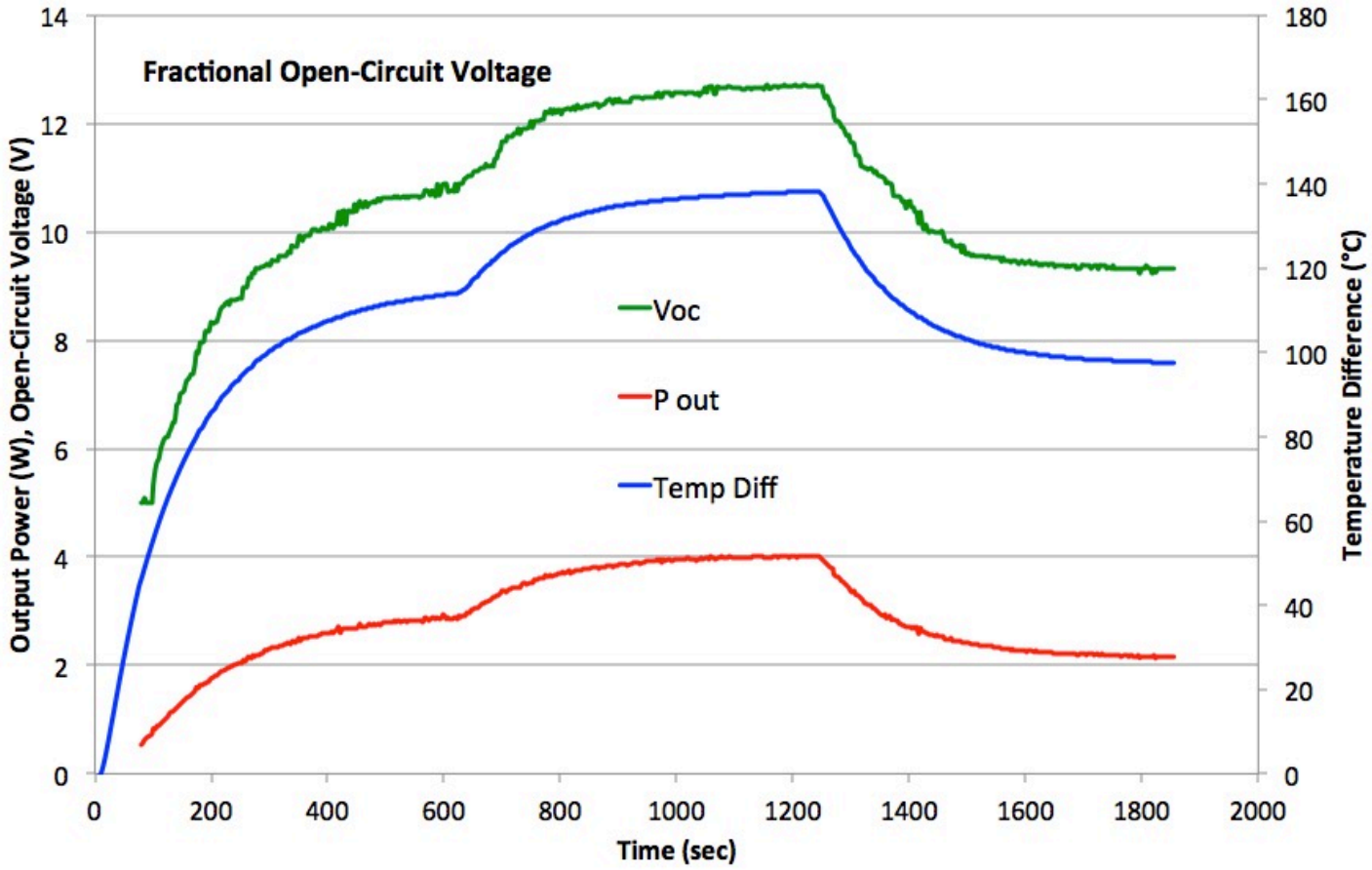

Perturb and Observe MPPT

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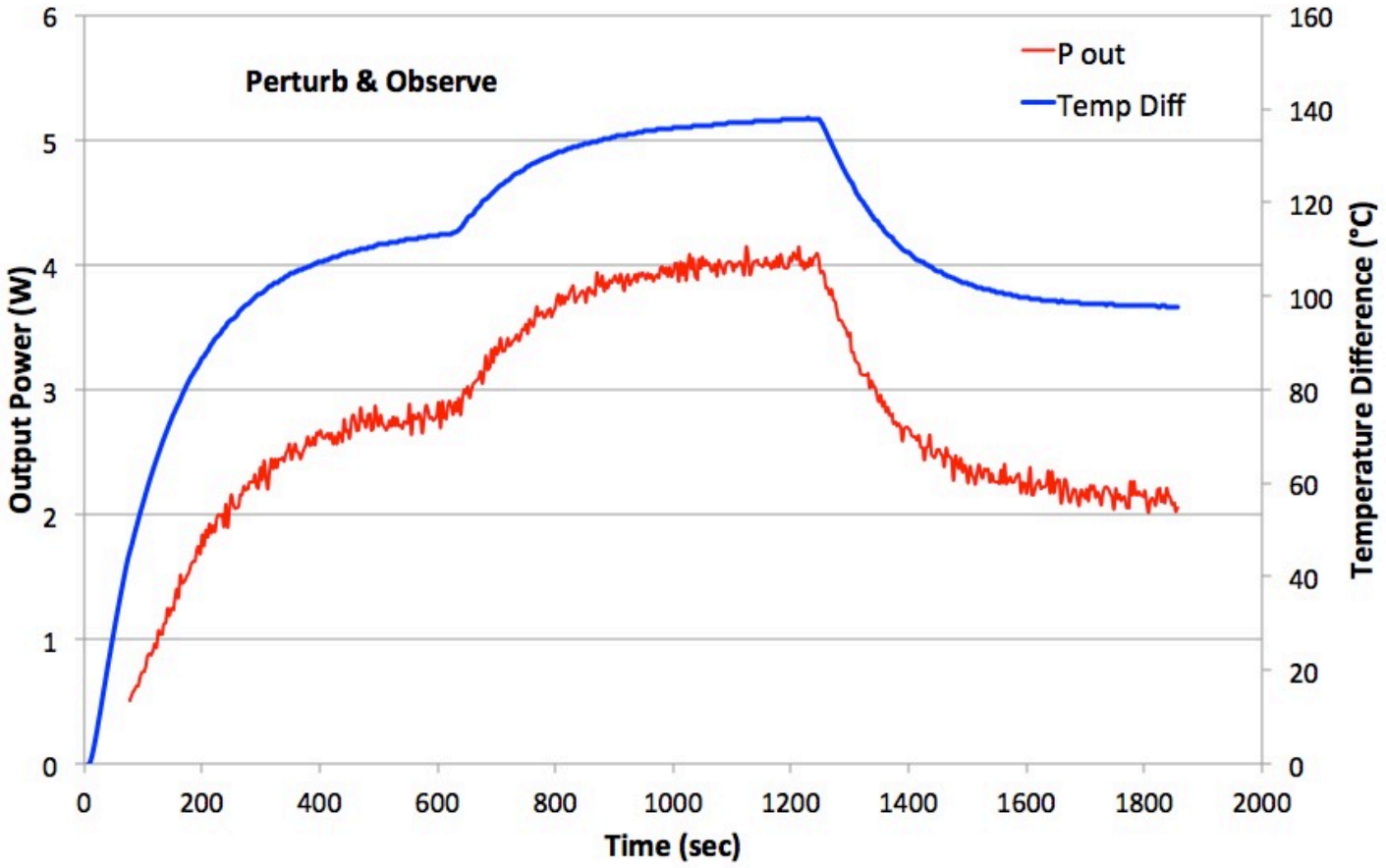

Modified FOC

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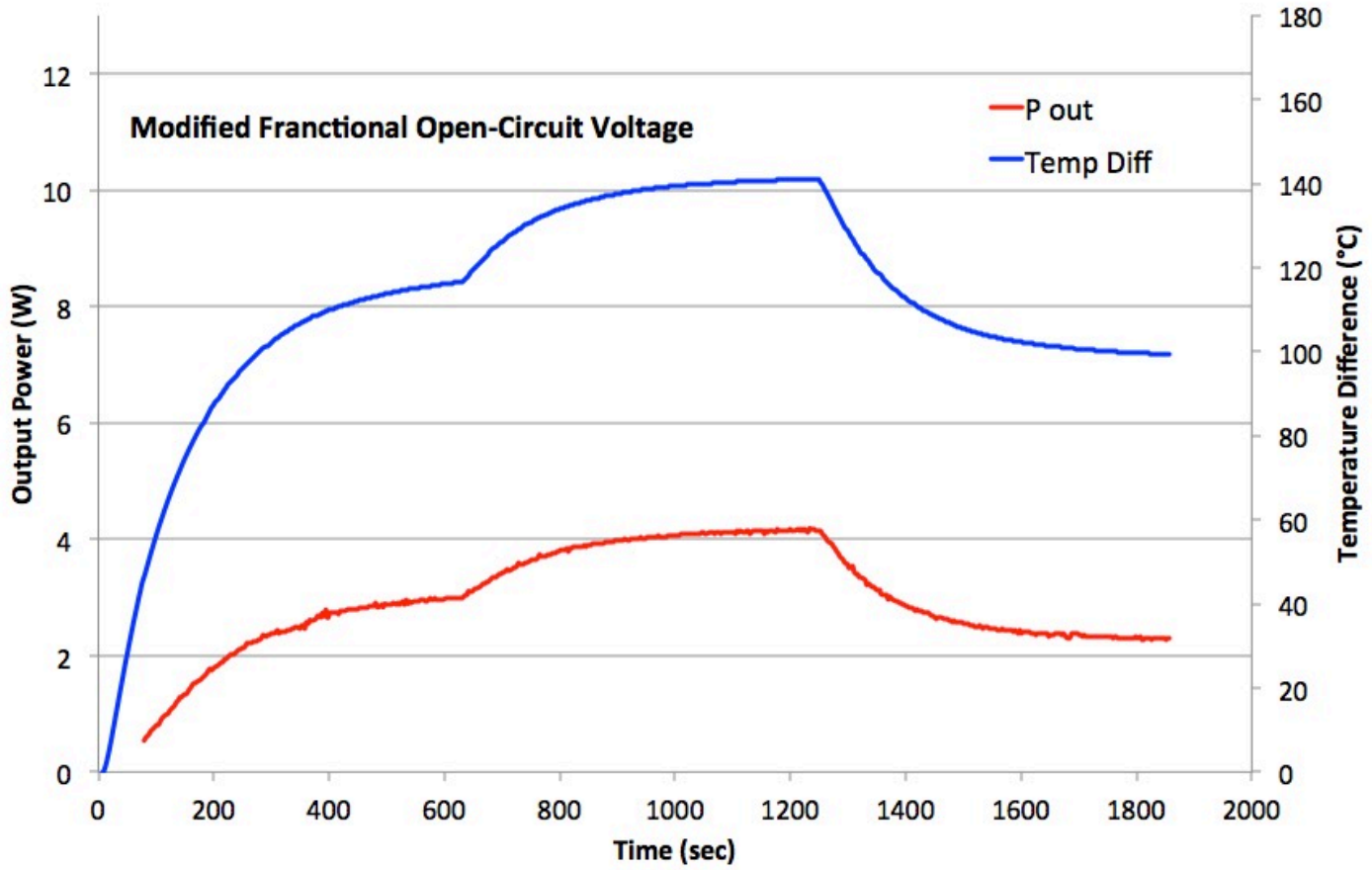

Summary of Results: Temperature Difference

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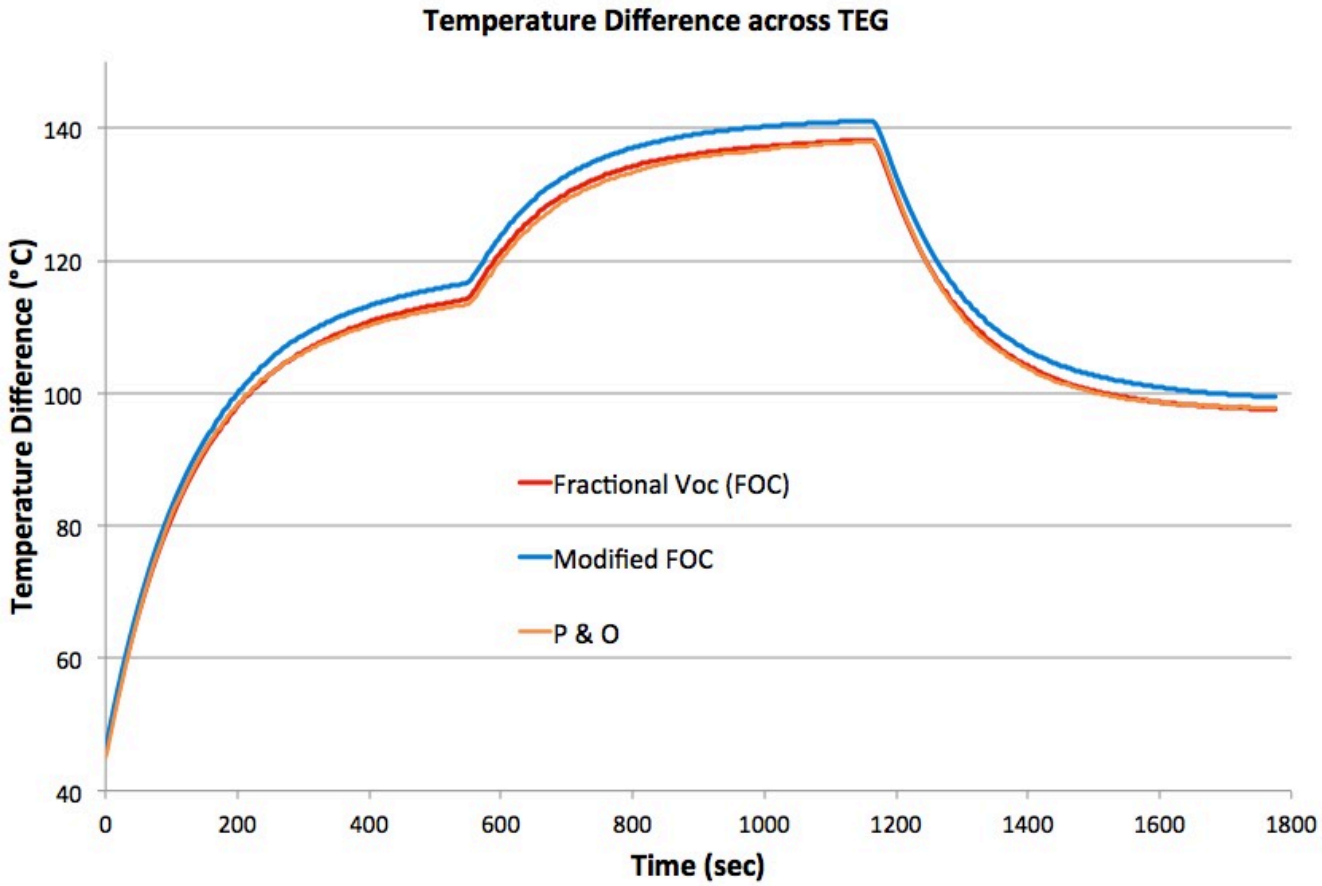

Summary of Results: Electrical Output Power

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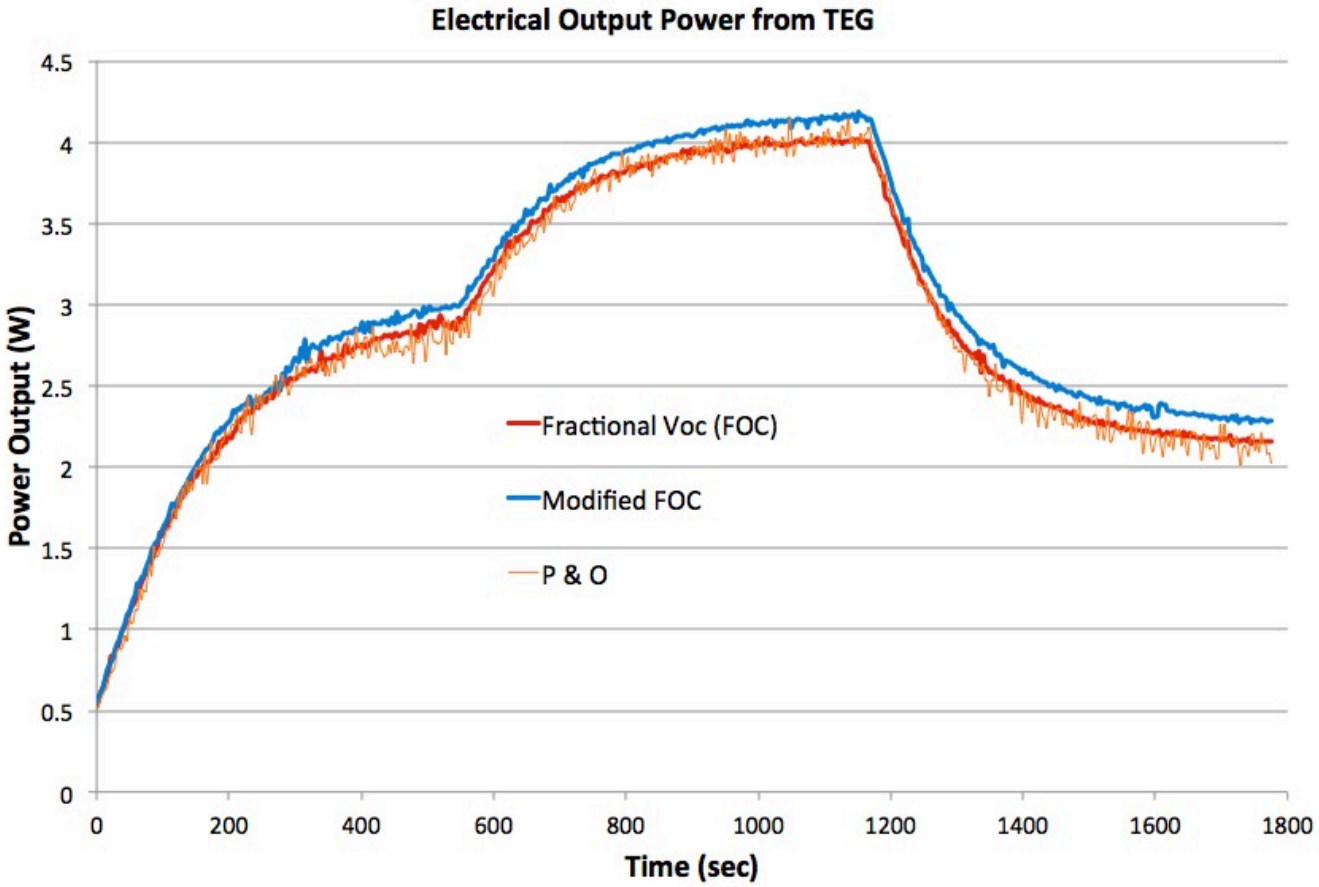

Summary

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	FOC (50% V_{OC})	P & O	Modified FOC
Total Energy Obtained (kJ)	5.11	5.07	5.30
Percentage increase from FOC (50% V_{OC})	/	-0.7%	+3.7%
MPPT Efficiency (100% when $V_L=V_{OC}/2$)	99.9%	99.3%	103.7%

- Using the "Modified FOC" method **less heat is transferred to the cold side**
- P&O requires *current sensing* and more *computational power*
- The "Modified FOC" method outperforms conventional MPPT algorithms

Monitoring Thermoelectric Device: monTE

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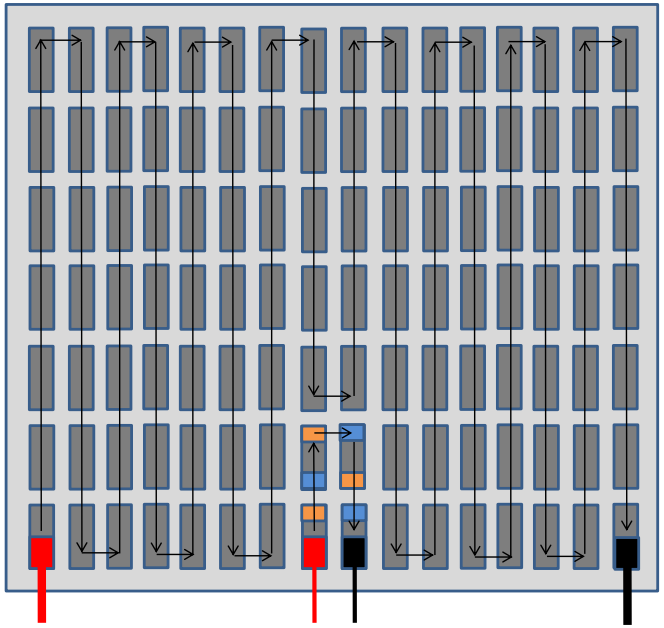

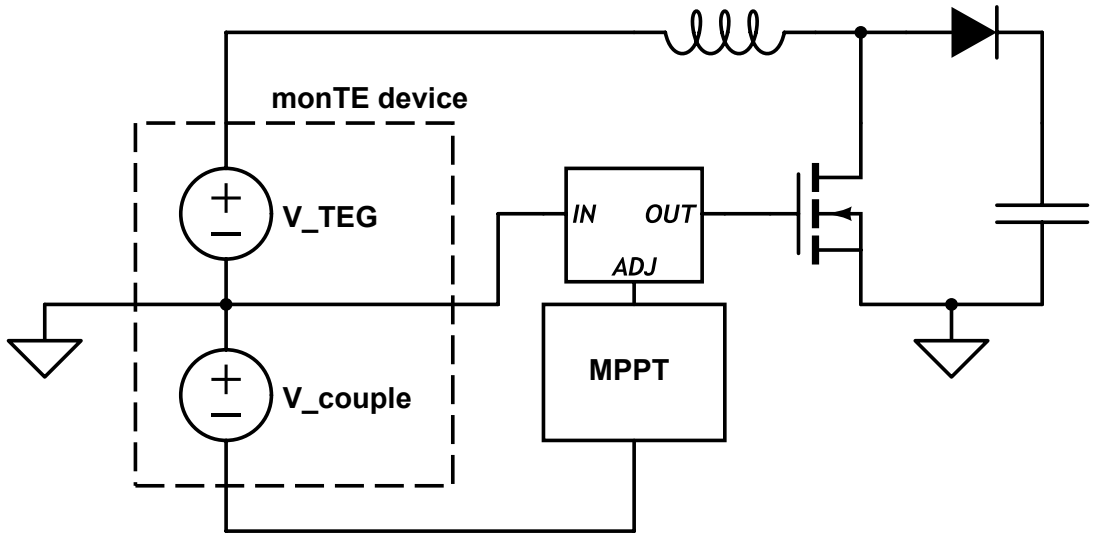

- Continuous and indirect Info about:
  - Temperature Difference
  - Open-circuit Voltage
- Filed Patent about its System Use

Experimental use of monTE

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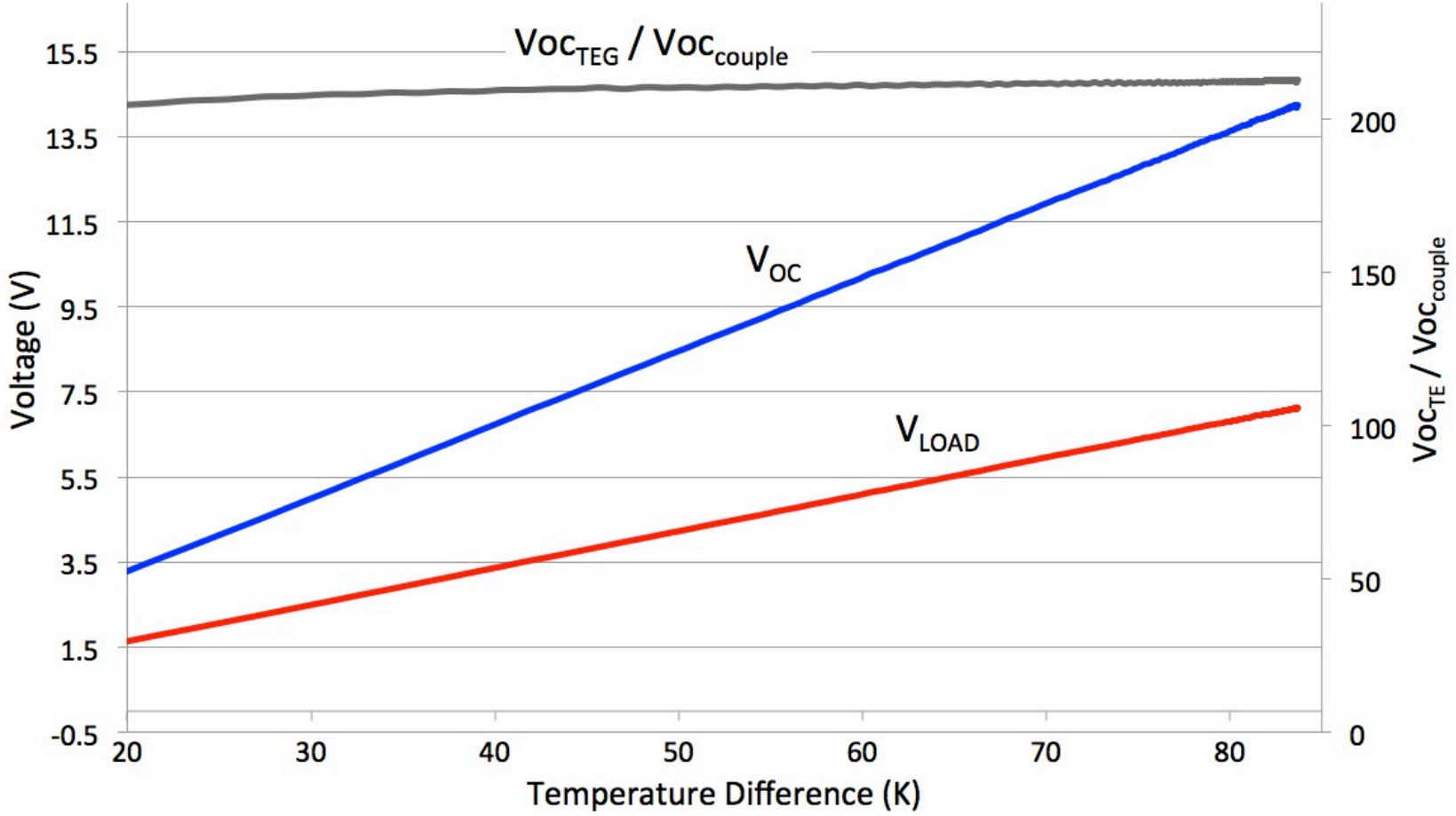

Test and Characterisation

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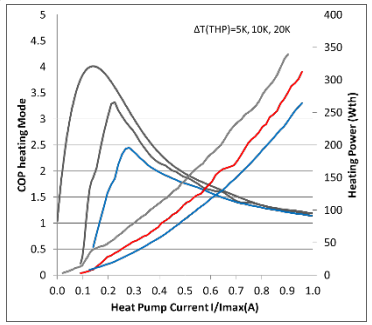
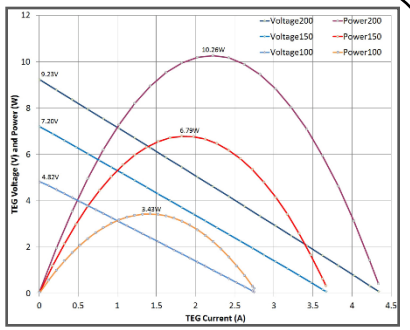
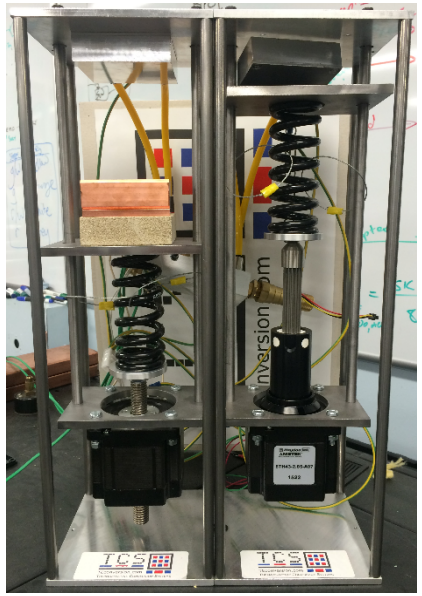




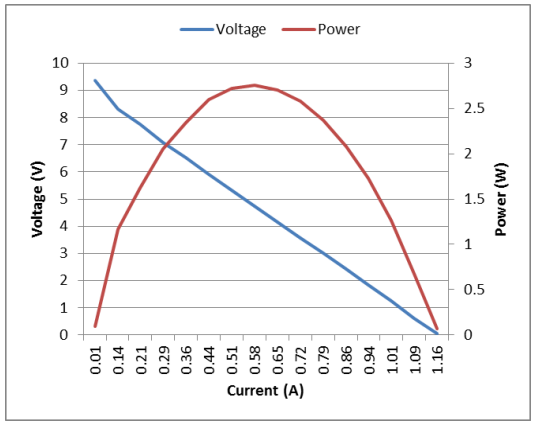


- Clamping up to 5000N
- Hot-side up to 700°C
- TE up to 8cm x 8cm
- Fully automatic, with pressure compensation
- Single/multichannel
- I-V curve and data in Excel
- Constant P or T

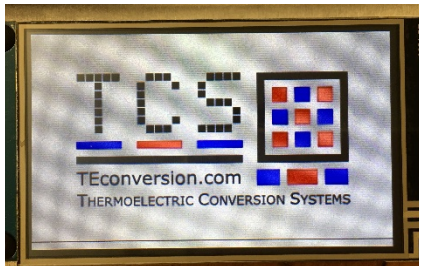
RO Series: I-V Tracer

RO2 – At-load TEG tester

- Instant 16 point I-V curve (32 msec)
- Dynamic tracking of any V_{oc} %
- Display: V_{oc} V_{MP} I_{MP} I_{SC} Temperature



RO3 – Dynamic TEG tester



- Maximise TEG (or PV) power with P&O or FOC MPPT mode
- Instant multi-point I-V curve (*better than* 32 msec)
- Dynamic tracking in constant V, I, P (up to 180W)
- Display: V_{oc} V_{MP} I_{MP} I_{SC}
- USB-Computer Interface -> plotting
- Auto-ranging measurement range from 1 mV, 100 µA to 48 V, 25 A

Power Converters & Energy Harvesters

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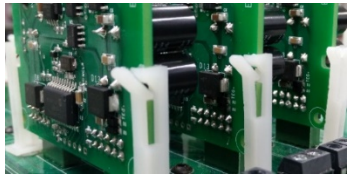
KM2 series 64 W 32 V 8 A input rating

- Up to 97% electrical efficiency
- Up to 100% MPPT efficiency
- Communication Interface
- Optional Measurements board

B16:



- Up to 1kW input power with measurements, communication and protection

PG1:

- 200W 14V 26A Boost converter with up to 98% electrical efficiency

Teaching Thermoelectrics

- Hot Side Control (electrical heater)
- Cool Side Control (fan)
- Instant IV trace using RO2
- Prepared Laboratory experiments:
  - TEGs and TECs

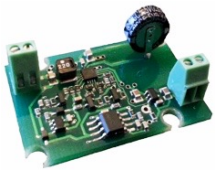
Thermoelectric Cooler Controller

KS30:

- Up to 30W cooling or heating power
- Controllable constant output

KS200:

- Up to 200W buck converter

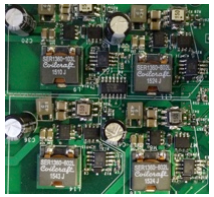


Harvesters

- AM2: Vin from 80mV to 5V
- AM3: Vin from 20mV to 0.5V
- **Integrated: Supercap or Li-Ion Battery**

2.1A USB Charger (5V output)

- Input voltage from 0.65V to 7V
- Compatible with USB 2.0 and 3.0



BM4 series 32 W 14 V 5 A input rating

- Quad-channel boost converter
- Ideal for Distributed MPPT
- Combined total power of **128W**

Thermoelectric Team

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Andrew Knox

Technical Director

Tasks:

- Group leader.
- Founder TCS.
- Project leader for £ multi-million EU and UK research projects into Thermoelectrics.

Dr. Andrea Montecucco

Lead Electronics Engineer

Tasks:

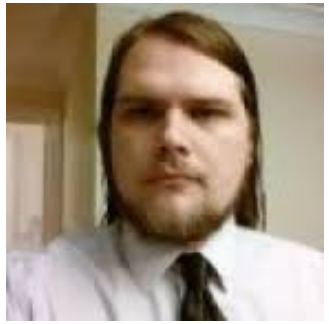
- Founder of TCS
- MPPT algorithms for TEGs.
- DC-DC converters for TEGs (mW to kW.
- Electronics for I-V characterization.
- Electro-mechanical test systems for thermal and electrical characterization of TEGs.

Dr. Jonathan Siviter

Managing Director

Tasks:

- Founder of TCS
- Heat amplifier testing.
- TEG, solar thermal and PV systems for household, automotive, industry.
- Electro-mechanical test systems for thermal and electrical characterization of TECs/THPs.



Paul Mullen

Lead Software Engineer

Tasks:

- Founder of TCS
- Heat storage with phase change material triggered by thermoelectric module.
- PCB design.

Thermoelectric Team @ Glasgow University

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Elena Anamaria Man

Research Associate

Tasks:

- Test systems assembly and control for TEG and THP testing.
- Concentrated PV systems.

Matt Garland

Assistant Engineer

Tasks:

- PCB and mechanical product assembly.
- Testing of completed products.
- Assisting with development of experimental equipment.

Marcos Compadre

PhD Student

Tasks:

- MPPT algorithm for constant heat operation.
- DC-DC converters for TEGs.

Emmanouil Nikolakakis

6 month MEng Placement

Tasks:

- Integrated control unit for test fixture.

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Bridging the gap from device to system

Jonathan Siviter, Ph.D.

Managing Director

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Mob.: +44 (0) 7790 250 772

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www.TEconversion.com

Thank you!

Any Questions?