

ROYAL CIVIL SERVICE COMMISSION  
BHUTAN CIVIL SERVICE EXAMINATION (BCSE) 2010  
EXAMINATION CATEGORY: TECHNICAL

**PAPER III: SUBJECT SPECIALIZATION PAPER for ELECTRICAL ENGG. /  
ELECTRICAL & ELECTRONICS ENGG. GROUP**

**Date** : 24<sup>th</sup> November 2010  
**Total Marks** : 100  
**Examination Time** : 2.5 Hours  
**Reading Time** : 15 Minutes (Prior to examination time)

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**READ THE FOLLOWING INSTRUCTIONS CAREFULLY:**

1. Write your Roll Number clearly on the Answer Booklet in the space provided.
2. **Do not write** for the first **15 minutes**. This time is to be spent in reading the question paper and to check if all questions and pages are correct and intact.
3. The **maximum time** allotted for writing this paper is **2.5 hours**.
4. All answers to the questions must be written in the separate **Answer Sheet** provided. You are not allowed to write anything on this Question Paper.
5. Use of programmable calculators is not allowed in this exam.
6. This paper consists of **TWO Sections – Section A and Section B**. Section A has two parts, Part I and Part II. Part I consists of 30 multiple choice questions carrying one (1) mark each and Part II consists of 4 short answer type questions carrying five (5) marks each. All questions under Section A are compulsory.

While answering the multiple choice questions, write only the letter of the correct answer chosen against the question number, clearly and legibly (Eg: Q1- c; Q2- b; etc.). Any double writing or smudgy answers shall not be evaluated.

7. Section B consists of **TWO (2)** Case Studies, out of which you must answer only ONE (1). The Case Study question carries 50 marks and the marks are allocated beside the questions.
8. Marks for answers to the short answer questions under Part II of Section A will be awarded based on the knowledge of the subject, clarity and preciseness of the responses, while answers to questions under Section B will be evaluated based on the ability to comprehend the case, apply your knowledge and present the case with solutions.
9. This paper has **ELEVEN (11) printed pages** in all, including this Instruction Page.

## SECTION A – Answer All the Questions

### PART I – MULTIPLE CHOICE QUESTIONS

Choose the correct answer and write down the letter of the correct answer chosen in the Answer Sheet against the question number. Each question carries ONE (1) mark.

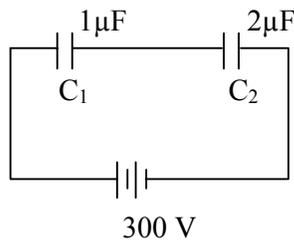
1. The unit of *resistivity* is:
  - a) ohm
  - b) ohm/m
  - c) ohm/m<sup>2</sup>
  - d) ohm-m
  
2. Which of the following material has a negative temperature coefficient of resistance?
  - a) brass
  - b) carbon
  - c) copper
  - d) aluminum
  
3. Superposition Theorem can be applied only to circuits having ..... elements.
  - a) linear bilateral
  - b) non-linear
  - c) passive
  - d) resistive
  
4. A diesel-electric generating set supplies an output of 25 kW. The calorific value of the fuel oil used is 12,500 kcal/kg. If the overall efficiency of the unit is 35%, the mass of oil required per hour will be:
  - a) 0.2 kg
  - b) 4.91 kg
  - c) 25 kg
  - d) 60.2 kg
  
5. In a hydroelectric generating station, the mean head available is 400 m. If the overall efficiency of the generating station is 0.7, how many litres of water will be required to generate 1 kWh of electric energy, assuming one litre water to have a mass of 1 kg?
  - a) 360 kg
  - b) 400 kg
  - c) 917 kg
  - d) 1310 kg
  
6. If a 220 V heater is used on a 110 V supply, the heat produced will be ..... as much.
  - a) one-fourth
  - b) one-half
  - c) twice
  - d) four times

7. Which of the following is zero inside a charged conducting sphere?

- a) potential
- b) electric intensity
- c) both (a) and (b)
- d) none of the above

8. In Fig. 1 below, the voltage across capacitor  $C_1$  will be:

- a) 100 V
- b) 150 V
- c) 200 V
- d) 300 V



**Fig. 1**

9. Permeability in a magnetic circuit corresponds ..... in an electric circuit.

- a) conductivity
- b) reluctance
- c) resistivity
- d) conductance

10. In a d.c. generator, the generated e.m.f is directly proportional to the:

- a) number of armature parallel paths
- b) number of dummy coils
- c) field current
- d) pole flux

11. ....states that “electromagnetically induced current always flows in such direction that the action of the magnetic field set up by it tends to oppose the very cause which produces it”.

- a) Lenz’s Law
- b) Gauss Law
- c) Millman’s Theorem
- d) Reciprocity Theorem

12. Which of the following instruments has its reading independent of the waveform and frequency of the a.c. supply?

- a) moving iron
- b) hot-wire
- c) induction
- d) electrostatic

13. Transformers are rated in kVA instead of kW because:
- it has become customary to manufacturers
  - load power factor is often unknown
  - total transformer loss depends on volt-ampere
  - kVA is fixed whereas kW depends on load p.f
14. The main purpose of performing open-circuit (or no-load) test on a transformer is to measure the:
- Cu loss
  - core loss
  - total loss
  - insulation resistance
15. The phenomenon of conduction of electricity without resistance at very low temperatures is called:
- superconductivity
  - relative conductivity
  - poor conductivity
  - none of the above
16. The equation  $(d^2x/dt^2) + (2dx/dt) + \sin x = f(t)$  represents a:
- linear system
  - non-linear system
  - time-varying system
  - discrete system
17. Table 1 below represents the truth table for a 2-input ..... logic gate.

**Table 1**

Inputs		Output
A	B	Y
0	0	0
0	1	1
1	0	1
1	1	1

- AND
- OR
- NOT
- NAND

18. The digital circuit shown in Fig. 2 below is a realization of which logical equation?



Fig. 2

- a)  $Y = A \cdot B + A \cdot B$
- b)  $Y = A \cdot B + A \cdot B$
- c)  $Y = A \cdot B + A \cdot B$
- d)  $Y = A \cdot B + A \cdot B$

19. The root locus is a plot of the characteristic equation of a closed loop system as a function of the gain. It incorporates both the transient response and the frequency response methods.

The main objective of drawing/plotting the root locus is to find the:

- a) stability of the system
- b) time response of the system
- c) frequency response of the system
- d) roots of the characteristic equation for different values of the system parameters

20. In the equation  $P = \sqrt{3}VI \cos \Phi$ , which represents power in a 3-phase system,  $\Phi$  is the angle between:

- a) line voltage and line current
- b) phase voltage and phase current
- c) line voltage and phase current
- d) phase voltage and line current

21. In an a.c. circuit, the ratio kW/kVA represents:

- a) power factor
- b) load factor
- c) form factor
- d) diversity factor

22. If three similar resistors are connected in star across a 400 V, 3-phase lines with a line current of 5A, the value of each resistor will be:

- a) 26.6  $\Omega$
- b) 46.2  $\Omega$
- c) 80  $\Omega$
- d) 2000  $\Omega$

23. A Wheatstone Bridge is a device suitable for the measurement of:

- a) very high resistance
- b) very low resistance
- c) medium resistance
- d) none of the above

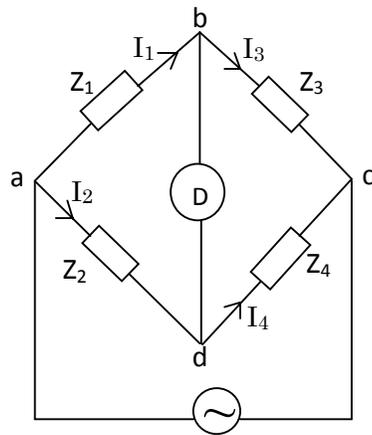
24. From the point of view of safety, the resistance of an earthing electrode should be:

- a) low
- b) high
- c) medium
- d) very high

25. The source of emission of electrons in a CRT (Cathode Ray Tube) is:

- a) PN junction diode
- b) a barium and strontium oxide coated cathode
- c) accelerating anodes
- d) post-accelerating anodes

26. In order for the a.c. bridge given in Fig. 3 to be balanced, which of the following conditions apply?



**Fig 3**

- a)  $I_1=I_3$  and  $I_2=I_4$
- b)  $Z_1Z_4 = Z_2Z_3$
- c)  $\angle\theta_1 + \angle\theta_4 = \angle\theta_2 + \angle\theta_3$
- d) all of the above

27. The necessity for interrupting small inductive current arises while disconnecting transformers on no-load. When interrupting such low inductive currents, the rapid deionization of contact space and blast effect may cause the current to be interrupted before its natural zero.

The phenomenon of interruption of current before its natural zero is called:

- a) current disruption
- b) current balancing
- c) current chopping
- d) none of the above

28. The rated normal current of a circuit breaker is the ..... value of current which the circuit breaker can carry continuously and with temperature rise of the various parts within specified limits.

- a) rms
- b) highest
- c) lowest
- d) specified

29. Which of the following is NOT TRUE about SF<sub>6</sub> circuit breakers?

- a) requirement of SF<sub>6</sub> gas is small due to re-circulation
- b) there is no danger of fire or explosion
- c) there is no over-voltage problem
- d) SF<sub>6</sub> gas is non-poisonous under any circumstance

30. The 1020 MW Tala Hydroelectric Project has ..... generators in the underground power house:

- a) two 510 MW
- b) four 255 MW
- c) six 170 MW
- d) ten 102 MW

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## PART II- SHORT ANSWER QUESTIONS

Answer all questions. Each question carries FIVE (5) marks.

1. Two capacitors A and B are connected in series across a 100V supply and it is observed that the potential differences across them are 60V and 40V respectively. A capacitor of  $2\mu\text{F}$  capacitance is then connected in parallel with capacitor A and the potential difference across capacitor B rises to 90V. Calculate the value of capacitors A and B. Draw appropriate circuit diagrams to illustrate your answer.
2. What is corona loss in transmission lines? List and briefly explain any three factors that affect corona loss. What is disruptive critical voltage?
3. Write the Boolean expression for output C of Fig. 4 and verify the results with a truth table.

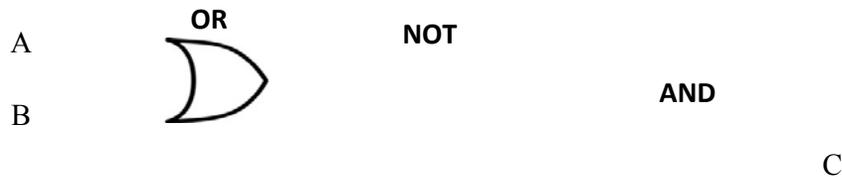


Fig. 4

4. A circuit consists of four 100-W lamps connected in parallel across a 230V supply. Inadvertently, a voltmeter has been connected in series with the lamps, as shown in Figure 5 below. The resistance of the voltmeter is  $1500\ \Omega$  and that of the lamps under the conditions stated is six times their value when burning normally. What will be the reading of the voltmeter?

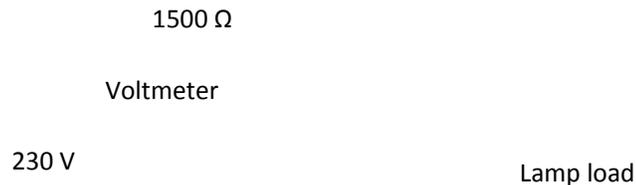


Fig. 5

**SECTION B – CASE STUDY - Answer only ONE (1) Question**

Q1. The Utility Company has planned for the improvement and up-gradation of the power transmission and distribution for the Mega City in view of its accelerated growth over the recent years. The Utility while preparing the plan has submitted the proposal as follows:

- Construction of a 400kV double circuit ring-main transmission network connecting major Substations of A, B, C and D where all will be located in the outskirts of the city;
- The 200kV system has been chosen as the transmission feeders to the City load centers emanating from those four main substations;
- The power from the two thermal stations (TS1 & TS2) is planned for connecting the Substation B at 400kV while the 1500 MW hydroelectric power station located at a distance of 800 km is planned for connecting with the substation D through the HVDC bi-pole link;
- A large nuclear power station already supplying power to another distant city via 765kV double circuit line is planned for connecting the ring-main Substation C through the Loop-In-Loop-Out (LILO) arrangement and this substation also feeds the nearby industrial load at 132kV.

Given the above information, answer the following:

- i) Draw a conceptual single-line diagram of the power supply network being proposed for the mega city. Show the schematics for HVDC and LILO connections to the ring-main system. (20 Marks)
- ii) If the HVAC substations were to be built with the bus bar system involving a breaker and a half scheme, illustrate the working of such a scheme. What are its main advantages? (7 Marks)
- iii) For the substations to be constructed, the engineers will have to ensure that the earthing system is effective through validation of tests carried out over several periods of the year. If you were to be engaged as one of the engineers in the project, explain how the fall of potential method can be employed for ascertaining the correct value of the earth's resistance. Illustrate with the help of the circuit diagram and graphs as well. (15 Marks)
- iv) What are the commonly used devices for protection against lightning surges at a substation? Explain how the Overhead Ground Wires provide protection against direct lightning strokes. (8 Marks)

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Q2. A nation endowed with huge hydropower potential has identified development of its hydropower potential under its common minimum programme to achieve a capacity of 50,000MW by 2030. This initiative was adopted mainly to enhance the power generation to meet the growing internal demand and for export of electricity so as to stimulate the growth of industries and earn revenues for the socio-economic development of the country. However, all the project sites are located far away from the load centers. In an effort to realize the set target, the agency entrusted with the responsibility to achieve the target has initiated on the following:

- Engagement of national and international consultants to carry out and prepare the necessary and definitive prefeasibility studies and the detailed project reports.
- Engagement of an international consultant to develop a transmission master plan so as to ensure the reliable supply of electricity in the country and ensure smooth evacuation of export power.
- Seeking financial resources from the national and international financial institutions for the commitment of funds for the development of hydropower projects confirmed for development.

Considering the advanced stage of the above initiatives, answer the following;

- i) The transmission costs as per the master plan study team have been found to be high, explain? List down the possible voltage levels to be considered in the master plan given the capacity of potential to be developed and why? What would be the purpose of undertaking such a transmission master plan study? (8 Marks)
- ii) Describe the various components of a hydropower plant with the help of the schematic diagram and also discuss on the merits and demerits of the hydroelectric plants. (15 Marks)
- iii) The choice of frequency to be adopted has been debated among the experts and ultimately 50Hz has been chosen instead of the possible 60Hz considering the involvement of long transmission lines for the evacuation of power from the hydroelectric plants. Explain why 50Hz is preferable to 60Hz under such a case. If the power is to be distributed at 60 Hz, what economic advantage would it entail? (10 Marks)
- iv) If one of the potential hydroelectric project sites has been estimated with a minimum runoff of about  $112 \text{ m}^3/\text{sec}$  and the head available has been determined to be 175 m, what would be the firm capacity of the project and its yearly gross output assuming the efficiency of the plant to be 90%. If the plant is to be built as a stand-alone project, what should be the rating of the generator assuming a load factor of 40%? Also, the study confirmed the per-unit cost of power production from the hydroelectric plants to be the determining factor in the economics of its development with certain rate of depreciation considered per annum. List the different types of depreciation methods applicable and which method would you apply and why? (12 Marks).

- v) The project authority formed for construction of one of the remote hydropower project desires to install a diesel generator to meet the initial power supply requirements at the project site having the following particulars:
- 100 camp houses with average connected load of 1.5 kW in each camp. The demand factor and the diversity factor being assumed 0.4 and 2.5 respectively;
  - Ten locations having heavy duty construction machines with maximum overall demand of 100 kW;
  - Seven tunneling machines of 8 kW each and operating together in the morning.

The diversity factor among the above three types of loads is 1.2. What should be the minimum capacity of the diesel plant to be installed at site? (5 Marks)

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