



Diploma in Electrical Engineering: Summer – 2016 Examinations

Subject Code : 17640 (MET)

Model Answers

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Important Instructions to examiners:

- 1) The answers should be examined by key words and not as word-to-word as given in the model answer scheme.
- 2) The model answer and the answer written by candidate may vary but the examiner may try to assess the understanding level of the candidate.
- 3) The language errors such as grammatical, spelling errors should not be given more importance (Not applicable for subject English and Communication Skills).
- 4) While assessing figures, examiner may give credit for principal components indicated in the figure. The figures drawn by candidate and model answer may vary. The examiner may give credit for any equivalent figure drawn.
- 5) Credits may be given step wise for numerical problems. In some cases, the assumed constant values may vary and there may be some difference in the candidate's answers and model answer.
- 6) In case of some questions credit may be given by judgement on part of examiner of relevant answer based on candidate's understanding.
- 7) For programming language papers, credit may be given to any other program based on equivalent concept.



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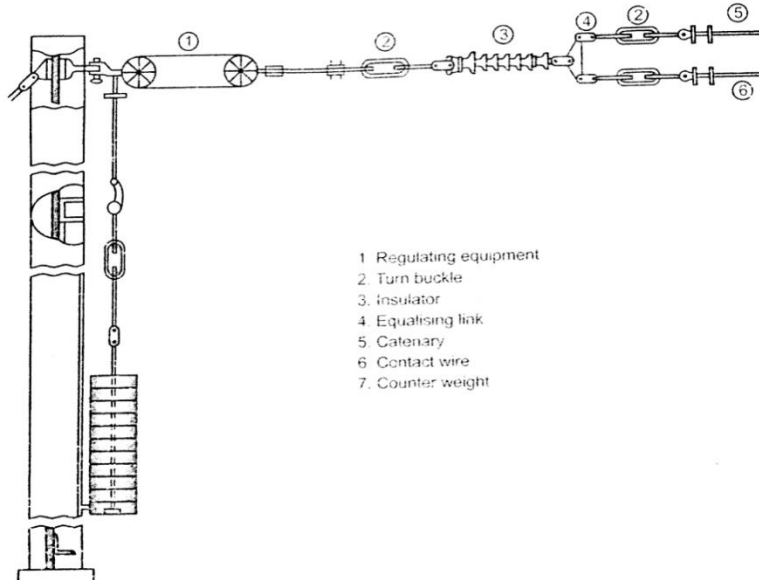
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- 1 **Attempt any FIVE:** **20**
- 1 a) State any two miscellaneous equipment at control post with their functions.
Ans: 1 mark for name of any two equipment = 2 M
- Miscellaneous equipment at control post:**
1. **Lightening arrester:** provides protection against voltage surges
 2. **Auxiliary transformer:** provides 230 V, 50 Hz, supply to operate battery charger, remote control equipment, signally and lighting. 1 mark for function of each above = 2 M
 3. **PT:** provides continuous indication regarding the condition of supply.
 4. **Battery:** for operation of remote control equipment and interrupter.
 5. **Battery charging equipment:** charge batteries at the control post.
- 1 b) List four special features of traction transformer.
Ans: 1 mark for each of any four features = 4 M
1. Specially designed to withstand severe operating conditions.
 2. Have high short time peak capacity.
 3. Class A insulation specially reinforced to withstand stresses of frequent short circuits.
 4. Can take overloads as- 50 % for 15 min , 100 % for 5 min , 120 % for instantaneous
 5. Impulse withstand voltage nearly 5 times higher
 6. To limits the effect of SC , impedance not less than 8.5 % for 10 MVA and 10 % for 12.5 MVA.
- 1 c) Explain effect of speed on OHE (Any four points).
Ans:
The type of the construction of OHE to be used is primarily determined by the train speed. The effect of train speed on the current collection by the pantograph will be understood when the behavior of OHE under the passage of pantograph is followed. 1 mark each for any two points = 2 M
- 1) The pan of pantograph along the overhead wire pushes it up by a certain amount of pushup.
 - 2) The contact wire after the passage of pantograph, suddenly sags and starts vibrating vertically due to elasticity of the system.
 - 3) When the collecting speed exceeds 120 kmph, a contact break phenomenon is likely to occur in the overhead wire system having simple catenary system.
- In order to have satisfactory current collection at various speeds, various modifications in the construction of OHE are carried out. 1 mark each for any two points = 2 M
- i) For speeds up to 100 kmph: Simple Catenary construction (for employing regulation of mechanical tension)
 - ii) For speeds up to 120 kmph: Simple Catenary construction
 - iii) For speeds up to 160 kmph: Modified Y Simple Catenary construction
 - iv) For speeds beyond 160 kmph: Modified Y Compound Catenary construction
- 1 d) Draw a neat labelled diagram to show Automatic weight tension and Temperature compensation of OHE.
Ans:



Automatic weight tension and Temperature compensation of OHE:



- 1 Regulating equipment
- 2 Turn buckle
- 3 insulator
- 4 Equalising link
- 5 Catenary
- 6 Contact wire
- 7. Counter weight

Labeled
fig.-4 mark

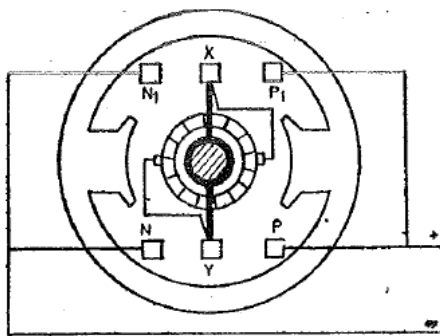
Partially
labelled
fig. 3 marks

Unlabeled
fig.
2 mark

- 1 e) With the help of neat diagram, explain the method to obtain unidirectional polarity in train lighting.

Ans:

Method to obtain unidirectional polarity in train lighting:



Dynamo has rocker arm mounted on the shaft, friction tight. When the direction of rotation of the shaft is clockwise, terminal X (positive) touches P₁ while terminal Y (negative) touches N. Thus, giving the output polarity as shown in figure. When the direction of rotation is anticlockwise, X (negative) terminal of the rocker arm will now touch to N₁ brush and Y (positive) terminal of the

2 marks for
figure

1 mark for
clockwise

And 1 mark
for
anticlockwise

rocker arm will touch to P. Thus, the output polarities will be obtained as shown in figure. Thus, unidirectional polarity is obtained.

- 1 f) What is end on generation? State any two advantages.

Ans:

End on generation:

Scheme of providing diesel AC generator car at either end of train is end on generation. In this system electric power to the train is supplied from diesel generating set at 400V, 3 phase, 50Hz, ac.

- Coaches are provided with through wiring for transmitting 400V, 3phase supply from end to end.
- 5KVA transformers are used for light and fan at 110V ac.
- Heating , cooling loads in the pantry car are provided with 415/230 V ac.
- Fluorescent lighting is used
- fans with shaded pole motor are used

2 marks for
Definition
and
explanation



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- for improvement of PF static capacitors in generator car are used.

Advantages of End on Generation

- Almost 100% reliability.
- Use of fluorescent lighting improves illumination
- AC fans require no maintenance
- System is theft proof.
- Economical in capital and running cost for 16 or more coaches.
- Weight of equipment in coaches reduced hence additional coaches can be used.
- More amenities to the passengers of deluxe trains can be provided.

1 mark each
for any two
advantages =
2 M

- 1 g) List any eight equipment used in auxiliary circuit of electric locomotive.

Ans:

- 1) Batteries , 2) Compressor , 3) Blowers , 4) Exhausters , 5) Pumps , 6) Cab ventilating fans. 7) Locomotive heating (if any) , 8) Transformer oil cooling radiator. 9) head light , 10) Flasher light , 11) Marker light , 12) Engine Horn

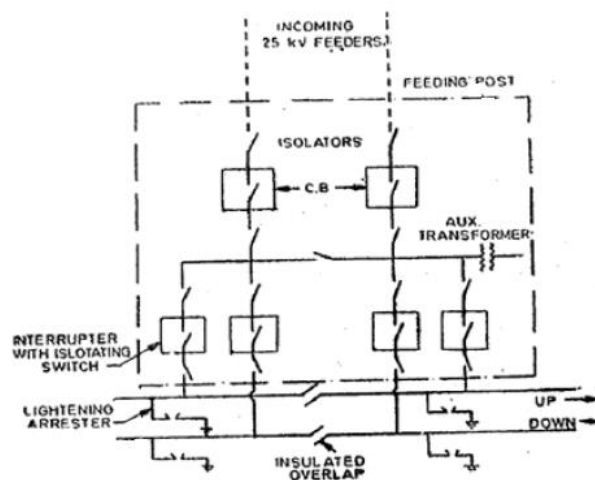
½ mark each
for any eight
equipment
= 4 marks

- 2 **Attempt any TWO of the following:**

16

- 2 a) Draw a neat labelled diagram of feeding post and write any four points related to it.

Ans:



4 marks for
labelled
diagram,
OR
3 marks for
partially
labelled
diagram,
OR
2 marks for
unlabelled
diagram

Feeding post:

- 1) Each feeder has two conductors one insulated for 25 kV (connected to bus-bar) and other for 3 kV (connected to track for return current).
- 2) Located as near as possible to substation with maximum distance being 2 km.
- 3) Feeders connected to two sets of bus-bars which are used to maintain supply to OHE in case of failure of one of them or when under maintenance.
- 4) The 25 kV CB of FP are controlled from RCC of railway.
- 5) Interlocked double pole isolators provided on both side of CB.
- 6) The interrupters which are remotely controlled are supposed to operate only under normal current as they are not provided with protection for the same.

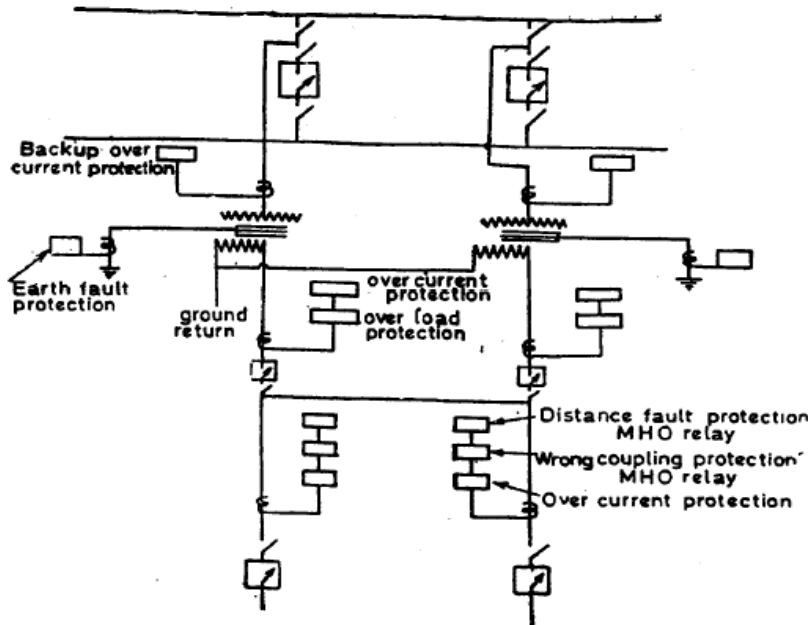
1 mark each
for any four
points
= 4 M

- 2 b) Draw a neat labeled diagram to show protective system for AC traction and give the function of each relay used in it.

Ans:



Protective system for AC traction:



Protective System For AC Traction

Diagram fully labeled 4 marks,
partially labeled 3 marks,
unlabeled 2 mark

Function Of Each Relay:

For transformer -

- Inverse time over current relay– as back up protection on primary (HV side) over current protection of transformer and other equipment.
- Overload thermal relay – protection against sustained overloads on t/f
- Earth fault relay – earth fault protection of transformer
- Buchholz relay – Protection from incipient earth or inter winding faults inside the transformer

For catenary -

- MHO relay – wrong coupling protection
- MHO relay – over current protection at farthest point.
- over current relay - over current protection against faults near substation
- Under voltage relay – protection against faults far away from substation

1 mark each for any two relay functions for transformer = 2 M
1 mark each for any two relay functions for catenary = 2 M

2 c) Draw and explain construction of Faiveley type pantograph collector. Also explain its working in brief.

Ans:

Faiveley type pantograph collector:

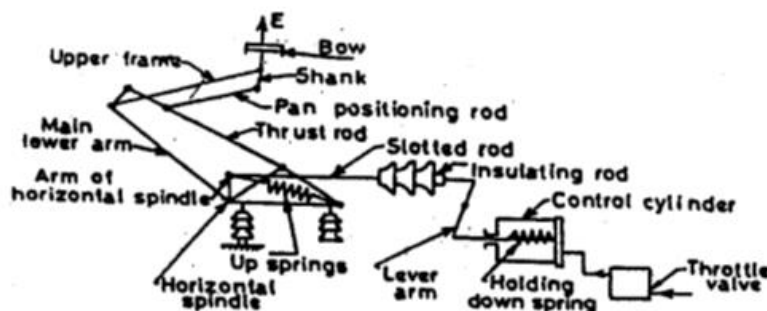


Diagram fully labeled 4 marks,
partially labeled 3 marks,
unlabeled 2 mark



Construction of Faiveley type pantograph collector :

- It consists of
 - i) sub frame or base, ii) Articulated system, iii) Pneumatic control system including throttle valve, iv) Two raising springs v) Four insulators.
- The base is made up of welded sections and houses two ball bearings on which is carried the articulated system.
- Rubber stops are provided to limit the folding of the articulated system at the lower part.
- Articulated system consists of:
 - a) Horizontal spindle turning into two ball bearings which are part of the base.
 - b) Lower arm integral with horizontal spindle and supporting at the upper end bearing on which are fitted two tubes of the upper frame.
 - c) Thrust rod articulated at lower end on fixed point of the base frame and on upper end on bearing housed in the yoke casting at upper end of lower arm.
 - d) Transversal tube rotating in the sleeves fitted on the tube ends of upper frame.
 - e) Positioning rod articulated on a pin fitted on the thrust rod and on one side & on the crank pin fitted to the shank as shown in the figure.
 - f) Bow consists of frame on which are bolted two connecting strips.
 - g) Whole pantograph is fitted on the roof of the vehicle by means of four insulators.

2 mark for construction

Working of Faiveley type pantograph collector:

- When compressed air is admitted in the central cylinder, piston compresses the holding down springs and slotted rod gets translatory motion which permits horizontal spindle to rotate under the action of up springs.
- The pantograph then rises until collector touches the OHE.
- The articulated system then stops and piston complete its stroke.
- Piston remains stationary during normal operation.
- The pin of horizontal spindle is permitted to move freely in the slot of slotted rod & pantograph is operated purely by the up springs.

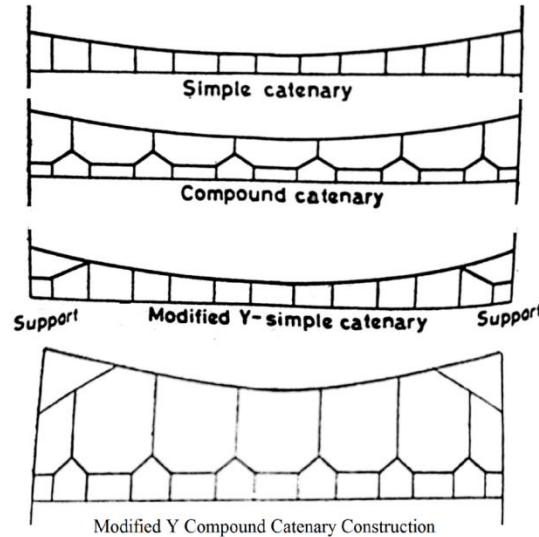
2 mark for working



- 3 a) List and draw any four polygonal OHE constructions stating its speed suitability.

Ans:

Types of Polygonal OHE:



1 mark for
diagram of
each type
= 4 M

½ mark for
each name
= 2 M
and ½ mark
for speed of
each = 2 M

- 1) Single or Simple Catenary Construction: Speeds up to 120 kmph
- 2) Compound Catenary Construction: Speed range from 190 to 225 kmph
- 3) Modified Y Simple Catenary : 10m Y Speed up to 140 to 160 kmph
- 4) Modified Y Compound Catenary Construction: Speeds up to 200 kmph

- 3 b) State the function of (i) Neutral section, (ii) Section insulator, (iii) Un-insulated overlap, (iv) Insulated overlap.

Ans:

- i) **Neutral section:** Passing of pantograph under insulated overlap will cause short circuit between two phases of the supply system, damaging OHE & pantograph. To avoid this bridging of two different sections fed by two different phases, a neutral section is inserted between them.
Located between two substations.
- ii) **Section insulator:** Section insulators are provided to insulate OHE of one elementary section from the OHE of another adjacent elementary section.
Located at cross over from one track to other, from main line to siding.
- iii) **Un-insulated overlap:** Two contact wires belonging to two adjacent sub elementary sections running parallel to each other for one span are electrically connected by jumpers. This is called as uninsulated overlap. To rectify faults in one contact wire of two running in parallel wires without affecting power to OHE. Located at two adjacent sub-elementary sections.
- iv) **Insulated overlap:** To provide isolation for operation and maintenance of OHE if two lengths of OHE belong to two elementary sections.
Located at feeding posts, sub sectioning posts and booster sections.

2 marks for
function of
each
= 8 M

- 3 c) i) List two major equipment at traction sub-station with their functions.

Ans:

Major equipment at traction substation:

- 1) Transformer:
To step down the busbar voltage from 132 kV to 25 kV.

1 mark each
for any two
equipment
= 2 M



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2) Circuit Breaker:

To disconnect the circuit in case of fault. Transformer CB trips on internal faults of transformer. Feeder CB trips on occurrence of fault on OHE.

1 mark for function of each above = 2 M

3) Interrupter:

To disconnect the circuit in case of fault. It cannot operate automatically.

3 c) ii) Draw a neat layout diagram of traction substation.

Ans:

Layout Diagram of Traction Substation:

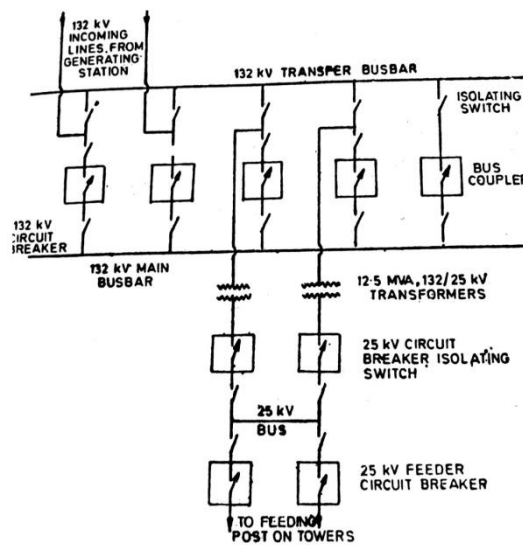


Diagram fully labeled 4 marks,

partially labeled 3 marks,

unlabeled 2 mark

4 Attempt any TWO of the following:

16

4 a) Draw the neat labelled diagram of AC track circuit and explain the function of impedance bond present in it and also give the advantage of AC track circuit.

Ans:

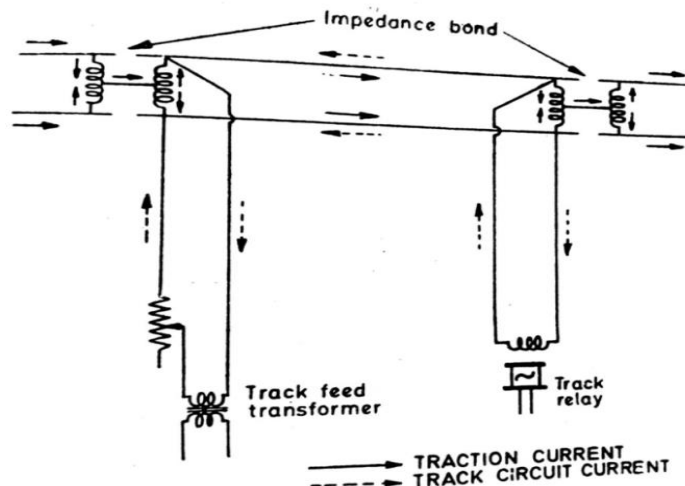


Diagram fully labeled 4 marks,

partially labeled 3 marks,

unlabeled 2 mark

Function of Impedance Bond:

- 1) To provide a path of low resistance for traction currents to pass through insulated track.
- 2) To provide a path of high impedance for AC signaling currents between two rails of the track.

1 mark each for any two functions = 2 M



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3) To keep the signaling currents restricted to the insulated track circuit.

Advantages of AC track circuit:

- | | |
|--|-------------|
| 1) Free from effects of stray currents. | 1 mark each |
| 2) Track circuit of a long length up to 3 to 5 km is possible. | for any two |
| 3) Cheaper in costs as compared to DC track circuit. | advantages |
| 4) Easy to install than DC track circuit. | = 2 M |
| 5) Easy to maintain | |

4 b) List any two types of relays and contactors with their function used in AC locomotive.

Ans:

Types of relays and their function in AC locomotive:

- | | |
|---|--------------|
| 1) Buchholz Relay: To protect traction transformer from incipient faults. | 1 mark each |
| 2) Earth fault or Ground fault Relay: To protect the system against all kinds of faults related to ground. | for any two |
| 3) Notching Relay: To protect DC motor power circuit. | types of |
| 4) No-volt Relay: Ensures that too much current is not applied to DC motor which has lost the speed while the current is off. | relays = |
| 5) Overload Relay: This relay detects excessive current in the circuit. | 2 M |
| 6) Wheel-Spin Relay: Protects motor from rise in current due to over-speeding of another motor. | 1 mark for |
| 7) Electromagnetic Relay: For sequencing of operations of machines and equipment. | function of |
| 8) Current Limiting Relay: Sense current values during the starting of motors and maintain them at limiting values during automatic acceleration of motors. | each of |
| | above two |
| | relays = 2 M |

Types of Contactors and their function in AC locomotive:

- | | |
|--|-----------------|
| Each contactor makes or breaks the power circuit. | 1 mark each |
| i) Electromagnetic Contactor – when operating coil is energized attracts a soft iron armature which in turn operates moving power contact. When coil is de energized moving contact drops | for any two |
| ii) Electro-pneumatic Contactor – moving power contact operates to close the circuit when compressed air acts on a piston in cylinder. Releasing air pressure spring forces the piston to open the contact. | types of |
| iii) Cam and Roller operated Contactor – moving contact is carried at one end of hinged arm and roller is carried at other end. Roller is engaged with cam on shaft. Cam shaft can be moved by air engine or vane motor. | contactors |
| | = 2 M |
| | 1 mark each |
| | for function of |
| | above two |
| | contactors |
| | = 2 M |

4 c) i) State any four ideal requirements of signaling system.

Ans:

- | | |
|---|--------------|
| i) Unless the whole section of track governed by the signal is clear & safe, it should not be possible to display 'safe' indication. | 1 mark each |
| ii) Failure of any component of signaling scheme should give danger indication. | for any four |
| iii) There should be provision of automatic application of brakes to the train, should the driver ignore the danger indication of the signal. | requirements |
| iv) Electric lock should be provided on the lever working the home signal. | = 4 M |



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- v) To indicate the presence of train on sections out of view of signal man owing to the presence of obstructions.
- vi) All traction signals are located on the left side of the track.
- vii) The signal units are so fixed that the height of the center line of the red signal shall be approximately 3.65m above the track.
- viii) No part of the signal without track indicator shall normally be higher than 5.2m above the track.
- ix) If signals are located between the tracks, no OHE structures shall be provided in the same track space for at least 600m in the rear of the signal.

4 c) ii) Give any four advantages of Voice frequency signals over DC signaling system.

Ans:

Advantages of Voice frequency signals over DC signaling system:

- 1) Large number of circuits can be easily derived over a single pair of wires (single pair can control 18 stations).
- 2) Signal attenuation can be compensated by use of repeater stations.
- 3) No interference and cross talk over adjacent conductors.
- 4) Can be used over long distances.
- 5) Can be used where large number of equipment are to be controlled.

1 mark each
for any four
advantages
= 4 M

5 Attempt any TWO of the following:

16

5 a) With the help of neat labeled diagram, explain the working of Double Battery Parallel Block system used in train lighting.

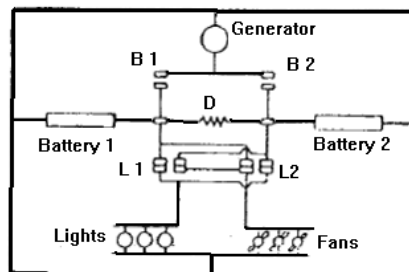
Ans:

Double battery parallel block system for train lighting:

- When train is stationary or runs slowly - fig(a)- generator contacts B₁ and B₂ are open, both batteries supply the load through closed contacts L₁ and L₂, lamp resistance D short circuited.

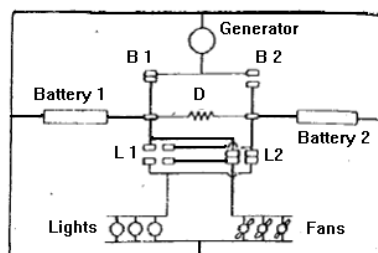
1 mark

Fig a:



2 marks
diagram

Fig b:



2 marks
diagram

- When train is in motion and lights on - fig(b) –



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Generator is connected to battery 1 through closed contact B_1

Lighting load is connected to battery 2 through closed contact L_2 .

Generator output is divided between battery 1 and lamp load.

2 mark

Battery 2 is maintained in floating condition.

- When train is in motion and lighting and other loads are switched off -

Switches L_1 and L_2 are open ,

Lamp resistance D is short circuited

Generator contacts B_1 and B_2 are closed

both batteries will then be charged in parallel.

1 mark

- 5 b) Draw neat labeled diagram of single phase AC locomotive showing its various equipments of power circuit and give function of each equipment used in power circuit.

Ans:

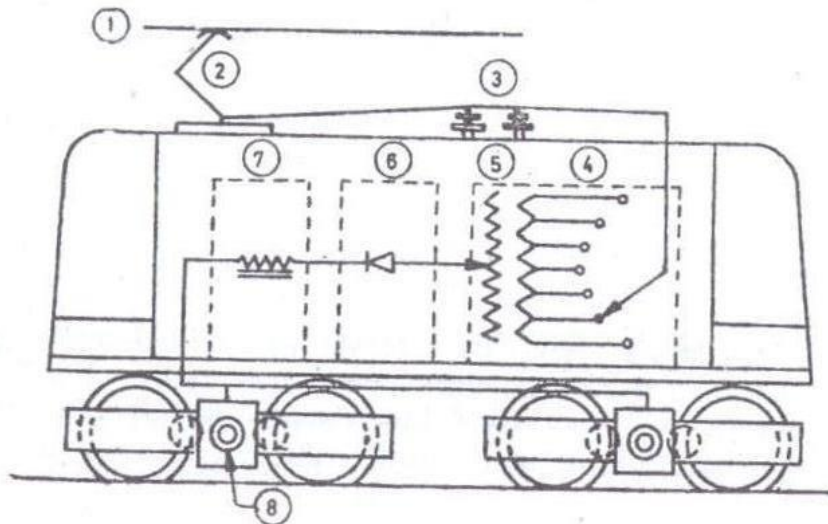
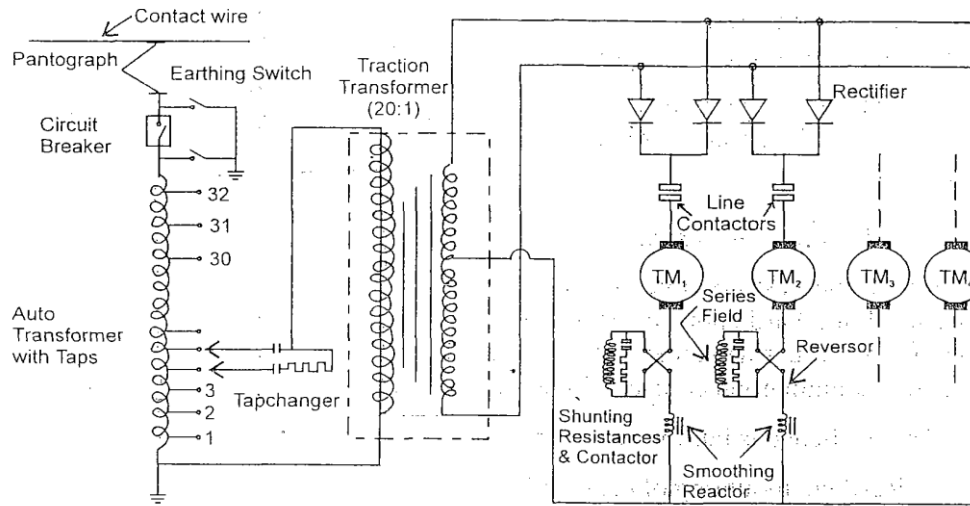


Diagram
fully labeled
4 marks,
partially
labeled 3
marks,
unlabeled 2
mark

- | | |
|--------------------|------------------------|
| 1. OHE | 2. Pantograph |
| 3. Circuit breaker | 4. On load tap changer |
| 5. Transformer | 6. Rectifier |
| 7. Smoothing choke | 8. Traction motor |

OR



Schematic arrangement of power circuit

Functions of any four 1 mark each = 4 marks

Functions of equipment:

- 1) circuit breaker: disconnects the locomotive equipment from the supply in the event of fault in the equipment / loco.
- 2) On load tap changer, used to control the voltage to the traction motors through the rectifier for speed control.
- 3) Traction transformer, steps down the voltage to the suitable value for the traction motor. It has a ratio of 20:1.
- 4) Rectifier: converts input AC to DC for further use by series traction motors.
- 5) Smoothing reactor/choke: smoothen out the ripples in the DC output current of rectifier.
- 6) Traction motor: operates as per the required operating characteristics to take on the traction load.

5 c) i) Explain the need of maintenance of electric locomotive.

Ans:

Need for maintenance :

- To correct the effects of Wearing out.
- To correct the effects of deterioration of locomotive component during normal use.
- In the long run (aging) performance gets affected and finally beyond safe limit components may fail altogether.
- Increase the life of equipment.
- Maintain the proper quality of output of equipment.
- Maintain the efficiency of the equipment.

1 mark for each valid point any four = 4 marks

OR

Maintenance of electric locomotive is needed as it:

- Extends the useful life of parts / components of locomotive .
- Ensures proper availability of locomotive.



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- Ensures reliability and operational readiness.
- Ensures safety by all means.

5 c) ii) State four important features of LEM that differ it from normal electric motor.

Ans:

- 1) In LEM primary & secondary or stator & rotor have Longitudinal arrangement while normal has circular parts.
- 2) Air gap between stator & rotor is more as compare to normal motor.
- 3) Power factor is poor as compare to normal motor.
- 4) Linear relative magnetic field is produced as compare to rotary magnetic field of normal motor.
- 5) Speed is measure in **m/sec** as compare to **RPM** in normal motor.
- 6) No speed limit for LEM while maximum speed of normal motor is 3000 RPM.
- 7) Less efficiency as compare to normal motor.
- 8) Used in high speed levitated system while normal motor provides rotary mechanical output.

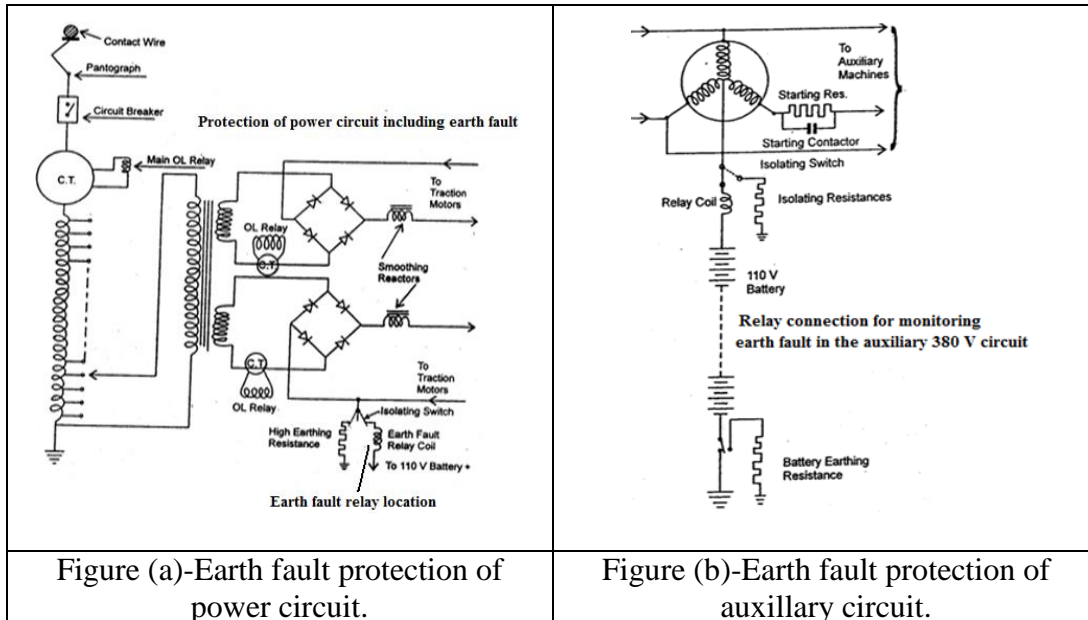
1 mark each
any 4 = 4
marks,
other valid
points must
also be
considered
on merit.

6 Attempt any TWO of the following:

16

6 a) Explain with necessary diagram the earth fault protection of power and auxiliary circuit.

6 a) Ans:



3 marks for each diagram

i) **Earth fault protection for power circuit in Loco:**

When any earth fault occurs in the traction power circuit the fault current flows through the relay coil as the battery negative is also earthed. This trips the main CB. The relay can be temporarily isolated by connecting the faulty traction circuit through a high earthing resistance to earth.

1 mark for description



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ii) Earth fault protection for auxiliaries in Loco:

1 mark for description

Detection of any earth fault in auxiliary circuit of Loco is a very important element of the protection strategy. Since earth fault should not lead to dangerous condition till another fault occurs, this protection is provided with facility of isolation.

The protective relay for monitoring earth fault in the auxiliary circuit is connected to the star point of the Arno as shown in figure. An earth fault occurring anywhere in the auxiliary circuit gets monitored by the relay which acts to trip the main CB. Since earth fault is not dangerous, the locomotive can be worked temporarily by isolating the relay which connects the star point to earth through a high resistance.

- 6 b) List any four types of electrical faults that may occur on electric locomotive with their causes.

- 6 b) Ans:

Electric faults and causes in electric locomotive:

- Changes in the conditions of overloading leading to heating of winding , failure of insulation.
- Changes in the operating environments such as temperature, moisture, dust etc. leading to failure of insulation, over- heating and chances of short circuit.
- Changes in the condition of equipment itself such as aging leads to open circuit, deterioration of insulation, wear leads to chances of short circuit.
- External influences of abnormal nature like voltage surges, lightning, short circuits elsewhere leading to chances of short circuit, overheating, burning of equipment etc.
- Improper operation due to bad maintenance either due to lack of attention which should have been given .

2 mark each
any four = 8
marks

- 6 c) With respect to LIM propelled railway traction system state points of;
i) Strengths of LIM
ii) Weaknesses of LIM

- 6 c) i) Ans:

Strengths of LIM propelled railway traction:

- 1) Pull produced for propelling the system is independent of adhesion between the wheels of motorized coach and rail.
- 2) No driving wheels and hence no associated adhesion problem. This feature permits negotiation of steeper gradients.
- 3) Two wheels fixed to an axle can rotate independent of each other and hence curve negotiating property improves.
- 4) System does not require gears therefore reduction in the associated noise level and cost of maintenance.
- 5) Floor height above the rail level is substantially reduced. This results in reduction in the height of bridges, diameter of tunnels along the route.
- 6) Avoidance of rotation of parts leads to low mechanical losses.
- 7) Useful for high speed levitation trains due to absence of gears and adhesion.

1 mark each
for any four
strengths
= 4 marks



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6 c) ii) Ans:

Weaknesses of LIM propelled railway traction:

- 1) The system requires laying of Al reaction rail all along the route. This considerably adds to the cost of track.
- 2) Reaction rail consist of Al plate backed by mild steel plate all along the route, this also increase the cost.
- 3) Since Al is relatively expensive material, hence chances of theft are more, hence disruption of service
- 4) Due to more air gap in LIM than RIM, power factor is poor and increased motor losses.
- 5) Due to discontinuity in the magnetic and electric circuits at entry and exit ends of motor, poor motor efficiency.
- 6) As power supply for traction is single phase ac power inverters are needed for operation of LIM this adds to cost.

1 mark each
for any four
weaknesses
= 4 marks
