

**Model Answer**  
**Summer – 2019 Examinations**  
**Subject & Code: Modern Electric Traction (17640)**

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 should assess the understanding level of the candidate.
- 3) The language errors such as grammatical, spelling errors should not be given 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 should give credit for any equivalent figure/figures drawn.
- 5) Credits to 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 (as long as the assumptions are not incorrect).
- 6) In case of some questions credit may be given by judgment 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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- 1 Attempt any FIVE of the following: 20**
- 1 a) List four constituents of supply system.
- Ans:**  
**Constituents of Supply System:**
- 1) **Substation:** It has 132kV, 50c/s three phase double circuit input supply and output of 25 kV, 50 c/s single phase double circuit.
  - 2) **Feeding posts:** A double circuit line between substation outputs to feeding post at tracks as protected and controlled feeder line. 1 Mark for each of any four constituents = 4 Marks
  - 3) **Feeding and sectioning arrangements:** The arrangement is used to avoid unbalance in loading of three phase power system.
  - 4) **Sectioning and paralleling posts:** It is an arrangement of power system feeding for two parallel rail track supply lines between feeding post and neutral section.
  - 5) **Sub sectioning posts:** Each subsection again further divided in one or more sections and parallel posts. They are normally 10-15km in length.
  - 6) **Elementary section:** Subsection of 10-15 km in length is too large for repairs and maintenance point view so for fast isolation of faulty part, the subsection is further divided into elementary section.
- 1 b) List four factors which decides cross section of overhead contact wire.
- Ans:**  
**Factors Which Decides Cross Section of Overhead Contact Wire:**
- 1) Assessment of load current from the consideration of traffic density.
  - 2) Assessment of load current from the consideration of train loading time schedules. 1 Mark for each of any four factors = 4 Marks
  - 3) Assessment of load current from the consideration of track gradients.
  - 4) Distance apart from feeding point.
  - 5) Consideration of the permissible temperature rise of the contact wire.
  - 6) Voltage drop in contact wire.
  - 7) Expected life of contact wire.
  - 8) Cross section of overhead contact wire is decided taking into the consideration of an overload of 50% for 3 minutes.
  - 9) Resistivity of contact wire.
  - 10) Material used for contact wire.
- 1 c) What are track circuits? State any two functions of it.
- Ans:**  
**Track Circuits:**  
A track circuit is an electrical circuit used to detect the presence / absence of a train on rail tracks, which is further used to inform signalers for controlling the relevant signals. 2 Marks
- Functions of track circuits:**
- 1) It prevents the second train to come on that portion of the track on which the first train is already present. 1 Mark for each of any two functions = 2 Marks
  - 2) Due to bridges, buildings, long steep curvatures, and single is out of view of signal man, track circuit helps to indicate the present of train on that section.
  - 3) It indicates presence of train on any particular sections.
  - 4) It indicates absence of train on any particular sections.

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- 1 d) State two functions of auxiliary circuit of Ac locomotive.

**Ans:**

**Functions of Auxiliary Circuit of AC Locomotive:**

- 1) Auxiliary circuit is equipped with various auxiliary equipment like batteries, exhausters, air compressors, blowers, pumps, ventilating fans, heat light, flash light, horn which are helpful for operation of train.
- 2) The batteries are used for supplying relays and for emergency supply, charging batteries are possible with auxiliary circuit.
- 3) Exhauster and air compressors required for vacuum breaks and air breaks and they are controlled by auxiliary circuit.
- 4) Blowers and fans are used for cooling and ventilating purposes and they are controlled by auxiliary circuit.
- 5) Pumps are used for pumping, oil and water and they are controlled by auxiliary circuit.
- 6) Head light, flasher light is used for light up the track and also to warn the people on the track and they are controlled by auxiliary circuit.
- 7) Horn is used for to make alert people and animal about the presence of train and they are controlled by auxiliary circuit.

1 Mark for each of any four factors = 4 Marks

- 1 e) Explain the means to improve reliability of locomotive.

**Ans:**

**Means to Improve Reliability:**

- 1) **Proper inspection:** Failures of locos are due to defects such as excessive wear and tear of components which gradually develops to prevent these defects time to time inspection on schedule basis will work.
- 2) **Proper method of trouble shooting & repairs:** In order to save time and do exact work the trouble shooting charts are very much helpful
- 3) **Proper technical investigations:** It is important to analyses the problems and components which are failed most of time in this regard an expert will suggest proper technical changes in design, modification of part etc.
- 4) **Suitable repair facilities in loco shed:** Good job cannot be only done by workmen but requires good tools as well good place with proper facilities.
- 5) **Test and trail of locomotive:** The reliability of locomotive can be improved by knowing the behavior of certain components in actual service for these purpose test and trails are carried out on the locomotive.

2 Marks each point with explanation for any two = 4 Marks

- 1 f) Explain why LEM is called as wheel less drive.

**Ans:**

**LEM is called as Wheel Less Drive:**

Linear electric motor is a special type of induction motor which gives linear motion. It works on principle that when 3 phase AC supply is applied to stator of LEM then magnetic field which is linearly moving nature is induced. The moving magnetic field is cut by short circuited conductors and emfs are induced in them. Therefore currents flow through them. The currents interact with the moving magnetic field and electromagnetic forces are produced on conductors. Under the influence these forces, according to Lenz's law, the conductors try to move in such way as to eliminate the induced currents. Hence the conductors move linearly within the magnetic field. Therefore, the rotor and the drive starts moving in linear way. As in this linear motion, there is no contribution of wheels

4 Marks

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so it is called as wheel less drive.

- 1 g) List four important features of moving primary & fixed secondary single sided LEM.

**Ans:**

**Features of the Moving Primary and Fixed Secondary Single Sided LEM:**

- 1) Name of motor as primary stator and secondary rotor.
- 2) A primary winding moving and securing a low cost secondary track per km.
- 3) Impose transferring full propulsion electric power.
- 4) Movable primary is placed above permanent magnet track with alternate polarity.
- 5) Magnetic field is static of fixed secondary.
- 6) In single sided repulsion forces levitate the moving rotor by pushing its conductor away.
- 7) LIM principle of working on Transverse flux i.e. two poles placed opposite side by side.
- 8) Using longer poles, speed and efficiency can be increased.

1 Mark for each of any four features = 4 Marks

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

**16**

- 2 a) List four miscellaneous equipment at control post with function of each. Draw the labeled diagram of traction substation.

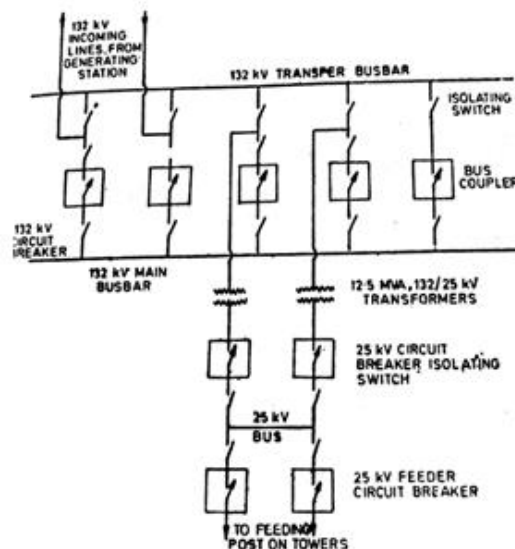
**Ans:**

**Miscellaneous Equipment at Control Post:**

- 1) **Lightning Arrestor:** Provides protection against lightning over-voltages / surges.
- 2) **Auxiliary transformer:** Provides 230 V, 50 Hz, supply to operate battery charger, remote control equipment, signal and lighting at control post.
- 3) **PT:** Measure H.V. and indicate its value at each sub sector of remote control center.
- 4) **Battery:** For operation of remote control equipment and interrupter.
- 5) **Battery charging equipment:** For charging of batteries at the control post.

1 Mark for each of any four equipment = 4 Marks

**Diagram of Traction Substation:**



4 Marks for labeled diagram  
 3 Marks for partially-labeled diagram  
 2 Marks for unlabeled diagram

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2 b) State the function of following:

- (i) Feeding post
- (ii) Sectioning & Paralleling Post
- (iii) Sub-sectioning Post
- (iv) Elementary Section

**Ans:**

**(i)Function of Feeding post:**

- 1) 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.
- 2) The 25 kV CB of feeding post are controlled from RCC of railway.

**(ii)Function of Sectioning & Paralleling Post:**

- 1) Sectioning and paralleling post consists of two paralleling interrupters used to parallel OHE of up and down tracks, one on the side of neutral section.
- 2) Two bridging interrupters are normally kept open unless emergency feed is required. It should only be closed after taking special precautions to warn the drivers to drop the pantograph when passing the feeding post up to which feed is extended. This is necessary because no neutral section is provided in front of feeding post except on an insulated overlap.
- 3) Each substation feeds two sections.
- 4) Supply to each section is controlled by one CB.

2 Marks for  
two functions  
of each  
= 8 Marks

**(iii) Function of Sub-sectioning Post:**

- 1) This facilitates isolation of faulty section.
- 2) At some stations with large yards change over switch is sometimes provided so that supply may be divided either from OHE of one subsection or other.
- 3) There is no interrupter for paralleling the up and down track line.

**(iv) Function of Elementary Section:**

- 1) To ensure rapid isolation of fault on OHE and facilitate repairs each subsection is further divided into elementary sections.
- 2) Adjacent elementary subsections are separated by insulated overlap bridged by isolators which are manually operated on no load.

2 c) (i) List out special features of traction transformer as compared to conventional transformer.

**Ans:**

**Special Features of Traction Transformer as Compared to Conventional Transformer:**

- 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 overload as 50% for 15 min, 100% for 5 min, 120% for instantaneous.
- 5) Impulse withstand voltage is nearly 5 times higher.
- 6) To limit the effect of short circuit, impedance should not be less than 8.5 % for 10 MVA and 10 % for 12.5 MVA.

1 Mark for  
each of any  
four features  
= 4 Marks

2 c) (ii) Explain the function or need of traction substation.

**Ans:**

**Functions or Need of Traction Substation:**

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- 1) Insure that all the 24 hours of a day and throughout the year continuous electric supply is to be provided to OHE traction lines so that no shut down or disturbance occurs in train movements. This is possible with substation.
- 2) In the event of failure of one source of supply, the second (standby) remain intact to provide service through the substation.
- 3) Protective systems are provided in the substation to safe guard all the supply lines from faults.
- 4) Required voltage levels (by step up / step down) can be obtained using transformers in substations.
- 5) The required characteristics of electric supply (i.e. change of frequency etc) can be obtained by using proper equipment which is provided in substation.
- 6) Conversion of AC to DC vice versa required for traction purpose is done in substations.
- 7) Rapid isolation of faulty line which further damages the system can be made from substation.
- 8) Traction substations are used to convert electrical power as supplied by the power utility to a form suitable for providing power to a rail system (via third rail or overhead line).
- 9) Alternating current supply on the traction side is single phase and can lead to imbalance on the three phase utility beyond allowable limits. Balancing devices (Scott transformers, static convertors, etc.) are often used to achieve these limits in substation.
- 10) Generally traction substations will be controlled by SCADA systems and will likely provide power for auxiliary systems such as signaling and other track side purposes.

1 Mark for each of any four points = 4 Marks

**3 Attempt any TWO of the following:**

**16**

- 3 a) i) What is OHE? State its function & draw the simplest form of OHE showing various parameters on it.

**Ans:**

**OHE (Over Head Equipment):**

The power supply arrangement in which the power is fed to traction unit from overhead wire is called OHE.

1 Mark

**OR**

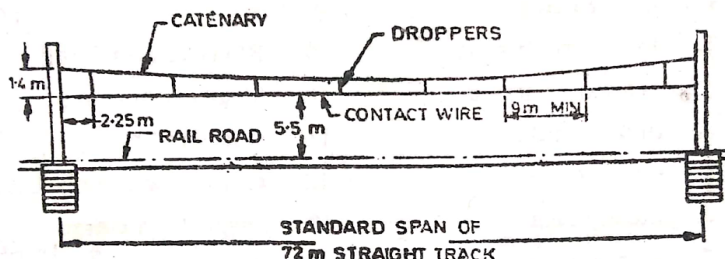
Overhead Equipment means arrangement of Catenary (messenger), contact wire, droppers, and overhead supporting structure.

**Function of OHE :**

To provide electric power to traction unit.

1 Mark

**Simplest Form of OHE:**



2 Marks for diagram

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3 a) ii) Compare uninsulated overlap & insulated overlap in four point.

**Ans:**

**Comparison between Uninsulated Overlap & Insulated Overlap:**

Uninsulated Overlap	Insulated Overlap
Section cannot be made dead to do work.	With isolator section can be made dead and work can be done.
Anchoring portion of catenary and contact wire cannot be separated.	These can be separated from the rest of the portion by means of insulators.
Gap between the contact wires is less.	Gap between the contact wires is more.
No isolation possible.	Isolation is possible for operation and maintenance of OHE.
Electrically connected by means of Jumpers.	Electrical continuity by means of jumpers in series with isolators or interrupters.

1 Mark for each of any four points = 4 Marks

3 b) i) State the function of neutral section and section insulator.

**Ans:**

**Function of Neutral Section:**

- 1) Passing of pantograph under insulated overlap will cause short circuit between two phases, damaging OHE & pantograph. To avoid this bridging, a neutral section is inserted between them.
- 2) Since neutral section is dead, it becomes necessary for the drivers of an electric train to switch off power, before approaching neutral section and coast through the other zone.

2 Marks for one function

**Function of Section Insulator:**

Section insulators are provided to insulate OHE of one elementary section from the OHE of another adjacent elementary section.

2 Marks

3 b) ii) Compare conductor rail system and overhead system used for supplying power in electric traction in four point.

**Ans:**

**Comparison Between Conductor Rail System and Overhead System Used for Supplying Power in Electric Traction:**

Sr. No.	Third Rail System	Overhead Collection System
1	In this system current is collected from third rail.	In this system current is collected from overhead wire.
2	This system is economical.	This system is costly.
3	There is possibility of electric shock hazard close to ground	There is no possibility of electric shock hazard close to ground
4	Rail is rigid body so current collection is difficult.	OH wire is flexible so current collection is easy.
5	Applicable only for low voltage applications below 1500volts	Applicable for high voltage applications
6	Less safe	More safe

1 Mark for each of any four points = 4 Marks

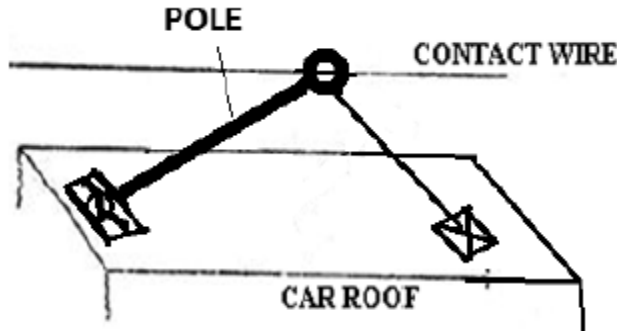
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7	Applicable to slow speed trains	Applicable to high speed trains
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3 c) i) Draw the labeled diagram of pole collector and bow collector.

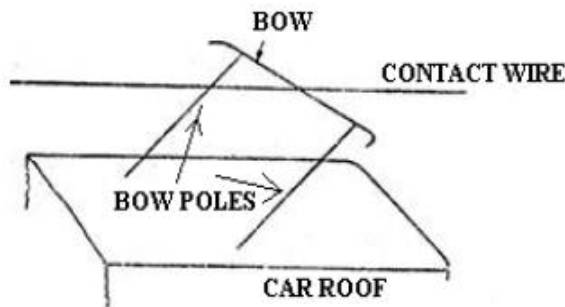
**Ans:**

**Diagram of Pole Collector:**



2 Marks

**Diagram of Bow Collector:**



2 Marks

3 c) ii) List three advantages with one application of Pantograph collector.

**Ans:**

**Advantages of Pantograph Collector:**

- 1) Reversible operation is possible.
- 2) Current collection capacity is high.
- 3) It requires less maintenance.
- 4) It maintains positive contact pressure at varying speeds in different climate and wind conditions.
- 5) It may raise or lowered from cabin.
- 6) Spark less Current collection.
- 7) Higher currents are handled.

1 Mark for each of any three advantages = 3 Marks

**Applications of Pantograph Collector:**

- 1) It is used for 1500V DC traction system.
- 2) It is used for 25 kV AC traction systems.
- 3) It is used for high speed electric locomotives.

1 Mark for each of any one application = 1 Marks

**4 Attempt any TWO of the following:**

**16**

4 a) i) List four functions of Railway signaling.

**Ans:**

**Functions of Railway Signaling:**

- 1) Heavy traffic can be controlled effectively and safely if the railway signaling is the co-ordinate.
- 2) The trains have heavy mass, which needs sufficient braking distance. Signals are helpful to avoid chances of collision.

1 Mark for each of any four points = 4 Marks



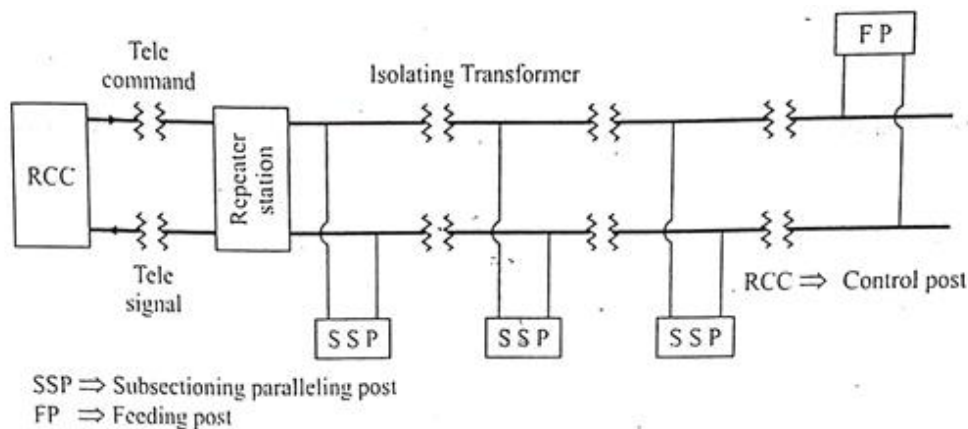
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- 3) Control the movement of trains to avoid hazardous movements & accidents.
- 4) Indicate to the driver when to stop the train.
- 5) Indicate to the driver when to proceed on a certain rail route.
- 6) Indicate to the driver when to proceed with caution on a certain rail route.
- 7) Indicate to the driver when to proceed with full speed.
- 8) Indicate to the driver position of an obstruction is seen ahead.
- 9) Indicate to the driver his action during shunting operations.

4 a) ii) Draw the block diagram of remote control system used in supervisory control.

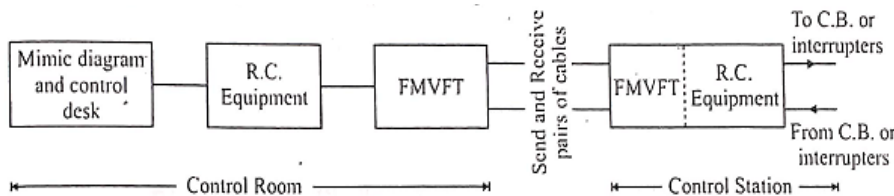
**Ans:**

**Block Diagram of Remote Control System used in Supervisory Control:**



4 Marks for labeled diagram  
 3 Marks for partially-labeled diagram  
 2 Marks for unlabeled diagram

**OR**



4 b) i) State the function of colour light signals.

**Ans:**

**Function of Colour Light Signals:**

- 1) **Two-aspect colour-light signals:** In this each signal has two lamps (one above the other). The higher of the two is a green lamp, and the lower one is a red lamp. The green lamp when lit indicates clear (the proceed indication) and when the red lamp lit it is used for STOP indication.
- 2) **Three-aspect colour-light signals:** In this, each signal has three lamps arranged vertically. The top one is green, the middle one yellow and the bottom one is red. The green lamp when lit indicates clear (the proceed indication) and when the red lamp lit it is used for STOP indication and the yellow lamp shows the caution indication.
- 3) **Four aspects of colour light signaling:** 4<sup>th</sup> aspect is attention aspect given by 2 yellow lights in vertical fashion interpreted as "prepared to pass next signal at restricted speed". Signal-1 & 2 located less than braking distance apart. Signal- 3 shows attention aspect, when signal-2 is at caution. A driver sighting signal-3, must pass signal-2 at restricted speed & stop has to be made at signal-1.

2 Marks for each of any two types  
 = 4 Marks

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4 b) ii) State the suitability of colour light signals & also state its three types.

**Ans:**

**Suitability of Colour Light Signals:**

- 1) Colour light signal displays the same aspect during day and night.
- 2) Colour light signal gives information of next signal in advance to the driver i.e. gives pre warning to control the speed of train.
- 3) No moving part, hence virtually maintenance-free.
- 4) Light weight structure, hence fast and easy installation.
- 5) Better visibility particularly during foggy weather.
- 6) Economical.
- 7) Simplicity of indication to drivers.
- 8) Better ability to deal with traffic of varying speed.
- 9) Simpler and easier in operation.
- 10) Control on large signals at heavily worked stations.
- 11) Colour light signals have multiple units, depending upon the aspects to be conveyed.

1 Mark for  
each of any  
two points  
= 2 Marks

**Types Colour Light Signals:**

- 1) Two aspects of colour light signals.
- 2) Three aspects of colour light signals.
- 3) Four aspects of colour light signals.

2 Marks

**OR**

- 1) Short range colour light signals.
- 2) Long range colour light signals.
- 3) Search light colour light signals.

4 c) i) List any two requirements of train lighting.

**Ans:**

**Requirements of Train Lighting:**

- 1) D.C. dynamo used to supply train lighting is of totally enclosed type and robust in construction so that road dust and jerks have no effect on its working.
- 2) Since dynamo has to operate in parallel with the battery, it is essential that its polarity should not change in the change to the direction of rotation of dynamo.
- 3) Dynamo should provide nearly constant output at varying speeds.
- 4) As dynamo is in parallel with the batteries and charging them, it is inherently of self-regulating.

2 Marks for  
each of any  
two points  
= 4 Marks

4 c) ii) List four causes of failures of underframe generating equipment.

**Ans:**

**Causes of Failures of Under-frame Generating Equipment:**

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

1 Mark for  
each of any  
four points  
= 4 Marks

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9) Vandalism of various components such as field coils, brush holder etc.

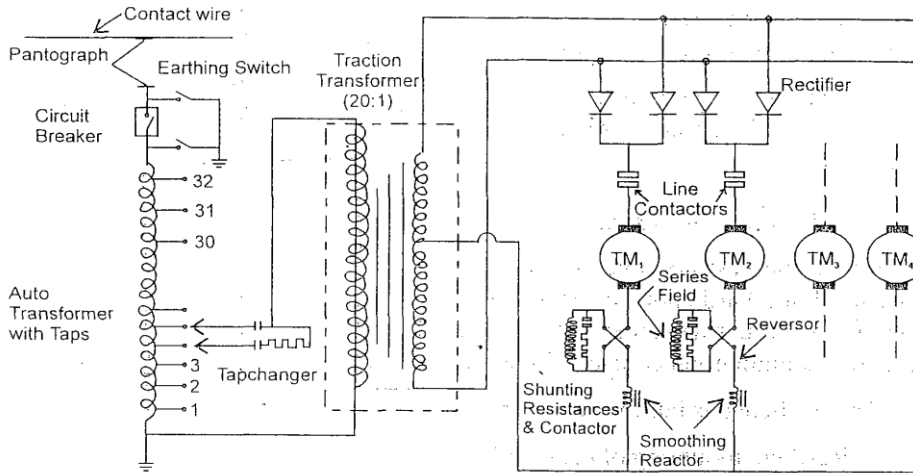
5 Attempt any **TWO** of the following:

16

5 a) i) Draw the labeled diagram of power circuit of AC locomotive.

**Ans:**

**Diagram of Power Circuit of AC Locomotive:**



Schematic arrangement of power circuit

4 Marks for labeled diagram  
3 Marks for partially-labeled diagram  
2 Marks for unlabeled diagram

5 a) ii) State the function of following equipment in power circuit of AC locomotive:

- (A) Tap changer                      (B) Traction Transformer  
(C) Circuit breaker                (D) Smoothing reactor

**Ans:**

- (A) **Functions of Tap Changer:** Used to control the voltage to the traction motors through the rectifier for speed control.  
(B) **Functions of Traction Transformer:** Steps down the voltage to the suitable value for the traction motor. It has a ratio of 20:1.  
(C) **Functions of Circuit Breaker:** Disconnects the locomotive equipment from the supply in the event of fault in the equipment / loco.  
(D) **Functions of Smoothing Reactor:** Smoothen out the ripples in the DC output current of rectifier.

1 Mark for each bit  
= 4 Marks

5 b) i) State the function of contactors in electric locomotive & also list its any two types.

**Ans:**

**Function of contactors:**

Contactors in electric locos is a switch which makes and breaks a power circuit on load and is remotely controlled.

2 Marks

**Different Contactors used in Electric Locomotives:**

- 1) Electromagnetic contactor
- 2) Electro pneumatic contactor
- 3) Cam & roller operated contactor.

2 Marks

5 b) ii) List any four equipment used in auxiliary circuits of AC locomotive.

**Ans:**

**Equipment used in Auxiliary Circuits of AC Locomotive:**

- 1) Batteries

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- |   |   |
|---|---|
| 2) Compressor<br>3) Blowers<br>4) Exhausters<br>5) Pumps<br>6) Cab ventilating fans<br>7) Locomotive heating (if any)<br>8) Transformer oil cooling radiator<br>9) Head light<br>10) Flasher light<br>11) Marker light<br>12) Engine Horn | 1 Mark for<br>each of any<br>four<br>equipment<br>= 4 Marks |
|---|---|

5 c) i) Classify types of locomotives on basis of

- (A) Types of service
- (B) Types of Track gauge
- (C) Type of supply

**Ans:**

**Classification of Locomotive:**

A) Based on the types of service rendered:

- 1) Freight service for transportation of goods only.
- 2) Passenger service for transportation of passengers.
- 3) Mixed traffic service (goods and passenger transportation).
- 4) Shunting service at stations and sheds.
- 5) Banking service to bank the coaches at proper locations.

2 Marks

B) Based on the Track Gauge:

- 1) Broad gauge (W)
- 2) Meter gauge (Y).

1 Mark

C) Based on the type of supply used:

- 1) Alternating current (AC) locomotive
- 2) Direct current (DC) locomotive

1 Mark

5 c) ii) State function of relay used in electric locomotive & also state its two types.

**Ans:**

**Function of Relay Used in Electric Locomotive:**

Relays sense abnormal conditions in the respective sections of the system and give the trip / alarm signal to the circuit breaker / indicator panel.

2 Marks

**Types of Relay Used in Electric Locomotive:**

- 1) Buchholz Relay
- 2) Earth fault or Ground fault Relay
- 3) Notching Relay
- 4) No-volt Relay
- 5) Overload Relay
- 6) Wheel-Spin Relay
- 7) Electromagnetic Relay
- 8) Current Limiting Relay

1 Mark for  
each of any  
two types  
= 2 Marks

**6 Attempt any TWO:**

**16**

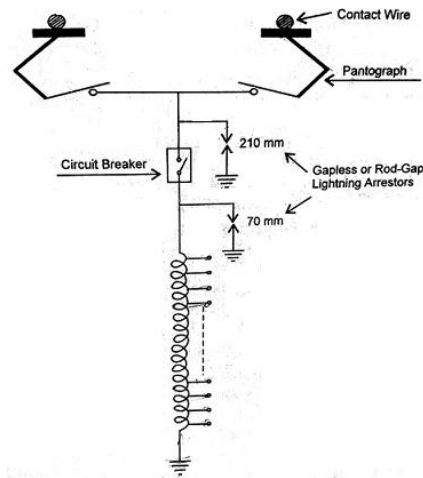
6 a) Explain with neat sketch protection of locos against lightning surges.

**Ans:**

**Protection of Locos Against Lightning Surges:**

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- 1) The direct lightning strokes may strike on the overhead conductor on the roof of the locomotive.
- 2) To protect the locomotive from lightning strokes lightning arrester 1 (LA1) is provided it is generally a Rod gap type having the gap length of 210mm.
- 3) The lightning arrester provides a low resistance path for high voltages and high resistance path for normal power frequency working voltages. The lightning stroke is thus diverted towards earth via lightning arrester.
- 4) The transformer is critical and costly equipment hence lightning arrester 2 (LA2) is provided along with LA1. The gap of LA2 is 70mm so that its operation time is less..



4 Marks for labeled diagram

4 Marks for explanation

6 b) Explain Ideal Maintenance of electric locomotive.

**Ans:**

**Ideal Maintenance of Electric Locomotive:**

- Maintenance of the components includes all the steps taken to preserve it from deteriorating and enable it to give economical service with reasonable operating efficiency up to the full expected life.
- Maintenance can be classified into three different categories namely running repairs, trouble shooting and preventive maintenance.

**Running repairs:**

- These are carried out when the component has actually failed.
- This method of repair is technically unsteady or unsafe and may result in dangerous consequences specially when applied to the electric traction components.

2 Marks

**Troubleshooting:**

- Troubleshooting involves rectification of the defects by making temporary repairs so that the component is made 'get going on' till it is taken out for permanent and effective repairs.
- For temporary troubleshooting, the locomotive operator has to take the help of carefully prepared troubleshooting chart.
- These charts provide procedure for identifying and rectifying the defects and suggest the action to be taken in various possible type of faults affecting the component.

2 Marks

**Preventive Maintenance:**

- In case of preventive maintenance, advance actions have to be taken to hold off the future failures.
- This is achieved by systematic inspection of various components and their timely repairs so that they should continue to give trouble free service up to the next inspection.
- The ideal maintenance can be judged by the following three criteria:
  - i. **Reliability of the Locomotive:** The quality of the locomotive and the

4 Marks

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standards of maintenance can be judged from the frequency of cases when the locomotive has to be withdrawn from the service for the attention of the maintenance staff.

**ii. Availability of the Locomotive for Traffic use:** The quality of the locomotives and of the maintenance work may be appreciated by the percentage of locomotive hours available for traffic use as compared to the locomotive on line.

**iii. Maintenance Cost:** Overall cost locomotive maintenances.

These three criteria which determine the quality of maintenance is not independent of each other but influence each other.

**OR Equivalent Answer**

- 6 c) List four strengths & four weaknesses of LEM propelled Railway traction system.

**Ans:**

**Strengths of LEM Propelled Railway Traction System:**

- 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 for  
each of any  
four points  
= 4 Marks

**Weaknesses of LEM Propelled Railway Traction System:**

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

1 Mark for  
each of any  
four points  
= 4 Marks