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 (40 MARKS)

The candidate should attempt ALL questions in this section.

1. A charge of 35 mC is transferred between two points in a circuit in a time of 20 ms. Calculate the value of current flowing. (3 Marks)

$$Q = 35 \times 10^{-3}\,\text{C}; t = 20 \times 10^{-3}\,\text{s}$$

$$I = \frac{Q}{t}\ \text{amp}$$

$$= \frac{35 \times 10^{-3}}{20 \times 10^{-3}}$$

$$I = 1.75\ \text{A}\ \textbf{Ans}$$

2. A 10Ω resistor, a 20Ω resistor and a 30Ω resistor are connected (a) in series, and then (b) in parallel with each other. Calculate the total resistance for each of the two connections. (6 Marks)

✓ ***Series connection***

R_T***= (10+20+30) Ω***

=60 Ω

✓ ***Parallel connection***

$1/R_T$***= (1/10+1/20+1/30) Ω***

=5.46Ω

3. A current of 5.5 mA flows through a 33kΩ resistor. Calculate the p.d. thus developed across it. (3 Marks)

$$I = 5.5 \times 10^{-3}\,\text{A};\quad R = 33 \times 10^{3}\,\Omega$$

$$V = IR\ \text{volt}$$

$$= 5.5 \times 10^{-3} \times 33 \times 10^{3}$$

$$V = 181.5\ \text{V}\ \textbf{Ans}$$

4. A battery of emf 6 V has an internal resistance of 0.15Ω. Calculate its terminal p.d. when delivering a current of (a) 0.5 A, (b) 2 A, and (c) 10 A. (6 Marks)

$E = 6\text{V}; r = 0.15\,\Omega$

(a) $V = E - Ir$ volt

$= 6 - (0.5 \times 0.15) = 6 - 0.075$

so, $V = 5.925\text{V}$ **Ans**

(b) $V = 6 - (2 \times 0.15) = 6 - 0.3$

so, $V = 5.7\text{V}$ **Ans**

(c) $V = 6 - (10 \times 0.15) = 6 - 1.5$

so, $V = 4.5\text{V}$ **Ans**

Note: This example verifies that the terminal p.d. of a source of emf decreases as the load on it (the current drawn from it) is increased.

5. Differentiate between an electric motor and a generator.

An electric motor is a rotating machine, which converts an electrical input power into a mechanical power output. A generator converts a mechanical power input into an electrical power output.

(2 Marks)

6. A current of 200 mA flows through a resistance of 750Ω for a time of 5 minutes. Calculate (a) the p.d. developed, and (b) the energy dissipated.
(4 Marks)

$I = 200\,\text{mA} = 0.2\text{A}; t = 5 \times 60 = 300\,s; R = 750\,\Omega$

(a) $V = IR$ volt

$= 0.2 \times 750$

$V = 150\,\text{V}$ **Ans**

(b) $W = I^2Rt$ joule

$= 0.2 \times 750 \times 300$

$W = 9000\text{ J or } 9\text{kJ}$ **Ans**

7. The resistance of a sample of material depends upon four factors. Which are these factors?

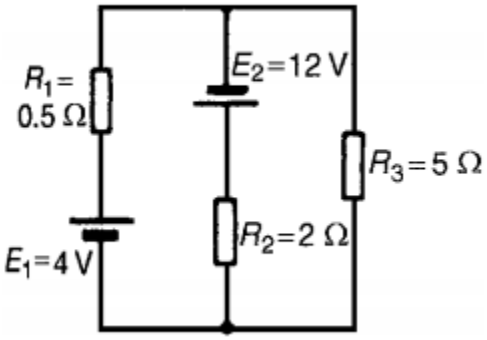
(3 Marks)

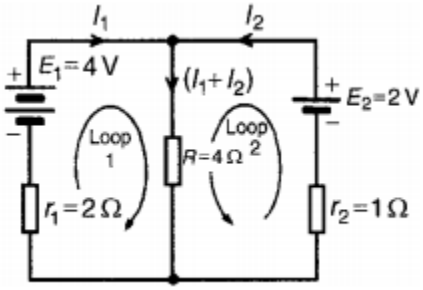
- ✓ ***Length***
- ✓ ***Cross-sectional area (CSA)***
- ✓ ***Temperature***

8. There are various basic quantities and their SI units as used in engineering and science. State four of these basic quantities and give its corresponding SI units? (4 Marks)

   - ✓ ***Length-Metre (m)***
   - ✓ ***Mass-Kilogram (Kg)***
   - ✓ ***Electric Current-Ampere (A)***
   - ✓ ***Time-Seconds(s)***

9. Determine using Kirchoff's Laws, each branch current for the network shown: (6 Marks)





$$E_1 = I_1 r_1 + (I_1 + I_2)R$$
$$4 = 2I_1 + 4(I_1 + I_2),$$
$$6I_1 + 4I_2 = 4 \qquad (1)$$

$$E_2 = I_2 r_2 + (I_1 + I_2)R$$
$$2 = I_2 + 4(I_1 + I_2)$$
$$4I_1 + 5I_2 = 2 \qquad (2)$$

Solve Equations (1) and (2) for I_1 and I_2

$2 \times (1)$ gives: $12I_1 + 8I_2 = 8$ (3)

$3 \times (2)$ gives: $12I_1 + 15I_2 = 6$ (4)

$(3) - (4)$ gives: $-7I_2 = 2$

hence $I_2 = -2/7 = \mathbf{-0.286\,A}$

(i.e. I_2 is flowing in the opposite direction to that shown in Fig. 13.5)

From (1) $6I_1 + 4(-0.286) = 4$

$6I_1 = 4 + 1.144$

Hence $I_1 = \dfrac{5.144}{6} = \mathbf{0.857\,A}$

Current flowing through resistance R is

$(I_1 + I_2) = 0.857 + (-0.286)$

$= \mathbf{0.571\,A}$

10. Modern mechatronics systems are fitted with power protection devices. State three of these devices.

(3 Marks)

- ✓ ***Switches***
- ✓ ***Fuses***
- ✓ ***Circuit breakers***

SECTION B: EXTENDED ANSWER QUESTIONS (60 MARKS)

The candidate should Attempt ANY THREE questions in this section.

11.

i). A moving coil meter has a figure of merit of 10 kΩ / V. The coil has a resistance of 50Ω. Calculate the value of multiplier required for

(a) the 10 V d.c. range,

(b) the 10 V a.c. range.

(12 Marks)

$R_c = 50\,\Omega$; figure of merit $= 10\,\text{k}\Omega/\text{V}$; $V = 10\,\text{V}$

(a) $I_{fsd} = 1/10\,000 = 100\,\mu\text{A}$

$$\text{total meter resistance, } R = \frac{V}{I_{fsd}}\,\text{ohm} = \frac{10}{10^{-4}}$$

so, $R = 100\ \text{k}\Omega$; and since $R = R_m + R_c$, then:

$R_m = 100\,000 - 50 = 99.95\ \text{k}\Omega$ **Ans**

(b) $I_{fsd} = 100\,\mu\text{A} = I_{av}$

therefore, r.m.s. value,

$$I - 1.11 \times 100 - 111\,\mu\text{A}$$

$$\text{so, } R = \frac{10}{111 \times 10^{-6}} = 90.09\ \text{k}\Omega$$

$$\text{therefore, } R_m = 90\,090 - 50$$

$$= 90.04\ \text{k}\Omega \textbf{ Ans}$$

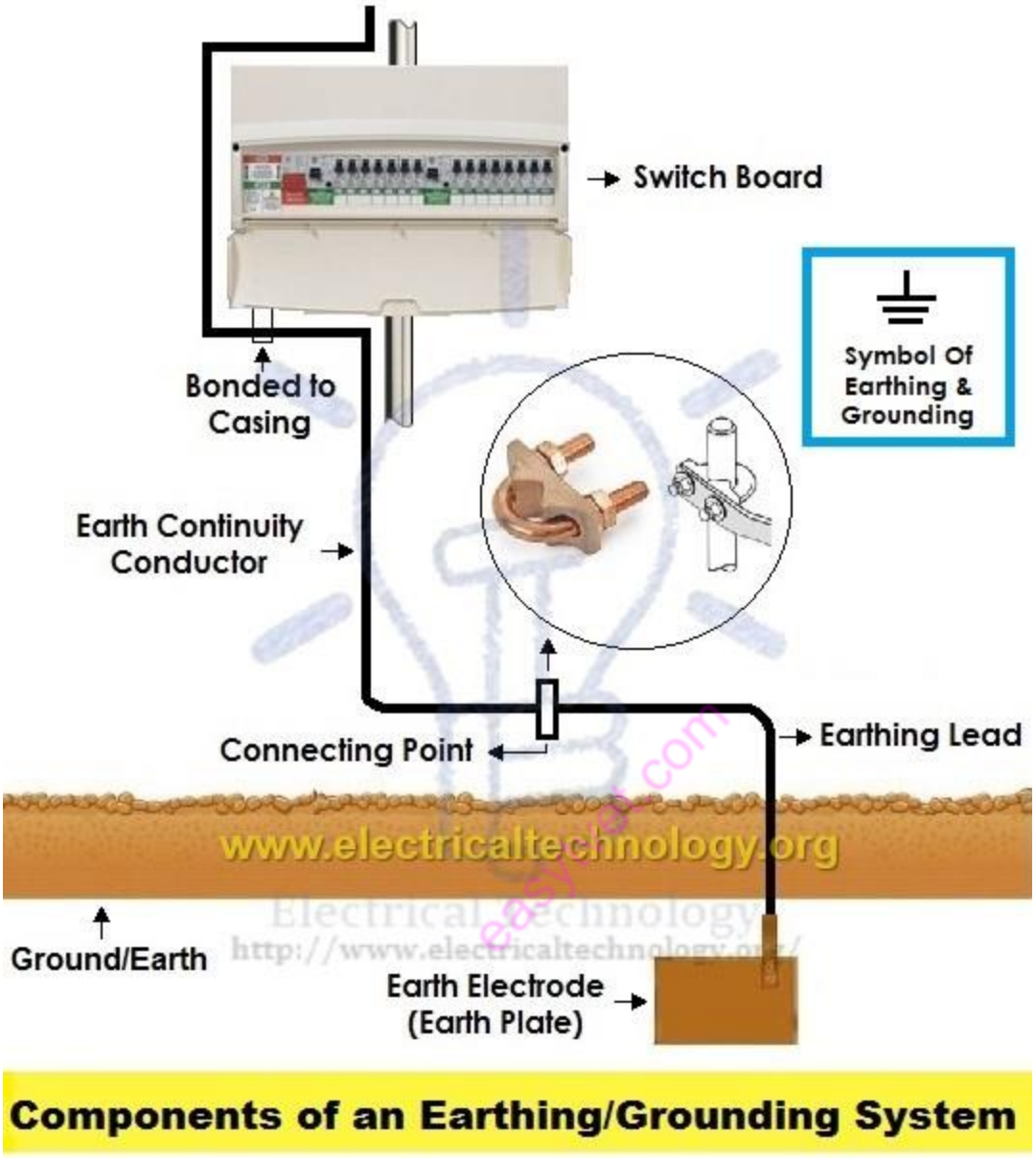
ii). You are asked by your technical supervisor to carry out maintenance of the company earthing system. Briefly explain by *'earthing'* and describe *any three* components of an earthing system. (8 Marks)

a) ***Earth Continuity Conductor or Earth Wire:*** *That part of the earthing system which interconnects the overall metallic parts of electrical installation e.g. conduit, ducts, boxes, metallic shells of the switches, distribution boards, fuses, Regulating and controlling devices, metallic parts of electrical machines such as, motors, generators,*

transformers and the metallic framework where electrical devices and components are installed is known as earth wire or earth continuity conductor.

b) ***Earthing Lead or Earthing Joint:*** *The conductor wire connected between earth continuity conductor and earth electrode or earth plate is called earthing joint or "Earthing lead". The point where earth continuity conductor and earth electrode meet is known as "connecting point" Earthing lead is the final part of the earthing system which is connected to the earth electrode (which is underground) through earth connecting point.*

c) ***Earthing Electrode Or Earthing Plate:*** *A metallic electrode or plate which is buried in the earth (underground) and it is the last part of the electrical earthing system. In simple words, the final underground metallic (plate) part of the earthing system which is connected with earthing lead is called earth plate or earth electrode.*



Components of an Earthing/Grounding System

12.

i). The resistance of the field winding of a shunt generator is 200Ω. When the machine is delivering 80 kW the generated emf and terminal voltage are 475 V and 450 V respectively. Calculate

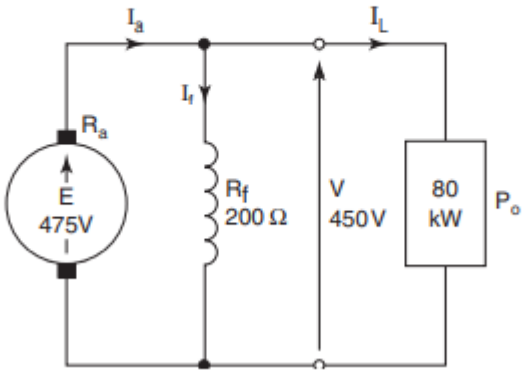
(a) the armature resistance, and

(b) the value of generated emf when the output is 50 kW, the terminal voltage then being 460 V.

(12 Marks)

$R_f = 200\,\Omega$; $P_o = 80 \times 10^3$ watt; $V = 450$V; $E = 475$ V

The circuit diagram is shown in Fig. 7.17. It is always good practice to sketch the appropriate circuit diagram when solving machine problems.



(a) $P_o = V I_L$ watt; so $I_L = \frac{P_o}{V}$ amp

therefore $I_L = \frac{80 \times 10^3}{450} = 177.8$ A

$I_f = \frac{V}{R_f}$ amp $= \frac{450}{200} = 2.25$ A

$I_a = I_L + I_f$ amp $= 180.05$ A

$I_a R_a = E - V$ volt $= 475 - 450 = 25$ V

therefore $R_a = \frac{25}{180.05}$ ohm $= 0.139\,\Omega$ **Ans**

(b) When $P_o = 50 \times 10^3$ W, $V = 460$ V

thus $I_L = \frac{50 \times 10^3}{460} = 108.7$ A

$I_f = \frac{V}{R_f} = \frac{460}{200} = 2.3$ A

hence, $I_a = 108.7 + 2.3 = 111$ A

$E = V + I_a R_a$ volt $= 460 + (111 \times 0.139)$

therefore $E = 475.4$ V **Ans**

ii) Give any two differences between a series wound dc motor and a shunt wound dc motor. (4marks)

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*

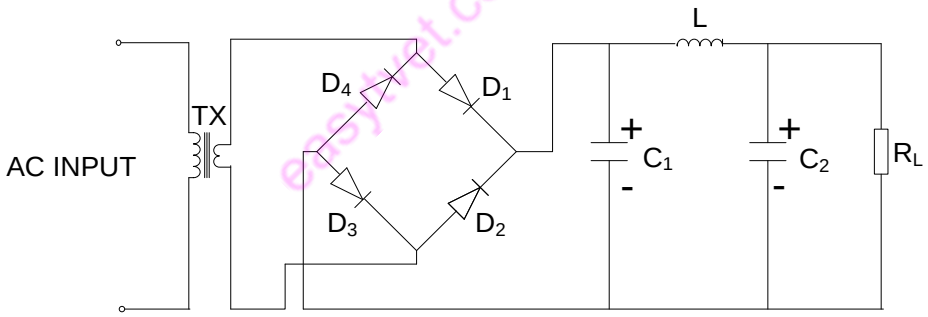
iii). List any four applications where you can use a shunt dc motor. (4marks)

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

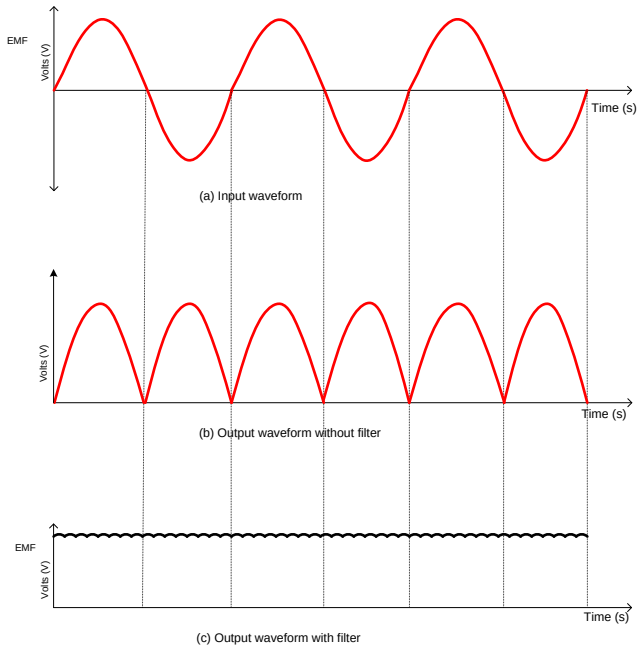
13.

a) With the aid of a diagram briefly describe bridge rectification with pie filter (10 Marks)

During the positive input half cycle, diodes D_1 andD_3 conduct at the same time and during the negative input half cycle D_2 and D_4 also conduct at the same time. The input and output waves forms are as shown in the



Full-wave rectifier using four diodes with π filter



b) In the network shown in figure 1, find using thevenin's theorem the current following in the 10 Ω resistor. (10 marks)

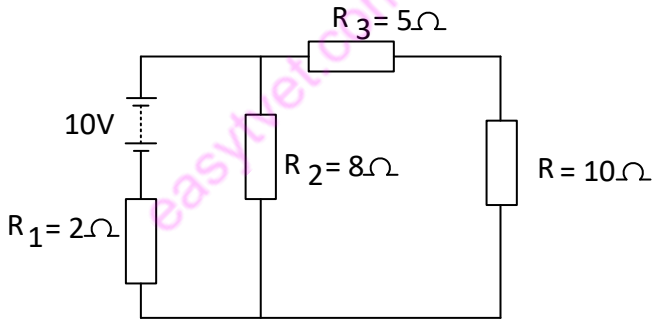
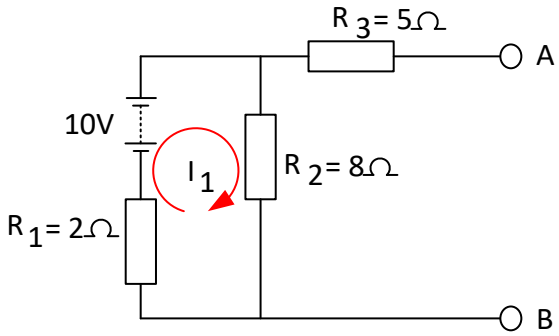


Figure 1

$$I_1 = \frac{10}{2+8} = 1A$$



$$p.d\ across\ R_2 = 1 \times 8 = 8V$$

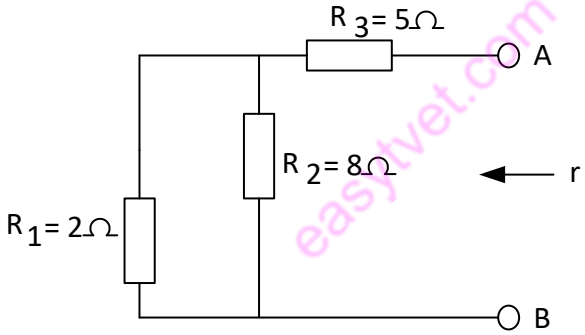
Hence the open circuit voltage across break $E = 8V$

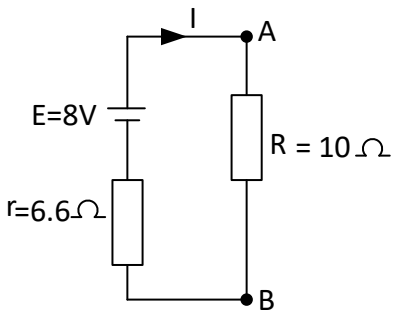
Removing the source emf

$$\boldsymbol{r = R_3 + \frac{R_1 R_2}{R_1 + R_2}}$$

$$\boldsymbol{r = 5 + \frac{2 \times 8}{2 + 8} = 6.6\ Ohms}$$

The equivalent thevenin's circuit





$\boldsymbol{I = \frac{E}{R+r} = \frac{8}{10+6.6} = 0.482A}$(Current through 10Ω resistor)

14. A 415V three phase, 50Hz, 4 pole star connected induction motor runs at 24rev/s on full load. The rotor resistance and reactance per phase are 0.35Ω and 3.5Ω respectively and the effective rotor stator turns ratio is 0.85:1. Determine;

i. The synchronous speed

Synchronous speed, ns=(f/p)=(50/2)

= 25rev/s or (25×60)=1500rev/min

ii. The slip

Slip, s=ns−nr/ ns

=25−24 /25

=0.04 or 4%

iii. The full load torques

(c) Phase voltage,

E1 =415 /√3 =239.6volts

Full load torque,T

= 3(0.85) ^2 /2π (25)((0.04) (239.6) ^2(0.35) / (0.35) ^2+(0.04×3.5)2)

= (0.01380) (803.7/1 0.1421)

= 78.05Nm

The power output if mechanical losses amount to 770w

iv. Output power, including friction losses,

Pm =2πnrT

=2π(24)(78.05)

=11770watts

Hence, power output=Pm −mechanical losses

=11770−770

=11000W =11kW

v. The maximum torque

Maximum torque occurs when R2=Xr=0.35

Slip, s= R2 /X2 = 0.35 3.5 =0.1

Hence maximum torque,

Tm =(0.01380)(sE1^2 R2/ R2^ 2 +(sX2)^2

from part (c) =(0.01380)0.1(239.6)20.35 0.352 +0.352

=(0.01380)(2009.29/ 0.245)

=113.18Nm (20 marks)