THE UNITED REPUBLIC OF TANZANIA

NATIONAL EXAMINATIONS COUNCIL

CERTIFICATE OF SECONDARY EDUCATION EXAMINATION

181 ELECTRICAL INSTALLATION

(For Both School and Private Candidates)

Time: 3 Hours **ANSWERS** **Year: 2015**

Instructions

1. This paper consists of SIXTEEN questions.

2. Answer all questions in section A and B and THREE questions from section C.

(i) A d.c shunt motor is applied to run constant speed machines such as
A electric drills
B cranes and hoists
C conveyors
D centrifugal pumps
E electric locomotives

Answer: C conveyors
Reason: DC shunt motors maintain constant speed under varying load, ideal for conveyor applications.

(ii) A double wound transformer having 120 V in primary winding consists 600 turns. The value of volts per turn will be
A 0.5 V/turn
B 0.2 V/turn
C 5 V/turn
D 0.02 V/turn
E 2 V/turn

Answer: A 0.5 V/turn
Reason: Volts per turn = 120 V / 600 turns = 0.5 V/turn

(iii) Two 2-way switches and one intermediate switch can be used in a domestic lighting circuit to control lights from
A four positions
B two positions
C three positions
D five positions
E one position

Answer: C three positions
Reason: An intermediate switch allows three-position control in conjunction with two 2-way switches.

(iv) When measuring load current, an ammeter is always connected in
A series without load
B series-parallel with load
C parallel with load
D series with load
E parallel without load

Answer: D series with load
Reason: Ammeter must be in series so that the current flowing through the load also flows through it.

(v) The purpose of carrying polarity verification test in an installation is to make sure that

A insulation of the conductor is strong
B no leakage current occurs in an installation
C all fuses and switches are connected to live wire
D the resistance of earth continuity conductor is properly measured and obtained
E there is no short circuit between the current carrying conductors

Answer: C all fuses and switches are connected to live wire
Reason: Polarity test ensures live wire is properly identified and connected to the correct terminal.

(vi) The term efficacy as used in lighting system refers to
A the ratio of mounting height of the lamp to area of the illuminated room
B the ratio of lamp output in lumens to lamp power in watts
C the ratio of illumination output to mounting height of the lamp
D the ratio of the lamp output luminous intensity to lamp output lumens
E the lamp rating in candelas to the expected illumination in lux

Answer: B the ratio of lamp output in lumens to lamp power in watts
Reason: Lighting efficacy measures how effectively electrical power is converted into visible light.

(vii) What is the recommended cable size for supplying a domestic installation in Tanzania?
A A 16 mm^2 twin armoured cable
B A 25 mm^2 twin armoured cable
C A 6 mm^2 twin armoured cable
D A 4 mm^2 twin armoured cable
E A 2.5 mm^2 twin armoured cable

Answer: E A 2.5 mm^2 twin armoured cable
Reason: 2.5 mm^2 cable is standard for lighting and general-purpose socket outlets in homes.

(viii) Armature reaction in an a.c generator affects
A rotor speed
B terminal voltage per phase
C frequency of armature
D generated voltage per phase
E frequency of generated voltage

Answer: B terminal voltage per phase
Reason: Armature reaction distorts the flux and affects the voltage at the generator terminals.

(ix) A grid system is defined as
A a parallel operation of generators at high voltage
B a three phase 4 - wire distribution system
C a number of power stations connected together at high voltage

D a parallel operation of transformers at high voltage
E a parallel operation of switch gears at high voltage

Answer: C a number of power stations connected together at high voltage
Reason: A grid system interconnects several power stations to ensure reliability and stable supply.

2. Name two physical properties and one chemical property of a good insulator.
Physical properties:
- High electrical resistivity to restrict current flow.
- High dielectric strength to withstand high voltage without breakdown.
Chemical property:
- Resistance to chemical degradation or corrosion.

3. Mention three functions of the main switch gear in an electrical installation.
- To isolate the electrical supply from the entire installation for maintenance.
- To protect circuits and equipment from overload and short-circuits.
- To allow manual or automatic control of power distribution.

4. (a) (i) Briefly explain why is it necessary to use high voltage for transmission and distribution of electrical energy?
High voltage reduces current for the same power, which minimizes I^2R losses in conductors, improving efficiency and reducing conductor size.

(ii) Balance the loads on a three phase system?
Load balancing ensures that current in all three phases remains equal, reducing neutral current, avoiding overheating, and maintaining voltage stability.

(b) Why single-core armoured cable should not be used to carry a.c current?
AC current produces magnetic fields that induce eddy currents in the armour of single-core cables, causing heating and power loss due to the absence of return flux cancellation.

5. Explain the precaution that should be taken when the metallic conduit system is being installed to prevent each of the following:
(a) High resistance joints in the system
- Ensure joints are clean, tight, and properly aligned to maintain electrical continuity.

(b) Rusting of conduit and threads
- Use galvanized or corrosion-resistant conduits and apply anti-rust coating on threaded parts.

(c) Conduit blockages after erection
- Keep ends covered during installation and use proper bending techniques to avoid kinks that may trap wires.

6. Define the following terms as used in consumer circuits:
(a) Final sub circuit
- The last part of the electrical wiring system that directly supplies power to sockets, lights, or appliances.

(b) Domestic ring circuit
- A closed loop circuit supplying socket outlets, where both ends of the circuit are connected to the distribution board to ensure redundancy and balance.

(c) Spur of a ring circuit
- An additional branch taken from any point of the ring circuit to supply an extra socket or point, typically limited in length and load.

7. (a) Explain how the following can be measured:
(i) Current through a lighting point
- Connect an ammeter in series with the lighting circuit using a clamp meter or multimeter.

(ii) Voltage across a lighting point
- Connect a voltmeter in parallel across the lighting terminals to read the voltage supplied.

(b) Give one application of a clamp meter.
- Measuring current in a conductor without disconnecting it from the circuit.

8. (a) How does the speed of a compound motor be varied?
- By adjusting the field current, using series resistors, or varying the supply voltage to control the speed.

(b) Give two applications of an a.c universal motor.
- Electric drills
- Domestic food mixers

9. (a) What is the main purpose of inspecting and testing an electrical installation?
- To ensure safety, proper operation, and compliance with regulations before the installation is energized.

(b) What is the main objective of performing the following tests in an electrical installation?
(i) Continuity test
- To verify that all conductors and protective earth paths are electrically continuous.

(ii) Insulation resistance test
- To check for any leakage paths between live conductors and earth, ensuring proper insulation.

10. Mention three domestic and three industrial applications of electric heating.
Domestic:
- Water heaters
- Electric cookers

- Room heaters

Industrial:
- Drying ovens
- Melting furnaces
- Heat treatment of metals

11. (a) What type of d.c generator is suitable for constant voltage applications?
- Shunt wound d.c generator

(b) A 220 V d.c generator has an armature resistance of 0.5 Ω. If the full load armature current is 20 A, find the induced e.m.f of the generator.
$E = V + I \times Ra = 220 + (20 \times 0.5) = 220 + 10 = 230$ V
Induced e.m.f = 230 V
12. (a) Define the following terms:
(i) Resistivity
It is the property of a material that opposes the flow of electric current, defined as resistance per unit length and unit cross-sectional area. Its unit is ohm-centimeter (Ω·cm) or ohm-meter (Ω·m).

(ii) Temperature coefficient of a resistance
It is the ratio of the change in resistance per degree Celsius to the original resistance at 0°C, denoting how much resistance increases or decreases with temperature.

(b) Give three reasons why aluminium conductors are largely used in overhead transmission of electrical power.
- Aluminium is lightweight, reducing the load on towers and poles.
- It is cheaper than copper, making it cost-effective.
- It offers good conductivity to weight ratio, suitable for long-span installations.

(c) A PVC twin copper cable 50 m long has a total voltage drop of 8 V when carrying a d.c current of 40 A at 20°C. The resistivity of copper is 1.754 μΩ·cm. Calculate:
(i) The resistance of the cable
$V = I \times R \rightarrow R = V / I = 8 / 40 = 0.2\ \Omega$

(ii) Cross-sectional area of the cable (in cm²)
$R = \rho L / A \rightarrow A = \rho L / R$
$\rho = 1.754\ \mu\Omega\cdot cm = 1.754 \times 10^{-6}\ \Omega\cdot cm$
$L = 2 \times 50 = 100\ m = 10000\ cm$
$A = (1.754 \times 10^{-6} \times 10000) / 0.2 = 0.0877\ cm^2$

(iii) Current density of the cable
Current density = $I / A = 40 / 0.0877 = 456.2\ A/cm^2$

(iv) Power lost along the cable
$P = I^2 \times R = 40^2 \times 0.2 = 1600 \times 0.2 = 320$ W

(v) Power lost along the cable when temperature rises to 50°C ($\alpha = 0.0043/°C$)
New resistance = $R_2 = R_1[1 + \alpha(T_2 - T_1)]$
$R_2 = 0.2[1 + 0.0043 \times (50 - 20)] = 0.2[1 + 0.129] = 0.2 \times 1.129 = 0.2258\ \Omega$
$P_2 = I^2 \times R_2 = 1600 \times 0.2258 = 361.3$ W

13. A 20 kVA transformer was found to have 600 W iron losses and 700 W copper losses when supplying full load at 0.8 power factor. Calculate the efficiency on:
(a) Full load
Output = $20 \times 0.8 = 16$ kW
Total loss = $600 + 700 = 1300$ W
Efficiency = Output / (Output + Losses) × 100 = 16000 / (16000 + 1300) × 100
= 16000 / 17300 × 100 = 92.5%

(b) Half load
Output = $10 \times 0.8 = 8$ kW
Copper loss at half load = (700 / 4) = 175 W
Total loss = 600 + 175 = 775 W
Efficiency = 8000 / (8000 + 775) × 100 = 91.2%

14. By using two 2-way switches, one intermediate switch and two bulbs, draw the following circuits for bright light.
(a) Single line diagram
[To be provided as diagram]

(b) Schematic diagram
[To be provided as diagram]

(c) Wiring diagram
[To be provided as diagram]

15. (a) Describe three main types of tariffs.
- Flat rate tariff: Same rate per unit regardless of time or amount consumed.
- Block rate tariff: Different charges based on consumption blocks (e.g., first 50 units, next 100 units).
- Time-of-day tariff: Charges vary depending on usage time (peak/off-peak).

(b) Explain the meaning of the following terms as applied to electric tariffs. In each case give two examples:
(i) Standing costs
Fixed costs incurred regardless of usage, e.g., salaries, building rent.

(ii) Running costs

Variable costs depending on consumption, e.g., fuel, lubricants, water usage.

(c) The power consumer with constant maximum demand throughout a year is offered the following tariff: TZS 2,500/= per kVA of maximum demand plus TZS 150/= per unit.
Given: Maximum demand = 250 kW, Power factor = 0.7, Annual consumption = 350,000 units

(i) Annual cost
Maximum demand in kVA = 250 / 0.7 = 357.14 kVA
Cost = (357.14 × 2500) + (350000 × 150)
= 892,857.14 + 52,500,000 = TZS 53,392,857.14

(ii) Average price per unit
= Total cost / Total units = 53392857.14 / 350000 = TZS 152.6 per unit

16. (a) Briefly explain how to reverse the direction of rotation of each of the following types of motor:
(i) Three phase induction motor
- Interchange any two supply phases.

(ii) Single phase split-phase induction motor
- Reverse the connection of either the main winding or auxiliary winding.

(iii) Single phase universal motor
- Reverse connections to either the field winding or the armature winding.

(b) Draw the circuit of a capacitor-start single phase induction motor.

(c) A three-phase star connected motor takes 8 kW power at a power factor of 0.8 lagging from a 460 V, 3-phase supply. Calculate:
(i) Line current
$P = \sqrt{3} \times V \times I \times pf$
$I = P / (\sqrt{3} \times V \times pf) = 8000 / (1.732 \times 460 \times 0.8) = 8000 / 636.57 = 12.57$ A

(ii) Phase current
= Line current = 12.57 A (in star connection)

(iii) Phase voltage
$Vph = V / \sqrt{3} = 460 / 1.732 = 265.5$ V

(iv) Impedance per phase
$Z = Vph / Iph = 265.5 / 12.57 = 21.12\ \Omega$

(v) Resistance per phase

$P = 3I^2Rpf \rightarrow R = P / (3 \times I^2 \times pf)$
$R = 8000 / (3 \times 12.57^2 \times 0.8) = 8000 / (3 \times 158.04 \times 0.8) = 8000 / 379.3 = 21.09\ \Omega$