Zero Power, Large Area Rail Track Monitoring

£1.8m EPSRC funded project (Academic Research)

£0.5m Innovate UK project (Industry Research)

[a, b] Professor Meiling Zhu

[a, b] Dr Zheng Jun Chew

[a, b] Dr Tingwen Ruan

Faculty of Environment, Science and Economy

[a] University of Exeter, UK

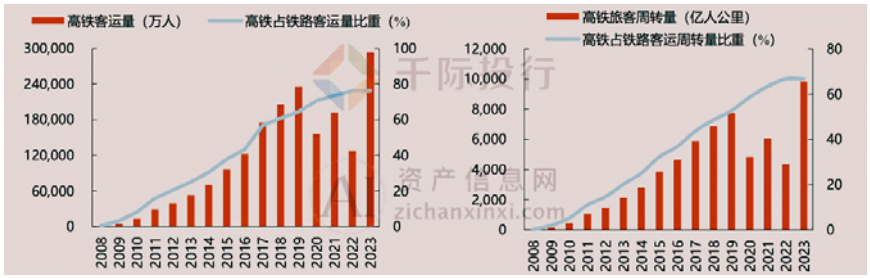
[b] Encortec Limited, UK

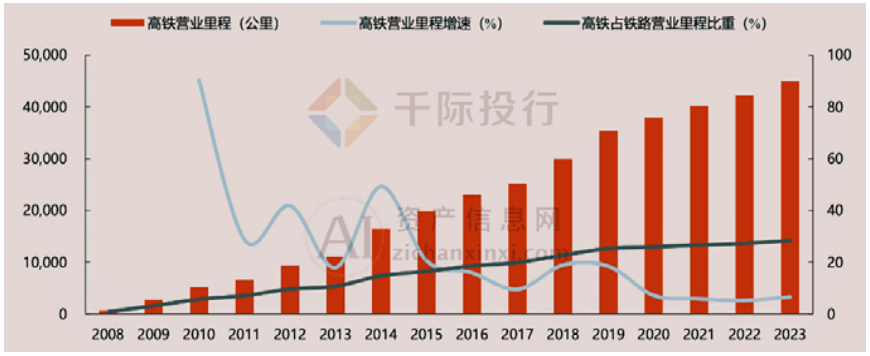
University of Exeter

ENCORTEC SELF-POWERED MONITORING

Traditional Rail Track Monitoring Problems

Demanding 24/7 Real-time Monitoring





University of Exeter

ENCORTEC
SELF-POWERED MONITORING

Morden Rail Track Monitoring Problems

Cable Powered

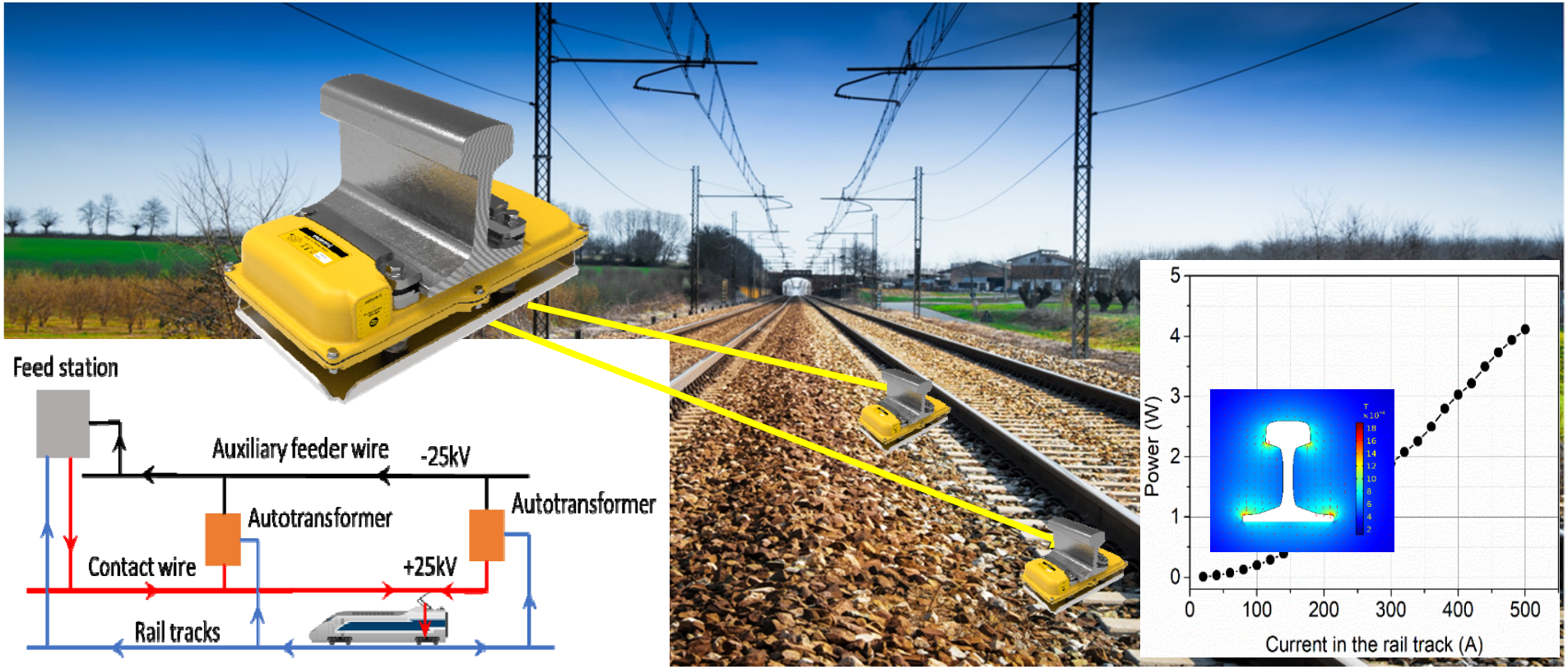
Solar powered

Battery powered

Mini-wind turbine powered

Our Zero Power Rail Track Monitoring

Harvesting electromagnetic energy when trains pass by

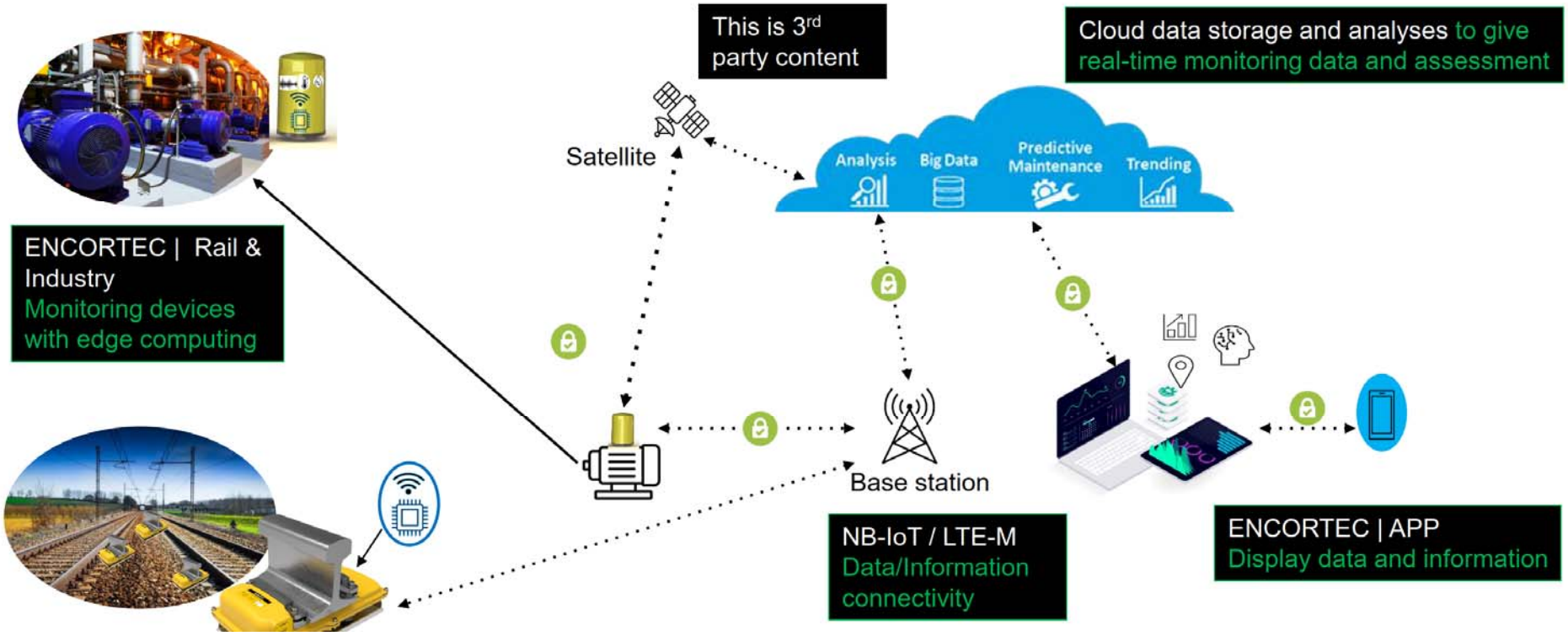


University of Exeter

ENCORTEC
SELF-POWERED MONITORING

Our End-to-End System

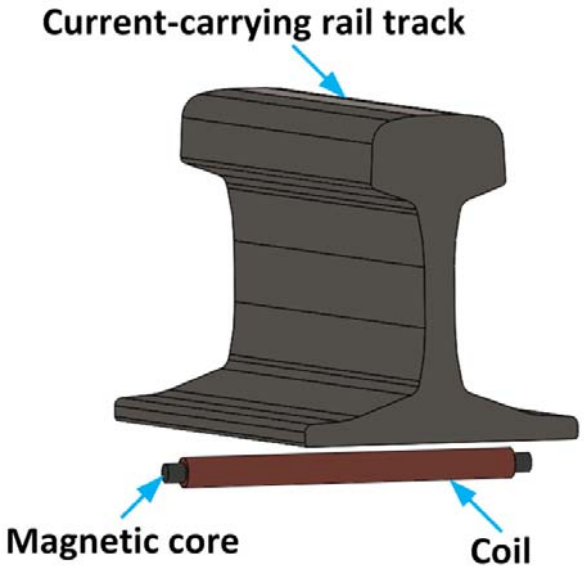
We developed an end-to-end system technology solution from energy harvesting, power management, wireless sensors, data transmission, and condition monitoring.

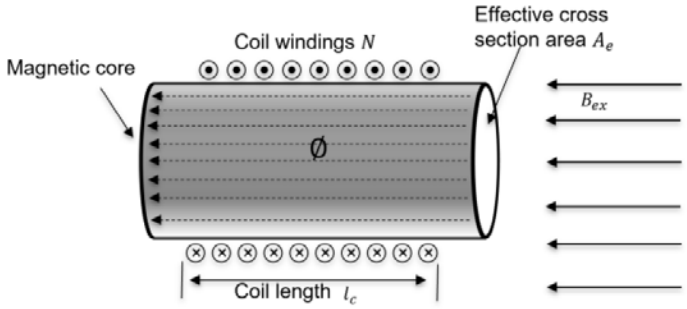


University of Exeter

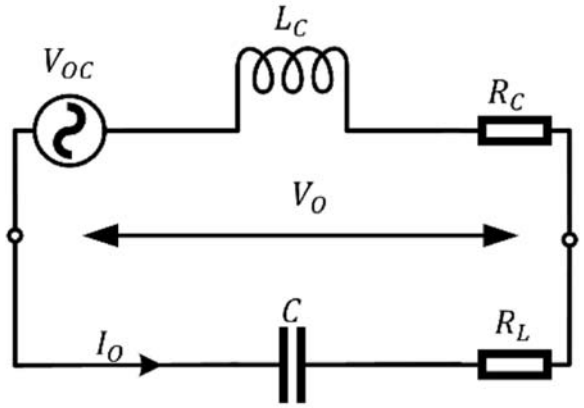
ENCORTEC
SELF-POWERED MONITORING

E;ectromagentic Energy Harvesting





Energy Harvesting Analysis



$$V_{oc} = N\omega A_e \mu_e B_{ex} = N\omega A_e B_{oc}$$

$$C = \frac{1}{\omega^2 L_c}, L_c = \frac{\mu_0 \mu_{r,e} N^2 A_e}{l_c}$$

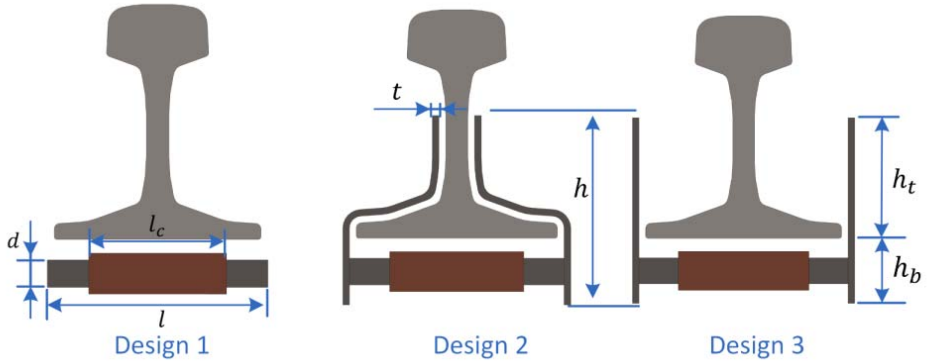
$$R_c = R_w + R_{ed}$$

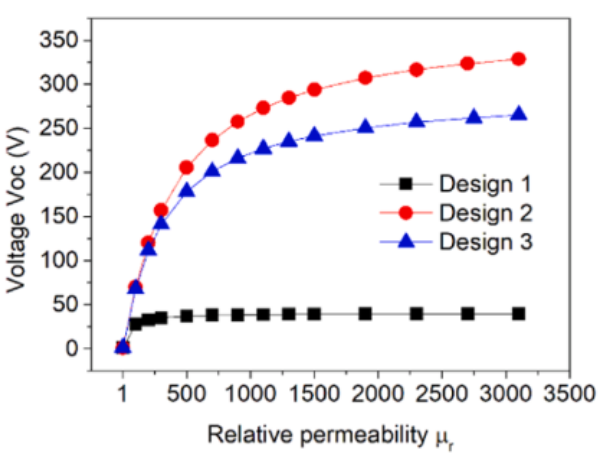
$$P_m = \frac{V_{oc}^2}{8R_c} = \frac{N^2\omega^2 A_e^2 \mu_{r,e}^2 B_{ex}^2}{8R_c}$$

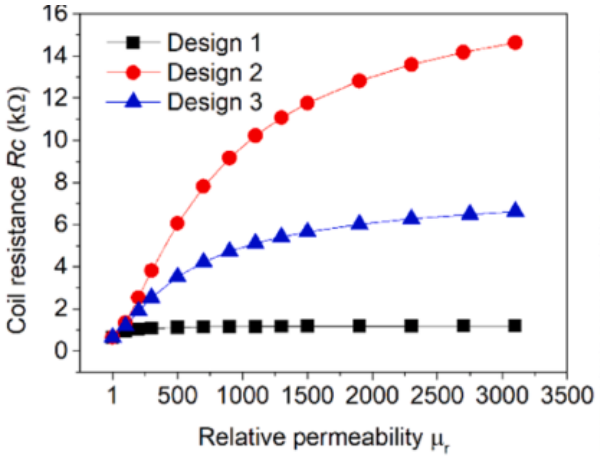
R_c and $\mu_{r,e}$ is critical to increase the power output. The shape of the magnetic core can be optimised to increase $\mu_{r,e}$ and decrearse R_c .

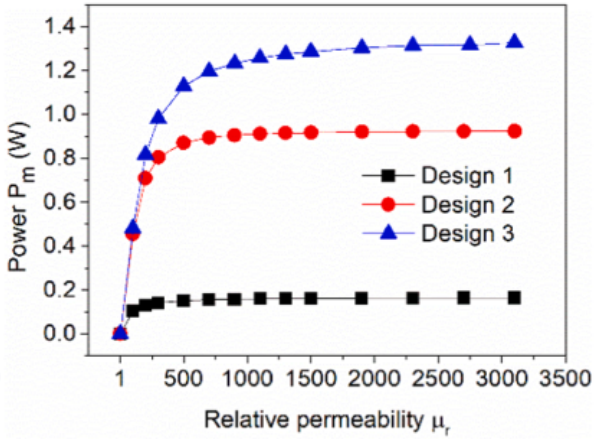
Meiling Zhu, et al. (2021) Magnetic field energy harvesting from the traction return current in rail tracks, Applied Energy, volume 292, page 116911.

Different Energy Harvester Designs

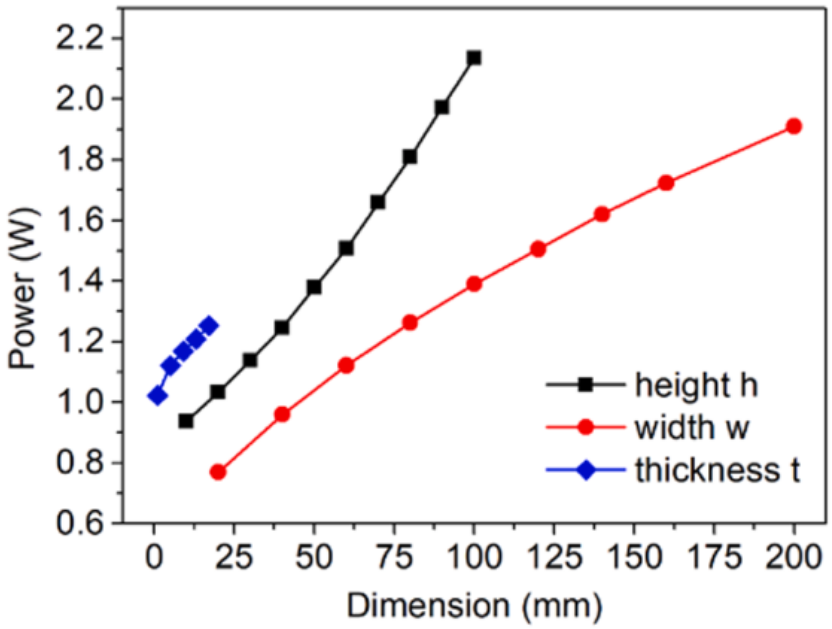




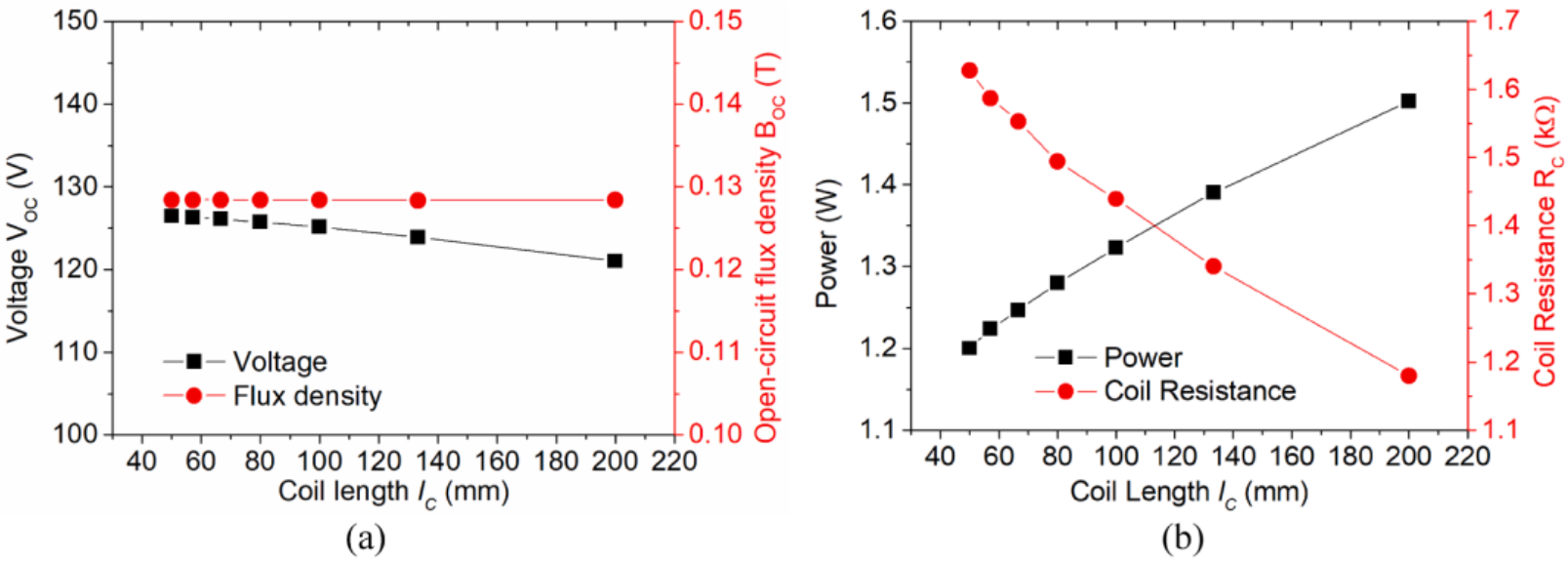




Parameter Study for Design 3



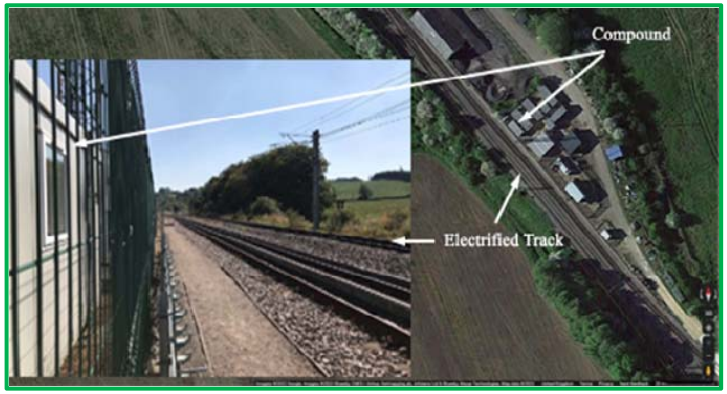
Parameter Study for Coil Length

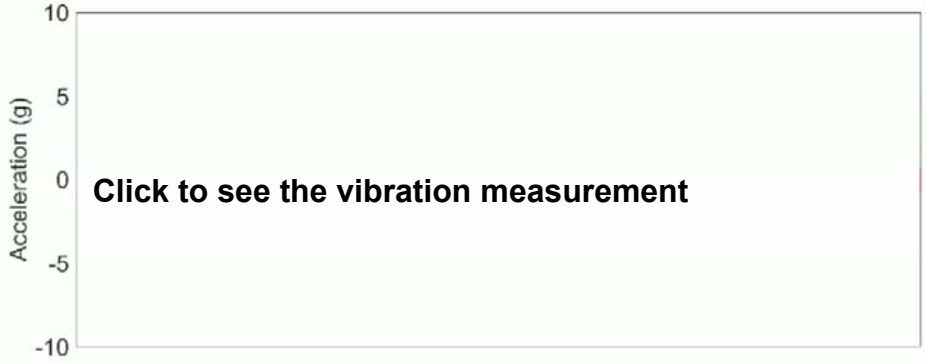


Effect of the coil length lc on (a) the open-circuit voltage and magnetic flux density and (b) the power output and coil resistance of the MFEH when the number of coil windings is fixed at 10,000.

Testing at RIDC Site

(Rail Innovation & Development Centre)

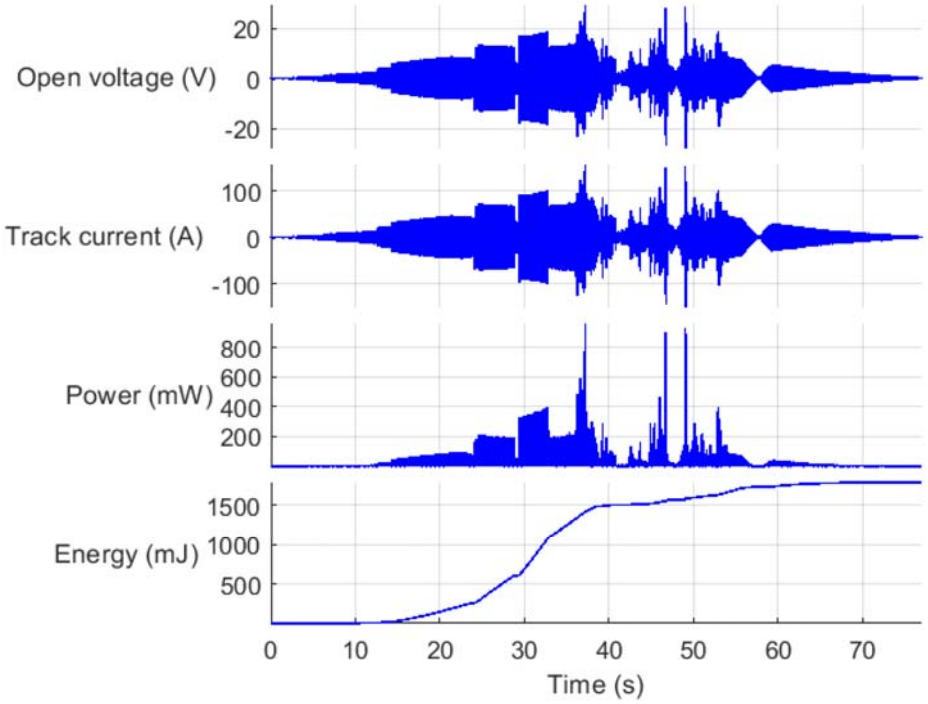


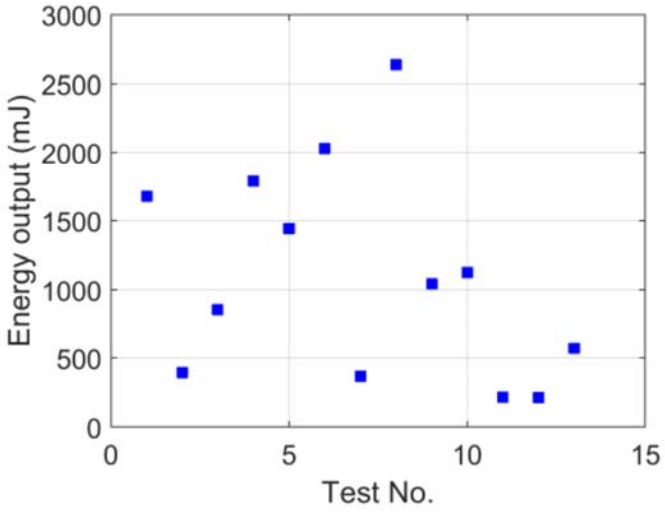


University of Exeter

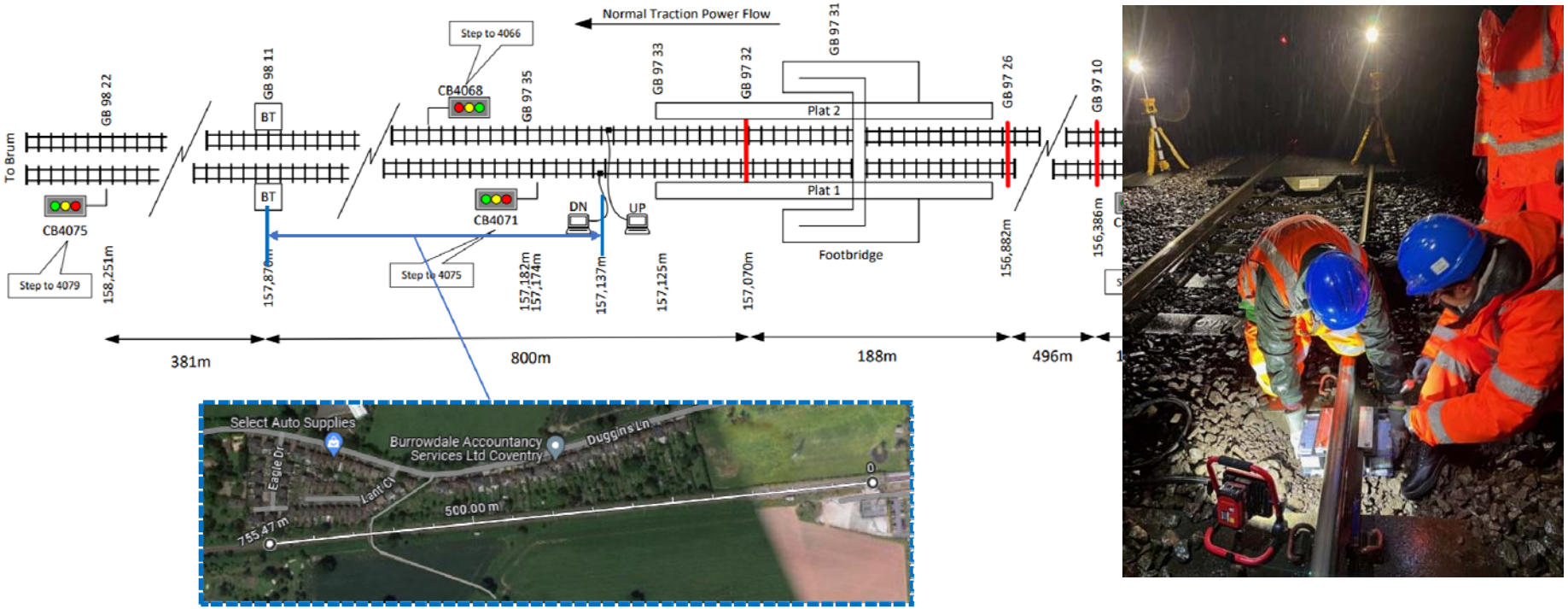
ENCORTEC
SELF-POWERED MONITORING

Testing Results at Testing Track of RIDC





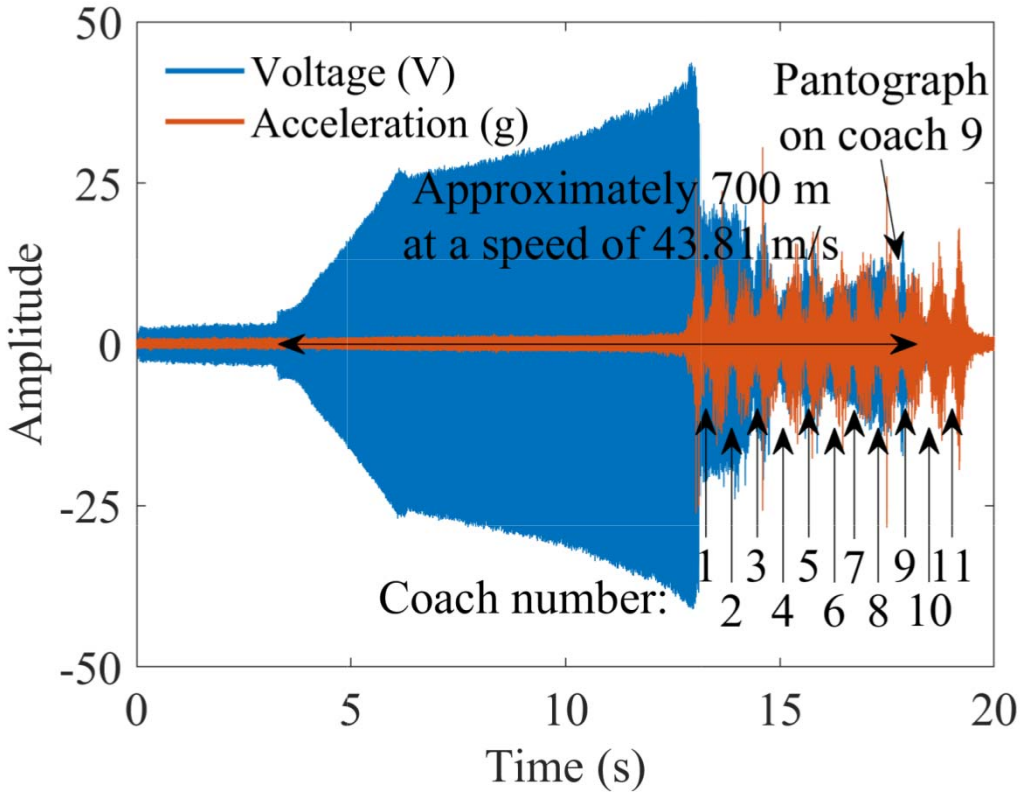
Testing at Tile Hill Operational Track



University of Exeter

ENCORTEC
SELF-POWERED MONITORING

Testing Results at Tile Hill Operational Track



Rail Track Condition Monitoring

Monitoring capability

- Rail temperature
- Flooding
- Movement detection
- Return current
- GPS location

Device Capability

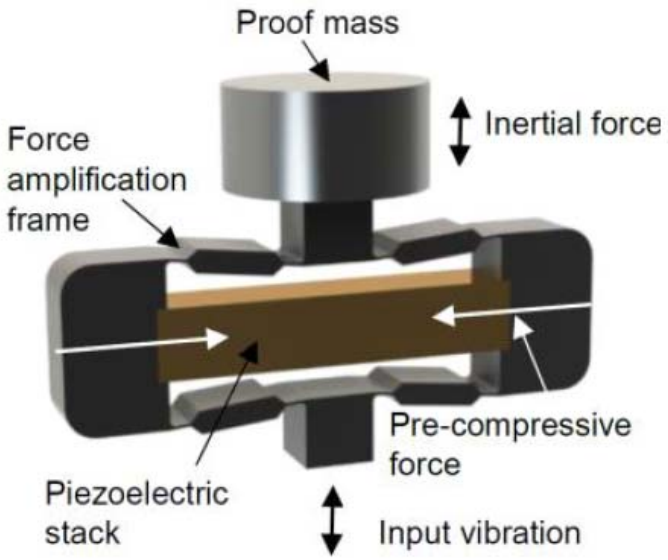
- Energy harvesting
- Mobile connected
- Cloud monitoring
- Fit and forget

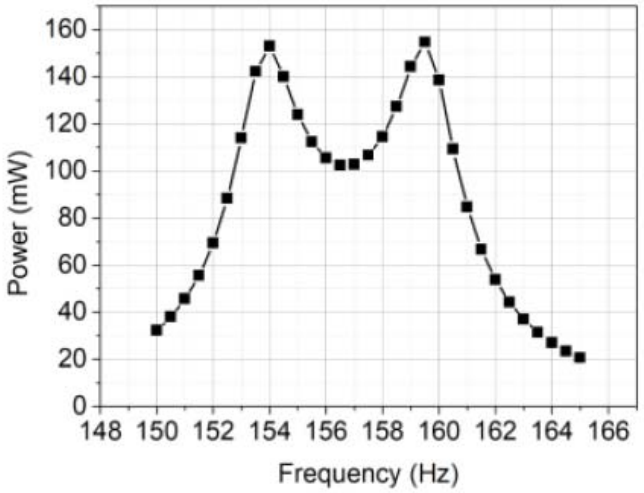
Strongly Coupled Piezoelectric Harvesters

University *of* Exeter

ENCORTEC
SELF-POWERED MONITORING

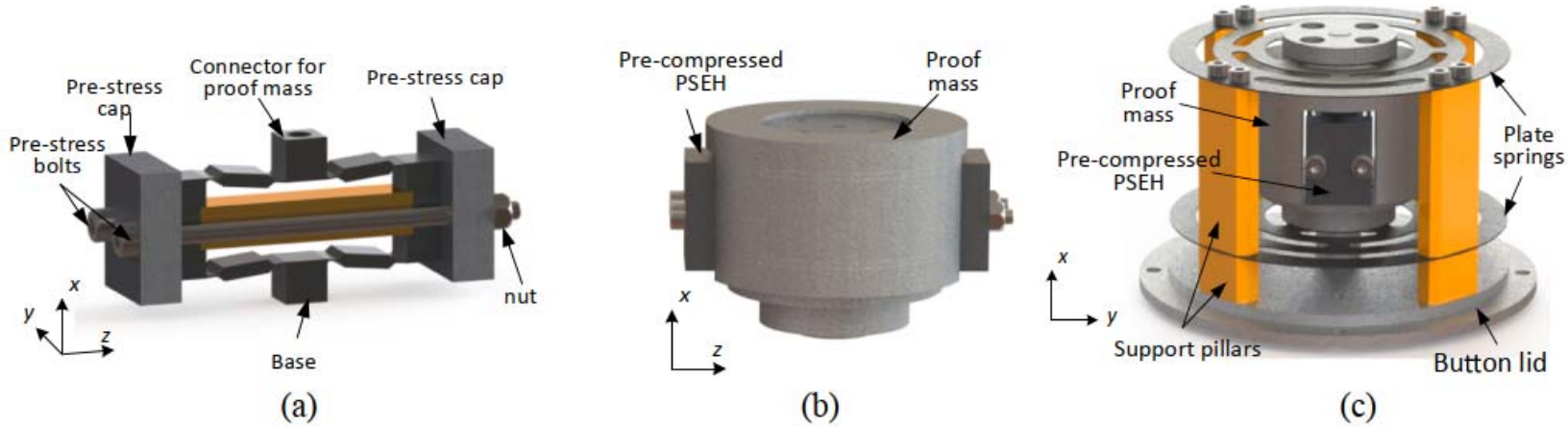
Strongly Coupled Piezoelectric Harvesters





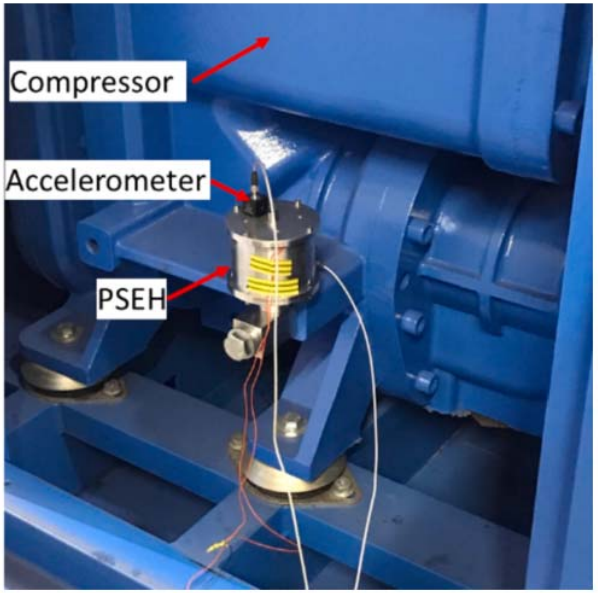
Schematic and power performance of of the piezoelectric stack transducer
(at 0.5g acceleration of input vibration with 0.4kg of proof mass)

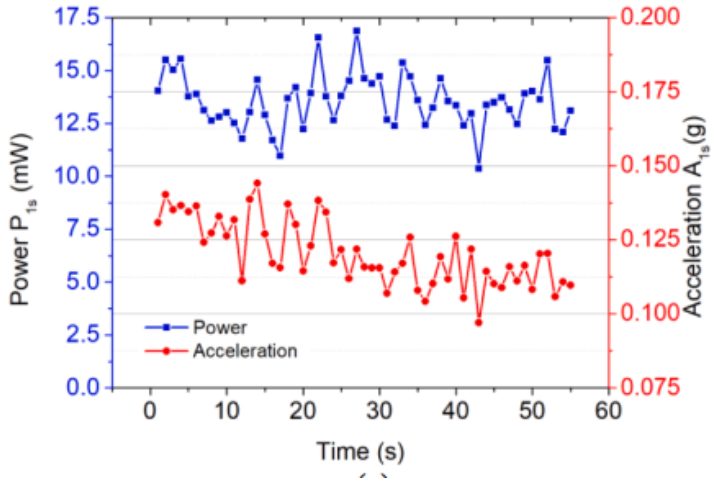
Our Devices

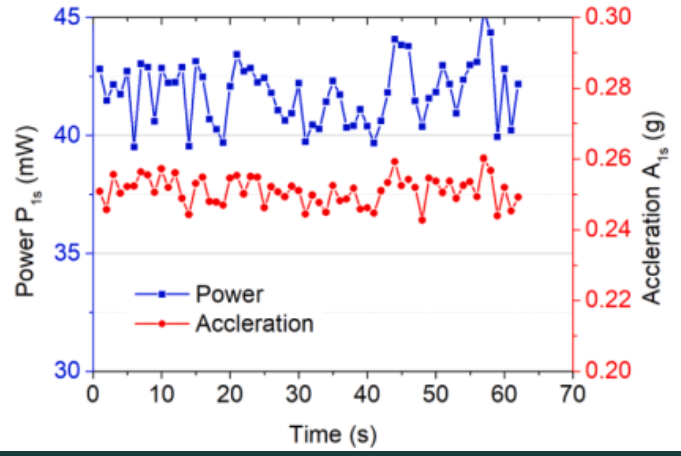


Meiling Zhu et al (2022) Strongly coupled piezoelectric energy harvesters: Optimised design with over 100 mW power, high durability and robustness for self-powered condition monitoring, Energy Conversion and Management 237 (2021) 114129.

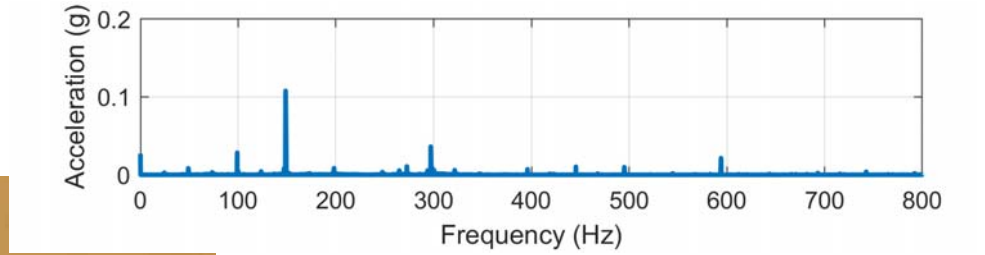
Testing at 200kW Air Compressor

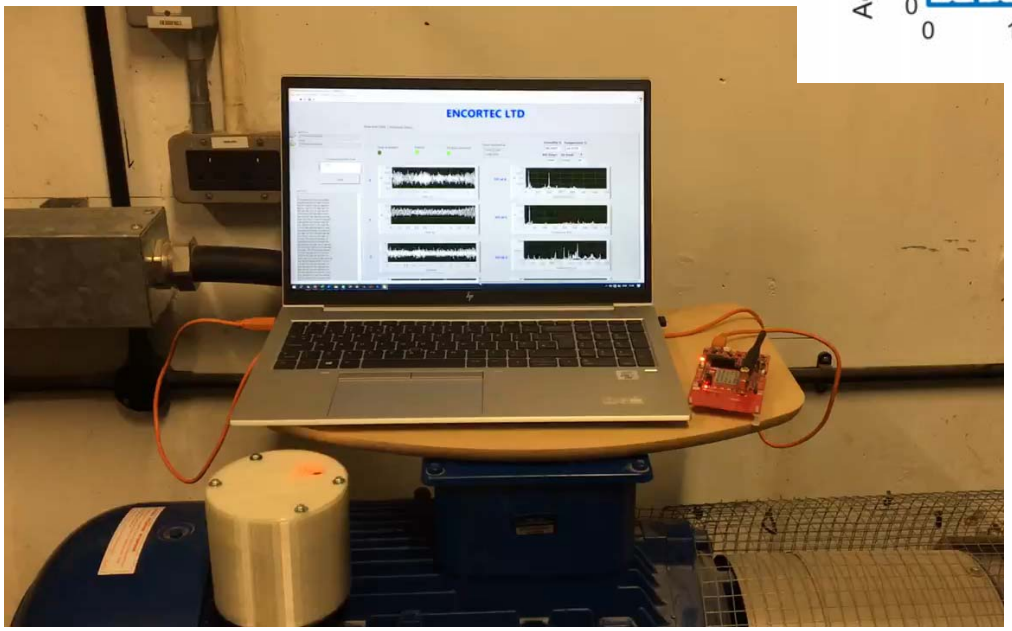






Testing at 25kW Water Pump Station of the University of Exeter





- Monitoring every >10 seconds, capable of close to continuous and truly real-time monitoring and assessing equipment with vibration in all industry sectors and assessment
- Data transmitted : >2048
- Collect data on:
  - ✓ vibration
  - ✓ temperature
  - ✓ and humidity

University of Exeter

ENCORTEC SELF-POWERED MONITORING