STELLENBOSCH UNIVERSITY

FACULTY OF ENGINEERING

STUDY GUIDE

1 MODULE DATA

YEAR	MODULE CODE	MODULE	SAQA CREDITS	WORKLOAD
2014	**11949324**	**ELECTRICAL DRIVES SYSTEMS 324 (A & E)**	**15**	**12**

YEAR	SEMESTER	LECTURING LOAD PER WEEK	HOME DEPARTMENT
3	1	3L, 1P and 2T and 0S	**E&E ENGINEERING**

LECTURER	PORTFOLIO	OFFICE NUMBER	EMAIL ADDRESS
Mr. P.J. Randewijk	General & Lectures	E313 or p/a E309/E310	pjrandew@sun.ac.za
Mnr. P. Pieterse	Practical	E213 of p/a E309/E310	petrus@sun.ac.za
Prof. M.J. Kamper	Tutorials	E311 of p/a E309/E310	kamper@sun.ac.za

CLASSIFICATION OF KNOWLEDGE AREAS *(weighted by credits)*	MATHEMATICS	BASIC SCIENCE	ENGINEERING SCIENCE	DESIGN & SYNTHESIS	COMPUTING & I.T.	COMPLEMENTARY STUDY
	0	0	15	0	0	0

ECSA EXIT LEVEL OUTCOMES *(Marked with X only if the module has ECSA exit level outcomes)*	Problem solving	Application of scientific and engineering knowledge	Engineering design and synthesis	Investigations, experiments and data analysis	Engineering methods, skills, tools and IT	Professional & technical communications	Impact of engineering activity	Individual, team and multidisciplinary work	Independent learning ability	Engineering professionalism

PREREQUISITE MODULES	PREREQUISITE PASS (P⩾50)	PREREQUISITE (40⩽P<50 or K⩾40)	CO-REQUISITE
		ELECTROTECNIQUES 143	*none*

ASSESSMENT DETAILS	METHOD	FINAL MARK FORMULA
See Calendar Part 1 & Part 11 for regulations	FLEXIBLE ASSESSMENT COMPRISING OF: T_1 – Main Test 1 (during Test Week) T_2 – Main Test 2 (during 1st Exam) T_3 – Main Test 3 (during 2nd Exam) S – Joint Mark (from Practicals, 50% & Tutorial Tests, 50%)	If all pass pre-requisites of the module are met, the *PP* may be calculated as follows: $PP = 0{,}3 \cdot T_1 + 0{,}2 \cdot S + 0{,}5 \cdot T_2$ T_3 may be taken and used to replace T_1 or T_2 under the following conditions: – Approved absence of T_1 or T_2; or – $40 \leqslant PP < 50$ after completion of T_1 and T_2, but only a final $PP \leqslant 50$ may afterwards be awarded. A subminimum of 40% in T2 or T3 is required to pass. In case of contention or uncertainty the Faculty's Standard Assessment Policy will be applied. A student *also* has to meet the specified outcomes of the module in the relevant assessments/questions in order for a final mark of 50 or above to be awarded. A numerically calculated mark of 50 or above does not necessarily mean a pass.

Approved by:

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Programme Coordinator / Chairperson

2 ECSA ASSESSERING

ECSA Outcomes Assessed in this Module		
Outcomes	**How is Exit Level Outcome Assessed?** Assessment criteria and assessment methods.	**What is satisfactory performance?** Using the knowledge gained in this module, a student can do the following at the level of a graduate engineer.
1. Problem solving: Demonstrate competence to identify, assess, formulate and solve convergent and divergent engineering problems creatively and innovatively.	No exit level outcomes.	
2. Application of scientific and engineering knowledge: Demonstrate competence to apply knowledge of mathematics, basic science and engineering sciences from first principles to solve engineering problems.	No exit level outcomes.	
3. Engineering design and synthesis: Demonstrate competence to perform creative, procedural and non-procedural design and synthesis of components, systems, engineering works, products or processes.	No exit level outcomes.	
4. Investigations, experiments and data analysis: Demonstrate competence to design and conduct investigations and experiments.	No exit level outcomes.	
5. Engineering methods, skills, tools and IT: Demonstrate competence to use appropriate engineering methods, skills and tools, including those based on information technology.	No exit level outcomes.	
6. Professional & technical communications: Demonstrate competence to communicate effectively, both orally and in writing, with engineering audiences and the community at large.	No exit level outcomes.	

ECSA Outcomes Assessed in this Module

Outcomes	**How is Exit Level Outcome Assessed?** Assessment criteria and assessment methods.	**What is satisfactory performance?** Using the knowledge gained in this module, a student can do the following at the level of a graduate engineer.
7. Impact of engineering activity: Demonstrate critical awareness of the impact of engineering activity on the social, industrial and physical environment.	No exit level outcomes.	
7. Impact of engineering activity: Demonstrate critical awareness of the impact of engineering activity on the social, industrial and physical environment.	No exit level outcomes.	
9. Independent learning ability: Demonstrate competence to engage in independent learning through well-developed learning skills.	No exit level outcomes.	
10. Engineering professionalism: Demonstrate critical awareness of the need to act professionally and ethically and to exercise judgement and take responsibility within own limits of competence.	No exit level outcomes.	

3 SPECIFIC OUTCOMES AND ASSESSMENT CRITERIA

CAPABILITIES These are the aims of the module.
A STUDENT WHO HAS SUCCESSFULLY COMPLETED THIS MODULE CAN ☞ Understand the basic (theoretical) principle of operation of the various types of electrical machines, i.e. DC machines, induction machines, synchronous machines and single-phase machines (including stepper motors). ☞ Mathematically express the relationship between the electrical and the mechanical "side" of a machine (i.e. make basic calculations relating to power, efficiency, torque, speed, power factor, voltage regulation, etc.) for an electrical drives systems. ☞ Represent electrical machines in terms of their equivalent electrical circuit. ☞ Determine the equivalent circuit parameters on an electrical machine from measurements done. ☞ Understand the operation of the basic switch-gear and protection devices available and will be able to design a simple main and control circuit as used for industrial three-phase motor control. ☞ Understand the principles on which the control of an electrical drive systems are based to perform speed, torque (and position) control. ☞ Understand the basics of power electronics and the different topologies used in DC & AC electrical drive systems.

PERFORMANCES Students are required to demonstrate competence and understanding in the following areas More than one of these performances can be expected in a single exam or test question.	**ASSESSMENT CRITERIA** The examiners will give credit if the student successfully performs the following tasks.	**RANGE STATEMENTS** These statements further describe the nature and complexity of the required performance.
✍ Short discussion type questions, e.g.: Explain why the manufacturing cost of DC machines are much higher than that of three-phase induction machines for the same "kW" size. ✍ These short discussion type questions can count for ±15% of the question paper.	☑ These type of questions test the knowledge & comprehension of the student ☑ E.g. for the given question, the answer should: (a) Compare the construction of the armature & field of the DC machine with the construction of the rotor & stator of the three-phase induction machine. (b) List additional construction requirement of the DC machine (e.g. commutation poles, commutator brushes, etc.) to explain why the manufacturing cost of DC machines are higher.	In order to answer this question, the learner must ☞ Understand the basic construction of the various electrical machines discussed in the course. ☞ Understand the different methods of speed control available for the various electrical machines. ☞ Know the different industrial switch and control gear available and understand the working thereof. ☞ Know and understand the basic principles of the different power electronic devices used for DC and AC drives. ☞ Understand the basic block-diagram/system layout of an electrical (AC/DC) drive system.
✍ Short theory type question, e.g.: Using the 'double revolving MMF theory' explain why the developed torque of a single phase induction motor is zero at standstill. ✍ These short theory type questions can count for ±15% of the question paper.	☑ These type of questions test the comprehension & analysis (i.e. insight) of the student ☑ E.g. for the given question, the answer should: Explain what is meant by the 'double revolving MMF theory', using sketches and graphs and then explain (using the theory) what will happen when the speed of the motor is zero.	☞ Understand the basic physics governing the operation of the various electrical machines discussed in the course. ☞ Understand the principle on which the different speed control methods, for the various machines, are based on. ☞ Understand the basic machine-equations for the various types machines ☞ Understand the operation and function of each "block" of an electrical drive system.

PERFORMANCES Students are required to demonstrate competence and understanding in the following areas More than one of these performances can be expected in a single exam or test question.	**ASSESSMENT CRITERIA** The examiners will give credit if the student successfully performs the following tasks.	**RANGE STATEMENTS** These statements further describe the nature and complexity of the required performance.
✍ For a number of different operating conditions, with the nameplate data and a given'st measurement values, calculate the parameters of a'sparately excited DC machine (e.g. R_a, K_m, η, etc.)	☑ Draw the equivalent circuit diagram of the DC machine with the current direction and voltage polarity correctly shown. ☑ Correctly deduce the voltage equations for the different operating conditions. ☑ Correctly calculate the parameters of the DC machine.	☞ Understand the operation of the DC machine for both motor and generator operation. ☞ Know the two basic equations (for torque and induced voltage) of a DC machine and how to apply them in order to solve the terminal voltage of the DC machine using basic Kirchhoff analysis methods.
✍ Discuss the power-flow diagram of an'sparately excited DC machine for motor or generator operation. (can also be asked for a three-phase induction machine, incl. brake operation)	☑ Draw a power-flow diagram, showing the input- and output power and all the losses ☑ Give a short description and/or equation for each "power". ☑ Correctly calculate the different "powers" (if required).	☞ Know and understand the equivalent circuit and the direction of power flow for the different operating conditions (i.e. motor, generator, brake). ☞ Know, understand and be able to calculate all the losses that may occurs in the machine.
✍ With the no-load and locked-rotor test results for a specific three-phase induction machine given, calculate the (approximate) equivalent circuit parameters of the induction machine.	☑ Correctly calculate the approximate parameters of the three-phase induction machine from the given'st of test results.	☞ Know the approximate equivalent circuit of the three-phase induction machine. ☞ Be able to calculate the approximate equivalent circuit parameters from the test results.
✍ From the nameplate data and for a given'st of equivalent circuit parameters for a three-phase induction machine, calculate the: (a) starting torque (b) starting current (c) peak torque (d) slip at a given speed (e) torque at a given speed (f) efficiency at a given speed (g) line current at a given speed (h) power factor at a given speed (i) power generated during dynamic braking with volt-per-hertz control etc.	☑ Correctly draw the equivalent circuit ☑ Correctly calculate the required value for the question using elementary AC steady-state circuit analysis. ☑ Correct scaling of the supply voltage and equivalent circuit inductances for volts-per-hertz control.	☞ Know the approximate equivalent circuit of the three-phase induction machine. ☞ Know how the equivalent circuit can be used to do the necessary calculations. ☞ Understand the principle of volts-per-hertz control.
✍ Calculate the percentage by which the field current of a three synchronous machine should be adjusted in order to deliver (or absorb) a certain amount of reactive power without changing the value of the active power. Draw the phasor diagrams for the operating condition before and after adjustment of the field current. (*this question can also be asked in the "reverse"*)	☑ Draw the equivalent circuit diagram of the synchronous machine with the current direction and voltage polarity correctly shown. ☑ Correctly analyse the operating condition of the machine before and after the adjustment of the field current. ☑ Correctly calculate the new operating condition in terms of voltage, current and power values. ☑ Correctly calculate the field current (*or reactive power*). ☑ Correctly draw the phasor diagram for the operating condition(s).	☞ Know and understand the equivalent circuit of the three-phase synchronous machine. ☞ Know how to use the power equation of the synchronous machine and how to solve the equivalent circuit using Kirchhoff circuit analysis methods. ☞ Be able to draw a phasor diagram for the different operating conditions (i.e. generator – lead/lag, motor – lead/lag)

PERFORMANCES Students are required to demonstrate competence and understanding in the following areas More than one of these performances can be expected in a single exam or test question.	**ASSESSMENT CRITERIA** The examiners will give credit if the student successfully performs the following tasks.	**RANGE STATEMENTS** These statements further describe the nature and complexity of the required performance.
✍ Design the main- (i.e. the three-phase) and control circuit for an industrial three-phase induction motor application e.g. (a) D.O.L. start/stop (b) D.O.L. forward/reverse (c) plugging (d) auto/manual starting with'snsor control (e) reduce voltage starting	☑ Correctly design and draw the main (three-phase) circuit with the necessary switch-gear en protection devices using IEC symbols. ☑ Correctly design and draw the control circuit with the necessary interlocking using IEC symbols.	☞ Understand the operation of the basic three-phase switch-gear and protection devices. ☞ Understand the basic principles of D.O.L. forward and reverse starting, plugging and reduced voltage starting. ☞ Understand the basic principles of interlocking using auxiliary contacts and'snsors with "dry-contacts" ☞ Know the basic IEC symbols used for industrial control applications.
✍ With 1/2/4-quadrant DC-DC converter connected to a'sparately excited (or permanent magnet) DC-machine (a) calculate the duty-cycle required to deliver a certain amount of torque at a given speed (could also be asked in the reverse) (b) calculate the current & torque ripple (c) draw various voltage & current waveforms (d) calculate the conduction losses in the converter (e) calculate the efficiently of the drive system at a give operating point in comparison to a linear drive	☑ Correctly calculate the duty-cycle and average terminal voltage ☑ Correctly calculate the current and torque ripple ☑ Correctly draw the various voltage and current waveforms as required ☑ Correctly calculate the conduction losses in the converter.	☞ Understand the operation of a 1/2/4-quadrant DC-DC converter as used for DC Drive applications. ☞ Understand how to calculate the voltages and current for these type of converters when connected to a DC motor. ☞ Understand the operation of a typical power electronic switching device.
✍ For a three-phase variable speed drive, explain: (a) the function of the (three-phase) rectifier (b) the dc dump & brake resistor (c) the three-phase inverter (d) the basic operation of PWM (*could also be asked for a DC-DC converter*) (e) the principle of volts-per-hertz (scalar) control (f) the principle of (flux) vector control (g) the principle of direct-torque control	☑ Correctly identify and explain the functionality of the different "parts" of a three-phase variable speed drive. ☑ Correctly describe the operation of PWM with the aid of adequate sketches. ☑ Correctly describe the difference between scalar, vector and direct-torque control with the aid of adequate sketches.	☞ Understand the basic principles "block diagram layout" of a three-phase variable speed drive. ☞ Understand the basic principle of PWM. ☞ Understand the differences between scalar, vector and direct-torque control.

4 MODULE CONTENTS AND PRESENTATION PLAN

REFERENCES & ADDITIONAL READING MATERIAL

RESOURCES

Prescribed Textbook

- ☞ Chapman, S.J.; *Electric Machinery Fundamentals, Fifth Edition*, Mc Graw Hill, 2012, ISBN: 978-0-07-352954-7

Electrical Drive Systems 324 on – `http://courses.ee.sun.ac.za`

- ☞ `http://courses.ee.sun.ac.za/Electrical_Drive_Systems_324`

Additional Reading

- ☞ Fitzgerald, A.E., Kingsley, C. Jr. and Umans, S.D.; *Electric Machinery, Sixth Edition*, Mc Graw Hill, 2003, ISBN: 0-07-045994-0
- ☞ Mohan, N., Undeland, T.M. and Robbins, W.P; *Power Electronics : Converters, Applications, and Design Third Edition*, John Wiley & Sons, 2002, ISBN: 0-471-22693-9
- ☞ Sen, P.C.; *Principles of Electric Machines and Power Electronics, Second Edition*, John Wiley & Sons, 1997, ISBN: 0-471-02295-0

PRESENTATION PLAN

LECTURES

WEEK	SUBJECT	REFERENCES	PRAC/TUT (Thursdays & Fridays)
Week 1			
2014-02-03	Introduction to Electrical Drive Systems 344		Tutorial for All
2014-02-04	Basic Mechanics & Magnetics	Chapman Hfst. 1	
2014-02-06	Faraday's Law & Transformers	Chapman Hfst. 1 & 2	
Week 2			
2014-02-10	Transformers I	Chapman Hfst. 2	Tutorial for All
2014-02-11	Transformers II	Chapman Hfst. 2	
2014-02-13	Introduction to DC Machines I	Chapman Hfst. 7	
Week 3			
2014-02-17	Introduction to DC Machines II	Chapman Hfst. 7	Practical I (A–L)
2014-02-18	DC Machines I	Chapman Hfst. 8	Tutorial (M–Z)
2014-02-20	DC Machines II	Chapman Hfst. 8	
Week 4			
2014-02-24	DC Machines III	Chapman Hfst. 8	Practical I (M–Z)
2014-02-25	DC Machines IV	Chapman Hfst. 8	Tutorial (A–L)
2014-02-27	Introduction to Three-phase AC Machines I	Chapman Hfst. 3	
Week 5			
2014-03-03	Introduction to Three-phase AC Machines II	Chapman Hfst. 3	Practical II (M–Z)
2014-03-04	Three-phase Synchronous Generators I	Chapman Hfst. 4	Tutorial (A–L)
2014-03-06	Three-phase Synchronous Generators II	Chapman Hfst. 4	
Week 6			
2014-03-10	Three-phase Synchronous Generators III	Chapman Hfst. 4	Practical II (A–L)
2014-03-11	Three-phase Synchronous Generators IV	Chapman Hfst. 4	Tutorial (M–Z)
2014-03-13	Three-phase Synchronous Motors I	Chapman Hfst. 5	
Week 7			
2014-03-17	Three-phase Synchronous Motors II	Chapman Hfst. 5	*No Practical or Tutorial*
2014-03-18	Three-phase Synchronous Motors III	Chapman Hfst. 5	
2014-03-20	*Test Week Starts*		
Week 8	**TEST WEEK**		
2014-03-27 *(11:00)*	**Main Test 1**	*all the above work - weeks 1–7*	
Recess	**UNIVERSITY RECESS**		
2014-03-31			
Week 9			
2014-04-07	Three-phase Induction Machines I	Chapman Hfst. 6	Tutorial for All
2014-04-08	Three-phase Induction Machines II	Chapman Hfst. 6	
2014-04-10	Three-phase Induction Machines III	Chapman Hfst. 6	
Week 10			
2014-04-14	Three-phase Induction Machines IV	Chapman Hfst. 6	Practical III (A–L)
2014-04-15	Three-phase Induction Machines V	Chapman Hfst. 6	Tutorial (M–Z)
2014-04-17	Three-phase Induction Machines VI	Chapman Hfst. 6	
Week 11			
2014-04-21	*Family Day*	Chapman Hfst. 6 & Notas	Practical III (M–Z)
2014-04-22	Industrial Automation I	Chapman Hfst. 6 & Notas	Tutorial (A–L)
2014-04-24	Industrial Automation II	Chapman Hfst. 6 & Notas	
Week 12			
2014-04-28	*Freedom Day++*	Chapman Hfst. 8 & Notas	*No Practical or Tutorial*
2014-04-29	Industrial Automation III	Chapman Hfst. 8 & Notas	
2014-05-01	*Workers Day*	Chapman Hfst. 8 & Notas	
Week 13			
2014-05-05	Introduction to Power Electronics I	Chapman Hfst. 6 & Notas	Practical IV (M–Z)
2014-05-06	Introduction to Power Electronics II	Chapman Hfst. 6 & Notas	Tutorial (A–L)
2014-05-08	Introduction to Power Electronics III	Chapman Hfst. 8 & Notas	
Week 14			
2014-05-12	Single-phase & Special Machines	Chapman Hfst. 9	Practical IV (A–L)
2014-05-13	Single-phase & Special Machines	Chapman Hfst. 9	Tutorial (M–Z)
2014-05-15	Single-phase & Special Machines	Chapman Hfst. 9	

LECTURES			
WEEK	**SUBJECT**	**REFERENCES**	**PRAC/TUT (Thursdays & Fridays)**
1st Exam 2014-05-27 *(14:00)*	**NOVEMBER FIRST EXAMINATION** **Main Test 2**	*all the above work - weeks 1–14, with the focus on 9–14*	
2nd Exam 2014-06-20 *(14:00)*	**NOVEMBER SECOND EXAMINATION** **Main Test 3**	*all the above work - weeks 1–14, with the focus on* ***everything***	

P.S.: The "Presentation Plan" presented above may be changed by the Lecturer at short notice...

5 GENERAL INFORMATION

5.1 Import information from the Calendar – Part 1

☞ See Admission and Registration, Section 10 & 11 on p 212 – 213

5.2 Practicals

☞ Four Practicals will be done in total, all of these Practicals will be conducted in the Electrical Machines Laboratory (EMLAB). A Practical usually takes 2 $\frac{1}{2}$ hours to complete and is scheduled on Thursday afternoon for Group 1 and Friday afternoons for Group 2 from 14:00–16:30.

☞ All Practical are compulsory. This includes students that are repeating this module, as the Practical add to the final mark, (*PP*). Non attendance will result in an *IN COMPLETE*.

☞ Exemption of Practicals for repeaters will only be allowed if there is a clash of classes and a "Pink form" has been filled in and signed by the lecturer. The Practical mark of the previous year will then be used for the calculation of the the final mark.

⚡ Students are warned that in order to avoid (*or lessen*) the possibility of electrical shock, due to the relative high voltages used, students are required to wear "closed" shoes and "long" pants or dresses (etc.) which should hangs "till over their knees". Non compliance will result in the student(s) concerned being sent home and it will be deemed that they have not attended the Practical... These students will have to make arrangements for a suitable time to redo the Practical.

☞ For optimum participation to the Practicals, groups will be limited to ***four*** students per work bench.

☞ Students are warned to arrive on time for the Practicals as the EMLAB's doors will be locked at 14:00, after which a ±15 min. lecture on important aspects of the Practical will be presented which will also highlight all the safety aspects that needs to be adhered to. Latecomers will have to make arrangements for a suitable time to redo the Practical.

☞ Students are warned to be well prepared for the Practical as a thorough set of results (including sketches, graphs, measurement taken, etc.) must be filled in on the Practical Instruction Sheet by ***each group*** for the Practical. The completed Practical Instruction Sheet has to be handed in after each Practical for which a combined mark for ***each group*** will be given. A short oral assessment will also be conducted with each group in order to determine of each member of the group understands the practical results

☞ In the June Exam/Holidays a sessions will be scheduled for students that have to redo a Practical or for students that missed a Practical due to sickness or any other reason.

5.3 Tutorials

☞ The Tutorials are compulsory. Students must ensure that they show their completed (or near completed) tutorial to the lecturer on duty before 16:00 in order to be signed off for the tutorial. For this, their student cards would be required.

☞ Students that are not signed off for more than three (3) tutorials, will receive an incomplete.

☞ Six (6) unannounced Tutorial Test will be conducted during the semester in the tutorial period @ 16:00. The **top four** test will contribute to the final mark (*PP*). Students that miss a test, regardless of the reason, will receive a zero (0) for that test.

☞ Exemption for Tutorials and Tutorial Tests for repeaters will only be allowed if there is a clash of classes and a "Pink form" has been filled in and signed by the lecturer. The Tutorial Test mark of the previous year will then be used for the calculation of the the final mark.

5.4 Tests and Examination

- ☞ This subject makes use of the new "Flexible Assessment".
- ☞ The first Main Test (T_1) will be conducted on 27 March 2014, during Test Week at the start of the second quarter.
- ☞ The second Main Test (T_2) is scheduled during the First Examination on 27 May 2014 at 14:00
- ☞ The third Main Test (T_3) is scheduled during the Second Examination on 20 June 2014 at 14:00 and are only required for those students who have missed the first or second Main Test due to sickness or any other valid reason, or for those students with a final mark, $40 \leqslant PP < 50$.
- ☞ The combined mark (S) will consist of 50% from the Practicals and 50% from the Tutorial Tests.
- ☞ Only prescribed calculators may be used in the class tests and exams. No information in electronic format may be brought into the test - or exam venue.
- ☞ NO final mark (P) may be given to student before hand according to the new University policy. Students should wait until the official results are displayed on the notice boards, or at the lecturer's office.

6 ENGLISH/AFRIKAANS TERMINOLOGY IN ELECTRICAL DRIVES

air-core lugkern

airgap MMF lugspleet MMK

airgap power lugspleet drywing

apparent power skyndrywing [S in kVA]

armature anker

armature reaction ankerreaksie

armature reaction reactance ankerreaksie reaktansie

armature winding ankerwikkeling

back emf teen emk (elektromotoriese krag)

blocked-rotor test vashourotortoets

chorded winding verkorte spoelsteek wikkeling

coil spoel

coil pitch spoelsteek

commutation kommutasie

compensating winding kompensasie wikkeling

compound dubbelsluiting (by DC-masjien)

- **cumulative compounding** versterkende dubbelsluiting
- **differential compounding** verswakkende dubbelsluiting
- **flat compounding** gelyk dubbelsluiting
- **over compounding** –
- **under compounding** –

core kern

core losses kernverliese

current density stroomdigtheid [J]

damper winding demper wikkeling

distribution factor verspreidingsfaktor

double-cage rotor dubbelkou rotor

double layer winding dubbellaag wikkeling

eddy currents warrelstrome

efficiency benuttingsgraad

exciting current opwekstroom

field control veldbeheer

field weakening veldverswakking

field winding veldwikkeling

flux density vloeddigtheid [B]

full-load vollas

full-pitch winding volsteek wikkeling

full-pitch coil volsteek spoel

hysteresis histerese

impedance impedansie

induced voltage geïnduseerde spanning

induction machine induksiemasjien

interpoles tussenpole

iron core ysterkern

iron losses ysterverliese

lamination laminasie

lap winding luswikkeling

leakage inductance sprei-induktansie

leakage flux spreivloed

leakage reactance spreireaktansie

magnetic field strength magnetiese veldsterkte [H]

magnetic flux magnetiese vloed [Φ]

magnetising current magnetiseerstroom

magnetising inductance magnetiserings-induktansie

magnetising reactance magnetiseringsreaktansie

magnetomotive force (MMF) magnetiese motoriese krag (MMK)

MMF distribution MMK verspreiding

mutual inductance wedersydse induktansie

no-load test nullastoets

open-circuit test oopbaantoets (nullastoets)

permeability permeabiliteit

per unit system per-eenheid stelsel

pole pitch poolsteek

power drywing

power factor arbeidsfaktor

power flow drywingsvloei

primary winding primêre wikkeling

pull-out torque uitval-draaimoment

rated value kenwaarde

reactance reaktansie [X in Ω]

synchronous reactance sinchrone reaktansie

reactive power reaktiewe drywing [Q in VAR]

real power werkdrywing [P in Watt]

reluctance reluktansie

reluctance torque reluktansie draaimoment

resistance weerstand (R in Ω)

root-mean-square (rms) wortel-van-die-gemiddeld-kwadrate (WGK of w.g.k.)

rotating magnetic field roterende magneetveld (draaiveld)

rotational losses roterende verliese (meestal ysterverliese plus wind-en-wrywing verliese)

salient pole speekpool

secondary winding ’skondêre wikkeling

separately excited afsonderlik opgewek

series field winding ’srie veldwikkeling

shaft power asdrywing

short circuit test kortsluittoets

short-pitch verkorte spoelsteek

shunt dc machine newesluiting gs-masjien

sinusoidal excitation sinusvormige opwekking

skin effect huid-effek

slip glip

slip frequency glipfrekwensie

slip rings sleepringe

squirrel-cage rotor kourotor

synchronous machine sinchroonmasjien

synchronous impedance sinchrone impedansie

synchronous reactance sinchrone reaktansie

synchronous generator sinchroongenerator

torque draaimoment

transformer transformator

travelling wave loopgolf (draaiveld)

turn winding

voltage regulation spanningsregulasie

wave winding golfwikkeling

windage and friction losses wind-en-wrywing verliese

winding wikkeling

winding factor wikkelingsfaktor