ELC - Electrotechnics

T001

Thursday, 22/11/2018

08:30 – 11:30 AM

WORKFORCE DEVELOPMENT AUTHORITY

P.O. BOX 2707 Kigali, Rwanda Tel: (+250) 255113365

ADVANCED LEVEL NATIONAL EXAMINATIONS, 2018, TECHNICAL AND PROFESSIONAL STUDIES

EXAM TITLE: **ELECTROTECHNICS**

OPTION: **Electricity (ELC)**

DURATION: **3 hours**

INSTRUCTIONS:

The paper is composed of the following sections:

Section I: Eighteen (18) compulsory questions. **55 marks**

Section II: Attempt **any three (3)** out of five questions. **30 marks**

Section III: Attempt **any one (1)** out of three questions. **15 marks**

The use of a scientific calculator is accepted

Note:

Every candidate is required to carefully comply with the above instructions. Penalty measures will be applied on their strict consideration

01. For any two alternating signals, what do you understand by "leading signal"? **(1 mark)**

02. State the laws of electrostatics. **(3 marks)**

03. What do you understand by an over-excited synchronous motor? **(2 marks)**

04. A multiple plate capacitor has 10 plates, each of area 10 square cm and separation between 2 plates is 1 mm with air as dielectric. Determine the energy stored when voltage of 100 volts is applied across the capacitor. **(3 marks)**

05. Calculate the distribution factor for a 36 slots, 4-pole, single layer three-phase winding. **(3 marks)**

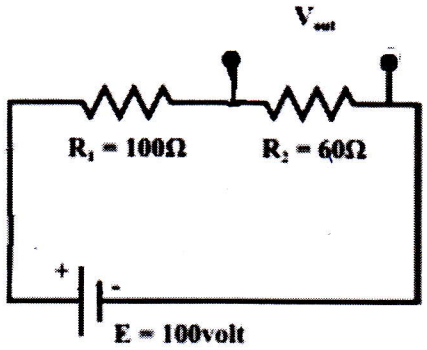
06. Define the following expressions and mention their units: **(4 marks)**

a) Self-inductance,

b) Mutual inductance

c) Derive an expression for the energy stored in an inductor of self-inductance 'L' henry carrying the current of 'I' amperes.

07. For the circuit shown in Figure below, calculate V_{out} across 60Ω resistor, ignoring the internal resistance of the source *E*. Use voltage division.



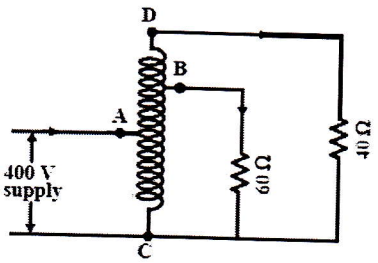
(3 marks)

08. A 12-pole, 3-phase alternator driven at a speed of 500 r.p.m. supplies power to an 8-pole, 3-phase induction motor. If the slip of the motor at full-load is 3%, calculate the full-load speed of the motor. **(3 marks)**

09. Express the difference between a "linear" and "non linear" circuits.

(3 marks)

10. An autotransformer has a coil with total number of turns *NCD* = 200 between terminals **C** and **D**. It has got one tapping at **A** such that the number of turns *NAC* = 100 and another tapping at **B** such that the number of turns *NBA* = 50. As shown in figure.



Calculate the current and voltage for each resistance of the circuit, when 400 V supply is connected across AC. **(4 marks)**

11. Calculate the speed at which a 2-pole machine must rotate to obtain a voltage having frequency of 50Hz. **(1 mark)**

12. An alternating voltage e = 200 sin 314t is applied to a device which offers an ohmic resistance of 20 Ω to the flow of current in one direction, while preventing the flow of current in opposite direction. Calculate for the current over one cycle:

a) RMS value,

b) average value and

c) Form factor. **(3 marks)**

13. Explain the following terms related to magnetic circuits:

a) Reluctance

b) Magnetomotive force **(2 marks)**

14. What do you understand by the term 'back e.m.f.'? **(1 mark)**

15. A d.c. motor connected to a 460-V supply has an armature resistance of 0.15 Ω. Calculate:

a) The value of back e.m.f. when the armature current is 120 A.

b) The value of armature current when the back e.m.f. is 447.4V.

(4 marks)

16. A resistance of 10 Ω is connected in series with two resistances each of 15 Ω arranged in parallel. What resistance must be shunted across this parallel combination so that the total current taken shall be 1.5 A with 20 V applied? **(5 marks)**

17. A single-phase transformer has 400 primary and 1000 secondary turns. The net cross-sectional area of the core is 60 cm^2. If the primary winding is connected to a 50-Hz supply at 520 V, calculate:

(i) The maximum value of flux density in the core.

(ii) The voltage induced in the secondary winding.

(4 marks)

18. Two batteries **A** and **B** are connected in parallel and load of 10 Ω is connected across their terminals. **A** has an e.m.f. of 12 V and an internal resistance of 2 Ω ; **B** has an e.m.f. of 8 V and an internal resistance of 1 Ω. Use Kirchhoff 's laws to determine:

a) the values and directions of the currents flowing in each of the batteries

b) The value and direction of current in the external resistance.

c) Also determine the potential difference across the external resistance. **(6 marks)**

19. An iron ring has a cross-section of 3 cm^2 and a mean diameter of 25 cm. An air-gap of 0.4 mm has been cut across the section of the ring. The ring is wound with a coil of 200 turns through which a current of 2 A is passed. If the total magnetic flux is 0.24 mWb, find the relative permeability of iron, assuming no magnetic leakage.

10 marks)

20. A 220 V d.c series motor has armature and field resistances of 0.15 Ω and 0.10 Ω respectively. It takes a current of 30 A from the supply while running at 1000 rpm. If an external resistance of 1 Ω is inserted in series with the motor, calculate the new steady state armature current and the speed. Assume the load torque remains constant.

(10 marks)

21. **a)** Draw a diagram showing the power stages for a DC generator.

b) What is "Armature reaction" and what are its effects?

c) A 4-pole generator has a wave-wound armature with 722 conductors, and it delivers 100A on full load. If the brush lead is 8°, calculate the armature demagnetising and cross-magnetising ampere turns per pole.

(10 marks)

22. A 3-phase, 50-Hz transformer has a delta-connected primary and star-connected secondary, the line voltages being 22,000 V and 400 V respectively. The secondary has a star connected balanced load at 0.8 power factor lagging. The line current on the primary side is 5 A. Determine:

i) The current in each coil of the primary,

ii) The current in each secondary line,

iii) What is the output of the transformer in kW? **(10 marks)**

23. The power input to the rotor of 440 V, 50 Hz, 6-pole, 3-phase, and induction motor is 80 kW. The rotor electromotive force is observed to make 100 complete alterations per minute.

Calculate:

(i) The slip,

(ii) The rotor speed,

(iii) Rotor copper losses per phase.

(10 marks)

Section III. Choose and answer any one (1) question. **15 marks**

---

24. A single phase a.c. generator supplies the following loads:

- Lighting load of 20 kW at unity power factor.
- Induction motor load of 100 kW at p.f. 0·707 lagging.
- Synchronous motor load of 50 kW at p.f. 0·9 leading.

Calculate:

a) the total real power,

b) total reactive power,

c) total apparent power,

d) the power factor at which the generator works.

(15 marks)

25. A shunt generator delivers 195 A at terminal p.d. of 250 V. The armature resistance and shunt field resistance are 0.02 Ω and 50 Ω respectively. The iron and friction losses equal 950 W.

Find:

a) E.M.F. generated

b) Cu losses

c) Output of the prime motor

d) Commercial, mechanical and electrical efficiencies.

(15 marks)

26. A single phase motor connected to 400 V, 50 Hz supply takes 31·7A at a power factor of 0·7 lagging. Calculate the capacitance required in parallel with the motor to raise the power factor to 0·9 lagging.

(15 marks)