

**ROYAL CIVIL SERVICE COMMISSION
BHUTAN CIVIL SERVICE EXAMINATION (BCSE) 2025
EXAMINATION CATEGORY: TECHNICAL**

PAPER III: SUBJECT SPECIALISATION PAPER FOR ELECTRICAL ENGINEERING

Date	:	October 11, 2025
Total Marks	:	100
Writing Time	:	150 minutes (2.5 hours)
Reading Time	:	15 minutes (prior to writing time)

GENERAL INSTRUCTIONS:

1. Write your Registration Number clearly and correctly on the Answer Booklet.
2. The first 15 minutes is provided to check the number of pages of the Question Paper, printing errors, clarify doubts and to read the instructions. You are NOT permitted to write during this time.
3. This paper consists of **TWO SECTIONS**, namely SECTION A & SECTION B:
 - **SECTION A** has two parts: Part I - 30 Multiple Choice Questions
 Part II - 4 Short Answer Questions
 All questions under SECTION A are **COMPULSORY**.
 - **SECTION B** consists of two Case Studies. Choose only **ONE** case study and answer the questions of your choice.
4. All answers should be written on the Answer Booklet provided to you. Candidates are not allowed to write anything on the question paper. If required, ask for additional Answer Booklet.
5. All answers should be written with correct numbering of Section, Part and Question Number in the Answer Booklet provided to you. Note that any answer written without indicating the Section, Part and Question Number will NOT be evaluated and no marks will be awarded.
6. Begin each Section and Part on a fresh page of the Answer Booklet.
7. You are not permitted to tear off any sheet(s) of the Answer Booklet as well as the Question Paper.
8. Use of any other paper including paper for rough work is not permitted.
9. **You must hand over the Answer Booklet to the Invigilator before leaving the examination hall.**
10. This paper has **9 printed pages**, including this instruction page.

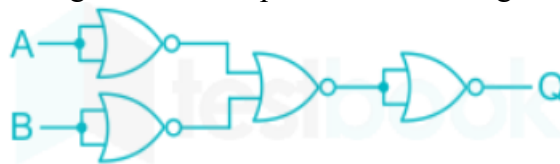
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SECTION A

PART I: Multiple Choice Questions [30 marks]

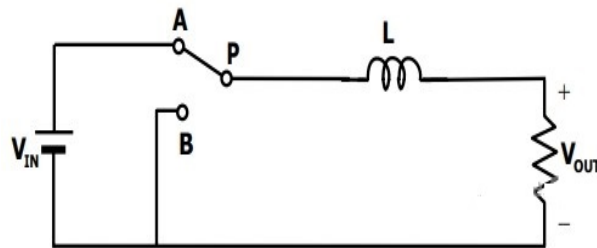
Choose the correct answer and write down the letter of your chosen answer in the Answer Booklet against the question number e. g. 31 (d). Each question carries ONE mark. Any double writing, smudgy answers or writing more than one choice shall not be evaluated.

1. In an open loop control system:
 - a) Output is independent of control input
 - b) Output is dependent on control input
 - c) Only system parameters have effect on the control output
 - d) None of the above
2. A system with poles at -1, -2, and +3 is:
 - a) Marginally stable
 - b) Unstable
 - c) Stable
 - d) Conditionally stable
3. The Nyquist sampling rate is given by:
 - a) $F_s = 2 F_m$
 - b) $F_s = 3 F_m$
 - c) $F_s = 4 F_m$
 - d) $F_s = F_m$
4. Which of the following is a universal gate:
 - a) NAND
 - b) NOT
 - c) OR
 - d) AND
5. The resulting logic circuit obtained when both inputs of NOR and NAND gates are connected together is:
 - a) AND
 - b) XOR
 - c) OR
 - d) NOT
6. The output of logic circuit given below representgate:



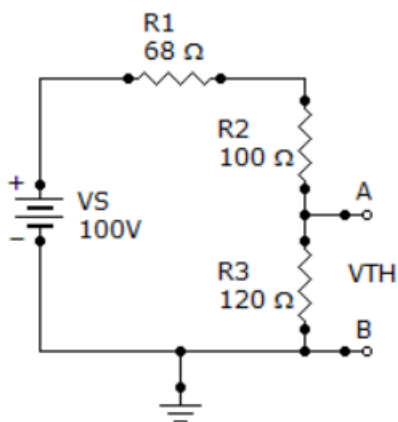
- a) OR
- b) NOR
- c) AND
- d) NAND

7. How much time is the output power of a full bridge inverter to a half bridge inverter?
- Four times
 - One time
 - Two times
 - Three times
8. In a Boost converter, the output voltage is always:
- Equal to the input voltage
 - Greater than the input voltage
 - Less than the input voltage
 - 200 Volts
9. The power electronic converter shown in the figure below has a single-pole double-throw switch. The pole P of the switch is connected alternately to throw A and B . The converter shown is a:



- Buck converter
 - Boost converter
 - Half wave rectifier
 - Chopper converter
10. Which of the following devices is used to measure relatively high temperatures, such as encountered in furnaces:
- Barometer
 - Ammeter
 - Pyrometer
 - Fluxmeter
11. A voltmeter is connected in a with the circuit component across which potential difference is to be measured:
- Parallel
 - Series
 - Series or parallel
 - None of the above
12. A heater is rated as 230 V, 10 kW, A.C. The value 230 V refers to:
- Average voltage
 - peak voltage
 - r.m.s. voltage
 - none of the above

13. Four capacitors each of $40\ \mu\text{F}$ are connected in parallel, the equivalent capacitance of the system will be:
- a) $160\ \mu\text{F}$
 - b) $10\ \mu\text{F}$
 - c) $40\ \mu\text{F}$
 - d) $5\ \mu\text{F}$
14. Find the Thevenin equivalent (V_{TH} and R_{TH}) between terminals A and B of the circuit given below.



- a) $4.16\text{ V}, 120\ \Omega$
 - b) $41.6\text{ V}, 120\ \Omega$
 - c) $4.16\text{ V}, 70\ \Omega$
 - d) $41.67\text{ V}, 70\ \Omega$
15. When short circuit occurs, voltage in circuit will be:
- a) Nearly Zero
 - b) Rated supply voltage
 - c) Cannot be determined
 - d) Infinite
16. Which variables are specified by slack bus in the load flow studies:
- a) $|V|, P$
 - b) $|V|, \delta$
 - c) P, Q
 - d) Q, δ
17. Four identical alternators each are rated as 20 MVA, 11 kV having a subtransient reactance of 16% are working in parallel. The short circuit level at the busbar is:
- a) 500 MVA
 - b) 400 MVA
 - c) 125 MVA
 - d) 100 MVA

18. If the fault current is 2000 A, the relay setting is 50% and CT ratio is 400 : 5, then plug setting multiplier will be:
- a) 10
 - b) 15
 - c) 25
 - d) 50
19. Over excitation synchronous phase modifier works as:
- a) Series capacitor
 - b) Shunt reactor
 - c) Shunt capacitor
 - d) None of the above
20. The transmission voltage levels in Bhutan are:
- a) 765 kV, 400 kV, 220 kV, 132 kV
 - b) 400 kV, 220 kV, 132 kV, 66 kV
 - c) 800 kV, 400 kV, 220 kV, 132 kV
 - d) 800kV, 765 kV, 400 kV, 220 kV
21. The zero-sequence current flows in a power system during:
- a) Line to line fault
 - b) Double line to ground fault
 - c) Symmetrical three phase fault
 - d) Open conductor fault
22. The main purpose of a tap-changing transformer is to:
- a) Increase fault current
 - b) Reduce harmonics
 - c) Improve power factor
 - d) Regulate voltage
23. The back EMF in a DC motor is given by:
- a) $E_b = V + I_a R_a$
 - b) $E_b = V - I_a R_a$
 - c) $E_b = V \times I_a$
 - d) $E_b = V/I_a$
24. The slip of a 4-pole, 50 Hz induction motor running at 1440 rpm is:
- a) 2 %
 - b) 4 %
 - c) 6 %
 - d) 8 %
25. A synchronous motor operates at unity power factor when:
- a) Field current is adjusted for zero reactive power
 - b) It is under-excited
 - c) It is over-excited
 - d) Load torque is maximum

26. Why does an induction motor never run at synchronous speed?
- a) Rotor windings would burn out
 - b) No relative motion means no induced current/torque
 - c) Back EMF would exceed supply voltage
 - d) This is incorrect, induction motors can reach synchronous speed
27. A transformer works on the principle of:
- a) Self – induction
 - b) Mutual – induction
 - c) Electrostatic induction
 - d) Electromagnetic conduction
28. The frequency of electrical grid in Bhutan is:
- a) 50 Hz
 - b) 55 Hz
 - c) 60 Hz
 - d) 100 Hz
29. What percentage of Bhutan's total electricity generation comes from hydropower?
- a) 50 – 60 %
 - b) 70 – 80 %
 - c) 99 – 100 %
 - d) 30 – 40 %
30. The agency responsible for overall power system planning in Bhutan is:
- a) Bhutan Power Corporation Limited
 - b) Bhutan Power System Operator
 - c) Department of Energy
 - d) Druk Green Power Corporation Limited

PART II – Short Answer Questions [20 marks]

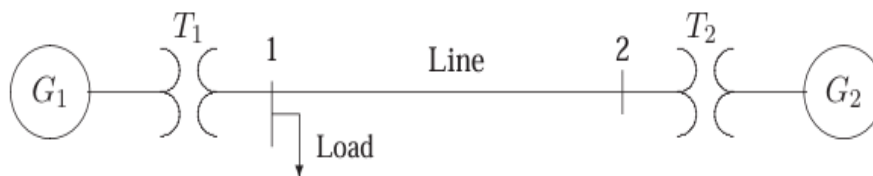
This part has 4 Short Answer Questions. Answer ALL the questions. Each question carries 5 marks. Mark for each sub-question is indicated in the brackets.

1. A power is exported to India from one of the hydropower plants through a three-phase, 50-Hz, completely transposed 400 kV, 150 km transmission line. The line has the following positive sequence constants:
 - $z = 0.032 + j0.35 \Omega/\text{km}$
 - $y = j4.2 \times 10^{-6} \text{ S/km}$

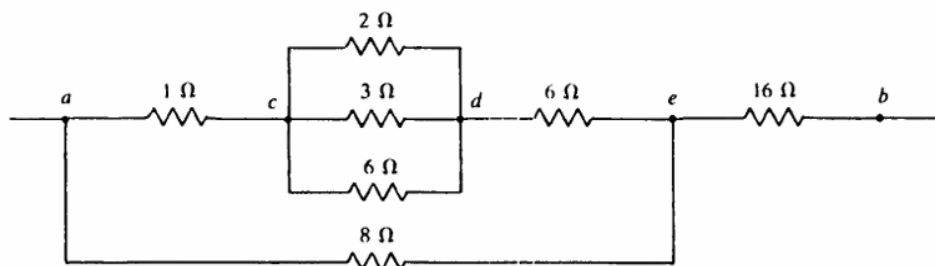
Full load at the receiving end of the line is 700 MW at 0.99 p.f. leading and at 95% of rated voltage. Assuming a medium length line, compute A, B, C, and D parameters. **(5 marks)**

2. Draw an impedance diagram for the electric power system shown in Figure below showing all impedances per unit on a 100 MVA base. Choose 20kV as the voltage base for generators. The three-phase power and line-line ratings are given below. **(5 marks)**

- G1: 90MVA 20kV X=9%
- T1: 80MVA 20/200kV X=16%
- T2: 80MVA 200/20kV X=20%
- G2: 90MVA 18kV X=9%
- Line: 200kV X=120
- Load: 200kV S=48MW + sj64Mvar



3. Reduce the circuit between the terminals a and b, to a single resistor in the figure given below. **(5 marks)**



4. In a factory, a three-phase, 4-kV, 400-kVA synchronous machine is installed along with other induction motors. The following are the loads on the machine:

- Induction motors: 500 kVA at 0.8 power factor lagging
- Synchronous motor: 300 kVA at unity power factor

Determine the overall power factor of the factory loads.

(5 marks)

SECTION B: CASE STUDY [50 marks]

Choose either CASE I OR CASE II from this section. Each case study carries 50 marks. Mark for each sub-question is indicated in the brackets.

CASE I

Bhutan has officially launched the National Energy Policy 2025 (NEP 2025) with the vision of transforming the country's power sector through modernization, diversification, and sustainability. The policy sets ambitious targets of achieving 25,000 MW installed capacity by 2040, of which 20,000 MW is expected from hydropower and 5,000 MW from solar. The policy also emphasizes private and foreign investment, promotion of pumped storage and hybrid systems, and adoption of energy efficiency, grid flexibility, and smart technologies.

In the context of NEP 2025, answer the following questions:

1. Explain how integrating the solar PV and pumped storage with hydropower enhances grid reliability and addresses winter shortages? **(5 marks)**
2. Define the concept of grid inertia. How does large-scale integration of inverter-based solar PV affect system inertia and stability? **(5 marks)**
3. Describe how black-start capability could be affected in a grid with high solar penetration. **(5 marks)**
4. Propose two strategies to address seasonal variation of hydropower generation in line with NEP 2025. **(5 marks)**
5. Total Harmonic Distortion (THD) at the substation bus was measured as 7%. State IEEE recommended limits for THD and suggest two mitigation measures. **(5 marks)**
6. The PV modules have a rating of 400 W each at STC.
 - i. Estimate the total number of modules required for the 100 MWp solar plant. **(3 marks)**
 - ii. If the modules are connected in strings of 25, how many strings are needed? **(2 marks)**
7. The plant with 100 MWp is planned with an inverter loading ratio (ILR) of 1.2.
 - i. Calculate the required AC inverter capacity (MW). **(2 marks)**
 - ii. If each inverter is rated at 2.5 MW, how many inverters are needed? **(3 marks)**
8. Explain how phasor measurement units (PMUs) can improve monitoring of renewable-rich grids. **(5 marks)**
9. Describe one example of how artificial intelligence (AI) could support Bhutan's grid operations under NEP 2025. **(5 marks)**
10. Suggest one policy-oriented research area universities in Bhutan could focus on to strengthen NEP 2025 implementation. **(5 marks)**

CASE II

A 220 kV double-circuit transmission line connects a large hydropower plant (600 MW) to a regional load center. The system recently experienced multiple disturbances:

- A single line-to-ground fault causing relay misoperation,
- Power swings during sudden load rejection,
- Voltage instability during peak demand.

As an electrical engineer in the transmission utility, you are tasked with analyzing the situation. In this context, answer the following questions:

1. Define power system stability and differentiate between transient, dynamic, and steady-state stability. **(6 marks)**
2. Explain the equal area criterion and its application in transient stability analysis **(5 marks)**
3. What is the role of system inertia in power system stability? **(4 marks)**
4. If the line reactance is 0.3 pu on a 100 MVA base and the sending and receiving voltages are equal, determine the maximum power transfer capability using the power angle equation. **(5 marks)**
5. A fault occurs at 90% of the line length from the sending end. Explain how a distance relay determines the fault location using impedance measurement and time delay **(6 marks)**
6. Explain the difference between radial and ring distribution systems. Discuss their reliability and fault isolation characteristics. **(4 marks)**
7. During a three-phase fault at the middle of the line, the measured fault current was 10 kA. If the CT ratio is 1000:1, calculate the secondary current entering the relay. **(4 marks)**
8. Define the concept of voltage stability margin and describe how it can be monitored using PV and QV curves. **(6 marks)**
9. Compare the use of SVC and STATCOM for reactive power support on this line. Which is better and why? **(5 marks)**
10. A generator is operating at 0.85 lagging power factor. Explain the impact of this condition on reactive power demand and voltage regulation **(5 marks)**

TASHI DELEK