THE UNITED REPUBLIC OF TANZANIA

NATIONAL EXAMINATIONS COUNCIL

CERTIFICATE OF SECONDARY EDUCATION EXAMINATION

082 **ELECTRICAL ENGINEERING SCIENCE**

(For Both School and Private Candidates)

Time : 3 Hours **ANSWERS** **Year : 2006**

Instructions

1. This paper consists of sections A, B and C.
2. Answer all questions in section A and B and **three (3)** questions from section C.
3. Non-programmable calculators may be used.
4. Communication devices and any unauthorised materials are **not** allowed in the examination room.
5. Write your **Examination Number** on every page of your answer booklet(s).

1. For each of the items (i) – (x) choose the correct answer from among the given alternatives and write its letter beside the item number.

(i) The unit used to measure an absolute temperature is

A. kg/°C

B. tesla

C. candela

D. kelvin

E. N/m²

Correct answer: D. The unit of absolute temperature is Kelvin (K).

(ii) The ripples of a radio can be smoothed by using the following component:

A. Transistor

B. Capacitor

C. Thyristor

D. Diode

E. Resistor

Correct answer: B. A capacitor is used to smooth ripples in a radio or power supply circuit.

(iii) Resonance frequency in a series circuit can appear when

A. $XL < XC$

B. $XC < XL$

C. $XL^2 > XC$

D. $XL = XC$

E. $XL \neq XC$

Correct answer: D. Resonance occurs when inductive reactance (XL) equals capacitive reactance (XC).

(iv) The current flowing through a no load ac circuit is

A. maximum

B. 240 A

C. 0 A

D. half of the maximum current flow

E. 220 A

Correct answer: C. In an ideal no-load a.c. circuit, the current is zero (no load).

(v) A circuit connected to a resistor only without capacitor and an inductor is known as pure resistive circuit. The current flowing through it is

A. in phase with voltage

B. leading

C. lagging

D. maximum power with voltage

E. 90° with voltage

Correct answer: A. In a pure resistive circuit, current is in phase with voltage.

(vi) The maximum voltage in a parallel circuit can be measured by a voltmeter connected

A. in series with the load

B. across the supply

C. in parallel-series with the load

D. in series-parallel with load

E. there is no answer

Correct answer: B. In a parallel circuit, voltage is measured across the supply.

(vii) The expression used to find phase current in three phase star-connected circuit is

A. $Ip = IL/\sqrt{3}$

B. $Ip = IL$

C. $Ip = \sqrt{3}\ IL$

D. $Ip = \sqrt{3} \times VL$

E. $Ip = VL/\ pf$

Correct answer: A. In star connection, line current $IL = \sqrt{3} \times Ip$, hence phase current $Ip = IL / \sqrt{3}$.

(viii) Which of the following is the correct statement?

A. A generator is a machine which converts electric energy into mechanical power

B. A generator is a machine which converts energy to power

C. A generator is a machine which converts current to voltage

D. A generator is a machine which converts electromotive force to voltage

E. A generator is a machine which converts mechanical power to electrical power

Correct answer: E. A generator converts mechanical power into electrical power.

(ix) The copper loss of a transformer can be obtained by

A. V^2

B. R

C. VI

D. VI cos θ

E. I^2R

Correct answer: E. Copper loss in a transformer is given by I^2R.

(x) The rate of doing work in a straight line is given by

A. FV

B. FL

C. Ft

D. FE

E. S/t

Correct answer: A. The rate of doing work is power, given by Force × velocity (FV).

2. Mention three (3) common sources of electricity used in Tanzania.

Hydroelectric power, generated from dams such as Kidatu and Mtera.

Natural gas power, produced from gas fields like Songo Songo and Mnazi Bay.

Diesel or thermal power plants, which use fossil fuels to generate electricity.

3. Give the main types of ac generators.

Synchronous generators, which operate at a constant speed and frequency.

Induction generators, which are driven above synchronous speed to generate power.

4. A simple Leclanché cell consists of four components. Mention three of them.

   Anode made of zinc rod.

   Cathode made of carbon rod surrounded by manganese dioxide.

   Electrolyte consisting of ammonium chloride solution or paste.

5. Write down two (2) units of electric current.

   Ampere (A).

   Milliampere (mA).

6. Mention three (3) effects of electric current.

   Heating effect, which is applied in electric heaters and irons.

   Magnetic effect, which is used in electromagnets and electric motors.

   Chemical effect, which is observed in electrolysis and electroplating.

7. What are the three types of single phase motors?

   Single-phase induction motors.

   Universal motors, which can operate on both a.c. and d.c. supply.

   Repulsion motors, which use repulsion between magnetic fields to produce torque.

8. Calculate the illumination on a working plane at a point 8.7 m vertically below a lamp emitting 850 candela. The surface is at right angle to the light source.

   Illumination $E = I / d^2$.
   Here, I = 850 cd, d = 8.7 m.
   $E = 850 / (8.7)^2 = 850 / 75.69 = 11.23$ lux.

9. Define an armature reaction of a d.c. machine.

   Armature reaction is the effect of the magnetic field set up by the armature current on the distribution of the flux under the main poles of a d.c. machine. It distorts and weakens the main flux, affecting commutation and machine performance.

10. A three phase star-connected system has 400 V between wires. Estimate the voltage in each conductor.

Line voltage VL = 400 V.
In star connection, phase voltage Vph = VL / √3 = 400 / 1.732 = 231 V.

11. Write down the functions of the following machines:

(a) Motor – Converts electrical energy into mechanical energy.
(b) Alternator – Converts mechanical energy into electrical energy (a.c. power).
(c) Transformer – Transfers electrical energy from one circuit to another at different voltage levels without changing frequency.

12. An a.c. system supplies maximum voltage of 225 V at the terminals of the load when it is not connected.

(a) Calculate the peak to peak voltage of the system.
Peak voltage = 225 V. Peak-to-peak = 2 × 225 = 450 V.

(b) Calculate the mean value due to the following ordinates: 0.13, 0.383, 0.609, 0.793, 0.924, 0.991.
Mean value = (Σ ordinates)/n = (0.13+0.383+0.609+0.793+0.924+0.991)/6 = 3.83/6 = 0.638.

(c) Find the root mean square value of the ordinates in 12(b).
RMS = √[(Σx²)/n].
= √[(0.13²+0.383²+0.609²+0.793²+0.924²+0.991²)/6].
= √[(0.0169+0.146+0.371+0.629+0.854+0.982)/6].
= √[2.999/6] = √0.5 = 0.707.

(d) Determine the instantaneous voltage of an a.c. system whose equation is V = 10 sin 349.8t, where t = 0.02 seconds.
V = 10 sin (349.8 × 0.02) = 10 sin 6.996 ≈ 10 × 0.122 = 1.22 V.

13. Draw a well labelled diagram of a moving coil instrument and explain its principle of operation.

A moving coil instrument consists of a rectangular coil wound on an aluminium former, placed in a radial magnetic field produced by a permanent magnet. When current passes through the coil, it

experiences a torque which causes deflection proportional to the current. The deflection is opposed by a spring, and a pointer indicates the reading on a scale.

14. (a) Name the function of the following parts of d.c. machines:

(i) Commutator – Converts the a.c. induced in the armature winding into direct current.
(ii) Poles – Produce the magnetic flux required for the machine operation.
(iii) Armature – The rotating part where e.m.f. is induced and torque is developed.

(b) State with the aid of circuit diagrams, the difference between series, shunt and compound generators.
Series generator – The field winding is in series with the armature.
Shunt generator – The field winding is connected in parallel with the armature.
Compound generator – Has both series and shunt field windings for better voltage regulation.

15. A three phase 415 V, 4 poles, 60 Hz induction motor develops a total torque of 150 Nm. If the frequency of the rotor is 2 Hz, calculate:

(a) the slip and rotor speed.
Slip $s = fr/fs = 2 / 60 = 0.0333$.
Synchronous speed $Ns = 120f/P = (120 \times 60)/4 = 1800$ rpm.
Rotor speed $Nr = (1 – s)Ns = (1 – 0.0333) \times 1800 = 1740$ rpm.

(b) the rotor copper loss.
Rotor copper loss = s × Pg. Power developed Pg = Torque × 2πN/60.
$= 150 \times 2\pi \times 1740 / 60 = 27{,}300$ W.
Rotor copper loss = 0.0333 × 27,300 = 910 W approx.

16. A consumer requires an immersion heater for a tank containing 200 litres of water. The water is to be heated from 10°C to 70°C in 4 hours. Calculate the nearest element size in kW if the efficiency of the heating system is 80%. Take specific heat capacity of water to be 4200 J/kgK.

Mass of water = 200 litres = 200 kg.
Temperature rise = 70 – 10 = 60°C.
Heat required $Q = mc\Delta T = 200 \times 4200 \times 60 = 50{,}400{,}000$ J.
Time = 4 hours = 4 × 3600 = 14,400 s.

Power required = Q/t = 50,400,000 / 14,400 = 3500 W.

Considering efficiency = 0.8, Input Power = 3500 / 0.8 = 4375 W = 4.38 kW.