



Prifysgol Cymru
Y Drindod Dewi Sant
University of Wales
Trinity Saint David

Examination Answer Books

12 Pages

Instructions to Candidates

1. Please give the information requested in the boxes below.
2. Enter your name in the space provided to the right, fold over and seal down (using the label provided) to hide your name.
3. The answers must be legibly written. The Examiners cannot ignore illegible script or have it typed and the expense of typing charged to the candidate.
4. Write your answers in ink.
5. Begin each answer on a fresh page. Do all rough work in the answer book and cross it through.
6. No part of this book is to be torn out; it must be handed in complete.
7. If more books than one are used, fasten them together using the tags available from the invigilator(s).
8. Every book must be handed in. In no circumstances may answer books, used or unused, be taken out of the examination venue.

Complete, fold and seal
(see note 2 below)

SURNAME: LOCKHART

FORENAME(S): DEREK

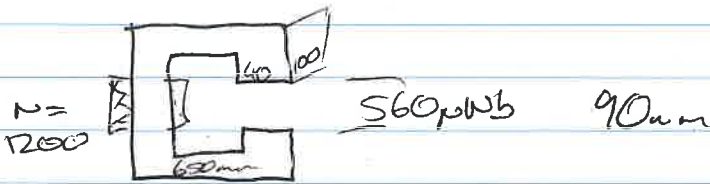
1	Student Number	P151664
2	Title of Examination Paper	ELECTRICAL MACHINES
3	Module Code	M6X00373
4	Date and Time of Examination	17/5/19 15:00
5	Examination Venue	1Q310
6	Seat Number	G063
7	Number of Answer Books handed in	1

List the numbers of the questions you have attempted	Office Use
1	10 10
2	6 6
3	10 10
4	2 2
5	2 2
6	9 9
7	7 7
Total	46 46

(Gweler yr ochr arall am y fersiwn Cymraeg)

92%

92%
1.1



$$B = \frac{\Phi}{A} = \frac{560 \text{ mWb}}{90 \text{ mm} \times 100 \text{ mm}}$$

$$= \frac{560 \text{ mWb}}{2 \times 10^{-3} \text{ m}^2}$$

$$B = 140 \text{ mT}$$

From the graph of cast Iron

$$140 \text{ mT} \equiv H = 325 \text{ A/m}$$

$$\begin{aligned} \text{mmf}_{\text{core}} &= H_{\text{core}} \times L_{\text{core}} = 211.25 \text{ At/m} \\ &= 325 \times 0.65 = 211.25 \text{ At/m} \end{aligned}$$

$$H_{\text{gap}} = \frac{B_{\text{gap}}}{\mu_0} = \frac{0.14 \text{ T}}{4\pi \times 10^{-7}} = 111408.46 \text{ A/m}$$

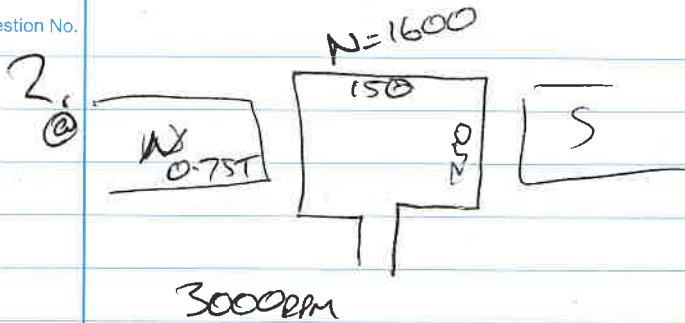
$$\begin{aligned} \text{mmf}_{\text{gap}} &= H_{\text{gap}} \times L_{\text{gap}} = 111408.46 \times 0.09 \\ &= 10026.76 \text{ At/m} \end{aligned}$$

$$I = \frac{\text{mmf}_{\text{gap}} + \text{mmf}_{\text{core}}}{\text{Turns}} = \frac{10026.76 + 211.25}{1200}$$

$$= \underline{\underline{8.53 \text{ Amps}}}$$

10

10



$$emf = NBA\omega$$

$$\begin{aligned}\omega &= 2\pi f \\ f &= 3000/60 \\ f &= 50\text{Hz} \\ \omega &= 314.16\end{aligned}$$

$$\begin{aligned}A &= 0.15 \times 0.25\text{m} \\ &= 37.5 \times 10^{-3}\text{m}^2\end{aligned}$$

$$\begin{aligned}emf &= 1600 \times 0.75 \times 37.5 \times 10^{-3} \times 314.16 \\ &= 14.1372 \times 10^3 \text{ V} = \underline{\underline{14.14 \text{ kV}}}\end{aligned}$$

⑥

$$\begin{aligned}\Phi &= BA \\ &= 0.75 \times 37.5 \times 10^{-3} = \underline{\underline{28.125 \text{ mWb}}}\end{aligned}$$

3. A 3 ϕ induction motor will generally use a star configuration at one end (allows neutral connection) and the 3 ϕ s are applied to the stator, the stator will also include laminations of steel (or other) to aid flux linkage. The effect of the three phases is that they produce what is effectively a rotating magnetic field ~~at~~ linked to the supply frequency.

The rotor has no power supplied to it however a squirrel cage around a iron (or other) core will have a current induced into it by the stator's magnetic field, this is due to the bars of the squirrel cage being shorted out at each end.

This current in the squirrel cage bars creates its own magnetic field that interacts with the stator's rotating magnetic field and ~~the~~ starts to overcome the rotor inertia and rotation begins.

As the rotation picks up speed the current in the squirrel cage reduces (due to less interaction with stator field now seen as a static magnetic field by the spinning cage) and the unloaded rotor will draw less work from the supply.

As the rotor approaches the rotation speed of the stator field its lower interaction will mean it will not reach full speed and therefore be slower than stator field speed this is 'slip'.

To smooth out the interaction of the cage and stator field the cagebars are skewed.

In comparison a 3ϕ synchronous motor would be unable to self start. a synchronous motor achieves synchronisation by having an active magnetic field on its rotor, not induced from the stator.

This active field on the rotor is supplied by either ~~adynamo~~ dynamo or external source. Its interaction with the stator field will be unable to overcome the rotor inertia and start, the rotor will simply judder in successive attractions and repulsions.

The synch motor must therefore be started as an induction motor using a squirrel cage, as before.

As the squirrel cage approaches stator field rotation speed the power is applied to the rotor field and this will magnetically lock the rotor speed to the stator field speed.

Sync motors can retain their output speed irrespective of load (within reason) inductive motors cannot, they will ~~increase~~ ^{vary} slip as load varies.

Speed of the motors can be controlled only by altering frequency of the supply. This would be done via rectification-inversion to create a variable freq supply.



Induction motors are simpler and cheaper than sync motors and tend to be more rugged.

Sync motors can be more efficient and the motor's losses include

Flux loss

I^2R losses in winding.

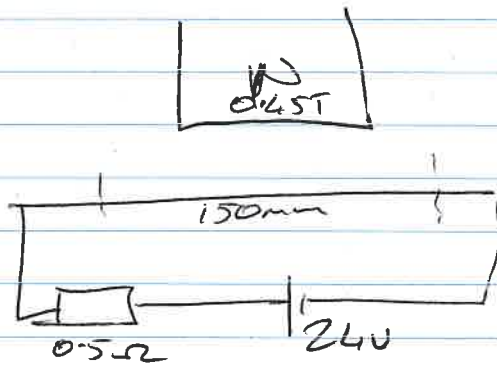
Hysteresis losses in stator/rotor material
eddy current losses counteracted by laminations

Excellent

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4.



$$I = \frac{V}{R} = \frac{24}{0.5} = \underline{\underline{48A}}$$

$$F = NBIL \sin \theta$$

$$\text{as } \theta = 90^\circ \Rightarrow 1$$

$$\times N = 1$$

$$F = BIL$$

$$= 0.45 \times 48 \times 150 \text{ mm}$$

$$= \underline{\underline{3.24 \text{ N}}}$$

(2)

(2)

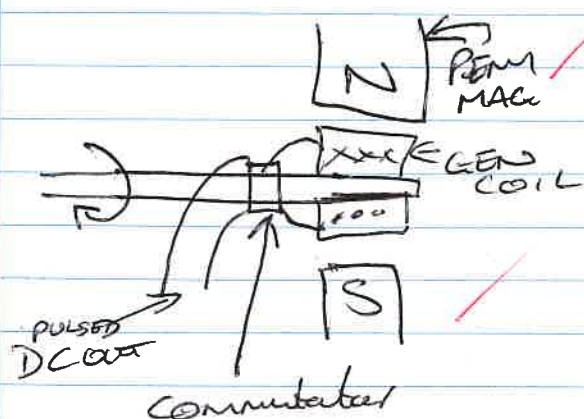
5. A single pole^{pair} alternator required to work at $50 \text{ Hz} \Rightarrow 50 \times 60 = 3000 \text{ rpm}$
 a 3 pole pair alternator would require $3000/3$
 $= \underline{\underline{1000 \text{ rpm}}}$

(2)

(2)

6. A Dynamo is a type of DC generator.

the rotation of the prime mover will spin



the generating coil inside

the magnetic field.

the output of this coil

will be a sinusoid.

The output however is taken via a commutator

the commutator has the effect of being

a rectifier and creates a pulsing DC

signal output that can be further

smoothed as required to produce pure

DC. the output is defined by the equation

$\text{emf} = NBA\omega$ where the dynamo output

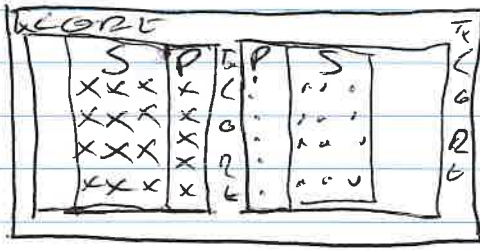
is directly proportional to the turns, flux density,

Area of the coil and rotation speed.

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7.



Among the losses from a transformer (Hysteresis, I^2R , magnetostriction etc) Flux linkage loss is the inefficiency caused by Flux generated by the primary windings not ~~be~~ inducing current in the secondary winding.

These losses can be reduced if the shell type transformer encapsulates the primary fully such that all flux is passed either directly to the secondary or via the shell into the secondary.

This reduced flux loss will increase the efficiency.

The transformer shall still have other losses that must be ~~reduced~~, ~~as~~ ~~are~~ such as eddy currents reduced by laminations of the core material etc



Therefore as the current in the primary produces flux appropriate to the supply current this flux will be collected by the secondary (directly or via the core material) and induce a current flow that is proportional to the turns ratio difference between the pri and sec.

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