TVET CURRICULUM DEVELOPMENT, ASSESSMENT AND CERTIFICATION COUNCIL (TVET CDACC)

Qualification Code : 071606T4MCT

Qualification : Mechatronics Technician Level 6

Unit Code : ENG/OS/MC/CC/04/6/A

Unit of Competency : Apply Electrical and Electronics Principles

ASSESSOR'S GUIDE

INSTRUCTIONS TO ASSESSOR

1. Marks for each question are indicated in the brackets.
2. Answers provided are model answers.

SECTION A: SHORT ANSWER QUESTIONS (40MARKS)

*Candidate is expected to attempt **ALL** questions from this section*

1. List four factors that affect resistance of an electrical conductor. (4 Marks)

- ✓ ***Length of the conductor***
- ✓ ***Cross-sectional area of the conductor***
- ✓ ***Type of the material used for the conductor***
- ✓ ***Temperature of the material***

2. When a current flows in a resistive circuit, power is dissipated. Name two electrical measuring equipment used to calculate of power dissipated. (2 Marks)

- ✓ ***Ohmmeter-measures circuit resistance***
- ✓ ***Ammeter-measures current***

3. A filament lamp drawing a current of 3 Amperes is observed to get hot when touched. Show the amount of electrical energy dissipated when it is switched on for 2hours if the resistance of the filament is 80Ω. (5 Marks)

Power=I^2.R

*=3^2*80= 720w*

*Energy=power * time*

*E= 720*60*60=2592000 Joules*

E=2.592MJ

4. A charge of 300 Coulombs is to be transferred from a capacitor in 2 minutes. What is the current flowing? (4 Marks)

Charge= current xtime

Q=I *t

Current =300/120=2.5Amperes

5. A woman lifts a jerican of 20N through a height of 2metres.What is the total work done by her? (4 Marks)

Work done =Force x height

Work done =20x2=40 Joules

6. One method of protecting against lightning strikes is by erecting lightening arresters. List three main parts of a lightening arresters. (3 Marks)

- ✓ ***Air termination***
- ✓ ***Down conductors***
- ✓ ***Earth terminations***

7. What is the main reason behind connecting lamps in parallel? (2 Marks)

- ✓ ***To ensure uniform voltage supply across all lamps. This results to uniform brightness for all lamps.***

8. An electrical technician connected two resistances R_1 and R_2 in series as shown in *fig.1* and measured the cumulative total resistance R_T. What was his observation? (2 Marks)

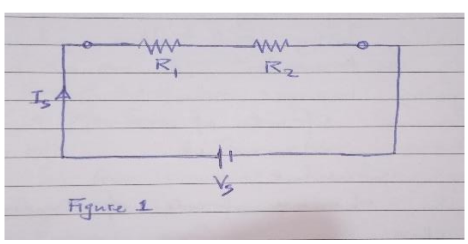


Figure 1

- ✓ ***Total resistance R_T was observed to be more than the value of the individual resistances R_1 or R_2.***

9. The armature of a DC generator has a resistance of 0.5Ω. If a voltage of 200V causes a current of 30A to flow. calculate the generated voltage. (4 Marks)

E_g=200V + 30x0.5 =215V

10. An electrical technician wanted to construct a smoothening circuit for a power supply. List any four types of smoothening circuits. (4 Marks)

- ✓ ***Capacitor filters***
- ✓ ***RC filters***
- ✓ ***Pie filters***
- ✓ ***T filters***

11. An electric single phase induction motor driving a posho mill was abnormally getting hot. Give four reasons for that. (4 Marks)

- ✓ ***Overloading***
- ✓ ***Ground fault***
- ✓ ***Faulty bearing***
- ✓ ***Faulty starting/running capacitors***

12. A smoothening circuit must be used in the last stage of power supply construction. List its importance. (2 Marks)

- ✓ ***Remove AC component (ripple) in the rectified DC***

SECTION B: EXTENDED ANSWER QUESTIONS [60MARKS]

*Candidate is expected to answer any **THREE** questions from this section*

13. (a) The rotor of a squirrel cage induction motor is skewed. Give three reasons why it is done. (6 Marks)

(b) A water pump is driven by 440-V, 3-φ, 50-Hz, 4-pole, Y-connected induction motor which has a full-load speed of 1425 rpm. The rotor has an impedance of (0.4 + J 4) ohm and rotor/stator turn ratio of 0.8. Calculate:

(i) full-load torque;

(ii) rotor current and full-load rotor Cu loss;

(iii) power output if windage and friction losses amount to 500 W;

(iv) maximum torque and the speed at which it occurs;

(v) starting current;

(vi) starting torque.

(14 Marks)

Solution. $N_s = 120 \times 50/4 = 1500 \text{ rpm} = 25 \text{ rps}, s = 75/1500 = 0.05$

$E_1 = 440/1.73 = 254 \text{ V/phase}$

(*i*) Full-load $T_f = \dfrac{3}{2\pi \times 25} \times \dfrac{0.05\,(0.8 \times 254)^2 \times 0.4}{(0.4)^2 + (0.05 \times 4)^2}$

$= \mathbf{78.87 \text{ N-m}}$

(*ii*) $I_r = \dfrac{sE_2}{\sqrt{R_2^2 + (sX_2)^2}} = \dfrac{sKE_1}{\sqrt{R_2^2 + (sX_2)^2}} = \dfrac{0.05 \times (0.8 \times 254)}{\sqrt{(0.4)^2 + (0.05 \times 4)^2}}$

$= \mathbf{22.73 \text{ A}}$

Total Cu loss $= 3I_r^2 R = 3 \times 22.73^2 \times 0.4 = \mathbf{620 \text{ W}}$

(*iii*) Now, $P_m = 2\pi NT = 2\,\pi \times (1425/60) \times 78.87 = 11{,}745\ \Omega$

$\therefore$ $P_{out} = P_m - \text{windage and friction loss} = 11{,}745 - 500 = \mathbf{11{,}245 \text{ W}}$

(*iv*) For maximum torque, $s = R_2/X_2 = 0.4/4 = 0.1$

$\therefore$ $T_{max} = \dfrac{3}{2\pi \times 25} \times \dfrac{0.1 \times (0.8 \times 254)^2 \times 0.4}{(0.4)^2 + (0.1 \times 4)^2} = \mathbf{98.5 \text{ N-m}}$

Since $s = 0.1$, slip speed $= s\,N_s = 0.1 \times 1500 = 150$ rpm.

$\therefore$ Speed for maximum torque $= 1500 - 150 = \mathbf{1350 \text{ rpm.}}$

(*v*) starting current $= \dfrac{E_2}{\sqrt{R_2^2 + X_2^2}} = \dfrac{KE_1}{\sqrt{R_2^2 + X_2^2}} = \dfrac{0.8 \times 254}{\sqrt{0.4^2 + 4^2}} = \mathbf{50.5 \text{ A}}$

(*vi*) At start, $s = 1$, hence

$T_{st} = \dfrac{3}{2\pi \times 25} \times \dfrac{(0.8 \times 254)^2 \times 0.4}{(0.4)^2 + 4^2} = \mathbf{19.5 \text{ N-m}}$

14. A student asked an electrical engineer at ***Jamji Power Station*** why they connect alternators in parallel. Explain three reason he might have given.

(6 Marks)

Two generators used in olkaria Power station A and B operate in parallel and supply a load of 10 MW at 0.8 p.f. lagging.

i. By adjusting steam supply of A, its power output is adjusted to 6,000 kW and by changing its excitation, its p.f. is adjusted to 0.92 lag. Find the p.f. of generator B. (7marks)

ii. If steam supply of both machines is left unchanged, but excitation of B is reduced so that its p.f. becomes 0.92 lead, find new p.f. of A .(7 Marks)

Solution. (*a*) $\cos\phi = 0.8$, $\phi = 36.9°$, $\tan\phi = 0.7508$; $\cos\phi_A = 0.92$, $\phi_A = 23°$; $\tan\phi_A = 0.4245$

load kW = 10,000, load kVAR = 10,000 × 0.7508 = 7508 (lag)

kW of A = 6,000, kVAR of A = 6,000 × 0.4245 = 2547 (lag)

Keeping in mind the convention that lagging kVAR is taken as negative we have,

kW of *B* = (10,000 − 6,000) = 4,000 : kVAR of *B* = (7508 − 2547) = 4961 (lag)

$\therefore$ kVA of $B = 4{,}000 - j4961 = 6373 \angle -51.1°$; $\cos\phi_B = \cos 51.1° =$ **0.628**

(*b*) Since steam supply remains unchanged, load kW of each machine remains as before but due to change in excitation, kVARs of the two machines are changed.

kW of *B* = 4,000, new kVAR of B = 4000 × 0.4245 = 1698 (lead)

kW of *A* = 6,000, new kVAR of A = −7508 − (+1698) = − 9206 (lag.)

$\therefore$ new kVA of $A = 6{,}000 - j9206 = 10{,}988 \angle -56.9°$; $\cos\phi_A =$ **0.546 (lag)**

15. a). A three-phase synchronous motor is an example of a synchronous machine. Explain any four unique features associated with it.

(8 Marks)

b). A synchronous motor absorbing 60 kW is connected in parallel with a factory load of 240 kW having a lagging p.f. of 0.8. If the combined load has a p.f. of 0.9,

(i) What is the value of the leading kVAR supplied by the motor,

(ii) At what p.f. is it working.

(12 Marks)

Total load $= 240 + 60 = 300$ kW; combined p.f. $= 0.9$ (lag)

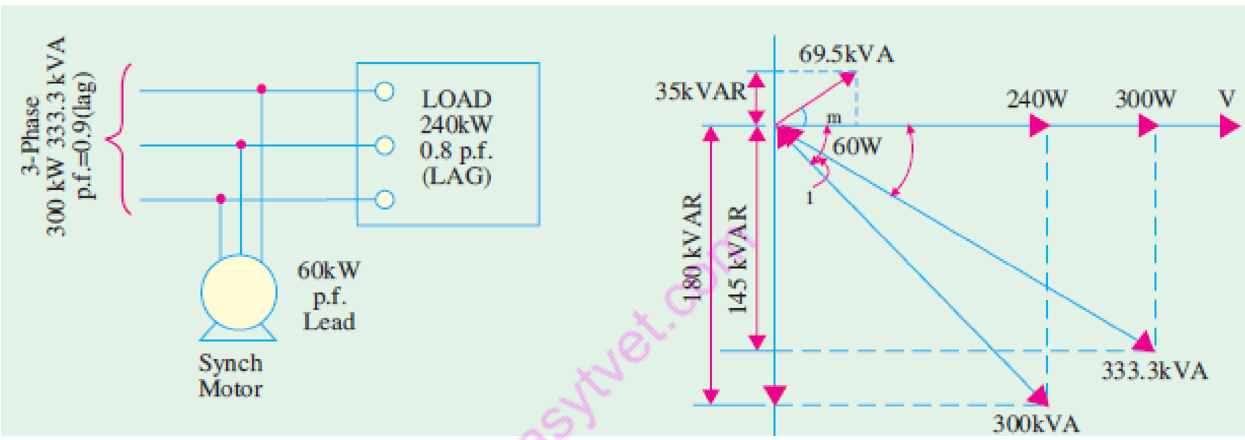
$\phi = 25.8°$, $\tan\phi = 0.4834$, combined kVAR $= 300 \times 0.4834 = 145$(lag)

Factory Load

$\cos\phi_L = 0.8$, $\phi_L = 36.9°$, $\tan\phi_L = 0.75$, load kVAR $= 240 \times 0.75 = 180$ (lag)

or load kVA $= 240/0.8 = 300$, kVAR $= 300 \times \sin\phi_L = 300 \times 0.6 = 180$

$\therefore$ *leading* kVAR supplied by synchronous motor $= 180 - 145 =$ **35.**



For Synchronous Motor

kW $= 60$, leading kVAR $= 35$, $\tan\phi_m = 35/60$; $\phi_m = 30.3°$; $\cos 30.3° = 0.863$

$\therefore$ motor p.f. $=$ **0.863 (lead).** Incidentally, motor kVA $= \sqrt{60^2 + 35^2} =$ **69.5.**

16. Give any two differences between a series wound dc motor and a shunt wound DC motor. (4 Marks)

Series dc motor	**Shunt dc motor**
Has very high starting torque	*Starting torque less when compared to series motor.*
Running torque decreases	*Torque remains constant*
Has few but thick turns of field windings	*Field windings turns are many*

Must be started on load	*Can be started even on no load*

(b) List any four applications where you can use a shunt dc motor. (4 Marks)

- ✓ ***Driving steel mills.***
- ✓ ***Electric traction***
- ✓ ***Elevators***
- ✓ ***Driving heavy loads eg in cement factory***

(c) Routine maintenance is necessary to keep machines in good working conditions. List any two maintenances carried out on dc motors. (2 Marks)

- ✓ ***Brushes replacement.***
- ✓ ***Cleaning of commutator segments.***

(d) In a tube mill factory, a 220-V, d.c. shunt motor takes 4 A at no-load when running at 700 r.p.m. The field resistance is 100 Ω. The resistance of armature at standstill gives a drop of 6 volts across armature terminals when 10 A were passed through it. Calculate:

i. Speed on load;

ii. Torque inN-m;

iii. Efficiency. The normal input of the motor is 8 kW. (10 Marks)

$I_{sh} = 200/100 = 2$ A

F.L. Power input $= 8{,}000$ W; F.L. line current $= 8{,}000/200 = 40$ A

$I_a = 40 - 2 = 38$ A; $R_a = 6/10 = 0.6\ \Omega$

$E_{b0} = 200 - 2 \times 0.6 = 198.8$ V; $E_b = 200 - 38 \times 0.6 = 177.2$ V

Now, $\dfrac{N}{N_0} = \dfrac{E_b}{E_{b0}}$ or $\dfrac{N}{700} = \dfrac{177.2}{198.8}$; $N =$ **623.9 r.p.m.**

(*b*) $T_a = 9.55\, E_b I_a / N = 9.55 \times 177.2 \times 38/623.9 =$ **103 N-m**

(*c*) N.L. power input $= 200 \times 4 = 800$ W; Arm. Cu loss $= I_a^2 R_a = 2^2 \times 0.6 = 2.4$ W

Constant losses $= 800 - 2.4 = 797.6$ W; F.L. arm. Cu loss $= 38^2 \times 0.6 = 866.4$ W

Total F.L. losses $= 797.6 + 866.4 = 1664$ W; F.L. output $= 8{,}000 - 1664 = 6336$ W

F.L. Motor efficiency $= 6336/8{,}000 = 0.792$ or **79.2 %**