

ACTIVE PROJECTS 2001

Power Electronics Drives and Machines Research Group

1. Precise Speed Holding

Sponsor: EPSRC, Dupont Teijin Films Amount: £180,668
PPA, DJA
Start & end dates: 1.11.97 - 30.04.01

The web production process is used in a wide range of UK industries, including paper-, steel-, film- and cable-making, and is characterised by the presence of a large number of electric drives, which must be synchronised to operate either at a common and precise speed, or at an exact multiple of the common speed. Speed control is a complex task, involving a hierarchy of individual drive controllers and an overall system controller, because a disturbance in the speed of any one drive is transmitted, via the web, to all of the other drives in the process. It is the purpose of the proposed project to improve the control of the web production process, so that the speed disturbances, and consequent product quality variations, are minimised. The overall strategy of the project is to enhance the functionality of the drive components so that they become sources of information, as well as actuating devices.

2. Real-time Power Electronic Device Temperature Estimation and Control

Sponsor: EPSRC, Semelab Amount: £200,869
PPA, CMJ
Start & end dates: 1.5.01 - 30.4.04

The aim of this project is to establish, and utilise, fast and reliable methods of on-line estimation of temperature in the power switching devices of variable-frequency converters and pulsed power supplies. Estimation of temperature is to be implemented using closed-loop observers, which incorporate lumped parameter electro-thermal models of the devices, so a significant component of the project has the objective of establishing models suitable for real-time calculations and defining test procedures for the determination of model parameters. After investigating and realising techniques of temperature estimation, the project can make a unique and innovative contribution to two important issues in the design and operation of power converters: a) active current limiting; b) reliability of switching devices in pulsed power supplies.

3. Improvement to Grid Connected Converters for Photovoltaic Systems

Sponsor: EPSRC Amount: £176,227
DJA, CMJ
Start & end dates: 1.8.98 - 27.06.02

There is increasing interest in the use of grid connected inverters for the interfacing of renewable energy sources, such as photovoltaic (PV) panels, to the electrical power network. The inverter and associated control and interface components can, however, form a substantial part of the system cost and may prove a prohibiting factor in some applications. If these costs were to be reduced, the market for the inverter systems and for the renewable energy sources themselves would be strengthened, leading to a more widespread application. This research project is, therefore, concerned with effective means of achieving cost reductions and performance improvements in such inverter systems.

4. Permanent Magnet Drives

Sponsor: EPSRC Amount: £158,396
DJA
Start & end dates: 1.1.97 - 8.6.00

Fault Tolerant Drive for aircraft fuel pumping application of fault tolerance to power conversion equipment. Application of sensorless estimation to fault tolerant permanent magnet drive.

5. Portable Appliance

Sponsor: Teaching Co/Euremica Amount: £1,800
CRA
Start & end dates: 11.1.99 - 1.4.99

The objective of the project was to apply embedded digital systems to the monitoring and storage of physical quantities like pressure, temperature. The ultimate aim was to replace the existing electro-mechanical instrument but retain all the features and add new features to it. The equipment was portable and offered computer networking to allow the transfer of records to a host computer where it was archived and presented as a series of hardcopy charts.

6. Colonoscopy

Sponsor: Beating Bowel Cancer Charity Amount: £32,000
CRA

Start & end dates: 1.7.01 - 30.6.02

The short term aims would be to provide valuable data regarding a) the torque and push/pull forces that are applied externally to a colonoscope by endoscopists – both experienced and trainees b) the forces that the endoscope shaft exerts internally on the bowel wall during sigmoid looping and c) the flexural rigidity (and other relevant mechanical parameters) that determine the stiffness of commercially available flexible sigmoidoscopes and colonoscopes. Such data would aid in the development of more life-like computer colonoscopy simulators as well as aid the trainers in assessing the force that trainees are actually applying during colonoscopy/flexible sigmoidoscopy. We have already obtained Ethical Approval from the Royal Sunderland hospital to study these various parameters in patients undergoing both flexible sigmoidoscopy and colonoscopy. Copies of the various Ethical Committee submissions are available on request from GDB. The long term aim is to develop a working prototype of a new generation of worm or snake-like colonoscope which would allow rapid and relatively painless total colonoscopy in non sedated patients. We hope to incorporate 1) the real time wireless 3-D endoscope positioning data 2) tactile pressure data from the outside of the endoscope and 3) an actuator mechanism which draws/pushes the endoscope through the intestinal tract. The actuation would be produced by an electric motor(s)/hydraulic system(s) controlled by a digital computer. Combining these 3 activities should allow a computer controlled flexible endoscope system to be developed for colonoscopy. Such a system has potential for intelligent computer-based actuation.

7. Reluctance Drives

Sponsor: EPSRC Amount: £164,653
BCM

Start & end dates: 1.7.98 - 28.02.02

This project will research high performance switched reluctance motor drives, based around machines with fully pitched windings. These new configurations offer better performance than either induction machines or conventional SRMs. New converter topologies are proposed to minimise the converter volt-ampere requirement, utilising diodes to recirculate most of the magnetising current within the machine. The project compares a number of competing topologies, evaluating performance, cost and controllability of each. A new flux controller for fully pitched winding SRMs will be developed, and used as a basis for establishing torque control, and thus torque ripple minimisation. Flux control can produce schemes which minimise the rate of change of flux, and therefore the converter voltage requirement. Iron losses in fully pitched winding machines will be determined for the first time, including indirect measurement on an experimental rig and simulation using rate of change of flux evaluation. Two demonstrator drives will be designed, built and tested. A 300W drive for an automotive application will focus upon cost minimisation within a demanding performance specification and a 10kW servomotor demonstrator will place emphasis upon high specific torque, low inertia and high dynamic performance.

8. Soft Magnetic Composites

Sponsor: EPSRC Amount: £251,426
AGJ

Start & end dates: 1.1.99 - 31.3.01

This project is concerned with learning how best to use the unique advantages offered to electrical machines by armature cores constructed from soft magnetic composites (SMC), ie insulated iron powder compacts. This project follows an earlier award which has demonstrated gains in performance of more than 50%, combined with reduced material, reduced dimensions and strong indications of lower costs for permanent magnet servo motors. The motors to be tested in the later stages of this first phase promise further improvement. Funding for the first stage was for a limited period to allow proof of viability. This has amply been demonstrated. The proposed project seeks to complete the investigation of the underlying science including new higher temperature insulation systems, warm compaction, fatigue, thermal cycle life, powder flow during compaction or co-compaction with windings (and hence punch and die design) and optimal geometries for machines using SMC.

9. CASE Ross Hall

Sponsor: Commercially sensitive Amount: £6,400
AGJ
Start & end dates: 1.10.00 - 30.9.03

Case studentship for Ross Hall

10. Motor Concepts

Sponsor: Commercially sensitive Amount: £131,717
AGJ
Start & end dates: 1.1.00 - 31.12.01

11. Penetration of SMC

Sponsor: Commercially sensitive Amount: £115,000
AGJ
Start & end dates: 1.1.01 - 31.12.02

12. Powder Metallurgy

Sponsor: Commercially sensitive Amount: £61,000
AGJ
Start & end dates: 1.9.98 - 28.2.00

13. Regulation

Sponsor: Commercially sensitive Amount: £9,000
AGJ
Start & end dates: 23.2.01 - 1.8.01

14. Vacuum Pump Motor

Sponsor: Commercially sensitive Amount: £10,654
AGJ
Start & end dates: 1.7.00 - 30.9.00

Construction of a very high speed vacuum pump motor to be used in the semiconductor industry.

15. Compressor Motor Design

Sponsor: Commercially sensitive Amount: £25,869
BCM
Start & end dates: 1.1.99 - 31.10.99

Design study of a range of permanent magnet and switched reluctance motors for a compressor.

16. High Torque

Sponsor: Commercially sensitive Amount: £16,259
BCM
Start & end dates: 1.1.98 - 31.12.98

Design study of a novel form of switched reluctance motor for high torque applications.

17. High Torque Machine

Sponsor: Commercially sensitive Amount: £11,000
BCM
Start & end dates: 1.12.97 - 31.10.99

Design and production of an electronically commutated electric drive to replace a geared production version. The final product is integrated into a power tool product.

18. Mouse Motor Design

Sponsor: Commercially sensitive Amount: £3,000
BCM
Start & end dates: 1.4.00 - 31.08.00

Design of an integrated motor for a Black & Decker 'Mouse' sander.

19. Outer Rotor

Sponsor: Commercially sensitive Amount: £2,000
BCM
Start & end dates: 1.8.00 - 30.11.00

Investigation into the performance capability of a novel, small permanent magnet motor.

20. Vacuum Pump Motor Design

Sponsor: Commercially sensitive Amount: £1,000
BCM
Start & end dates: 1.4.00 - 31.5.00

Preliminary design study for a very high speed vacuum pump motor, to be used in the semiconductor industry.

21. Euremica

Sponsor: Teaching Co/Euremica Amount: £82,338
CRA
Start & end dates: 15.7.97 - 16.11.99

This follow-on teaching company scheme looks at a number of applications for the generic instrument developed on the first scheme. In particular a pressure / temperature measurement and datalogging instrument for the process engineering industry. The emphasis on this project is the development of programmable graphics user interfaces in the windows environment and data compression methods.

22. ANN Drives

Sponsor: Commercially sensitive Amount: £7,200
DJA
Start & end dates: 1.10.00 - 30.9.03

Much research has been carried out in the past into possible areas of application for Artificial Neural Networks (ANN) within the control structures used in all types of electric drives. This research as far as has been published has never ventured beyond the scope of idealised simulation, this is the area that this research project will aim to address. The initial aim of the project is to design and construct a generalised drive system that is built as far as possible from commercial off the shelf parts, thus reducing the technical risk and development time. Once a rig is successfully constructed algorithms will be developed and tested in the following areas, induction motor identification, drive inverter identification and lastly use of an ANN for use as an 'adjuster' model within a Model Reference Adaptive Controller.

23. Embedded Control

Sponsor: Royal Commission Amount: £14,000
DJA
Start & end dates: 1.1.01 - 31.12.02

Currently there is much interest in embedded generation from renewable energy sources such as wind turbines. This project will make investigations into real time embedded control.

24. Motor Testing

Sponsor: Commercially sensitive

Amount: £4,760

PPA

Start & end dates: 1.4.01 - 31.12.01

25. Motor Testing 2

Sponsor: Commercially sensitive

Amount: £4,760

PPA

Start & end dates: 1.4.01 - 31.12.01

26. Supply Interaction

Sponsor: Commercially sensitive

Amount: £30,647

PPA

Start & end dates: 1.10.99 - 30.09.00

Postgraduate Research Projects Active in 2000/01

27. Virtual Dental Practice using 3D force and posture sensors, haptic feedback and control

Postgraduate: Su Yu
Supervisor: Charles Allen

The accurate modeling and analysis of medical treatment plays an important role in modern medical science. This paper describes an attempt to apply current sensor and control techniques to realistically simulate medical surgical techniques. By Modeling the movement of human hand, tooth and the dental tools, the force and posture applied on patient tooth and the control of Z-axis linear motor in response to over-force applied to tooth, this system can accurately simulate the complete dental treatment. It could be used as both a teaching facility and a base for further research, which lead to more accurate posture capturing and object virtualizing for generic application.

28. Development of a force-sensing device for general dental practitioners to evaluate and control brushing force in dental patients

Postgraduate: Michal Baszinski
Supervisor: Charles Allen

Gingival recession with exposure of root surfaces is prevalent amongst all age groups of the population. Excessive tooth brushing force (>300g/f) and a non-structured brushing technique are pivotal and very common predisposing factors. The treatment of gingival recession is both complex and expensive, and frequently only palliative in nature. A preventive approach is the best strategy. Our project aims to develop a device that measures both brushing force and posture in relation to different parts of the dentition by incorporating virtual sensor technology. The proposed instrument will be available to all general and specialist dental practitioners, and dental hygienists, as a device with which they can professionally instruct dental patients at the chair-side.

Project objectives

The objectives of the project are to:

- develop a miniature computer system to record the forces applied during brushing, using both manual and powered devices.
- determine the effectiveness of the instrument as a generic dental hygiene and rehabilitation device in a series of controlled clinical trials.
- enhance the force-sensing instrument by the addition of a 3D position-imaging sensor into the handle of the device.
- evaluate the potential of the developed instrument as a self-help, virtual-reality product to ensure non traumatic tooth brushing.

These objectives have been developed by dental clinicians and electrical engineers together with the proposed industrial sponsor. There appears to be a market of considerable potential for a pressure-sensitive device that can be used both to evaluate and prevent damage to the teeth and their adjacent soft tissues. The development of a force / position dental device will be pursued closely with a major European electronics company.

29. Artificial Neural Networks for Control of Electric Drives

Postgraduate: Stephen Turner
Supervisor: Dave Atkinson

Much research has been carried out in the past into possible areas of application for Artificial Neural Networks (ANN) within the control structures used in all types of electric drives. This research as far has been published has never ventured beyond the scope of idealised simulation, this is the area that this research project will aim to address. The initial aim of the project is to design and construct a generalised drive system that is built as far as possible from commercial off the shelf parts, thus reducing the technical risk and development time. Once a rig is successfully constructed algorithms will be developed and tested in the following areas, induction motor identification, drive inverter identification and lastly use of an ANN for use as an 'adjuster' model within a Model Reference Adaptive Controller.

30. Sensor-less Vector Control in Induction Machine Drive

Postgraduate: Satya Kumara
Supervisor: Dave Atkinson

This work is to investigate the encoder-less control for high performance squirrel-cage induction machine drive. Particular focus is given to low speed performance. The model reference adaptive system is chosen to estimate the speed of the motor. In the model reference adaptive system two models based on motor equations are developed. One model is called reference model and the other is adjustable one. A controller is used to adapt the speed of the motor by converging the two models so that the estimated rotor speed tracks the actual speed.

In application where operation with constant speed is important, drive should be able to maintain the speed regardless the presence of load coupled to it or at least minimise its effect. A study is being carried out to incorporate some forms of the load information as an additional input to the controller so that the drive can be made robust to load variation.

31. Tuning of Brushless Dc Drive Speed Control in The Presence of Load Disturbance

Postgraduate: Y Al-Saddiq
Supervisor: Paul Acarnley

Speed controllers for brushless dc drives operating in the presence of load disturbances are being investigated. Controller configurations include conventional proportional-integral controllers with integrator anti-windup and fuzzy controllers. Methods for automated tuning of speed controllers, using genetic algorithms and simulated annealing, are being compared.

32. Tuning PI Speed Controller using a Neural Network for DC Brushless Motor Optimum Speed Control

Postgraduate: Tariq El-Balluq
Supervisor: Paul Acarnley

Neural network techniques for adaptive speed control of brushless dc drives are being investigated using simulation and experimental approaches. A simple neural network can adjust the gains of a proportional-integral controller according to the instantaneous values of such quantities as speed, speed error and load torque. The relative merits of various learning algorithms are being compared.

33. Design of an Integrated Starter/Generator for a Jet Engine

Postgraduate: Ross Hall
Supervisor: Alan Jack

The concept of replacing mechanical systems in aircraft with electrical machines in an effort to give greater flexibility of where devices can be located in the airframe, and to increase the operating efficiency of the systems initiates the requirement for substantial on-board electrical power generation. A generator capable of power generation for an aircraft can also be considered suitable to be employed as a starter motor, replacing the existing one.

Research in the first year will be twofold - work will begin with me gaining knowledge of the internal geometry of a jet engine from which I will be able to determine the dimensions for the starter/generator and an available location for it within the jet engine structure. This will be followed by a case study to find the power requirement for the machine and its operating parameters, e.g. speed in generating mode.

Once determined basic SRM designs can be drawn up and their electromagnetic behaviour modelled using a Finite Element package. Criteria such as iron and thermal losses will also be included in calculating the power rating for the generator designs.

The second part of the research will be centred on the machine construction - the environment in which the machine is required to operate will be very harsh with a likely operating temperature of 400C. Investigations into suitable construction materials along with the examination of possible coil production strategies with fault tolerance in mind will be done.

34. A Flexible Learning Resource for The Teaching of MSc.

Postgraduate: Fred Wallace
Supervisor: Mark Johnson

This describes a joint project between Newcastle, Birmingham and Nottingham Universities to develop a media rich, Web based teaching resource for the teaching of power electronics at MSc level. The objectives of the project are presented together with a consideration of the components that are required to build the course. The general framework and layout is described. Maintainability and the use of templates and style sheets are introduced. Some of the methods used to present the course material are given.

35. Improved Line Voltage Zero-Crossing Detection Techniques For PV Inverters

Postgraduate: Tusitha Abeyasekera
Supervisor: Dave Atkinson

This paper presents a comparison of two different zero-crossing detection techniques used in grid-connected photovoltaic Inverters. The current controlled Inverter should be synchronised with the supply grid to allow a steady power flow with a controlled power factor. The obvious and the most widely used method is by using a zero crossing detector. This however, is prone to errors due to various distortions found usually on the grid. A detailed grid distortion model is derived to be used for simulations. Two zero-crossing techniques based on predictive filtering and Phase-locked loops are modelled and simulated for comparison.

36. Speed Controllers for a Polymer Film Casting Drum Drive Facility

Postgraduate: Elliott Makin
Supervisor: Paul Acarnley

Methods for the precise speed control of a belt-driven polymer film casting drum are being investigated using simulation and a purpose-built laboratory drive system. To ensure adequate product quality, excellent speed holding (better than 1%) is needed even in the presence of substantial (greater than 50% rated) load torque disturbances. A real-time load torque observer, which takes account of drive belt dynamics, has been developed and has produced substantial improvements in speed holding when used in a torque feedforward controller.

37. Increasing the Torque Capability of Switched Reluctance Motor

Postgraduate: Eyhab El-Kharashi
Supervisor: Barrie Mecrow/John Finch

This paper examines new magnetic structures for switched reluctance motors. In this novel motor the rotor magnetic structure is made from a series of isolated segments of laminations in an attempt to increase the saliency ratio and thus the torque capability. The paper first examines the concept for a very simple case: a direct comparison with conventional topologies is undertaken and design principles established. Two specific designs topologies are then introduced : one which uses simple windings placed around a single tooth, and one which uses fully pitched windings, spanning a complete magnetic pole. Design trends are calculated and used to help maximise the torque capability of each machine. Detailed comparisons are then made between the new machines and their more established counterparts with conventional magnetic circuits.

38. Using Iron Powder to Enhance the Performance and Reduce the Enviromental Cost of Motor Production

Postgraduate: Phil Dickinson
Supervisor: Alan Jack

Electrical machines play a huge part in the everyday lives of everyone in the developed world. From the motor that rotates the washing machine to clean our clothes to the tens if not hundreds of motors in the

vehicles we drive to work. The purpose of this paper is to look at the possibilities of enhancing the performance and reducing the environmental cost of motor construction. This was achieved by using a soft magnetic composite, powdered iron material, rather than the traditionally used steel lamination. The first part of this paper looks at the properties of this new material. Then the different geometries for machine construction when using powdered iron are discussed. Finally the different loads applied to electrical machines are discussed along with their implications for machines constructed from powdered iron.

39. Modelling of Electromagnetic Processes Using Soft Computing Techniques

Postgraduate: M Z Daud
Supervisor: Paul Acarnley

This project is investigating the potential advantages of neural networks for real-time modelling of complex electromagnetic processes, including magnetic non-linearities and eddy current effects. Training of the neural networks, using experimental data, is accomplished using a variety of algorithms, such as back-propagation and genetic algorithms.

Taught Masters Project Titles for 2000/01

MSc in Automation and Control

Remote control of a stair lift
Self-levelling control of a stair lift
Modelling, position estimation and control in a magnetic suspension system
PLC based Automation System using CAN Bus
Automation Cell Master Controller For Can Bus Using A PLC
Drive systems for a stair lift
Computer Controlled Colonoscopy

MSc in Electrical Power

Rotating Transformer
Printed Circuit Board Angular Position Detector
Power electronics for single-phase permanent-magnet motors
Sensors For Navigation And Collision Avoidance For A Mobile Vehicle
Issues related to DC transmission for distributed renewable generating sources
Low Cost Power Electronic Drive