IAAPS
ADVANCING PROPULSION

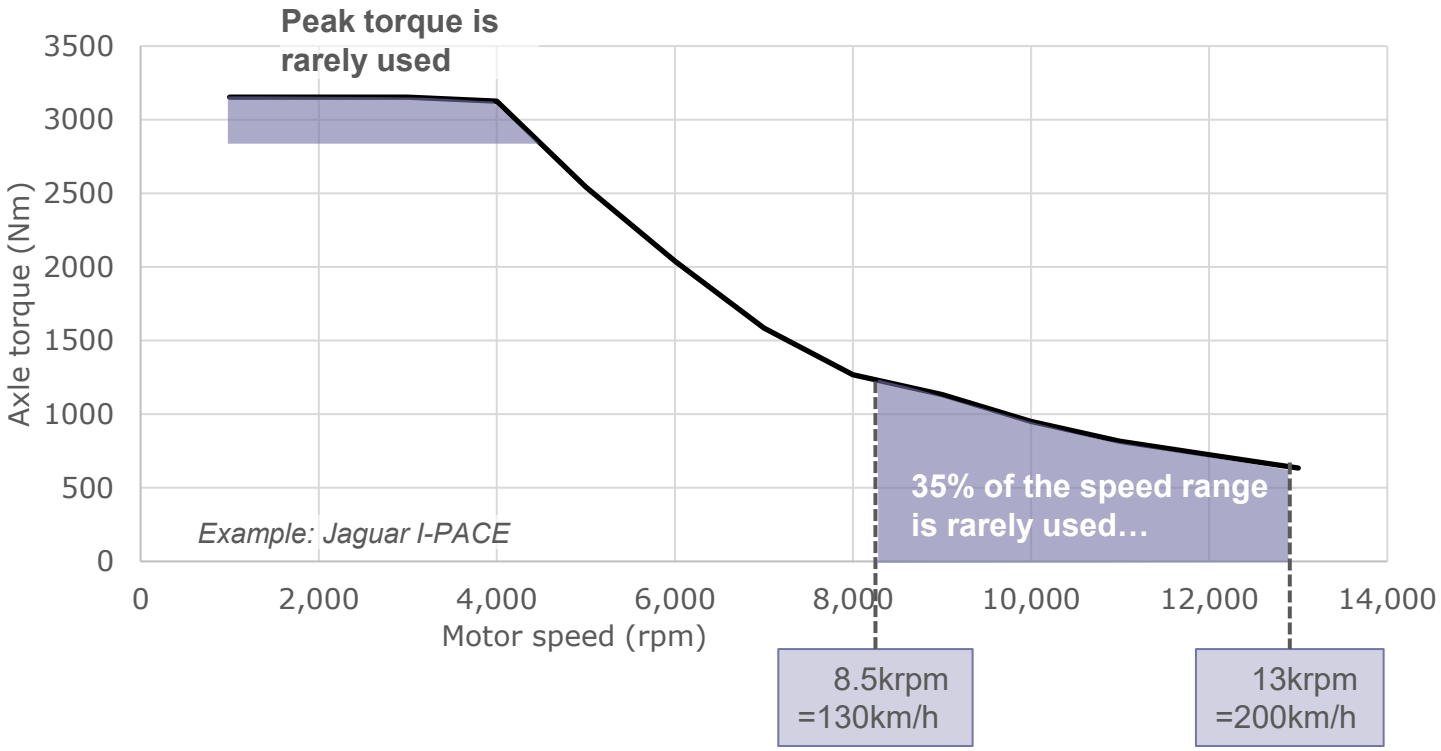
# Making Reconfigurable Motor Windings a reality:

## *An Electro-Mechanical Solution*

Christopher Vagg
crmv20@bath.ac.uk

25 February 2026

# Why an eGear?




➔ **Compromise & over-dimensioning** in drivetrain system, including high-value parts.

# 2-speed EVs?

*Porsche Taycan (2019–)*

*Audi e-tron GT (2020–)*


*MG Marvel R (2021–)*

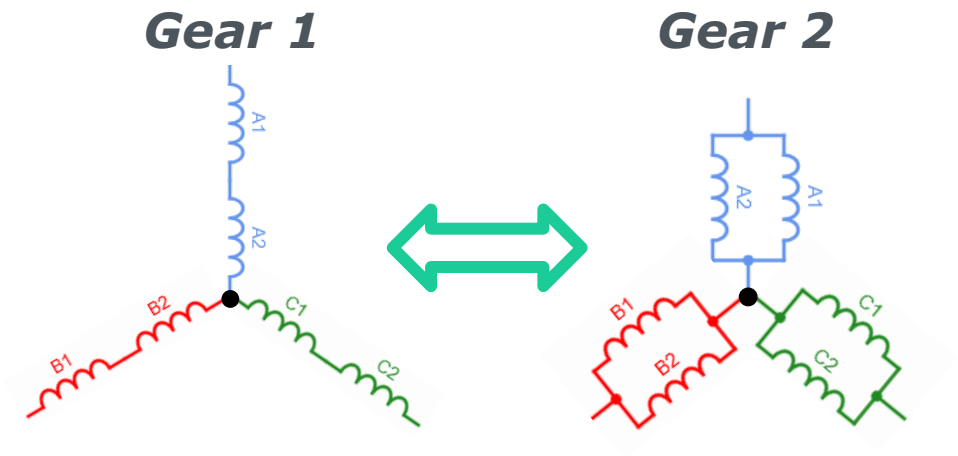
*Lotus Eletre (2022–)*

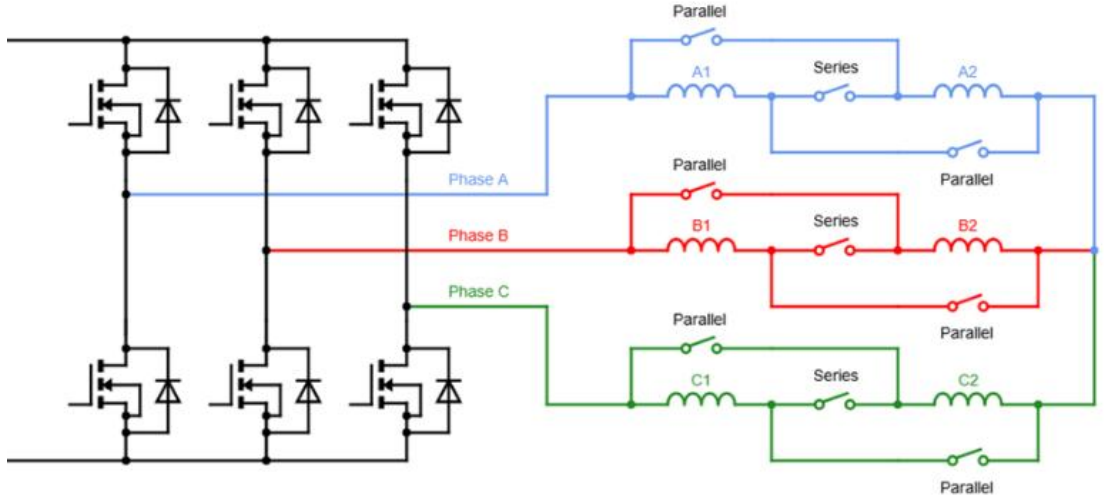
*Mercedes CLA (2025–)*

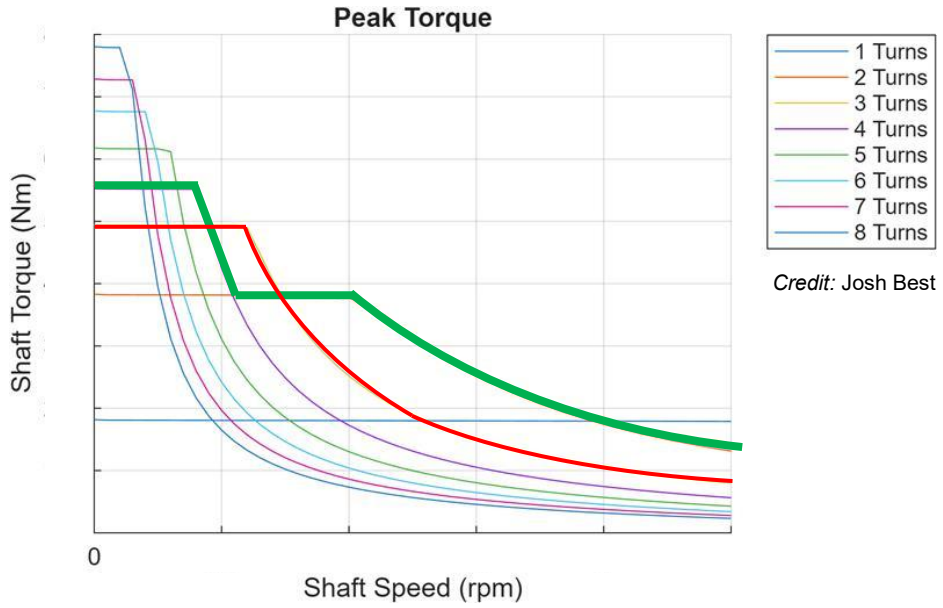


IAAPS UNIVERSITY OF BATH

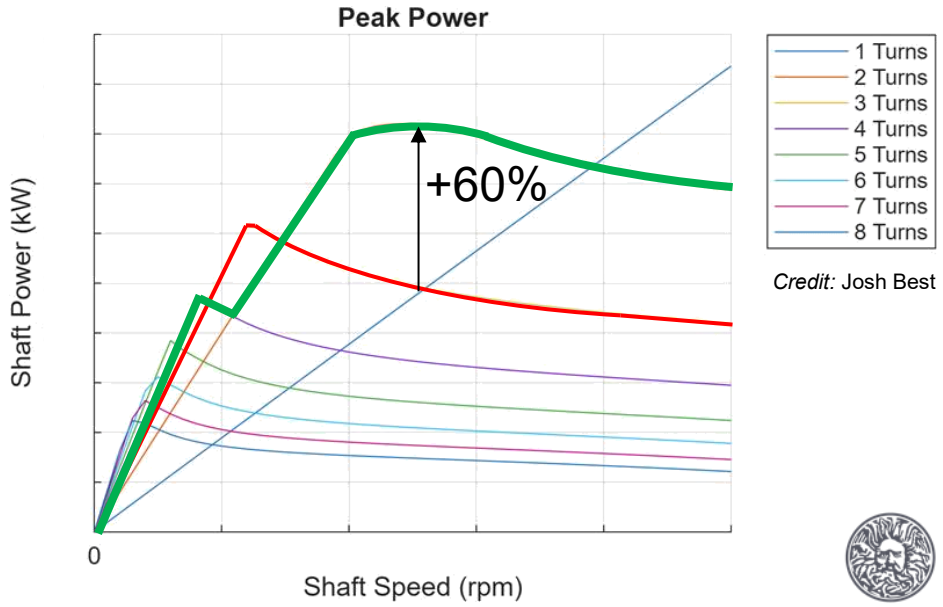
# Electric Gearing Principle




*Credit:* Josh Best




*Credit:* Josh Best

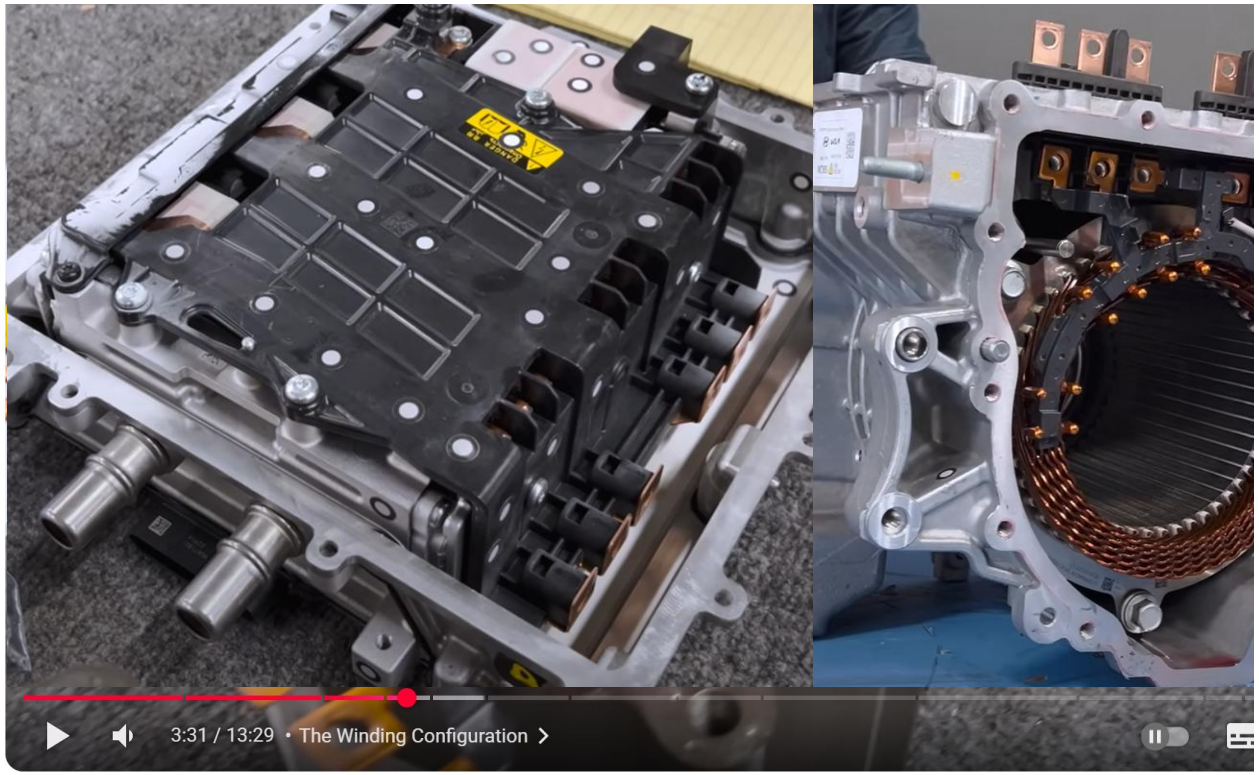


UNIVERSITY OF BATH

# Kia EV9 Dual-Inverter semiconductor solution

*"This is an idea which has been kicking around in the industry for 20+ years, and no one's been able to come up with a **practical way to implement this** for a traction machine in an EV."*

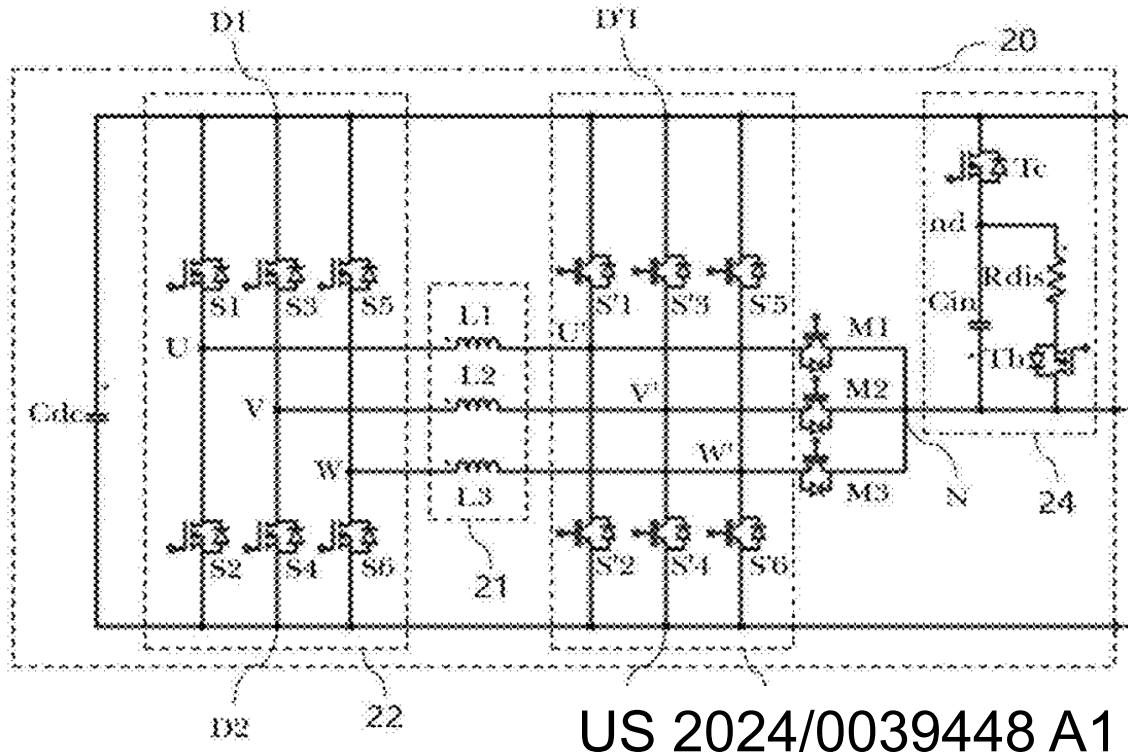
– Paul Turnbull (Lead Engineer, Munro & Associates)




KIA EV9 Dual-Stage Motor & Inverter Breakdown: Engineering Unveiled

MUNRO LIVE Munro

469K su

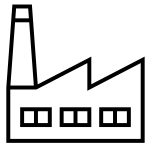



US 2024/0039448 A1

# eGear Objectives

Industry relevant

➔ *Heavy integration with motor*



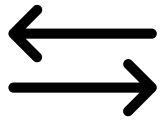
Cost

➔ ***Electromechanical***, *not semiconductor*

EM-TECH

E-Gear

100/150 Arms

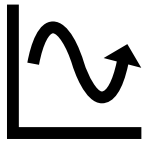


Single actuator

$\eta\%$

Negligible losses

Failsafe



Robust to Vibration

Shift time <100ms

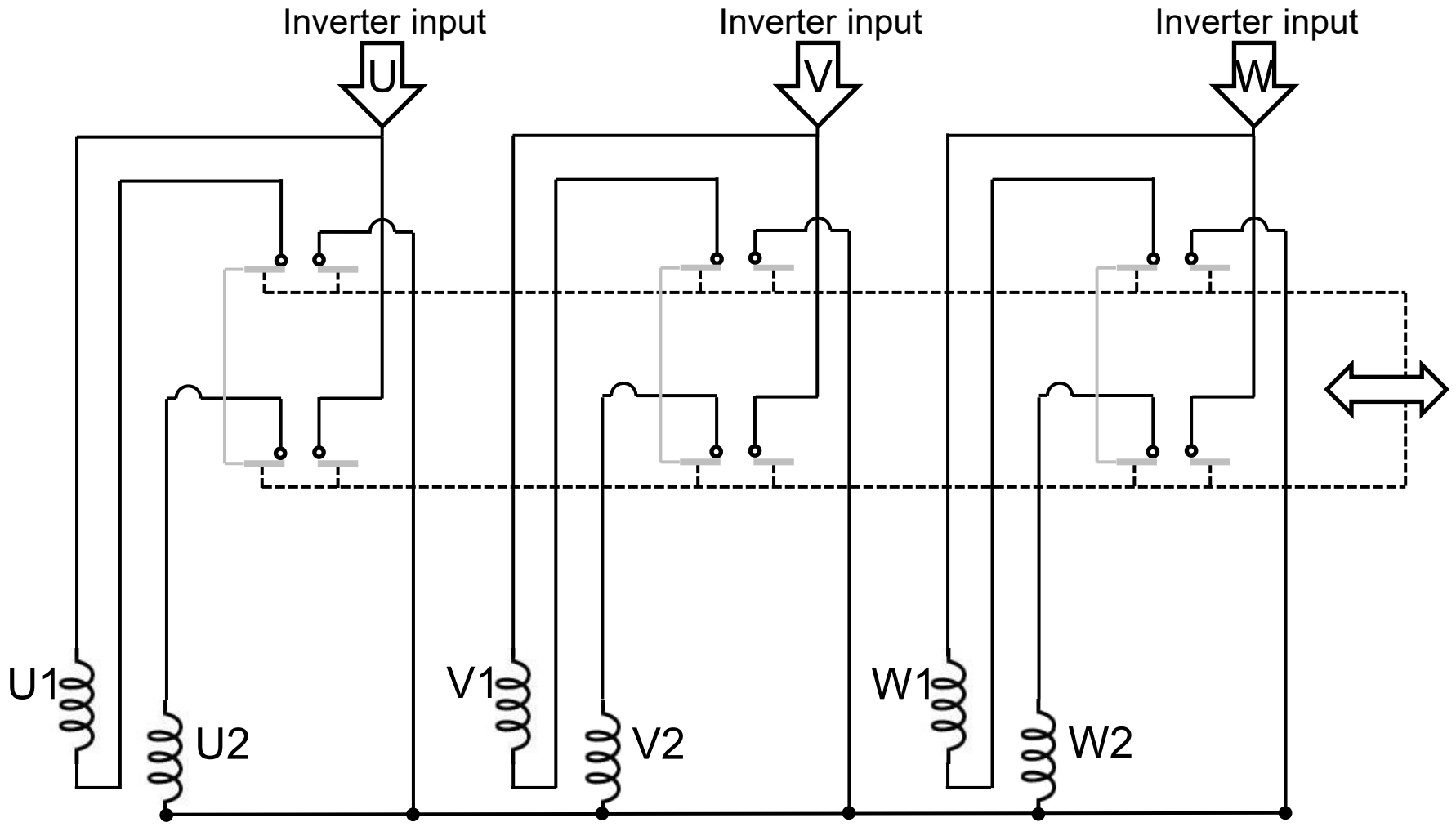
Preferably no cooling
180°C windings



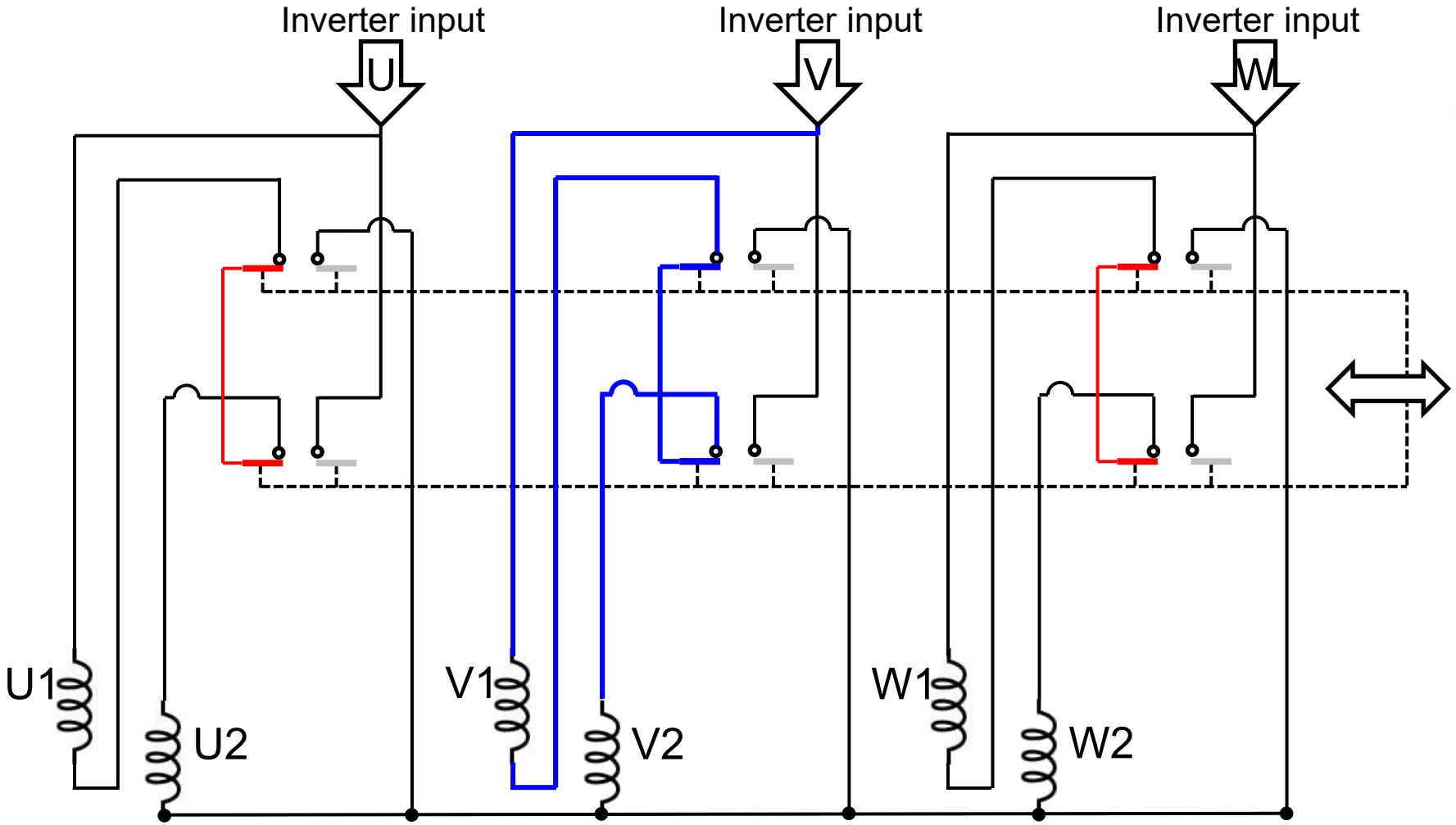
IAAPS

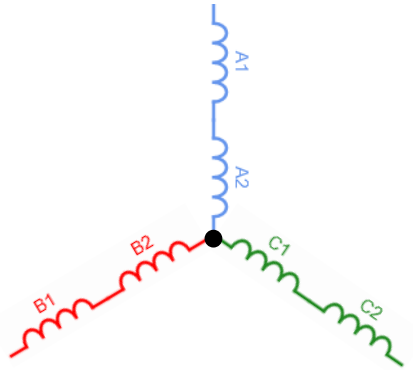
UNIVERSITY OF BATH

# Electrical schematic

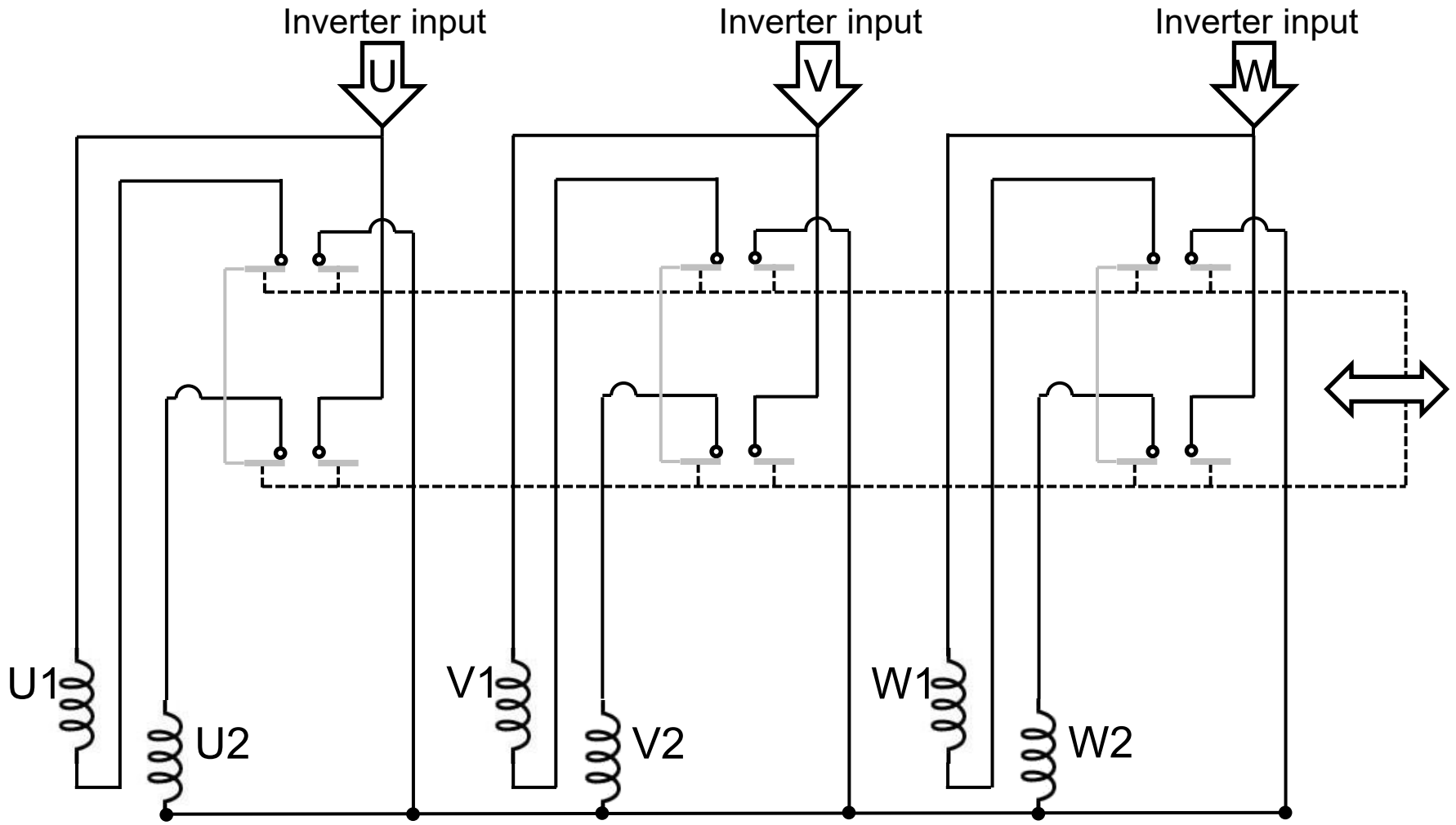


# Electrical schematic
## … Series

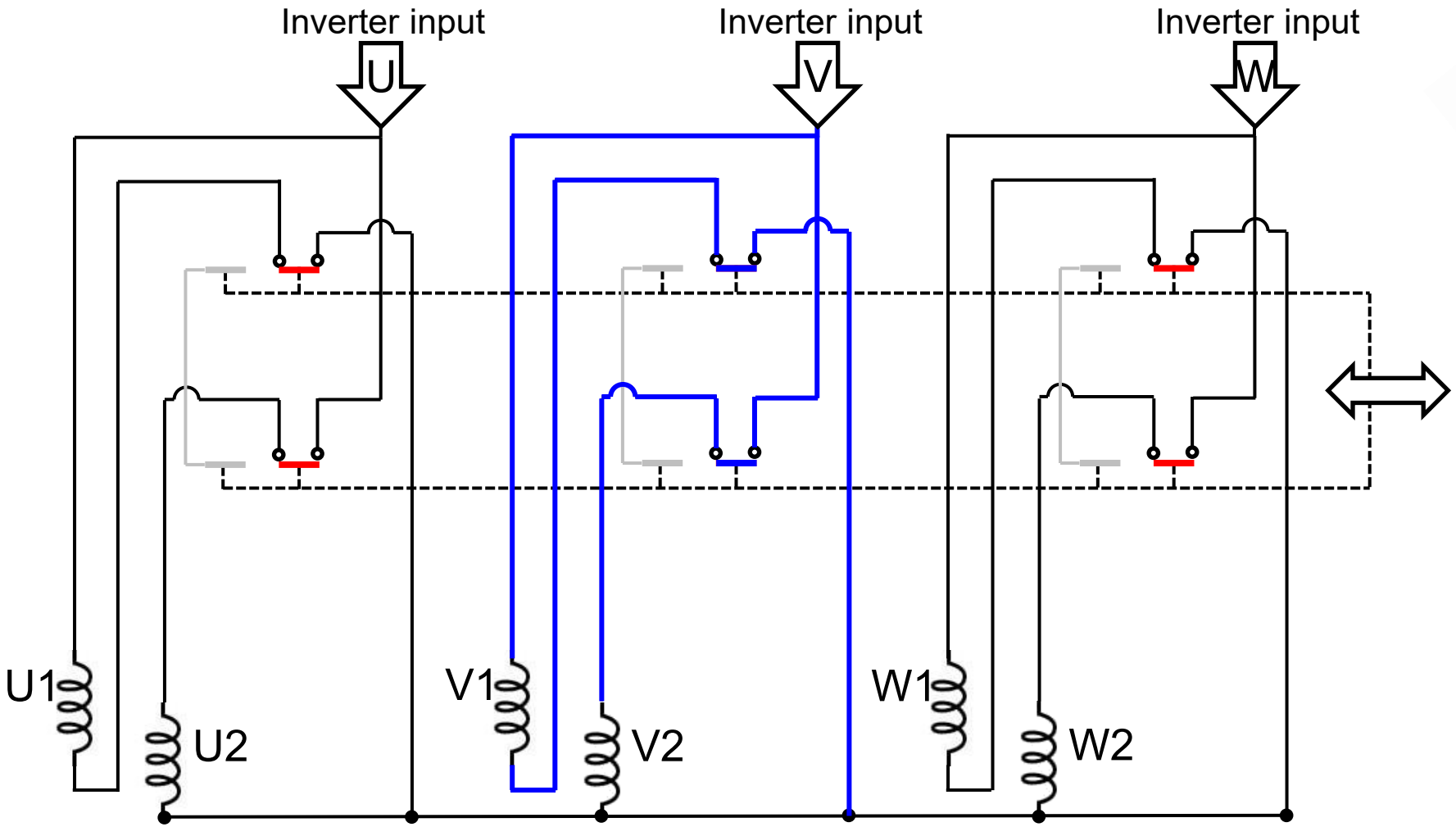


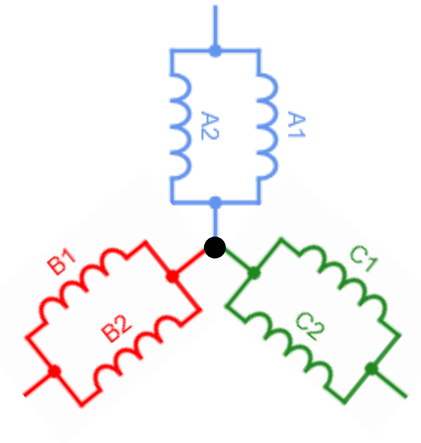



# Electrical schematic
## … Shifting

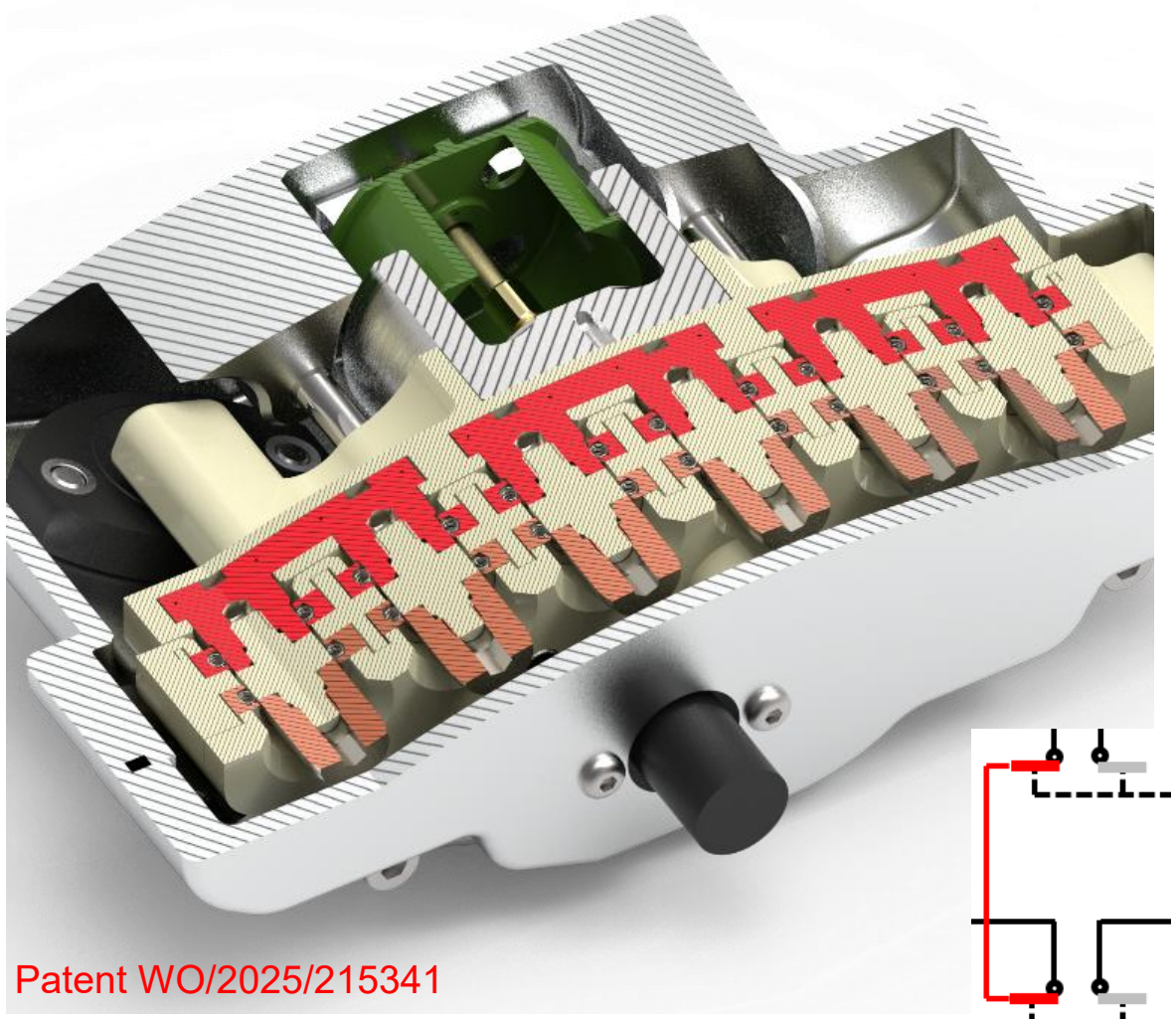


# Electrical schematic
## … Parallel

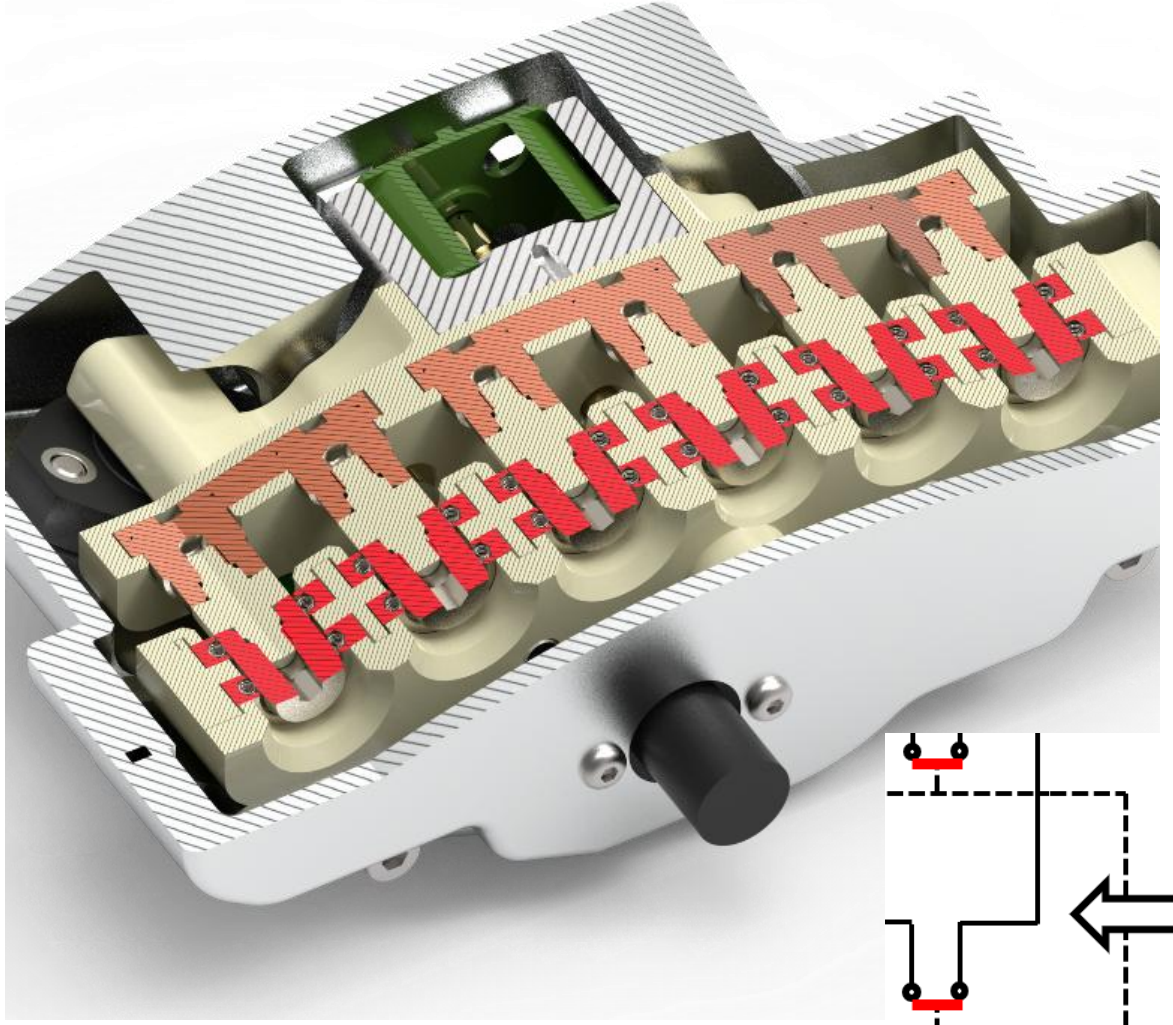


# Internal Design

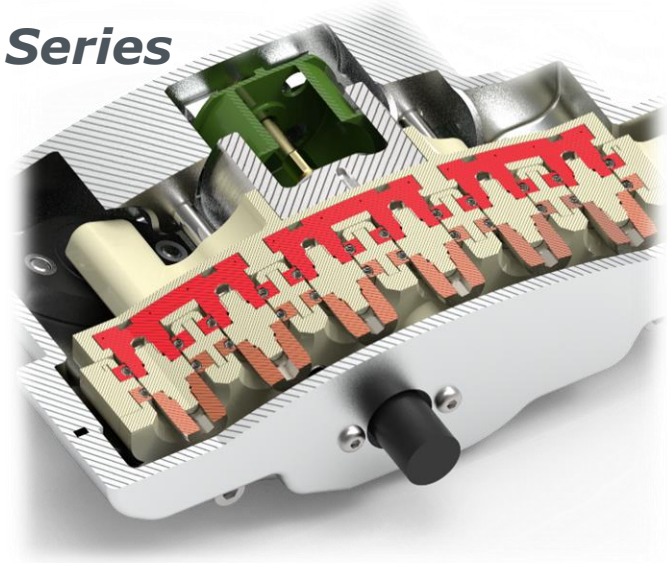


Patent WO/2025/215341

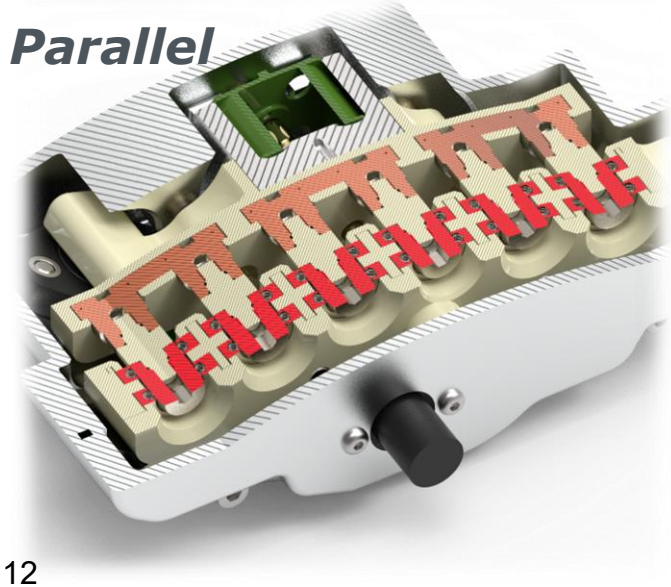


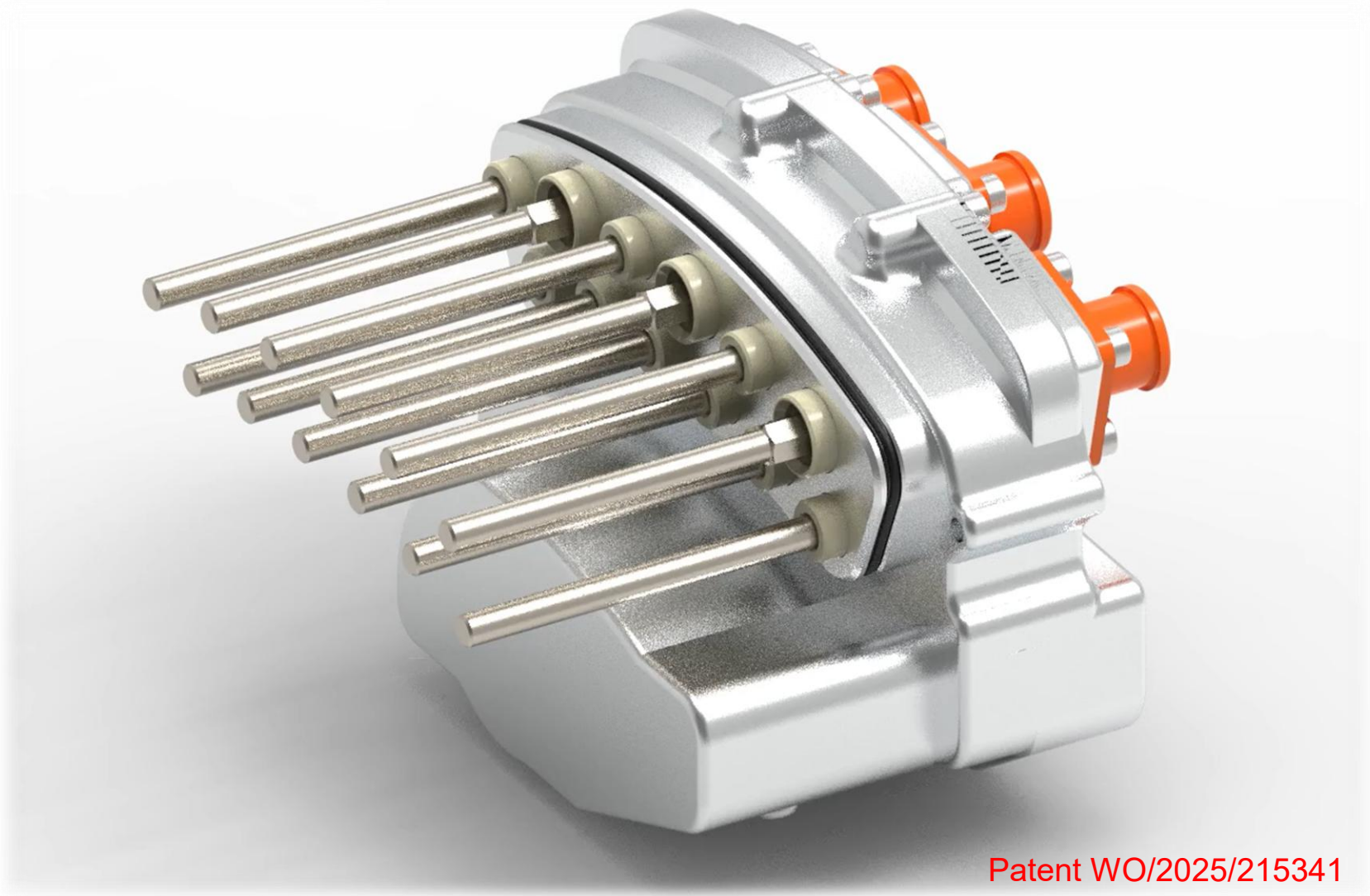
# Internal Design

***Series***



***Parallel***





Patent WO/2025/215341



IAAPS UNIVERSITY OF BATH

# Motor integration

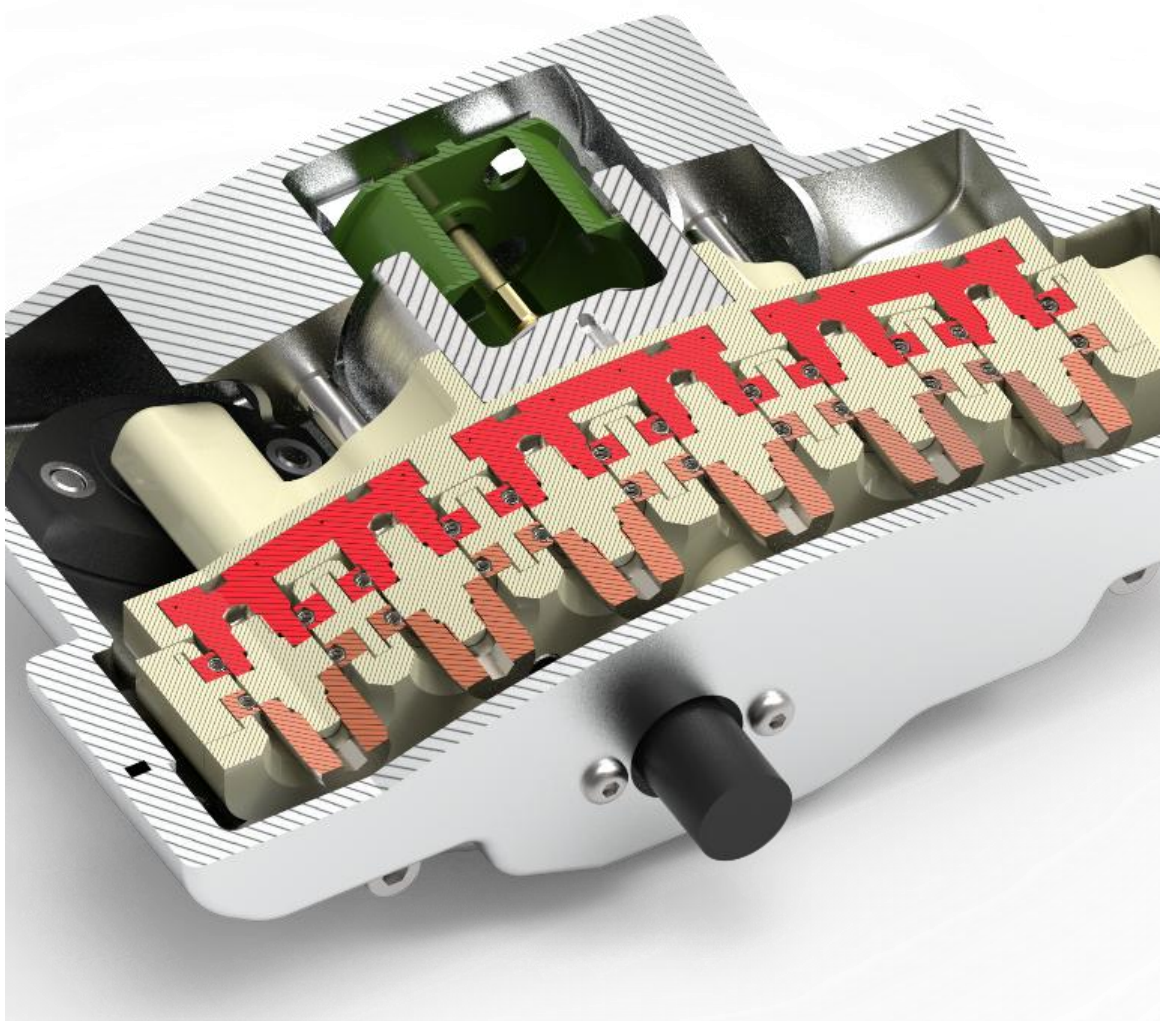
Patent WO/2025/215341

elaphe
Propulsion Technologies

IAAPS

UNIVERSITY OF BATH

# Internal Design



## Key specifications:

- 100Arms cont. / 150Arms peak
- Vibration resistant and failsafe
- Voice Coil Actuator:
  - 24V, 5A
  - 25N
- Mass: 1.8kg
- Volume: 0.63L

# Physical prototype

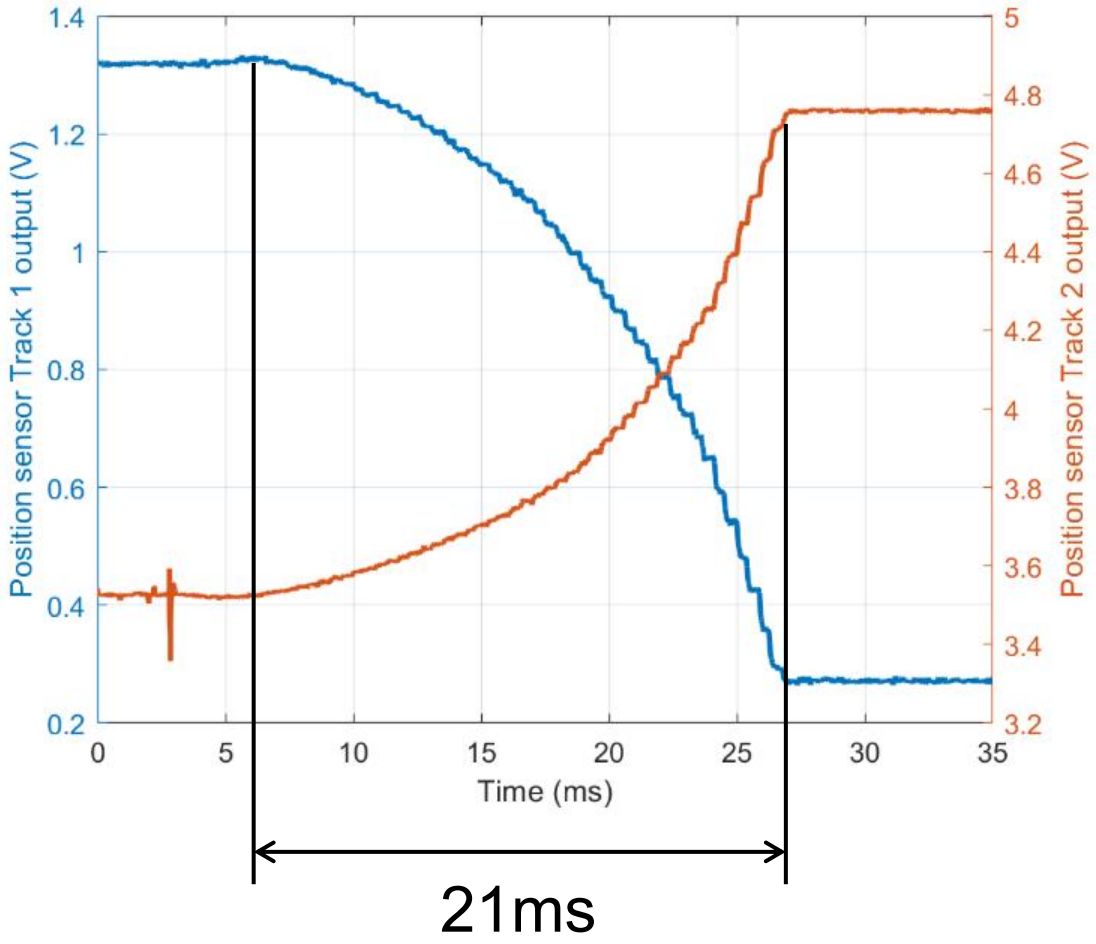


IAAPS

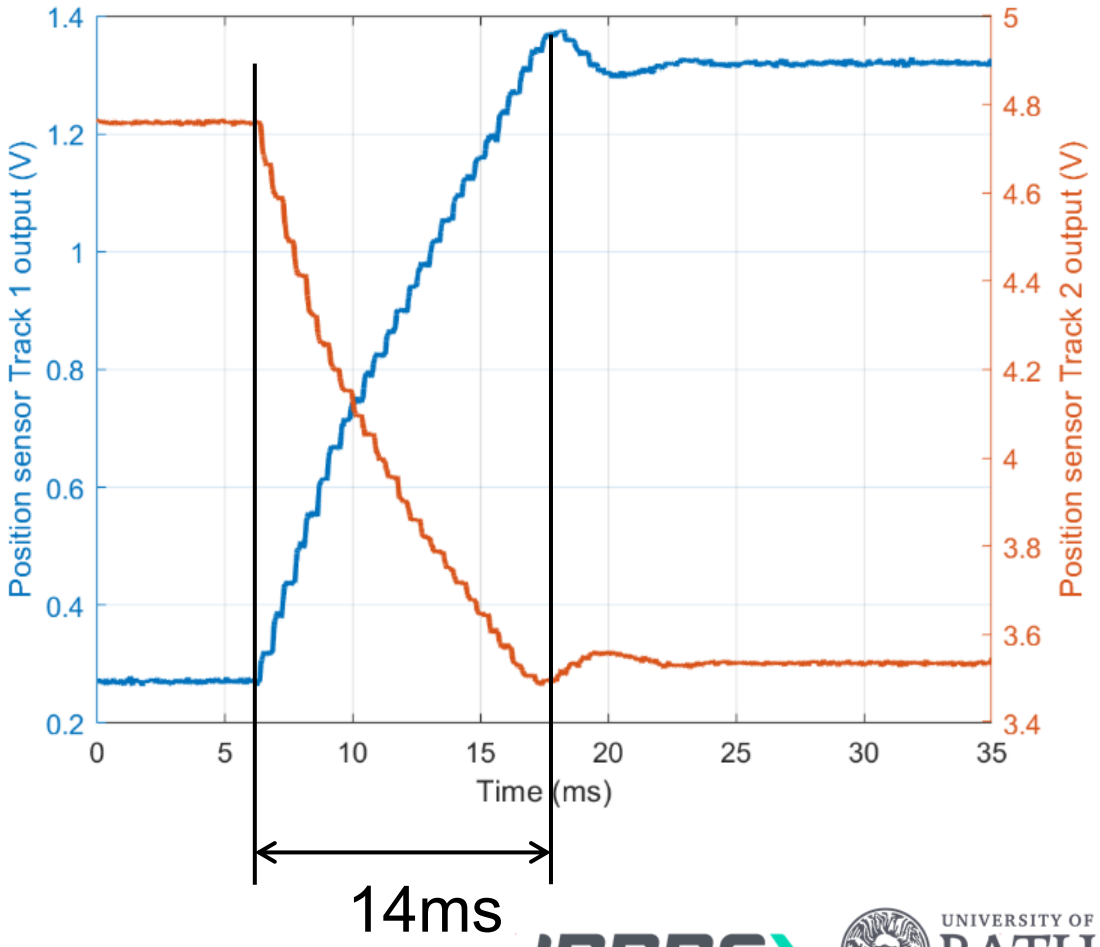
UNIVERSITY OF BATH

# Experimental Validation

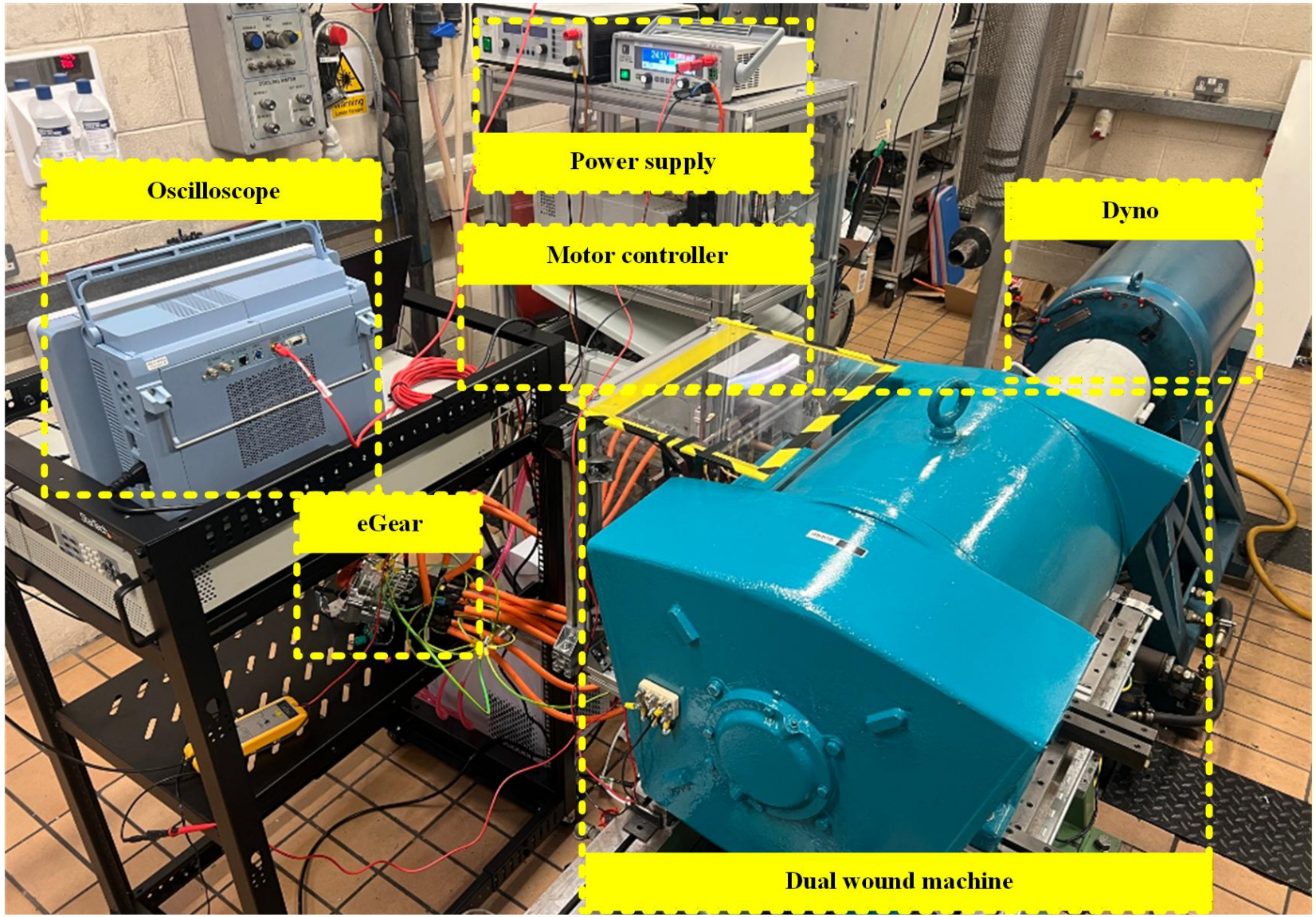
## Series → Parallel




## Parallel → Series

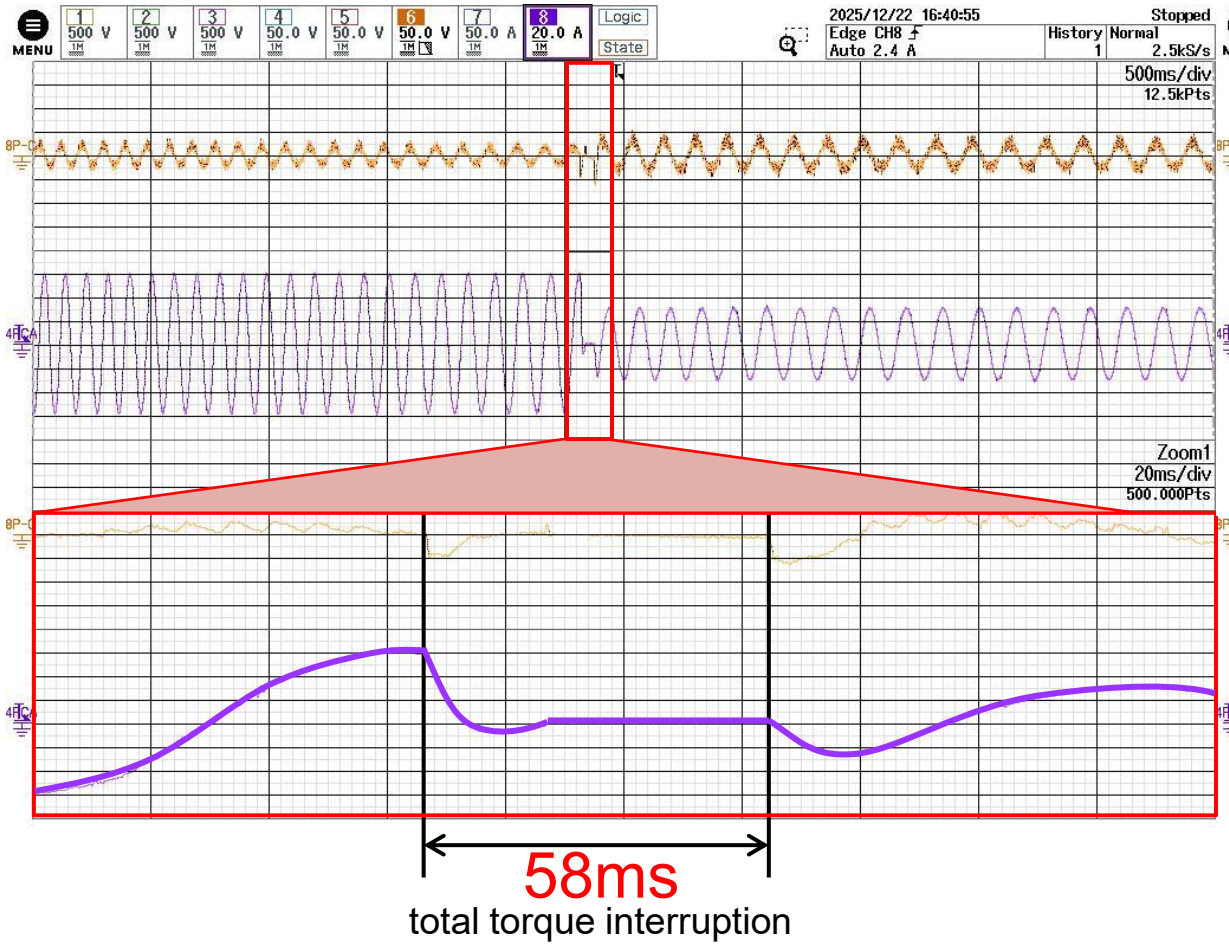


# Experimental Validation

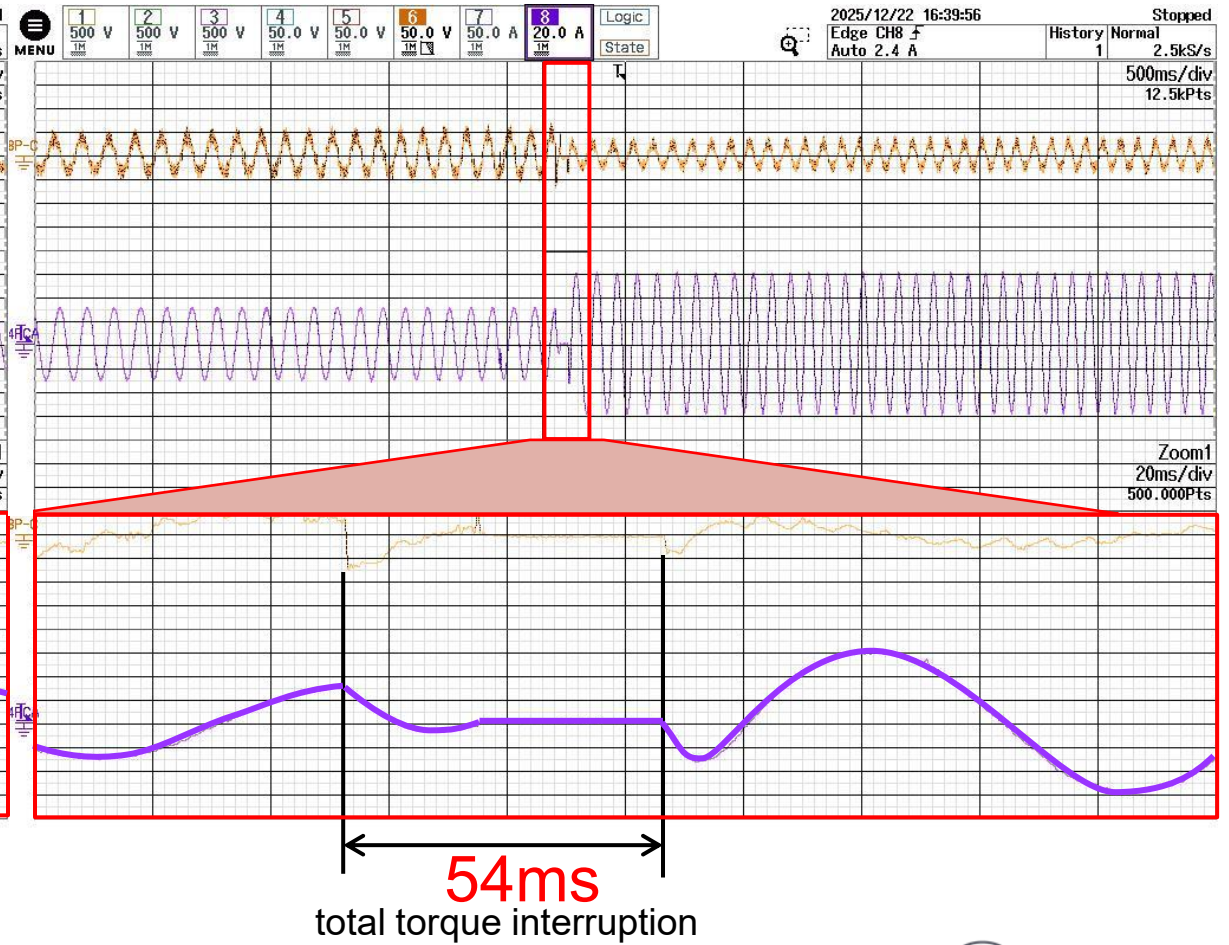


# Experimental Validation

## Parallel → Series

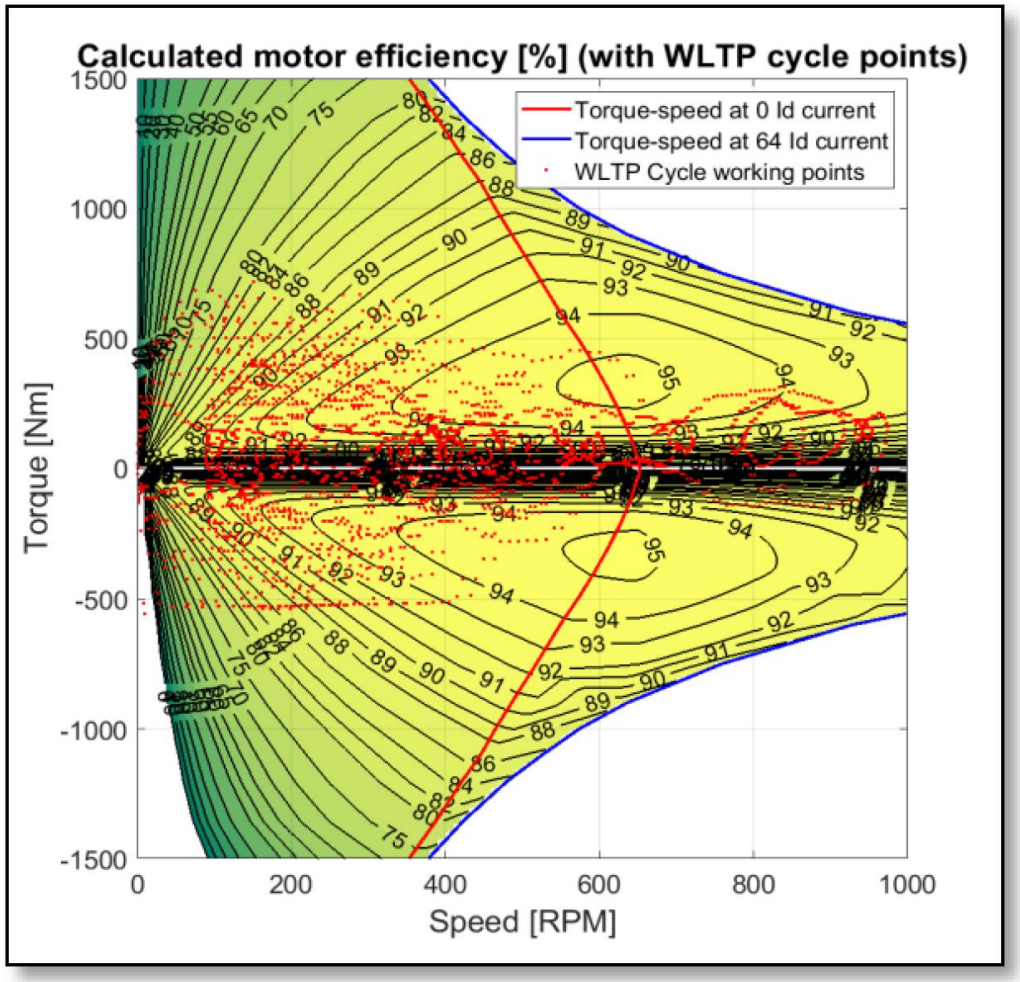


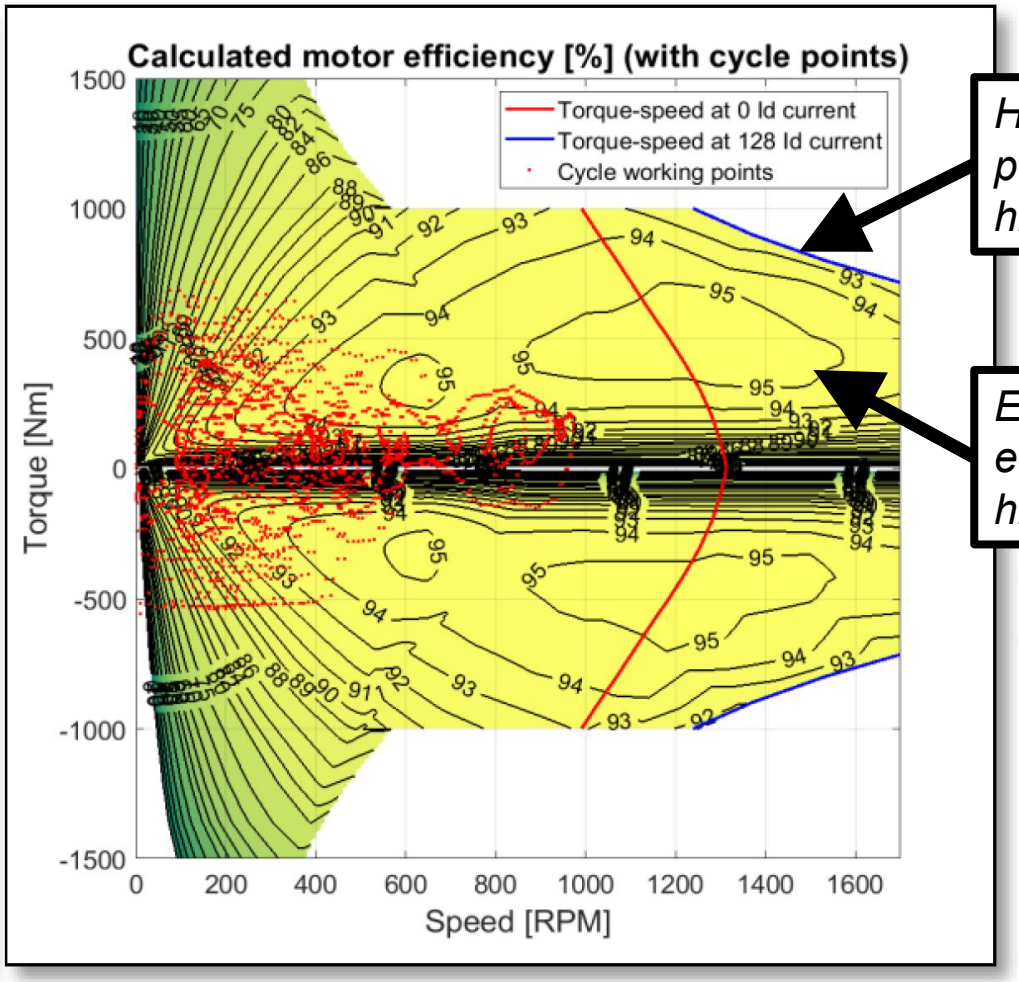

## Series → Parallel




**Plenty more optimisation possible!**

# Performance benefit




*Huge increase in power availability at higher speeds*

*Enlarged high-efficiency island at high speeds*

elaphe
Propulsion Technologies



IAAPS

UNIVERSITY OF BATH

# EM-TECH In-Wheel Motor Results & Outcomes

| Action & Objective | EM-TECH | Comment |
|---|---|---|
| Torque density | 44.5 Nm/kg | 15% increase compared to the baseline motor |
| Power density increase | 124 kW | 86% increase |
| HRE content reduction | 39% reduction | Surpassed 20% target |
| IWM BOM cost target | 5,73 EUR/kW | Target was < 6 EUR/kW |

# Acknowledgments

EM-TECH

Funded by:

Funded by the European Union

*Funded by the European Union under grant agreement No 101096083. Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union or the European Climate, Infrastructure and Environment Executive Agency (CINEA). Neither the European Union nor CINEA can be held responsible for them.*

UK Research and Innovation

*Supported by the UKRI Horizon Guarantee grant number 10061830.*

IAAPS

UNIVERSITY OF BATH

# With thanks to our funders

West of England LOCAL ENTERPRISE PARTNERSHIP

HM Government

Research England

IAAPS

UNIVERSITY OF BATH