`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.

1 Attempt any FIVE of the following: 20

1 a) State where interrupter is located. What is its function? And which one is the important difference between it and CB?

Ans:

Interruptor is a non-automatic type circuit breaker located at feeding, paralleling and subsectioning posts. 2 marks

Important difference with respect to CB:

i) Not provided with protective relay signals for operation as in CB. 2 marks
ii) Cannot be operated automatically on faults as CB.

1 b) Distinguish between third rail system and over head collection system- any 4 points.

Ans:

Sr. No.	Third rail system	Overhead collection system
1	In this system current is collected from third rail placed at a distance of 0.3m to 0.4 m from the tracks.	In this system current is collected from overhead wire
2	This system is economical to install	This system is costly to install
3	There is possibility of electric shock hazard close to ground	There is no possibility of electric shock hazard close to ground
4	Resistive losses are more	Resistive losses are less.
5	Applicable only for low voltage applications below 1500volts	Applicable for high voltage applications
6	Less safe	More safe
7	Applicable to slow speed trains	Applicable to high speed trains

1 mark for each of any four points = 4 marks

OR Any other valid points

1 c) State the necessity of the signaling system.

Ans:

Necessity of signaling system:

Control the movement of trains to avoid hazardous movements, avoid accidents, operate optimally by the following: 1 mark

- Indicate to the driver when to stop
- Indicate to the driver when to proceed on a certain rail route,
- Indicate to the driver when to proceed with caution on a certain rail route,
- Indicate to the driver when to proceed with full speed,
- Indicate to the driver position of a hidden or obscured signal,
- Indicate to the driver his action during shunting operations.

1 mark each any three = 3 marks

OR

Other valid answers.

1 d) Explain the meaning of the terms WAM_1, WAV_3, YAV_1, WAG_1.

Ans:

- WAM_1: Broad gauge AC locomotive for mixed freight (goods) and people design class 1.
- (~~WAV_3~~) WAU3: Broad gauge AC locomotive EMU design class 3.
- (~~YAV_1~~) YAU_1: Meter gauge AC locomotive EMU design class 1
- WAG_1: Broad gauge AC locomotive for goods freight design class 1.

1 mark each = 4 marks

1 e) Describe different causes of defects in locomotive (any 2) and the remedial actions will you suggest for the same.

Ans:

Causes of Defects in locomotive :

1) Defective design material
2) Defective workmanship by the manufacturer
3) Inadequate maintenance due to negligence on the part of maintenance staff
4) Lacuna in maintenance schedules which may necessitate change in the periodicity of inspection.

1 mark each for any two causes = 2 marks

Remedial actions:

Above defect (1) & (2) can be eliminated by appropriate action taken by manufacturer.
Defects (3) and (4) can be minimized by practicing the ideal maintenance schedule.

1 mark for each remedy = 2 marks

1 f) Differentiate between LIM and ordinary IM.

Ans:

1) In LIM primary & secondary or stator & rotor have longitudinal arrangement while normal has circular parts.
2) Air gap between stator & rotor is more in LIM as compared to IM.
3) Power factor is poor in LIM as compared to IM.
4) Linear relative magnetic field is produced in LIM and the rotary magnetic field is produced in IM.
5) Speed is measured in **m/sec** in LIM and in **RPM** in IM.
6) No speed limit for LIM while maximum speed of IM is 3000 RPM.
7) LIM has Less efficiency as compared to IM.
8) LIM is used in high speed levitated system while IM is used for rotary mechanical output.

1 mark each for any four points = 4 marks

1 g) List various miscellaneous equipment at control post. State use of each.

Ans:

Miscellaneous equipment at control post:

1. **Lightning Arrestor:** Provides protection against over-voltages / surges.
2. **Auxiliary transformer:** Provides 230 V, 50 Hz, supply to operate battery charger, remote control equipment, signally and lighting at control post.
3. **PT:** Provides continuous indication regarding the condition of supply, for measurement and protection purposes.
4. **Battery:** For operation of control equipment and interrupter.
5. **Battery charging equipment:** For charging of batteries at the control post.

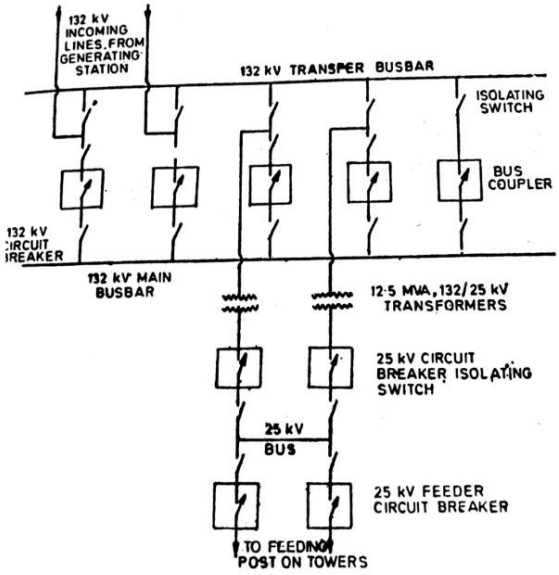
½ mark for name of any four equipment = 2 marks
½ mark for function of each above = 2 marks

2 Attempt any FOUR of the following: 16

2 a) Draw a neat labeled sketch of traction substation.

Ans:

Typical Traction Substation Layout Diagram:



4 marks for labeled diagram,

3 marks for partially labeled diagram,

2 marks for unlabeled diagram

OR

Any other equivalent layout diagram

2 b) Draw a neat labeled diagram of Automatic weight tension and Temperature compensation and give any two advantages of same.

Ans:

Automatic weight tension and Temperature compensation of OHE:

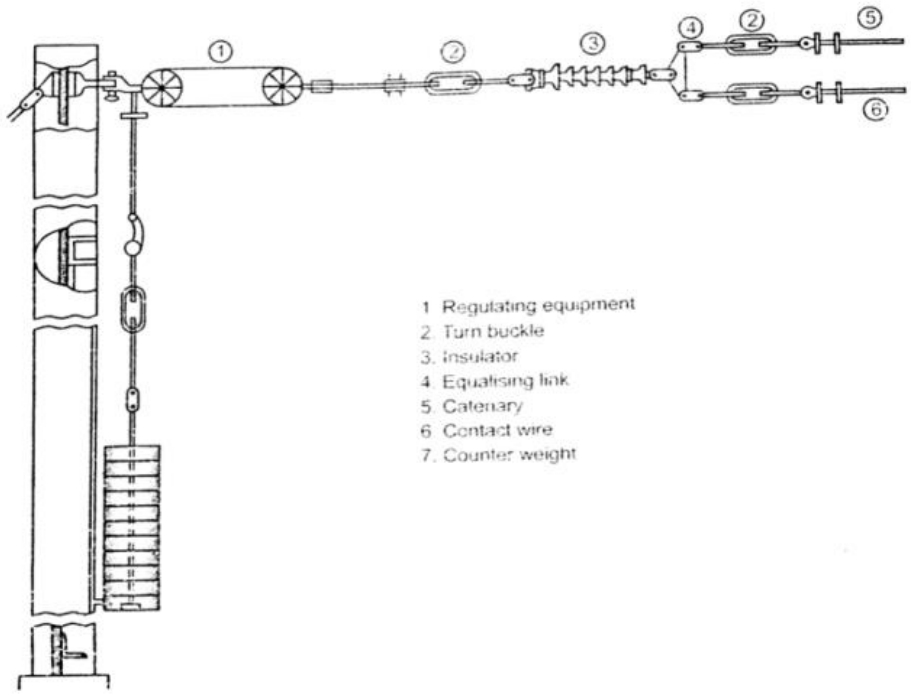


Diagram fully labeled 3 marks,

partially labeled 2 marks,

unlabeled 1 mark

Advantages:

1. Sparkles current collection under all atmospheric conditions.
2. Reduction of wear of both contact wire and pantograph collecting strips.
3. Creep of the conductors with the passage of time is automatically taken up by the tensioning device.
4. Below 40^0C although the equipment becomes fixed, the highest tensions reached are considerably less then with unregulated OHE, thereby permitting some economy in the design of supports and foundations.
5. The problem of providing adequate clearances under over line structures and in tunnels is allowed because with fixed tension in the OHE, fluctuations in its height are eliminated.
6. Owing to contact tension in the conductors, there is only one critical velocity of propagation of waves in the contact wire and this velocity is generally greater than that of unregulated OHE.

Any two advantages ½ mark each = 1 mark

2 c) Give purpose and location of (i) Un-insulated over-lap, (ii) Insulated overlap, (iii) Neutral section, and (iv) Section insulator.

Ans:

i) **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 un-insulated 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.

ii) **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.

iii) **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.

iv) **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.

½ mark for purpose of each and ½ mark for location of each = 4 marks

2 d) List any four advantages of multiaspect color light signals.

Ans:

Advantages of multiaspect color light signals:

1. Economical
2. Simplicity of indication to drivers
3. Better ability to deal with traffic of varying speed
4. Simpler and easier in operation
5. Control on large signals at heavily worked stations
6. Provide increased line capacity

1 mark for each of any four = 4 marks

2 e) Differentiate DC and AC track circuits on the basis of-

i) Length of circuit

ii) Application

iii) Effect of stray currents
iv) Maintenance

Ans:

i) Length of circuit :
AC track circuit is having long length up to 3 to 5 km while DC track circuit is having short length.

ii) Application :
AC track circuit is used where tracks are electrified while DC track circuit is used for electrified as well as non- electrified lines.

iii) Effect of stray currents:
Stray currents have no effect on AC track circuit while DC track lines are not recommended for use in places where fear exists for circulation of stray direct currents. They cause voltage drop in the un insulated rail, which limits the length of the DC track.

iv) Maintenance :
AC track circuit has easier and economical maintenance while DC track circuit has comparatively complex maintenance activities.

1 mark for each difference = 4 marks

2 f) Write any four points that state how a traction transformer is different from ordinary transformer.

Ans:

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 limit the effect of SC, impedance not less than 8.5 % for 10 MVA and 10 % for 12.5 MVA.

1 mark each for any four points = 4 marks

3 Attempt any FOUR of the following: 16

3 a) List any four characteristics of efficient maintenance of locomotive.

Ans:

Characteristics of Efficient Maintenance of locomotive:

1) Planning of schedule.
2) Investigation of failures.
3) Repair facilities such as adequate staff, shed, plant, machinery and repairing tools.
4) Staff training facility such as training school, instruction manuals etc.
5) Proper inventory/optimum stocks of regular and emergency maintenance spares.
6) Good design and drawing office for the preparation of detailed working drawings and specifications for maintenance spares.
7) Inspection of stores purchased according to working drawings and specifications.

1 mark each of any four = 4 marks

3 b) With the help of neat figure explain differential current protection of traction circuit.

Ans:

Differential current protection of traction circuit:

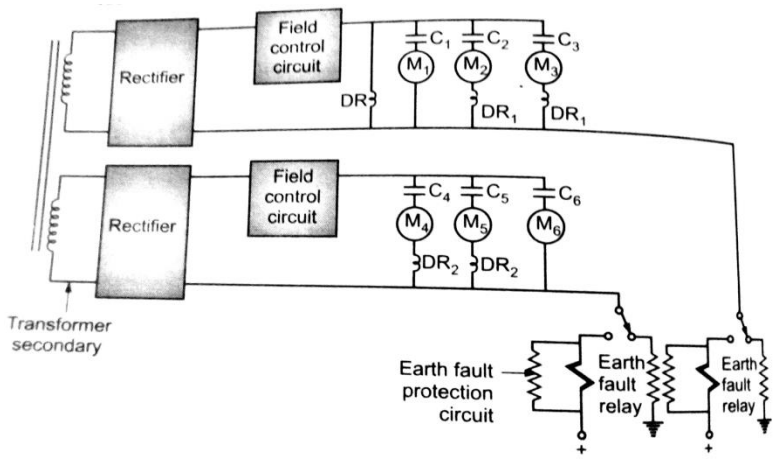
Figure shows differential current protection scheme for 6 motors

1. The main differential relay (DR) is connected in the motor circuit as shown in

the figure. 2 marks for explanation

2. The differential current relay 1 (DR_1) is connected in traction motor 1, 2 & 3 circuit and the differential current relay 2 (DR_2) is connected in traction motors 4, 5 & 6 circuit.
3. If the difference in the currents between the group of motors exceeds a permissible limit, the respective differential current relay DR_1 or DR_2 operates.
4. The indication is given by pilot lamp & autoregration process takes place.
5. The main differential relay (DR) is energized & it initiate autoregration process when the difference between current reduces and then autoregration process stops.

2 marks for diagram



Differential current protection of traction circuit

3 c) List any 4 strengths of LIM propelled railway traction.

Ans:

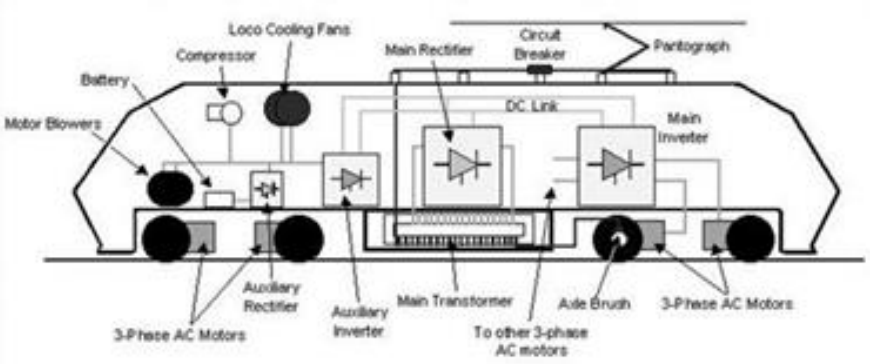
Strengths of LIM propelled railway traction:

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

3 d) Draw a neat sketch of power circuit of 3-phase locomotive.

Ans:



Power circuit of three phase AC locomotive

Diagram fully labeled 4 marks,

partially labeled 3 marks,

unlabeled 2 mark

OR

Any other equivalent Diagram

3 e) For a pantograph write any 2

i)Types, ii)Advantages, iii) Methods of raising, iv) Materials of collector strip

Ans:

i)Types:

a) Diamond Type Pantograph

b) Faiveley Type Pantograph ½ mark each

ii)Advantages:

a)Reversible operation is possible

b)Current collection capacity is high ½ mark each

iii) Methods of raising:

a) Air raised

b) Spring raised ½ mark each

iv) Materials of collector strip:

copper, copper steel combination, silicon manganese steel ,aluminum steel, bronze, Metallized carbon or carbon (any two) ½ mark each

3 f) Explain use of traction transformer and its specialty.

Ans:

Use of Traction Transformer:

To vary the applied voltage to traction motor circuits so that the currents are controlled to reasonable limits. This is done by the transformer in combination with the tap changer arrangement. The transformer is used in this manner to obtain voltages in the range of 15 kV to 25 kV for traction units even though the utilization voltages are very low. 1 mark for use

Specialty:

- Specially designed to withstand severe operating conditions
- Traction transformers have to withstand peak capacity for short time hence windings require class 'A' insulation.
- The windings are specially designed to withstand the stresses of frequent short

1 mark for each of any three specialities = 3 marks

circuits on 25KV OHE.

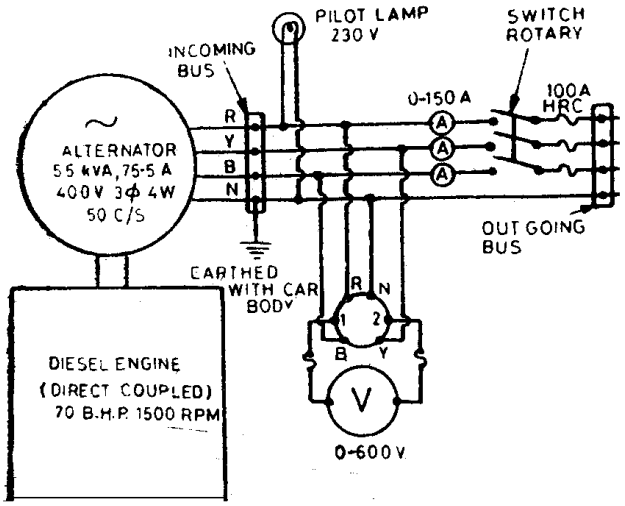
- In order to limit the effect of short circuit, impedance of transformer is not less than 8.5% for 10MVA capacity and 10% for 12.5MVA capacity.
- Can take overloads as 50% for 15 min, 100% for 5 min, 120% for instantaneous loads.
- Impulse voltage withstand capacity nearly 5 times higher.
- Transformers are not provided with on load tap changers.

4 Attempt any FOUR of the following: 16

4 a) With a neat figure, explain End-on generation.

Ans:

End on generation:



2 marks for Diagram

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

2 marks for Explanation

4 b) Draw a neat sketch of earth fault protection of auxiliary circuit of electric loco. State the function of relay and isolating resistance.

Ans:

Function of relay:

The earth fault occurring anywhere in the auxiliary circuit gets monitored by the relay which acts to trip the main CB.

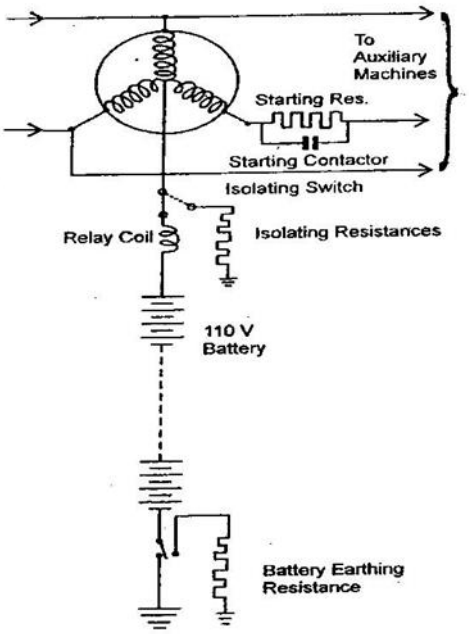
1 mark for Function of relay

Function of isolating resistance:

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 so that the relay operation is avoided.

1 mark for Function of isolating resistance

Earth fault protection for auxiliaries in Loco:



Relay connection for monitoring the earth fault in the auxiliary 380 volt circuit

Diagram fully labeled 2 marks,

Partially/ unlabeled 1 marks,

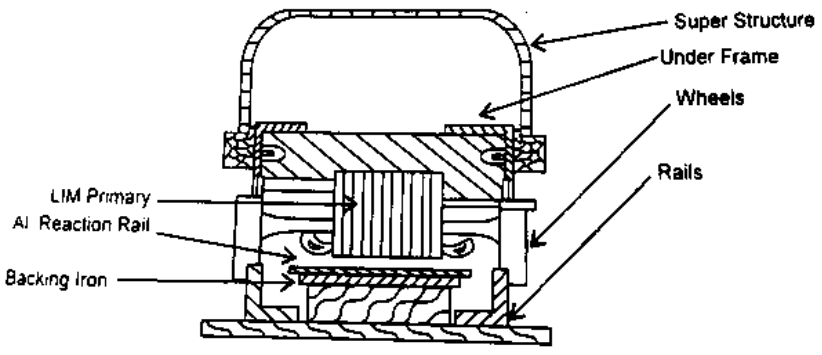
4 c) Explain moving primary fixed secondary single sided LIM with the help of figure.

Ans:

Moving primary and fixed secondary single sided LIM:

- Primary on moving coach and secondary (Al reaction rail) laid down.
- Secondary (Al reaction rail) faces primary on upper side only.
- Primary laminated.
- Backing iron needed for completion of magnetic path with minimum reluctance.
- Maintaining uniform mechanical clearance between secondary Al plate and primary is easier at all locations compared to other configurations.

2 marks for explanation



Moving-primary fixed-secondary single-sided LIM

2 marks for diagram

4 d) How to improve the reliability of locomotive?

Ans:

Means to improve reliability:

1) Proper inspection
2) Proper method of trouble shooting & repairs
3) Proper technical investigations
4) Suitable repair facilities

1 mark each for any four = 4 marks

4 e) Write any 4 equipment and their function in auxiliary circuits of electric locomotive.

Ans:

Auxiliaries with function:

1) Batteries – to run baby compressor which supplies air for initial raising of pantograph and closing of air blast circuit breaker.
2) Air compressor – operation of air control and application of brakes.
3) Exhausters – for vacuum brakes.
4) Blowers – as transformer blower, reactor blower, SCR blower, traction motor blower etc.
5) Pumps – transformer oil pump, water pump etc.
6) Fan – cab ventilation
7) Heater – locomotive heating

(½ + ½) =1 mark each any four = 4 marks

4 f) Draw neat labeled sketch of feeding post.

Ans:

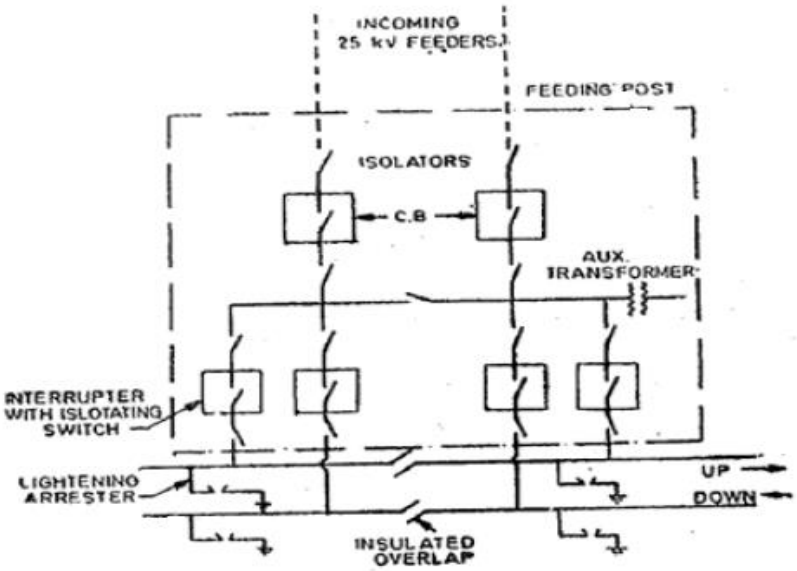


Diagram fully labeled 4 marks,

partially labeled 3 marks,

unlabeled 2 mark

5 Attempt any FOUR of the following: 16

5 a) State effect of speed on OHE.

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) The pan of pantograph along the overhead wire pushes it up by a certain amount of pushup.

1 mark each for any two points = 2 marks

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 satisfactory current collection at various speeds, various modifications in the construction of OHE are carried out.

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 mark each for any two points = 2 marks

5 b) State what is meant by mimic diagram and what is the indication in mimic diagram of following coloured lamps.
1) Green lamp, 2) Milky white lamp, 3) Red lamp.

Ans:

Mimic diagram:

It depicts the power supply arrangement for the overhead 25 kV traction system in the remote control centre on a small scale in the traction power control centre.

1 mark for mimic diagram meaning

- Mimic diagram is installed at each control centre to give actual visual position of electric supply system. It describes diagrammatically overhead system as well as various substations and control posts.
- Remote controlled equipments in the mimic diagram are represented by a control discrepancy switch (DS).

1) Green lamp lights up whenever impulse train is being transmitted from or received by remote control centre.
2) Milky white lamp lights up when alarm is received from any station in the panel.
3) Red lamp lights up when either send or receive channel fails.

1 mark for each of lamp indication = 3 marks

5 c) State any 4 limitations of Arno converter.

Ans:

Limitations of Arno converter:

1. Unbalanced current in the 3-phase of stator winding
2. Undue heat produced in the winding.
3. Voltage fluctuation and voltage unbalance. Output voltage obtained from Arno converter fluctuates from 290 V to 460 V.
4. When output voltage of Arno converter raises to 460 V, because of excessive magnetizing current, p.f. is poor.
5. Stator winding carries single phase motoring current and 3ϕ generating current.
6. Motoring phases carry both motoring and generating currents, resultant current is small, whereas generating phase carries only generating current, its magnitude is higher than that of motoring phases.
7. Negative sequence torque has pronounced effect on starting torque.
8. Problem in starting.

1 mark for each of any four = 4 mark

5 d) Write 4 major equipment and their functions at traction substation.

Ans:

Major equipment at traction substation and their functions:

1) Traction transformer: The function is to step down the voltage to suitable levels for feeding to the OH lines withstanding the severe operating conditions.
2) Transformer circuit breakers: These are placed on 25 kV side to trip only under internal fault conditions in transformer.
3) Feeder circuit breakers: To operate due to faults in the OHE.
4) Interruptor: It is a non-automatic type circuit breaker installed at feeding, paralleling and subsectioning posts. Opens / closes the OHE on remote control centre signals.

1 mark each = 4 marks

5 e) Draw a neat and labeled figure of Faiveley type pantograph.

Ans:

Faiveley type pantograph collector:

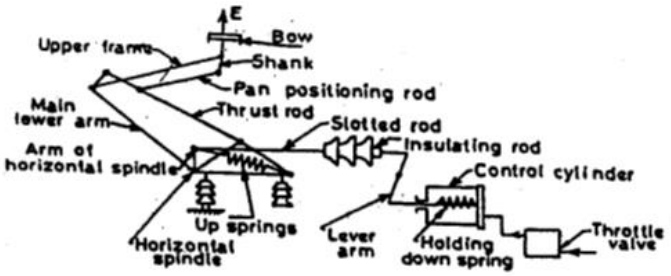


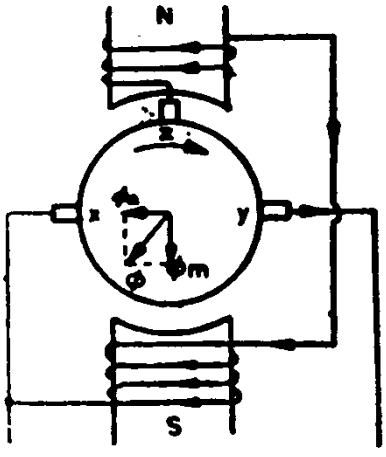
Diagram fully labeled 4 marks,

Partially labeled 3 marks,

Unlabeled 2 marks

5 f) Write a step-by-step procedure of obtaining constant output using 3-brush generator.

Ans:



1 mark for figure

Step by step procedure of obtaining constant o/p using three brush generator:

1. The field is excited from one main brush X and third brush Z fixed at 90° electrical with normal axis of brushes X and Y.
2. As the load on the generator increases the armature reaction flux Øa increases. This is cross magnetizing flux (crosses the main flux Øm).
3. Main flux Øm is distorted. The resultant flux Ør at brushes 'ZX' reduces. The effect is that the emf generated across them reduces .The effect is the reduction in field excitation.
4. This further reduces the emf generated across the main brushes XY. The result is in controlling increased load and keeping o/p as far as possible as constant.

3 marks for all steps and proportionally lower marks for lesser steps.

6 Attempt any FOUR of the following: 16

6 a) List any four contactors and their purpose.

Ans:

Types of Contactors in traction and their purpose :

Each contactor makes or breaks the power circuit.

i) Electromagnetic Contactor : When operating coil is energized, it attracts a soft iron armature which in turn operates moving power contact. When coil is de-energized moving contact drops. — 2 marks

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. — 1 mark

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. — 1 mark

6 b) State any 8 causes of failure of under-frame equipment.

Ans:

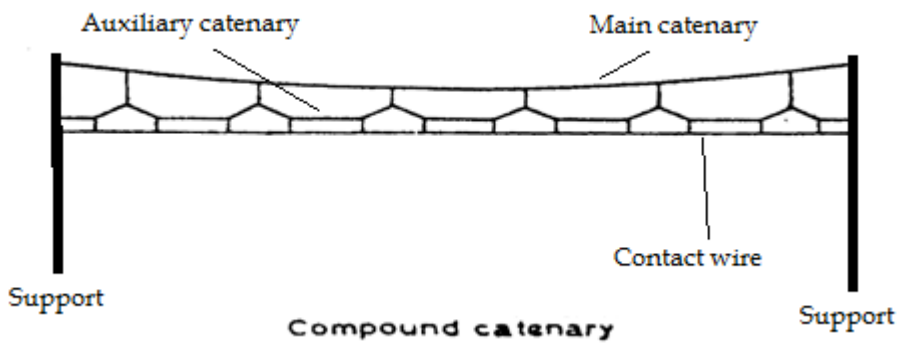
Causes of failure of under-frame equipment:

1) Generator belts falling off or becoming loose.
2) Poor quality of generator brushes
3) Sticking in brush boxes
4) Commutator getting dirty.
5) Generator fuses blowing off.
6) Generator solder running out.
7) Defective cells.
8) Propeller shaft becoming loose.
9) Axle pulley becoming loose.

½ mark for each of any eight = 4 marks

6 c) Draw a neat and labeled sketch of compound catenary construction and state its speed limits.

Ans:



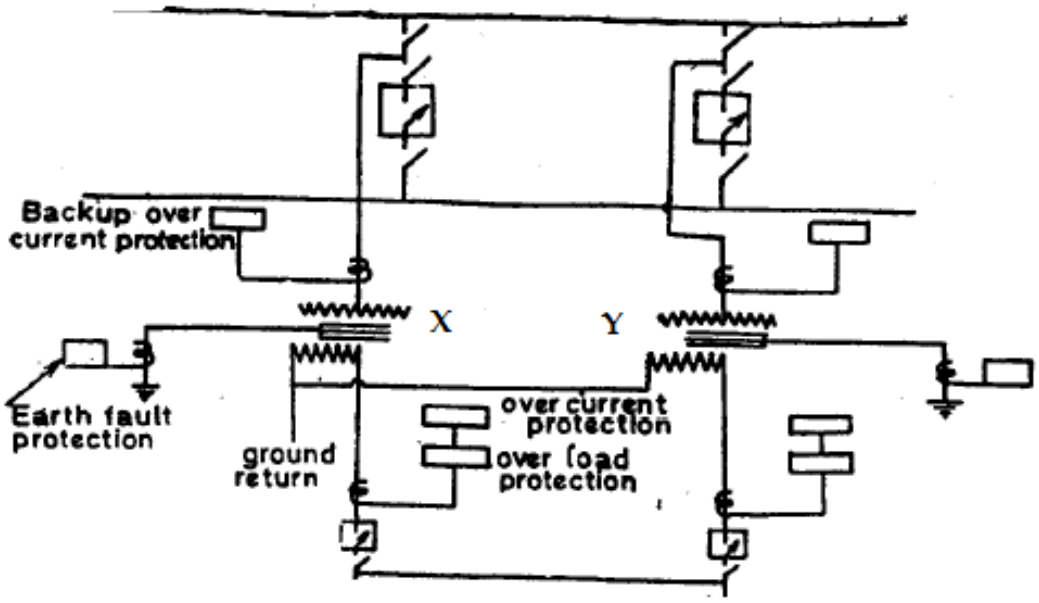
Compound catenary

Fully labeled as shown only then 3 marks else only 1 mark for any other figure.

Compound catenary - for train speeds between 190 to 225 kmph — 1 mark

6 d) Draw a neat and labeled sketch of transformer protection.

Ans:



Protection system for AC traction transformers X and Y

Diagram fully labeled 4 marks,

Partially labeled 3 marks,

Unlabeled 2 marks

6 e) What is encumbrance? Write its value in normal situation.

Ans:

Encumbrance:

It is the axial distance between catenary and contact wire. 2 marks

Its value is maintained at 1.4 m except at turn outs, overlaps and in the vicinity of overline structure. 2 marks

6 f) State the advantages of remote control system in traction(any 4)

Ans:

Advantages of remote control systems:

1) As substations and control posts are unattended (due to remote controls) there is considerable savings due to less manpower.
2) Central control station houses the complete info of the route (supervision of all individual posts is simple) hence coordination is very good.
3) As oral instructions are very less, human error based problems are minimized, otherwise oral instructions given over phone may lead to errors.
4) Correct and rapid supervision is possible.
5) Switching operations are carried out safely, quickly, and economically.
6) Maintenance cost is low.

1 mark each for any 4 = 4 marks