**ROYAL CIVIL SERVICE COMMISSION**

**BHUTAN CIVIL SERVICE EXAMINATION (BCSE) 2014**

**EXAMINATION CATEGORY: TECHNICAL**

**PAPER III: SUBJECT SPECIALIZATION PAPER for *Electrical/Electrical & Electronics Engineering***

**Date** : 12 October 2014

**Total Marks** : 100

**Examination Time** : 150 minutes (2.5 hours)

**Reading Time** : 15 Minutes (prior to examination time)

**GENERAL INSTRUCTIONS:**

1. Write your Roll Number clearly and correctly on the Answer Booklet.
2. The first 15 minutes is being provided to check the number of pages of 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 and 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 under your choice.
1. 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 any or correct Section, Part and Question Number will NOT be evaluated and no marks would be awarded.
2. Begin each Section and Part in a fresh page of the Answer Booklet.
3. You are not permitted to tear off any sheet(s) of the Answer Booklet as well as the Question Paper.
4. Use of any other paper including paper for rough work is not permitted.
5. You are required to hand over the Answer Booklet to the Invigilator before leaving the examination hall.
6. This paper has **14** printed pages in all, including this instruction page.

**GOOD LUCK!**

**SECTION A**

**PART I – Multiple Choice Questions (30 Marks)**

**Choose the correct answer and write down the letter of the correct answer chosen in the Answer Booklet against the question number {eg. 1 a), 2 b), and so on}. Each question carries ONE (1) mark. Any double writing, smudgy answers or writing more than one choice shall not be evaluated.**

1. Effective impedance of a parallel resonance circuit will be
2. R
3. $\frac{L}{CR}$
4. $\frac{V}{R}$
5. $\frac{wL}{R}$
6. The electromotive force can be defined as
7. The force developed in an electromagnet
8. The voltage produced by unidirectional electromagnetic waves
9. The voltage produced by a current source
10. The voltage produced by a voltage source
11. The Ohm’s Law can be applied only when the circuit fulfils the following condition(s)
12. Current should be proportional to the voltage
13. Voltage should remain constant
14. Temperature should remain constant
15. All of the above
16. WLED stands for
17. White Lead Emitting Diode
18. White Liquid Emitting Diode
19. White Light Emitting Display
20. White Light Emitting Diode
21. If you want less distortion of signal and more output power, you will use
22. Push Pull Amplifier
23. Negative Feedback Amplifier
24. Differential Amplifier
25. Operational Amplifier
26. Binary number equivalent of decimal number 999 is
27. 1111100111
28. 1111110111
29. 1111100110
30. 1111100101
31. If two given impedances of Z1= (3+j4) and Z2 = (4+j3) are connected in series, then the equivalent impedance will be
32. 5 /600
33. 7 /900
34. 10 /450
35. 10 /86.60
36. The voltage across terminal P and Q, VPQ is

 6V 2Ω P

 12V

 5A 1Ω

 Q

1. 12V
2. 6V
3. 4V
4. 2V
5. The magnetic induction near a long, straight conductor, such as wire, varies inversely as the distance from the conductor and directly as the intensity of the current in the conductor. This is called
6. Coulomb’s Law
7. Biot Savart Law
8. Gauss’s Theorem
9. Ampere’s Law
10. PLCC stands for
11. Power Line Communication Cable
12. Power Load Communication Carrier
13. Power Line Carrier Communication
14. Power Load Carrying Capacity
15. The phenomenon of field and current concentration close to the surface of the conductor due to rapid attenuation of field inside the conductor is called
16. Ohm’s effect
17. Electromagnetic concentration effect
18. Corona effect
19. Skin effect
20. For a distortionless transmission line, the line parameters are related as
21. $\frac{R}{G}=\frac{L}{C}$
22. $\frac{R}{G}=\frac{C}{L}$
23. RG = LC
24. $\frac{R}{L}=\frac{G}{C}$
25. The current flow mechanism in semiconductor is due to
26. Drift only
27. Diffusion only
28. Convection only
29. Drift and diffusion
30. When positive terminal of the battery is connected to n-side and negative terminal to p-side of the p-n junction, the p-n junction becomes
31. Forward biased
32. Reverse biased
33. Unbiased
34. None of the above
35. If one hour rating of a machine is √3 times its continuous rating and if steady temperature rise for one hour rating is twice that on normal load, the ratio of iron loss to copper loss at full load will be
36. Equal
37. 2
38. 0.5
39. 4
40. Humming sound produced by transformer is due to
41. Hysteresis loss
42. Eddy current loss
43. Copper loss
44. Corona loss
45. If the voltage is kept constant in a transformer, the relationship between hysteresis loss and frequency will be given by
46. Hysteresis loss is directly proportional to frequency
47. Hysteresis loss will remain constant regardless of change in frequency
48. Hysteresis loss is inversely proportional to frequency
49. Hysteresis loss will double for every squared frequency
50. Two wattmeter method is used to measure power flowing in a 3-phase, 3-wire balanced load system. If the readings of two wattmeters are +7500 Watt and −1500 Watt, the power factor of the system will be
51. 0.259
52. 0.573
53. 0.358
54. 0.423
55. The production of a voltage difference across an electrical conductor, slanting to an electric current in the conductor and a magnetic field perpendicular to the current is called
56. Hall effect
57. Electromagnetic effect
58. Electrostatic effect
59. Thermal effect
60. Equivalent circuit of a short transmission line (upto 80 km) can be represented by
61. Series Resistance and Capacitance
62. Series Resistance and Inductance
63. Series Resistance, Inductance and Capacitance
64. Shunt Inductance and Conductance
65. A closed loop feedback control system which is used to control position, velocity or acceleration is called
66. Servo mechanism
67. Regulator
68. Detector
69. Transformer
70. In Boolean Algebra, A+A+A+A is
71. 1
72. $\frac{A}{4}$
73. 4 A
74. A
75. The output function ‘F’ of the given Figure is

A

NAND

B F

NAND

A

NAND

B

a) AB + AB

b) A + AB

c) AB + B

d) AB + AB

1. In a direct current (DC) motor, when a current carrying conductor is placed in a magnetic field, it produces a mechanical force whose direction is given by
2. Right Thump Rule
3. Fleming’s Right Hand Rule
4. Fleming’s Left Hand Rule
5. Kirchhoff’s Rule
6. A shunt generator delivers 100 Ampere at 200 Volts. If its shunt field resistance is 100 Ω and armature resistance is 0.05 Ω, the electromotive force (emf) generated will be
7. 205.1 Volts
8. 200.5 Volts
9. 199.5 Volts
10. 194.9 Volts
11. The transformer is not used in a direct current (DC) power system because
12. harmonics developed in the transformer will cause large distortion of voltage
13. there is no need to step up the DC voltage
14. DC Transformers will have high losses
15. Faraday’s law is not applicable as the rate of change of flux is zero
16. Demand factor is the ratio of
17. average load to the maximum load of a generating station
18. kWh delivered by a generating station in a day to twenty four hours
19. number of units of energy supplied in a specified period to maximum number of units of energy that can be supplied
20. average demand to the rated capacity
21. If the receiving end voltage of a transmission line is Vr and the sending end voltage is Vs with their phase angle difference (torque angle) of β, and reactance of the line is X with negligible Resistance, then the power transmitted by the line will be given by

 Vs Vr

1. --------------------- sin β

 X

 Vs Vr

1. --------------------- cos β

 X

 Vs Vr

1. --------------------- tan β

 X

 Vs Vr

1. --------------------- log β

 X

1. For transmitting 11 MW of power over a distance of 260 km, the most suitable voltage level will be
2. 11 kV
3. 33 kV
4. 66 kV
5. 220 kV
6. If a three-phase circuit breaker is rated at 1250A, 2000MVA, 33kV and 4Sec, its rated symmetrical breaking current (rms) will be about
7. 61kA
8. 1.25kA
9. 35kA
10. 89kA

**PART II – Short Answer Type Questions (20 Marks)**

**Answer ALL the questions. Each question carries 5 marks. Mark for each sub-question is indicated in the brackets.**

1. As part of a student’s project work, he constructs the following logic circuit.

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1. From the logic circuit above, write down the Boolean expressions for:

D = ……………………………………………………………… (1mark)

E = ……………………………………………………………… (2 marks)

1. Write down the Boolean expression for Q in terms of D and E. (2 marks)

2. Inside a microprocessor, a logic circuit called a binary half adder is used to add two 1-bit binary numbers. The basic building block of such a circuit is shown below:

**binary half adder**

 bit **A** Sum of the bits, **S**

 bit **B** carry, **C**

The device operates as shown in the following truth table.

|  |  |  |  |
| --- | --- | --- | --- |
| **A** | **B** | **S** | **C** |
| 0 | 0 | 0 | 0 |
| 0 | 1 | 1 | 0 |
| 1 | 0 | 1 | 0 |
| 1 | 1 | 0 | 1 |

1. Draw a logic diagram using only NAND gates that performs the OR gate function.

(3.5 marks)

1. Give two reasons why it is often an advantage to convert a circuit using a mixture of

different gates into one that uses a single type of gate. (1.5 marks)

3. a. A set of ten independent measurements is given as:

1.570, 1.597, 1.591, 1.562, 1.577, 1.580, 1.564, 1.586, 1.550, 1.575

Calculate the Arithmetic Mean, Standard Deviation and Median. (2.5 marks)

b. Consider second order system 2d²y/dt² + 4dy/dt + 8y = 8x. Calculate the damping ratio, damping coefficient and time constant. (2.5 marks)

4. The manufacturer of a selected diode gives the rate of fall of the diode current di/dt = 20

 A/ms, and a reverse recovery time of trr =5 ms. What is value of peak reverse current?  (5 marks)

**SECTION B**

**Case Study**

**Choose either Case 1 or Case 2 from this Section. Each Case carries 50 marks. Mark for each sub-question is indicated in the brackets.**

**CASE 1**

The Royal Government of Bhutan is envisaging the establishment of few new industrial estates along the Southern borders during the current Five Year Plan. You, being an Engineer In-charge (Electrical), is required to plan and design an air insulated power substation for one of the industrial estates taking into consideration the following information (you can make appropriate/relevant assumptions for any missing information with clear justifications).

* The estimated power/load demand of the estate during initial stages of industrial development can be assumed to be around 100 MW which will happen by 2018.
* The ultimate power/load demand of the estate can be assumed as 200 MW by 2025.
* The substation should meet at least (n-1) planning/contingency criteria.
* The substation should have minimum of three incoming lines marked “Incomer 1”, “Incomer 2” and “Incomer 3”. “Incomer 1” will be of 400 kV. “Incomer 2” and “Incomer 3” will both be of 220 kV.
* The substation should have minimum of ten 66 kV outgoing lines for different industries in the estate.
* The substation should have provision for supplying its own load and local residential loads at 33kV/11kV/400 Volt.
* The substation should have at least two power transformers for meeting initial load demand of the estate.
* The substation should have adequate provision for catering to full load demand of 200 MW in future.
* The substation should have switching schemes of ‘breaker and a half’ for the 400 kV voltage level and ‘double main and transfer bus’ for the 220 kV voltage level.
* The substation should have all standard equipment such as bus bars, circuit breakers, disconnectors/earth switches, current transformers, voltage transformers, surge arrestors, power transformers, other protection devices, etc.

Based on the given/assumed information, answer the following questions:

1. How will you go about planning this power substation? List down at least five activities.

(2.5 marks)

1. Explain what you understand by the (N-2) or (N-1-1) planning/contingency criteria.

(1.5 marks)

1. Using appropriate circuit symbols and the given/assumed information, draw a detail single line diagram of the proposed substation with clear illustration of the required switching schemes of ‘breaker and a half’ for the 400 kV voltage level and ‘double main and transfer bus’ for the 220 kV voltage level among others. Label all the components of the substation in the diagram. (20 marks)
2. Describe all possible faults that will be encountered by this substation during its operation. (4 marks)
3. Explain some of the features and/or elements you will incorporate into the design of this substation to overcome the possible faults you described under Sl. No. d) above.

(4 marks)

1. Why do engineers perform load flow study and short circuit analysis for a power system?

(3 marks)

1. What is the main difference between ‘suspension tower’, ‘tension/angle tower’ and the dead-end tower? (3 marks)
2. Why is it important to have Direct Current (DC) power supply such as battery banks and battery chargers at AC power substation? (2 marks)
3. What is the function of Wave Trap you normally see at power substation? (2 marks)
4. Write down the advantages and disadvantages of using SF6 circuit breaker over oil circuit breaker? (4 marks)
5. How would you ensure effective grounding/earthing for your substation? Explain briefly your proposed grounding/earthing design for this substation. What should be the acceptable range of earth resistance in ohms (Ω) considering that this will be a major power substation in the country? (4 marks)

**CASE 2**

1. A 110 kVA, 2200 V/110 V, 60 Hz transformer has the following circuit constants: R1 = 0.22Ω, R2= 0.5mΩ, X1= 2.0Ω, X2=5mΩ, Rc= 5.5kΩ, Xm= 1.1kΩ. During one day(24 hrs), the transformer has the following load cycle:

4h on no-load;

8h on ¼ full load at 0.8 power factor;

8h on ½ full load at unity power factor; &

4h on full-load at unity power factor.

1. Assuming a constant core loss of 1.346 kW, find the all-day efficiency of the transformer. (10 marks)
2. Assuming there are 400 turns of wire in an iron- core coil and this coil is to be used as the primary of a transformer, how many turns must be wound on the coil to form the secondary winding of the transformer to have a secondary voltage of one volt if the primary voltage is five volts? (4 marks)
3. Why are transformers rated in kVA? (1.5 marks)
4. What are the factors for hysteresis loss? (1.5 marks)
5. What is the function of transformer oil in a transformer? (1 marks)
6. What is the purpose of laminating the core in a transformer? (1 mark)
7. Give the emf equation of a transformer and define each term? (3 marks)
8. What are the applications of the step-up and step-down transformer? ( 3 marks)
9. You are given a DC shunt machine which when run as a motor at no load takes 400W at 200 V running at 1000 rpm. The field current is 1.0A and the armature resistance is 0.5Ω.
	1. Calculate the efficiency when the machine is run as a generator delivering 40 A at 220 V.

 (5 marks)

* 1. Calculate the efficiency when the machine is run as a motor taking 40 A from the supply of 220 V. (5 marks)
	2. What are the main parts of a d.c motor? (2 marks)
	3. What are the factors to be considered for the selection of no. of poles in a d.c machine?

(2 marks)

1. What is the function of carbon brush used in d.c generators? (1.5 marks)
2. Why is equalizer connection necessary for the armature winding of a d.c machine

with lap winding? (1 mark)

1. What are the effects of armature reaction? (1 mark)
2. State different losses in a d.c machine. (2 marks)
3. Why is the armature core in d.c machines constructed with laminated steel sheets

instead of solid steel sheets? (1.5 marks)

1. How will you change the direction of rotation of d.c.motor? (1 mark)
2. How does d.c. motor differ from d.c. generator in construction? (3 marks)

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