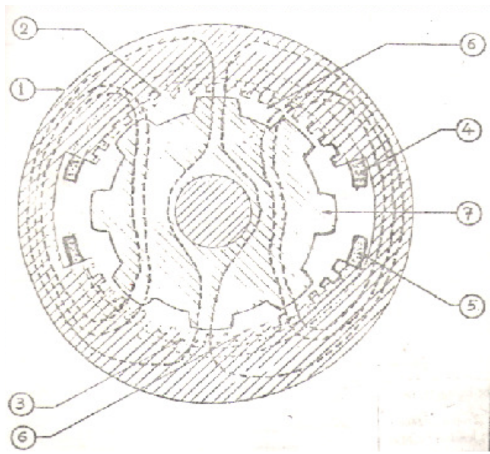
1. What is the principle of a brush less alternator? Explain with figure?



1. Stator

2. North pole

3. South Pole

4&5 Field coil

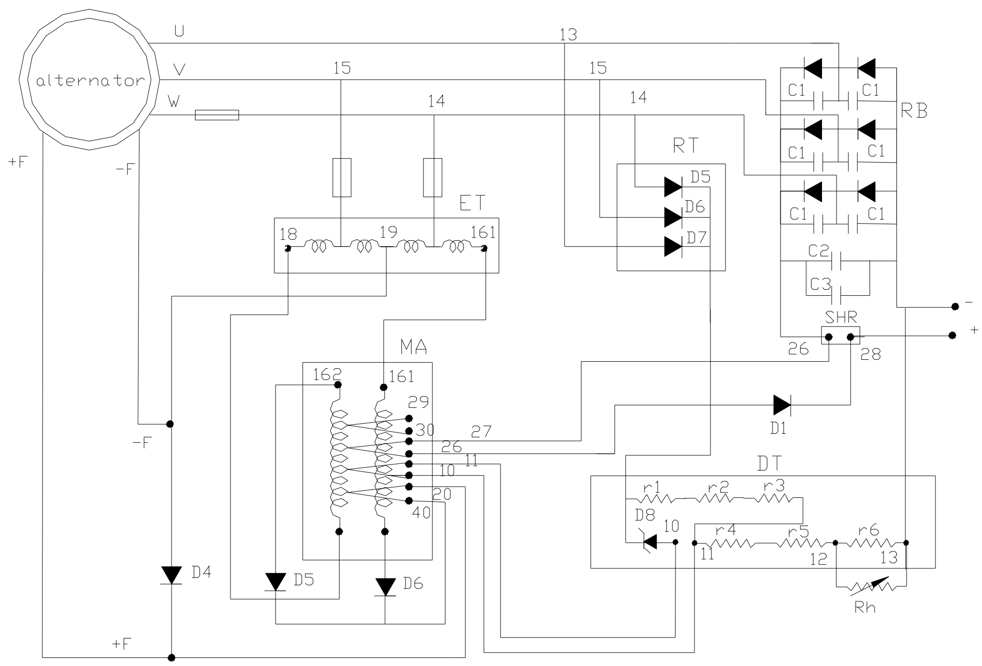
6. Armature Winding

7. Rotor

- The brushless alternator consists of 3 phase AC winding and DC field winding on the stator.
- AC winding are distributed in smaller slots. The field windings are concentrated in two slots.
- The rotor consists of stacked stamping with 8 sets of teeth and slot arrangements for 4.5 KW alternators. Rotor is made up of silicon steel lamination and resembles a cogged wheel.
- The core of the stator, will retain a small residual magnetism if the coil excited by a battery once. The flux produced by the field coil finds it's path through the rotor. When the rotor is rotated, the teeth and slots alternately under the field form a variable reluctance path for the flux produced by the coil. The flux, which varies periodically, links with AC coils and induces as alternating current in the AC coil.
- The field is controlled through regulator to get the desired output D.C Voltage. The magnitude of voltage depends upon speed of rotor and level of excitation.

2. What are the functions of a rectifier cum regulator? Draw 110 V MA types regulator and explain?

- The circuit diagram of a MA type regulator rectifier unit is shown below.



The regulator-rectifier unit has the following functions

- Rectifying 3 phase AC output of alternator to DC using full wave rectifier bridge
- Regulating the voltage generated by alternator at set value. 124V 4.5, 127V 25KW
- Regulating the output current at set value. 37.5A, 4.5 kw, 135A 25KW.
- Over voltage protection.

To achieve the above functions the RRU uses the following components.

1. Power rectifier 2. Magnetic Amplifier (MA) 3. Excitation transformer (ET) 4. Voltage detector(DT) 5. OVPR

POWER RECTIFIER

- It consists of six silicon diodes connection in 3 phase full wave bridges to convert 3phase AC to DC.
- Each diode is protected against transient surge voltage by capacitor C1.
- The whole bridge is protected against high frequency surges by capacitor C3 and the DC output is filtered by capacitor C2.

EXCITATION TRANSFORMER (ET):

- This is a single winding transformer with tapings for input and output. The transformer step down the voltage for the field coils.

VOLTAGE DETECTOR (DT):

- The voltage detector serves the function of providing necessary error signal for voltage regulation. It consists of a network of Zener diode, potential divider and Resistor.
- When the output voltage of the alternator exceeds the set value, the voltage drop across R1 reaches sufficient value to cause the Zener break down and this will send a current through the control winding 10-11 of magnetic amplifier which causes an increase in the impedance of load winding, there by decreasing the field current maintaining the output voltage of alternator at set value. The voltage drop across R1 can be varied by varying the resistance Rh.

MAGNETIC AMPLIFIER (MA):

- The magnetic amplifier works on the principle of saturation of magnetic core. It has six sets of windings.
- The load winding is connected in the field circuit, and the field current passes through these winding subjects to the command from the voltage and current sensing circuits maintained through control winding 10-11 and 26-27 respectively, load windings offers a variable impedance to the field circuit there by regulating the voltage and the current at set value.

FIELD RECTIFIER UNIT (D2-D3):

- Silicon diode D2 and D3 act as a full wave rectifier for the fields supply.

FREE WHEELING DIODE (D4):

- In case there is a voltage surge due to field current which will have a polarity opposite to that of excitation the free Wheeling diode will conduct avoiding creepage of surge voltage to important components like magnetic amplifier.

RECTIFIER BRIDGE (RT):

- It consists of three silicon diodes for three phase full wave rectification with the negative terminal taken from the power rectifier bridge TR1. It rectifies the AC output of the alternator and supplies DC voltage to the voltage detector for voltage sensing.

CURRENT REGULATION:

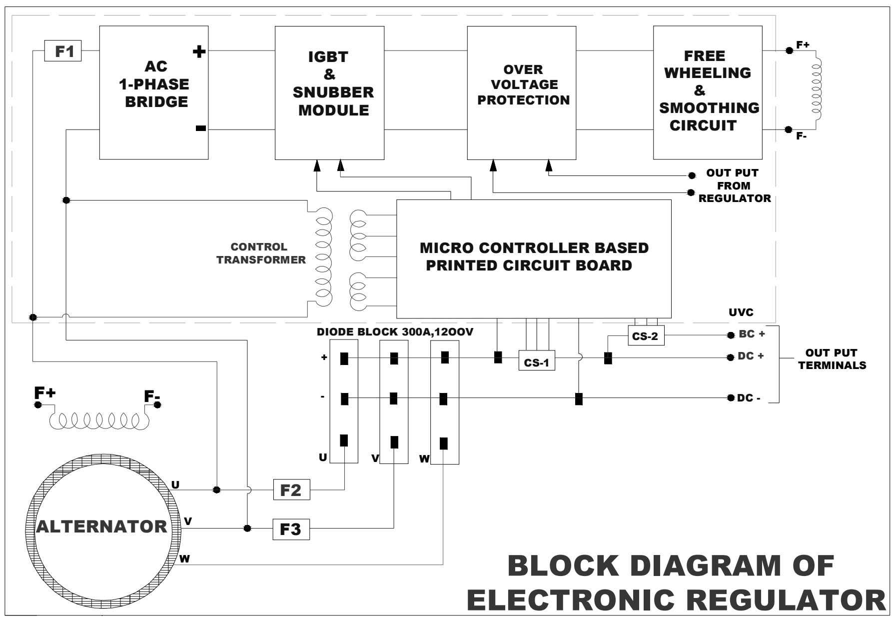
- Current regulation circuit consists of variable shunt (SHR) connected in series with the load circuit and a diode D1. When the load current exceeds the set value the drop across the shunt will be sufficient to drive the diode D1 into conduction and pass a current through the control winding 26-27 of magnetic amplifier. The effect of thus control current is to retain the current at the limited value reducing the output voltage on further loading the current limiting circuit prevent the alternator from over loading.

Working of the RRU

- The 3 phase AC from the alternator is rectified by the bridge rectifier and fed to battery and load.
- When the coach is stationary, the out put of the alternator and ET is zero.
- When the coach starts moving, due to residual magnetism the alternator starts generating.
- The out put of the ET increases and it gives a positive feed back to the field.
- The out put voltage of the alternator goes on increasing based on the increase in speed of the alternator. The out put of the alternator increases up to the voltage setting of the voltage detector. If the out put voltage increases more than the set voltage , the zener in the DT conducts and send an error signal to 10 and 11 of MA.
- MA reduces the field excitation and controls the out put voltage.
- The current control is done by the Shunt. As explained above, when the load current exceeds 37.5 A an error signal is fed to 26 and 27 of the MA which reduces the field excitation thus decreases the out put voltage and current.

3. Explain ERRU . What are the advantages of ERRU over RRU.

- The RRU with MA has inherent problems of poor regulation, poor response high voltage and current ripple on battery charging current, no limit on battery charging current. These problems are solved in the Electronic Rectifier Regulator Unit.
- The Electronic Rectifier regulator unit (ERRU) employs IGBT with driver circuit for the control of field excitation. It employs Micro controller for the control of output DC voltage , Out put current , Battery charging current and field current.
- The block diagram of the ERRU is shown below.



- The main components used in the ERRU is 1. Universal voltage controller (UVC) 2. Iso pack power diode assembly. 3. Hall effect sensor. 4. IGBT 5. Static over voltage protection unit.

Universal Voltage Controller(UVC)

- The Universal Voltage controller (UVC) is a micro controller based Electronic control unit employing IGBT switching for control of field current. The UVC consists of following modules. 1. Power module 2. Control module. 3. Display module.
- The power module provides the power supply requirement for the entire UVC, drive requirements for IGBT and also implement start up logic.
- The control module is the heart of the system and consists of the digital and analog controller and associated circuitry
- Display module consists of soft touch keys , displays and associated circuitry.

ISO Pack Power diodes

- This unit consists of six diode module in a single pack. And can be directly mounted on the heat sink without insulation. The 3 phase AC output of the alternator is rectified by this diode module. A capacitor unit protected the diode module against surges.

Hall effect sensor

- 2 Hall effect sensors are used to sense the output DC current and battery current. The output signal of the sensors are fed to the UVC for control against over current.

Static over voltage production unit

- The static type over voltage protection is provided in the system. When the out put voltage exceeds the set value of 145 ± 2 volts , the relay energizes and field circuit is open circuited. The alternator stops generation and bring down the voltage.

The advantages of ERRU over RRU.

- The Voltage regulation is ± 2% compared to ± 5% for RRU.
- The output Voltage and current ripple is less compared to RRU.
- Hall effect sensors are used in ERRU which have got high accuracy than shunt/CT used in RRU
- Universal voltage controller (UVC) is interchangeable with all types of electronic regulators from 4.5 kW to 25 kW.
- Isolated power packs directly mounted on the heat sink to have better heat dissipation compared to ordinary diode rectifiers used in RRU.
- Microcontrollers are used in place of Magnetic amplifiers .
- Microcontrollers are having fast response which can incorporate data logger, over current protection, over voltage protection , various annunciation for indication of system status.
- The separate Battery charging terminal will help to charge the VRLA battery with current limit at constant voltage. This will help to increase the life of battery and reduced the maintenance on batteries.
- Automatic alternator paralleling operation facility available

4. What is the principle of a lead Acid Battery? Explain with chemical equation?

- The over all reaction inside the cell during discharge and charge is given below.

$$\underbrace{PbO_2 + Pb + 2H_2SO_4}_{\text{Charged condition}} \leftrightarrows \underbrace{2PbSO_4 + 2H_2O.}_{\text{discharged condition}}$$

Fully charged condition

- Positive active material is lead peroxide (pbo2).
- The negative plate is spongy lead (Pb).
- Dilute sulphuric acid (H_2SO4 + H_2O) serves as electrolyte.
- The specific gravity is about 1.210 – 1.220.
- Voltage is 2.2 v/cell.

Discharged condition

- +ve and –ve plate will become lead sulphate ($PbSO_4$).
- Specific gravity will be 1.180
- Voltage around 1.8 volts.
- In the discharge process sulphuric acid is consumed (H_2SO_4) and water (H2O) is formed. Consequently the specific gravity of electrolyte falls.

During charging

The lead sulphate on the positive plate is re-converted in to lead peroxide and the lead sulphate in the negative plate into spongy lead. Sulphuric acid is formed and the water consumed. The specific gravity of electrolyte rises.

5. Write down the initial charging procedure of a lead acid cell?

The lead acid cells are supplied by manufactures in dry and uncharged condition. Therefore the consumer has to provide initial charge to the cell.

Following are the initial charging procedure for lead acid battery

- Arrange the same make of cells on the bench.
- Provide Inter cell connections.
- Apply petroleum jelly in the ICC
- Fill the cells with electrolyte of s.p.g as per manufactures recommendation(1.190-1.200)
- Allow the cell to rest for 12 Hrs- 24Hrs.
- If the level of electrolyte falls slightly, restore level by adding acid of same specific gravity.
- Connect the +ve and -ve of the source to the +ve and -ve terminal of the battery.
- Charge the cells at **6A rate for 75-100 hrs.**
- During the charging do not allow the temperature of electrolyte to exceed 50^0C, if it cross 50^0C stop charging immediately.
- At the finishing stage, Do temperature correction at the rate of .007 points for every 10^0C rise of temperature above 27^0C
- Do gravity correction.
- After fully charging , Give rest for 12Hrs to 24Hrs.
- Discharge the cells at 10Hrs rate till the voltage of any one cell falls to 1.8V.
- Charge the cells at normal rate (12A) until a specific gravity and voltage raises and remain constant for 3 consecutive readings.
- The cells are now ready for service.

6. Write down the POH charging procedure of lead Acid Cell?

1. Arrange the cells on the charging bench (9+9 = 18 crates)
2. Replace missing & broken floats.
3. Remove all vent plugs, give series connection to cells using intercell connectors duly applying petroleum jelly and taking care to give the correct polarity.
4. Connect the positive and negative terminal of the cells to the positive and negative terminals of the charging panel respectively.
5. Do arrival discharge for 10 mts.
6. Top up the cell with demineralised water for minimum level as indicated by the float.
7. Open Log sheet with the coach number, make, Key date and open circuit voltage & specific gravity.
8. Charge with normal rate at 12 Amphere
9. Record the specific gravity, voltage of individual cells every 3 hours.
10. Charge until 3 hours constancy recording
11. Short discharge with normal rate (12A) for 5 hours
12. Record the specific gravity and voltage of individual cells every hour.
13. Charge with normal rate(12A) for9 hours and then for 3 hours constancy recording specific gravity and voltage of individual cells every 3 hours.
14. Use demineralised water in case of high specific gravity cells,
15. Give capacity discharge at normal rate till 1.8 V of individual cells, recording hourly reading of specific gravity and voltage of individual cells.
16. Note the number of hourly readings taken till it reaches 1.8V as the capacity of cells. For example: 9 reading = 90% capacity.
17. Charge at normal rate for 13 hours and 3 hours constancy recording.
18. Add electrolyte /water for specific gravity correction and correct float level.
19. Now the cells are ready for issue.

7. What are the various defects in a lead acid cell? Explain the remedial action?

The various defects in lead acid cells are

1. Sulphation.
2. Buckled and cracked plates.
3. Reversal of cells.
4. Shedding of active materials.
5. Sedimentation.

SULPHATION:

Reasons for Sulphation are

- The discharge beyond 1.8V per cell causes while insoluble sulphate to be formed. These sulphate is a non conductor and rises the internal resistance of a cell.
- Impurities in acid, plates or electrolyte will cause hard Sulphation.
- If the top of the plates is not covered by electrolyte, due to low level, these portions will be sulphated.

Problem due to Sulphation:

- The specific gravity of electrolyte gradually falls
- Loss of capacity of cell.
- Over heating of electrolyte:

Treatment for soft Sulphation.

- Soft Sulphation can be removed by charging the cells at a slow rate approximately 1/3 of the normal rate.
- The charge should be continued, till cells gassing freely.
- Repeat charge and discharge two the three times till specific gravity of cell is reached upto 1.220.

Hard Sulphation:

- At first substance inside the container is removed, and after clearing the container, fill with pure distilled water.
- Charge now at normal rate and test specific gravity at intervals and if it is above 1.150 stop charge and empty out the electrolyte from the container.
- After sulphate is removed, empty the container and should be refilled with electrolyte of specific gravity 1.200. Now initial charging is given to the cells to put in service.

BUCKLED AND CRACKED PLATES:

Reasons

- Over charging and over discharging
- Production of sulphate crystals causes over heating of plates.
- The formation of Sulphation results increase in volume of active material which tends to extends pressure on the grids causing bucking

Treatment for buckled plates:

- Re-plated method can be used to change the badly affected plates.

REVERSAL OF CELLS:

Reasons

- Grouping of different makes and lug dates in a same group.
- The weak cell in the group during discharge will charge in reverse polarity.
  In this action the positive plate is partially converted in to spongy lead and negative plate is converted with lead peroxide.
  Treatment:
- The cells should be charged at a low rate continuously for a long time till the polarity of the cell to be corrected.

SHEDDING OF ACTIVE MATERIAL:

- Shedding of active material takes place at +ve plates more than that of –ve plates.
- Excessive gassing and Sulphation are the chief causes of shedding which deteriorates the plates.

TREATMENT:

- If the plates are sulphated, charging current should be very much below normal rate to prevent expansion.

SEDIMENTATION CAUSE:

Reasons

- When raw water is poured the impurities inside the cell will sediment on the bottom of the container.
- Due to loose vent plug, foreign particles will go inside the container.

Treatment:

- Electrolyte of the container should be removed and after clearing the container fresh electrolyte should be pored in to the container and initial charge should be given to the cell.

8. Write down the chemical equation of VRLA battery? Compare VRLA battery with flooded cells?

1. The Chemical reaction in all lead acid batteries including V.R.L.A battery is basically identical.

$$\underbrace{PbO_2 + Pb + 2H_2SO_4}_{\text{Charged condition}} \leftrightarrows \underbrace{2PbSO_4 + 2H_2O.}_{\text{discharged condition}}$$

2. When flooded cell is over charged, the charging energy is consumed for electrolyte to decompose water in to Hydrogen and Oxygen. The +ve plate liberate oxygen gas and the negative plates generates hydrogen gas. This causes loss of water.
3. Under typical charging conditions, oxygen at the positive plate liberate before hydrogen evolution at the negative. This feature is utilized in the design of V.R.L.A batteries.
4. In V.R.L.A. batteries the oxygen gas evolved in the positive plate instead of bubbling upwards is transported in the gas phase through the separator medium to the negative plates.
5. The separator is a highly adsorbent glass mat (AGM) type with very high porosity through which the oxygen gas finds an uninterrupted path to the negative plate.
6. The oxygen gas gets reduced by reaction with the spongy lead at the negative plate turning a part of it in to partially discharged condition there by effectively suppressing the hydrogen gas evolution at the negative plate. This is what is known as the **oxygen re combination principle**.
7. Reaction at negative plate

   $Pb + ½\, 0_2 \rightarrow PbO$

   $Pbo + H_2\, SO_4 \rightarrow Pbso_4 + H_2O$ to reaction

9. Write down various anti theft measures adopted in coaches?

1. 'V' belts are used in place of flat belts.
2. The safety chains in the alternator will help to avoid theft of alternators.
3. Wiring of under frame cables are taken through conduit pipes.
4. The special type of key is required to open the regulators box.
5. Provision of antitheft rod in battery box.
6. Screw type holder for lamps are provided in place of BC lamp and holder.
7. Railway logo is used in bulbs.
8. Special key for opening light fitting cover is provided
9. Special key for rotary type switches.
10. Special type of tool is required to remove the fans.
11. The inspection cover of the fan shall be provided with locking arrangements.
12. Fix split pin by passing through the hub of the blade and armature shall to prevent easy removal of armature
13. Use aluminum field coils instead of copper field coils for fans..

10. What are the causes for fire in coaches?

Causes are

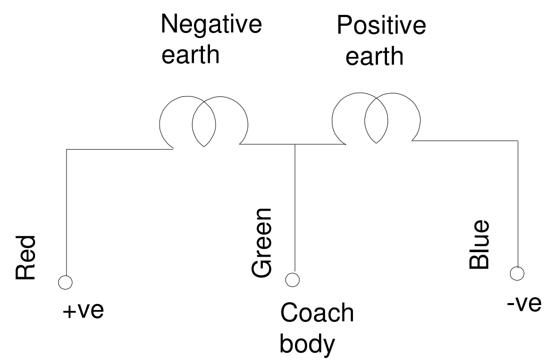
1) Heavy short circuit
2) Use of lower size of wires or loose connection
3) Provision of over size of fuse wires.
4) Failure of protective devices
5) Wire with improper insulation.
6) Wrong location of protective fuses and MCBs
7) Leakage of the roof of the coach caused rain water falling on T/L items in rainy seasons.
8) Due to overlapping of +ve and –ve cables.
9) Due to earth fault
10) Improper maintenance of cells.

FIRE PREVENTION STEPS ADOPTED IN TRAIN LIGHTING COACHES:

1) Use of P V C cables for coaches wiring.
2) Crimping of all end termination with shoes.
3) The wires are passed through metallic holes using rubber bush.
4) Alternator terminal cover and regulators cover is provided with gaskets to avoid water entry.
5) Good packing is given for batteries in the battery box to avoid acid spillage.
6) Fuses of proper ratings are used.
7) Crossing of +ve and –ve wires are eliminated by segregation of +ve and –ve wiring on both sides of the coaches.
8) Fan, lights connections are provided with terminal strip connector.
9) Rubber pads are used for fans.
10) Insulation resistance of coaches wiring should be checked time to time on all base depots.
11) No loose joints are allowed.
12) Leakage of the roof should be pointed out to the mechanical branch to avoid short circuit of wiring due to entry of rain water or water feeding up pipes of the over head tank.

11. Explain the earth in a coach? How to trouble shoot earth on coach wiring?

- There are two types of earth fault can occur in a Coach .
- They are 1. Positive earth 2. negative earth
- The earth in a coach can be detected by two test lamps connected in series with three leads as shown below.



- Red wire of test lamp should be connected to the positive main , blue to negative and green to coach body of the fuse cum junction box..
- The test lamp may have four conditions. 1. both lamps not glowing 2.lamps glow unequally 3. both lamps glow equally 4.one lamp burns brightly, while the other is not glowing at all.
    - If the both lamps are not glowing the reason will be 1. one of the lamp or both the lamps might have fused. 2. No supply from the under frame.
    - The reasons for lamps glowing unequally are 1. The wattage of the lamps may be different 2. Electrolyte spillage in the battery box. 3. Partial earth due to carbon dust in the fans.
    - Both lamps glow equally means the coach is healthy.
    - If one lamp burns brightly , and the other one not glowing at all the coach will have positive or negative earth. In the test lamp it will clearly show positive earth or negative earth.

TROUBLE SHOOTING

- For positive earth switch off L1 + , L2+ , F+ and SPM and isolate roof wiring . If the earth fault remains the fault is in the under frame.
- Isolate one by one under frame equipment and rectify the fault.
- If the fault is in the roof , switch on one by one MCB's and identify the earth is in L1 + or L2+ or F+ or SPM circuit.
- If the fault is in L1+ circuit isolate one by one lights points and rectify the earth.
- If the fault is in L2 + circuit isolate one by one lights points and rectify the earth.
- If the fault is in F+ circuit isolate one by one fan points and rectify the earth.
- If the fault is in SPM circuit isolate one by one EFT points and rectify the earth.

12. Compare 110V & 24V coach system.

S.No	24 V System	110 V Current
1	High current	Less current
2	Alternator regulation 4.5 KW 150A for BG Coaches	Alternator regulator 4.5 KW 37.5 A for BG coach.
3	Higher size cable is used	Lower size cable is used.
4	In Regulator Diodes, M.A used are higher cost	In Regulator Diodes, M.A are lesser cost
5	Battery of 320 AH capacity is used	Battery Capacity 120 AH is used
6	M.C.B fuses and switches of higher rating is used which result in to high cost	Lower rating of protective devices thus it is less cost.
7	Wattage of lamp used maximum 30 watts	Maximum wattage of lamp is 60 Watts.
8	Fans having lower air velocity	Fans having higher air velocity.
9	F/L flitting to be provided with high cost inverter	F/L provided with low cost electronic ballast.
10	Poor passenger amenities	Increased passenger amenities
11	Risk of fire is more.	Risk of fire is less.
12	Fault current is less.	High fault current.
13	Total cost is more for electrical items	Total cost is less

13. Compare 'V' belt system & Flat belt system.

S.No	Flat Belt	"V" Belt
1.	Only one flat belt is used	4 Nos of "V" blets are used spare belts also can be used
2.	Slip is more	Slip is less
3.	Replacement of flat belt is very easy	Replacement of "V" belt is difficult. For providing "V" belt the coach has to be lifted.
4.	Chances of theft is more	Theft is less
5.	Less cost	High cost
6.	Transmission of power is less	Transmission of power is more
7.	140mm P C D pulley is used	185 mm P C D "V" groove pulley is used
8.	Flat belt tension can be adjusted by tensioning wheel provided on the under frame of the coach	Spring tension arrangement is used for adjusting "V" belt tension by tensioning rod.
9.	Size of flat belt 4.1 mts x 100 mm x 5 mm	C 122 "V" belt is used

14.Draw a TL coach-wiring diagram. (U/F & Roof)