Intel Micro-Wind Turbine Seedling Project

Progress Update 14 November 2017

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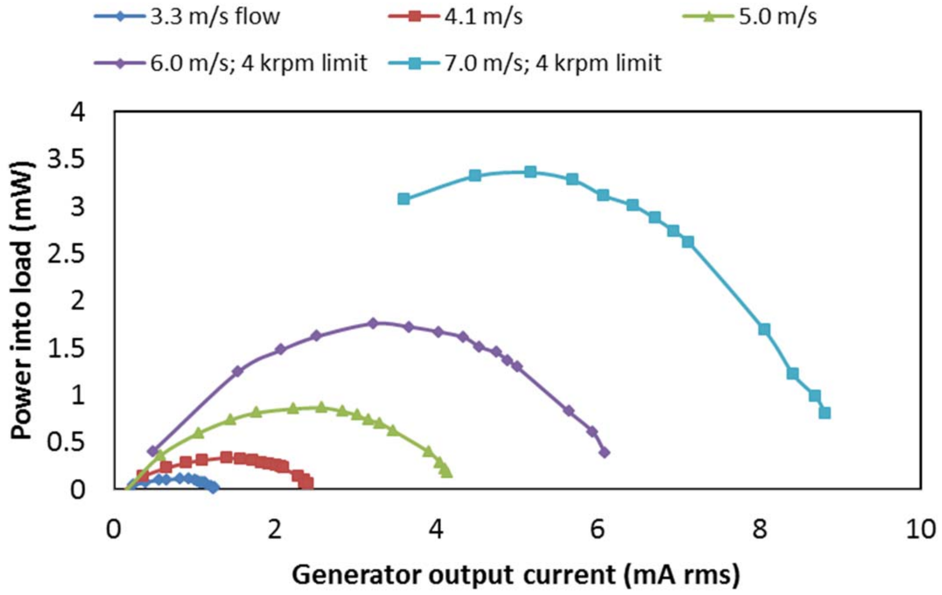
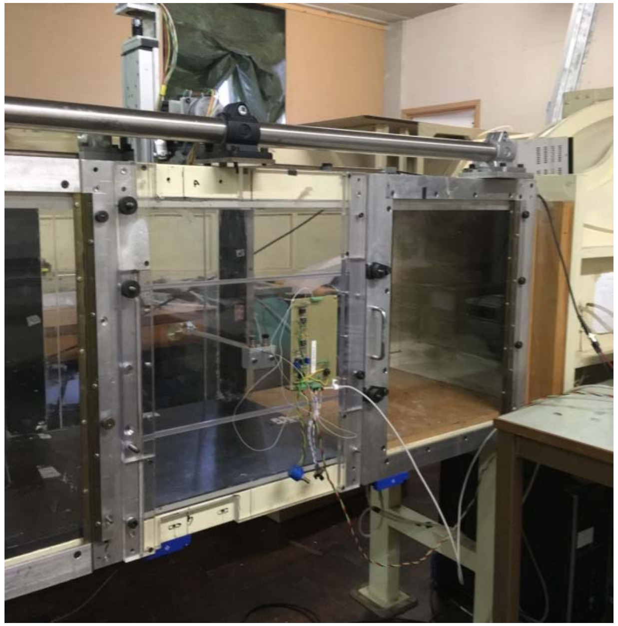
"Clone" MWT for UCB

- Completed at end of July
- Tested in wind tunnel w/c 31 July
- Shipped to Berkeley 15th August
- Similar to our earlier design but with fully 3D-printed rotor and modified blade angles (following additional modelling)





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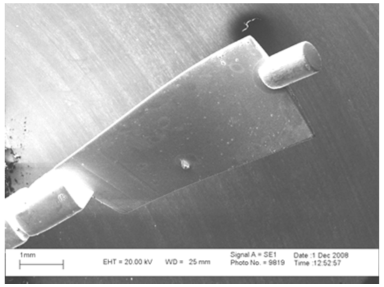
Performance Comparison

Alternative rotor fabrication methods investigated to avoid high-resolution RP used in original device:

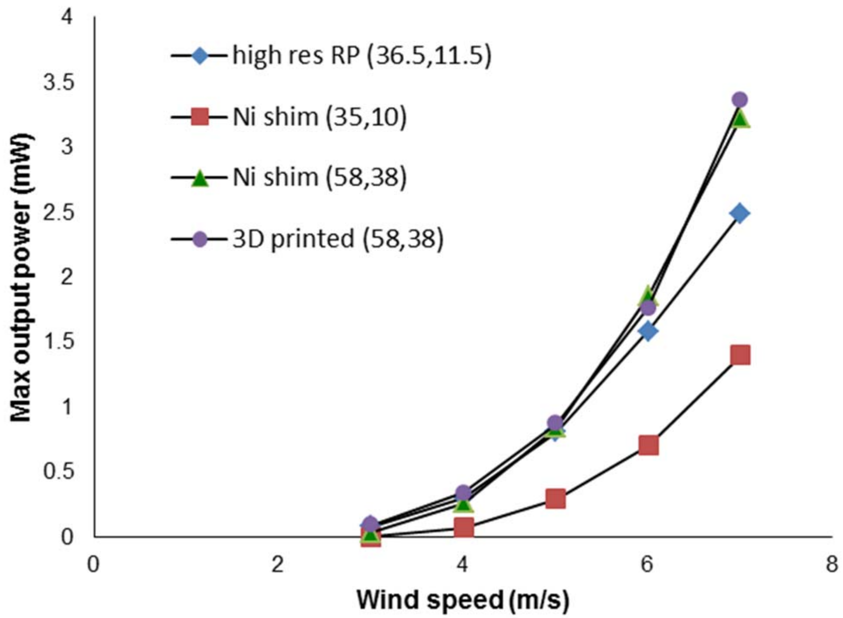
- Laser-cut nickel shim blades glued to 3D printed hub and rim parts
- Fully 3D printed rotors (Objet printer; Vero-white material)

- Some performance lost in going from high-res RP (aerofoil) to Ni shim (rectangular), but this recovered by improved rotor design (blade angles)
- Similar performance from Ni shim and fully 3D printed rotors

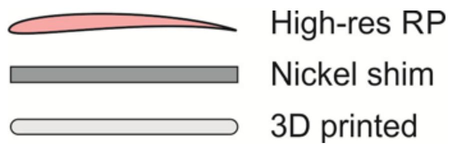
High-res RP



Nickel shim / 3D printed



Blade cross-sections:



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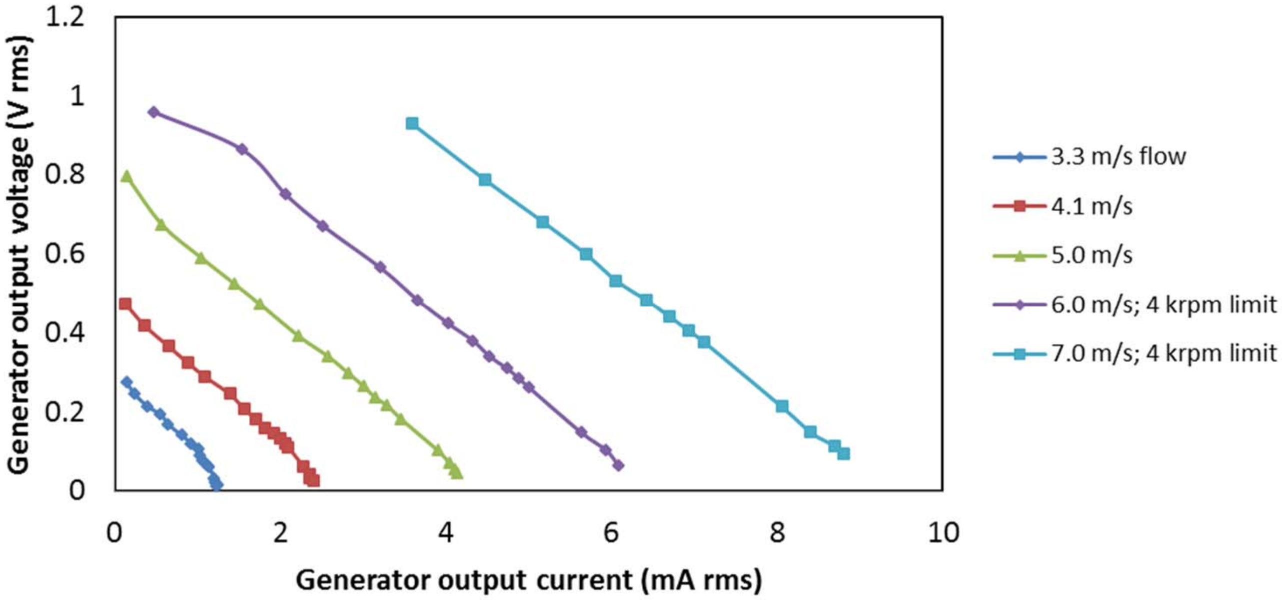
I-V Characteristics of Clone MWT



I-V curves at different flow speeds are much more consistent (in terms of effective source resistance) than for earlier device – we are not sure why…

Suggests a simple MPPT algorithm such as implemented by BQ25505 may be adequate

Slopes correspond to an effective source resistance of ~150 Ω; this is >> generator source resistance of 21 Ω because it includes turbine response to loading

See data supplied with clone for more detail

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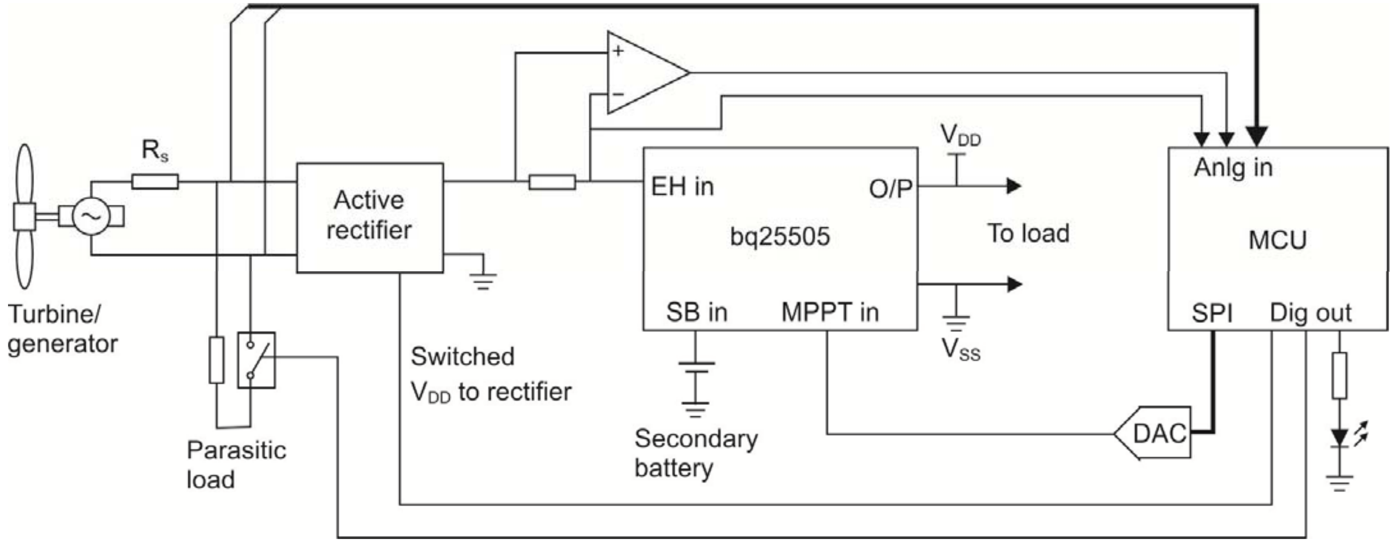
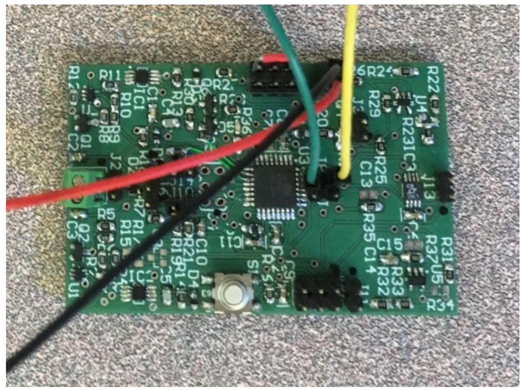
MWT Power Module

Work at Imperial in August and September was focused on development of a power conditioning module



Functionality aimed for:

- Active rectification
- Maximum power point tracking
- Overspeed protection (parasitic load)
- Ultra-low power sleep mode when turbine stopped



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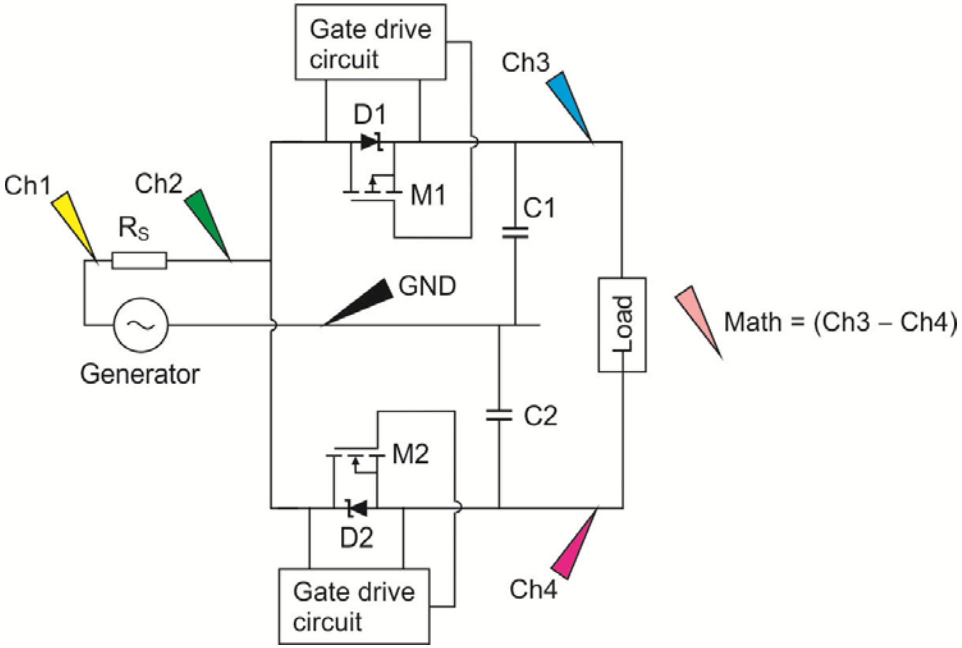
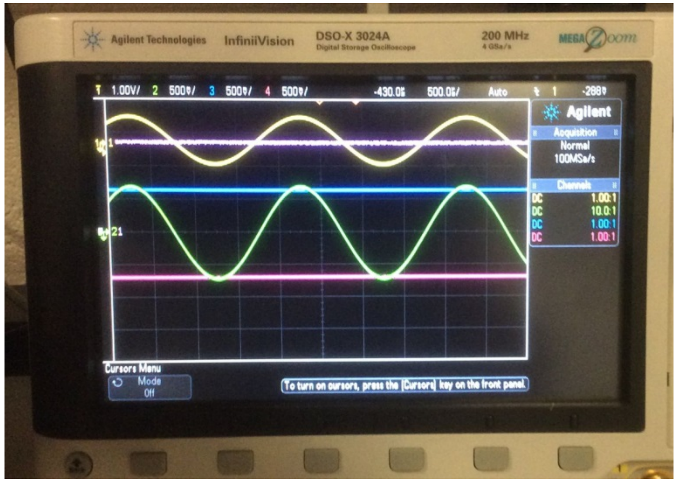
Active Rectifier

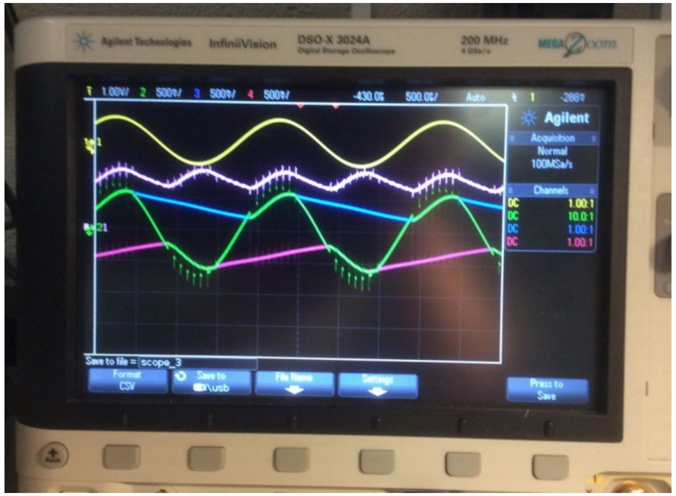
- Opted for full-wave voltage doubler - simpler than full-wave rectifier, with higher output voltage



Rload →∞



Rload = 470 Ω



- Scope traces are for 500 Hz, 500 mVrms source with Rs = 20 Ω
- Spikes on Chs 2-4 & Math are artefacts of gate control method

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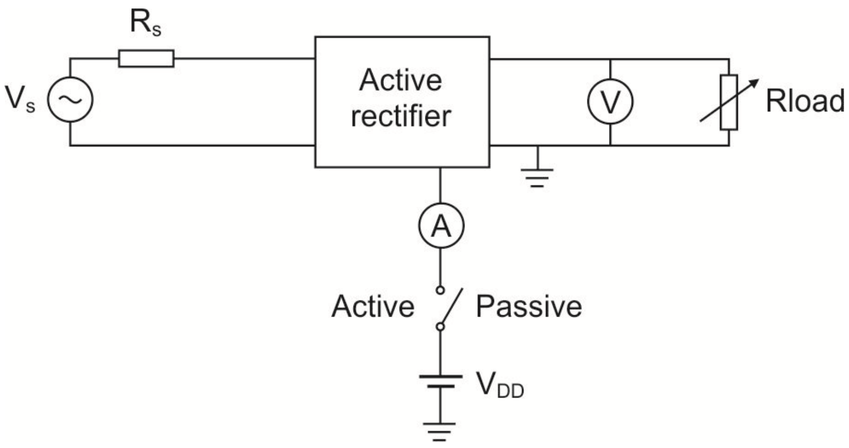
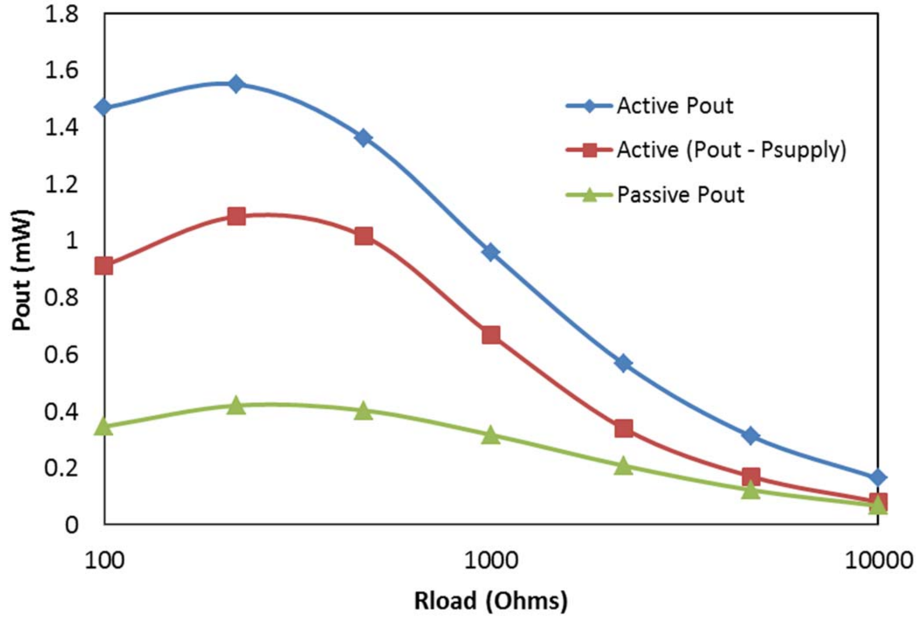
Active Rectifier Performance

- Rectifier characterised for a range of input voltages/frequencies and output loads





- Data shown is for 500 Hz, 500 mVrms source with Rs = 20 Ω
- When Rload < 1 kΩ, which is where we are expecting to be working:

Pout_active >2× Pout_passive

- Performance gain depends on source amplitude and frequency

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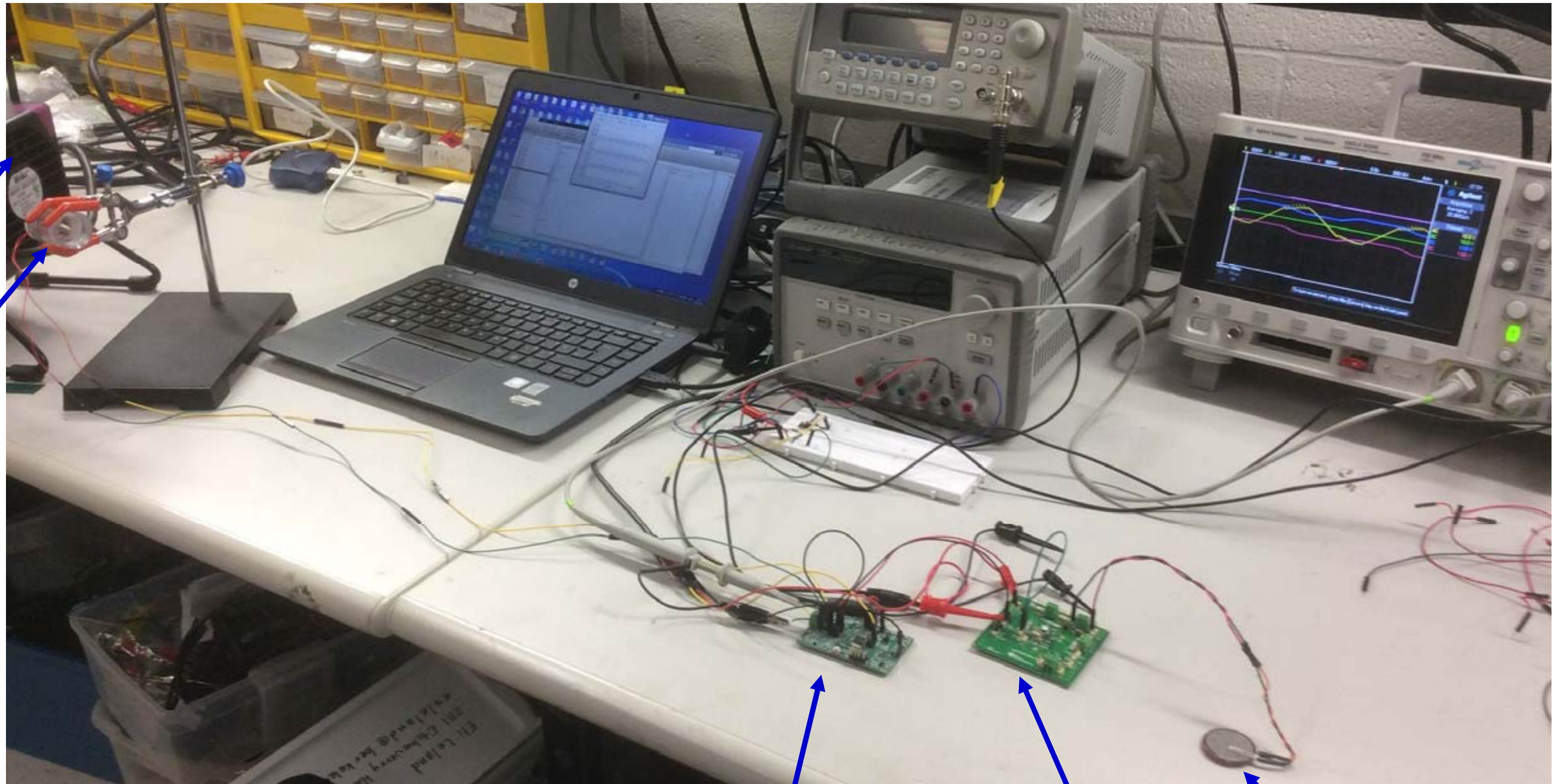
Power Module Debugging & Testing

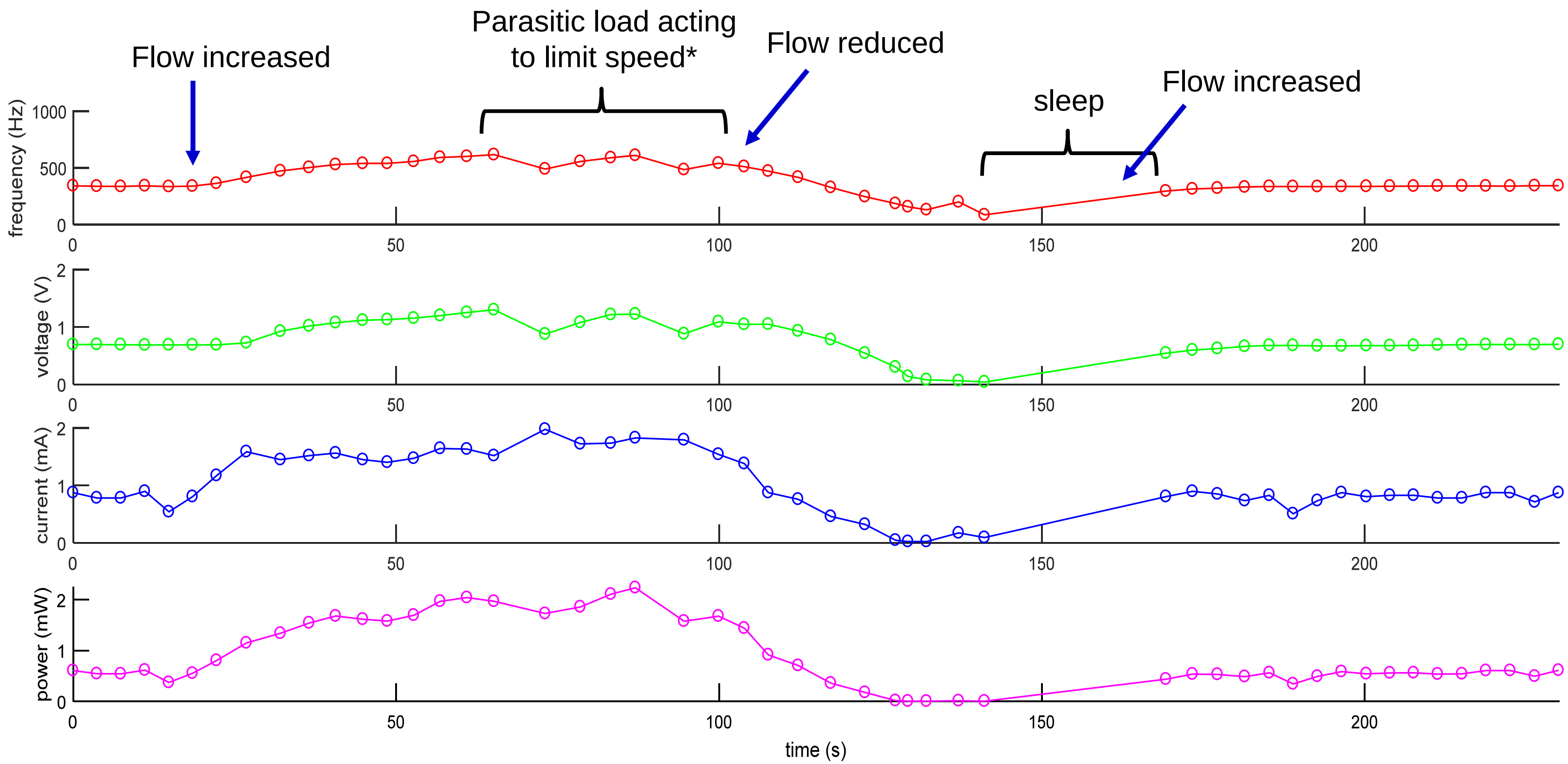
(Berkeley trip Oct/Nov, working with Bala)

- Addition of UART communications to Power Module MCU code to enable serial readout of key parameters (generator frequency, rectifier Vout & Iout)
- Power Module functionality tested and code de-bugged



Energy Harvesting Demo

- Plots show logged values of generator frequency, rectifier Vout & Iout, and power into BQ25505



*Parasitic load threshold set to 600 Hz

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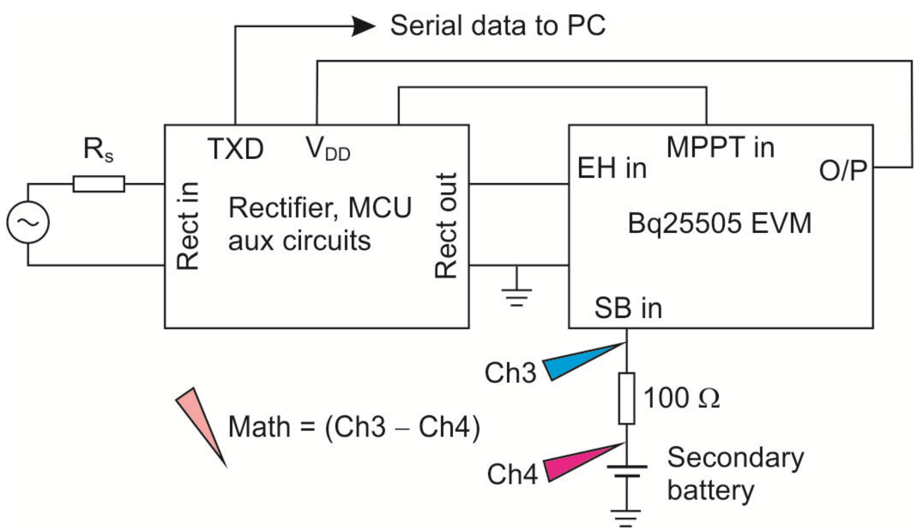
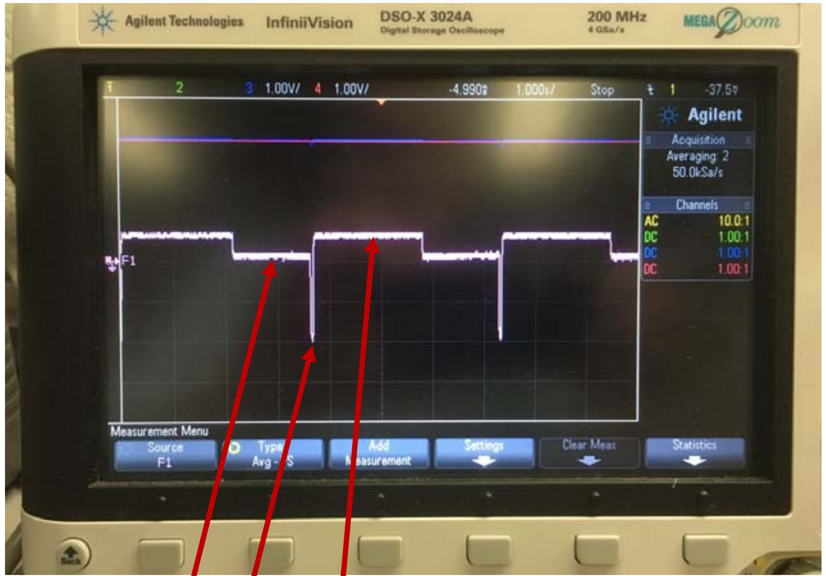
Battery Current Measurement

- Current into/from secondary battery monitored when BQ EVM providing power for Power Module (i.e. no ext supply)





- Scope trace shown is for 750 Hz, 750 mVrms source with Rs = 20 Ω
- Average current into battery is ~110 μA, corresponding to 330 μW at 3 V
- System not optimised

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Summary & Next Steps

- “Clone” MWT completed, characterised and delivered to UCB
- MWT power module developed, including active rectifier, acquisition of key data (generator freq, rectifier Vout & Iout), maximum power point tracking, overspeed protection, and sleep mode
- Power Module de-bugging and testing carried out during 4-week visit to UCB
- Work started on comparative study of HAWT and VAWT devices (at early stage and not reported here)
- In the next period we will continue with testing and optimisation of the Power Module, and integration with the UCB wireless mote. We will also continue with the comparative study

Plans for Year 2

- Explore alternative bearing solutions that will allow a reduction in starting speed
- Develop optimised energy storage solutions, building on study of wind speed characteristics started in Year 1
- Complete design and fabrication and test of first generation system; design to be informed by paper study and results obtained from prototype platform in Year 1
- Complete design of second generation system