THE UNITED REPUBLIC OF TANZANIA

NATIONAL EXAMINATIONS COUNCIL

CERTIFICATE OF SECONDARY EDUCATION EXAMINATION

082 ELECTRICAL ENGINEERING SCIENCE

(For Private Candidates Only)

Time : 3 Hours **ANSWERS** **Year : 2014**

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).

(i) The magnitude of the induced e.m.f in a conductor depends on the

A. amount of the flux cut

B. amount of the flux linkage

C. rate of change of flux linkage

D. magnetic field strength

E. flux density of the magnetic field.

Correct answer: C. The induced e.m.f depends on the rate of change of flux linkage according to Faraday's law.

(ii) The SI unit of illuminance is

A. lumen

B. cd/m^2

C. lumen/m^2

D. candela

E. lumen/watt.

Correct answer: C. Illuminance is measured in lumen per square metre (lux).

(iii) If 0.0006 microfarad is converted to pico farads, the result will be

A. 0.0006×10^{-6} pF

B. 0.0006×10^{-13} pF

C. 0.0006×10^{-12} pF

D. 0.0006×10^{-9} pF

E. 0.0006×10^{6} pF.

Correct answer: E. 1 μF = 10^6 pF, so 0.0006 μF = 0.0006×10^6 pF = 600 pF.

(iv) Which is the lightest atom particle when compared to others?

A. electrons

B. nucleus

C. molecule

D. protons

E. neutrons.

Correct answer: A. Electrons are the lightest subatomic particles compared to protons, neutrons, molecules, or nuclei.

(v) What will happen if an ammeter is used as a voltmeter?

A. It will indicate higher reading

B. It will indicate no reading

C. It will indicate medium reading

D. It will burn out

E. It will give extremely low reading.

Correct answer: D. An ammeter has very low resistance; if used as a voltmeter, it would likely burn out due to high current.

(vi) The frequency of rotor current in a 6-pole, 50 Hz, 3-phase induction motor running at 950 r.p.m. is

A. 2.5 Hz

B. 1.5 Hz

C. 5 Hz

D. 0.05 Hz

E. 95 Hz.

Correct answer: A. Synchronous speed = (120 × 50)/6 = 1000 rpm. Slip = (1000 – 950)/1000 = 0.05. Rotor frequency = slip × supply frequency = 0.05 × 50 = 2.5 Hz.

(vii) Digital instruments are those which

A. have numerical readout

B. use LED or LCD displays

C. have a circuitry of digital design

D. contain electronic device

E. use deflection type meter movement.

Correct answer: A. Digital instruments provide numerical readout rather than deflection.

(viii) The deflection sensitivity of a cathode ray tube depends inversely on the

A. deflecting voltage

B. length of the vertical deflection plates

C. separation between Y-plates

D. distance between screen and deflecting plates

E. separation between X-plates.

Correct answer: D. Deflection sensitivity is inversely proportional to the distance between the screen and deflecting plates.

(ix) Which of the following frequencies has got longest period?

A. 1 Hz

B. 10 Hz

C. 1 kHz

D. 10 kHz

E. 100 kHz.

Correct answer: A. Period = 1/frequency. Lowest frequency (1 Hz) has the longest period (1 second).

(x) The voltage of the electric system connected in delta is given by

A. $\sqrt{}VL = 3\ VPH$

B. $VL = VPH$

C. $VL = \sqrt{3}\ VPH$

D. $VPH = \sqrt{3}\ VL$

E. $VPH = 3\ VL$.

Correct answer: C. In delta connection, line voltage = $\sqrt{3}$ × phase voltage.

2. The equation for an alternating current is given by $i = 28.28 \sin(314t + 30°)$ A. Find its r.m.s value and frequency.

The peak value of current is 28.28 A. The r.m.s value = $I_{max}/\sqrt{2} = 28.28/1.414 = 20$ A.
The angular frequency $\omega = 314$ rad/s. Frequency $f = \omega/2\pi = 314/6.28 = 50$ Hz.

3. Figure 1 shows an electric circuit in which some of the quantities are represented by numbers, others by letters. Calculate the values of X and R.

The total current entering the circuit is 6.4 A. Two branches carry 3.2 A each, so the parallel currents add up to 6.4 A. The branch with 5.2 A and the unknown X must also balance. Hence, by Kirchhoff's law, X = 1.2 A.

Using Ohm's law, R = V/I. The voltage across branch is the same. Suppose V = 5.2 × R = 3.2 × R. After solving, R = 2 Ω.

4. An eight pole lap connected armature has 96 slots with 6 conductors per slot and is driven at 25 r/s. The useful flux per pole is 0.09 Wb. Calculate the generated e.m.f.

Total conductors = 96 × 6 = 576.

Number of poles = 8. Number of parallel paths (lap winding) = 8.

Total turns per path = 576/8 = 72.

Generated e.m.f. Eg = (Φ × N × Z × P) / (60 × A).

Here, Φ = 0.09 Wb, N = 25 × 60 = 1500 rpm, Z = 576, P = 8, A = 8.

Eg = (0.09 × 1500 × 576 × 8) / (60 × 8) = (622080) / 480 = 1296 V.

5. Find the heat energy required to raise the temperature of 0.068 m^3 of water from 15°C to 80°C. The mass of 1 m^3 of water = 10^3 kg and the specific heat capacity of water is 4187 J/kg°C.

Mass of water = 0.068 × 1000 = 68 kg.

Temperature rise = 80 – 15 = 65°C.

Heat energy Q = mcΔT = 68 × 4187 × 65 = 18,497,660 J ≈ 1.85×10^7 J.

6. An electronic beam has a velocity of 10^7 m/s when it enters a magnetic field perpendicular to the direction of the flux. If the axial length of the magnetic field is 2 m. Calculate the
   (a) radius of the curvature of the electron path in the magnetic field.
   (b) angle through which the electron is deflected. Assume e/m = 1.76×10^{11} C/kg.

(a) Radius r = mv/eB. But using e/m, r = v / (B × e/m). Magnetic field length L = 2 m. Assume B = 1 T.

$r = 10^7 / (1 \times 1.76 \times 10^{11}) = 5.68 \times 10^{-5}$ m.

(b) Angle $\theta = L / r = 2 / (5.68 \times 10^{-5}) \approx 3.52 \times 10^4$ radians.

7. Mention six methods of identifying conductors.

By colour coding of insulation.

By size or diameter of the wire.

By resistance measurement.

By labelling or tagging.

By continuity testing with a multimeter.

By tracing from circuit diagrams or terminal markings.

8. Briefly, explain three advantages of three-phase system over a single phase system.

A three-phase system transmits more power compared to single-phase with the same current rating.

Three-phase machines are more efficient and self-starting, unlike single-phase which may need auxiliary means.

Voltage regulation and stability are better in three-phase systems than in single-phase systems.

9. What modifications would be necessary if a motor is required to operate on voltage which is different from that originally designed?

Use a transformer to step up or step down the supply voltage.

Rewind the motor windings to suit the new voltage.

Use an autotransformer starter or tap changer to match supply with motor rating.

10. Give three practical applications of chemical effect of electric current.

Electroplating of metals like gold, silver, or chromium.

Electrolysis for extraction of metals like aluminum and copper.

Charging of storage batteries like lead-acid accumulators.

11. (a) Define the term inverter as used in power supply.

An inverter is an electrical device that converts direct current (DC) into alternating current (AC) at the desired voltage and frequency.

(b) The main components which are really required for conversion from AC to DC are a transformer and a rectifier. Briefly explain the function of each in a power supply.

A transformer is used to step up or step down the incoming AC voltage to the desired level before rectification.

A rectifier converts the AC voltage from the transformer into a DC voltage by allowing current to flow in only one direction, using diodes or other semiconductor devices.

12. (a) Why are transformers used in electrical transmission and distribution systems?

Transformers are used to step up the voltage for long-distance transmission to reduce power loss due to I^2R losses.

They are also used to step down the voltage to safe levels suitable for distribution and usage in industries, commercial buildings, and homes.

(b) A step-down transformer has a turns ratio of 6:1. The input to the transformer is 3 kV at 1 kVA; calculate the value of the secondary current. Neglect losses.

Turns ratio = 6:1, so Vp/Vs = 6.
Primary voltage Vp = 3000 V.
Secondary voltage Vs = 3000/6 = 500 V.
Power = 1000 VA.
Secondary current Is = Power/Vs = 1000/500 = 2 A.

13. (a) A 600 kVA single-phase transformer when working at unity power factor has an efficiency of 92 % at full load and also at half load. Determine its efficiency when it operates at unity power factor and 60 % of full load.

Output at 60% = $0.6 \times 600 = 360$ kVA.

Efficiency η = Output / (Output + Losses).

At full load: Efficiency = 0.92 = 600 / (600 + Losses).

600 + Losses = 600/0.92 = 652.17.

So losses = 52.17 kW.

At 60% load: Output = 360. Losses = fixed + variable (load^2).

Losses total = $(\frac{1}{2} \times 52.17) + (0.6^2 \times \frac{1}{2} \times 52.17) \approx 26.09 + 18.78 = 44.87$.

Efficiency = $360 / (360 + 44.87) = 360 / 404.87 \approx 88.9$ %.

(b) Mention and explain three classifications of secondary instruments. In each case give one example of the instrument which falls under that category.

Indicating instruments – show the magnitude of an electrical quantity at a particular instant, e.g. ammeter, voltmeter.

Recording instruments – continuously record the variations of a quantity with respect to time, e.g. chart recorder.

Integrating instruments – measure the total quantity of electricity over a period of time, e.g. energy meter.

14. (a) A galvanometer has a resistance of 5 Ω between terminals and full scale deflection is obtained with a current of 0.015 A. The instrument is to be used with a manganin shunt to measure 10 A full scale. Calculate the error caused by a 20 °C rise in temperature when:

(i) The internal resistance is 5 Ω (no copper).

(ii) The galvanometer shunt is 1 Ω used in series with a copper resistor of 1 Ω.

(i) Shunt resistance $R_s = (I_g \times R_g) / (I - I_g)$.

$= (0.015 \times 5) / (10 - 0.015) = 0.075 / 9.985 \approx 0.0075\ \Omega$.

For manganin, temp coeff ≈ 0.00002/°C. Rise = 20°C. Error = negligible (~0.03%).

(ii) Copper resistance temp coeff = 0.004/°C.

20°C rise = 0.004 × 20 = 0.08 = 8 % increase.

Error in current measurement ≈ 8 %.

(b) Distinguish between line voltage and phase voltage.

In a star connection, line voltage = √3 × phase voltage.

In a delta connection, line voltage = phase voltage.

15. (a) A 15 kW, 440V three-phase d.c motor has an efficiency of 80% and a power factor of 0.6 when delivering its rated output. Calculate the line current input.

Output power = 15 kW. Efficiency = 0.8. Input power = 15/0.8 = 18.75 kW.

Input apparent power = P / pf = 18.75 / 0.6 = 31.25 kVA.

Line current = S / (√3 × V) = 31,250 / (1.732 × 440) = 31,250 / 761 ≈ 41 A.

(b) A 400 V (line to line) three-phase star connected load consists of 4 equal resistances in series with 3 Ω inductive reactance. Find:

(i) line current and

(ii) total power supplied.

Each phase: R = 4 Ω, XL = 3 Ω. Impedance $Z = \sqrt{(4^2 + 3^2)} = 5$ Ω.

Phase voltage = 400/√3 = 231 V.

Current per phase = 231/5 = 46.2 A.

Line current = 46.2 A.

Power per phase = V × I × cosφ. cosφ = R/Z = 4/5 = 0.8.

Power per phase = 231 × 46.2 × 0.8 = 8530 W.

Total power = 3 × 8530 ≈ 25.6 kW.

16. (a) State two laws mostly applied in the calculations of the illumination values.

Inverse square law – illuminance is inversely proportional to the square of the distance.

Lambert's cosine law – illuminance is proportional to the cosine of the angle of incidence.

(b) Why the inert gases, like argon and neon, are filled in fluorescent tubes or bulbs?

They reduce filament evaporation and protect the electrodes. They also help in maintaining a steady discharge.

(c) What do you understand by the term 'stroboscopic effect' as applied in the lighting system?

It is the optical illusion where a moving object appears stationary or moving differently due to fluctuations in light intensity from discharge lamps.

(d) Enumerate three factors which used to reduce stroboscopic effect in discharge lamps.

Using high frequency electronic ballasts.

Providing phase-shifted operation with multiple lamps.

Using lamps connected on different phases in three-phase supply.

(e) What is the luminous function of a photo meter as far as the lighting system is concerned?

It measures the luminous intensity, illuminance, or brightness of a light source to ensure correct lighting levels.

(f) A hall 15 m by 20 m is to be illuminated to a level of 70 lux, luminous having an efficiency of 20 lumens per watt and a depreciation factor of 0.8. Effective utilisation factor is 0.5. Calculate the power of each luminaire.

Area = $15 \times 20 = 300$ m².
Total lumens required = illuminance × area = $70 \times 300 = 21{,}000$ lumens.
Corrected lumens = $21{,}000 / (0.8 \times 0.5) = 21{,}000 / 0.4 = 52{,}500$ lumens.

Power required = 52,500 / 20 = 2625 W.

If each luminaire has one lamp, then each should be rated at about 2.6 kW.