School of Electrical and Electronic Engineering

Newcastle University

Electrical Power Research Group - Nick Baker

SIEMENS

Global Principal Academic Partner

ECPE Competence Centre

dyson

Research Centre for Power Electronics & Electric Machines

Newcastle University

Newcastle University

Key Facts

~24,700 students

£475M Total income

£123M Research income

- 5,800 employed staff

Figures: end July 2015

School of Electrical and Electronic Engineering

- Communications, Sensors, Signal & Information Processing (ComS2IP)
- µSystems (µS)
- Emerging Technology and Materials (ETM)
- Electrical Power (EP)

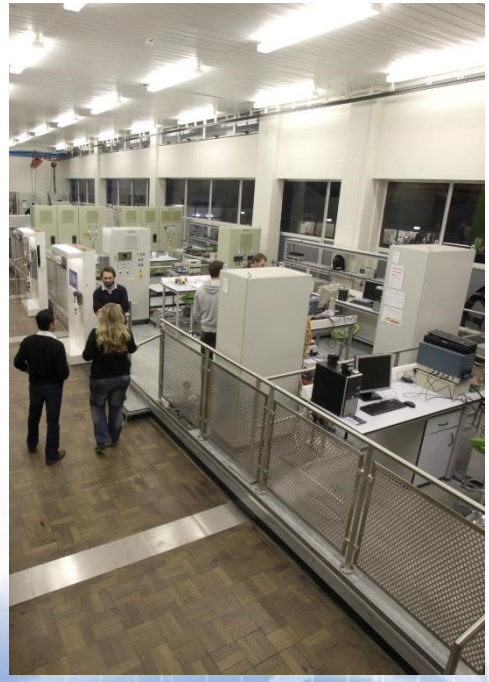
Electrical Power Research Group

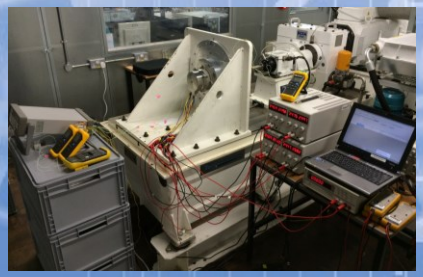
- Power Electronics
- Drives and Control
- Machines
- Power Systems

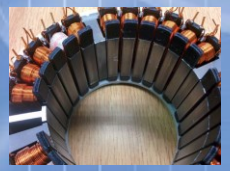
20 academics, including 6 in Singapore
28 research staff
~50 PhD students
>100 MSc students

Transport (Air, Land, Sea)	Power Systems and Energy (Small/Large)	High Volume Products (Low cost, Efficiency)
		
		
		

World-class facilities







Test equipment

- State-of-art instrumentation
- Dynomometers

(up to 500kW and up to 100,000 revs/min)

- Chiller, environmental oven etc

Simulation hardware and software

- Matlab, Saber, MagNet, Jmag, PLECS, FE and CFD, ANSYS, thermal

Manufacturing equipment

- Wire erosion machine
- SMD, PCB
- Balancing, magnetising and winding machines
- Dedicated mechanical and electronic workshops

World-class facilities

SIEMENS

Smart Grids Laboratory in Collaboration with Siemens (Global Principal Partner)

- £2m investment
- Low-carbon technology emulators
- State-of-the-art smart grid control systems
- Real-time network simulation and power-hardware-in-the-loop (PHIL)

World-class facilities

Dyson Research Centre

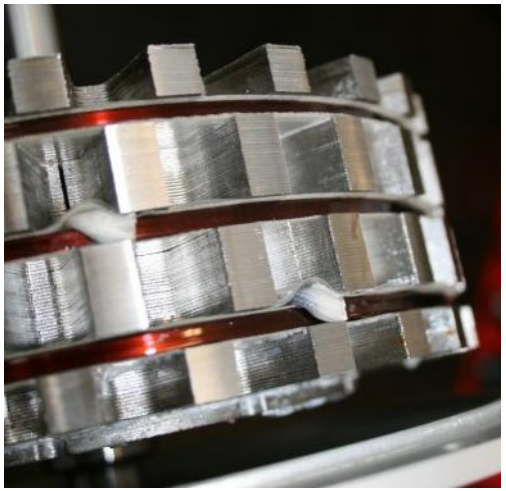
- Long term close relationship with Dyson
- Only university Dyson collaborate with on electrical research
- Help develop ultra high speed drives through to product
- Our sensorless scheme now used in products.

dyson

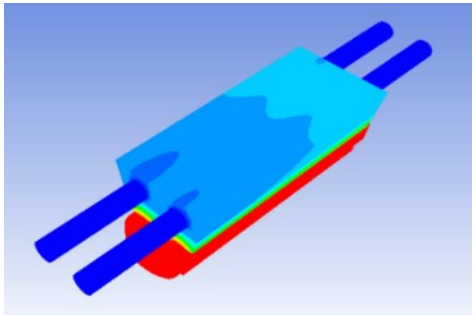
World-class facilities

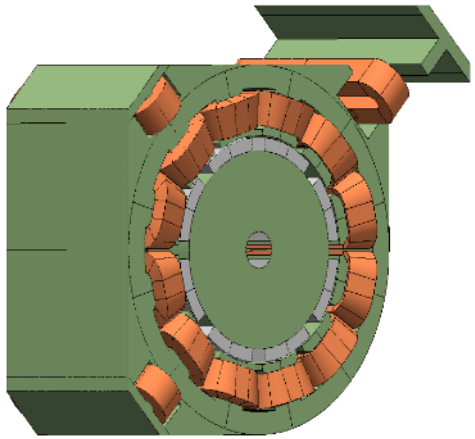
Höganäs Research Centre

- Very long term relationship with Swedish company Höganäs
- Research into applications of Soft Magnetic Composite Material
- Has resulted in development of volume products



Höganäs





Recognised UK Leadership in Electrical Drives

Underpinning Power Electronics

- £23m total project value, funded by UK Research Council
- Four Themes: **Newcastle leads the drive theme**.

Research topics:

- **Integrated drives**
- Use of fast switching devices
- Increased reliability
- High temperature operation

POWER ELECTRONICSUK Underpinning Research

EPSRC Engineering and Physical Sciences Research Council

Case Study: Smarter network storage

‘largest in Europe’, 10 MWh, 6 MW Lithium-ion grid-connected energy storage system

- Defer need for additional circuit to primary substation
- Offset costs by gaining revenue from commercial markets
- Explore supportive modifications to market and regulatory rules

Newcastle research provides:

- Demand forecasting: reserve power and energy for network’s needs with uncertainty in future demand
- System for commercial optimisation: tracking of available power and energy so commercial contracts can be made

Collaborators: UK Power Networks, S&C Electric

Machines

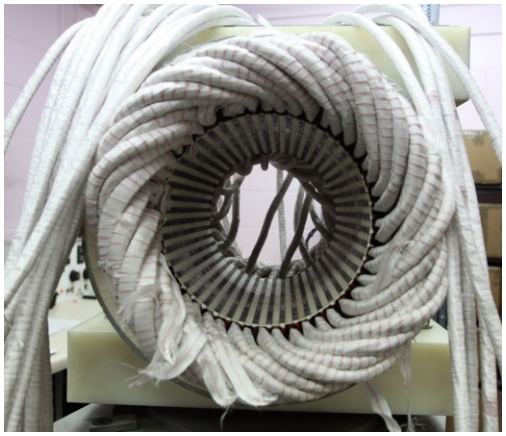
Research ranges from very small, ultra high speed machines through to turbo-generators.

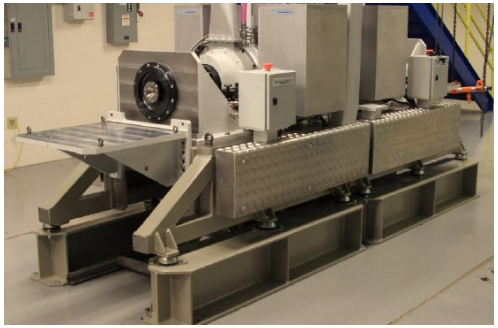
TECHNICAL AREAS

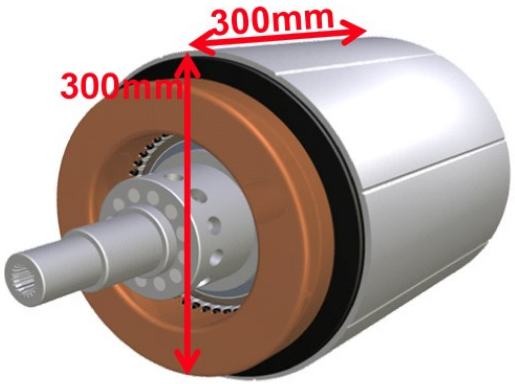
1. Increased speed, power and torque density
2. New topologies + manufacture
3. Fault tolerance
4. Reduced cost

APPLICATIONS

1. automotive
2. aerospace
3. consumer product
4. renewable





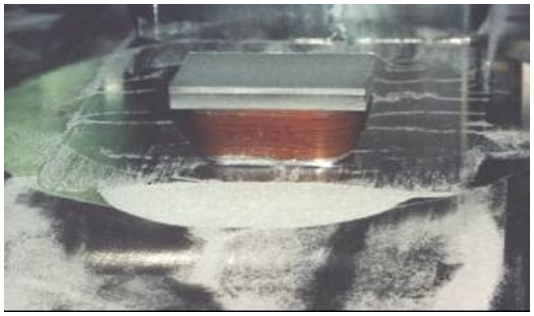


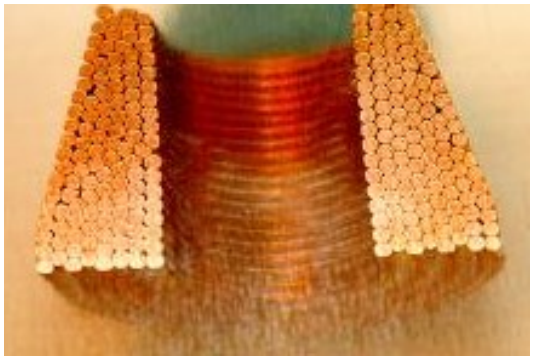
1, Ultra High Power Density

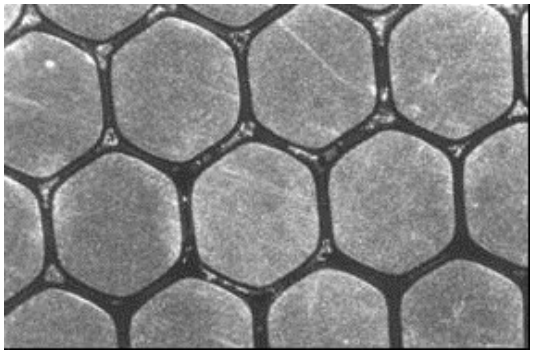
High speed, high power density

- 1.0 MW, 30,000rpm
- World-leading speed/power
- On the edge of the limit of material properties
- Integrated design of machine with converter
- In service as high speed turbine test bed

Collaborator: Torquemeters Ltd

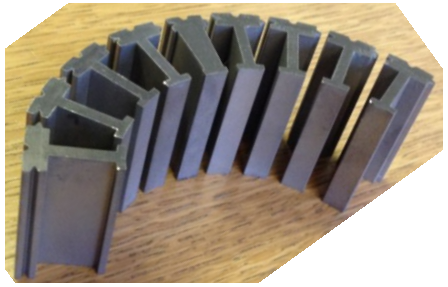


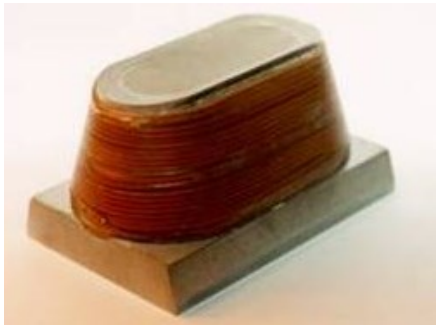


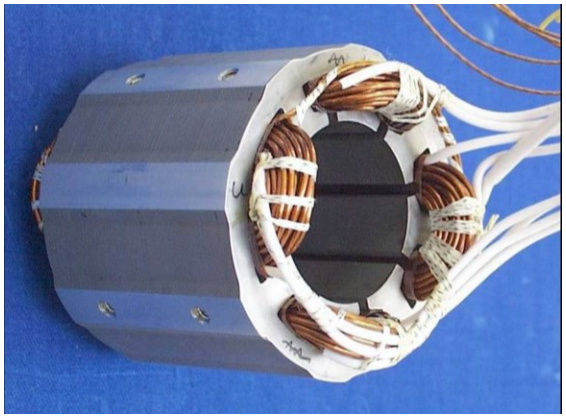


2, New Methods of Manufacture

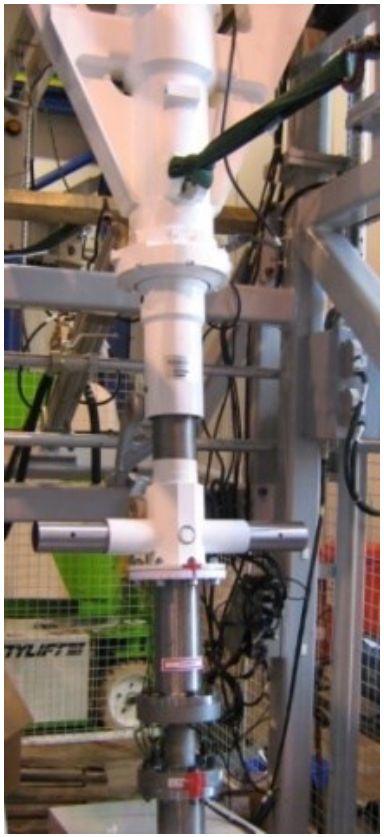
- Pressed windings,
- Aluminium windings
- Modular construction
- Soft magnetic composites
- Transverse flux machines
- E.g Jaguar-Landrover, **Höganäs**, Airbus, Rolls Royce



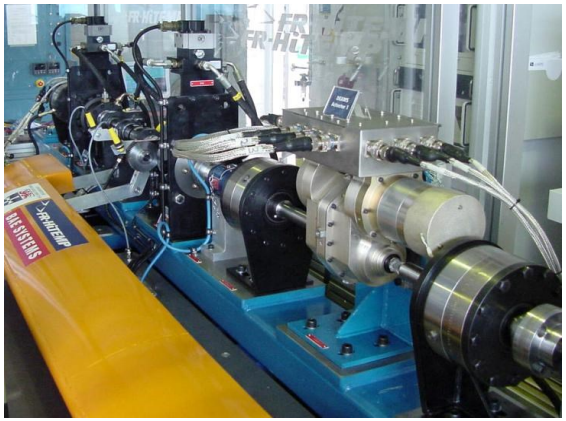




3, Fault tolerant Machines and Drives

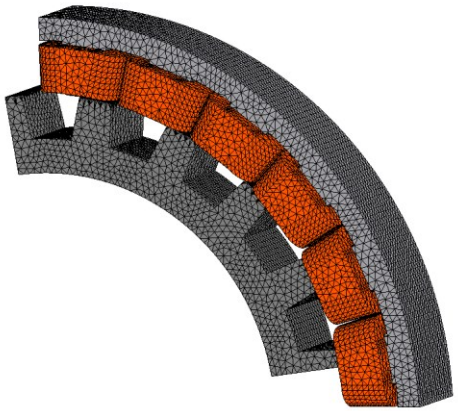


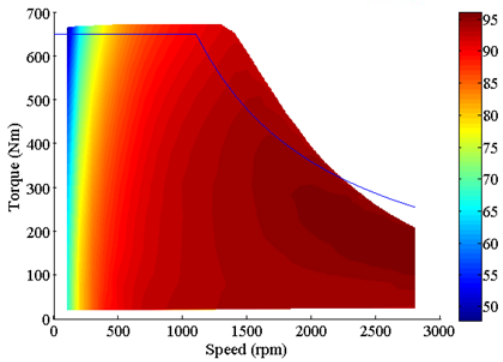
- Leader in fault tolerance
- Use for flight critical applications
- Demonstrators built and then tested by aerospace manufacturers.



4, Reduced Cost

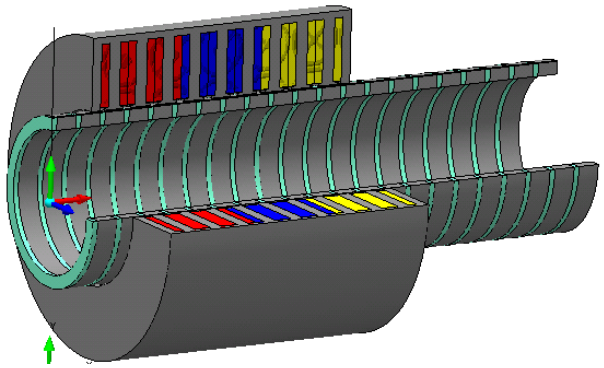
High torque density switched reluctance drive system

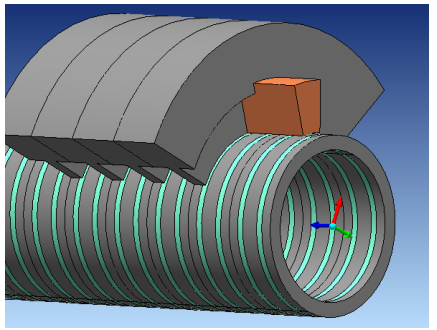


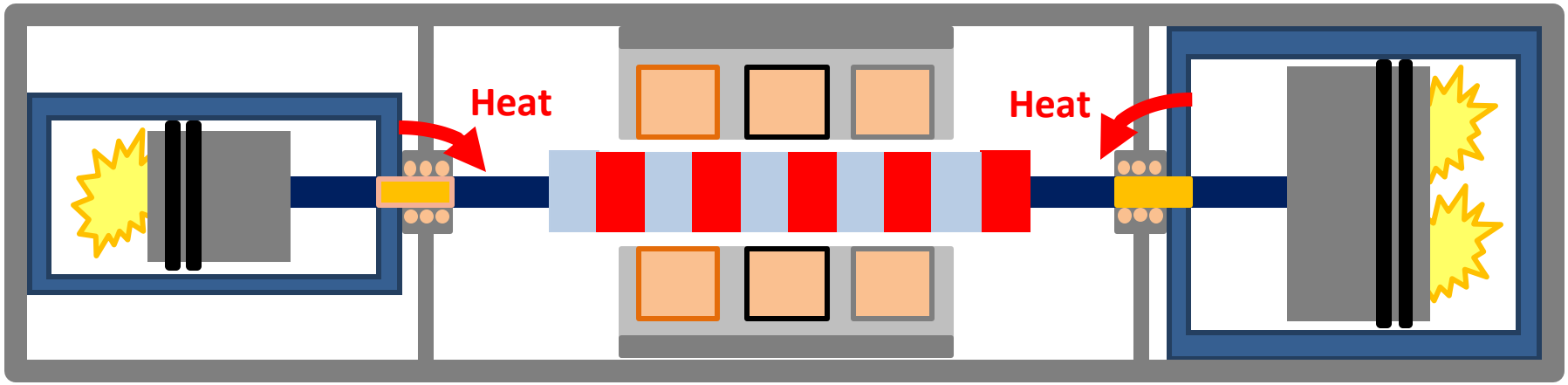


- Extending fundamental, research to the market
- **Novel low cost** machine and drive topologies

Linear machine for Free Piston Engine







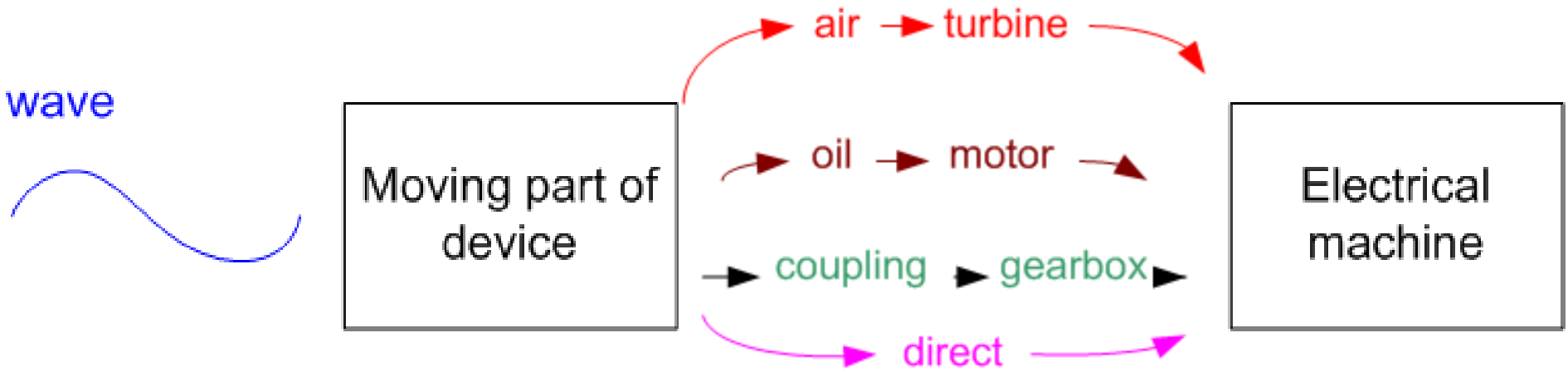
- Novel Machine
- Renewable energy / Hybrid Vehicles

Wave Energy

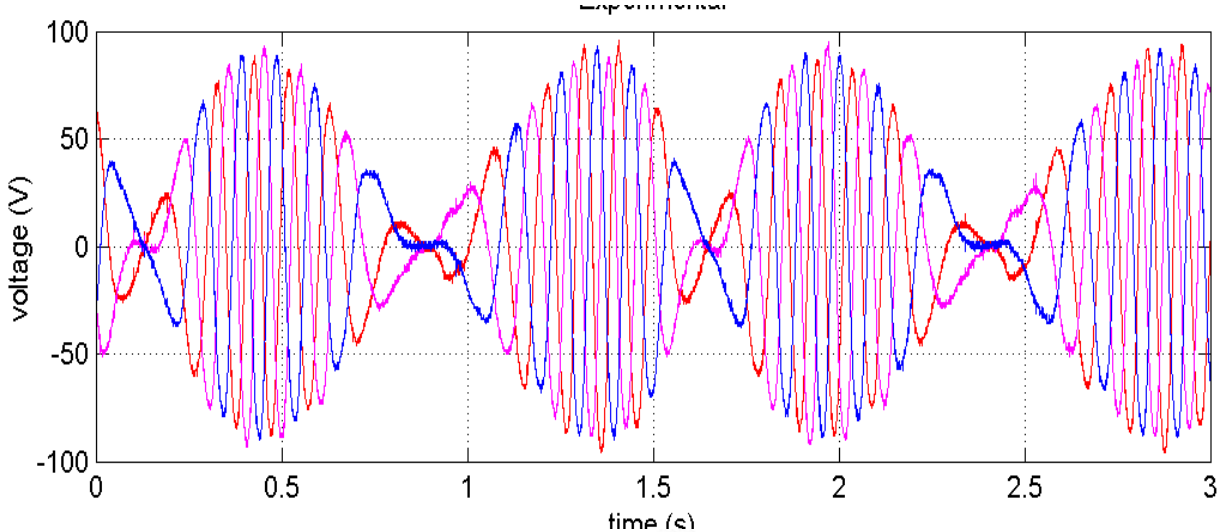
Electrical machines designed at **high speed rotary motion**

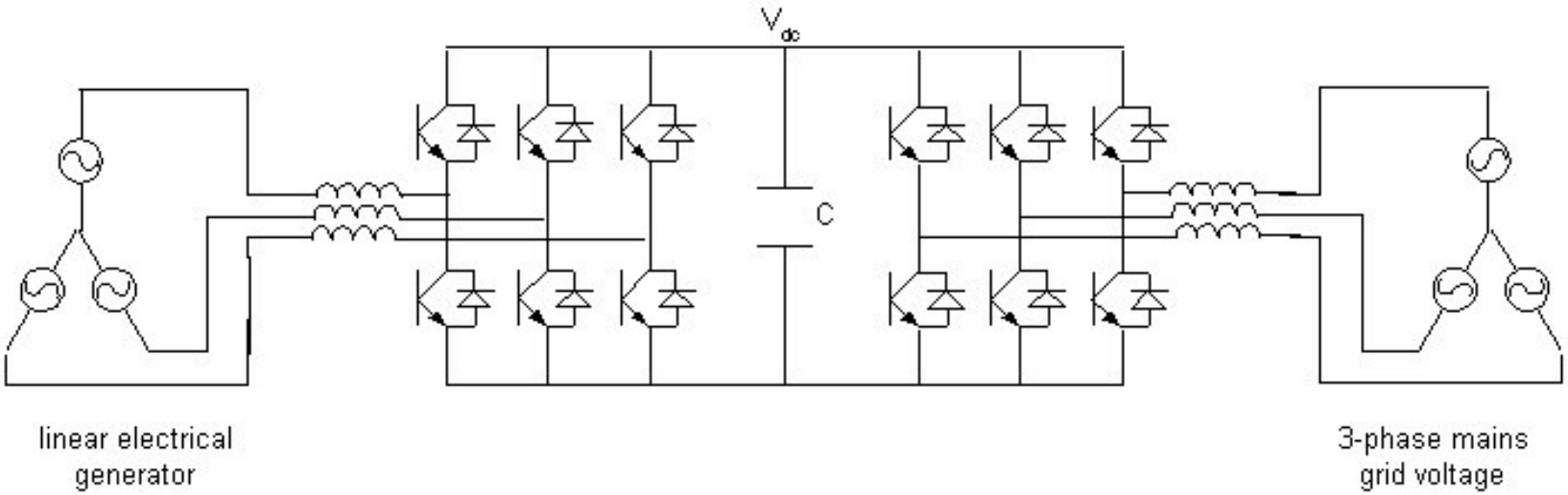
3000rpm, diameter of 200mm = air gap speed of 30 m/sec.

Typical WEC **linear** oscillatory motion with velocities in the region of **0.5-2m/s**.

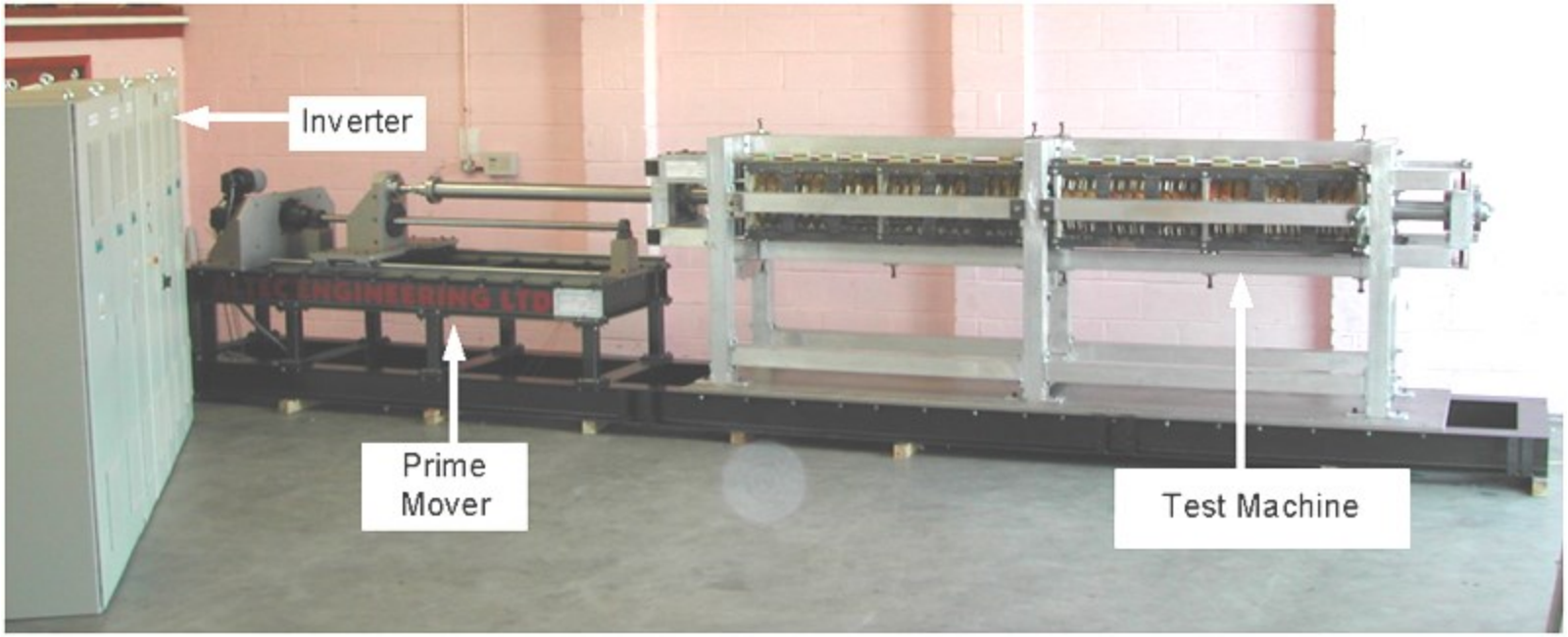


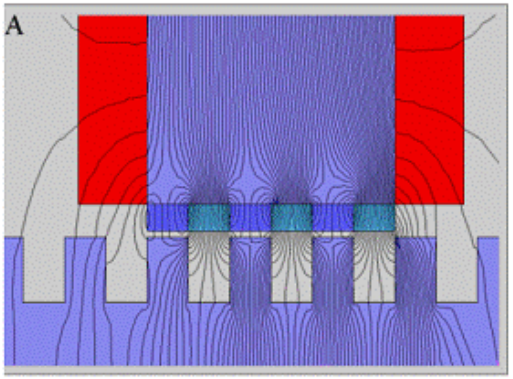
Direct Drive

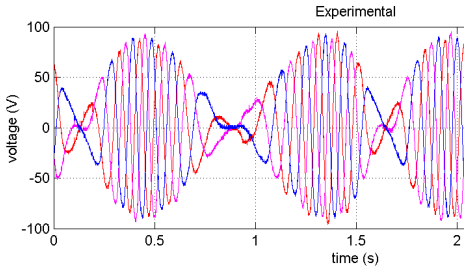




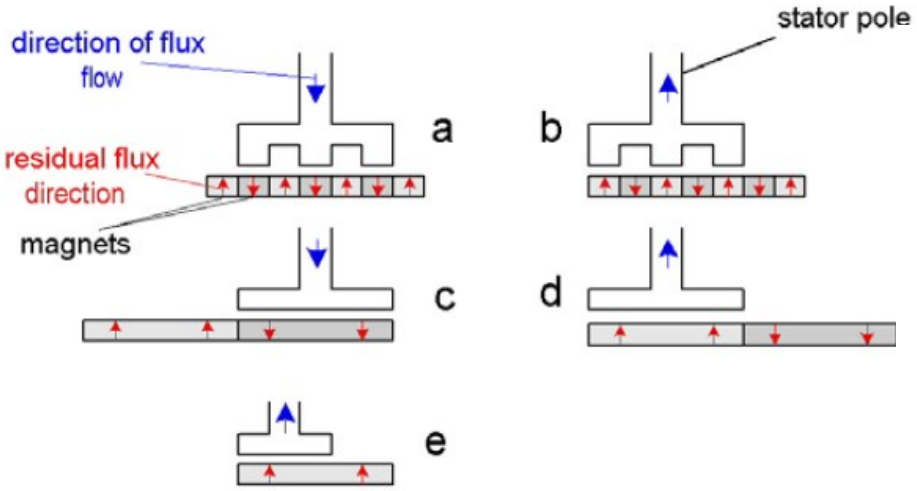
Previous work on linear machines

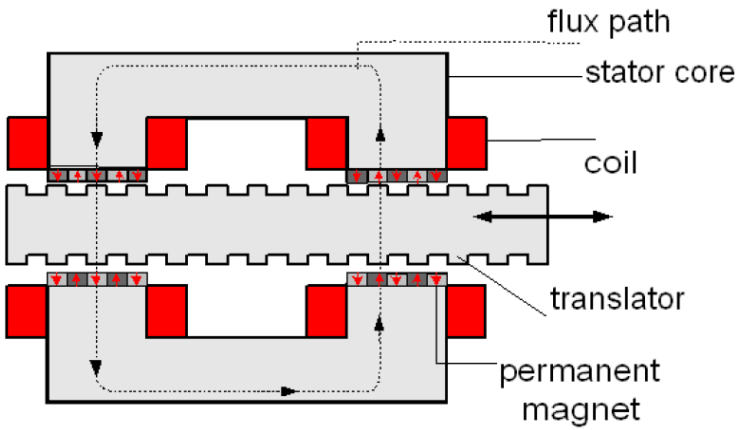




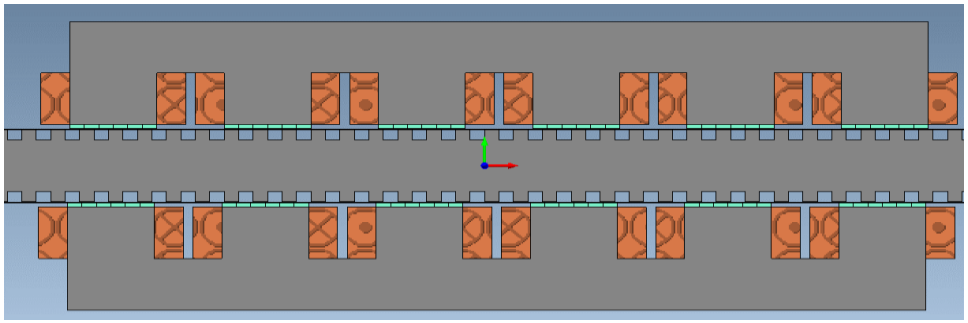


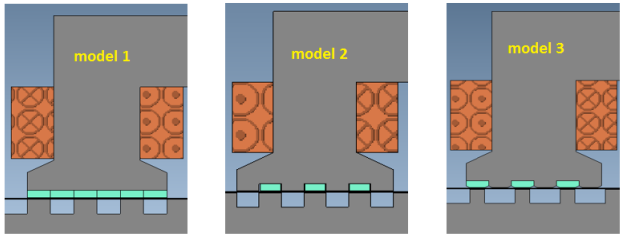
EDRIVE machines work

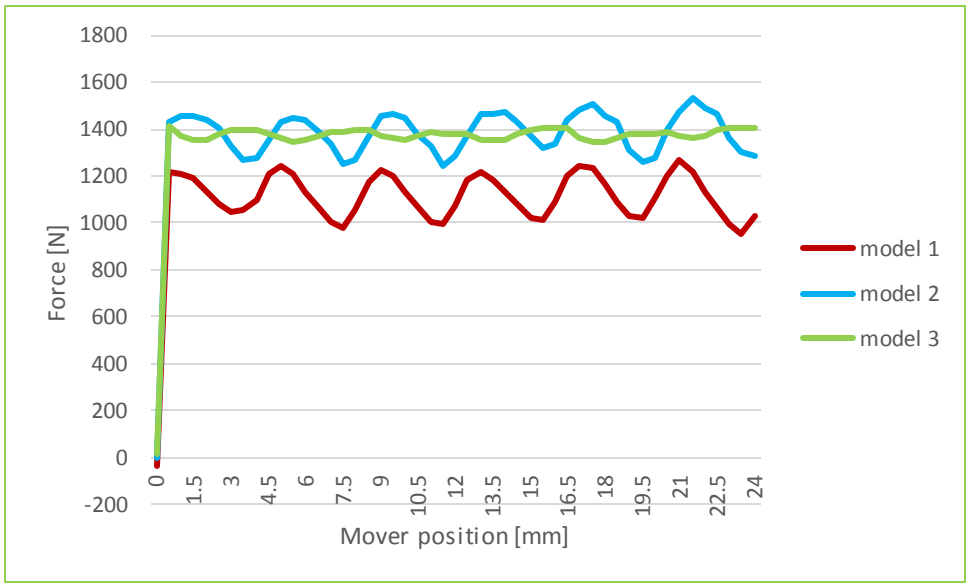


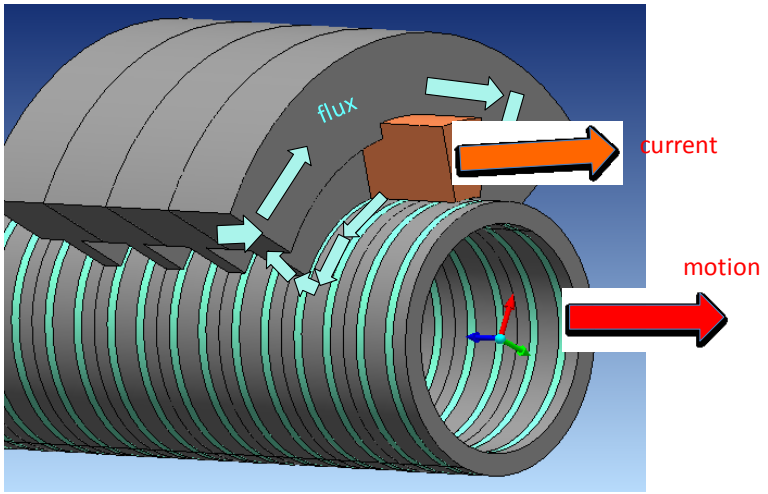


EDRIVE machines work – 2PhDs









EDRIVE machines work

WP1 Integrated Electrical Generator Speed Enhancement

Low speed machines with integrated magnetic gearing

Speed enhancement through control

High shear stress topologies

- Linear
- oscillating rotary

Integrated machine design (eg effect of cogging and inductance on device / converter)

Power electronic

EDRIVE Converter Work (Steve McDonald)

EDRIVE Converter Work - Aims

WP2 Integrated Power Converter Generator Systems

Prioritise reliability of converters *within* wave devices.

Thermal management / pulsating power

Variable device loading

Multi level, reliable, flexible, modular and scalable

Drive implications of “electronic” spring / control on the VA rating of the converter

What Newcastle needs….

Specifications of…
power rating, force, amplitude, frequency, target mass, available space