



UCT Electric Machines Research and Laboratory

Advanced Machines and Energy Systems (AMES) Group

Department of Electrical Engineering



Overview

- **Vision**
- **Key Group Members**
- **Collaboration**
- **Research Outputs & HR Development**
- **Laboratory Facility**
- **Research Areas**
- **Details of Current Research**

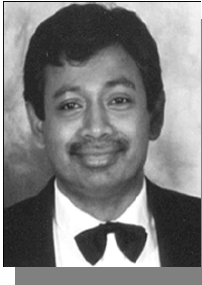


Vision

- To provide feasible technical solutions to relevant industrial problems, whilst maintaining a high scholarly research content
- This is achieved by engaging highly skilled personnel and by applying a methodical approach to problem solving
- To disseminated research findings through technical reports and peer-reviewed publications
- To develop human resource capacity in electrical machines, drives and energy systems, which will eventually contribute toward the future technical innovativeness of our nation



Key Group Members



Prof. Pragasen Pillay
PhD, CEng, FIEEE, FIET
Professor UCT, Clarkson
Electrical Machines, Drives
and Renewable Energy



Dr. Azeem Khan
PhD, MIEEE
Lecturer, UCT
PM Machines & Drives,
Wind Energy



Dr. Ben Sebitosi
PhD, CEng, MIEEE
Snr Research Officer, UCT
Rural Electrification,
Renewables, Energy Policy



Mr. Paul Barendse
MSc, MIEEE
Lecturer, UCT
Electric Drives, Fault
Diagnosis



Mr. Marubini Manyage
MSc, MIEEE
Research Officer, UCT
Machine Design, Energy
Efficiency



Mr. Chris Wozniak
BSc
Technical Officer, UCT
Electrical Machines &
Energy Systems

Post Graduate Students (Current)

- **PhD Students: (7)**
 - Mr F. Endrejat, Mr D. Singh, Mr R. Okou, Mr P. Barendse, Mr M. Manyage, Mr R. Naidoo, Mr D. Johnson
- **MSc Students: (6)**
 - Miss P. Ijumba, Miss K. Masemola, Mr R. Solomon, Mr G. Mwaba, Mr T. Madangombe, Mr H. Mzungu
- **BSc(Eng) Final-year Thesis Students: (15)**
 - About 15 students supervised per year for final-year thesis project



Collaboration – South Africa

▪ Academic Institutions:

- DUT - Deepak Singh, Senior Lecturer - Physics
- DUT - Dr. Poobie Govender, Prof Krishnan Kanny
- University of Pretoria - Mr Raj Naidoo, Senior Lecturer - EE
- University of Stellenbosch - CRSES Hub, Prof M.J. Kamper, Mr D. Johnson

▪ Government / Parastatals:

- NRF
- THRIP
- DST
- SANERI

▪ Industry:

- ESKOM
- SASOL
- Denel



Collaboration – International

- **Clarkson University, Potsdam, NY, USA**
 - **SMMA** - The Motor and Motion Association
 - **EMERF Consortium** - Electrical Motors Educational and Research Foundation
 - **NYSERDA** - New York State Energy Research and Development Authority

- **Aalborg University, Denmark** (wind energy)

- **University of Picardie, France** (condition monitoring)

- **Politecnico di Torino, Torino, Italy** (motor lamination losses)

- **Graduate school of Telecom. and IT, Addis Ababa, Ethiopia** (Cellphone Keyboard Customization for Rural Applications)

- **GTZ, German Aid Agency** (environment and rural electrification)

- **Centre for Research in Energy and Energy Conservation of Makerere University, Uganda** (white LEDs dissemination)



Research Outputs & HR Development

	2007	2006	2005	2004
Human Resource Development	3xPhD 1xMSc 12xBSc	2xPhD 0xMSc 6xBSc	1xPhD 1xMSc 5XBSc	1xPhD 0xMSc 6XBSc
Journals papers (Peer-reviewed, international)	2	4	6	11
Conference papers (Refereed international mainly and some local)	10	12	14	7
Contract Research - Eskom	3	3	1	1
Contract Research - Other Industries	1	1	1	0

Laboratory Facility

- Flexible distribution system with the capability of various DC and AC supplies
- Two, 250kW DC machines and 4-quadrant drives
 - Fed directly from the UCT 11kV ring mains through 11kV/500V transformers
- 6.6kV, 520kW Alternator (driven by afore-mentioned DC machines)
- 75kW induction motor with a 75kW drive
- Several small and medium DC, AC machines and drives including test benches and testing equipment
- These unique capabilities, allows lab testing of machines that is not capable at some international institutions





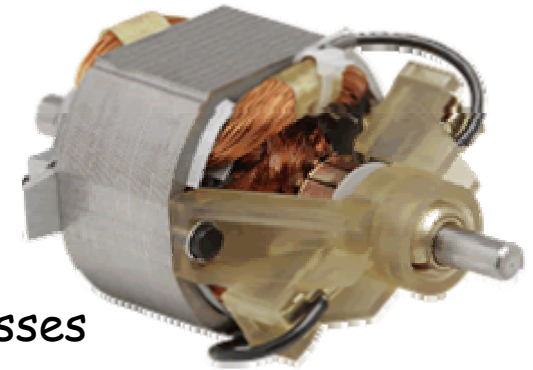
Current Research Areas

- **Energy Efficiency - Machines**
 - Core loss study
 - Electric motors for demand side management
 - MV petrochemical drives
- **Machine Design Projects**
 - Small wind generator design
 - Low voltage High Current Traction motor design
- **Condition Monitoring**
 - Fault studies and condition monitoring of induction motors, PM motors and wind generators
- **Rural Electrification and Alternate Energy Sources**
 - Applications of white LEDs
 - Optimization of solar water pumping systems
 - Solar water heaters
 - Flywheels for energy storage
 - Biomass
- **Power Systems Applications**
 - Power quality
 - Dip classification using wavelets
 - Impacts of renewable energy sources on power systems

Motor Lamination Core Losses

Background:

- Motorized applications are major electricity consumers, in SA and USA, 64 % and 60 % of total electricity, respectively
- Core losses can be 25 % ~ 30 % of the total losses, even higher with newer designs, such as SRMs and BDCMs
- Variable speed drives produce harmonics that increase core losses

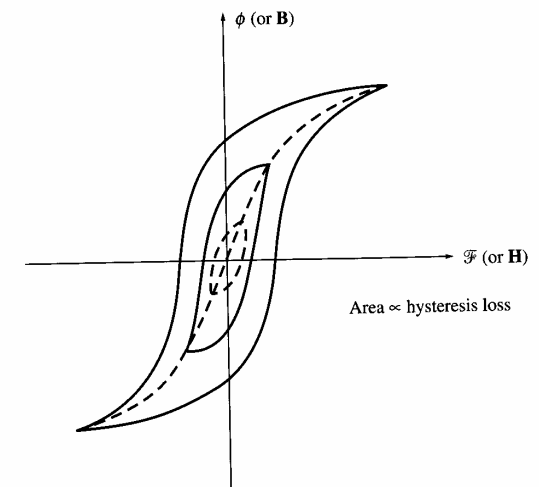


Research Focus:

- Develop a scientific understanding of lamination core losses
- Develop core loss design equations suitable for motor designs applications especially in software design packages

Goals:

- Improving motor efficiency by reducing core losses
- Aid motor designers with better models
- Realize energy and dollar savings
- Reducing peak demand levels and delaying the need for new stations



Environmental benefits:

- Reduce CO2 emissions by efficient use of electricity





Mr. Marbini Manyage

Funding: ESKOM Senior Fellowship, US DOE and NYSERDA

Traction Motor Design



■ Description and Use

- Design a high efficiency Low Voltage High Current Permanent Magnet Synchronous Motor for traction applications
- Motor will be used in a 24V battery-operated pallet truck
- Compete with DC and AC induction motors
- Benefits: Long battery lifespan and extended operating cycles

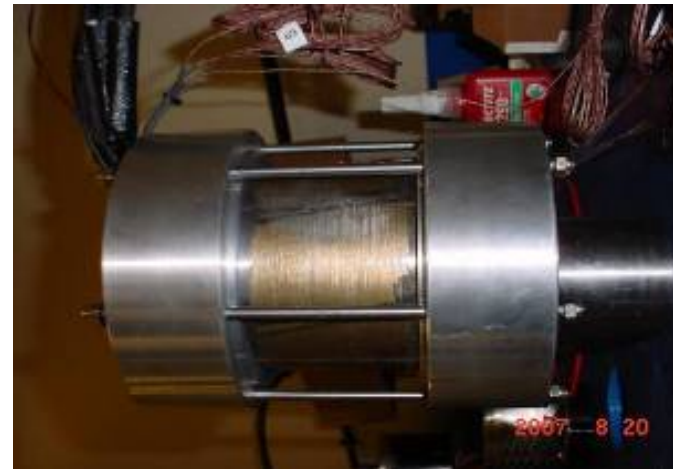
■ Design Challenges

- Low voltage inverter limit (14.5 VLL AC)
- Cogging and Ripple torque
- No cooling, Maximum temperature (180degC)
- Stator outer diameter < 120mm

■ Efficiency improvement

- Better core loss prediction using improved core loss formula and new test bench
- Choice of laminations
- Reduce winding resistance

Traction Motor Prototyping



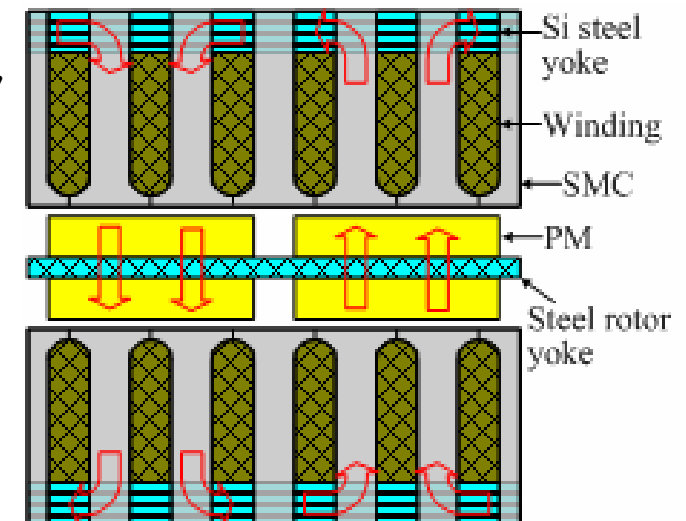
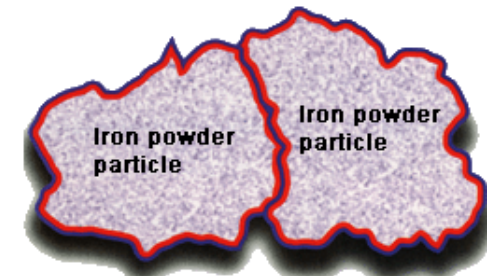
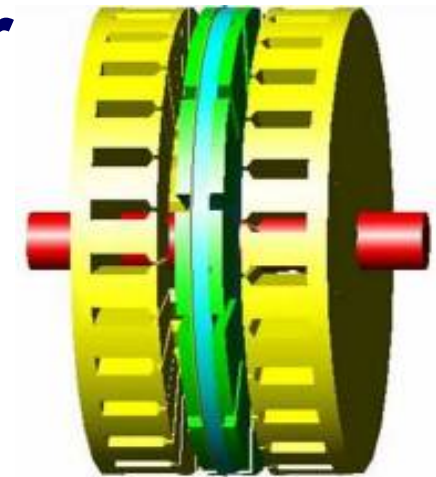


SMC Axial-flux PM Generator

Dr. Azeem Khan

Funding: 2004 – present NRF Thuthuka; April 2005 – December 2006
ESKOM, US DOE, NYSERDA, Warner Energy

- **Background:**
 - Axial-flux PM generator design has highest torque density
 - However, slotting of AFPM stator core is problematic:
 - ☒ Difficult to machine tape-wound stator core
 - ☒ Magnetic properties of core affect by machining process
- **SMC Axial-flux PM generator with single rotor, double stator:**
 - Uses Soft Magnetic Composite (SMC) material
 - Easy to manufacture - Slotted cores are pressed
 - Shorter flux paths, high torque density, high efficiency
- **Previous work showed need for composite (SMC + steel) stator core structure:**
 - Steel in magnetic circuit increases effective permeance of circuit, thus reducing effect of lower SMC permeability
 - Steel in circuit also reduces SMC required, thus reducing effect of higher SMC core loss



Stator cores tested

- **Two identical machined SMC cores prototyped:**
 - 1st case : machined SMC core with untreated teeth
 - 2nd case: machined SMC core with acid treated teeth



Untreated core



Acid treated core



Variable Speed Induction generator Systems for Fault Studies in Wind Energy Applications

Mr. Paul Barendse

Funding: ESKOM Fellowship, UCT scholarship, US DOE

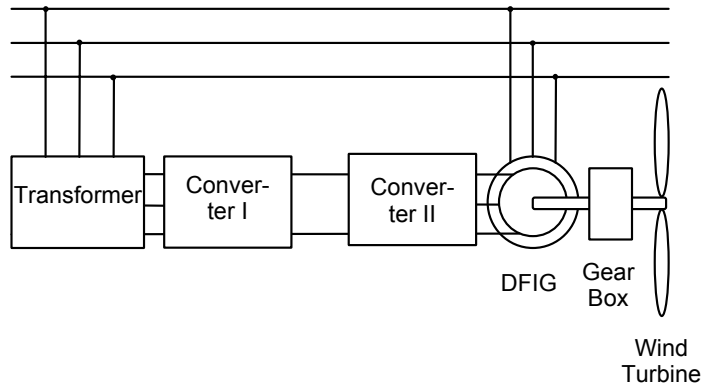
■ Background:

- Wind Energy Systems have received renewed interest in the past decade,
- A need exists for the reduction of operational and maintenance costs of these systems
- Continuous condition monitoring of these generators allows for early detection of degeneration and proactive responses, minimizing downtime & maximizing productivity

■ Project Aims:

- Design, model and implement two variable speed induction generator systems
- Implement the more common faults on the generators
- Attempt to identify them using steady state fault detection techniques
- Develop a platform for further research into the evaluation of fault detection techniques suitable for transient operation of the induction generator

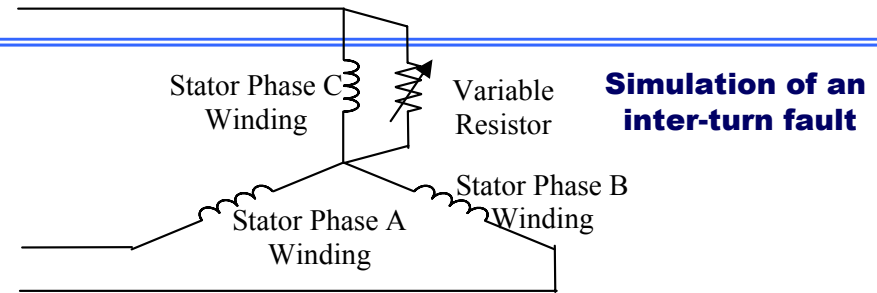




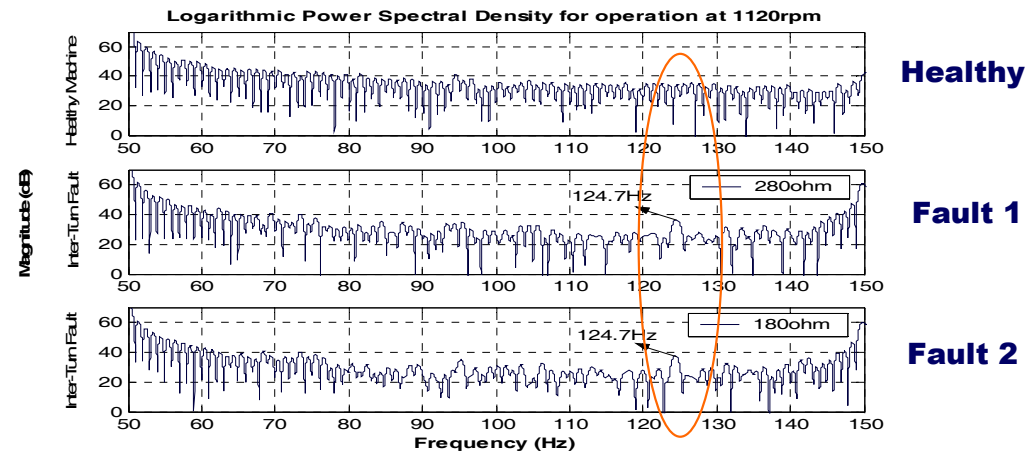
Variable speed wind energy conversion system-using a doubly-fed induction generator



Experimental setup of a variable speed wind energy conversion system using a doubly-fed induction generator

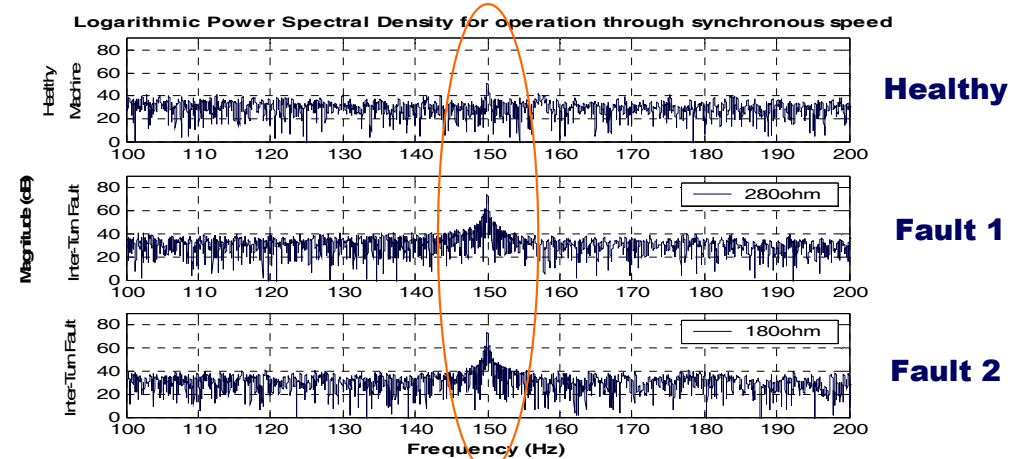


Steady state operation



Fault harmonics are identifiable during steady state

Transient operation



Fault harmonics not identifiable during transient

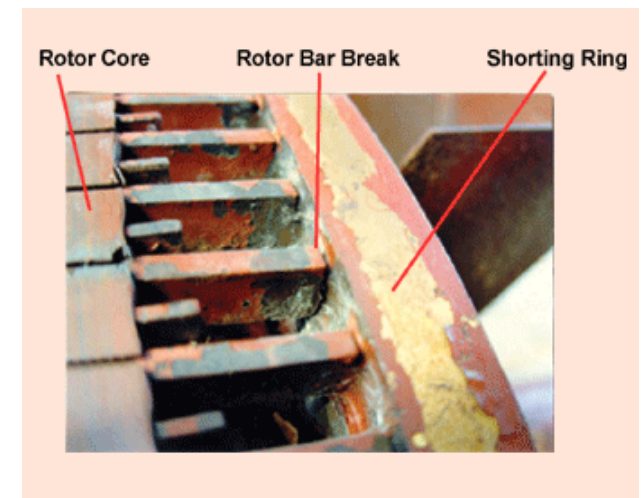


Broken Rotor Bar Detection of Induction Machines using Transient Analysis

Dr. Hugh Douglas

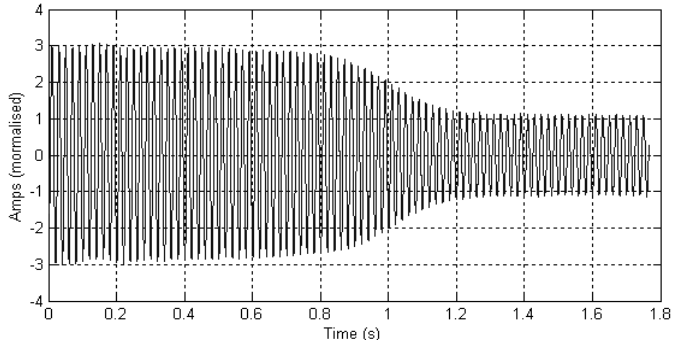
Funding: US ONR

- **Problems with steady state techniques:**
 - Machine speed is constant and known
 - The stator fundamental frequency is constant and known
 - The load is constant
- **Need for better tools that are:**
 - Non-destructive
 - Non-invasive
 - Immune to changes in rotor speed and load
- **New method proposed:**
 - A nonlinear adaptive filter can be used to extract the fundamental stator current
 - Wavelet analysis can be performed on the remaining waveform to successfully detect the broken bars

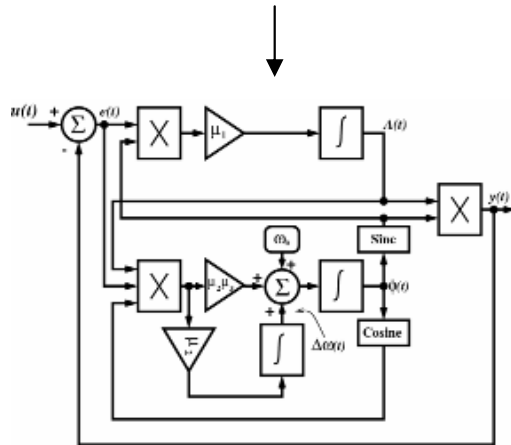




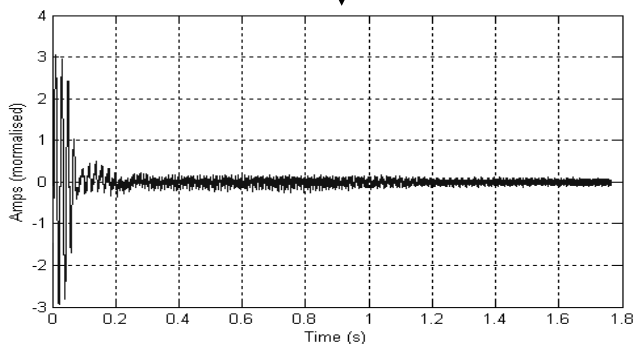
Method of
 Broken Rotor Bar
 Detection



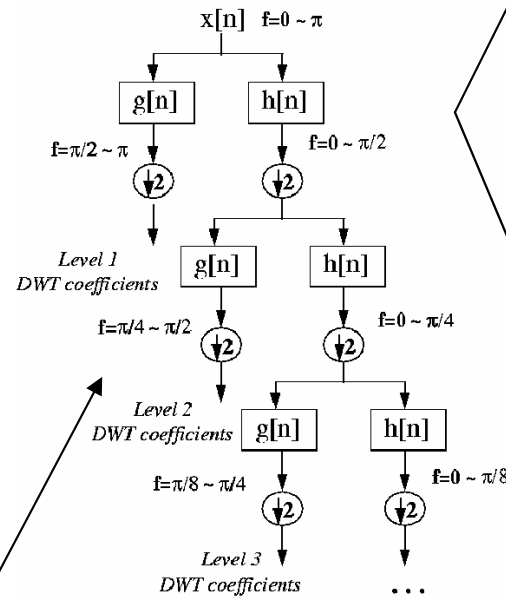
Time domain representation of current phasor



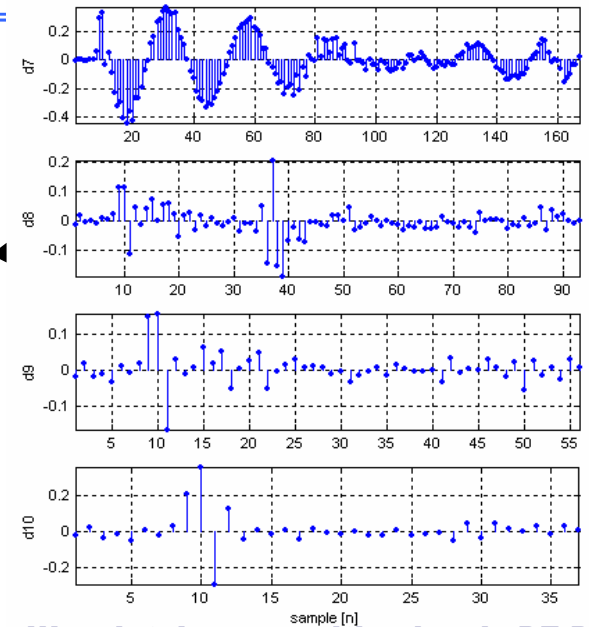
Non linear adaptive filter



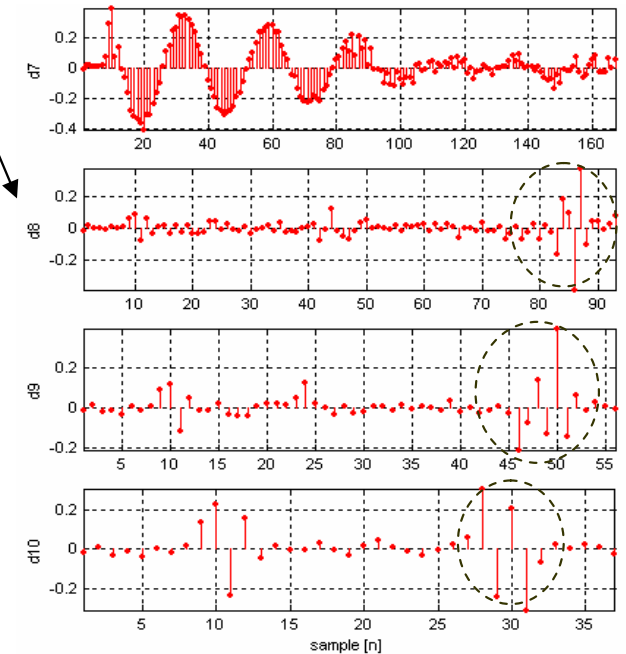
Residual current after extraction



Discrete Wavelet Transform



Wavelet decomposition levels D7-D10 of a fully loaded healthy machine



Wavelet decomposition levels D7-D10 of a fully loaded damaged machine



Mr. Heskin Mzungu

Funding: 2007 – ESKOM

Effect of Armature Rewinding on Induction Motor Efficiency



■ Background

- Motorized loads such as induction motors account for 60% the load in industry.
- The use of efficient motors has a large potential for energy savings

■ Research Focus

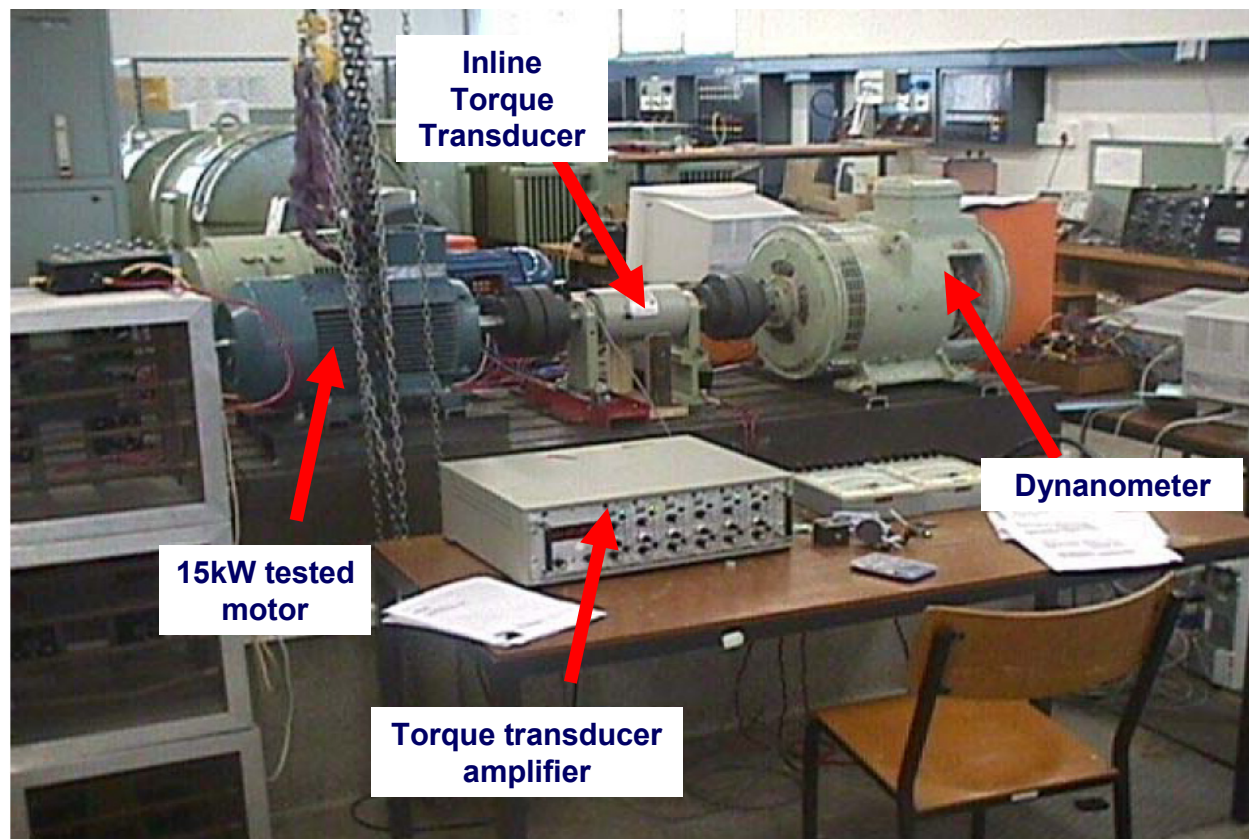
- Acquiring the procedures of different international standards
- The comparison of the different procedures followed in international standards such as the IEEE 112, IEC 6172 and JEC 37

■ Objectives

- Produce very accurate efficiency values for the different motors
- Rigorous testing of different rated induction motors from industry

Efficiency Testing

- 15kW test rig commissioned in Electric Machines lab at UCT
- Efficiency tests done on 15 kW motor as per new IEC 60034-2 standard
- Commissioning of 55kW and 75kW test rig currently in progress





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