इरिसेट IRISET

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POWER SUPPLY FOR SIGNALLING

Indian Railways Institute of
Signal Engineering and Telecommunications

SECUNDERABAD - 500 017

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CHAPTER – 1: SECONDARY CELLS

1.1 Cells which are reversible to a high degree, chemical as well as physical states of electrodes after discharge (current flow in opposite direction) are called secondary cells. I.e. In secondary cells chemical reactions are reversible. Because of its ability to store or accumulate energy this cell is sometimes termed as a “Storage Cell” or “Accumulator”.

In these cells, the electrical energy is stored in the form of chemical energy and on demand is converted into electrical energy to drive an external circuit. These are used in Signalling & Telecom Installations to supply Power to the equipments to cater for AC power failures.

1.2 Types of commonly used storage batteries

(a) Lead Acid Battery

(i) Conventional Flooded Lead Acid Battery.

(ii) Low Maintenance Lead Acid (LMLA) Battery.

(iii) Valve Regulated Lead Acid (VRLA) also referred as *Maintenance free* Battery

(This type of battery is banned for signalling applications as per Railway Board's letter No. 98/Sig/SGF/2 dated: 21.09.2005. Hence not dealt in this notes)

(b) Alkaline Battery

(i) Nickel Cadmium Battery.

(ii) Nickel Iron Battery.

(iii) Silver Zinc Battery.

1.3 Charging of a cell

Current is absorbed in the cell from the charging circuit, and the direction of the current in the cell is from the positive plate to negative plate.

1.4 Discharging of cell

Current is given out by the cell from the positive plate to negative plate, where as within the cell the current direction is negative plate to positive plate.

1.5 Efficiency of the cell

It is expressed in following 3-ways.

1.5.1 Ampere – Hour Efficiency

It is the ratio of the ampere-hours output during discharge to the ampere-hours input on recharge.

$$\text{\% of A.H. efficiency} = \frac{\text{Amp-hour discharge}}{\text{Amp-hour charge}} \times 100$$

Ampere-hour efficiency of a Lead acid cell is normally 85% to 90%. Ampere-hour efficiency loss is due to gassing. Since gassing is due to charging current, A.H. efficiency can be increased by keeping the charging current below the value of excessive gassing.

1.5.2 Volt efficiency

It is defined as the ratio of the average voltage of a cell during discharge to the average voltage of a cell during charge provided charge & discharge currents are kept constant in a stipulated time.

1.5.3 Watt – Hour efficiency

It is effected by the same factors as the AH efficiency, in addition to these it is effected by the average voltage relations on charge and discharge.

$$\text{Watt – Hour efficiency} = \text{AH efficiency} \times \frac{\text{Average voltage during discharge}}{\text{Average voltage during charge}} \times 100$$

It is always less than A.H. efficiency.

W.H. efficiency of a lead acid cell is varies between 70% to 80%

1.6 LEAD ACID CELL (Conventional Flooded Type)

The Electro-chemical device which uses lead and its derivatives and sulfuric acid as its constituents is called 'Lead Acid Battery' In this, the positive plate (Anode) consists of an active material 'Lead peroxide' (PbO_2) and grid structure of either pure lead or lead alloys which acts as a supporting structure as well as current carrying conductor. Similarly the negative plate consists of 'Spongy Lead' (Pb) as active material and pure lead or lead alloy for the grid structure. The electrolyte used is 'Diluted Sulfuric Acid'. The cut section view of a lead acid cell is shown is fig.1.1

Anode	: Lead Peroxide	PbO_2
Cathode	: Spongy Lead	Pb
Electrolyte	: Dilute Sulfuric Acid	[Dil-H_2SO_4]

1.6.1 CHEMICAL REACTIONS

During DIS-CHARGING:

At Anode : $PbO_2 + H_2SO_4 \longrightarrow PbSO_4 + H_2O + (O^-)$

At Cathode: $Pb + H_2SO_4 + (O^-) \longrightarrow PbSO_4 + H_2O$

$$PbO_2 + Pb + 2H_2SO_4 \longrightarrow 2PbSO_4 + 2H_2O$$

During CHARGING:

$$2PbSO_4 + 2H_2O \longrightarrow PbO_2 + Pb + 2H_2SO_4$$

During Charging and Discharging:

$$PbO_2 + Pb + 2H_2SO_4 \underset{\text{Charging}}{\overset{\text{Discharging}}{\rightleftarrows}} PbSo_4 + PbSo_4 + 2H_2O$$

(a) During discharge as the Lead peroxide (PbO_2) and Spongy lead (Pb) react with sulphuric acid (H_2SO_4) in the electrolyte and gradually positive negative plates transform into lead sulphate ($PbSO_4$) and finally water is left over. Then the sulphuric acid concentration decreases in the electrolyte due to the depletion of sulphate ions to the positive and negative plates.

(b) Conversely, when the battery is charged the positive and negative active materials, which have been turned into lead sulphates, gradually revert to lead peroxide and spongy lead respectively. The released sulphuric acid emerged in the active materials during which the sulphuric acid concentration increases.

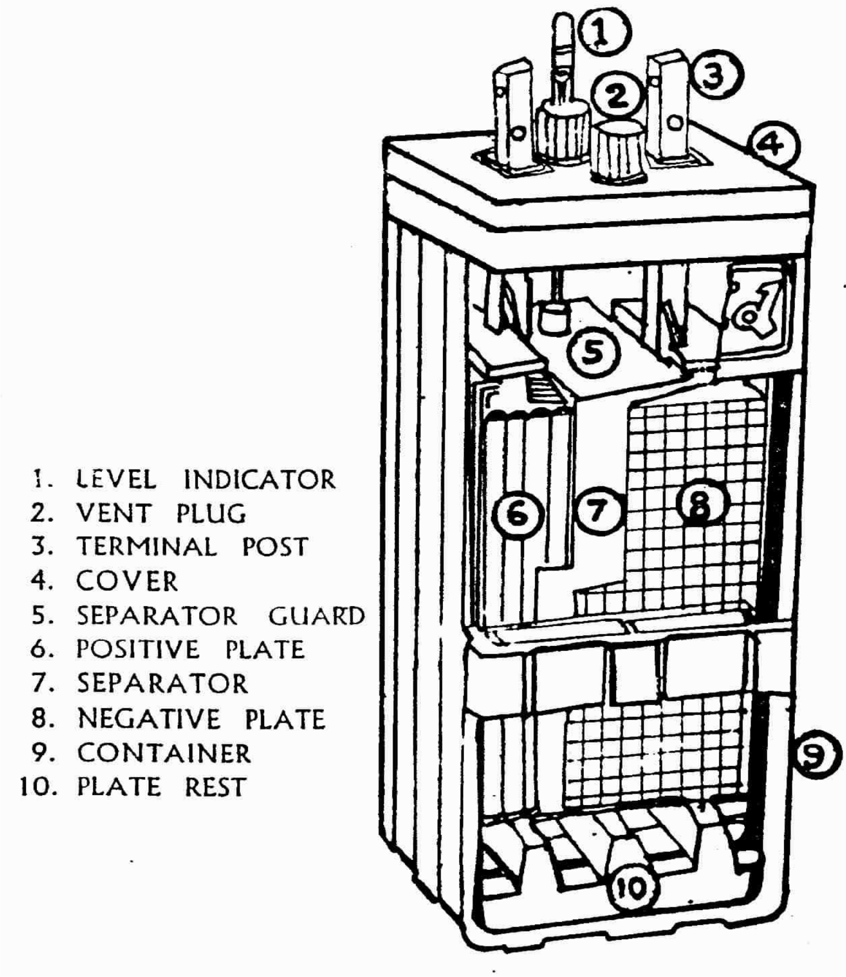


Fig: 1.1 CUT SECTION VIEW OF A CELL

(c) When the battery charging approaches its final stage, the charging current is consumed solely for electrolytic decomposition of water in the electrolyte resulting in generation Oxygen gas from positive plate and Hydrogen gas from negative plate. So the generated gas will escape outside the battery causing a decrease in the electrolyte quantity in the battery. Hence battery needs to be topped up with distilled water.

(d) The density of the electrolyte is maximum, when the cell is fully charged and it is minimum when the cell is under discharged condition.

(e) All the positive plates are welded to one bar and all the negative plates are welded to another bar called Anode and Cathode respectively. There is always one more negative plate than the positive plates, to provide equal working area on both sides of the positive plates. The outside plates are always negative plates.

(f) A hole is provided for pouring the electrolyte and this can be closed by a screwed cap This cap is, having minute holes for gases to escape, known as ‘Vent cap’.

(g) Voltage of the fully charged cell = 2.2V.

End point voltage of the discharged cell = 1.8 V

(h) Specific gravity of the fully charged cell = 1215 (1210 $\pm$ 5)

(i) specific gravity of the discharged cell = 1180

(j) Electrolyte level should be maintained 12mm to 15mm above the plates.

1.6.2 Importance of Specific gravity of the Electrolyte

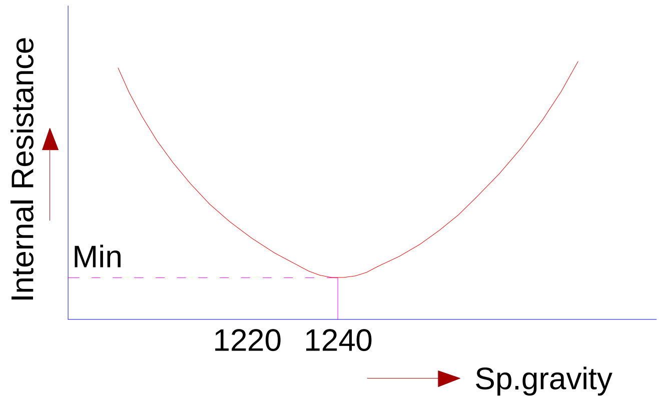


Fig: 1.2

1.	The conductivity of the electrolyte is High at sp. gravity of	1240 at 27^0C
2.	The Internal Resistance is minimum at sp. gravity of	1240
3.	Specific gravity of the fully charged cell	1215 (1210 $\pm$ 5) at 27^0C
4.	Sp. gravity of the discharged cell	1180 at 27^0C
5.	Temperature α	$\frac{1}{\text{Specific gravity}}$
6.	Change in specific gravity	0.7 per ^{0}C
7.	Specific gravity at T^0C	Sp. gravity at 27^0C – [(T-27) X 0.7]

Where, T ^{0}C = Room Temperature in ^{0}C

1.6.3 CHARGING OF A BATTERY

(a) Proper arrangements must be provided in SSE office or at site, preferably at site.

(b) For good performance of a battery, strictly manufacturer's instructions must be followed for preparation of electrolyte and the charging of a Battery.

(c) In the absence of manufacturer's instructions the following method shall be followed.

(i) All the cells, which are to be charged, must be of same capacity.

(ii) Preparation Of Electrolyte**:**

- Porcelain or Glass or Rubber or PVC or any other container with lead lining shall be taken. METALLIC CONTAINERS SHOULD NOT BE USED.
- Always use suitable goggles, rubber gloves and wear an apron, while working with Electrolyte.
- Always ADD ACID to DISTILLED WATER only, but not water to acid.

- Mix acid and distilled water in the ratio as given below:

Sp.gr. of Conc. H2SO4	Required Sp.gr. of solution Dil. H2 SO4	Ratio of Acid : distilled water
1825	1400	7:11
1825	1190	1:5
1400	1190	5:6

- With a Wooden rod (or) glass rod the solution must be stirred continuously, while adding the acid little by little.
- Temperature of the solution must be monitored continuously during the preparation and it should NOT be allowed more than 45^0C
- Allow the solution to cool at least for 10 to 12 Hours.
- After cooling measure the specific gravity. It shall be 1190 to 1200 at 27^0C.
- Since sp.gravity is inversely proportional to Temperature, Temperature correction must be applied.

Sp. gravity at 27^0C	sp.gr. at T^0C + [(T-27) X 0.7] Where, T = Room temp. (Electrolyte temp)
Change in specific gravity	0.7 /^{0}C
Specification of ACID	IS 266.
Specification of distilled water	IS 1069

(iii) Clean all the new cells with distilled water and fill them with electrolyte.

(iv) The level of the electrolyte should be 12mm to 15 mm (1/2”) above the plates (electrodes).

(v) The charger output terminal must be correctly connected to the Battery set. I.e. ‘+’ to ‘+’ and ‘-‘ to ‘-‘.

(vi) Initial Charging**:**

- Apply charge for 35 Hours at the Starting current rate of 4% of the AH capacity of the cells.

  Starting Current = capacity of cell X 0.04 amps for 35 Hrs.

- Check specific gravity & voltage readings at every 8 Hrs.
- Stop charging when sp.gravity becomes 1210 $\pm$ 5
- If the sp. gravity of a cell after charging does not improve to 1210 $\pm$ 5, then a small quantity of the electrolyte is taken out and is replaced with higher (1400) sp. gravity of electrolyte. After this, a fresh charging cycle must be given for 2 Hrs to ensure mixing of electrolyte.
- Discharge the battery through suitable load (lamps) till the sp.gravity reduces to 1180 to 1190 and voltage of cells to 1.8 V
- Repeat the cycle of charge and discharge once again and then charge it finally for use.

(vii) Equalising Charging:

- After initial charging, if the batteries are not connected to load (not put in use) for 15 days then equalising charge must be given.
- Equalising charging must be given, if the batteries are continuously used in "FLOAT Charging" for 3 months (or) whenever required (after restoration of power supply failure)
- Equalising charging current must given at the rate of C/10 Amp, till the voltage & sp. gravity of the all the cells have remains constant for 3 consecutive ½ Hourly readings. (C =AH capacity of the cell) i.e. Equalising charge (Boost mode) brings the sp. gravity of the cells to 1210±5 and voltage to 2.2V.

(viii) Apply a coat of petroleum jelly or non-oxidizing grease on the battery connections to avoid corrosion.

(ix) Close all the Vent caps and ensures that float indicators, indicates the electrolyte level are in proper position.

(x) Charger output voltage shall normally be adjusted to the following values in case of constant voltage type charging.

Float mode	2.25V/Cell adjustable from 2.12V to 2.3V/cell
Boost mode Equalising Charging	2.4/Cell
Initial Charging mode	2.7 V/Cell.

Note: Specific gravity mentioned in this notes is Hydrometer reading for easy reference. In fact, if the hydrometer reading is 1210 then the sp.gravity of the electrolyte = 1.210.

1.6.4 Installation of Batteries

(a) Batteries should be placed in well ventilated room. Normally natural Ventilation is sufficient.

(b) For large installation, forced ventilation by exhaust fans may be provided.

(c) Batteries should not expose to direct sunlight.

(d) Should be away from any heat radiating equipment.

(e) Keep the batteries free from water, oil and dirt.

(f) Do not hold the batteries/cells by the electrode terminals at the time of Transportation/installation.

(g) Should be installed on wooden racks. These racks are protected with 2 or more coatings of acid resistance paint.

(h) Sufficient air gap should be provided between the two cells/ Batteries and should be neatly aligned.

(i) The flexible connecting cables should have Lead coated eyelets/ lugs for making connections.

1.6.5 Maintenance and Inspection of Lead Acid Batteries

(a) For maintenance and repair works Disconnection memo must be given.

(b) Maintenance shall be done once in 15 days.

(c) Clean the dust or dirt from the battery top & connection.

(d) Wipe the battery using a wet cloth piece and allow it to dry

(e) If corrosion has occurred on the terminals and connections, it should be removed by wiping with a solution of washing soda (sodium bicarbonate) and water.

(f) Electrical connections should always be kept tight. Loose connections get heated up and leading to failures.

(g) Apply a coat of petroleum jelly (or) non-oxidizing geese on the battery connections to avoid corrosion.

(h) During charging electrolyte level goes down due to gassing (evaporation of water). Distilled water should be used to top up the cells to maintain the recommended level of the electrolyte.

(i) Electrolyte lost due to spillage should be replaced with proper amount of electrolyte of the same sp. gravity of the same or other cells of the battery bank.

(j) Measurements must be taken after switching OFF the charger and allow the battery 'ON' load for 1 to 4 Hrs. This helps to access the battery condition and also provides the discharge cycle.

(k) Terminal voltage and specific gravity of the each cell should be checked recorded.

(l) Equalising charge shall be given, if required.

(m) Defective cells should be replaced.

(n) Do not allow the batteries to over charging, excessive gassing and heating.

(o) Do not allow the batteries to fully discharged condition.

(p) Syringe type Hydrometer having a scale with one-division represents 5 units of sp. gravity shall be used.

(q) Voltmeter used should have internal resistance of at least 1000 Ω /V

(r) After the maintenance & repair works are completed battery must be tested with connected gears and then Reconnection memo shall be given.

1.7 Hydrometer

There is a direct relationship between the state of charge of the cell and the specific gravity of the electrolyte. In practice, the standard way to test the condition of cell is to measure the specific gravity of the electrolyte with a hydrometer. Two types commonly used, are

(a) The floating hydrometer, (Fig. 1.4.a), used with open type cells. It consists of a glass tube with a calibrated scale and a weighted bulb at the lower end. It is placed in the electrolyte of the cell, and sinks more or less into the solution depending on the specific gravity, which is read directly from the scale.

(b) The syringe hydrometer, (Fig.1.4. b), used with enclosed type cells, and also with open type cells where the separation between plates is small. The hydrometer float is contained in the enlarged portion of a glass cylinder, which has a rubber tube at the bottom and a rubber bulb at the top by means of which acid is sucked in it from the cell under test. After the reading is taken, the acid is restored to the cell.

How to read the hydrometer

To simplify records, and for convenient reference, the specific gravity is multiplied by 1000 and the hydrometer scales marked accordingly. Thus, when the hydrometer reads 1215, the specific gravity is 1.215.

When taking hydrometer readings, the electrolyte clings to the stem of the hydrometer at the surface. This is called the meniscus. To avoid errors, always read to the bottom of the meniscus (Fig.1.4. c).

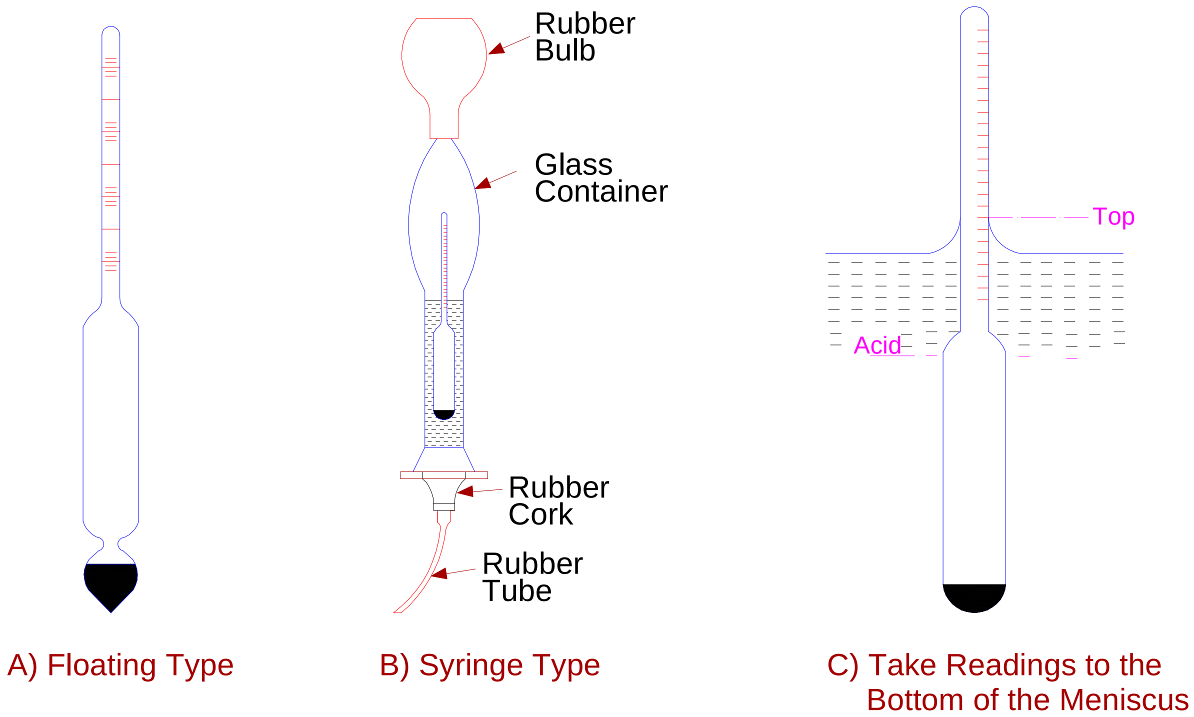


Fig: 1.4 HYDROMETER

1.8 Do's & Don'ts of a Lead Acid cell (flooded type)

Do's

(a) Ensure that the positive and negative wires are connected to positive and negative terminals respectively, while connecting the charger to the batteries.

(b) If the battery is not in use, keep the battery in full charged condition by giving an equalizing charge at least once every month.

(c) Ensure that the float indicator is available and in working order.

(d) Electrolyte is highly corrosive and should be handled carefully to avoid injury to person or damage to clothing or equipment. It the electrolyte is accidentally spilled, it should be flushed with plenty of water immediately, after treating with washing soda solution.

(e) After the resumption of power supply failure, battery should be charged on boost mode to maintain the battery in fully charged condition.

Don'ts

(a) Do not allow over charging, excessive gassing and heating.

(b) Do not allow the batteries to get fully discharged.

(c) Do not allow open flame/smoking near the batteries to eliminate danger from explosion or fire. Extreme care must be exercised to avoid a spark or flash when changing connections or working on or near the battery. Battery lead should first be disconnected at a point remote from the battery set.

(d) Cans or metal jugs should not be used for carrying water required for topping up.

(e) Don't mishandle the cells. Especially during transportation, "don't hold the cells by the electrode terminals."

1.9 Some Defects and Causes

(a) Battery does not charge

This may be due to:

(i) Disconnection in the charging circuit.

(ii) Blowing off of charger fuse DC or AC side.

(iii) Loose connections or high resistance at terminals.

(iv) Defective charger, not feeding current.

(v) No output from Transformer.

(vi) Wrong connections.

(vii) Acid Stratification.

(b) Takes more time to charge

This may be due to:

(i) Loose connections or high resistance at terminals,

(ii) Charger not able to feed enough boost charging current,

(iii) Excessively discharged,

(iv) Wrong connections.

(c) Battery does not last for long

Possible causes for this are:

(i) Low electrolyte level,

(ii) Uneven specific gravities and voltages of cells,

(iii) Not properly or fully charged,

(iv) Leakages in some cells,

(v) Reverse polarity on some cells, Inadequate number of cells or load current more

(vi) Low specific gravity,

(vii) Impure distilled water/acid.

(d) Battery overheats on charge/discharge

Possible causes for this are:

(i) Charging current very high, specially at the finish,

(ii) Charger voltage high,

(iii) Charged for longer period,

(iv) Over discharged or excessive load current,

(v) Poor ventilation, Temperature high,

(vi) Internal short circuit

(vii) More sediment material in the cell, Old/Worn out cells.

(viii) Low level of electrolyte.

(e) Low electrolyte level

Possible reasons are as under:

(i) Broken/cracked container,

(ii) Distilled water not recouped regularly/forgotten,

(iii) Excessive charging

(iv) Excessive heat,

(v) Vent caps missing.

(f) Voltages and specific gravities of cells unequal

Possible reasons are:

(i) Internal short circuit leakage,

(ii) Leakage of electrolyte through cracked cell, sealing compound and covers,

(iii) Dirty terminals and cell top,

(iv) Used with low electrolyte level,

(v) Sedimentation high inside the battery,

(vi) Plates worn out,

(vii) Impure electrolyte,

(viii) Overfilled with distilled water.

(g) Specific gravity is higher then normal during Float Charging

Possible reason is:

(i) Float voltage is high.

1.10 Life of a Secondary Cell

Signalling standards committee recommended that the life of a secondary cell is 5 Years if it is used in RE area and incase of Non-RE area its life is 4 Years.

1.11 Limitations of Conventional Lead Acid Cells

(a) Frequent topping up with distilled water is required and some times electrolyte with higher specific gravity needs to be added. This results in more maintenance.

(b) During charging cycle acid fumes are given out by the batteries and hence they are to be kept in separate room with proper ventilation.

* * *

CHAPTER – 2: LOW MAINTENANCE LEAD ACID CELLS

(Spec No.: **IRS: S-88/2004)**

The major problem faced in Conventional Lead acid batteries i.e water evaporation is minimised by improved technology described below.

2.1 Features

(a) Low antimony alloy, minimizes water loss thereby reduces the topping up frequencies

(b) Low Maintenance Lead Acid Tubular Cells are made of robust PPSFM (Polypropylene Structural Foam Moulded) container.

(c) Heavy duty tubular plates for excellent cycle life (1500 cycles at 80% Depth of Discharge and 5000 cycles at 20% Depth of Discharge).

(d) Low rate of self discharge less than 3% per month at 27℃.

(e) Capacity to withstand partial stage of charge operation (PSOC).

(f) Deep cycling capabilities.

(g) Higher ampere-hour and watt-hour efficiencies.

(h) Long Service Life.

2.2 Benefits

(a) Trouble free Performance - Higher reliability.

(b) Low maintenance cost.

(c) Long cycle life - Low life cycle cost.

(d) High power at low rate of discharge.

(e) Suitable for deep discharge application.

(f) Tolerant to high temperature applications.

2.3 CHEMICAL EQUATION

Reaction at positive electrode

$$PbO_2 + 3H^+ + H_2SO_4^- + 2e^- \underset{\text{Charge}}{\overset{\text{Discharge}}{\rightleftharpoons}} PbSO_4 + 2H_2O$$

Reaction at negative electrode

$$Pb + H_2SO_4^- \underset{\text{Charge}}{\overset{\text{Discharge}}{\rightleftharpoons}} PbSO_4 + H^+ + 2e^-$$

Oxygen Recombination step at Negative electrode

$$Pb + H_2SO_4^- + H^+ + \tfrac{1}{2} O2 \underset{\text{Charge}}{\overset{\text{Discharge}}{\rightleftharpoons}} PbSO4 + H_2O$$

Overall Cell Reaction

$$PbO_2 + Pb + 2H_2SO_4 \underset{\text{Charge}}{\overset{\text{Discharge}}{\rightleftharpoons}} 2PbSO_4 + 2H_2O$$

2.4 Filling of Electrolyte

(a) Electrolyte of 1180±5 (1.180+/- 0.005 Sp.gr)

(b) For electrolyte Quantity/Cell, refer data sheet.

Approx. Qty. of Electrolyte of sp.gr. of 1.180 is given in the table below.

Sl.No	AH Capacity of the Cell	Qty. of acid 1.18 sp.gr in Liters
1	100 AH	4.8 Liters
2	120 AH	4.6 Liters
3	200 AH	11.3 Liters
4	300 AH	10.6 Liters
5	400 AH	14.6 Liters
6	500 AH	13.7 Liters

(c) Electrolyte has to be filled through vent hole up to 'Green Mark' of float guide.

(d) Allow the soaking for 8-12 hrs, before charging.

(e) There will be drop in the level of electrolyte after soaking. This shall be restored by adding electrolyte of same Sp.gr.

CAUTION during electrolyte preparation & filling:

(i) Wear rubber gloves & shoes.

(ii) Goggles should be used for eye protection.

(iii) The water should not be added to the Sulphuric acid as it will splash dangerously.

Note: *First charging shall be started after the electrolyte cools down to room temp. and within 24Hrs after filling of electrolyte.*

2.5 INITIAL CHARGING

(a) LMLA Battery to be charged in constant current mode.

(b) Charge the cells at 10% of rated capacity till the cell reaches a voltage of 2.4 V/cell.

(c) Further, continue the charging at 5% of rated capacity till the cell reaches 2.65-2.75V/cell

(d) Terminate the charging when cell voltage & Sp.gr values remain constant for 3 consecutive hourly readings.

(e) Measure Sp.gr. once in 4 hours and add distilled water, if Sp.gr. is more than 1.200.

(f) After 60 hrs of charging if Sp. gr. is less than 1.200, then add 1.400 acid to correct to 1.200.

(g) Monitoring during Initial Charging:

(i) Record – Cell voltage, Charge current, Electrolyte sp.gr. and temp. as soon as charger is connected.

(ii) At the end of each hour, record the Battery Voltage & Current. At the interval of 4 hrs, record the Sp.gr. & temperature of electrolyte.

(iii) The temp. of electrolyte should not go beyond 50℃ during charging. If found, discontinue charging and allow the batteries to cool down to 40℃.Then restore charging.

(iv) After 80% of total AH I/P is given, take hourly readings of voltage & specific gravity.

(v) At the end of charge, the cells should gas. If any cell fails or delays in gassing or its gravity is lower than those of other cells, it should be examined and corrected. When corrected, the charge should be continued until the cell is brought up to the full charge.

(vi) Adjust the electrolyte level to Max. level position.

2.6 Battery on use / Operation

(a) Put the battery in service by connecting it to load & charger.

(b) During standby period, the battery to be under continuous charge at float voltage & electrical load to be always supported by Battery charger.

(c) The battery supports the load during the power failure.

2.7 FLOAT CHARGING

(a) The recommended float voltage is between 2.15 – 2.20V/cell.

(b) The float current to be adjusted within the range specified in below table.

Sl. No	AH Capacity of the Cell	Float Charging Current
1	100 AH	100 – 400 mA
2	120 AH	120 – 480 mA
3	200 AH	200 – 800 mA
4	300 AH	300 – 1200 mA
5	400 AH	400 – 1600 mA
6	500 AH	500 – 2000 mA

(c) The float charging keeps the battery fully charged without being overcharged.

(d) Very high float voltages will result in excess consumption of water & too low will reduce the discharge capacity.

(e) The temp. & Sp.gr. readings have to be taken weekly of pilot cell

(f) If low Sp.gr is found the battery should be given immediate charge to ensure full charge.

2.8 RECHARGING DETAILS

(a) Normal Charging:

(i) Normal charging to be carried out at the start & finishing rate.

(ii) Starting rate is charging current rate at 10% of rated capacity till the Cell voltage reaches 2.4V and finishing rate is charge current of 5% of rated capacity till the Cell reaches 2.65 –2.75 Volts.

(iii) The charging at finishing rate shall be terminated when Cell Voltage & Sp. gr. values remain constant for 3 consecutive hourly readings.

(b) Boost Charging: The charging current rate is 12.5% of rated capacity (0.125C) for a period of 10-12 hrs.

2.9 MAINTENANCE

(a) The temp. and sp. gravity readings of electrolyte have to be taken weekly of pilot cell. (Pilot Cells are selected out of every 60 Cells)

(b) Check float charge voltage and adjust to the specified value if required.

(c) Check the electrolyte level and top up with distilled water whenever required.

(d) Check the specific gravity of all cells in every month during the battery charge and the specific gravity shall be corrected accordingly.

(e) If the specific gravity is higher than it can be adjusted to the specified value by adding distilled water. Conversely if the sp. gr. is lower than the specified then add acid of 1.400 sp.gr.

(f) Ensure that specific gravity of electrolyte is uniform for all the cells & in the range of 1.200±0.005 at 27℃

(g) Keep battery room clean, dry, and well ventilated.

(h) If battery is idle, then give normal charge once a month.

(i) Recharge the battery immediately after every discharge.

(j) Check tightness of all electrical connections once a month.

(k) Maintain proper records of charge, discharge, Cell Voltages, Sp.gr. etc.

(l) Clean & wipe cells to remove acid, which may have dripped on cell during filling.

(m) Check the connection tightness.

(n) Apply petroleum jelly on terminals, nut, bolt & washers.

2.10 TEST PROCEDURE FOR CAPACITY TEST

(a) To carry out this test the battery has to be in fully charged condition.

(b) After standing on open circuit for not less than 12 hrs and not more than 24 hrs from the completion of full charge, the cell shall be discharged through a suitable variable resistance at constant current.

(c) Measure the open circuit voltage of all the cells. Note specific gravity of electrolyte & its temp. of pilot cell before applying the load.

(d) Connect external resistive load across the battery output and terminal adjust to desired current. i.e. 0.1C Amps (10% of battery rated capacity).

(e) During discharge note the following parameters at hourly intervals:

- (i) Voltages of all cells.
- (ii) Check and adjust the discharge current, if required.
- (iii) Sp. gravity of electrolyte.
- (iv) Temp. of pilot cell.

(f) Record the cell voltages more frequently (every 15 minutes) from 8th hour onwards until end of discharge.

(g) The discharge shall be terminated whenever any cell in the battery bank reaches to 1.85 Volts.

(h) The time in hours elapse between beginning and end of discharge shall be taken as period of discharge.

(i) The average electrolyte temp. of pilot cell is noted. In case the temp. is other than 27deg.C then the correction of the capacity shall be carried out by the formula.

Formula for capacity calculations at 27℃

$$C_a = C_t + (C_t \times R \times (27 - t)/100)$$

C_a = actual capacity at 27℃

C_t = Observed capacity at t℃

R = variation factor at given rate of discharge.

(0.43 for 0.1C discharge)

t = average room temp. in ℃

2.11 DO'S

(a) Unload the batteries carefully and place them upright on the floor in single tier.

(b) Store the batteries in cool & dry location.

(c) Unpack the batteries as per the unpacking instructions.

(d) Install the batteries in a cool and dry location.

(e) Keep the batteries area clean & dry.

(f) Check the polarity of the cells before connection.

(g) Check the Sp. gr. of electrolyte at regular intervals.

(h) Apply petroleum jelly to the connector portion. (terminal bolt, nut & washers)

(i) Check the float voltage & current regularly and adjust to the specified value.

(j) Give equalizing charge if specific gravity varies by 20 points among the cells.

(k) Top up the cells either with distilled water or the electrolyte based on the specific gravity measurements.

(l) Provide adequate vitalization & illumination in the battery room.

(m) Record should be regularly maintained.

(n) Always wear rubber gloves, aprons and goggles while handling acid.

(o) Contact battery manufacturer for additional help & guidance.

2.12 DON'T S

(a) Do not expose packed batteries to rain.

(b) Do not expose packed batteries to direct sunlight.

(c) Do not charge the batteries in sealed cubicles.

(d) Do not mix batteries of different types or makes.

(e) Do not make tap connections.

(f) Do not use metallic vessels for electrolyte preparation & filling.

(g) Do not short circuit cells while using spanner, L-handle etc.,

(h) Never allow an open flame, spark or smoking in the battery room.

2.13 BATTERY HISTORY CARD

Form No. S&T/BCP

Annexure 16

SEM- II Para 16.10.8

_______Railway _________Division

Station__________

Signal & Telecommunication Department

SECONDARY BATTERY HISTORY CARD

No. of cells :	Installation date :
Capacity (AH):	Circuit Reference:
Battery set No.	Charging Current:
Battery set voltage:	Charger make:
Battery make:	Charger capacity:

Date	Parameters	Cell Number									Work done & remarks	Sign.
		1	2	3	-	12	-	24	-	55		
	Specific Gravity 1220											
	Cell Voltage											
	Specific Gravity 1220											
	Cell Voltage											

2.13 RDSO approved list of firms for manufacture and supply of electrical signalling items: As on September 2009

ITEM: POWER SUPPLY EQUIPMENTS – SECONDARY CELL – LOW MAINTENANCE
Spec No.: IRS: S-88/2004

APPROVED UNDER PART: I

1. M/s Exide Industries Ltd.
2. M/s Southern Batteries Pvt Ltd,
3. M/s Lead Acid Batteries Co. (P) Ltd.,
4. M/s Bharat Battery Manufacturing Co.Pvt.Ltd.,

APPROVED UNDER PART: II

1. M/s Bharat Battery Manufacturing Co.Pvt.Ltd.,
2. M/s CELTEK Batteries Pvt.Ltd.,
3. M/s Exide Industries Ltd.
4. M/s Lead Acid Batteries Co. (P) Ltd.,
5. M/s Southern Batteries Pvt Ltd,
6. M/s Power Build Batteries Pvt. Limited

* * *

CHAPTER – 3: BATTERY CHARGERS

Battery Charger is an Electrical Equipment used for Charging Secondary cells.

3.1 Features of Battery Charger as per IRS: S-86/2000 with Amendment – 4

The battery Charger as per this specification is shown in fig 3 .1

(a) Battery charger shall be suitable for satisfactory operation with the Input Voltage range of 160V to 270V AC.

(b) In case of AC Input voltage goes below 160V AC or goes above 270V AC use of a separate AC voltage stabiliser is recommended in conjunction with the charger.

(c) The charger shall be rated for continuous output.

(d) The r.m.s ripple of the D.C output voltage of the charger through resistive load shall NOT be more than 5%.

(e) Chargers used for Axle counter installations, the r.m.s ripple shall be less than 10mV and the peak to peak noise voltage shall be less than 50mV.

(f) Normally the out put voltage of the charger shall be 2.25 V/Cell, adjustable between 2.12V/Cell to 2.3V/Cell by the voltage control preset, if it is working in auto float mode.

(g) Red LED indication shall appear with resettable alarm when the output voltage goes below 1.95V/Cell for I/P voltage variation of 160 V to 270V AC.

(h) It generates low battery alarm when the battery voltage falls to 1.95V/cell.

(i) It generates start DG set non-resettable alarm when the battery voltage falls to 1.90V/cell.

(j) It isolates battery from the load when the battery voltage falls to 1.80V/cell.

(k) If the current across battery terminals increases by 8% to 12% of the set current value and if the charger is in ‘Auto’ mode, the output voltage of the charger shall automatically change to 2.4V/Cell i.e. charger charging mode shall automatically change to Boost mode from the float mode. It shall continue to give this output till the batteries get fully charged and the current drawn by batteries is less than 5% of the set current value.

(l) The charger out put voltage shall be:

Float Mode: 2.15V/Cell (Adjustable 2.12V to 2.3V/Cell)

Boost Mode: 2.4V/Cell

(m) If there is no output voltage, the ‘LED’ indication against ‘AUTO’ mode will start flashing with audible alarm.

(n) The Watt efficiency shall NOT be less than 70% for charger of 500W or more rated output power & 65% for chargers of less than 500 W rated output power in all modes of working.

(o) The watt efficiency shall NOT be less than 60% for chargers of 12V, current up to 40A.

(p) The power factor of the charger shall not be less than 0.7 lagging in all modes of working.

(q) The no-load current of the charger shall NOT be more than 10% of the rated input current under float mode.

(r) If the capacity of the cell is 'C', then, recommended capacity (current rating) of the Charger can be identified from the following table. The maximum Permissible Load on battery bank shall be C/10 Amps.

Sl. No	Cell Capacity in AH	C/10 rate	Maximum permissible Load	Recommended (current rating charger (Amps)
1	40	4 A	4 A	10 A
2	80	8 A	8 A	20 A
3	120	12 A	12 A	30 A
4	200	20 A	20 A	40 A
5	300	30 A	30 A	60 A
6	400	40 A	40 A	80 A
7	500	50 A	50 A	100 A

(s) The nominal voltage ratings of 12, 24, 36, 48, 60, 110 & 120 volts are recommended for adoption by Railways. This will help in standardizing the equipment and ultimately in testing and maintenance.

(t) The charger of 12, 24, 60 & 110 volts output shall have a provision for charging number of cells as mentioned below:

Rated Output Voltage	Provision for charging No. of cells
12	6,7,8
24	12,13,14
60	30,31,32
110	55, 56, 57

LED indications are provided on the charger for indicating the no. of cells selected.

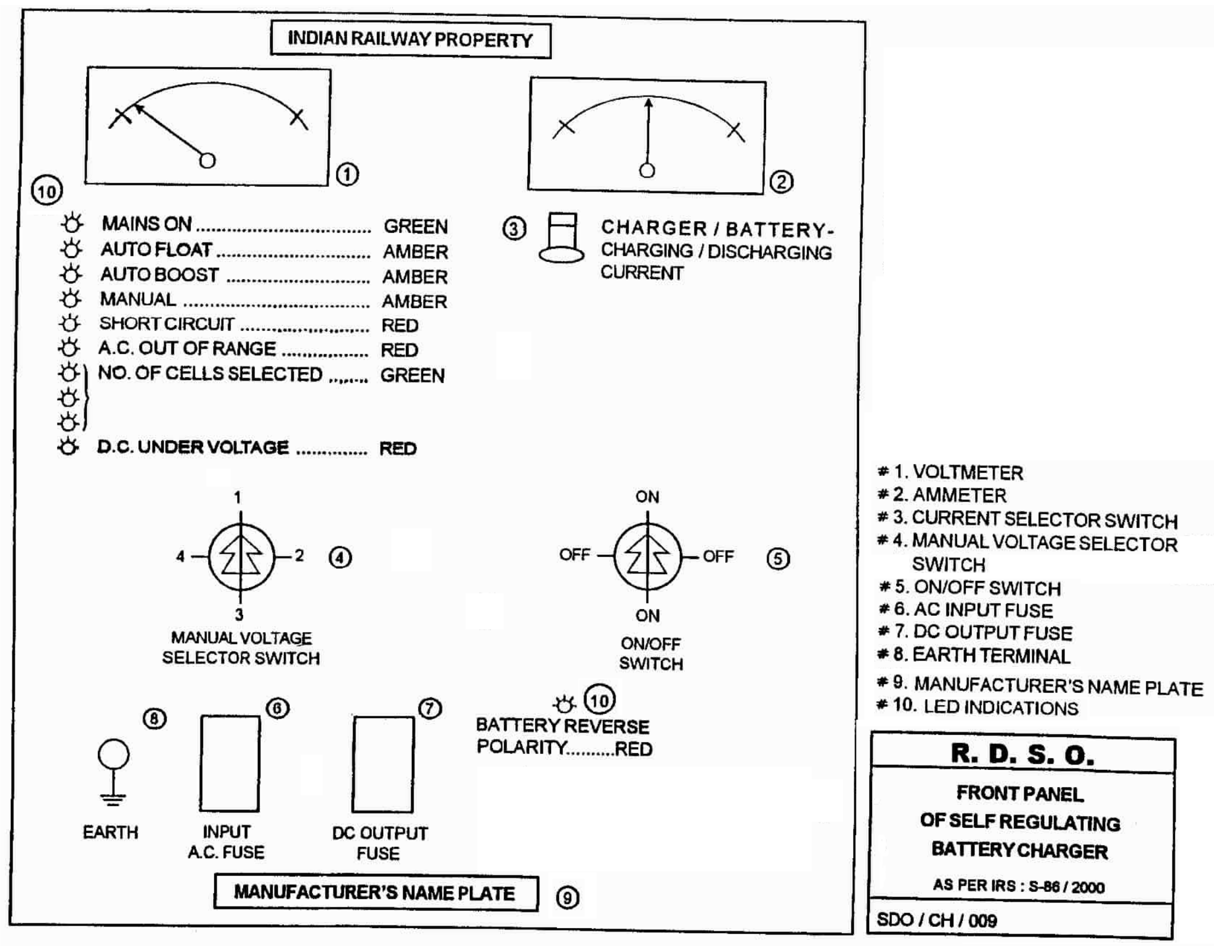


Fig: 3.1Front view of Self Regulating type Automatic Battery Charger

3.2 Description

The charger is designed to operate either in the AUTO mode or in the MANUAL mode. The mode selector switch is provided on the front panel. The mode selector switch will be positioned in the auto mode at the factory. The LED mounted on the front panel indicates the operation of the charger in the MANUAL mode. In the AUTO mode of operation, either AUTO FLOAT LED or AUTO BOOST LED will glow depending on the battery condition.

3.2.1 AUTO MODE

In this mode the charger automatically selects to operate in either of two different modes namely AUTO FLOAT or AUTO BOOST. In the FLOAT MODE of operation, the charger output voltage can be set to any voltage between 2.10 V/cell to 2.3 V/cell by a potentiometer called "Voltage Set Potentiometer" provided on the PCB. In the BOOST mode the charger is capable of delivering an output current through the battery terminals whose maximum magnitude can be selected by the "Current Control Potentiometer" provided on the Front panel. In this mode the charger delivers constant current which is selectable from 25% to 100% of the rating of the charger irrespective of the input voltage variations and the DC terminals voltage varying from 1.7V to 2.4 V/cell. At factory this potentiometer is set to the maximum rated current of the charger.

In auto mode of operation the charger automatically selects either the FLOAT mode of operation or BOOST mode of operation depending on the health of the battery. If the current drawn by the battery is more than 8 to 12 percent of the set charging current then the charger automatically switch to boost mode of operation. When the current drawn by the battery is less than 3 to 5 percent of the set charging current and the voltage across the battery terminals is 2.4V per cell, the charger is automatically switched back to the FLOAT mode.

3.2.2 MANUAL MODE OF WORKING

If the charger fails in AUTO MODE then the charger can be switched on to the MANUAL MODE by the mode selector switch mounted on the front panel. The operation of the charger either on the AUTO or MANUAL MODE is indicated by visual indication of LED's mounted on the front panel. Once this mode switch is placed in the MANUAL MODE the charger will no longer work as an automatic charger. In this mode the DC output voltage can be varied depending on the number of cells selected by tap changing the transformer with the help of a selector switch mounted inside the charger called "Manual Mode Selector Switch". This switch has three positions to select the DC voltage of 2.25V/cell depending on the number of cells selected. This DC output voltage in the MANUAL MODE is achieved through a separate Full Wave Bridge Rectifier.

3.2.3 The charger is designed for continuous operation at rated voltage and current ambient temperature of 500C. This unit is electronically protected against reverse polarity, short circuits, over voltage, over load and surge voltages. The entire system is housed in a cubicle made of angle-iron frame, which is covered by mild steel sheet of 2-mm thickness and is treated with zinc chromate primer followed by electrostatic epoxy power coating. The front panel is treated with raw silk white power.

3.3 CONTROLS, INDICATIONS AND PROTECTIONS

Sl. No	Controls, Indications and Protections	Description
1	Input ON/OFF Switch	This is a two-pole two-way on-off switch. When this switch is in the ON position the AC mains is connected to the unit.
2	Input Fuse	This is a HRC fuse on input side to protect the charger from any possible "Over Load" or "Short Circuit" condition.
3	Cell Selector Switch	This is a 4 Pole – 3 Way Switch mounted on PCB 001 to select the n, n+1, n+2 cells.
4	Auto/Manual Mode Selector Switch	This is a 4 pole 2 way switch. This switch is kept in the auto mode at the factory. When the charger fails in the auto mode, it is put into the manual mode
5	Manual Voltage Selector Switch	This is a 1 pole 3 way switch mounted on the front panel to select the DC output voltages of 2.25V/cell depending on the number of cells connected at nominal input and rated output current in the manual mode of working.
6	Voltage Control Potentiometer	This is a single turn potentiometer mounted on the PCB 001 used to adjust the output voltage from 2.12V/cell to 2.3V/cell in the Float mode of working.
7	Current Set Potentiometer	This is a single turn potentiometer mounted on the PCB 001 to select the maximum charging current in Boost working from 25% to 100% of the charger rating depending on the number of cells connected.
8	AC Mains LED	This LED will glow when AC power is fed to the Battery Charger through the input fuse, to indicate the power on condition of the charger.

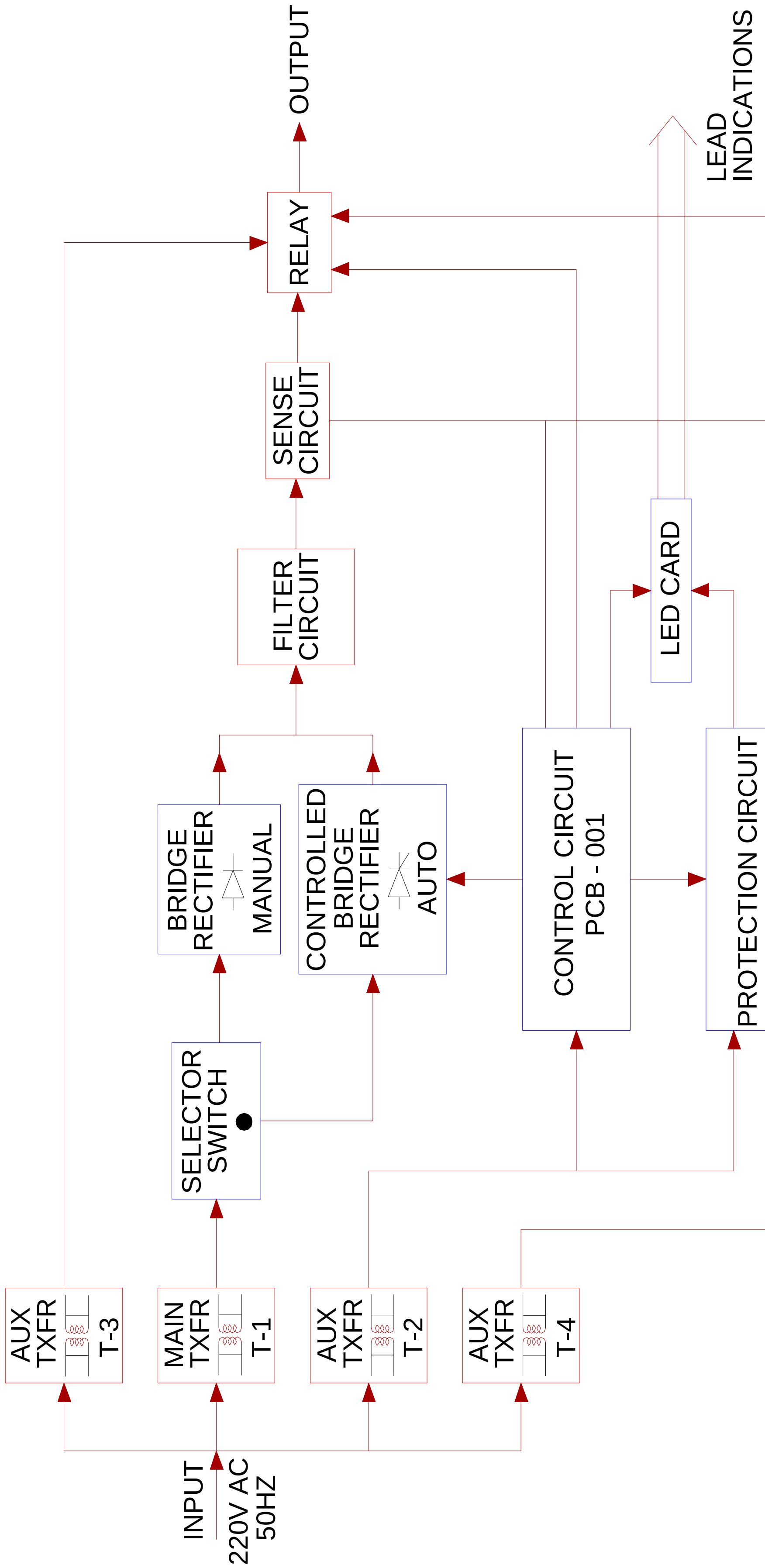
Sl. No	Controls, Indications and Protections	Description
9	Auto Float/Auto Boost LEDs	These LEDs indicate the mode of charging the battery in Auto Mode. The Auto Float LED will glow when the charger is working in the Float Mode and the Auto Boost LED will glow when the charger is working in the Boost Mode.
10	Auto mode Fail LED	This LED will indicate & flash the failure of the charger in Auto Mode of working.
11	Short Circuit Indication	This LED glows when there is a short circuit at the output of the charger.
12	Reverse Polarity LED	This LED will glow when the battery is connected with the reverse polarity (i.e. the +Ve terminal of the battery to the –Ve terminal of the charger and the –Ve terminal of the battery to the +Ve terminal of the charger.
13	Over Load LED	This LED will glow when the current delivered by the charger exceeds the rated current of the charger.
14	Manual Mode LED	This LED will glow when the mode selector switch is in the Manual Mode.
15	Cell Selector LED	There are three green colour LEDs to indicate the number of cells selected by the cell selector switch i.e. n, (n+1) and (n+2) cells.
16	AC Out of Range Indication LED	This LED will glow in the Auto Mode if the AC input voltage is out of range i.e. <160V AC or >270V AC.
17	DC Voltmeter	This Voltmeter indicates the DC output voltage of the charger in all modes of operation.
18	DC Ammeter	This ammeter indicates the charging or discharging current of the battery or the total current delivered by the charger to the battery and load.
19	Meter Selector Switch	This is a double pole push button switch to select the Ammeter to read either the charging/discharging current of the battery or the total current delivered by the charger to the battery and load.
20	Output Fuse	This is a HRC fuse provided on the output side to protect the equipment from any possible 'Over Load' or 'Short Circuit' conditions.

3.4 Working: Automatic / Manual mode working block diagram is shown in figure 3.2

3.4.1 AUTOMATIC MODE of the working of the charger

In this mode the charger senses the battery charging current drawn through the battery terminals. When the battery charging current increases to 8 to 12% of the selected current as selected by the current control pot, the charger switches from Float to Boost Mode irrespective of the current drawn by the load through load terminals.

The battery charger continues to be in Boost Mode till the battery terminal voltage reaches 2.4V/cell and the charging current is between 3 to 5% of the set charging current. Once this condition is satisfied the charger will switch back to the Float Mode of operation automatically.



BLOCK DIAGRAM OF AUTOMATIC/MANUAL MODE CHARGER WORKING

Fig.N0.3.2

3.4.2 MANUAL MODE of the working of the charger

If the charger fails to operate in the automatic Mode the charger can be made to operate in the manual mode by putting the mode selector switch into the manual mode. When the selector switch is in manual mode the circuit essentially consists of main transformer (T1), full wave diode bridge rectifier and LC filter. The main transformer secondary to the half controlled bridge is disconnected and also the AC input to the auxiliary transformer (T2) is disconnected and energizes the auxiliary transformer T3 and T4.

In this mode the output DC voltage is controlled by the Manual Mode voltage selector switch mounted on the front panel. When the voltage selector switch is in the first position, i.e. ‘n’ cells position the output voltage is n x 2.25V/cell at rated input voltage and rated output current. When the switch is in the ‘n+1’ position the output voltage is “(n+1) x 2.25V/cell” at the rated input voltage and rated output current. When the switch is in the ‘n+2’ position the output voltage is “(n+2) x 2.25V/cell” at the rated input voltage and rated output current.

3.5 ADJUSTMENTS FOR AUTOMATIC MODE OF WORKING

3.5.1 ADJUSTMENT FOR AUTO FLOAT MODE OF OPERATION

(a) Put the mode selector switch in the AUTO mode of working. If the battery is not connected the charger will be in FLOAT mode.

(b) Adjust the output voltage to the required value by Volt Adj. Potentiometer (2.15V/cell).

(c) Keep the current set potentiometer to C/10 of the battery ampere-hour capacity to charge the battery by turning it counterclockwise.

(d) Observe the battery charging current through the ammeter on the front panel by pressing the ammeter current selection switch. The magnitude of the charging current depends on the charge contained in the battery. As the battery is getting charged because of the current flowing through the cells, the charging current decreases and drops to float charging when the battery becomes fully charged.

3.5.2 ADJUSTMENT FOR AUTO BOOST MODE OF OPERATION

(a) If the charging current drawn by the battery is more than 8 to 12% of the selected current the charger will switch to BOOST mode. Adjust the current set potentiometer to C/10 of the battery ampere-hour capacity to charge the battery.

(b) The charger will continue to operate in BOOST mode until the battery is fully charged. In this mode the charger works as a constant current source.

3.6 Installation and Maintenance instructions for self regulating Battery charger as per IRS: S 86-2000 **(As per SEM Part-II, Annexure-15, Para 16.7.6)**

3.6.1 Output current rating less than 50A

Various Front panel control, switches and indications are given in Sketch No. SDO/CH/ 009 enclosed. i.e. in Fig .3.1

(a) INITIAL COMMISSIONING

(i) Auto Mode Working:

- Connect Earth terminal (#8) to earth. After connecting the 230V AC mains to input terminals at the back of the charger, Switch ON the unit by changing the ON/OFF Switch (#5) to “ON” position. Indication Mains ON (green LED) will glow.

- Set the Mode selector switch in "Auto" position provided inside the charger.
- Since there is no battery connected across the battery terminals, the charger will come in Auto Float mode immediately. Indication Auto Float will glow. Adjust the Float voltage to 2.15V/Cell. (25.8V for a 24V charger/12.9V for 12V charger) by adjusting Voltage control pot provided on the Control PCB inside the charger.
- Current control potentiometer is provided on the control card PCB inside the charger to adjust the output battery current of the battery charger as per actual battery current requirement. The control will permit the continuous variation from 25% to 100% of the rated current. These correspond to 25%, 50%, 75%, and 100% of the rated output current. The current across battery terminals should not exceed 10% of AH capacity of the battery (i.e. C_{10} rate of charging). The use of current control pot. Is explained by the followed example.

Example

Sometimes a higher current rating battery charger is used at site for charging a lower AH capacity batteries. For example, only 10A rating charger is required for charging 40AH battery set (Clause 1.4, Note 1 of the spec.) However, if 20A rating charger is connected to a 40AH battery set, the Current Control pot. Shall be adjustment to "50%" of the rated value therefore the rating of the charger becomes 10A. As long as the Current control pot remains at 50% position the total output current of the charger (Load current +Battery current) will not exceed 10A. Therefore overcharging of batteries can be avoided by making use of the Current control pot.

If the AH capacity of the batteries is matching with the charger output current rating (Clause 1.4, Note 1 of the spec.), the Current Control pot shall be kept at "100% position"

- Connect batteries across the battery terminals (#9). With mode selector switch in auto mode, the charger is in "auto float mode". But if the current drawn by the batteries changes by more than 8 to 12% of the set current, the charger automatically changes to "Auto Boost Mode" and it out put voltage changes to 2.4 V/Cell (28.8V in case of 24V charger and 14.4 V in case of 12V charger). It comes back to "Auto float mode" when the current drawn across battery terminals drops down to less than 5% of C_{10} rate and battery voltage builds up to 2.4V/Cell. This happens after the batteries have almost got fully charged.
- In this mode of working Manual voltage Selector switch (#4) is ineffective and therefore need not be touched.

(ii) Manual Mode

- Connect Earth terminal (#8) to earth. After connecting the 230V AC mains to input terminals at the back of the charger, Switch ON the unit by changing the ON/OFF Switch (#5) to "ON" position, Indication Main ON (greed LED) will glow.
- Change Mode selector switch provided inside the charger to manual position. The charger comes into manual mode and indication amber LED glows.
- Change manual voltage selector switch (#4) to first, second or third position as per the No. of cells connected to the charger.

- Connect the load across the load terminal, the out put voltage should be 2.25V per cell with the load connected across the load terminal.
- Initial setting in manual mode is to be done by the SSE/SE (Signal) depending on the load connected. ESM of the station should closely monitor the battery charger as per instructions of the SSE/SE (Signal).
- Manual mode is to be used when “Auto mode” fails. Manual mode is an unregulated mode where the output voltage changes with change in AC input voltage, and output load. Therefore, the maintainer should keep a watch so that batteries are not overcharged.

(b) PROTECTIONS AND INDICATIONS

[To be checked at the time of initial installation]

(i) Indication Mains ON (green LED) appears as soon on ON/OFF switch is switched “ON”.

(ii) When in auto mode, indications Auto Float or Auto Boost will appear depending on whether the charger is in Auto float or Auto boost mode.

(iii) Switch ON the charger in Auto mode and short the load terminals. Short circuit indication should glow and charger output becomes zero. If short circuit is removed, the indication extinguishes and the charger gives the required output without any other adjustment. The charger should not trip.

(c) ROUTINE OPERATION (BY ESM)

(i) Normally the charger will be working in Auto mode. Once it is initially commissioned in “Auto Mode” by the SSE/SE (Signal), no adjustment is required to be done by ESM.

(ii) Change over to Manual mode

- When “Auto mode” fails, the Mode Selector Switch provided inside the charger shall be turned to Manual position.
- Manual Voltage Selector Switch (#4) may be kept in position 1,2 or 3 depending on load/battery charging requirement.
- Failure of Auto mode will be immediately informed to SE (Signal), who in turn will check up the charger as soon as possible.

(d) ROUTINE MINTENANCE

(i) During the visit of ESM on duty to the station, he must check the front panel of the battery charger for correctness of the indications. The indications displayed must be in conformity with the mode in which the charger is working. If not so, he must refer to Para 3 above, changeover the battery charger to manual mode and report the failure to SE (Signal).

(ii) The ESM will check the tightness of the connections to battery and load terminals on the front panel and tighten the same if found loose.

(iii) If everything is normal and indications on the charger front panel are in conformity with the mode of working, the ESM shall not disturb the control switches of the charger.

3.6.2 Output current rating more than 50A

Additional protections and indications are provided for chargers of output ratings 50A and above. These are

(a) Fuses

(i) Rectifiers/SCR fuse

(ii) Condenser fuse

(b) Alarms (Audio & Visual)

(i) Main fuse blown

(ii) Output fuse blown

(iii) SCR/Rectifier fuse blown

(iv) Overload/Short circuit

(v) Condenser fuse blown

The installation & commissioning procedure is same as that for the charger or current rating less than 50A. There is an additional audio alarm resetting switch/button on the front panel which is required to be pressed by the ESM on duty to silence the buzzer/hooter. The visual indication will continue till the fuse is replaced or the fault rectified.

3.7 Frequently asked questions

3.7.1 What do you mean by FLOAT charging

In FLOAT charging, Output DC voltage of the charger is set at about 2.15 V per cell. (This voltage can be varied from 2.12V to 2.3V per cell by adjusting the Voltage control provided on the charger). The cells get charged as long as the FLOAT Voltage is more than the Cell voltage. The maximum current that can be pumped into the cells is controlled by the Current knob provided inside the charger. The FLOAT charging is like giving a normal diet to a healthy person.

3.7.2 What is BOOST charging?

In BOOST charging, Output DC voltage of charger is set at 2.4V per cell. (It happens when the selection switch is changed to BOOST mode position and no adjustment needs to be done). The maximum Current that can be pumped in to the cells is controlled by the Current knob provided inside the charger (it is the same knob used for FLOAT Charging). The BOOST charging is recommended when the cells have run down. The BOOST charging is like giving a special diet to a recouping patient.

3.7.3 How do you know that the cells have run down and require Boost charging?

When the cell voltage gone down to less than 2.0V per cell. When the cell voltage is not maintained at 2.0V per cell after the charger is switched off before the cells are giving at least 40% of their capacity.

3.7.4 What is INITIAL Charging?

In INITIAL charging, Output DC voltage of the charger is set at 2.7 V per cell. (This happens when the selection switch is charged to INITIAL mode position and no adjustment needs to be done). This mode is used only when the charger is used to charge an uncharged (new) cell. This mode can also be used temporarily for a short duration to charge the bank where more than the specified numbers of cells are connected. For example, to charge the bank consists of 14 cells from a 24V battery charger.

3.7.5 What is automatic mode of charging?

In automatic mode, the battery charger on its own charges from FLOAT mode to BOOST mode or from BOOST mode to FLOAT mode depending on the condition of the cells.

3.7.6 How does the charger know the condition of cell?

The charger senses the current drawn by the cells and the current limit set by the current control knob. If the current drawn by the cells is more than 8% to 12% of the current limit set, the charger switches over to BOOST mode if it is in FLOAT mode. Subsequently after the charging of the cells up to 2.4V per cell, if the current drawn by the cells reduces to less than 5% of the current limit set, the charger changes from BOOST mode to FLOAT mode.

3.7.7 In old charges there are only two output terminals to which both load and battery wires are connected. In the new chargers (IRS 86/2000) why are the load and Battery terminals separated?

To enable the charger to sense the current drawn by the battery, the terminals of battery and the load are separated. A small resistor of 0.01 Ohm is provided in the battery side positive wire inside the charger to sense the current drawn by the battery.

3.7.8 What happens if high resistance is developed in the links connecting the cells?

As long as the 230 V power supply is available, the charger supplies the current to the load. When the 230 V power supply fails, the battery starts supplying the current, however, the battery voltage drops due to high resistance in the cell links and causes failure.

3.7.9 What is short circuit protection? How does the charger behave under such situations?

Short circuit protection is the protection of the charger from any damage to its components due to the short circuit in the load.

Steady short circuit current shall not exceed the + 10% of the rated current The short circuit current is reduced by automatically reducing the output voltage (by sensing the output current). The charger functions normally without any resetting or adjustment after the short circuit fault is removed.

3.7.10 what are the 'Charger Protective features' available in the Specification IRS. S 86-92 & IRS: S – 86/2000?

(a) Short circuit protection,

(b) Overload protection &

(c) Reverse battery connection protection.

3.7.11 How do you adjust the charger when the cells are in run down condition, but the Charger is not giving sufficient current to the cells and the charger is in good Working condition?

(a) Check that the 'Voltage control' is kept at more than 2.15 volts/cells.

(b) Check that there is no abnormal voltage drop in the wires connected between the charger and the battery (If the voltage control is kept at 2.15 V/Cell and the drop in the wires is 0.15V/Cell the effective voltage at the cell terminal will be only 2.0V/Cell).

3.7.12 What are the limits of the 'Current Control'?

The current control shall permit continuous variation of the current over the entire range of charger starting from 500 Ma.

3.7.13 What are the limits of the 'Voltage Control'?

It shall be possible to adjust the output voltage over a range of 2.0V to 2.3 volts per cell under float mode of working.

3.7.14 What is the permitted r.m.s (root mean square) ripple content in the output Voltage?

The DC output of the charger shall be smooth such that the r.m.s ripple content of the output voltage when delivering the rated output current through a resistive load measured by an oscilloscope shall not be more than 5%. This requirement shall be met in all modes of working.

3.7.15 What is the additional requirement for battery chargers for telecommunication installations?

The output of the chargers shall not contain psophometric noise voltage of more than 2mV(rms), when delivering rated Output current in the float mode or set value of current in boost mode through resistive load.

3.7.16 What are the additional requirements for battery charger for axle counter installations?

PARD value (Peak Average Random Deviation of ripple and noise) of output voltage is specified as under:

(a) r.m.s ripple value shall be less than 10 mV

(b) Peak to Peak noise voltage shall be less than 50mV

Measured by means of storage type 50MHz oscilloscope when delivering rated output current in float mode or set value of current in boost mode.

3.7.17 What is the permitted variation in the output voltage over the entire range of Input AC supply variation?

$\pm$ 0.05V/Cell

3.7.18 What is the variation permitted in the 'Current set'?

The Current shall be maintained constant within + 5% of the selected value, with the Input voltage varying between the limits of 160V and 270V and the DC terminal voltage varying from 1.7V to 2.4V per cell for Boost mode and 1.7V to 2.7V for initial mode.

3.7.19 In AUTO mode (FLOAT) what is the voltage adjustment range?

Manual adjustment of Output voltage over a range of 2.0V to 2.3V per cell is possible by voltage control switch.

3.7.20 How do you commission an Automatic Battery Charger?

After opening the charger side plates, tighten all the terminals. Check for looseness in the fuses. Press the control cards with little force so that contacts which became loose during transportation will make proper contact.

Keep the charger in FLOAT mode By 'Voltage control variation set the voltage to (2.15 X No. of cells)

Keep 'Current Control' at minimum: Keep the charger in BOOST MODE. Connect the battery. Vary 'Current control' to the required position (C/10 rate of the cells)

Connect the load terminals. Change the Mode switch of the charger to 'AUTO'.

3.8.1 RDSO approved list of firms for manufacture and supply of electrical signalling items: as on September 2009

ITEM: POWER SUPPLY EQUIPMENTS - BATTERY CHARGER - SELF-REGULATING

Spec No.: IRS:S-86/2000 with Amendment – 4

APPROVED UNDER PART: I

1. M/s Cosine Comm. & Electronics (P) Ltd.,
2. M/s Electric Industries,
3. M/s Ex-Servicemen Electrical Industries,
4. M/s General Auto Electric Corporation,
5. M/s Ultra Electronics Pvt. Ltd.,

APPROVED UNDER PART: II

1. M/s Electro Star,
2. M/s Mani Electronics,
3. M/s Sree Chand Elect, Industries (P) Limited,

***

CHAPTER – 4: FERRO RESONANT TYPE AUTOMATIC VOLTAGE REGULATOR (IRS: S-74/89 with Amd. 6)

4.1 In this, primary side of the transformer operates below the saturation and Secondary side operates in the saturated region of magnetic curve, resulting in Constant voltage output inspite of wide input voltage fluctuations.

Core Materials used:

Primary side - **MILD STEEL** (unsaturated Iron)

Secondary side - **SILICON STEEL** (saturated Iron)

The capacitor of the proper value is connected across the secondary winding to form a **parallel resonance** circuit. If the voltage is applied on primary winding and it is gradually increased from zero to a particular voltage, called **KNEE VOLTAGE** (or) point of discontinuity, at which secondary is tuned to parallel resonance.

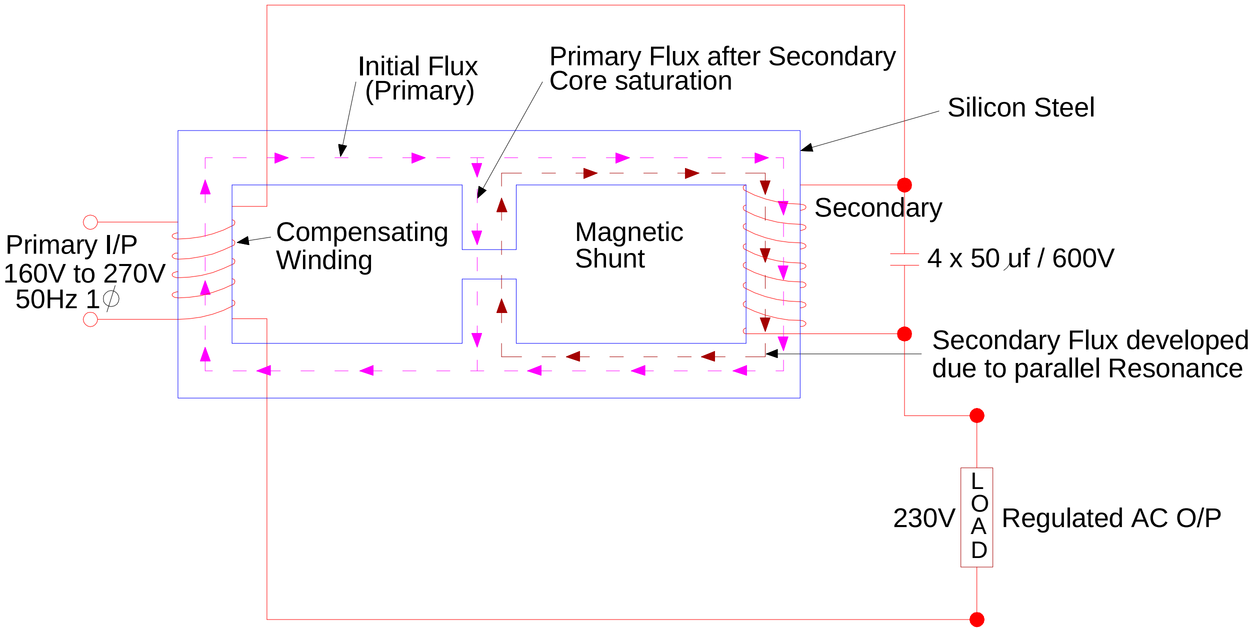


Fig: 5.1

Due to the resonance effect, the capacitor increases the secondary voltage abruptly. This result, in the secondary core magnetic flux is induced due to capacitance current flowing in the secondary winding. This magnetic flux is added to the magnetic flux flowing through secondary core due to the primary voltage. Hence **flux addition is** taking place **in the secondary core** causes secondary gets saturated.

The resonant voltage across the capacitor bank **[Vc]** is not more than **480 V** at all I/P voltage & frequency conditions at no load. Normally **Vc = 440V** on load. Capacitors are rated for **600 VAC** metal-can capacitors.

A magnetic shunt is provided between the two windings. When the secondary magnetic circuit is saturated, much of the secondary flux is de-coupled from the primary winding and passes through magnetic shunt.

At primary knee voltage secondary core is saturated and after knee voltage the increased amount of magnetic flux passes through the magnetic shunt and does not increase the flux at secondary. Hence secondary voltage remains more or less constant.

Part of the primary & secondary magnetic flux flowing through magnetic shunt increases magnetic isolation between the two windings.

To improve regulation a **compensating winding,** which is connected in series with the secondary winding, is added to the primary side of the transformer. The direction of flux induced by the compensating winding is opposite to the direction of the primary winding flux.

This compensating winding carries load current and opposes the primary flux.

If the secondary voltage is increased then the load current also increased. This current passing through the compensating winding causes reduction of primary flux there by reducing the induced voltage on secondary.

If the secondary voltage is reduced then the load current also reduced. This reduced current passing through the compensating winding causes increase in the resultant primary flux there by increasing induced voltage on secondary.

Hence regulation is taking place with compensating winding.

With compensating winding the I/P voltage operating range also increased to give constant O/P voltage. **With compensating winding short circuit protection is also achieved.** If output is short-circuited then the current passing through the compensating winding is also very high. This causes very high reduction in primary flux and there by reducing the induced secondary voltage.

4.2 Performance

This type of voltage regulators are generally used with minimum load of **25%** of it's rated capacity. However, the design of the voltage regulator shall cater for any load from no load to full load of its rated capacity.

The Harmonic distortion in the O/P voltage is maximum at no load.

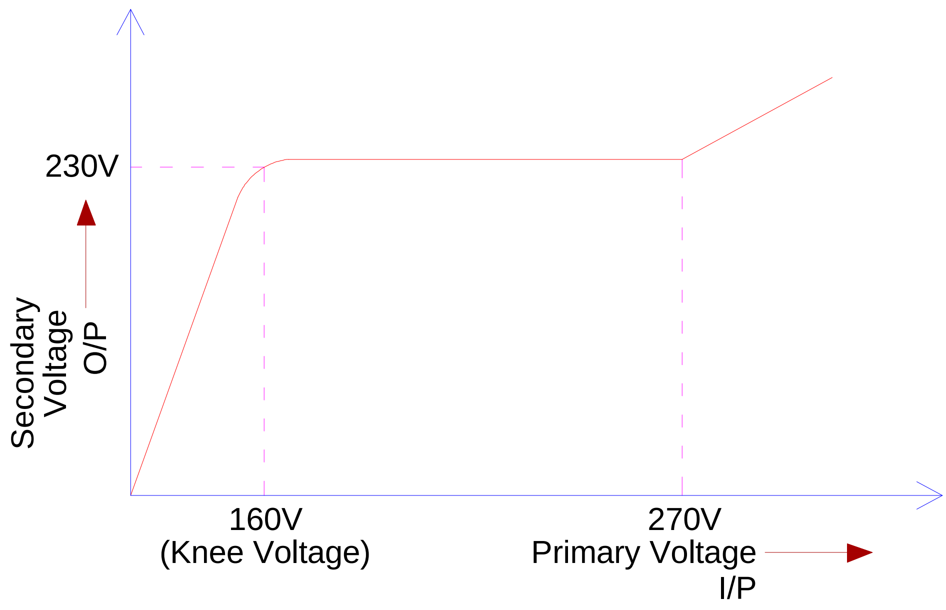


Fig: 5.2

4.3 Features

(a) Robust in construction.

(b) No moving parts.

(c) It's O/P Voltage=**230V $\pm$ 1%** for I/P Voltage range of **160V to 270 V** at **50Hz** when it is connected to rated load.

(d) Lower range may be extended from 160V to **150V**, if required by purchaser. In this case O/P voltage not less than **230V-4%** for all loads from **25%** to full load.

(e) Operating frequency = **50Hz $\pm$ 2.5 Hz.**

(f) **Power handling capacity 0.5 KVA to 10KVA.**

(g) Fast regulation. Response time is < 30m.sec for sudden changes of **50V** I/P voltage (or) load variation from 25% to 75% of rated load.

(h) No load current is not more than 30% of the rated I/P current.

(i) **No load power** is **not more than 15%** of the rated I/P power at I/P voltage of 230 V, 50 Hz.

(j) **Watt efficiency not less than 80% in case of 0.5 KVA & not less than 85% in case of 1KVA to 10 KVA at full load.**

(k) Complete automatic and continuous regulation.

(l) **Immune to short circuit at O/P.** It shall with stand short-circuit on O/P side for one hour with out any damage.

(m) Self-protection against over load.

4.4 Drawbacks

(a) The harmonic **distortion** in the O/P voltage is **Maximum at no load.** Minimum of 25% load of rated load must be provided.

(b) **O/P voltage is** frequency **dependent. O\P voltage variation is 1.5% for1% change in frequency.**

(c) At 50H frequency O\P voltage = 230V

At 47.5 Hz O\P voltage = 213V

At 52.5Hz O\P voltage = 247 V

i.e. for $\pm$ 1 Hz --- $\pm$ 3% O/P voltage variation.

4.5 FAULT LOCATION CHART OF FRVR

The entire system is well designed, robust in construction and is manufactured to give long service even in most demanding field conditions. However, fault may occur. Most of the faults, if understood properly, can be rectified in the field itself. Follow the fault location chart as under, to locate and understand the fault.

Sl. No .	FAULT/INDICATION	PROBABLE CAUSE	REMEDY
1	Red light 'OFF' Green light 'OFF'	No input power	Check input connection
2	No A. C. Output Green Lamp 'OFF' Red Lamp 'ON'	One or more capacitors Shorted.	Identify the faulty capacitor and replace.
		Secondary winding Shorted.	Remove the main transformer and send for replacement.
		Entire regulator overloaded	Remove overloading
		Entire regulator short Circuited	Remove short circuit
		Green lamp fused.	Replace green lamp
		Green lamp holder shorted	Replace lamp holder.
3	Low A .C. Output Indication at unit voltmeter	Unit voltmeter calibrations not correct. Input line frequency below 50Hz or above 50 Hz	Calibrate from a standard voltmeter or zero adjustment. Measure Output
4	Low A.C. Output at 50 Hz. Red Light normal Green light 'OFF' or dim	Capacitor Open	Identify Capacitor and replace
		Indicating Voltmeter Faulty	Replace
		Partly overloaded	Remove overloading
		In put voltage below specified limit	Higher input of 160 V (150V) required.
5	No Voltmeter Indication Red light ON, Green light ON	Voltmeter defective	Replace
6	No Ammeter Indication Red light ON, Green light ON	Ammeter Defective	Replace
		Very low load connected	Increase load
7	Fuse at input line blowing repeatedly on turning ON the unit. No green light	Improper Input connection	Check input connection
		Primary winding shorted	Replace transformer
		Check Insulation Resistance of the Transformer. It shall not be less than 100 MΩ	If insulation resistance is found low then replace the transformer.

CAUTION: High voltage components inside. Exercise extreme caution while checking the voltages with regulator power on. Voltage across the capacitor is 660 V A.C.

***Note**: Output of the regulator depends on the line frequency. Ferro Resonant Regulator generate heat even at the no load condition. Neutral and Earth at the output side are shorted.*

4.6 PART LIST

Sl. no	Description	Ratings	Application
1	Red Neon Holder		Input ON Indication
2	Green Neon Holder		Output ON Indication
3	Voltmeter	0-300V	Input/output voltage Indication
4	Ammeter	Depends on rating of Regulator	Output load current
5	Rotary Switch	2 pole	ON/OFF
6	Rotary Switch	2 pole 2 way 6A	Voltage selector switch.
7	Main Transformer	1.0 KVA/3KVA	Regulation and isolation.
8	Filter Choke Harmonics	1.0 KVA/3KVA	Filtering Harmonics
9	Capacitors	30mfd/660VA.C 36mfd/660VA.C 10mfd/660VA.C	For Saturation of main transformer.

4.7 RDSO approved list of firms for manufacture and supply of electrical signalling items: as on September 2009

ITEM: POWER SUPPLY EQUIPMENTS– VOLTAGE REGULATOR-FERRO RESONANT

Spec No.: IRS: S-74/89 with Amd. 6

APPROVED UNDER PART: I

1. M/s Apple Systems Pvt. Ltd.,
2. M/s Starvision Power Systems,
3. M/s Sree Chand Elect, Industries (P) Limited,
4. M/s Electro Star,

APPROVED UNDER PART: II

1. M/s Ex-Servicemen Electrical Industries
2. M/s Mani Electronics

* * *

CHAPTER – 5: INTEGRATED POWER SUPPLY SYSTEM

(RDSO/SPN/165/2004 with Amendment-5)

5.1 Introduction

A typical 4 line station requires power supplies of 24 V D.C(5 nos) , 12 V.DC (5nos), 6V (2 nos), 110 V DC and 110 V AC for signalling. These require as many chargers and Secondary cells & Invertors requiring more maintenance & spares. Can they be Integrated in to one system?.

Thus the concept of Integrated Power Supply has been evolved by integrating concepts - One Charger, One set of Battery Bank feeding Invertors and D.C- D.C converters for deriving various D.C & A.C. voltages.

RDSO issued Specification in 1997 and installations commenced in 1998. Integrated power supply system delivers both AC & DC Power supplies as an output with the output voltage tolerance of ± 2 %.

5.2 Advantages

(a) Reduces maintenance on Batteries, Battery charger & overall maintenance.

(b) Its construction is in modules and hence occupies less space. Reduced space requirement, resulting in saving of space for power supply rooms.

(c) Provides centralized power system for complete signalling installation with continuous display of working status of system for easier monitoring.

(d) Defect in sub-units of system is shown both by visual & audible indication. Reflects the condition of battery with warning.

(e) Replacement of defective modules is quick & easy without disturbing the working of the system.

(f) It uses (n+1) modular technology hot standby arrangement and hence high reliability and more availability of the system.

(g) The system provides uninterrupted supply to all signalling system even during the power failures. Thus, No blank Signal for the approaching drivers.

(h) System can be easily configured to suit load requirement.

(i) The diesel generator set running (Non-RE area) is reduced almost to 'NIL'. Hence, low wear and tear of D.G. set components & reduced diesel oil consumption.

5.3 Specification

RDSO Specification No. RDSO/SPN/165/2004. The specification mainly covers the requirement for the following types of wayside Signalling installations:

Up to 4 lines (without AFTC)	Up to 6 lines (without AFTC)
(a) RE Area	(a) RE Area
(b) Non – RE Area	(b) Non – RE Area
(c) RE/Non RE Area with DC Lit LED Signal	
Note: Since DC track circuits have battery backup, IPS does not feed 110 V ac for Track Circuits. But in case of AFTC, no such battery back up exists. Hence 110 V ac also to be fed from IPS requiring higher capacity of Invertors & Batteries. Current specification does not cover this arrangement.	

5.4 COMPONENTS

(a) Un-interrupted power supply (U P S)

(i) SMPS Battery chargers with Hot stand-by mode.

(ii) Hot Standby PWM Inverters with auto changeover

(iii) CVT Regulator [FRVS]

(b) AC distribution board [ACDB]

(i) STEP DOWN TRANSFORMERS

(c) DC distribution board [DCDB]

(i) DC-DC converters.

5.5 Construction

IPS is mainly consists of:

(a) SMR (Switch Mode Rectifier) Panel / SMPS based Float cum Boost Charger (FRBC) Panel.

(b) A.C. Distribution Panel.

(c) D.C. Distribution Panel.

(d) Battery Bank. (110V DC).

(e) Status Monitoring Panel.

5.6 Working

IPS works satisfactorily for A.C input variation of 150V AC to 275V AC with single-phase power supply and frequency variation from 48 Hz to 52 Hz. The input is fed to SMPS charger, which converts in to 110 V.D.C as output. It is fed as input to three sub units.

(a) To battery bank charging the batteries.

(b) To ON line inverters that converts 110 V.D.C in to 230 VAC ± 2%as output.

(c) As 110 V.D.C bus bar to D.C Distribution Panel as an input to various D.C-D.C converters located in it.

(d) A 110 V Battery Bank of VRLA cells are connected to SMPS Panel. IPS Status Monitoring Panel is located at ASM room or at S&T staff room if round the clock S&T staff is available at Station.

5.6.1 SMR (Switch Mode Rectifier) Panel / SMPS based Float cum Boost Charger (FRBC) Panel

It consists of SMR / FRBC modules and Supervisory & Control Unit. SMPS based SMRs (converters)/ SMPS based Float cum Boost Chargers (FRBC) modules are provided with (n+1) modular technology hot standby arrangement with active load sharing basis and 1 additional module as a cold standby (n+2). **Supervisory & Control Unit**, which controls and monitor the complete system. It has various indications on the panel reflecting the working of the panel. FRBCs are suitable for operating in parallel on active load sharing basis with one or more modules of similar type, make and rating.

n = required no. of modules to cater for actual current requirement.

5.6.2 A.C Distribution Panel

It is made of ON-Line inverters with (1+1) modular technology hot standby arrangement & CVT (Constant Voltage Transformer) / AVR (Automatic Voltage Regulator) and set of step down transformers.

The inverter is protected against overload and short circuit with auto reset facility. Whenever the failure occurs, it trips and restart automatically after about 10 to 20 sec. But if the problem persists, the protection is permanently gets latched and it will not be switched ON again unless the fault is cleared followed by pressing of reset button. The output of inverters is regulated to 230V AC ± 2%, 50Hz ±1Hz for an input voltage variation of 90V DC to 140V DC.

Normally both the Inverters are powered ON and both are delivering the Output voltage but only one (main) inverter is connected to the Load. If main inverter is failed then only the stand-by inverter will come on Load automatically with in 500msec. At 70% Depth of Discharge (DOD) of the battery bank 110VDC supply to the inverters will be cut-off. So the Signals feed will be cut-off.

The auto-change over arrangement is also provided for bringing the CVT in circuit with in 500msec, when the both the inverters output is failed. It has various indications on the panel reflecting the working of the panel.

5.6.3 D.C Distribution Panel

It takes care of D.C Power supply requirements of our signalling. It consists of sets of D.C-D.C converters for individual D.C power requirements with (n+1) modular technology hot standby arrangement with active load sharing basis. The DC-DC converters of Relay Internal are provided with (n+1) modular technology hot standby arrangement with active load sharing basis and 1 additional module as a cold standby (n+2).

The DC-DC converter works satisfactorily with the input voltage variation of 98VDC to 138VDC. At 90% Depth of Discharge (DOD) of the battery bank all the DC-DC converters 110VDC Input supply will be cut-off, except for Block Tele DC-DC converters. The supply for Point operation is also catered through a 20A fuse by this unit. It is also provided with various indications that reflect its working.

5.6.4 Status Monitoring Panel

IPS status monitoring panel has been provided in the ASM room for giving the important alarms and indications to ASM. Status Panel tells present working status of IPS displaying battery voltage continuously and five other indications, which will light according to IPS status. During normal working these indications will not lit. Whenever the battery has come on to the load and has discharged by 50% D.O.D. (Depth of Discharge) then first Red indication lit with description “START GENERATOR” with audio Alarm. i.e. DG set is to be started and put on the load. If DG set is not started with this warning, then if battery gets further discharged to 60% D.O.D and second Red indications appears with description “Emergency Start generator” with audio alarm, even now if DG set is failed to be started, the battery further gets discharged to 70 % D.O.D and 3rd Red indications appear with description “ System shut down” with audio alarm, which will continue till Generator is started, resulting in A.C output from IPS is automatically cut off, results all the signals will become blank.

When there is any defect in any sub module of IPS even without affecting working of system, the 4th Red indication appears with description “Call S&T Staff” with audio alarm, so the ASM advises S&T staff accordingly. Green LED 5th indication comes with the description “Stop Generator” with audio alarm, when the DG set is running and if the Battery bank is fully charged condition.

Details of alarms and indications provided in status monitoring panel are as under:

Sl. No	Instruction	Condition	LED indication	Remarks
1.	Start Generator	50% DOD	RED	Audio/ visual alarm can be acknowledged for audio cut off.
2.	Emergency Start Generator	60% DOD	RED	Audio/ visual alarm can be acknowledged for audio cut off.
3.	System Shut-down	70% DOD	RED	Signal feed cut off but all DC-DC converters continue to work. Audio alarm will continue till Generator is started.
4.	Call S & T Staff	Equipment fault.	RED	Failure of any module will give the alarm in ASM's panel. Alarm can be acknowledged for audio cut off.
5.	Stop Generator	FRBC change over to float mode	GREEN	Audio / Visual Alarm.

**** Note:***

- *DOD – Depth of discharge of battery bank.*
- *At 90% Depth of Discharge (DOD) of the battery bank, 110VDC Input supply will be cut-off to all the DC-DC converters, except to Block Tele DC-DC converters*

5.7 Earthing

The IPS systems and its individual modules are having earth terminals and all these are properly earthed with earth resistance of less than 1 Ω. Earth provided shall preferably be maintenance free using ground resistance improvement compound. (The acceptable Earth Resistance at earth busbar shall not be more than 1 ohm. Ref: Spec. No. RDSO/SPN/197/2008; Code of practice for earthing and bonding system for signalling equipments.)

5.7.1 Lightning and Transient Protection in IPS

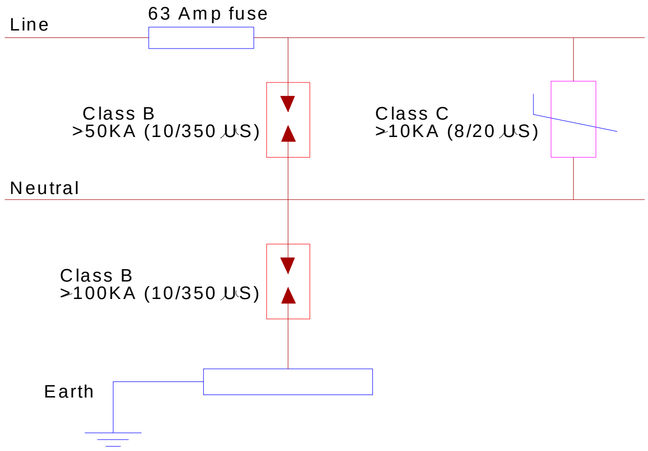
Manufacturer will provide Stage1 & Stage 2 protection along with the IPS , .These are described below.

Stage 1 protection is of Class B type, against Lightning Electro-Magnetic Impulse (LEMP) & other high surges, provided at Power Distribution Panel. It is provided with a 63 Amp fuse in phase line and is connected between Line and the Neutral and also between the Neutral and Earth.

Stage 2 protection (Power line protection at Equipment level) is of Class C type, against low voltage surges, provided at the equipment input level. This is thermal disconnecting type and equipped with protection against SPD (surge protection device) failure due to open & short circuit of SPDs and is connected between the Line and the Neutral. If supply / data / signalling lines (AC/DC) are carried through overhead wires or cables above ground to any nearby building or any location outside the equipment room, additional protection of Stage 2 type shall be provided at such locations.

Class B & Class C arrestor is provided on a separate wall mounting type enclosure in IPS room.

Connection of Lightning Arrestors



Stage3 protection (Protection for signalling/data line) is of Class D type. All external data/ signalling lines (AC/DC) shall be protected by using this Class D type device. It consists of a combination of Varistors and Gas Discharge Tube with voltage and current limiting facilities.

(Note: IPS manufacturer will provide the Stage3 protection on demand.)

5.8 FEATURES

(a) Chargers used in this system are of SMPS technology chargers with 90% efficiency. These chargers are supported with hot standby mode with (n+1) modular technology.

(b) One/two sets of Maintenance free Battery banks (110VDC). Normally one set (110VDC) of Battery bank is used. Conventional flooded type Lead Acid Batteries or Low Maintenance Lead Acid batteries can also be used. (SMRs settings are required to be adjusted depending on the type of Batteries used.) Various voltage levels of battery banks are avoided. Reduction in Battery maintenance & less flour area required.

(c) DC-DC Converters working from 110V Central battery have been used for all dc supplies. This has improved overall efficiency of the system since number of conversion from AC to DC have been reduced to 2 stage as compared to 3 stage conversion in case of transformer-rectifier system.

(d) DC-DC converters are available in modules. Easy replacement of defective modules. This ensures less down time.

(e) DC-DC Converters are used in load sharing N+1 configuration (i.e. with hot standby with N+1 modular technology) to improve the reliability & availability of the system.

(f) Capacity of inverter has been brought down to 1.5 KVA from 5 KVA and used for feeding only Signals supply. Hot standby inverter is provided with auto changeover facility. This improves the availability of the overall system.

(g) High efficiency inverter is used with PWM (Pulse Width Modulation) technology in place of Ferro-resonant technology based inverter. This improves the efficiency of the overall system.

(h) Continuous power to Signal Circuits even in absence of DG set/Local Power Supply.

(i) Generators need not be switched ON every time during train movement.

(j) Metal-to-metal relay installations and block working by axle counters have also been covered.

(k) Supply of spare modules/Components/Cells have been included as part of main supply.

(l) Provides highly regulated voltage to all signal relays & lamps for better life.

5.9 The environment in IPS room

The environment in IPS room is needed to be maintained at requisite level. Following may be adopted as a standard practice of IPS room:

(a) Use of removable filter in the window of IPS room.

(b) One fresh air fan of suitable type, preferably with dampers on outside, to protect against dust.

(c) Adequate space shall be provided on the front and rear of the system for maintenance and cooling.

(d) Ceramic tiles shall be on the floors.

(e) Entry to IPS room to be through another room or there should be provision of double doors in the IPS room.

5.10 Problems faced in IPS system

(a) SMRs, DC-DC Converters and Inverters modules are failing frequently. To overcome these frequent failures the following can be considered:

(i) Provision of Voltage stabilizer at the input stage of IPS.

(ii) Provision of proper Earthing and Lightening Arrester arrangements.

(iii) Provision of Exhaust fan in IPS room and leaving good space for ventilation. The room size shall be sufficient for heat dissipation and attending to maintenance

(iv) Storing sufficient spares for sub-systems.

(v) Dust plays a critical role in the failures of various modules. As such, protection from entrance of dust in IPS room is necessary.

(vi) The signal lighting load is around 50% of the total load. It is better to use LED signals with IPS in order to eliminate cases of overloading of inverters.

(vii) DG set, preferably echo-free DG set, of adequate capacity and quality (ensuring near sine wave waveform) shall be used to supplement input power for Battery charging whenever Mains supply is inadequate or un-reliable.

(viii) Remote monitoring of the healthiness of IPS through Dataloggers should be built in to the system.

(b) At a 3-4 line station, when the batteries are discharged to 50% of depth of discharge, IPS needs approximately 25 Amp. at 230V. It has been noticed that at some of the stations the local feeder is unable to feed this power requirement resulting in drop of AC input voltage and subsequent tripping of IPS. IPS working voltage range is 160-270V AC. Beyond this voltage, the system cuts off the AC supply for safety of the system. To overcome these failures the following can be considered:

(i) Local feeder should be strengthened.

(ii) Cable from local Transformer /AT should be of adequate size limiting the Voltage drop to 30 Volts under maximum current scenario.

(iii) Increase the input limit to IPS to 150-300Volts in place of existing limit of 160-270Volts.

5.11 Conclusion

(a) IPS not only provides reliable power supply to signalling system in CLS installation but also enhances safety in train operation (avoiding blanking of signals). It is, therefore, recommended by RDSO that IPS shall be installed in CLS installations.

(b) SECR uses two sets of 110VDC batteries in parallel compared to RDSO design of only one set.

(c) IPS for stations with 4 to 6 lines has 30A, 24VDC Internal Relay supply may be inadequate for some stations having more relays (Ex . SECR) . SECR modified IPS with similar but higher number of modules.

(e) In railways having end goompties, Mini IPSs are provided at Goompties with 24 V DC-DC convertors at Goompties (Note: 110 V Battery bank is at the center which is extended to Goompties through Power cable)

5.12 SMPS based IPS block diagrams & details of the system as per RDSO specification RDSO/SPN/165/2004 is shown as below

5.12.1 Block diagram of IPS used in RE area up to 4 lines without AFTC

IPS for upto 4 lines without AFTC RE Area

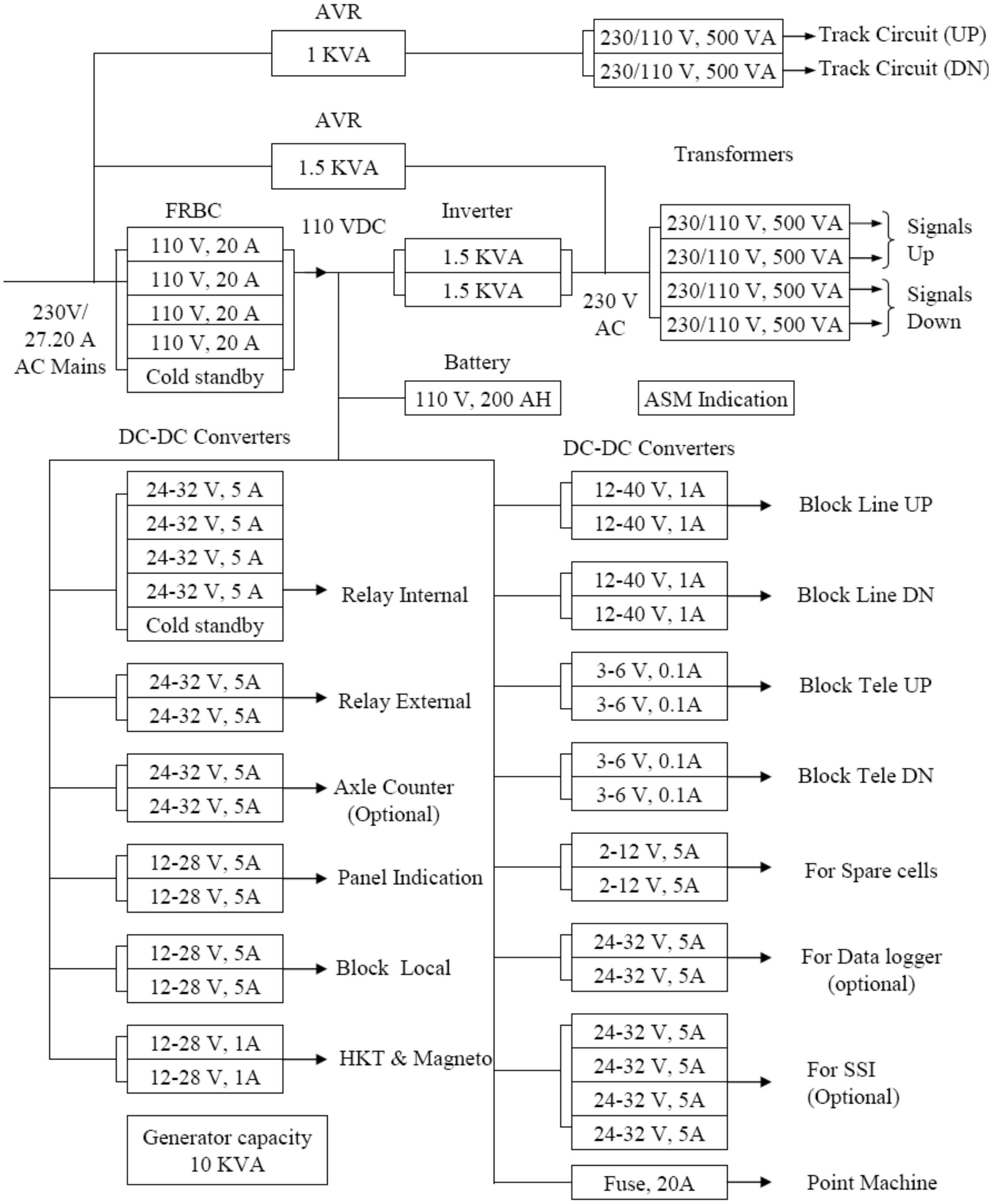


Fig: 5.1

5.12.2 Block diagram of IPS used in Non-RE area up to 4 lines without AFTC

IPS for upto 4 lines without AFTC Non – RE Area

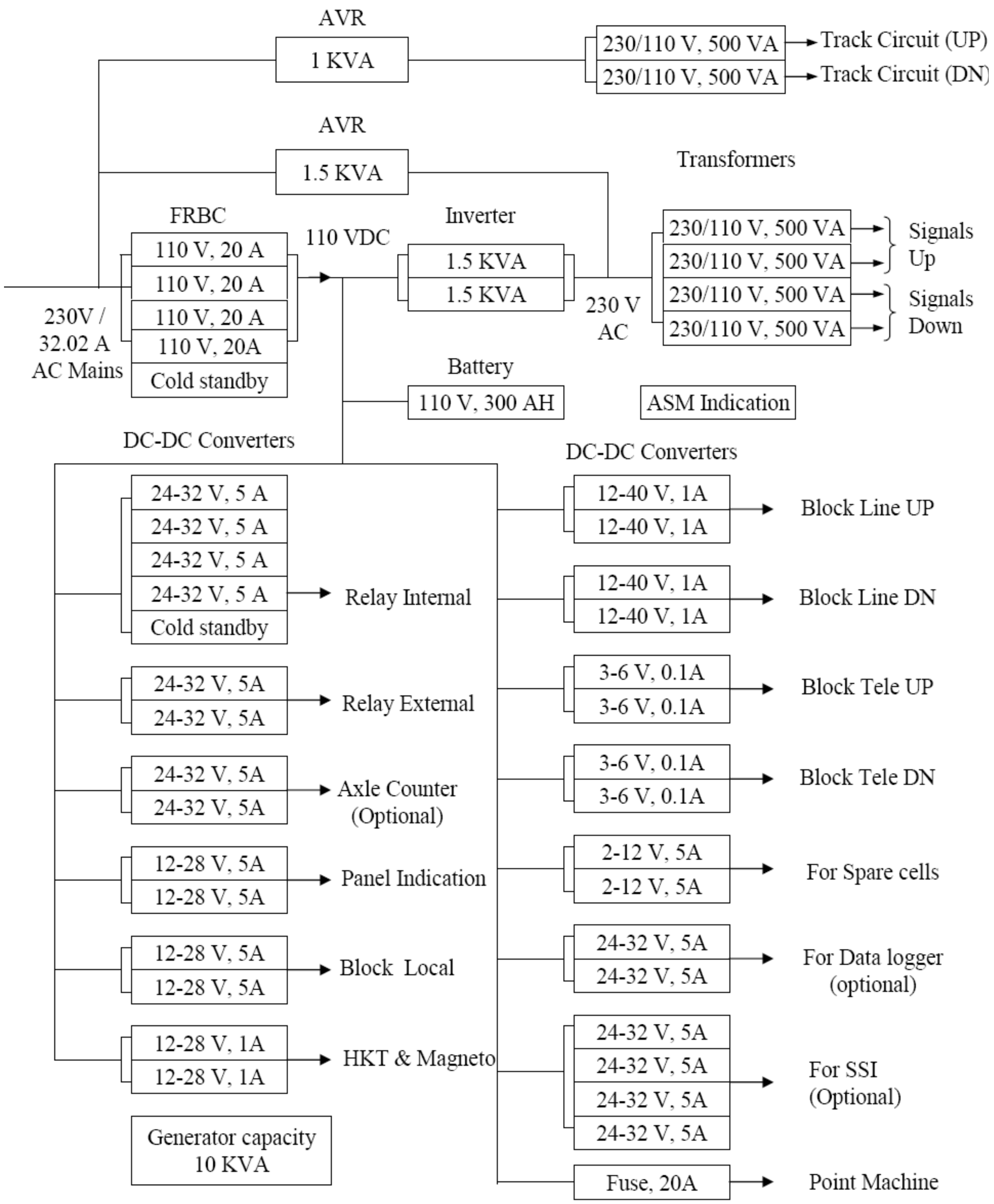


Fig: 5.2

5.12.3 Block diagram of IPS used in RE/Non RE Area for up to 4 lines with DC Lit LED Signal

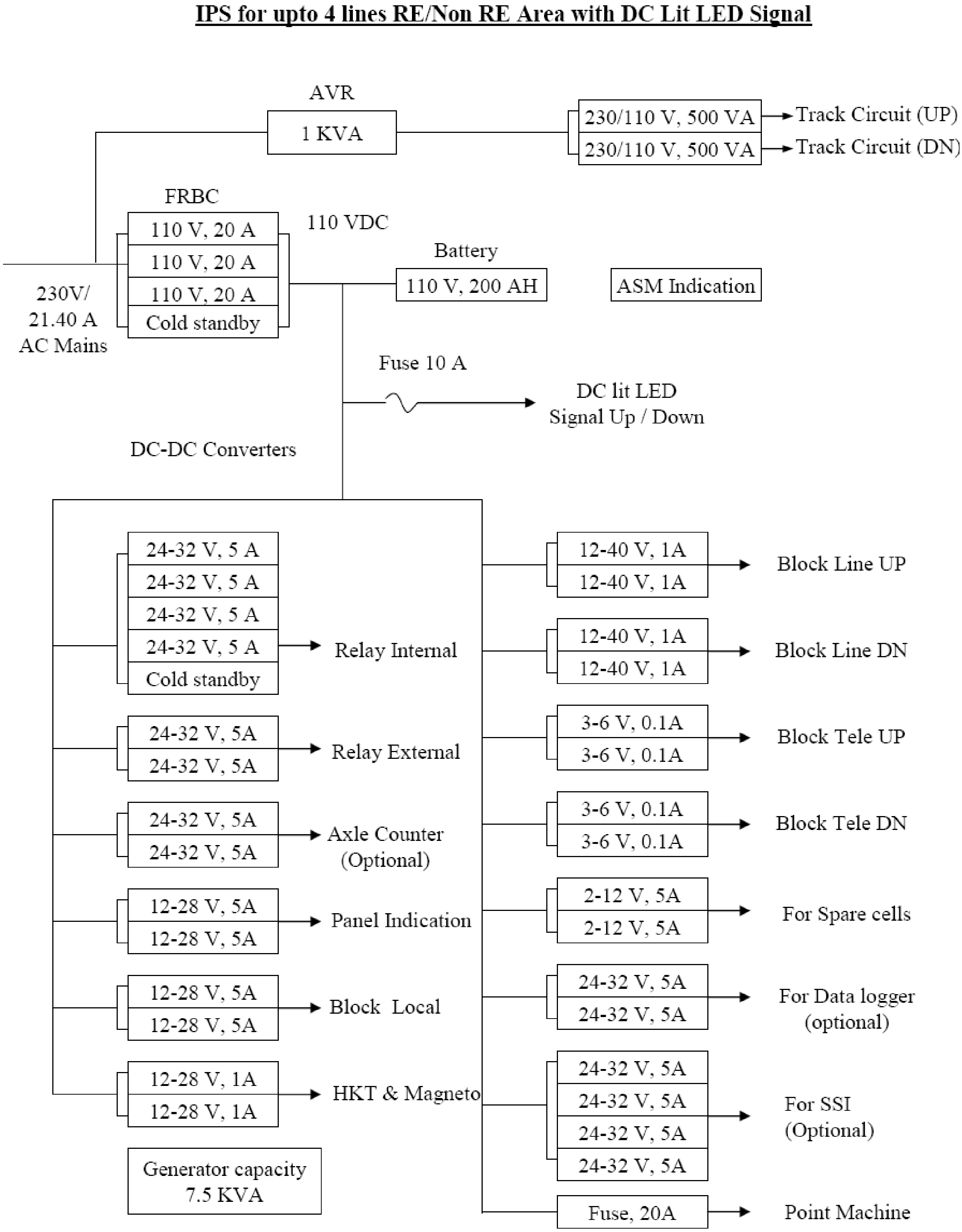


Fig: 5.3

5.12.4 Block diagram of IPS used in RE area up to 6 lines without AFTC

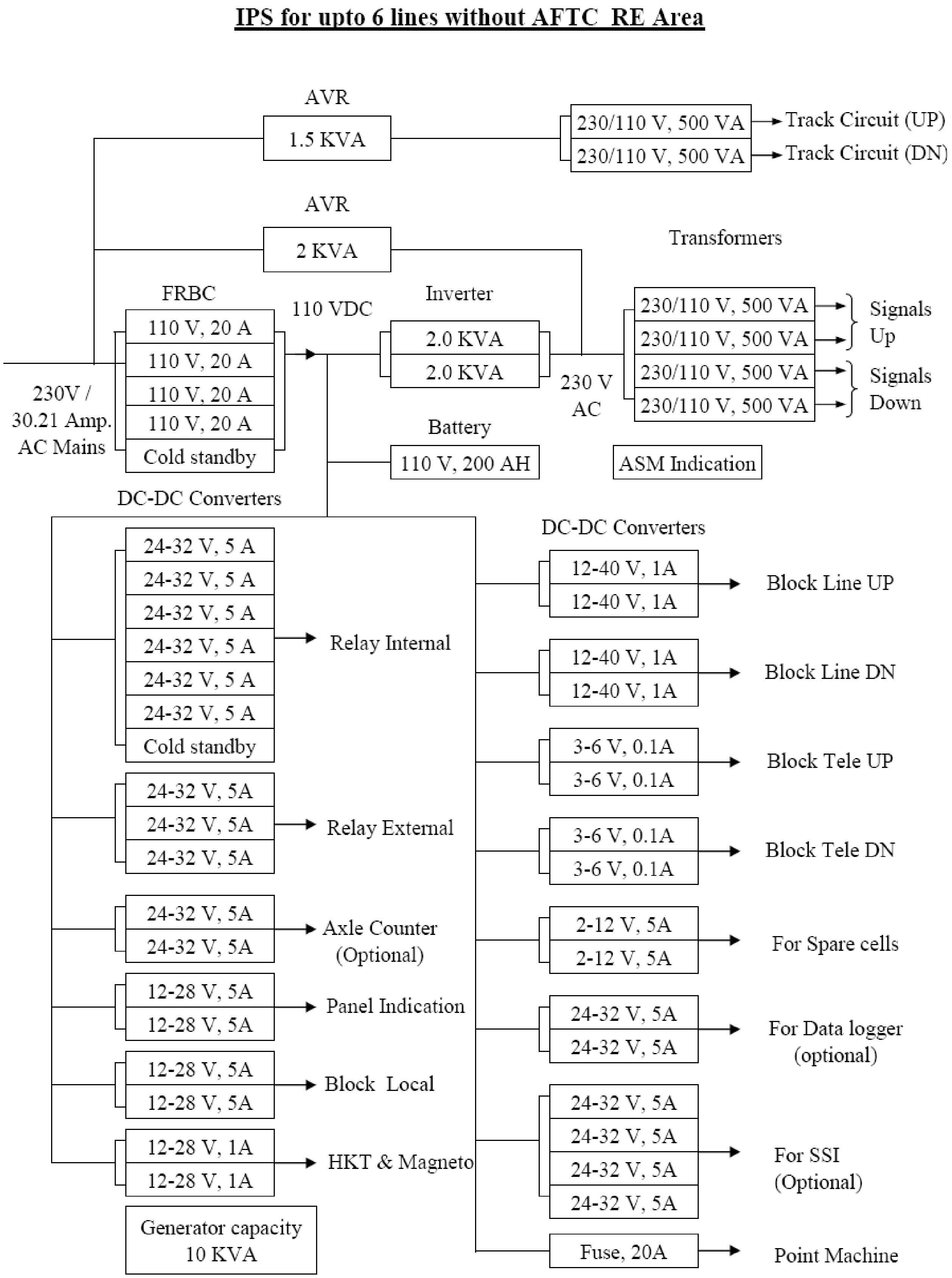


Fig: 5.4

5.12.5 Block diagram of IPS used in Non-RE area up to 6 lines without AFTC

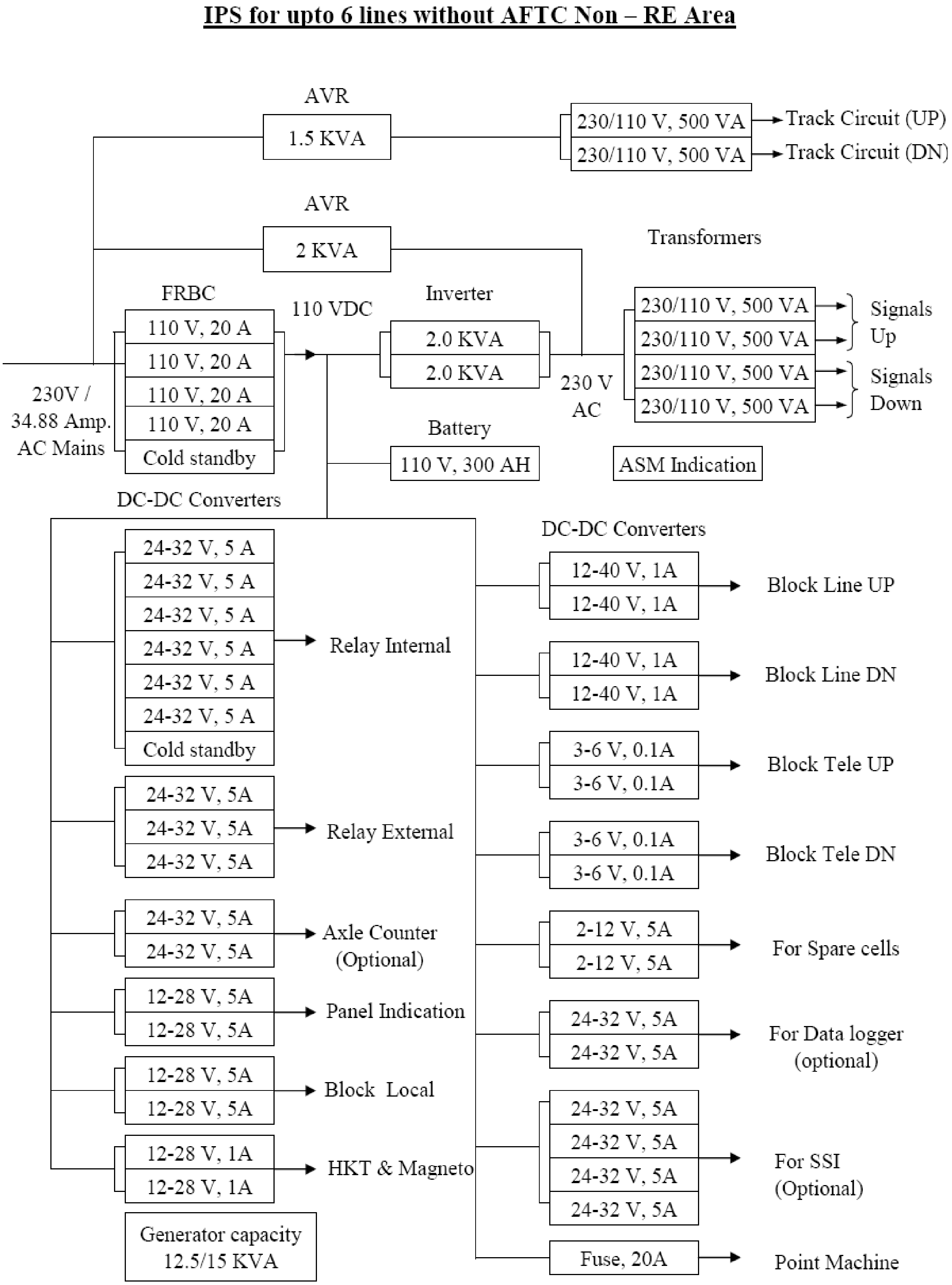


Fig: 5.5

5.13 RDSO approved list of firms for manufacture and supply of electrical signalling items: as on September 2009

ITEM: POWER SUPPLY EQUIPMENTS – SMPS BASED IPS

Spec No.: RDSO/SPN/165/2004 (Amendment-5)

APPROVED UNDER PART: I

1. M/s Statcon Power Controls Ltd.,
2. M/s Amara Raja power Systems Pvt. Ltd.,

APPROVED UNDER PART: II

1. M/s HBL Power System Ltd.

* * *

CHAPTER – 6: POWER SUPPLY ARRANGEMENTS

6.1 SCOPE

6.1.1 Power supply arrangements for signalling & telecommunication installations in 25 KV AC electrified areas as per Railway Board Letter No: 82/RE/250/1 dated: 13-09-2002.

6.1.2 Responsibilities of Electrical and S&T Departments.

6.2 PROVISION OF ATs / LOCAL SUPPLY/ DG SETS/ INVERTERS

The following provisions will be made.

6.2.1 WAY SIDE STATIONS/I.B.H/IBS ON DOUBLE LINE SECTION

(a) Two ATs of 10 KVA each connected to up and down catenaries will be provided.

(b) Local supply will be the standby source of supply.

6.2.2 WAY SIDE STATIONS / I.B.Hs / IBS ON SINGLE LINE SECTION

(a) One AT of 10 KVA connected to the catenary will be provided.

(b) Local supply will be the standby source of power supply.

(c) One DG set of adequate capacity will be provided.

(d) One Inverter of suitable capacity may also be provided by S&T, if required.

6.2.3 STATION SITUATED WITHIN 350M FROM TRACTION SWITCHING POST

(a) At a station where an AT of suitable capacity is installed at the traction switching post situated within 350 meters of signal cabin or a station building, 240 V supply from the AT will be extended to the station. However, a second AT of suitable capacity will also be provided at the station connected to other line in case of double line section.

6.2.4 BIG YARDS (MULTI CABIN STATIONS)/RRI INSTALLATIONS

(a) BIG YARDS (MULTI CABIN STATIONS)

(i) At big yards where a number of cabins are located, two/three cabins, depending upon load requirement, shall be grouped together and a set of two ATs of 10 KVA, one each connected to up and down catenary on double line section and one AT of 10 KVA on single line section will be provided at a convenient location to feed each such group.

(ii) Local supply will be the standby source of power supply.

(iii) DG sets as required will also be provided by S&T Deptt.

(b) RRI INSTALLATIONS

(i) The main source of supply will be three-phase local power supply.

(ii) The second source of supply will be provided by three numbers of 10/25/50 KVA ATs as per load requirement. Two sets of DG of adequate capacity will also be provided by S&T Department as standby source of supply.

(c) RELAY HUTS IN RRI INSTALLATIONS

(i) For relay huts located less than 2 kms from the RRI cabin, the supply will be extended from the cabin by S&T Deptt. In case local power supply is also available at the relay hut, an automatic change over switch of suitable capacity will also be provided by S&T Deptt.

(ii) For relay huts located beyond 2 kms from the RRI cabin, a separate set of ATs will be provided along with one local power supply by Electrical Deptt. Where load requirement so requires, two relay huts may be grouped. In this case, extension of power supply to the other relay hut will be done by S&T.

(d) END PANEL STATIONS

(i) The main source of power supply will be through two ATs in case of stations on double line and one AT in case of stations on single line. Capacity of ATs will be 10/25 KVA depending upon the load requirement.

(ii) Local supply will be the second source of power supply.

(iii) One DG set of adequate capacity will be provided for single line sections.

(iv) One inverter of suitable capacity may also be provided by S&T, if required.

6.2.5 INTERLOCKED LEVEL CROSSING GATES

(a) In case of double line sections, two ATs of 5 KVA each shall be provided and in case of single line sections one AT of 5 KVA shall be provided at each interlocked level crossing gate located more than 2 Kms away from the station. Wherever interlocked level crossing gates are located within 2 Kms of a station or other interlocked level crossing gate where a set of ATs has been provided, the power supply from the same ATs will be extended to these level crossing gates by S&T Deptt.

(b) Local power supply will be the standby source at the level crossing gates in the block sections.

6.2.6 AUTOMATIC BLOCK SIGNALLING INSTALLATIONS

(a) INSTALLATIONS WITHIN 2 KMS FROM THE STATION

Power supply to all signals within 2 kms from the RRI cabin or stations, shall be extended through signalling cable laid by S&T Deptt.

(b) INSTALLATIONS BEYOND 2 KMS FROM STATION:

For signals located beyond 2 Kms, a set of ATs will be provided from each up and down line in case of double line sections and one AT on single line sections.

6.3 MAIN / STANDBY SUPPLIES

6.3.1 Power supply from ATs will be the main source for all way stations, multi-cabin stations, end panel stations, L.C. Gates, IBHs, IBSs, auto relay huts. Local power supply will be the standby source.

6.3.2 In case of RRI installations, if local supply is reliable, it will be the main source of power supply while supply from ATs shall be the standby source of power supply.

6.4 POWER SUPPLY ARRANGEMENTS / AUTO CHANGE OVER etc

6.4.1 WAYSIDE STATIONS/IBS/IBH/MULTI CABIN STATIONS/ LC GATES/ END PANEL STATIONS/ AUTO SIGNALLING SECTIONS

(a) Auxiliary transformers (ATs), local supply, supply from inverter or supply from DG set, as the case may be, will be terminated on an automatic change over switch/ panel provided by Electrical Deptt. The auto-change over panel would conform to approved RDSO Specifications.

(b) Power supply will be extended from automatic change over panel to other cabins/ S&T equipments through a cable of suitable size and capacity. The cables will be laid from the panel in ASM's office/Cabins/gate lodge as the case may be to other cabin / S&T equipment by S&T Deptt.

(c) Normally, the changeover will be automatic. In case the change over panel is in manual mode in existing installations, the manual operation would be done by ASM / Cabin man / gate man as the case may be. This should be incorporated in the station working rules (SWR) of the station / cabin / gate.

(d) The manual change over switches in existing installations would be replaced by automatic changeover switches by Electrical Deptt. on a programmed basis.

(e) Wherever in existing installations, the cables from changeover panel to the cabin/equipment are maintained by Electrical Deptt., it will be continued to be so maintained till replaced by S&T on a programmed basis.

(f) In existing RRI installations and large stations, requiring ATs of higher capacity, 10 KVA ATs shall be replaced by 25/50 KVA ATs as per load requirement.

6.4.2 RRIs INCLUDING RRI RELAY HUTS

(a) Three phase local supply will be extended to the RRI power supply room and terminated on a distribution board by Elect. Deptt.

(b) Supply from all ATs will also be terminated by Elec. Deptt. on the distribution board.

(c) AT supply and local supply from the distribution board and supply from DG sets will be extended to the main power panel/panels of RRI by S&T Deptt.

(d) The power panels will have automatic changeover facility for the three sources of power supply.

6.5 TELECOMMUNICATION INSTALLATIONS

6.5.1 At stations, where telecom repeaters (for OFC, Microwave or cable) are located within 2 Kms. of stations, a power cable of suitable size will be laid from the automatic change over panel in ASM's room to the repeater stations by Electrical Department to provide standby power supply. Electrical Department will also provide an automatic changeover switch between local supply and AT supply. An emergency light and fan point will also be provided at each repeater station by Electrical Department. For installations beyond two Kms, separate ATs will be provided by Electrical Department.

6.5.2 DG supply may also be provided by S&T as a standby to AT supply and local supply. It will also be terminated on the automatic change over switch.

6.6 TYPES OF LOAD PERMISSIBLE ON A.T. POWER SUPPLY

6.6.1 The supply from ATs and DG sets will be exclusively used for signalling and telecommunication equipment only. No other load will be connected except the following:

(a) At way side stations where local supply is not available, a lighting circuit shall be provided, covering one light point in ASM's room, two points on the platform outside the station building, one at the ticket windows/waiting hail, on the FOBs and one in each cabin. Where local supply is available but prone to long interruptions this requirement may be met by drawing a separate emergency circuit.

(b) In each case a light point shall be provided in apparatus room, relay room, battery and equipment room, cabin basement where signalling equipments are provided and in telecom repeaters/cable huts.

6.7 MAINTENANCE RESPONSIBILITIES

The equipments installed by the Electrical Department will be maintained by the Electrical Department and those provided by the S&T Department will be maintained by the S&T Department.

6.8 SCHEMATIC DIAGRAMS

The schematic diagrams for various types of installations are shown in fig. 10.1 to 10.8. In the diagrams the dotted line depicts the jurisdiction of S&T Department and the thick line the jurisdiction of the Electrical Department. These standard layouts are representative in nature. Wherever conditions are different, local changes may be made keeping these principles in view.

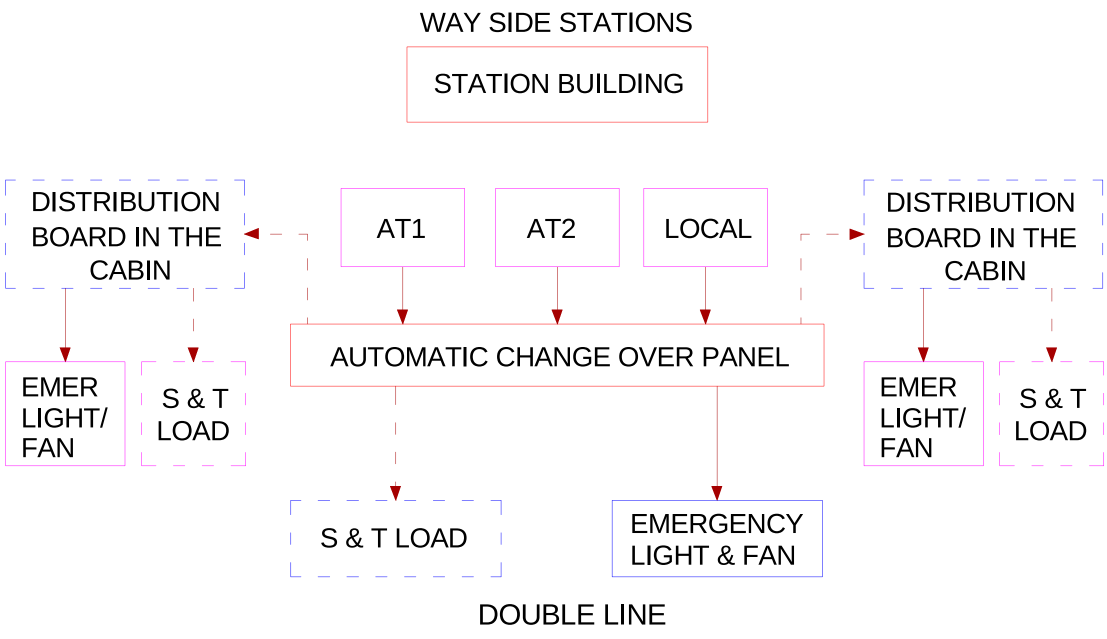
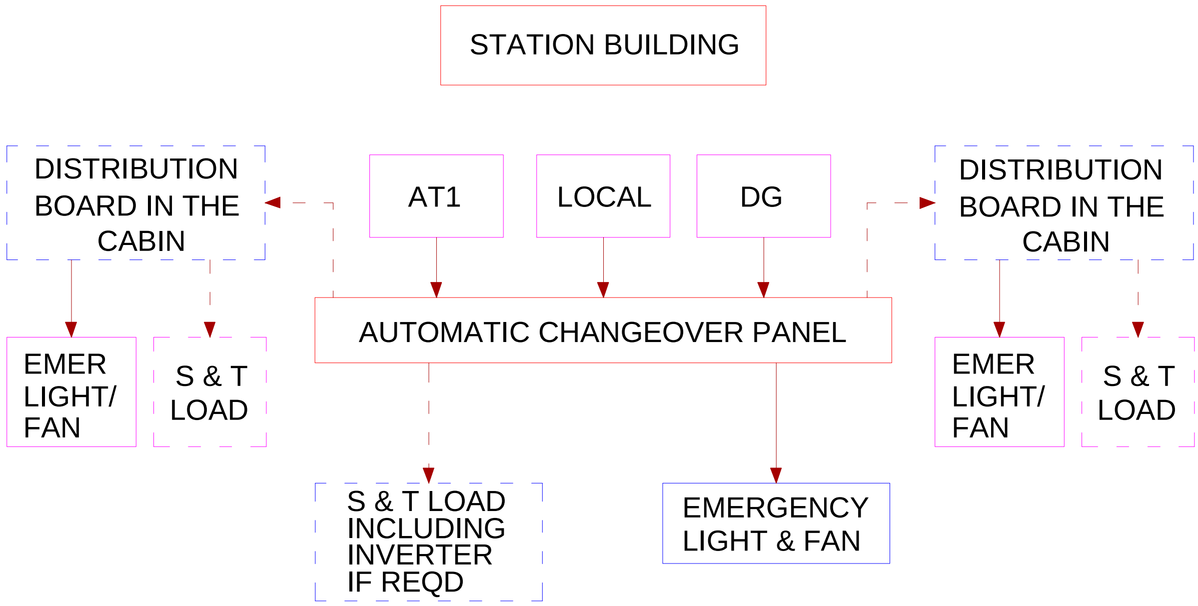


Fig: 6.1

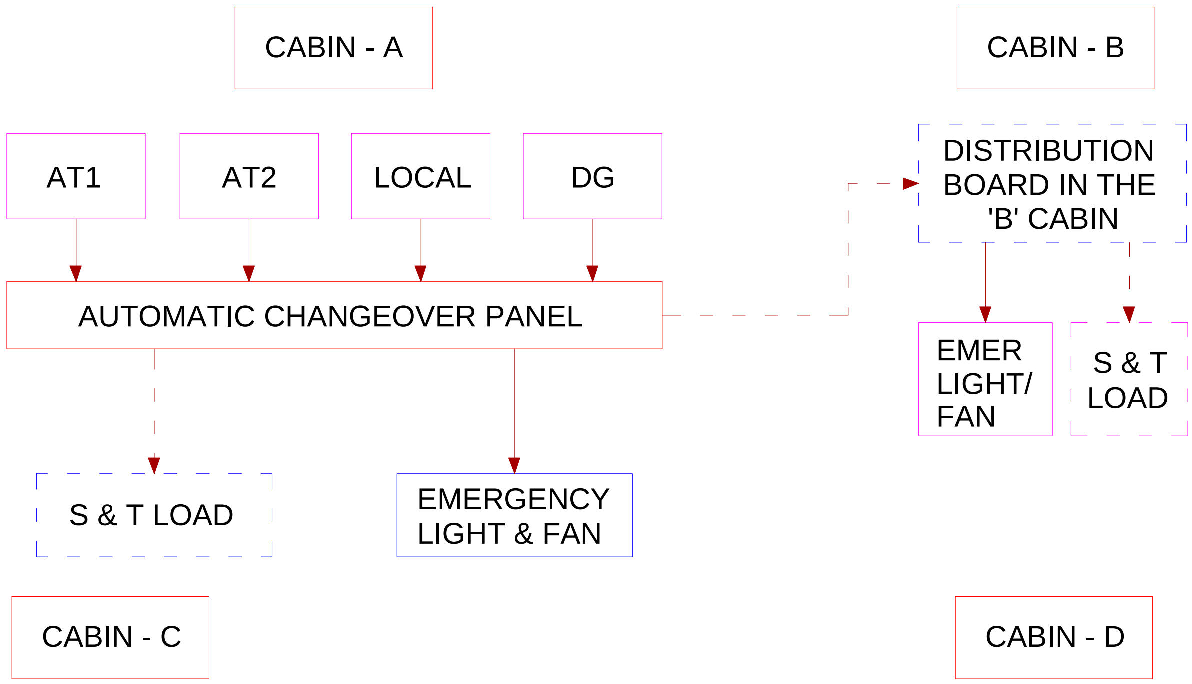


SINGLE LINE

* This arrangement shall hold good for end panel station also.

Fig: 6.2

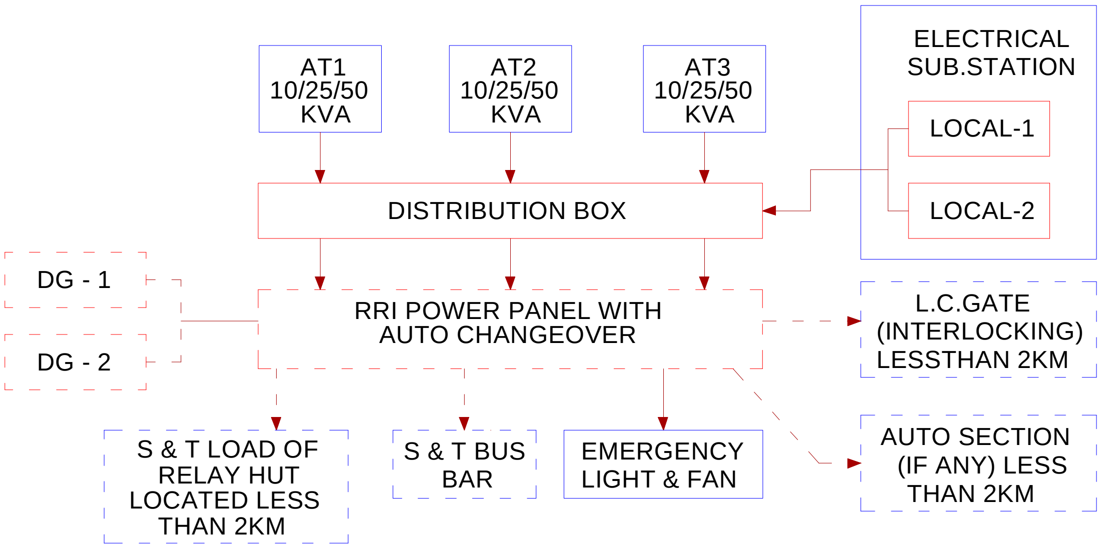
ANNEX-2



(Same arrangement will be duplicated here also for these two cabins)

MULTI CABIN

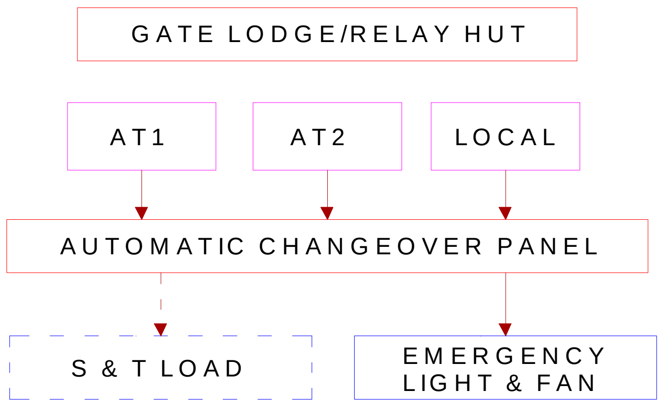
Fig: 6.3



FOR RRI CABIN

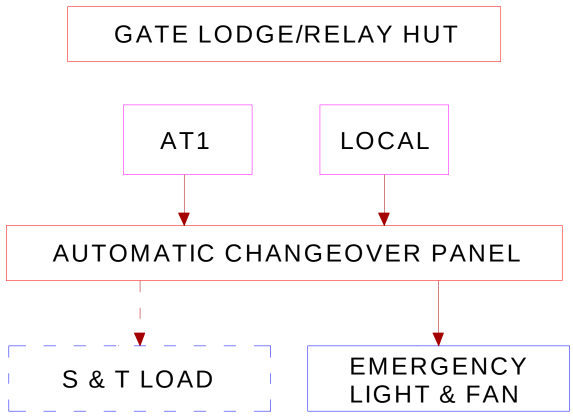
Fig: 6.4

LEVEL CROSSING GATES/IBH



DOUBLE LINE

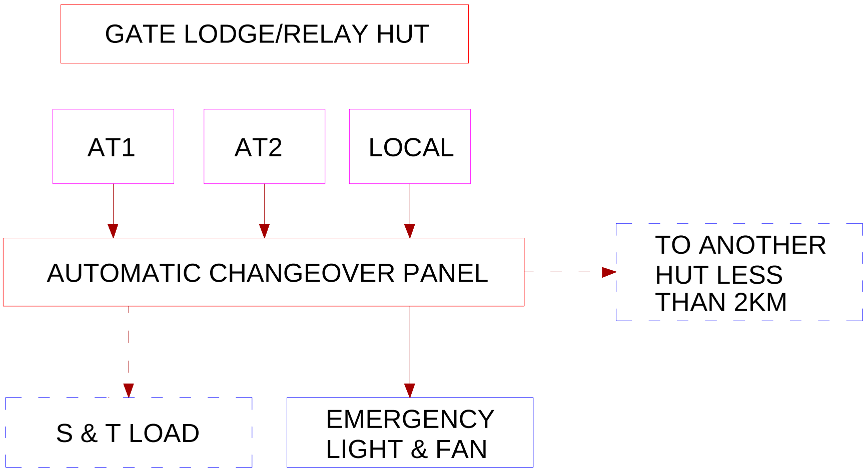
Fig: 6.5



SINGLE LINE

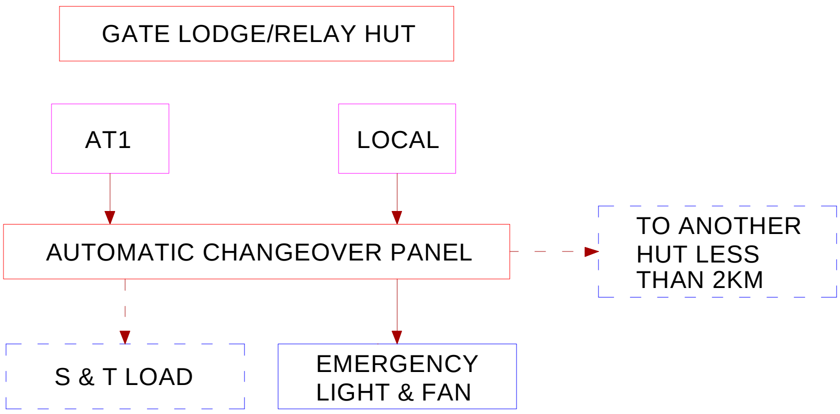
Fig: 6.6

AUTO HUT/RELAY HUT



DOUBLE LINE

Fig: 6.7



SINGLE LINE

Fig: 6.8

6.9 POWER SUPPLY ARRANGEMENTS AT RRIs

6.9.1 Estimation of Power Requirement

(a) DC Loads

(i) If battery fed – take into consideration the charging current of the cells and the actual load.

(ii) Efficiency of the charger and the power factor of the charger also shall be taken into consideration

(b) AC Loads

(i) Efficiency of the Inverter, if fed by inverter

(ii) Efficiency of the Transformer shall be considered

6.9.2 Redundancy of source

(a) State Supply (with separate sub station)

(b) UP and DN Traction Supply as AT1,AT2,AT3

(c) Diesel Generators – 2 Nos.

6.9.3 Selection of Sources

(a) Automatic

(b) Manual

6.9.4 Distribution of the Power Supply

Power Panel

(a) Generators 1 and 2 supply is selected by a switch in the generator Room

(b) Phase selection is done by a switch in the power distribution room before the supply is fed to the power panel

(c) AT1, AT2, AT3 supplies are fed to the Power Panel.

(d) Chargers, Stabilizers and Transformers are with 100% stand by

- (i) Manual Changeover
- (ii) Remote Changeover (from the Power Panel)

6.9.5 Functions carried out by the Power Panel

(a) Automatic Selection of one of the four supplies as per the set priority.

(b) Manual override catered for

(c) DC and AC supplies are brought to the Power Panel

(d) Power Supply failure indicated by buzzer

(e) Station ZR drops in case of power supply flickering – Route Release not allowed

(f) Flasher – Supply Distribution

(g) By passing of – stabilizer

6.9.6 Manual Changeover Switches – in the Equipment Room

(a) Chargers 6 pole

(b) Transformer 4 pole

(c) Stabilizer 8 pole

(d) Two, 4 Pole switches

6.9.7 How to overcome voltage drop problem

(a) INDOOR

- (i) Increase the bus-bar conductor size
- (ii) Use copper instead of Aluminum.
- (iii) Proper size terminals for termination of the bus-bar
- (iv) Reduce the bus-bar length
- (v) Select QS3 (24V, 1000 Ohms) relays for reduction in the operating current
  - Suitable for Q-style relay design only
  - Limited contacts

(b) OUT DOOR

- (i) Increase the bus-bar conductor size
- (ii) Keep the charger and the cells nearer to the Functions
- (iii) Select QSA3 (24V, 1000 Ohms) relays for reduction in the operating current.

6.9.8 Sizing of the Cells and Chargers

(a) CELLS

(i) Low maintenance battery

(ii) 4 to 6 Hr. stand by time with 50% depth of discharge

(b) CHARGERS

(i) IRS:S 86-2000 specification

(ii) Caters for 2 Additional cells

(iii) Current Capacity: LOAD + 10 Hr. Rate of charge of the cells.

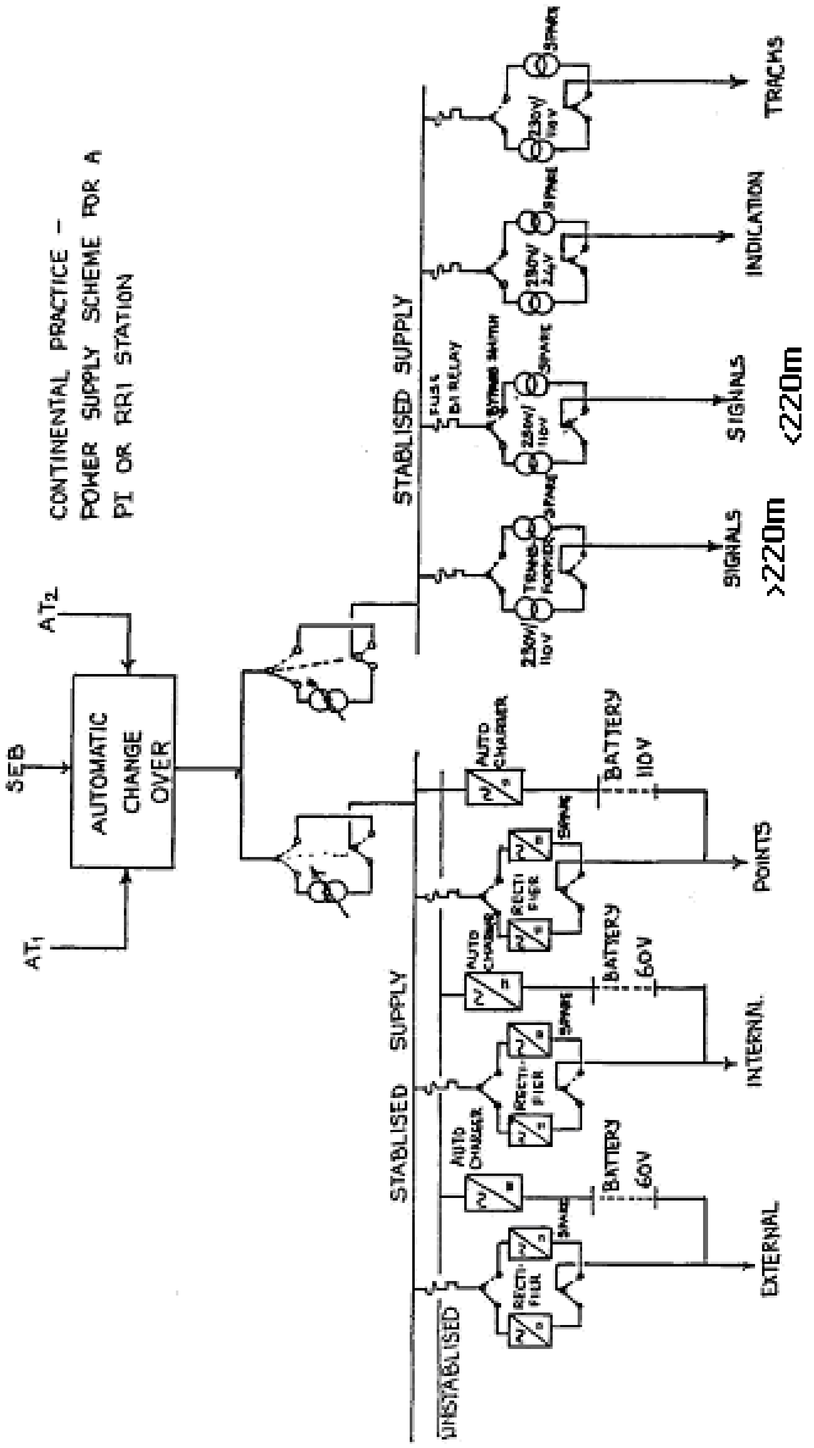


Fig: 6.9

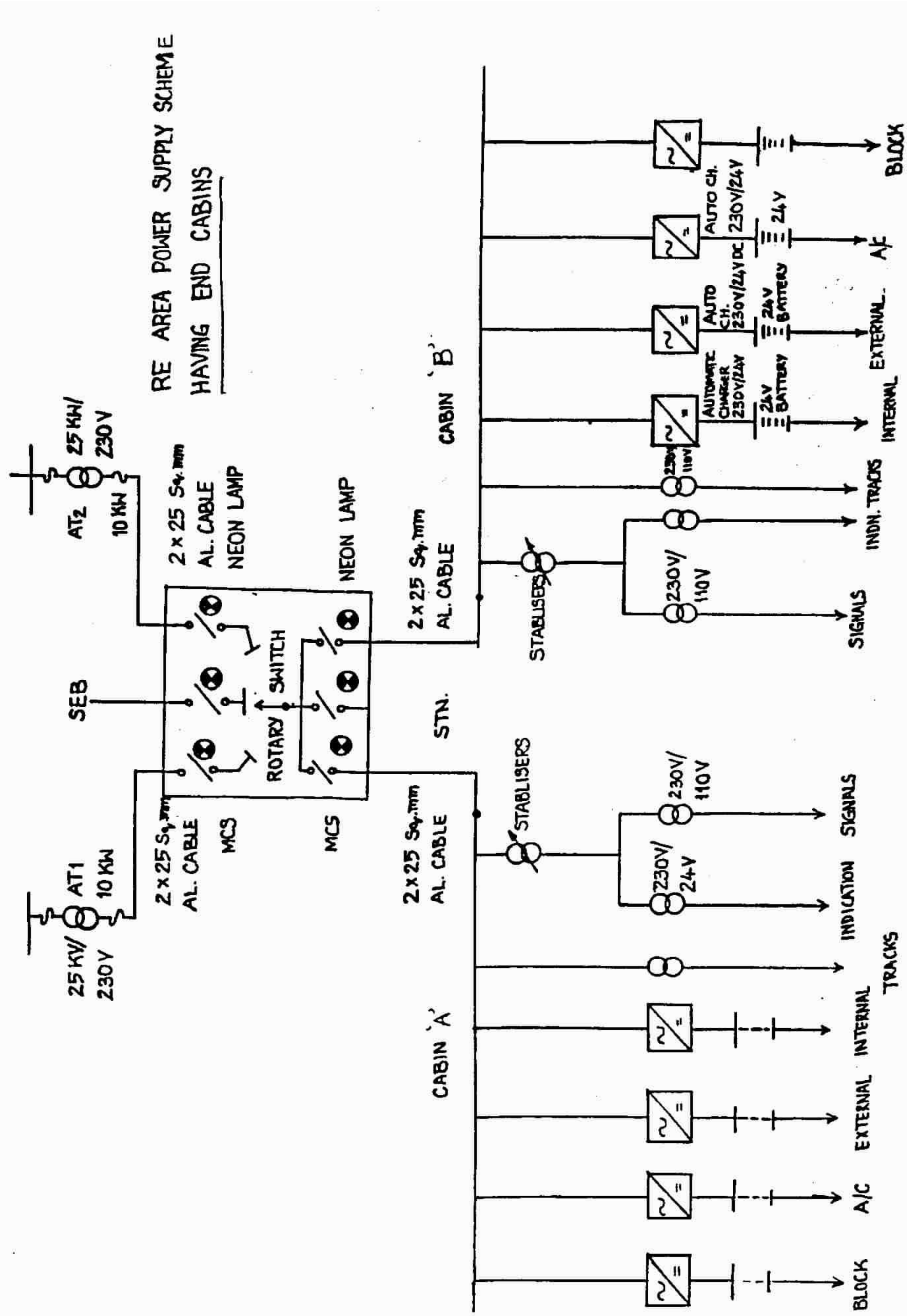

RE AREA POWER SUPPLY SCHEME
HAVING END CABINS
25 KV/ 230 V
AT1
10 KW
AT2
10 KW
25 KW/ 230 V
SEB
2 x 25 Sq.mm AL. CABLE
NEON LAMP
ROTARY SWITCH
MCS
STN.
CABIN 'A'
CABIN 'B'
STABLISERS
230V/ 110V
230V/ 24V
SIGNALS
INDICATION
TRACKS
INDN. TRACKS
INTERNAL
EXTERNAL
A/C
BLOCK
AUTOMATIC CHARGER 230V/24V
24V BATTERY
AUTO CH. 230V/24V DC
AUTO CH. 230V/24V
24V

Fig: 6.10

6.10 Sources of Power Supply

6.10.1 Non-Railway Electrified Area

(a) At the stations provided with CLS installations, in Non-Railway Electrified area, 230 V AC power supply shall be drawn from the station feeder.

(b) In addition two standby diesel generators shall be installed. The output of these DG sets shall be brought to the ASM's office and connected to Auto/Manual Change-Over Panel.

(c) Solar panels or other renewable source of energy with battery back up of suitable capacity, may be provided as main/standby source of power supply wherever feasible. Details may be seen in Annexure-III

6.10.2 Railway Electrified Area

(a) For stations in Railway Electrified area, power supply for signalling system shall normally be provided through Auxiliary Transformers (ATs) of suitable capacity by tapping 25KV OHE. At a station where AT of suitable capacity is installed at the traction switching post situated within 350 meters of the signal cabin or the station building, 230V AC supply from the AT will be extended to station.

(b) On double/multi line sections, the power supply shall be drawn from 25 KV OHE through ATs provided on UP and DOWN lines separately. It shall be ensured that supply from at least one AT is available in the event of power block.

(c) On single line section, where power supply is drawn from a single AT one number DG set of suitable capacity shall be installed.

(d) At stations where local power supply is also available, it shall act as a standby source of power supply.

In big yards, DG sets of adequate capacity shall be installed in addition to supply from ATs and local source.

Power supply from Auxiliary Transformers (ATs), Local source and DG set (s) shall be brought and terminated at a CLS power supply control & distribution panel (CLS Power Panel) in ASM's office/cabin or at LC gate as required. The CLS power panel shall be provided with the facilities for automatic changeover between these supplies as per availability in order of Main (AT)/First standby (Local Supply)/ Second standby (DG supply). In addition manual changeover facility shall also be provided in the control panel. Automatic changeover panel shall be provided as per approved RDSO specification.

The supply from CLS power panel as provided by Electrical Department shall be taken to various S&T installations by S&T department.

Supply from the CLS power panel shall be extended through separate MCBs to cabins, LC gates, Telecom installations etc. if these are falling within two KMs of CLS power panel. For locations beyond two KMs, a separate set of ATs and CLS power panel shall be provided.

6.11 Power supply Scheme on station provided with MACLS operated with relay based route setting type Central Panel/Electronic Interlocking with block proving by axle counters, on section not provided with 25 KV AC Traction (Non-RE area)

Power supply Scheme for typical 3 line station on single line section & 4 line station on double line section is given below. The same should be modified according to actual station load/station configuration.

The power supply for signalling circuits is designed with lighting with 110V AC used with unscreened cable. The load of such station has been worked out taking into account 25-30 track circuits.

Power supply of such stations has to cater for: -

(a) Lighting of signals with electric lamps.

(b) Track circuits.

(c) Motor operation of points.

(d) Block proving by Axle counters with block panel.

(e) For controlling of relays/switching circuits for interlocking (Q-series relays have been considered).

(f) For Solid State Interlocking (SSI).

(g) Indication Panel.

(h) Data Logger.

(i) Telephones.

Power supply to signalling system through Integrated Power Supply Equipment may be provided in terms of SEM Para 16.4.5. Alternatively, the following conventional type of power supply arrangement may be adopted as approved by CSTE of the Railways.

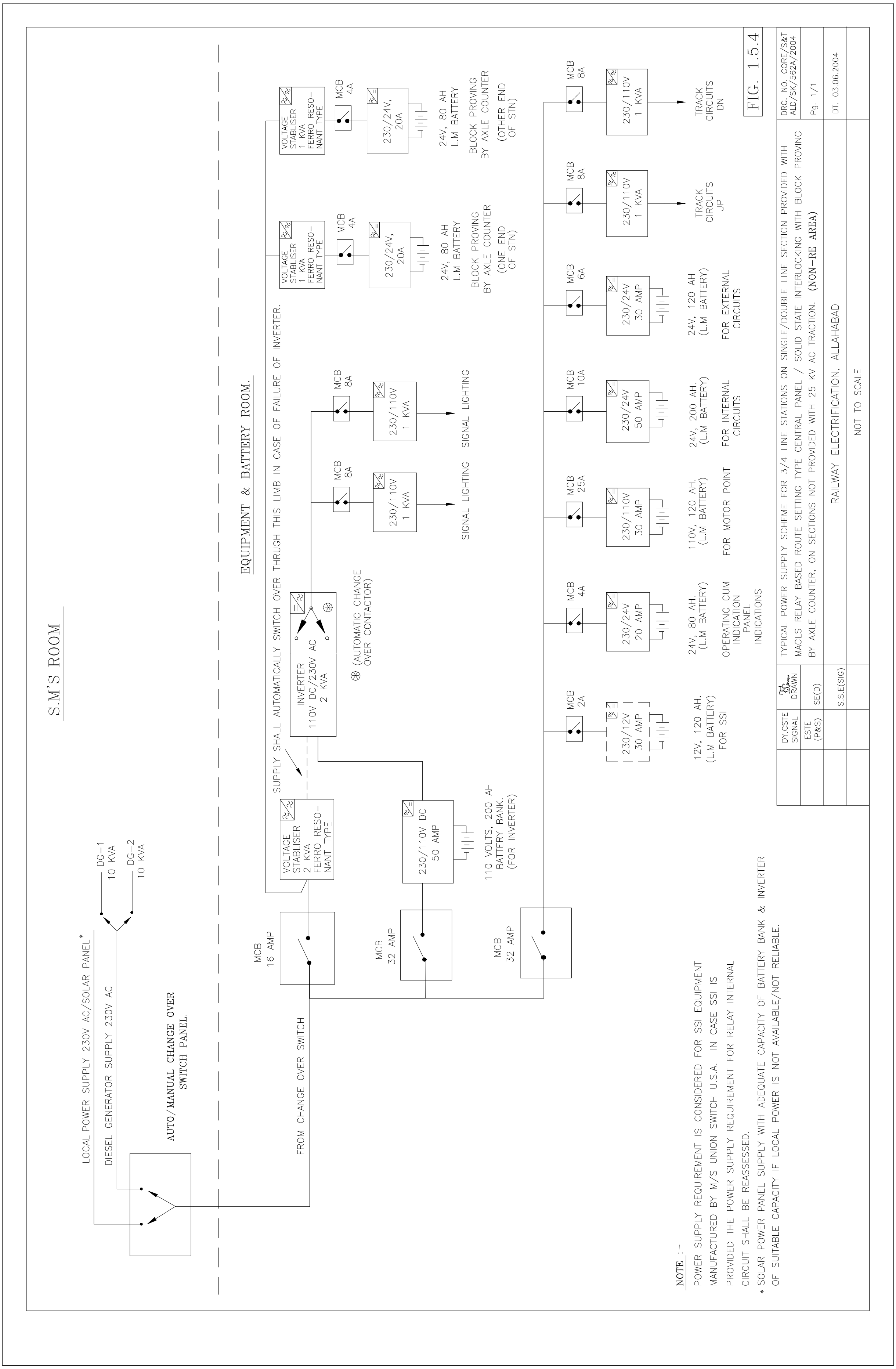
A Ferro resonant Voltage Stabilizer of 2 KVA capacity shall be connected to 230 V AC Local power supply through 16 Amp MCB. This shall be utilized to provided stabilized power supply for signal lighting.

Two Ferro resonant Voltage Stabilizer of 1 KVA capacity shall be connected to 230 V AC Local power supply through 8 Amp MCB, one each for each end of the BPAC equipments. This shall be utilised to provide stabilized power supply for block proving by axle counters only.

On stations on single line section or on double line section, an Inverter of 110V DC/230V AC 2KVA capacity supported with battery bank of 110V, 200AH Low maintenance cells shall be provided and connected for on line operation. A battery charger of 230V AC/110V DC, 50 Amp shall be provided to charge the battery bank.

Two sets of diesel generator of 10 KVA capacities shall be provided with a self-starter switch provided in the ASM's room. A power cable of suitable capacity shall be laid between the generator and ASM's room by S&T department, terminated on a changeover switch wired for automatic/manual changeover in case of failure of all other power supplies.

230V AC/110V AC, 1 KVA two transformers shall be provided for signal lighting, one each for UP & DOWN yards. 110V AC output of the transformer shall be provided as omnibus circuit for connecting feed to various signal aspects.


S.M'S ROOM
LOCAL POWER SUPPLY 230V AC/SOLAR PANEL*
DIESEL GENERATOR SUPPLY 230V AC
DG-1 10 KVA
DG-2 10 KVA
AUTO/MANUAL CHANGE OVER SWITCH PANEL.
EQUIPMENT & BATTERY ROOM.
FROM CHANGE OVER SWITCH
MCB 16 AMP
MCB 32 AMP
MCB 32 AMP
VOLTAGE STABLISER 2 KVA FERRO RESO-NANT TYPE
SUPPLY SHALL AUTOMATICALLY SWITCH OVER THRUGH THIS LIMB IN CASE OF FAILURE OF INVERTER.
INVERTER 110V DC/230V AC 2 KVA
⊛ (AUTOMATIC CHANGE OVER CONTACTOR)
230/110V DC 50 AMP
110 VOLTS, 200 AH BATTERY BANK. (FOR INVERTER)
MCB 8A
230/110V 1 KVA
SIGNAL LIGHTING
MCB 8A
230/110V 1 KVA
SIGNAL LIGHTING
VOLTAGE STABLISER 1 KVA FERRO RESO-NANT TYPE
MCB 4A
230/24V, 20A
24V, 80 AH L.M BATTERY
BLOCK PROVING BY AXLE COUNTER
(ONE END OF STN)
VOLTAGE STABLISER 1 KVA FERRO RESO-NANT TYPE
MCB 4A
230/24V, 20A
24V, 80 AH L.M BATTERY
BLOCK PROVING BY AXLE COUNTER
(OTHER END OF STN)
MCB 2A
230/12V 30 AMP
12V, 120 AH. (L.M BATTERY) FOR SSI
MCB 4A
230/24V 20 AMP
24V, 80 AH. (L.M BATTERY)
OPERATING CUM INDICATION PANEL INDICATIONS
MCB 25A
230/110V 30 AMP
110V, 120 AH. (L.M BATTERY)
FOR MOTOR POINT
MCB 10A
230/24V 50 AMP
24V, 200 AH. (L.M BATTERY)
FOR INTERNAL CIRCUITS
MCB 6A
230/24V 30 AMP
24V, 120 AH (L.M BATTERY)
FOR EXTERNAL CIRCUITS
MCB 8A
230/110V 1 KVA
TRACK CIRCUITS UP
MCB 8A
230/110V 1 KVA
TRACK CIRCUITS DN
NOTE :-
POWER SUPPLY REQUIREMENT IS CONSIDERED FOR SSI EQUIPMENT MANUFACTURED BY M/S UNION SWITCH U.S.A. IN CASE SSI IS PROVIDED THE POWER SUPPLY REQUIREMENT FOR RELAY INTERNAL CIRCUIT SHALL BE REASSESSED.
* SOLAR POWER PANEL SUPPLY WITH ADEQUATE CAPACITY OF BATTERY BANK & INVERTER OF SUITABLE CAPACITY IF LOCAL POWER IS NOT AVAILABLE/NOT RELIABLE.
FIG. 1.5.4
DY.CSTE SIGNAL
DRAWN
ESTE (P&S)
SE(D)
S.S.E(SIG)
TYPICAL POWER SUPPLY SCHEME FOR 3/4 LINE STATIONS ON SINGLE/DOUBLE LINE SECTION PROVIDED WITH MACLS RELAY BASED ROUTE SETTING TYPE CENTRAL PANEL / SOLID STATE INTERLOCKING WITH BLOCK PROVING BY AXLE COUNTER, ON SECTIONS NOT PROVIDED WITH 25 KV AC TRACTION. (NON-RE AREA)
RAILWAY ELECTRIFICATION, ALLAHABAD
NOT TO SCALE
DRG. NO. CORE/S&T ALD/SK/562A/2004
Pg. 1/1
DT. 03.06.2004

230V AC/110V AC, 1 KVA two transformers shall be provided for track feed battery chargers, one each for UP & DOWN yards. 110V AC output of the transformer shall be provided as omnibus circuit for connecting track feed battery chargers.

110V AC output of the transformer shall be provided as omnibus Circuit for connecting track feed battery chargers. 110 V AC/6V DC 5/10 Amp Track feed battery chargers shall be provided near feed end of each track circuit with a battery bank of 2, 3 or 4 cells of 2V each of capacity 40/80 AH, in series as per requirement at site.

One battery charger of 230V AC/110V DC, 30 Amp with battery bank of 120AH Low maintenance cells shall be provided for motor operation of points.

1 KVA Stabilized power supply shall be provided for each set of Block Proving by Axle Counters. Power requirement for devices used for analogue axle counter is as follows:

(i) Evaluator 21.6-28.8V DC, 1.5 amps.

(ii) Junction Box 21.6-28.8 V DC, <250 ma.

(iii) Resetting Box 21.6-28.8 V DC, 500ma, (Only when resetting key is pressed).

For power supply arrangement for Block proving by axle counter system, One 230V AC/24V DC, 20 Amp battery charger with a battery bank of 80 AH low maintenance cells shall be provided for power supply to DC-DC converter of Evaluator, Multiplexer and block panel, of block proving by axle counters.

In case of central panel with relay based interlocking, power supply for controlling relays and switching circuits for interlocking i.e. internal circuits, a 230V AC/24V DC, 50 Amp battery charger with battery bank of 200 AH L.MLA batteries shall be provided. One 230V AC/24V DC, 30 Amps battery Charger with a battery bank of 120AH low maintenance cells shall be provided for external circuits.

In case of central panel with Electronic Interlocking, power supply for controlling relays and switching circuits for interlocking, a 230V AC/24V DC 30 Amp battery charger with battery bank of 120 AH L.M. batteries shall be provided. An additional power supply for EI equipment shall be provided as per manufacturer's requirement.

In consideration of indication on Panel being LED lit, a 230V AC/24V DC-20 Amp battery charger with 80 AH Low Maintenance battery bank shall be provided. For panel with electric lamps, 230V AC/24 AC, 500 VA Transformer shall be provided for indication lamps through inverter provided for signals.

Primary cell, conforming to Specification No.IRS: S-95/96 (with latest amendments) shall be used for power supply to telephones connected with Block panel and magneto telephones connected between Station Master and Level Crossing gates. Each telephone shall have independent power supply and shall not be used for any other telephone or circuit.

6.12 Power supply scheme on stations provided with MACLS operated with relay based route setting type Central Panel/Solid State Interlocking along with block proving by axle counters on section provided with 25 KV AC Traction (RE Area)

Power supply scheme for typical 3 line station on single line section line and 4 line station on double line section is given below. The same should be modified according to actual station load/station configuration.

The power supply for circuit is designed with signal lighting with 110V AC used with unscreened cable. The load of such station has been worked out taking into account 25-30 track circuits.

Power supply of such stations shall be required for: -

(a) Lighting of signals with electric lamps.

(b) Track circuits.

(c) Motor operation of points.

(d) Block proving by Axle counters and block panel.

(e) For controlling of relays/switching circuits for interlocking (Q-series relays have been considered).

(f) For Electronic Interlocking.

(g) Indication Panel.

(h) Data Logger.

(i) Telephones.

Power supply to signalling system through Integrated Power Supply Equipment as mentioned in Para 1.3.3 may be provided in terms of SEM Para 16.4.5. Alternatively, the following conventional type of power supply arrangement may be adopted as approved by CSTE of the Railways.

A Ferro resonant Voltage Stabilizer of 2 KV A capacity shall be connected to 230V AC power supply through 16 Amp MCB. This shall be utilized to provide stabilized power supply for signal lighting only.

Two Ferro resonant Voltage Stabilizer of 1 KVA capacity shall be connected to 230 V AC General power supply through 8 Amp MCB, one each for each end of the BPAC equipments. This shall be utilised to provide stabilized power supply for block proving by axle counters only.

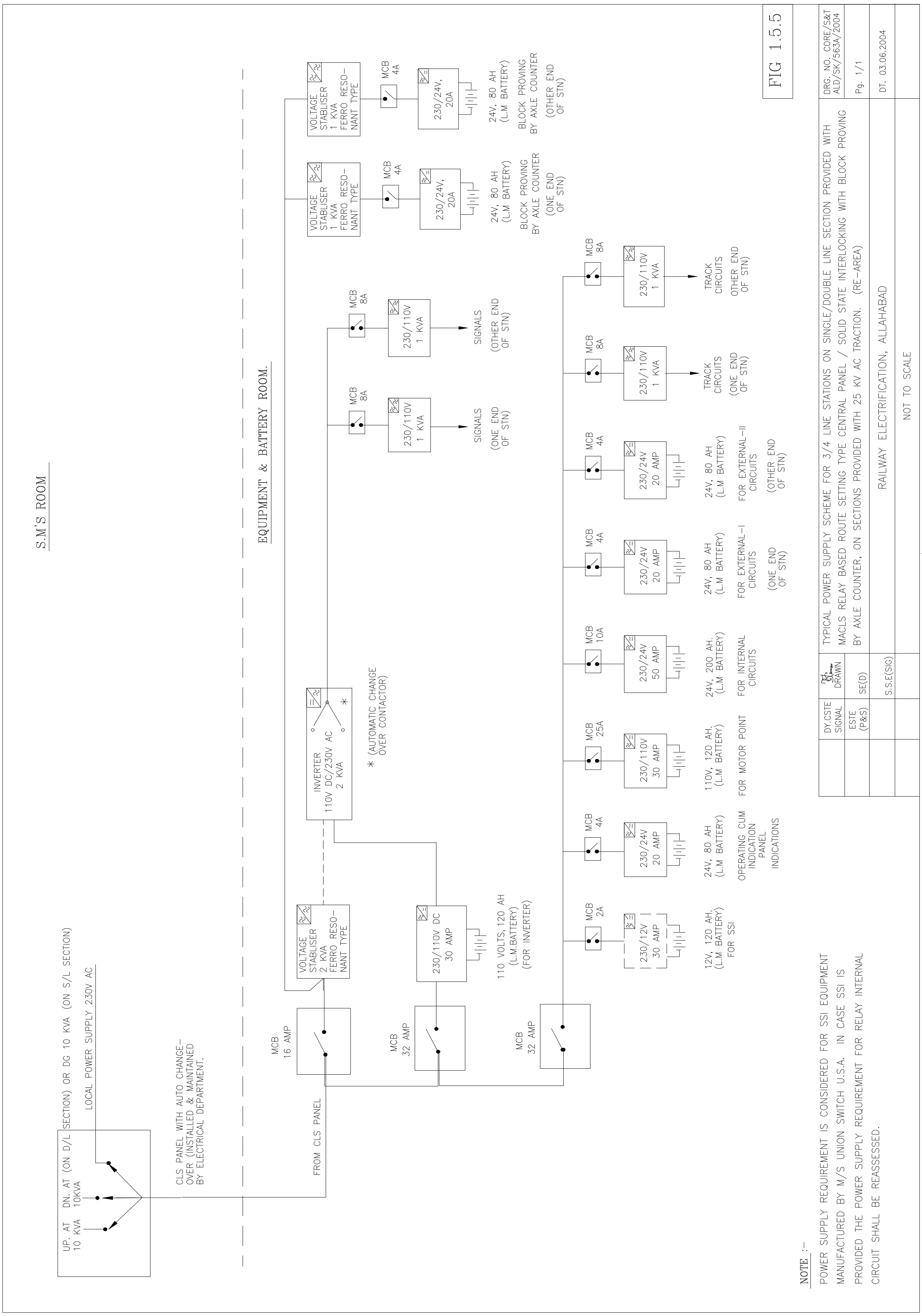
On stations on single line section or on double line section, an Inverter of 110V DC/230V AC, 2 KVA capacity supported with battery bank of 110V, 120AH Low Maintenance cells shall be provided and connected for on line operation. A battery charger of 230V AC/110V DC, 30 Amp shall be provided to charge the battery bank.

A generator of 10 KVA capacity shall be provided with a self-starter switch provided in the ASM's room on single line section only. A power cable of suitable capacity shall be laid between the generator and ASM's room by S&T department, terminated on a changeover switch wired for automatic/manual changeover in case of failure of all other power supplies.

230V AC/110V AC 1 KVA two transformers one each for either end of the Yard shall be provided for signal lighting. 110V AC out put of the transformer shall be provided as omnibus circuit for connecting feed to various signal aspects.

230V AC/110V AC two transformers of 1 KVA each shall be provided for track feed battery chargers on each side of the station separately. 110V AC output of the transformer shall be provided as omnibus circuit for connecting track feed battery chargers.

110V AC/6V DC, 5/10 Amp Track feed battery chargers shall be provided near feed end of each track circuit with a battery bank of 2, 3 or 4 cells of 2V, 40/80 AH each, in series as per requirement at site.



S.M'S ROOM
EQUIPMENT & BATTERY ROOM.
UP. AT 10 KVA
DN. AT 10KVA
(ON D/L SECTION) OR DG 10 KVA (ON S/L SECTION)
LOCAL POWER SUPPLY 230V AC
CLS PANEL WITH AUTO CHANGE-OVER (INSTALLED & MAINTAINED BY ELECTRICAL DEPARTMENT.
FROM CLS PANEL
MCB 16 AMP
MCB 32 AMP
MCB 32 AMP
VOLTAGE STABLISER 2 KVA FERRO RESO-NANT TYPE
230/110V DC 30 AMP
110 VOLTS, 120 AH (L.M.BATTERY) (FOR INVERTER)
INVERTER 110V DC/230V AC 2 KVA
* (AUTOMATIC CHANGE OVER CONTACTOR)
MCB 8A
230/110V 1 KVA
SIGNALS (ONE END OF STN)
SIGNALS (OTHER END OF STN)
VOLTAGE STABLISER 1 KVA FERRO RESO-NANT TYPE
MCB 4A
230/24V, 20A
24V, 80 AH (L.M BATTERY)
BLOCK PROVING BY AXLE COUNTER (ONE END OF STN)
BLOCK PROVING BY AXLE COUNTER (OTHER END OF STN)
MCB 2A
230/12V 30 AMP
12V, 120 AH, (L.M BATTERY) FOR SSI
MCB 4A
230/24V 20 AMP
24V, 80 AH (L.M BATTERY)
OPERATING CUM INDICATION PANEL INDICATIONS
MCB 25A
230/110V 30 AMP
110V, 120 AH, (L.M BATTERY)
FOR MOTOR POINT
MCB 10A
230/24V 50 AMP
24V, 200 AH, (L.M BATTERY)
FOR INTERNAL CIRCUITS
FOR EXTERNAL-I CIRCUITS (ONE END OF STN)
FOR EXTERNAL-II CIRCUITS (OTHER END OF STN)
230/110V 1 KVA
TRACK CIRCUITS (ONE END OF STN)
TRACK CIRCUITS OTHER END OF STN)
FIG 1.5.5
NOTE :-
POWER SUPPLY REQUIREMENT IS CONSIDERED FOR SSI EQUIPMENT MANUFACTURED BY M/S UNION SWITCH U.S.A. IN CASE SSI IS PROVIDED THE POWER SUPPLY REQUIREMENT FOR RELAY INTERNAL CIRCUIT SHALL BE REASSESSED.
DY.CSTE SIGNAL
DRAWN
ESTE (P&S)
SE(D)
S.S.E(SIG)
TYPICAL POWER SUPPLY SCHEME FOR 3/4 LINE STATIONS ON SINGLE/DOUBLE LINE SECTION PROVIDED WITH MACLS RELAY BASED ROUTE SETTING TYPE CENTRAL PANEL / SOLID STATE INTERLOCKING WITH BLOCK PROVING BY AXLE COUNTER, ON SECTIONS PROVIDED WITH 25 KV AC TRACTION. (RE-AREA)
RAILWAY ELECTRIFICATION, ALLAHABAD
NOT TO SCALE
DRG. NO. CORE/S&T ALD/SK/563A/2004
Pg. 1/1
DT. 03.06.2004

One battery charger of 230V AC/110V DC, 30 Amp with battery bank of 100V, 120 AH Low maintenance cells shall be provided for motor operation of points. This shall be used to operate points to a maximum length of parallelism of 2.8 KMs. In case the maximum length of parallelism is increased beyond 2.8 KMs, another set of same power supply shall be used keeping one for one side of the station.

For power supply arrangement for Block proving by axle counter system, One 230V AC/24V DC, 20 Amp battery charger with a battery bank of 80 AH low maintenance cells shall be provided for power supply to DC-DC converter of Evaluator, Multiplexer and block panel, of block proving by axle counters.

6.13 Power supply for controlling relays/switching circuits

Power supply for internal and external circuits shall be separate and completely isolated from each other.

In case of central panel with relay based interlocking, Power supply for controlling relays and switching circuits for interlocking i.e. internal circuits, a 230V AC/24V DC, 50 Amps battery charger with battery bank of 24V, 200 AH L.M. batteries shall be provided. For external circuits two 230V AC/24V DC, 20 Amps battery chargers with a battery bank of 24V, 80 AH low maintenance cells each, shall be provided for controlling relays and operation of equipment on either side of the station.

In case of central panel with Electronic Interlocking, Power supply for controlling relays and switching circuits for interlocking i.e. for internal circuits, a 230V AC/24V DC, 30 Amp battery charger with battery bank of 120 AH L.M. batteries shall be provided. An additional power supply for EI equipment shall be provided as per manufacturer's requirement. For external circuits, the arrangement shall be same as given above.

In consideration of indication on Panel being LED lit, a 230V AC/24 V DC, 20 Amp battery charger with 24V, 80 AH Low Maintenance battery bank shall be provided. For panel with electric lamps 230V AC/24V DC, 500 VA transformer shall be provided, through inverter provided for signal lighting.

Primary cell conforming to Specification No.IRS: S 95/96 (with latest amendments) shall be used for power supply to telephones connected with Block panel and magneto phones connected between Station Master and LC Gates. Each telephone shall have independent power supply & shall not be used in any other circuit

6.14 Cabling from AT / Local Supply to CLS Power Panel and from CLS Power Panel to Signalling Equipment room

The size of cable to be used is to be determined, considering the load. The Power cable shall be 1100 V grade, armoured, PVC sheathed conforming to IS: 1554 Part-I (latest version) or XLPE cable conforming to IS: 7098 Part-I (Amendment 1 or latest) as per RDSO's letter no. TI/PSI/PROTCT/CLS/02 Dtd 14.6.2002. Wherever power cable of lower coreage is provided, it shall be replaced in a phased manner, with proper coreage of cable or be supplemented by laying additional cable of appropriate coreage to make good the required cross section.

Source of power supply (AT/Local)	Size of cable
5KV A	2 X 25 sq mm Aluminium Conductor
10 KV A	2 X 70 sq mm Aluminium Conductor
25 KVA	2 X 185 sq mm Aluminium Conductor
50 KV A	2 X 300 sq mm Aluminium Conductor

Table: Source of Power Supply -vs- Type of Cable

* * *

CHAPTER – 7: POWER SUPPLY LOAD CALCULATIONS

7.1 Calculation of Signalling load for a 4 line Panel Interlocking Station with CLS in Double line RE Section ('Q' series relays are used)

The maximum load is considered when reception signals are taken off on loop lines when the main lines are occupied.

7.2 D.C Load Calculations

7.2.1 Points

Assume two points are operating at a time and are in obstructed in this case each point is taking maximum of 6A current then,

Load Current I = 12A

$$\text{Capacity of the Cell } C = \frac{\text{Load current x Backup time required}}{\text{Depth of Discharge permitted}}$$

$$= \frac{12A \text{ X } 6 \text{ Hrs}}{0.70} = 103 \text{ AH} \approx 120 \text{ AH}$$

$$\text{Recommended Capacity of the battery charger} = \frac{C \text{ X } 2}{10}$$

$$= \frac{120 \text{ X } 2}{10} = 24 \text{ A}$$

≈ 30A (as per Battery charger Spec.)

Since points operation is occasional, points load may not be considered.

$$\text{TOTAL LOAD} = \frac{\text{Voltage X Current}}{\text{Power Factor X Efficiency}}$$

$$= \frac{\text{Voltage X (Boost charging current of the cell + Load Current)}}{\text{Power factor X Efficiency of charger}}$$

$$= \frac{110V \text{ X } (12A + OA)}{0.8 \text{ X } 0.7} = 2357 \text{ VA} \quad \text{------ (A)}$$

7.2.2 Relays

Total No. of Signalled routes = 23

Consider 16 Relays per route are used.

Total No. of Relays used = 23 X 16 = 368 relays

Out of these, Internal relays (QN1) used are 75% and External relays (QNA1) used are 25%

Total No. of Internal relays used = 75% of 368 = 368 X 0.75 = 276 Internal relays

Total No. of External relays used = 25% of 368 = 368 X 0.25 = 92 External relays

7.2.3 Relays Internal

Total No. of Internal relays = 276

Assume 60% relays are in pickup condition.

No. of picked up internal relays = 276 X 0.60 = 166 relays

Each QN1 relay takes 60 mA Current.

Internal relays Load Current = 166 X 60mA = 9.96 A

$$\text{Capacity of the Cell C} = \frac{\text{Load current x Backup time required}}{\text{Depth of Discharge permitted}}$$

$$= \frac{9.96\text{A X10 Hrs}}{0.70} = 142\text{AH}$$

≈ 200AH (near by available capacity of the cell)

$$\text{Recommended Capacity of the battery charger} = \frac{\text{C X 2}}{10} = \frac{200 \text{ X } 2}{10} = 40 \text{ A}$$

$$\text{Total Load} = \frac{\text{Voltage X Current}}{\text{Power Factor X Efficiency}}$$

$$= \frac{\text{Voltage X (Boost charging current of the cell + Load Current)}}{\text{Power factor X Efficiency of charger}}$$

$$= \frac{24 \text{ V X } (20 \text{ A} + 9.96 \text{ A})}{0.8 \text{ X } 0.70} = 1284 \text{ VA} \qquad \text{-------- (B)}$$

7.2.4 Relays External

Total No. of External relays = 92

Assume 60% relays are in pickup condition.

No. of picked up External relays = 92 X 0.60 = 55 relays

Each QNA1 relay takes 120 mA Current.

External relays Load Current = 55 X 120mA = 6.6 A

$$\text{Capacity of the Cell C} = \frac{\text{Load current x Backup time required}}{\text{Depth of Discharge permitted}}$$

$$= \frac{6.6\text{A X10 Hrs}}{0.70} = 94.28 \text{ AH}$$

≈ 120AH (near by available capacity of the cell)

$$\text{Recommended Capacity of the battery charger} = \frac{C \times 2}{10} = \frac{120 \times 2}{10} = 24\ A \approx 30\ A$$

$$\text{Total Load} = \frac{\text{Voltage X Current}}{\text{Power Factor X Efficiency}}$$

$$= \frac{\text{Voltage X (Boost charging current of the cell + Load Current)}}{\text{Power factor X Efficiency of charger}}$$

$$= \frac{24\ V \times (12\ A + 6.6\ A)}{0.8 \times 0.70} = 797\ VA \qquad \text{-------- (C)}$$

7.2.5 Up side block Instrument

Load Current = 0.5A

$$\text{Capacity of the Cell C} = \frac{\text{Load current x Backup time required}}{\text{Depth of Discharge permitted}}$$

$$= \frac{0.5A \times 48\ Hrs}{0.70} = 34\ AH$$

≈ 40AH (near by available capacity of the cell)

$$\text{Recommended Capacity of the battery charger} = \frac{C \times 2}{10} = \frac{40 \times 2}{10} = 8\ A \approx 10\ A$$

$$\text{Total Load} = \frac{\text{Voltage X Current}}{\text{Power Factor X Efficiency}}$$

$$= \frac{\text{Voltage X(Boost charging current of the cell + Load Current)}}{\text{Power factor X Efficiency of charger}}$$

$$= \frac{24\ V \times (4\ A + 0.5\ A)}{0.8 \times 0.65} = 207.69\ VA \cong 208\ VA \text{ -------- (D)}$$

7.2.6 Down Side Block instrument

Load Current = 0.5A

$$\text{Capacity of the Cell C} = \frac{\text{Load current x Backup time required}}{\text{Depth of Discharge permitted}}$$

$$= \frac{0.5A \times 48\ Hrs}{0.70} = 34\ AH$$

≈ 40AH (nearby available capacity of the cell)

$$\text{Recommended Capacity of the battery charger} = \frac{C \times 2}{10} = \frac{40 \times 2}{10} = 8\ A \approx 10\ A$$

$$\text{Total Load} = \frac{\text{Voltage X Current}}{\text{Power Factor X Efficiency}}$$

$$= \frac{\text{Voltage X(Boost charging current of the cell + Load Current)}}{\text{Power factor X Efficiency of charger}}$$

$$= \frac{24\ V \times (4\ A + 0.5\ A)}{0.8 \times 0.65} = 207.69\ VA \cong 208\ VA \text{ -------- (E)}$$

TOTAL D.C LOAD (F) = (A) + (B) + (C) + (D) + (E)

= 2357 + 1284 + 797 + 208 + 208

= 4854 VA - (F)

7.3 A.C LOAD CALCULATION

7.3.1 Zone-1 Signals

Route indication lamps = 5 (25W each)

Shunt Signal lamps = 2 (25W each)

Total lamps = 7

$$\text{LOAD} = \frac{\text{Total lamps X wattage of each lamp}}{\text{Power Factor}}$$

$$= \frac{7 \times 25W}{0.8} = 218\ VA \quad \text{-----} \quad (1)$$

Main Signal aspects = 7 (33 W each) (for Distant Signal HG & HHG are considered)

110V/12V Signal lamp transformer efficiency = 80%

$$\text{LOAD} = \frac{\text{Total lamps X wattage of each lamp}}{\text{Power factor X efficiency of signal lamp transformer}}$$

$$= \frac{7 \times 33W}{0.8 \times 0.8} = 360\ VA \quad \text{-----} \quad (2)$$

Zone-1 Signals load

Zone-1 Signals load on the secondary side of the 230V/110V signal transformer

= (1) + (2)

= 218VA + 360 VA = 578 VA

Rating of the 230V/110V Signal transformer

= load on secondary side of the transformer X Factor of safety

= 578 VA X 1.5 = 867 VA

≅ 1 KVA (nearest higher rating available)

230/110V AC Signal transformer efficiency = 85%

Zone –1 Signals load on the primary side of the 230V/110V Signal transformer

$$= \frac{\text{Load on secondary side of the transformer}}{\text{Efficiency}}$$

$$= \frac{578\text{VA}}{0.85} = 680 \text{ VA} \qquad \text{-----} \qquad (3)$$

7.3.2 Zone-2 Signals

Route indication lamps = 5 (25W each)

Shunt Signal lamps = 2 (25W each)

Total lamps = 7

$$\text{LOAD} = \frac{\text{Total lamps X wattage of each lamp}}{\text{Power Factor}}$$

$$= \frac{7 \text{ X } 25\text{W}}{0.8} = 218 \text{ VA} \qquad \text{-----} \qquad (4)$$

Main Signal aspects = 6 (33 W each) (for Distant Signal HG & HHG are considered)

110V/12V Signal lamp transformer efficiency = 80%

$$\text{LOAD} = \frac{\text{Total lamps X wattage of each lamp}}{\text{Power factor X efficiency of signal lamp transformer}}$$

$$= \frac{6 \text{ X } 33\text{W}}{0.8 \text{ X } 0.8} = 309 \text{ VA} \qquad \text{-----} \qquad (5)$$

Zone-2 Signals load

Zone-2 Signals load on the secondary side of the 230V/110V signal transformer

= (4) + (5)

= 218VA + 309 VA = 527 VA

Rating of the 230V/110V Signal transformer

= load on secondary side of the transformer X Factor of safety

= 527 VA X 1.5 = 791 VA ≅ 1 KVA (Nearest higher rating available)

230/110V AC Signal transformer efficiency = 85%

Zone –2 Signals load on the primary side of the 230V/110V Signal transformer

$$= \frac{\text{Load on secondary side of the transformer}}{\text{Efficiency}} = \frac{527VA}{0.85} = 620VA \text{ ----- (6)}$$

7.3.3 Zone 1 Track Circuits

Total No. of track circuits in Zone 1 = 14

Load on each Track circuit = 0.5A

$$\text{Secondary cell capacity on each Track circuit} = \frac{\text{Load current x Backup time required}}{\text{Depth of Discharge permitted}}$$

$$= \frac{0.5A \times 48 \text{ Hrs}}{0.70} = 34 \text{ AH}$$

≈ 40 AH (Near by available capacity of the cell)

$$\text{LOAD} = \frac{\text{No. of track Ckts. X Voltage of Track circuit X (Boost charging I + load I)}}{\text{Power factor X efficiency of Track Feed Battery Charger}}$$

$$= \frac{14 \times 6V \times (4A + 0.5A)}{0.8 \times 0.5} = 945 \text{ VA}$$

Rating of the Zone – 1

230V/110V Track Transformer = load on secondary side of the transformer X Factor of safety

= 945 VA X 1.5 = 1418 VA

≅ 2 KVA (Nearest higher rating available)

Efficiency of the 230 V/110V AC Transformer = 85%

$$\text{Load on primary} = \frac{\text{Load on secondary side of the transformer}}{\text{Efficiency}}$$

$$= \frac{945VA}{0.85} = 1111 \text{ VA} \quad \text{----} \quad (7)$$

Zone – 2 Track circuits

Total No. of Track circuits in Zone-2 = 14 (same as in Zone-1)

Therefore Zone –2 Track transformer on primary = 1111 VA ----- (8)

Panel Indication lamps load:

Indication lamps rating = 24V/1.2W

Indication transformer used is 230V/24V AC.

Total No. of indication lamps:

(a) (i) Berthing tracks (8T/Ckts) - 4 Nos. (2 track circuits used per B.T)

Minimum 10 Nos. of lamps used per berthing track (B.T).

On Berthing tracks indication lamps used = 4 X 10 = 40 Nos.

(ii) Point Zone tracks (11-T/Ckts) - 6 points

6 Nos. of indication lamps for one point

Indication lamps used on points zone = 6 X 6 = 36 Nos.

(iii) Co-ON Tracks (2-T/Ckts) - 2 Nos.

Min. 2 Nos. of indication lamps for one Co-ON T/Ckt

Indication lamps used on Co-ON Tracks = 2 X 2 = 4 Nos.

(iv) Controlling Tracks - 7 Nos.

Min. 4 Nos. of indication lamps per Track Ckt

Indication lamps used on control T/Ckts = 7 X 4 = 28

(b) No. of indication lamps lit for signals 11(Main) + 2 (Shunt) + 2 (Co-ON) = 15

Total No. of Indication lamps used for Pts, Signals & T/Ckts = 40+36+4+28+15 =123

Misc. indication (15% of above) = 123X 15/100 = 19

Total No. of Indication lamps used = 123X 19 = 142 $\cong$ 150 lamps.

Indication transformer (230V / 24V AC) load on secondary side

$$= \frac{\text{No. of lamps X Wattage}}{\text{Power factor}}$$

$$= \frac{150 \text{ X } 1.2 \text{ W}}{0.8}$$

= 225VA.

Capacity of the indication transformer

= load on secondary side of the transformer X Factor of Safety

= 225VA X 1.5

= 337.5VA

$\cong$ 0.5 KVA

Efficiency of 230V/24V AC transformer = 85%

$$\text{Load on Primary of the Indication Transformer} = \frac{\text{Load on secondary side of the transformer}}{\text{Efficiency}}$$

= 225VA/0.85 = 265 VA ---- (9)

Total A.C LOAD = (3) + (6) + (7) + (8) + (9)

= 680VA+ 620VA + 1111VA + 1111VA + 265VA

= 3787 VA

7.4 Ferro Resonant Voltage Stabiliser (FRVS)

FRVS efficiency = 85%

Total AC load is taken from the output of the FRVS.

$$\text{FRVS I/P LOAD} = \frac{\text{Load on secondary of F R V S}}{\text{Efficiency}}$$

$$= \frac{3787 \text{ VA}}{0.85} = 4455 \text{ VA} \quad \text{------} \quad (10)$$

FRVS rating = 4455VA (No need to take Factor of Safety)

$\cong$ 5 KVA

7.5 Total load of the Installation

Total load of the Installation

= Total DC load on 230V AC side + Total AC load

= (F) + (10)

= 4854 VA + 4455 VA

= 9309 VA

$\cong$ 10 KVA

Required Capacity of D.G Set = Total load in VA X 1.3 (factor of safety for DG set)

= 9309 VA x 1.3 = 12102 VA

$\cong$ 12.5 KVA

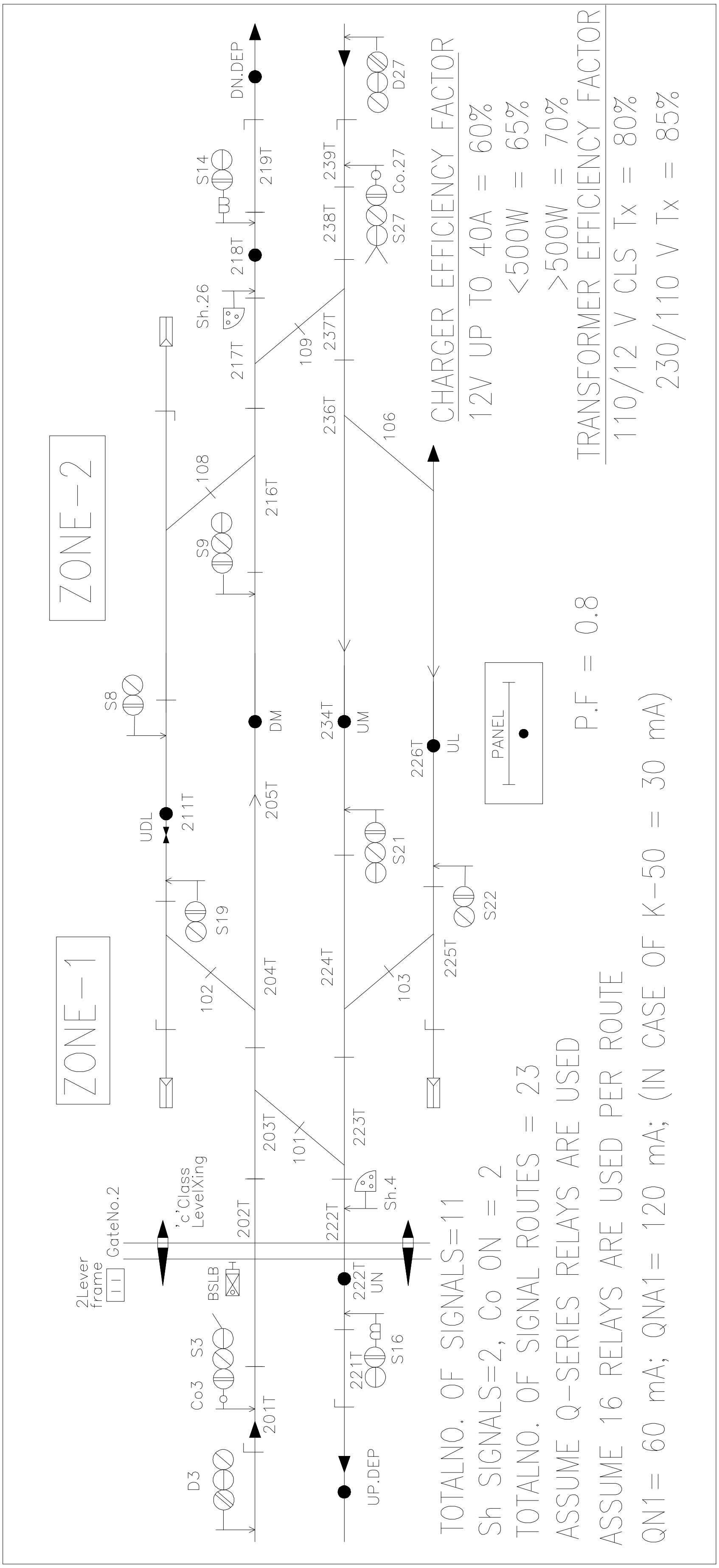


Fig 7.1 POWER LOAD CALCULATION FOR 4-ROAD PANEL INTERLOCKING STATION

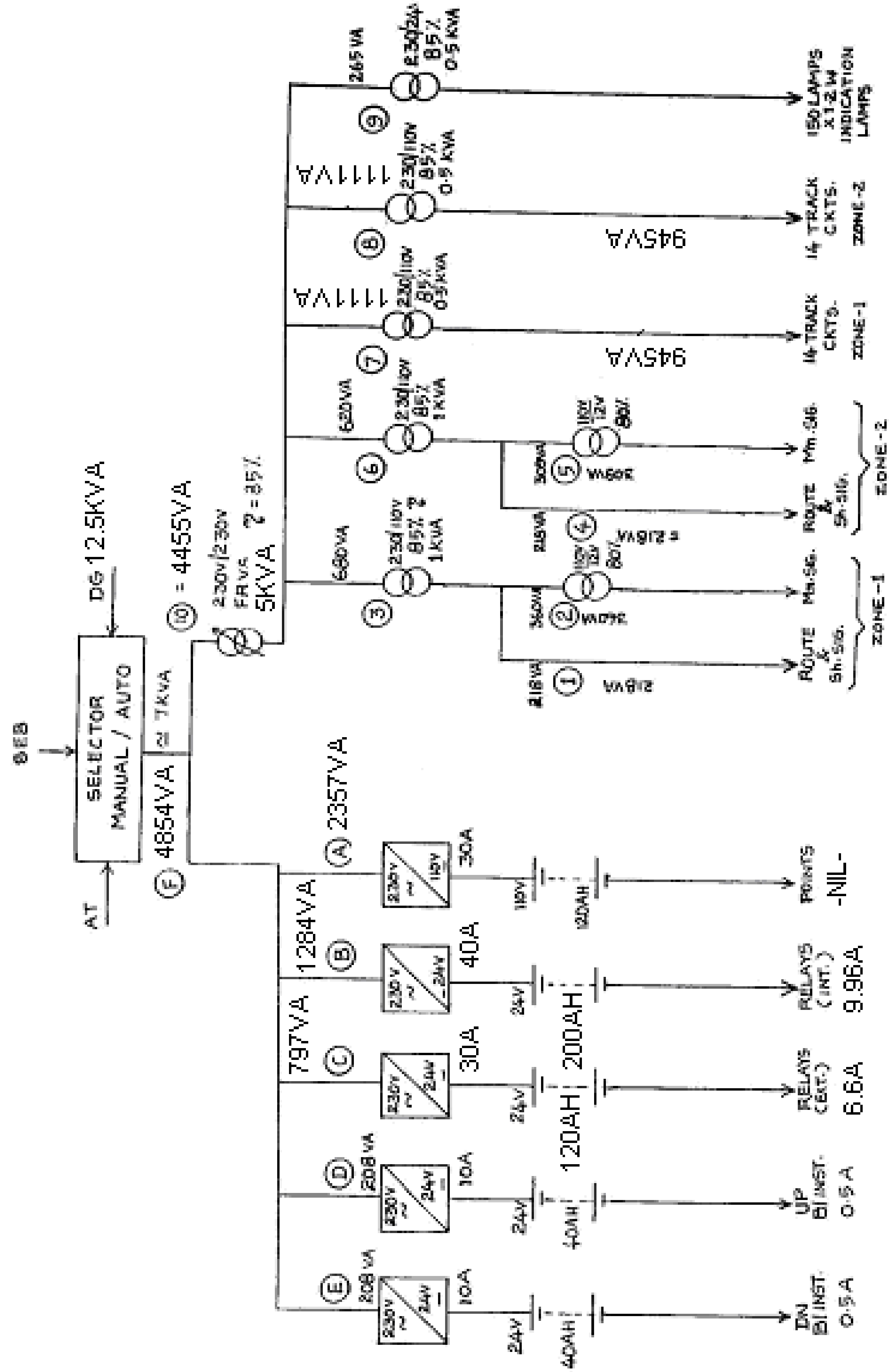

SEB
AT
DG 12.5KVA
SELECTOR
MANUAL / AUTO
≅ 7KVA
4854VA
= 4455VA
230V/230V
FR V.S.
5KVA
2357VA
1284VA
797VA
40A
30A
200AH
120AH
9.96A
6.6A
-NIL-
945VA
945VA
1111VA
1111VA
ZONE-1
ZONE-2

Fig 7.2

* * *

Annexure- I: CELLS

1. A cell is an Electro Chemical system that converts Chemical Energy in to usable Electrical Energy.

It mainly consists of:

(a) Anode : It is a positive electrode

(b) Cathode: It is a negative electrode.

(c) Electrolyte: A medium in the form of solution or paste for transfer of electrons.

2. The functions of electrolyte

(a) To conduct electricity readily one electrode to another electrode.

(b) To provide adequate ions.

(c) To dissolve the products of oxidization of negative electrode.

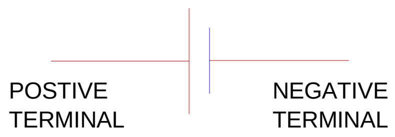
3. Ions

When the external circuit is connected to a cell the current is carried through charged particles called "IONS".

4. Electrolysis

The production of chemical charges by the passage of current through an 'electrolyte' is called electrolysis.

Symbol of a cell:



5. Battery

The combination of cells called Battery. The cells can be connected in series or parallel.

6. Open circuit voltage

It is the voltage across the cell without any external load.

It depends on the

(a) chemical constituents (No. of plates)

(b) Strength of electrolyte.

(c) Temperature of Electrolyte.

7. Capacity of the Cell

It is the amount of current given for a stipulated time. It is expressed in terms of Ampere Hours (AH)

It depends on the

(a) Type of the cell.

(b) Thickness of the plates.

(c) Construction of plates.

(d) The size of the cell.

E.g. 80AH Cell gives 8 Amp Current for 10 Hours.

Cell capacity can be selected depending upon the load current and backup time required.

Required capacity of cell = I_{Normal} X Back up time required X 1.5 (safety factor)

8. Polarisation or Back e.m.f of a cell

During charging or discharging of the cells the ions formed are collected and deposited on the both +ve & -ve electrodes. These ions have a tendency to go back in to the electrolyte, there by leaving them as oppositely charged electrodes. This tendency produces an e.m.f. "This opposing e.m.f, which is produced in an electrolyte due to absorption of gaseous ions by the electrolyte, from the two electrodes is known at the back e.m.f or polarisation". These ions can be neutralised by adding the depolariser.

Let E= Open circuit voltage of cell.

Connect 2 Ω Resistance across the cell for one minute. After 1 minute disconnect 2Ω resistance and measure the open circuit voltage, V (say).

$$\% \text{ polarisation} = \frac{E-V}{E} \times 100$$

% polarisation of a cell is NOT MORETHAN 15%

Polarisation also reduces the conducting area of the plate and so increases the Internal Resistance of the cell.

9. Depolarisation

Removal of gas which collects at the plates of an electric cell during charging or discharging is called Depolarisation. De-polariser is used for the above action.

10. Internal Resistance of cell

The internal resistance of a cell is its total resistance to the flow of current. It is due to the Electrodes, electrolyte, and depolariser, which are not perfect conductors.
The internal resistance (r) of a cell is:

(a) directly proportional to the distance between the electrodes (d)

(b) inversely proportional to the (immersed surface area) area of the electrodes (A)

$$r \propto \frac{d}{D}$$

It also depends on the

(i) Type of electrode
(ii) Aging of electrode
(iii) Aging of depolariser

v = Voltage due to internal resistance.
V1 = Open circuit Voltage (No Load Voltage)
V2 = On load Voltage

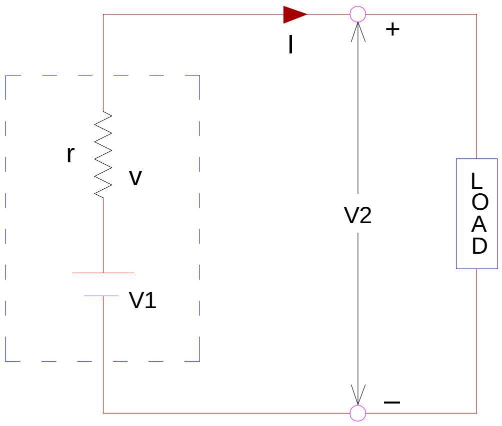


Fig: 1.3

$$V1 = \nu + V2$$

$$\nu = V1 - V2$$

$$\text{Internal resistance} = \frac{\nu}{I}$$

$$= \frac{V1 - V2}{I}\ \Omega$$

$$= \frac{V_{\text{No Load}} - V_{\text{Load}}}{\text{Circuit current}}\ \Omega$$

"Internal resistance of a cell shall NOT be more than 2Ω"

Charging: When the current is passing through the cell from positive plate to negative plate is called charging.

Discharging: When the cell is supplying current to an external circuit called discharging

11. Cells are classified as

(a) Primary Cells

Primary cells are cells in which chemical reactions are irreversible.

E.g. Torch cells, 6I cells, A.D cells etc

(b) Secondary cells

Secondary cells are cells in which chemical reactions are reversible.

E.g. Lead acid cells, Nickel cadmium cells, Nickel – iron cells etc.

* * *

Annexure II: PRIMARY CELLS

1. In primary cells, the active materials of the cell are exhausted /used during the process of providing electric energy and the cell has finished its useful life. In other words, in primary cells the stored chemical energy in the electrolyte is converted into electrical energy and the process is irreversible.

2. Requirements of primary cells

(a) Must be of high and constant terminal voltage.

(b) Must have very low internal resistance.

(c) No polarisation.

(d) No local actions.

(e) Should not emit harmful or injurious fumes.

(f) Initial cost must be low.

(g) Installation charges must be low.

(h) Replacement should be easy & at low cost.

(i) Must be small in size and easy to store.

(j) Maintenance time & cost must be minimum.

3. Primary cells can be sub divided in to

3.1 Dry Cells

In these cells the Electrolyte is in the form of paste these are used mainly to supply a relatively low current for intermittent service

E.g.: Torch Cell and 6 I Cell

(a) Leclanche Dry Cell

Anode : Carbon

Cathode : Zinc

Electrolyte: Ammonium chloride (NH4Cl) + Plaster of Paris.

Depolariser: Manganese dioxide (MnO2) Power.

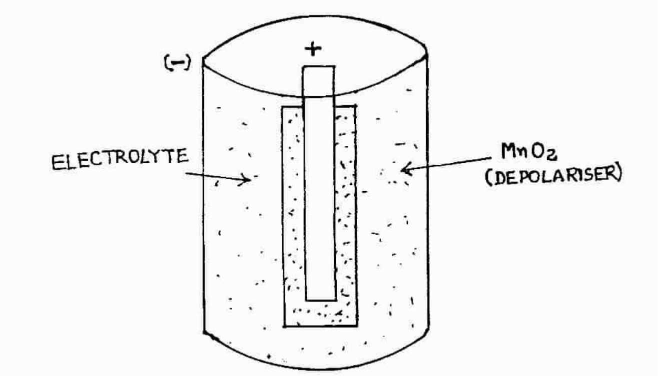


Fig: 2.1

(i) These cells are made in different sizes. Most commonly used cells are Torch Cells, 6I cells. 6 I cells have a long shelf life and capacity, where as Torch cells have a shorter shelf life and capacity.

(ii) A cylindrical Zinc container, which is also the negative electrode, is enclosed with a card board outer wrapping/PVC insulation to avoid damage and to insulate the electrode from the adjacent cells.

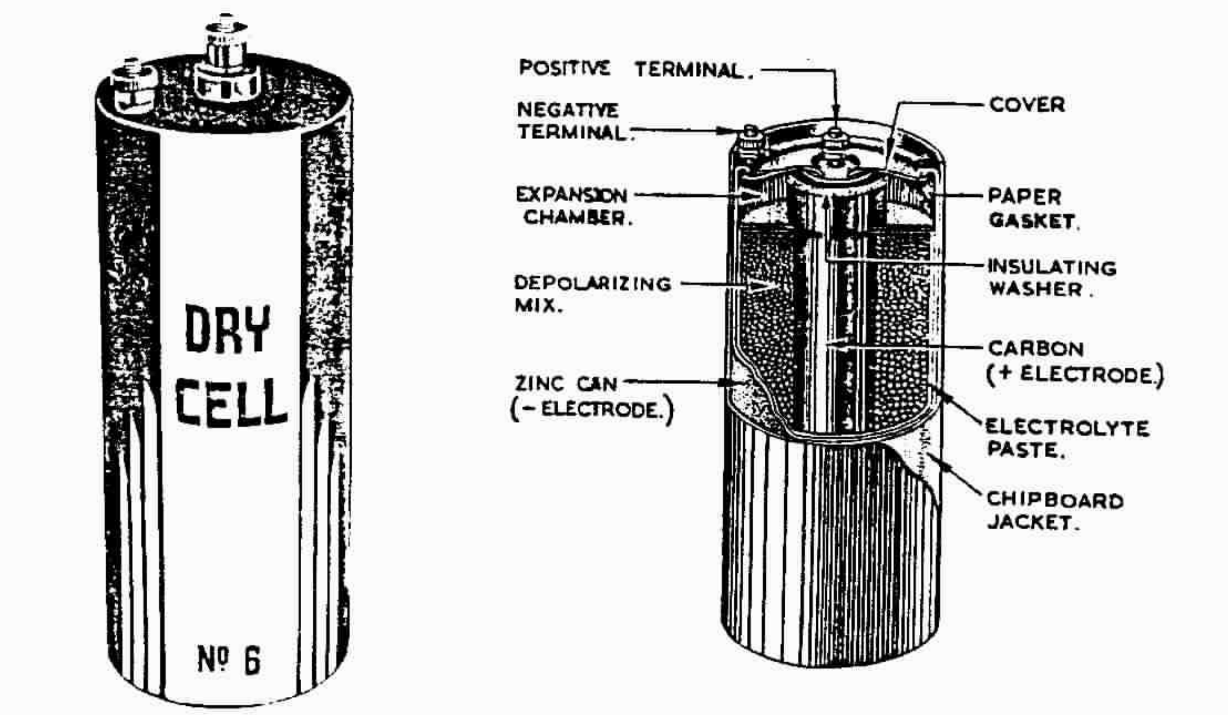


Fig: 2.2 6I DRY CELL – SECTIONAL VIEW

(iii) The positive electrode is a carbon rod surrounded by a depolarizing mixture of manganese dioxide and ground carbon.

(iv) The electrolyte, mixture of ammonium chloride and plaster of Paris or starch or gelatin made up in the form of a paste fill the space between the depolariser and the container.

3.2 Wet Cells

In these cells the electrolyte is in the form of liquid. These are used where higher capacity cells are required.

E.g. Leclanche wet cell

A.D. Cell.

Wet primary cells have been used but these are now replaced by the dry cell or secondary cell for use in the signalling department.

4. The following table gives the brief study of various primary cells

S.No	DESCRIPTION	LECLONCHE DRY	LECLONCHE WET	A.D. CELL
1	Anode (+)	C (Carbon)	C	C
2	Cathode (-)	Zn (Zinc)	Zn	Zn
3	Electrolyte	NH_4Cl + Plaster of Paris	NH_4Cl	NaOH
4	Depolariser	MnO_2	MnO_2	Air
5	Capacity	50AH	50AH to 100AH	500 AH
6	Full Voltage	1.5 V	1.5 V	1.5 V
7	End Point Voltage	1.1 V	1.1 V	0.9 V

5. Maintenance of Primary Cells: (as per SEM part II)

(a) Each cell shall be tested individually with a load of 10Ω Resistance and if the voltage of cell falls below 0.85 V, then the cell shall be discarded.

(b) The voltmeter used for this purpose shall have the sensitivity of not less than 1000Ω per volt.

* * *

Annexure-III
NICKEL-CADMIUM, NICKEL-IRON, LITHIUM-ION & SOLAR CELLS

1. NICKEL – CADMIUM BATTERIES

Anode: Nickel Hydroxide

Cathode: Cadmium Hydroxide

Electrolyte: 30% solution of Potassium Hydroxide.

Porous Nickel plates impregnated with Nickel Hydroxide becomes positive plates and those with Cadmium Hydroxide become Negative plates.

The Nickel plated steel container is lined inside with a separator which isolates the plate stacks from the cell container.

Positive and Negative plates are also insulated from each other by the use of separators.

Each plate has a 'Tab' of Nickel strip welded to it. All positive plate tabs are bunched together and welded to the positive terminal. Similarly Negative terminal.

The Electrolyte used is 30% solution of Potassium Hydroxide (KOH) having a specific gravity of 1300 (1.3)

Each cell has a removable Nylon filter cap for topping up of electrolyte with distilled water. This cap also vents out any excess pressure of air or Hydrogen/oxygen safely.

"Any acid contamination in the Nickel Cadmium (Nicd) battery will cause a permanent damage to the Battery."

Nominal voltage =1.2V/Cell.

End Point Voltage = 1.0V/cell.

With constant voltage charging:

Float charging voltage = 1.3V/Cell.

Boost charging voltage = 1.45V/cell.

1.1 SPECIAL FEATURES

(a) LONG OPERATING LIFE

(i) **Shelf Life**: Nicd batteries can be stored in the WET and USED condition for a period minimum of 4 years without detrimental effects. No damage of any kind takes place when stored in discharged condition, unlike Lead Acid Cells.

(ii) **Cycle Life**: It is about 750 to 1000 cycles at 100% depth of discharge (DOD). At lower DOD the cycle life can be extended to above 2000 cycle.

(iii) **Float Duty**: The Service life of Nicd batteries varies from 10 to 20 years. It is dependent up on the proper maintenance and usage.

(b) CONTINUOUS OVER - CHARGE CAPABILITY

(i) Nicd Cells can accommodate an extended overcharge exceeding 150% at Normal charging rates, without any detrimental effect on performance and life.

(c) HIGH RATE DISCHARGE CAPABILITY

Nicd battery has a VERY LOW INTERNAL RESISTANCE, which enables it to deliver energy at very rapid rate.

The battery can deliver short duration pulses of current at values as high as 10 x C (C= Capacity of the battery)

(d) HIGH RATE CHARGE ACCEPTANCE

It has the ability to accept very high charge rates. By using specially designed charger systems, the charging rate can be increased up to a rapid "C" rate, instead of Normal C/5 rate.

(e) OPERATION AT EXTREME TEMPARATURES

These batteries have excellent performance characteristics even at extreme temperatures. Operating temperature range = -30^{0}C to + 55^{0}C only temporary capacity loss occurs at extreme temperatures.

(f) RUGGED CONSTRUCTION

The Nicd battery is a very rugged device, both mechanically and electrochemically. It has an excellent resistance to shock and vibration. It can also withstand a wide range of physical & environmental conditions.

1.2 CHARGING METHODS OF A NI-CD BATTERY

The charging of Nicd batteries can be with:

Constant current method } by using charger
Constant Voltage method }

Solar Photo Voltaic modules

(a) Constant Current method

The recommended value of constant current charge ratings are 0.1C & 0.2 C, where C= Capacity of the Battery. The recharge time from a fully discharged condition (i.e. from end point voltage of 1.0V/Cell) is 14 Hours for 0.1C charging rate and 7 Hrs. for 0.2 C charging rate.

(b) Constant voltage method

The normal method of constant voltage charging involves current limitation.

Float charging voltage = 1.3 V/Cell.

Boost Charging Voltage = 1.45V/Cell.

(c) Compatibility with SOLAR PHOTO VOLTAIC MODULES

The charge current from the solar panel is fully utilised at rates above C/50. Solar panels can be sized to charge the battery at very high rates without any charge regulations. This is due to the inherent charge regulation properties of the Nicd battery, which causes the voltage to buildup and automatically reduces the current when the battery is fully charged. This prevents over charging of the battery during the summer season.

During the periods of continuous cloudy weather, the battery may get deep discharged. However, when the weather improves, the Nicd batteries will immediately pickup charge. Its life is not affected due to its deep discharge.

The charge retention of Nicd battery is around 80% even after one-month rest period. So, it can be also used as emergency backup source.

2. NICKEL- IRON BATTERIES

(a) In Nickel Iron Cells, the positive plates are made of Nickel-plated steel tubes filled alternate layers of NICKEL HYDRATE and METALLIC NICKEL FLAKES. The tubes are clamped rigidly in a steel frame to form a positive plate.

(b) The Negative plate consists of rectangular pockets of IRON OXIDE and IRON POWDER. These pockets are filled to form a Negative grid.

(c) The Electrolyte is Dilute POTASSIUM HYDROXIDE Solution (Dilute KOH)

(d) Rubber Separators are used between the plates and between the sides of the container and the plates.

(e) The container is made of steel, which is a great advantage of rough usage during handling. The electrolyte KOH has no chemical reaction with steel.

(f) But the electrolyte KOH has chemical reaction with CO_2 in the air. Hence the cells are provided with AIRTIGHT VENT PLUG to prevent the formation of Potassium Carbonate.

(g) SPECIFIC GRAVITY OF THE ELECTROLYTE REMAINS CONSTANT DURING THE CYCLES OF CHARGE AND DISCHARGE. (i.e. irrespective of the charge condition of the cell)

(h) THE VOLTAGE IS :

1.75v/Cell	in fully charged condition
1.2V/Cell	at Normal rate of discharge for a long time
1.15V/Cell	On fully discharged condition
1.1V/Cell	the End point voltage

3. Comparison between Nickel Iron (Ni-Fe) and Lead Acid Cells

(a) The capacity (per lb. weight) of the Ni-Fe Cell is 50% greater than Lead acid Cell.

(b) The steel container of the Ni-Fe Cell is rigid, since made of steel.

(c) Internal Resistance of the Ni-Fe Cell is more. Hence may be short-circuited safely without any damage.

(d) In Ni-Fe cells, the use of steel for tubes, pockets, grids etc eliminates buckling.

(e) Ni-Fe Cells may be

(i) Over Charged

(ii) Over discharged

(iii) Accidental short circuited

(iv) Charged in reverse direction.

(v) Left standing idle in a discharged condition indefinitely, without any injury.

(f) The efficiency of Ni-Fe cell is Low

Efficiency	Ni-Fe Cell	Lead Acid Cell
AH efficiency	70%	90%
WH efficiency	55%	70%

(g) Ni-Fe Cell is free from corrosive acid fumes.

(h) The operational life of Ni-Fe Cell is higher. The average life is 3000 to 4000 cycles of charge & discharge. The active life period may be up to 20 years.

(i) The cost of the Ni-Fe Cell is higher.

(j) Ni-Fe Cell discharges at 5 times of recommended rate in case of emergency

4. Lithium-ion batteries (Li-ion batteries)

Lithium-ion batteries are a type of rechargeable battery in which lithium ions move from the cathode to anode during discharge and from the cathode to the anode during charge.

Lithium-ion batteries are common in portable consumer electronics like cell phones, laptops, etc., because of their high energy-to-weight ratios, lack of memory effect, and slow self-discharge when not in use. In addition to consumer electronics, lithium-ion batteries are increasingly used in defense, automotive, and aerospace applications due to their high energy density. However, certain kinds of mistreatment may cause conventional Li-ion batteries to explode.

The three primary functional components of a lithium-ion battery are the anode, cathode, and electrolyte, for which a variety of materials may be used. Commercially, the most popular material for the anode is graphite. The cathode is generally one of three materials: a layered oxide (such as lithium cobalt oxide), one based on a polyanion (such as lithium iron phosphate), or a spinel (such as lithium manganese oxide), although materials such as TiS_2 (titanium disulfide) originally were also used. Depending on the choice of material for the anode, cathode, and electrolyte, the voltage, capacity, life, and safety of a lithium-ion battery can change dramatically. Recently, nano architectures have been employed to improve the performance of these batteries.

5. Solar Photo Voltaic Module (Spec. No: IRS: S- 84 / 92 with amendment-2)

(a) The basic photovoltaic device, which generates electricity when exposed to sunlight, is called a “Solar Cell”. A ‘Silicon’ Photo-Voltaic cell consists of a thin wafer of ‘silicon’ with its back surface completely silvered. Light rays entering the wafer force the electrons to move towards the rear surface. This results electrical energy is generated when exposed to light. Since light must pass through the front surface to create cell reaction, these photo-voltaic cells are interconnected in grid pattern.

(b) The smallest complete environmentally protected assembly of interconnected solar cells is called “Module”

(c) A group of modules fastened (joined) together, pre-assembled and interconnected, designed to serve as an installable unit in an Array shall be called “Panel”.

(d) A mechanically integrated assembly of modules or panels together with support structure, but exclusive of foundation, tracking, thermal control and other components, as required to form a DC Power producing unit shall be called an “Array”.

(e) 'Solar Photovoltaic Module' is required:

(i) To produce electrical power from solar energy.

(ii) To control, conduct, convert, distribute and store the energy produced by the array.

(f) Photovoltaic cells shall be used in conformity to specification IRS: S-84/92 (Amend. - 2 or latest). Photo voltaic cells shall be arranged in parallel-series array to get desired current-voltage of each module of solar panel.

(g) Each photo voltaic cell is of 0.5 volts and 2.2 Amp.

(h) The recommended values of maximum output power from each module are 4, 6, 9, 12, 30, 32, 35, 40, 50, 70, 80 & 100 watts.

(i) The recommended nominal voltages of each module are 4, 6, 9, 12 and 24 volts.

(j) The purchaser shall, however, specify the output wattage and voltage of the module required by him.

(k) It is used in Railway Signalling installations to supply electric power to:

(i) Signal lighting, controlling relays/switching circuits, reversers, indications, HKT, Lever locks, Block Instruments, Axle counters etc. at a way station operated by Lever Frame or Central Panel Interlocking or at Mid section LC gates etc. if local power supply is not available or unreliable.

(ii) Lighting of semaphore signals with electric lamp, through a twilight switch.

(iii) Operation of signal motors, with a battery bank and inverters, provided on semaphore signals.

(iv) Distant signals.

(v) Provision of power supply for telephones provided in mid section level crossing gates.

(vi) Train actuated warning device based on axle counters for level crossing gate.

5.1 Brief working

(a) The solar radiation falling on the Solar Photo Voltaic modules is converted in to electricity by photovoltaic principle.

(b) The generated current is used to charge the battery bank.

(c) The energy generation is maximum, when solar insolation is maximum and vice-versa.

(d) Insolation: The amount of sunlight reaching an area, usually expressed in Watt-hours per square meter per day.

(e) The solar module under this specification shall consist of the following three main components:

(i) Toughened front glass.

(ii) A suitable mounting frame.

(iii) An assembly of suitably interconnected, silicon solar cells working on the principle of photovoltaic conversion of sunlight into electricity.

(f) The major components used in this system are:

   (i) Solar Photo Voltaic (SPV) modules

   (ii) Solar charge controller cum regulator.

   (iii) LMLA Batteries

(g) The Solar charge controller unit is the interface between SPV module, Battery and load. It shall receive electrical energy from SPV-module and charge battery of suitable capacity, as well as feed the load directly during sunshine. The charge controller shall be suitable for charging either LMLA batteries as per specification IRS: S 88/93 (latest) or VRLA batteries as per specification IRS: S 93/96 A (latest) as required by purchaser.

(h) Solar charge controller cum regulator is a constant voltage controlled charger using PWM technique. It acts as ON switch till batteries reaches regulation set point & thereafter the battery is charged at constant voltage.

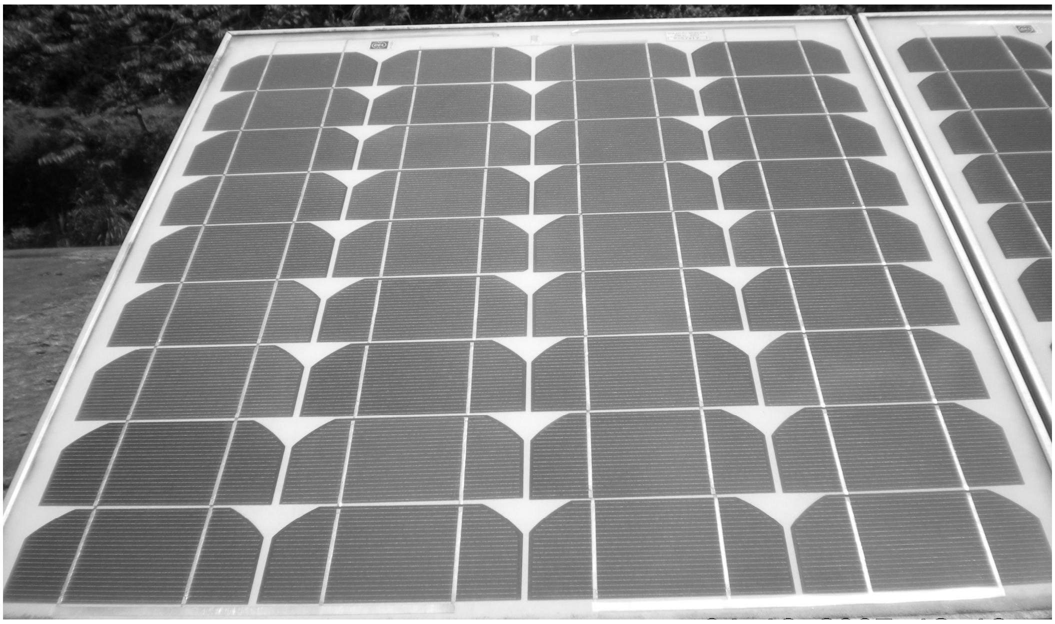


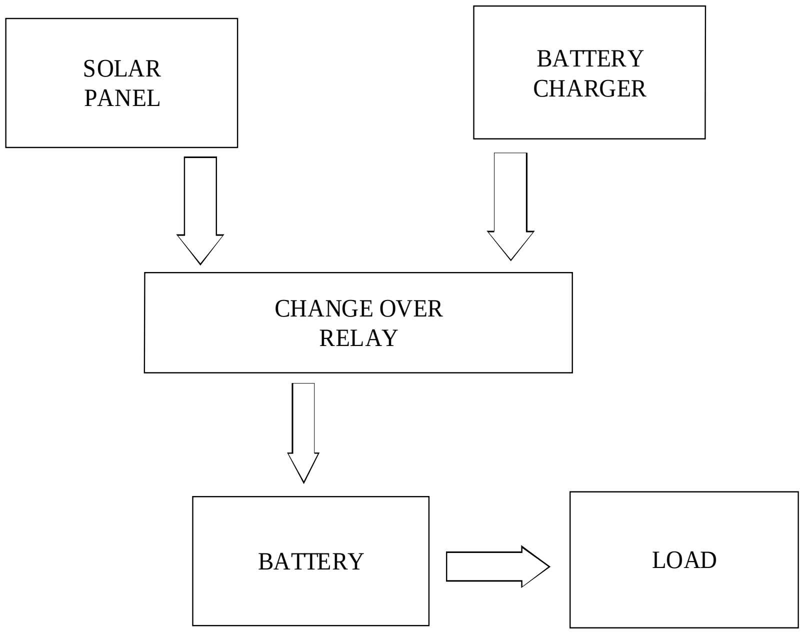
Fig: Solar array

(i) One Solar panel consists of 36 numbers of 0.5V photo voltaic cells connected in series and it gives an output of 12V/35W

(j) Solar panel manufactured by CEL India.

(k) Connecting series parallel combination of panels different voltage with different capacity can be attained which can be used for internal, external, point block circuits in panel station.

INDIVIDUAL SUPPLY

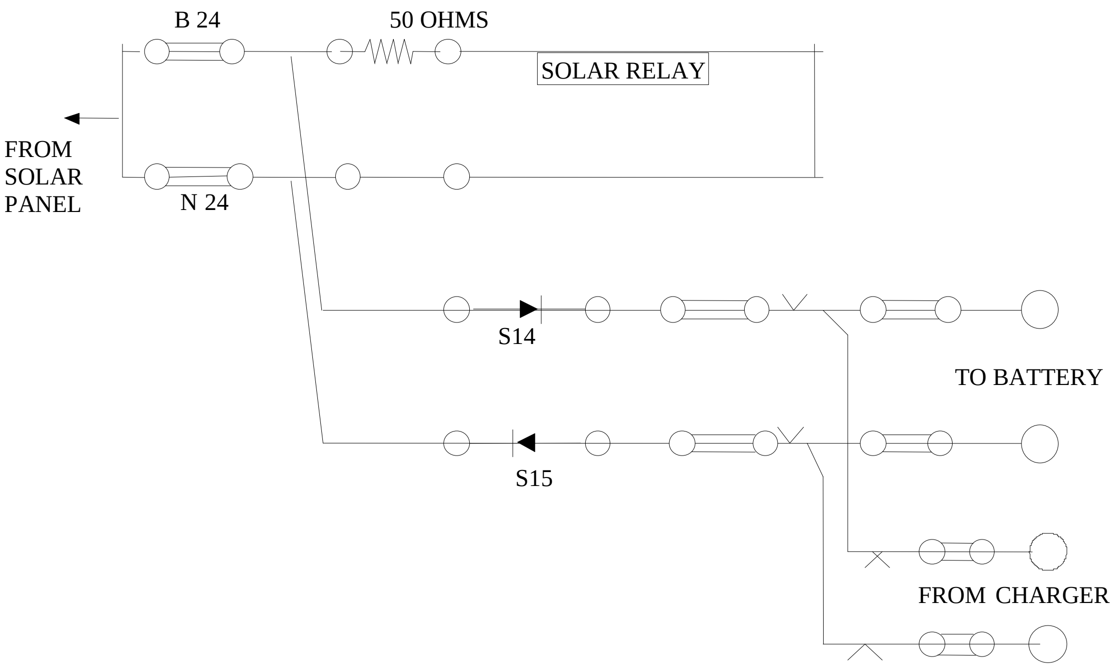


(l) Secondary cells for different circuits namely Internal, External, Point etc were charged through front contact of the Change Over Relay (SOLAR RELAY) with solar supply.

(m) Back contact of the relay is used for charging the cells with electrical charger during night and cloudy weather.

(n) Heavy duty contact change over relay is used for the changeover (PAK 18U-25A)

INTERNAL 24V



In southern Railway this is used in one station named PADIL which is in Palakkad Division. This is a 2 road station with two by pass line. This station is situated at a place there is no normal transportation facility. This station connects Southern Railway, Konkan Railway and South Western Railway. This is in Non RE section and the State Electricity Board supply is frequently fails. Except on rainy days/cloudy weather the batteries of internal, external, block & points are charged by solar panel and it is working without any problem. Since the solar power is freely available this can be put in station for signal supply.

Maintenance is less for solar panels only cleaning is required occasionally. This can be fixed on the roof of the station building which does not occupy useful space. This can be installed with metallic ankles fixing on the roof of the building.

Precautions while fixing the solar panel at stations:

1) The solar panels to be earthed
2) The series connecting diode should be of minimum 25 Amp rating.
3) Fixing of the panel should such a way that maximum sunlight falls throughout the day
4) The change over relay may be minimum 25 Amp rating or QBCA1

Load at PADIL station:

Supply	Load	Battery
INTERNAL	12Amps—(16A)	200AH
External	5Amps ---(8A)	120AH
Point	3Amps ---(7A)	300AH
Block	2Amps ---(5A)	80AH

* * *

Annexure- IV: Transformer 230/110V

IRS: S -72/88 with Amendment-2

1. Transformer is equipment, which step up or step down the input source voltage without change in its frequency.

This ‘230/110V 50 Hz single phase Transformer’ is used as Input voltage source:

(a) To Track Feed Battery Charger used for DC Track circuit

(b) To Color Light Signal Transformer used for lighting of signals.

230/110V Transformers are available with the ratings of 1 KVA, 2 KVA, 3 KVA, 4 KVA, 5 KVA and it is rated for continuous operation.

2. Transformer consists of

(a) Primary winding

(b) Secondary winding

(c) Core

(d) Terminals

(e) Casing

2.1 Core

(a) The Core of Transformer is made of magnetic material. The Core provides a path for the magnetic lines of flux between Primary and Secondary winding of Transformer.

(b) The Core of the Transformer is connected to Earth terminal of the Transformer Casing.

2.2 Primary Winding

(a) The Primary Winding is formed by winding the copper wire of required gauge on the core.

(b) To cater the input voltage variations, different tappings are provided on the Primary Winding. Whenever input voltage is less than or more than the rated input voltage, these tappings are used to give the required output voltage.

(c) The Primary Winding has Tappings at: 0 - 200 - 220 – 230V.

2.3 Secondary Winding

(a) The Secondary Winding is formed by winding the copper wire of required gauge on the core. The output of Secondary Winding is used to connect the load.

(b) Various tappings are provided on the Secondary Winding for adjusting Output Voltage to get required voltage. Whenever output voltage is less than or more than the rated output voltage, these tappings are used to get the required output voltage.

(c) The Secondary Winding is having tappings at: 0 – 110 – 120 – 130V.

2.4 Terminals

(a) The tappings on primary and secondary windings are terminated on "Top Screw Pillar Type" terminals with screws.

(b) Each Terminal consists of:

(i) Terminal Screw – Brass

(ii) Lock Nut or Clamp Nut – Brass

(iii) Washer – Brass

(iv) Binding Nut – Brass

(c) These Terminals are fixed on the Terminal Base plate. This Terminal Base plate is made of Bakelite sheet. On the Terminal Base plate, appropriate voltage is clearly engraved near the Input and Output Terminals.

2.5 Casing

(a) 230/110V Transformer is housed in a Mild Steel Casing of suitable size. Gromates are provided in the casing for incoming and outgoing wires.

(b) The Casing protects all the components of Transformer from dirt, moisture and mechanical damage. The Casing has provision for air circulation to enable natural air-cooling of the Transformer. The Casing prevents access to rodents, insects etc.

(c) An earth terminal with earth marking is provided on the Casing of the Transformer. This earth terminal is connected internally with the core of the Transformer, which is to be earthed.

3. How to select required capacity of the Transformer?

The capacity of the transformer depends on the load to be connected on the secondary side, which is calculated in terms of 'VA' (Volt Amperes).

The capacity of the Transformer is calculated as:

(i) Capacity = Load on Secondary in VA x 1.5

(Where 1.5 = Factor of safety)

(ii) Select nearest higher rating which are:

1 KVA, 2KVA, 3 KVA, 4KVA and 5 KVA

Note: *A single transformer can be used for feeding number of equipments depending upon the load current and the capacity of the transformer.*

4. How to calculate Load on 230V side of Transformer?

$$\text{The Load on 230V side of transformer} = \frac{\text{Load on secondary}}{\text{Efficiency of Transformer}}$$

$$= \frac{\text{Load on secondary in VA}}{0.85}$$

5. Maintenance and Scheduling

(a) Ensure proper rated fuse on power supply distribution board.

(b) Clean the Transformer using blower or any other suitable device.

(c) Ensure that the connecting wires are in good condition.

(d) Ensure that the connections are properly tightened.

(e) Record Primary voltage of the Transformer. In case any change is observed adjust the tappings.

(f) Record Secondary voltage of the Transformer. In case any change is observed adjust the tappings.

(g) Record primary and secondary currents of the transformer. In case any abnormal change is observed replace the transformer.

(h) The voltage and current shall be measured fortnightly.

(a) Insulation Resistance of Transformer shall be measured using Megger annually. The Insulation Resistance between each winding and core shall not be less than 100M Ω.

(b) Check the Transformer 'Earth Terminal' on the casing to external Earth connection. The earth resistance shall not be more 10 Ω.

6. Procedure to know the adequate size of input and output copper wires recommended for Transformer

Let us see the procedure for 1KVA rated Transformer.

Output current of the 230/110V

$$\text{Transformer at Full Load} = \frac{\text{Transformer rating}}{\text{Nominal output Voltage}} = \frac{1000\text{ VA}}{110\text{ V}} = 9.090\text{ A}$$

Efficiency of the Transformer = 0.85

$$\text{Input current at Full Load} = \frac{\text{Transformer rating}}{\text{Nominal input voltage X Efficiency of the Transformer}}$$

$$= 1000/\ (230\text{ X }0.85) = 5.11\text{ A}$$

(a) The gauge of copper wiring shall be such that the current density does not exceed 3Amps/sq.mm.

(b) So, for 5.11 A current the copper wire shall have minimum cross sectional area of 2 sq.mm. Equivalent flexible copper wire for 2 sq.mm. is 28/0.3.

(c) Hence, for 230 V AC input connections to 1 KVA rated Transformer, 2 sq.mm (28/0.3) flexible copper wire is recommended.

(d) Wires used for output connections of the 230/110V Transformer shall carry the rated output current of the Transformer.

(e) So, for 9.090A current the copper wire shall have minimum cross sectional area of 4 sq.mm, Equivalent flexible copper wire for 4 sq.mm is 56/0.3.

(f) Hence, for 110 VAC output connections to 1 KVA rated Transformer, 4sq.mm (56/0.3) flexible copper wire is recommended.

Note:

Cross-sectional Area of the Wire (in sq.mm)	**Equivalent flexible wire**
1	14/0.3
1.5	22/0.3
2	28/0.3
2.5	36/0.3
4	56/0.3
6	85/0.3
10	80/0.4
16	126/0.4

(14/0.3 means 14 strands/each strand diameter is 0.3mm)

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Annexure-V:
DIESEL GENERATOR SET (SINGLE PHASE, 250 V, 50 HZ)

1. The Generator is a compact & robust machine, used to generate electricity in emergency cases of power supply failure. There are various types of Generators like Diesel Generator, Petrol, and Kerosene depending upon the type of fuel used.

In Indian Railways, mostly Diesel Generators are used as standby or main supply where electrification work has not completed or in remote areas like microwave stations/level crossing gates/IBH etc.

Brief Description DG set and Working: Diesel Generator sets are divided into two major sections.

(a) Diesel Engine

(b) Alternator

2. DIESEL ENGINE

It is an internal combustion engine, in which mechanical energy is obtained from thermal energy of fuel through combustion, which takes place in the engine itself.

A diesel engine has no ignition system. In diesel engine the fuel is ignited by contact with hot air which has been highly compressed in the cylinder. A diesel engine draws into its cylinder air along and it compresses this air on its compression stroke before any fuel enters the cylinder.

2.1 Working of Diesel Engine

The internal combustion engines are of two types:

(a) Two stroke cycle

(b) Four stroke cycle

Each cycle can be divided into four operations:

(i) Intake of fuel.

(ii) Compression of fuel.

(iii) Power stroke

(iv) Exhaust of burnt gases.

2.2 Advantage of Diesel Engine over Other

(i) Small consumption of fuel.

(ii) Economy on light load.

(iii) Cheap fuel.

(iv) Greater safety – diesel fuel is non-explosive.

(v) Compactness

(vi) No external ignition system

(vii) Quick starting – ideal for supply emergency power.

(viii) It has no carburetor.

(ix) It has fuel injection pumps.

3. Alternator

An Alternator works on the Faradays law of Electromagnetic Induction. Its main function is to convert the kinetic energy into electrical energy. It has the following salient parts.

(a) Rotor

(b) Starter

(c) Exciter

3.1 Rotor

Rotors are of two types:

(a) Salient pole type.

(b) Smooth cylindrical type.

3.2 Starter

The starter motor is equipped with seal type bearing and requires no lubrication. Starter is insulated on one side with paper or varnish and house in a frame.

3.3 Exciter

The exciter is generally a DC shunt motor or compound generator whose voltage is 250V. In small alternator, the exciter is mounted on the same shaft of the alternator.

4. Storage

If engine is going to remain out of use for considerable period, following points should be done before storing the engine.

(a) Run Engine until it is warm.

(b) Drain the fuel oil from the tank, filter all fuel pipes. Fill in a suitable preservative and turn the engine to remove fuel from high pressure fuel lines and inject.

(c) Drain and flush the lubricating oil system and fill in a suitable preservative of the same SAE number, clean the filter.

(d) Drain all the water from cylinder head and cylinder block by removing the blank water flange on the cylinder block.

(e) Clean the exhaust silencer and spray preservative into this.

(f) Remove the injection nozzle and spray ¼ liter of preservative oil in the cylinder bores. Replace the nozzles.

(g) Clean the engine externally thoroughly.

(h) Cover it to protect from rain and dust.

(i) The starting battery shall be kept on TRICKLE Charge.

(j) Trickle charging current shall be 1 m.A / AH.

5. Installation

The procedure for installation of DG set is recommended as follows:

(a) The foundation of Diesel Engine must perform three functions:

(i) Support the weight of the Engine.

(ii) Maintain the Engine in proper alignment with the driven machinery.

(iii) Absorb vibrations produced by unbalanced forces.

(b) DG sets shall be installed in a separate room of adequate size with proper ventilation.

(c) The diesel generator set shall be mounted on anti-vibration pads.

(d) The exhaust pipe shall be extended outside the generator room and the silencer fixed away from the premises. Exhaust pipe shall be appropriately insulated.

(e) The starting battery shall be of adequate capacity to meet the starting load. Where automatic start has been provided, the generator once started should stop only with a time delay after Main supply is resumed.

(f) The connection between the battery and the DG Set shall be through sufficiently thick wire to avoid drop in voltage.

5.1 SPECIAL ATTENTION ON FOUNDATION

(a) Ground water level should be as low as possible and should be deeper at least one fourth of foundation below base plane. This reduces vibrations.

(b) DG set foundation should be separated from foundations of adjoining structures. If they are very close expansion joints should be provided.

(c) Any hot piping if embedded in the foundation should be properly isolated.

(d) Foundation must be protected from engine oil by means of acid resisting coating.

To achieve the above object the engine should always be installed on a good cement concrete foundation. The composition for concrete is one part cement, two part clean sharp sand and four to five parts of washed ballast. After pouring, the concrete should be allowed to set for at least 48 hours. Before engine is bolted down, in very hot and dry climate the block should be moistened with water during this period.

5.2 ERECTION

The Engine should be leveled up on the foundation block where the Engine is mounted on superstructures, there should be rigid construction leveled, before the engine is bolted down. In case of a direct coupled set, the driven unit must be lined up with the Engine and joined through a flexible coupling. In case of a trolley mounted Engine, the trolley should be parked on the horizontal ground.

6. Electrical Starting

To save the power failure DG sets have to be start with electric starting. Electric starting is to be by DC series motor, which is fed from storage batteries. Battery is either of 12V or 24V.

The starting motor is greased to the fly wheel of Diesel Engine on the circumference. It starts on heavy load of rotating the crank and flywheel requires high starting torque. Since DC series motor has good high starting torque. As torque decreases with increase in speed it also does not get overloaded.

7. Maintenance

To make the operation system more reliable, the maintenance of a diesel engine should be carried out regularly, as mentioned below:

7.1 Daily

(a) Check the lubricating oil level in the sump. Top up if necessary.

(b) Keep fuel tank full. The tank should be full completely with clean fuel oil at the end of day's work.

(c) Clean the engine at the end of day's work. If there are any leakages, dust will collect at the leaky spots during next day's work. Such leakages should be attended promptly.

(d) In case of tank or radiator cooled engines, check the water level and top up if necessary, before starting the Engine.

(e) Run the Engine 5 minutes daily, check working properly or not.

7.2 Weekly Maintenance

(a) Clean the air cleaner completely. Air cleaner are of two types:

(i) Paper air cleaner should be replaced if full.

(ii) Oil air cleaner should be clean with petrol or kerosene or change it.

(b) Clean fuel filter blows.

(c) Check the electrolyte level in the battery. If required top up with distilled water.

(d) Check the cable connection at starter and dynamo.

(e) Check the belt tension of dynamo/Alternator. It should be 8 to10 mm, if required adjust it with the help of Tension adjusting lever.

(f) The brushes should be examined after every 100/150 hrs. running to see that they are bedding properly.

(g) Make sure that the vent hole in fuel tank cap is clear.

(h) Check nut and bolts tighten if found loose.

(i) Check the cooling system is perfect or not, if water cooling, radiator should be full of water. If air cooling, check belt it should not loose.

7.3 Monthly Maintenance

(a) Drain the sump, flush out with approved brand or flushing oil and refill with new oil.

(b) Thoroughly clean out the fuel tank.

(c) Clean filter oil bowl.

(d) Change lubricating oil in the air cleaner after 250 hrs. Operation.

(e) Know out spot from the exhaust silencer.

(f) Clean inlet and exhaust valves, grind valves - decarbonise cylinder.

(g) After 200 hr. of operation examine bearing.

(h) Wash out lubrication oil pipes.

(i) Clean out water spaces in cylinder head and radiator.

7.4 Maintenance Procedure

Type of fuel:

(a) Use clear high speed diesel oil. IS: 1460 or BS : 2869

(b) The fuel oil system includes following fitments for ensuring cleanliness and consequences dependable service of fuel injection equipment for a long period.

(c) Ceramic filter at the bottom of the fuel tank.

All starter connection should be clean and tight. The brushes must slide freely in their holders and make full contact with commutator. Worn out brushes should be replaced.

7.5 Maintenance of Fuel Account

Where standby generators are provided at way side stations for signalling purposes and starting and stopping the standby engine is done by Traffic Staff, suitable instructions for maintenance of fuel account shall be issued locally. The log book shall be maintained by the ASM (Annexure- 14) as per SEM.

7.6 Fuel consumption log book is shown below as per Annexure14, Para 16.12.13.1 of SEM

____________Railway __________ Division

FUEL CONSUMPTION LOG BOOK

Page 1

1. Name of Station:
2. Date of commissioning:
3. Location:
4. Description of Generator:

   (Make, Capacity in KVA, Voltage, Power Factor Speed in RPM, Frequency, No. of Phases, Type of Excitation etc.)

5. Description of Engine:

   (Make, BHP, Speed in RPM, No. of Cylinders, Capacity of Fuel Tank, Fuel, Standard rate of Consumption, Type of start).

Page 2

Date	Time of Start	Time of close	Hours worked	Fuel filled in liters	Signature

8. Problem in General

8.1 Air lock in injection pump

Procedure:

(a) First fill the diesel in tank fully.

(b) Then open the fuel pump bleeding nipple screw and start crank handling until fuel comes out through the nipple.

(c) Tight the nipple screw.

(d) Start the Generator set.

8.2 Nozzle Choking

(a) Disconnect the nozzle from head (cylinder).

(b) Turn the nozzle to opposite then do crank handling, diesel in shape of spray will come out otherwise nozzle is choked.

(c) Clean the nozzle by very thin pin, it will open.

9. Trouble shooting

9.1 Engine Fail to Start

Possible reason may be:

(a) Dirty clogged air cleaner – clean it.

(b) Check fuel tank, if empty – refill it.

(c) Check air in injection pump – Bleed (as procedure given).

(d) Check pressure valve spring – replace if broken.

(e) Check leakage of fuel in external and internal connections.

(f) Check nozzle needing if jam clean or replace it.

(g) Check fuel filter – clean or replace it.

9.2 Engine starts but stops after some time

Check

(a) Air cleaner is clogged – clean it.

(b) No fuel – refuel it.

(c) Air in fuel line – bleed it.

(d) Fuel line is choked – clean it.

(e) Fuel filter is choked – clean it.

(f) Faulty fuel pump – replace it.

(g) Water mixed with fuel – change it.

9.3 Engine not gaining full speed

Possible reasons may be:

(a) Fuel tank may empty – refuel it.

(b) Governor spring is broken – replace it

(c) Dirty choked fuel filter – clean it.

9.4 Engine misses during operation

Possible causes may be:

(a) Air in fuel line – bleed.

(b) Choked fuel injection holes – clean them.

(c) Damaged or dribbling nozzle – replace it.

(d) Faulty fuel pump-replace it.

(e) Water mixed with fuel – change it.

9.5 Engine Lacks Power

Possible reasons may be:

(a) Pump injects insufficient quantity of fuel – readjust it.

(b) Nozzle not tight – provide new nozzle.

(c) Dirty clogged air, cleaner – clean it.

(d) Poor quality of fuel – change it.

(e) Choked fuel line – clean it.

(f) Dirty choked fuel filter – clean it.

(g) Water mixed with fuel – change it.

(h) Dirty cooling system – clean it.

9.6 Excessive smoke at no load

Possible reasons may be:

(a) Dirty clogged air cleaner – clean it.

(b) Choked fuel injection holes – clean it.

(c) Faulty fuel pump – change it.

9.7 Excessive Smoke at full load

Possible reasons may be:

(a) Dirty clogged air cleaner – clean it.

(b) Poor quality of fuel – use proper grade of fuel.

(c) Choke fuel injector holes – clear it.

(d) Nozzle damaged – replace it.

(f) Faulty fuel pump – replace it.

(g) Engine over loaded – adjust the load.

(h) Broken seized/worn-out piston rings – replace them.

(i) One or more cylinder not working – check and repair it.

(j) Engine needs overhauling – send for over hauling.

9.8 Engine gives out Blue smoke

Possible reason may be:

(a) Worn-out liner on piston – replace it.

(b) Wrong grade lubricating oil used.

(c) Engine used after a long time – ensure weekly starting.

9.9 Engine gives out White Smoke

This is due to:

(a) Water mixed with fuel.

9.10 Engine over heats

Possible causes may be:

(a) Faulty fuel pump – replace it.

(b) High exhaust back pressure – release the pressure.

(c) Wrong grade of lubricating oil used. – use fresh.

(d) Clogged oil passage – clear the passage.

(e) Faulty relief valve setting – adjust it.

(f) Loose fan belt – adjust it.

(g) Air leakage through cowling – repair it.

(h) Engine oil not changed – change oil.

(i) Engine over loaded – adjust the load.

(j) Broken/worn-out piston rings – replace them.

(k) Damaged main or connecting bearings – replace them.

9.11 Excessive Vibrations

Possible reasons are:

(a) Engine needs overhauling – Manufacturer representative or skilled mechanic should carry out O/H.

(b) Loose fly wheel

(c) Battery run down – Battery to be charge in boost mode or replace if defective.

9.12 Excessive fuel consumption

Possible reasons may be:

(a) Dirty clogged air cleaner – clean it.

(b) Poor quality of fuel – use proper grade oil.

(c) External/internal fuel leakage – checks it and prevent.

(d) Faulty fuel pump – replace it.

(e) Engine overloaded – adjust the load.

(f) Broken worn-out piston rings – replace them.

(g) Worn-out liner of piston – replace them.

(h) Damaged main or connecting bearing – replace them.

(i) Injector need adjustment – adjust it.

(j) Incorrect value of fuel timing – adjust properly.

9.13 Voltage Regulation is unsatisfactory

Possible causes may be:

(a) Incorrect speed of prime mover – Adjust the speed of prime mover to correct Value on no load or full load. The speed should be between 1560-1570 RPM on No Load and 1500 RPM at full load.

(b) Air gap of compounding transformer not correct – adjust it properly.

9.14 Over heating of Alternator

May be due to:

Excessive room temp/Improper ventilation-Machine should be installed in good ventilated room with exhaust fan.

(a) Misalignment – Check alignment and adjust.

(b) Faulty foundation – Reconstruct the foundations and properly level it.

(c) Over loading of machine – Check the load Current, if more than reduce the load.

(d) Block of ventilation holes – Clean the inlet and outlet holes.

9.15 Over heating of Armature

Possible causes may be:

(a) Overloading	– Adjust the load.
(b) Internal short circuit	– rewind the armature.

10 Do's and Don'ts

Do's:

(a) Ensure proper cleaning of air cleaner and fuel filter.

(b) Before starting ensure full tank of diesel in the tank.

(c) Connect the load only when generator voltage regulation is normal.

(d) Before starting the DG open the door and windows for proper ventilation.

(e) Check that engine running without load for few minutes before stopping.

(f) After every 100 hrs. running, check brush are bedding properly and having correct pressure.

(g) Change the lubricating oil periodically or after every 120 hours of running.

(h) Check the load current is within limit as prescribed in the machine plate.

(i) Clean the inlets and outlets ventilation weekly.

Don'ts:

(a) Don't mix water into fuel.

(b) Don't mix different grades of grease.

(c) Don't pour diesel when engine is running.

(d) Don't start the engine without checking the level of lubricating oil.

(e) Don't start the engine without opening fuel taps.

(f) Don't start the engine with load, first start the engine and allow it to gain full speed then put the load.

(g) Don't smoke in the Generator room and also don't keep inflammable goods in Generator room.

(h) Don't forget to clean silencer after every three-six months positively.

11 Spares and Consumables

The recommended spares are below, which are to be kept by DG mechanic:

(a)	Fuel Filter	2 Nos.
(b)	Oil Filter	2 Nos.
(c)	Fuel Pipe	2 set
(d)	Pressure pipe	1 No.
(e)	Air cleaner	1 No.
(f)	Nozzle	2 Nos.
(g)	Ring set	1 No.
(h)	Fan belt	2 Nos.
(i)	Grease	
(j)	Lubrication oil	
(k)	Cotton waste 'A' grade	

12 Tools

(a)	Hammer	2.5 Lbs.
(b)	Chisel	1 No.
(c)	Punch	1 No.
(d)	File flat	1 No.
(e)	File round	1 No.
(f)	File half round	1 No.
(g)	Spanner set	1 No.
(h)	Ring spanner set	1 No.
(i)	Box spanner set	1 No.
(j)	Calipers	1 No.
(k)	Filter gauge	1 No.
(l)	Grease Gun	1 No.
(m)	Valve lifter	1 No.
(n)	Screw driver set	1 No.

13 Duty Cycle

The generating sets should be run for a period of 18 to 20 hours maximum in 24 hours. As per the discussions of Signalling standards committee most of the CSTEs recommended that the life of the DG set is 15 Years.

* * *

Annexure-VI
Transients, Lightning, Surge Protection Systems and Earthing

It has been observed that a significant no of equipment failures were caused due to inadequate Protection against Lightning / Surge voltages or poor earthing. With the introduction of Electronic devices such as Axle Counters, Electronic Interlocking in Signalling , the subject has acquired more importance as these are vulnerable to Lightning / Surge voltages/ Earthing.

1. Transients

As the name implies, a transient condition on a power line, signal line or data line is an occurrence that is transient in nature. It is mostly unpredictable, and very quick in nature. Other common used words for transients are: "surge voltage", "spike", "voltage or current impulse" or "surge". A voltage or current transient can occur in microseconds. Fig. below shows the effect of a voltage transient induced onto a sine wave.

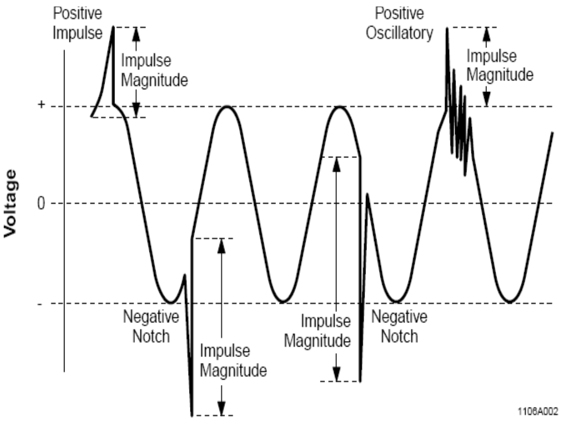


Fig.1: Effects of Voltage Transient on an AC Sine Wave

Transients result from natural occurrences (lightning), electrostatic discharge, or the use of certain types of electrical equipment either inside or outside the building. Transients generally fall into two categories: a) Impulse Transients and b) Oscillatory or Switching Transients.

Lightning is the most potentially damaging; however, switching events are extremely common and over the time will lead to the damage of equipments.

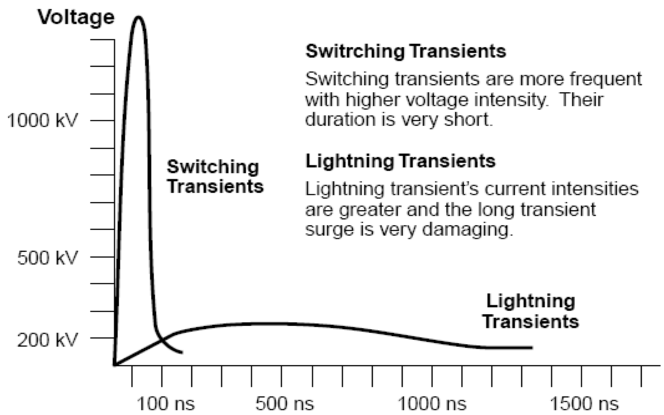


Fig.2: Characteristic Values of Transients

Electric utilities are also a source of many externally generated events. Capacitors are used by the utilities to correct the power factor on the grid. This is done to reduce losses and to support the voltage on the system. The downside is that the switching action can interact with the inductance of the power system to yield oscillatory transients when switched.

2. Phenomena of Lightning

Lightning is natural phenomenon. It is an unpredictable event. A lightning strike is essentially a high amplitude direct-current pulse with a well-defined waveform. During the lightning, pulses of amplitude ≈200 KA with wave shape of 10/350 ms are generated. Current rise times vary between 0.1 - 100 µs. There is no single technology that can eliminate the risk of lightning and its transients. While there are several types of lightning, the type that concerns us is the **cloud to ground** lightning.

Most lightning that reaches the ground (75% to 90%) is negatively charged. It begins to intercept the ground by lowering a stepped leader - a precursor to the actual lightning discharge. This leader progresses in steps toward the ground and is comprised of electric charge. It completes this process in a time period of tens of milliseconds.

Lightning effects can be DIRECT or INDIRECT. Direct lightning currents effects in 10/350 µsec where as Indirect lightning effects in 8/20 µsec.

The 10/350µsec waveform describes two parameters of an impulse of energy. The “10” denotes the amount of time in µsec, it takes to achieve 90% of its rise to peak amplitude. The “350” refers to the duration in µsec, it takes for the trailing edge to diminish down to 50% of that peak. Duration of 350µsec along with a high peak current will cause damage in almost all semiconductor based protection devices.

Surge effects can cause damage to sensitive electronic control systems through direct, inductive, and capacitive coupling. Each of these coupling can be potentially damaging.

3. Lightning and Surge Protection Systems

The principle of lightning protection systems is to intercept the lightning event by providing it a preferential attachment point on a structure and guiding it safely to earth through a preferred path.

A typical lightning and Surge protection system for a structure housing sensitive electronics equipments thus has two major subsystems:

(a) External Protection subsystem

(b) Internal Surge Suppression subsystems.

(a) External Protection (First Stage Protection): Class-A Protection

The external subsystem, also called as first stage protection or Class-A protection, essentially involves providing a preferred path to the lightning strike so that most of it can be diverted to ground and thereby preventing it from entering into the structure.

Main components of the external protection system are:

(i) Strike Termination

Strike terminations are objects that intercept the lightning event. Commonly pointed metal rods are used for this purpose and are termed as “Air Terminals” or “Lightning Rods.”

(ii) Down Conductors, Bonding and Shielding

This is an electrical path of low impedance that connects the strike termination subsystem to the grounding subsystem. Down conductors should be installed in a safe manner through a known route, outside of the structure. Gradual bends (min. eight inch radius) should be adopted to down conductors to avoid flashover problems.

Connector bonding should be thermal, not mechanical. Mechanical bonds are subject to corrosion and physical damage.

Shielding is an additional line of defense against induced effects. It prevents the higher frequency electromagnetic noise from interfering with the desired signal. It is accomplished by isolation of the signal wires from the source of noise.

(iii) Grounding

The grounding subsystem sinks the lightning current into the earth. The key parameter for the grounding system is low impedance. The impedance of the grounding system is inclusive in the overall impedance of the lightning protection system, so a high impedance grounding system can increase the chance of flashover and other damaging effects.

(b) Internal Surge Suppression System (Class B, C & D Protection)

The external protection system transfers 50% of lightning energy to the ground and remaining 50% energy enters the structure through various services such as power cable, communication cable, pipe lines etc.,

To protect equipments from damage, surge voltage limiting and arresting components based on different technologies available are gas filled surge voltage arrestors, arc-chopping spark gaps, Metal Oxide Varistors and surge suppressor diodes.

Stage1 protection is of Class B type, against Lightning Electro-Magnetic Impulse (LEMP) & other high surges, provided at Power Distribution Panel. It is provided with a 63Amp fuse in phase line and is connected between Line and the Neutral and also between the Neutral and Earth.

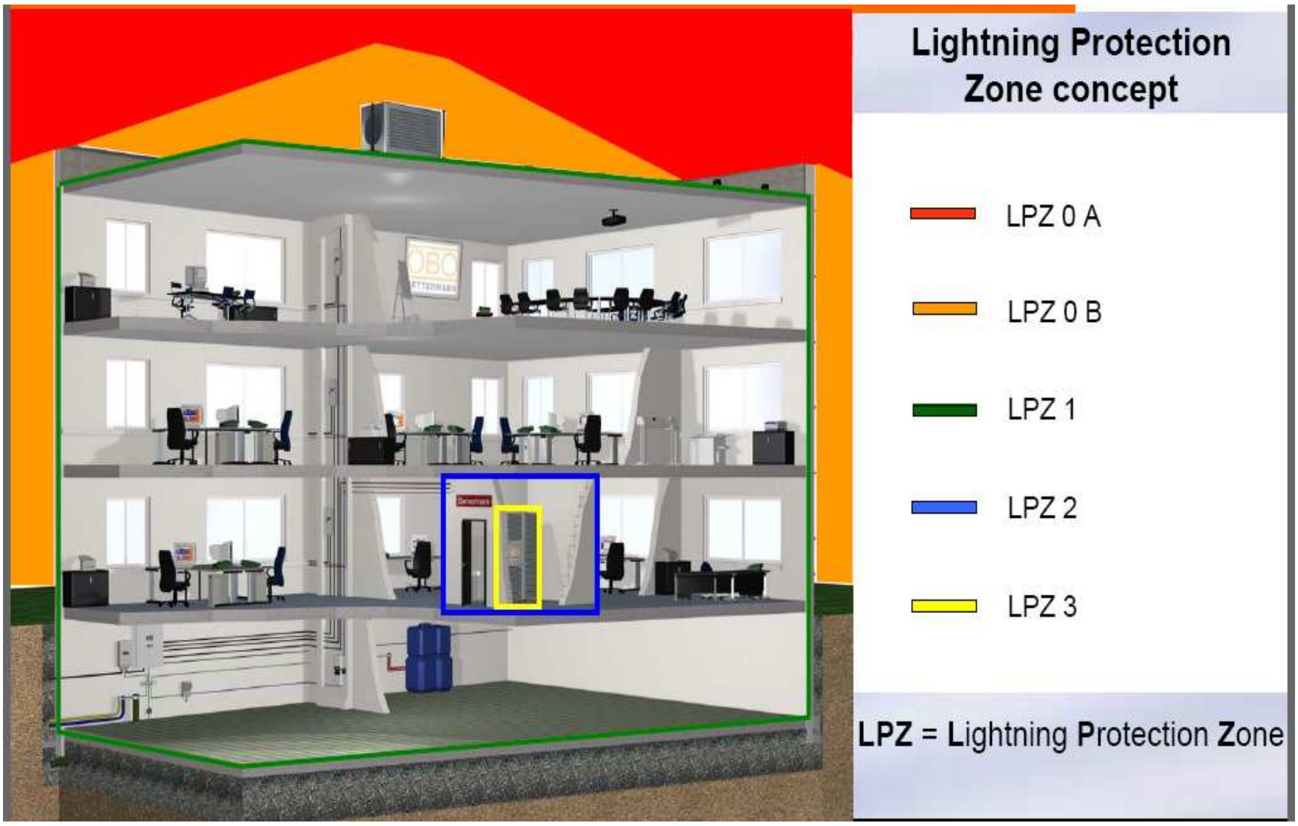
Stage2 protection (Power line protection at Equipment level) is of Class C type, against low voltage surges, provided at the equipment input level. This is thermal disconnecting type and equipped with protection against SPD (surge protection device) failure due to open & short circuit of SPDs and is connected between the Line and the Neutral.

Stage3 protection (Protection for signalling/data line) is of Class D type. All external data/ signalling lines (AC/DC) shall be protected by using this Class D type device. It consists of a combination of Varistors and Gas Discharge Tube with voltage and current limiting facilities.

If supply / data / signalling lines (AC/DC) are carried through overhead wires or cables above ground to any nearby building or any location outside the equipment room, additional protection of Stage2 type shall be provided at such locations.

To make these protection devices effective, proper grounding is required to be connected to these systems.

Class A Device	Class B Device	Class C Device
		



Lightning Protection Zone Concept According to IEC 61312-1 & IEC 62305-4

As there is no single technology / method that can eliminate the risk of lightning and its transients. IEC has recommended a series of protection measures by dividing in to zones shown above.

LPZ 0: Unprotected zone outside the building.

LPZ 0A :Direct lighting action. No shielding against Lightning (LEMP)

LPZ 0B :Zone protected by external lightning protection system.

Zone LPZ 1 -3: Inside the building

LPZ 1 : Low partial lightning energies possible

LPZ 2 : Low Surge Possible

LPZ 3 : No interference pulses though LEMP or surges present (inside equipment)

4. EARTHING AND BONDING SYSTEM FOR SIGNALLING EQUIPMENTS (Ref: SPECN. No. RDSO/SPN/197/2008)

This topic covers earthing & bonding system to be adopted for signalling equipments with solid state components which are more susceptible to damage due to surges, transients and over voltages being encountered in the system due to lightning, sub-station switching etc. These signalling equipments include Electronic Interlocking, Integrated Power supply equipment, Digital Axle counter, Data logger etc.

The first step in providing effective personnel and equipment protection is preparing a low impedance grounding electrode or grounding electrode system at each equipment housing room.

Once the low impedance earth ground is established for a signal housing, the apparatus in the house should be connected to the earth ground as described in the following sections

4.1 Importance of Earthing

The installation and maintenance of an effective low resistance earthing system is essential due to the following:

(a) Efficiently dissipate heavy fault currents and electrical surges, both in magnitude and duration, to protect equipment being damaged so as to minimize down time, service interruption and replacement cost.

(b) Provide a stable reference for electrical and RF circuits at the installation to minimize noise during normal operation.

(c) Protection of personnel who work within the area from dangerous electric shock caused due to “step potential” or “touch potential”.

4.2 Characteristics of good Earthing system

(a) Excellent electrical conductivity

(i) Low resistance and electrical impedance.

(ii) Conductors of sufficient dimensions capable of withstanding high fault currents with no evidence of fusing or mechanical deterioration.

(iii) Lower earth resistance ensures that energy is dissipated into the ground in the safest possible manner.

(iv) Lower the earth circuit impedance, the more likely that high frequency lightning impulses will flow through the ground electrode path, in preference to any other path.

(b) High corrosion resistance

(i) The choice of the material for grounding conductors, electrodes and connections is vital as most of the grounding system will be buried in the earth mass for many years. Copper is by far the most common material used. In addition to its inherent high conductivity, copper is usually cathodic with respect to other metals in association with grounding sites, which means that it is less likely to corrode in most environments.

(c) Mechanically robust and reliable.

4.3 Location for Earth

(a) Low lying areas close to the building or equipment are good for locating Earth Electrodes.

(b) The location can be close to any existing water bodies or water points but not naturally well-drained.

(c) Dry sand, lime stone, granite and any stony ground should be avoided.

(d) Earthing electrode should not be installed on high bank or made-up soil.

4.4 Acceptable Earth Resistance value

The acceptable Earth Resistance at earth busbar shall not be more than 1 Ω.

4.5 Components of Earthing & Bonding system

The components of Earthing & Bonding system are Earth electrode, Earth enhancement material, Earth pit, Equi-potential earth busbar, connecting cable & tape/strip and all other associated accessories.

4.6 Design of Earthing & Bonding system

4.6.1 Earth Electrode

(a) The earth electrode shall be made of high tensile low carbon steel circular rods, molecularly bonded with copper on outer surface to meet the requirements of Underwriters Laboratories (UL) 467-2007 or latest. Such copper bonded steel cored rod is preferred due to its overall combination of strength, corrosion resistance, low resistance path to earth and cost effectiveness.

(b) The earth electrode shall be UL listed and of minimum 17.0mm diameter and minimum 3.0 meters long.

(c) The minimum copper bonding thickness shall be of 250 microns.

(d) Marking: UL marking, Manufacturer’s name or trade name, length, diameter, catalogue number must be punched on every earth electrode.

(e) Earth electrode can be visually inspected, checked for dimensions and thickness of copper coating using micron gauge. The supplier shall arrange for such inspection at the time of supply, if so desired.

4.6.2 Earth Enhancement material

Earth enhancement material is a superior conductive material that improves earthing effectiveness, especially in areas of poor conductivity (rocky ground, areas of moisture variation, sandy soils etc.). It improves conductivity of the earth electrode and ground contact area.

Earth enhancement material shall have following characteristics:

(a) Shall mainly consist of Graphite and Portland cement. Bentonite content shall be negligible.

(b) Shall have high conductivity, improves earth’s absorbing power and humidity retention capability.

(c) Shall be non-corrosive in nature having low water solubility but highly hygroscopic.

(d) Shall have resistivity of less than 0.2 ohms-meter. Resistivity shall be tested by making a 20cm. cube of the material and checking resistance of the cube at the ends. The supplier shall arrange for such testing at the time of supply, if so desired. Necessary certificate from National/ International lab for the resistivity shall also be submitted.

(e) Shall be suitable for installation in dry form or in a slurry form.

(f) Shall not depend on the continuous presence of water to maintain its conductivity.

(g) Shall be permanent & maintenance free and in its "set form", maintains constant earth resistance with time.

(h) Shall be thermally stable between -100 C to +600 C ambient temperatures.

(i) Shall not dissolve, decompose or leach out with time.

(j) Shall not require periodic charging treatment nor replacement and maintenance.

(k) Shall be suitable for any kind of electrode and all kinds of soils of different resistivity.

(l) Shall not pollute the soil or local water table and meets environmental friendly requirements for landfill.

(m) Shall not be explosive.

(n) Shall not cause burns, irritation to eye, skin etc.

(o) Marking: The Earth enhancement material shall be supplied in sealed, moisture proof bags. These bags shall be marked with Manufacturer's name or trade name, quantity etc.

4.6.3 Backfill material

The excavated soil is suitable as a backfill but should be sieved to remove any large stones and placed around the electrode taking care to ensure that it is well compacted. Material like sand, salt, coke breeze, cinders and ash shall not be used because of its acidic and corrosive nature.

4.6.4 Earth Pit

(a) **Construction of unit earth pit:** Refer typical installation drawing no. SDO/RDSO/E&B/001.

(i) A hole of 100mm to 125mm dia shall be augured /dug to a depth of about 2.8 meters.

(ii) The earth electrode shall be placed into this hole.

(iii) It will be penetrated into the soil by gently driving on the top of the rod. Here natural soil is assumed to be available at the bottom of the electrode so that min. 150 mm of the electrode shall be inserted in the natural soil.

(iv) Earth enhancement material (minimum approx. 30-35 kg) shall be filled into the augured/dug hole in slurry form and allowed to set. After the material gets set, the diameter of the composite structure (earth electrode + earth enhancement material) shall be of minimum 100mm dia covering entire length of the hole.

(v) Remaining portion of the hole shall be covered by backfill soil, which is taken out during auguring /digging.

(vi) A copper strip of 150mmX25mmX6mm shall be exothermically welded to main earth electrode for taking the connection to the main equi-potential earth busbar in the equipment room and to other earth pits, if any.

(vii) Exothermic weld material shall be UL listed and tested as per provisions of IEEE 837 by NABL/ ILAC member labs.

(viii) The main earth pit shall be located as near to the main equi-potential earth busbar in the equipment room as possible.

(b) Construction of loop Earth by providing multiple earth pits

(i) At certain locations, it may not be possible to achieve earth resistance of ≤1ohm with one earth electrode /pit due to higher soil resistivity. In such cases, provision of loop earth consisting of more than one earth pit shall be done. The number of pits required shall be decided based on the resistance achieved for the earth pits already installed. The procedure mentioned above for one earth pit shall be repeated for other earth pits.

(ii) The distance between two successive earth electrodes shall be min. 3mtrs. and max. upto twice the length of the earth electrode i.e. 6 mtrs. approx.

(iii) These earth pits shall then be inter linked using 25X2 mm. copper tape to form a loop using exothermic welding technique.

(iv) The interconnecting tape shall be buried at depth not less than 500mm below the ground level. This interconnecting tape shall also be covered with earth enhancing compound.

(c) Measurement of Earth resistance

The earth resistance shall be measured at the Main Equi-potential Earth Busbar (MEEB) with all the earth pits interconnected.

(d) Inspection Chamber

(i) A 300X300X300 mm (inside dimension) concrete box with smooth cement plaster finish shall be provided on the top of the pit. A concrete lid, painted black, approx. 50 mm. thick with pulling hooks, shall be provided to cover the earth pit.

(ii) Care shall be taken regarding level of the floor surrounding the earth so that the connector is not too deep in the masonry or projecting out of it.

(iii) On backside of the cover, date of the testing and average resistance value shall be written with yellow paint on black background.

4.7 Equipotential Earth Busbar and its connection to equipments & Surge protection devices in the Equipment room:

4.7.1 Equi-potential earth busbars

There shall be one equi-potential earth busbar for each of the equipment room i.e. IPS/Battery charger room and EI/Relay room. The equi-potential earth busbars located in individual rooms shall be termed as Sub equi-potential busbars (SEEB). The equi-potential earth busbar located in the IPS /Battery charger room and directly connected to Class ‘B’ SPDs and the main earth pit shall be termed as Main equi-potential earth busbar (MEEB).

The EEBs shall have pre-drilled holes of suitable size for termination of bonding conductors. The EEBs shall be insulated from the building walls. Each EEB shall be installed on the wall with low voltage insulator spacers of height 60mm. The insulators used shall have suitable insulating and fire resistant properties for this application. The EEBs shall be installed at the height of 0.5m from the room floor surface for ease of installation & maintenance. All terminations on the EEBs shall be by using copper lugs with spring washers.

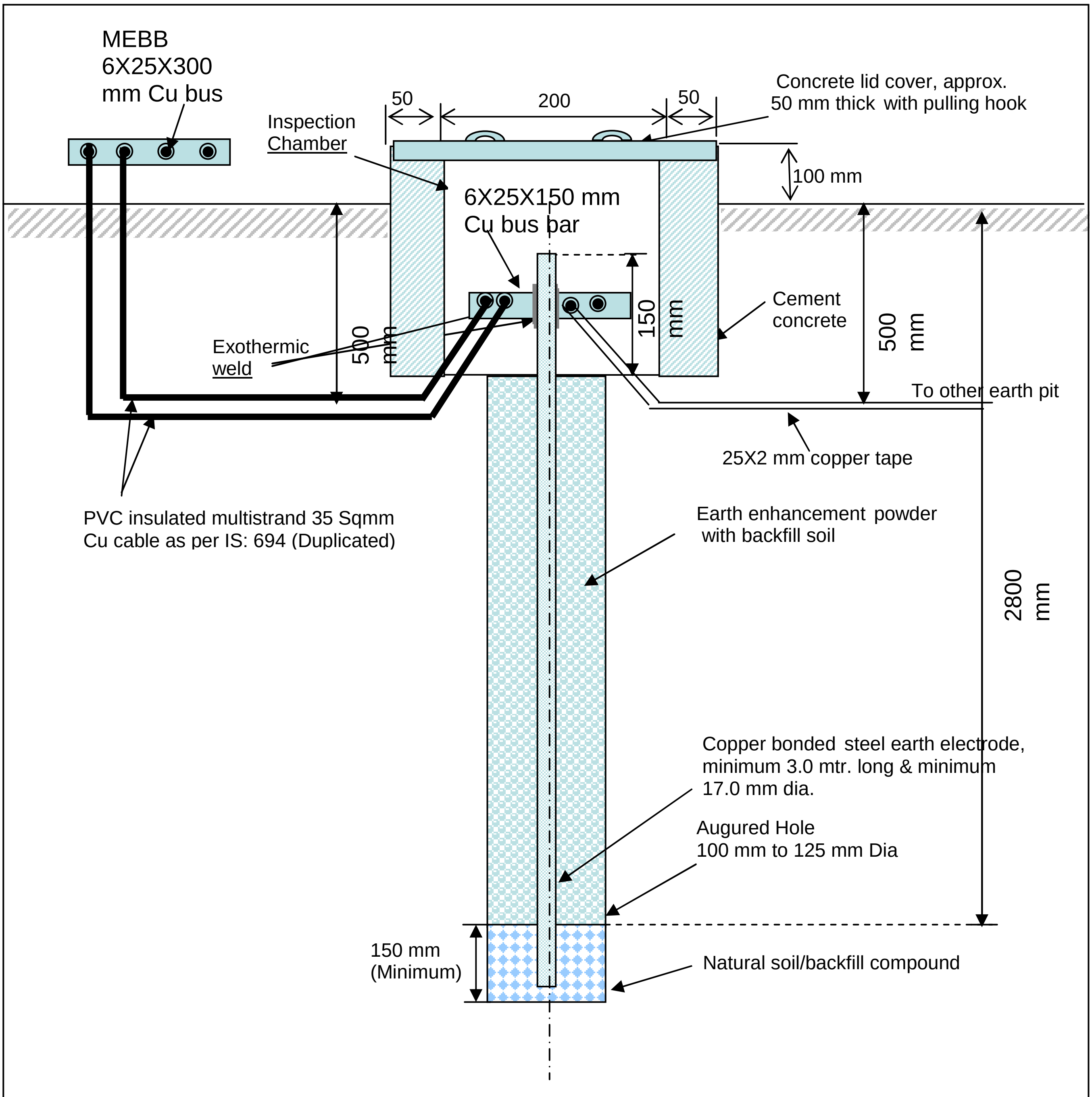
4.7.2 Bonding Connections

To minimize the effect of circulating earth loops and to provide equi-potential bonding, “star type” bonding connection is required. As such, each of the SEEBs installed in the rooms shall be directly connected to MEEB using bonding conductors. Also, equipment/racks in the room shall be directly connected to its SEEB. The bonding conductors shall be bonded to their respective lugs by exothermic welding.

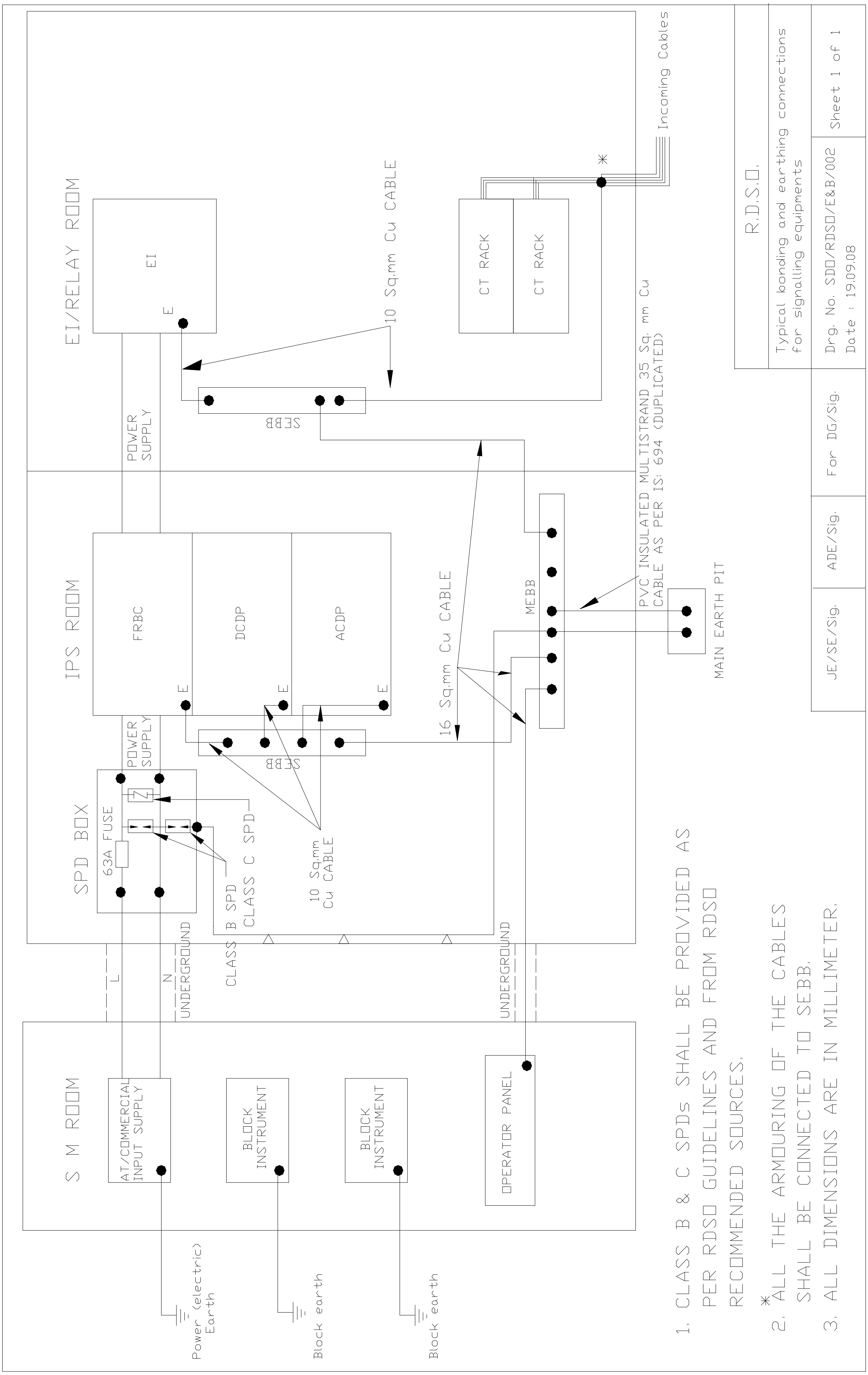
4.7.3 All connections i.e routing of bonding conductors from equipments to SEEB & from SEEBs to MEEB shall be as short and as direct as possible with min. bends and separated from other wiring. However, connection from SPD to MEEB shall be as short as possible and preferably without any bend.

4.7.4 Materials and dimensions of bonding components for connection of individual equipments with equipotential bus bar and earth electrode shall be as given below.

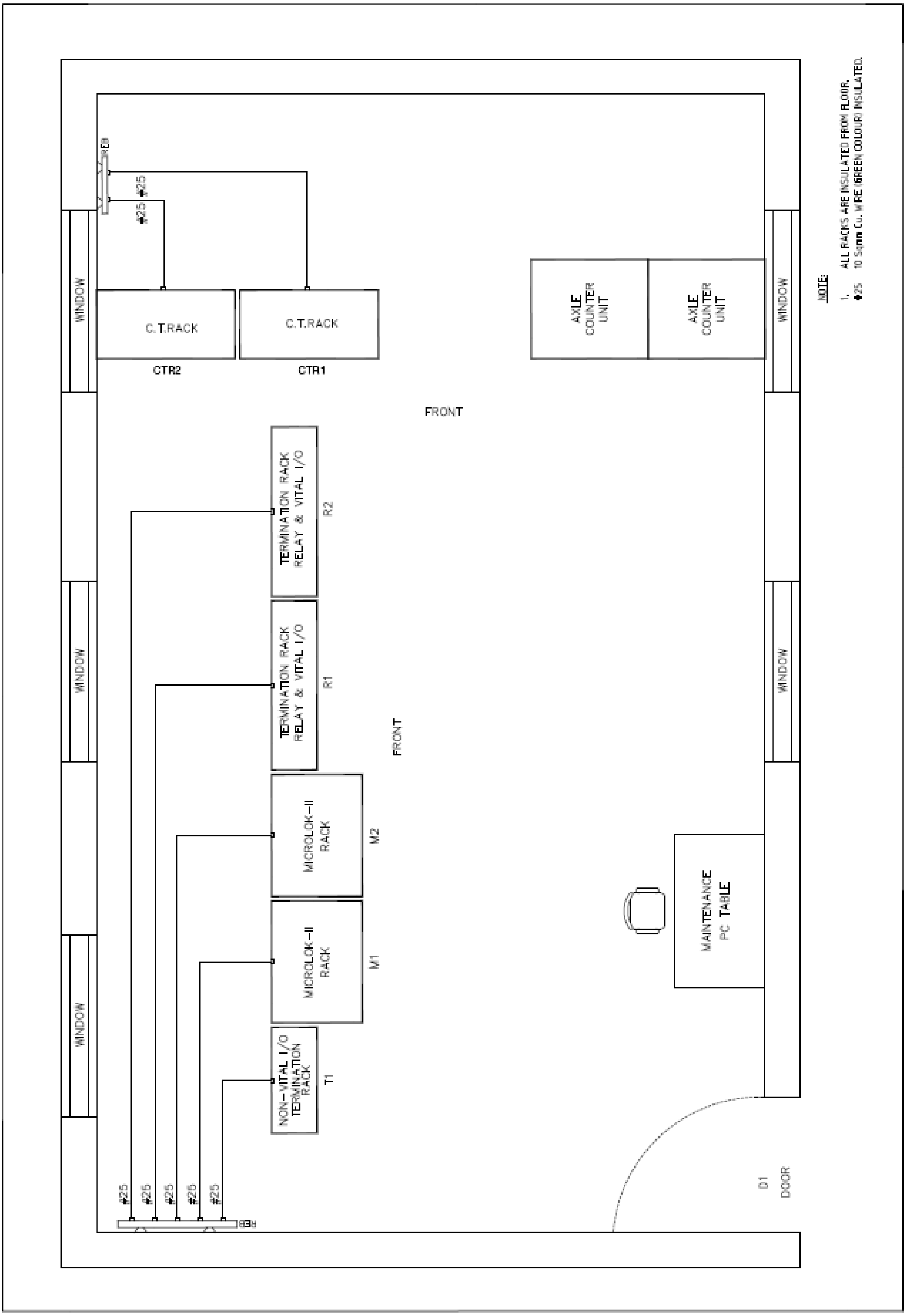
Component/Bonding	Material	Size
Main equipotential earth busbar (MEEB)	Copper	300X25X6 mm (min.)
Sub equipotential earth busbar (SEEB)	Copper	150X25X6 mm (min.)
Individual equipments to SEEB using copper lugs with stainless steel nut and bolts.	Multi-strand single core PVC insulated copper cable as per IS:694	10 sq.mm
SEEB to MEEB using copper lugs with stainless steel nut and bolts.	Multi-strand single core PVC insulated copper cable as per IS:694	16 sq.mm
Surge protection devices (SPD) to MEEB using copper lugs with stainless steel nut and bolts.	Multi-strand single core PVC insulated copper cable as per IS:694	16sq.mm
MEEB to main earth electrode	Multi-strand single core PVC insulated copper cable as per IS:694 (Duplicated)	35sq.mm
Main earth pit to other earth pit in case of loop earth	Copper tape	25X2 mm



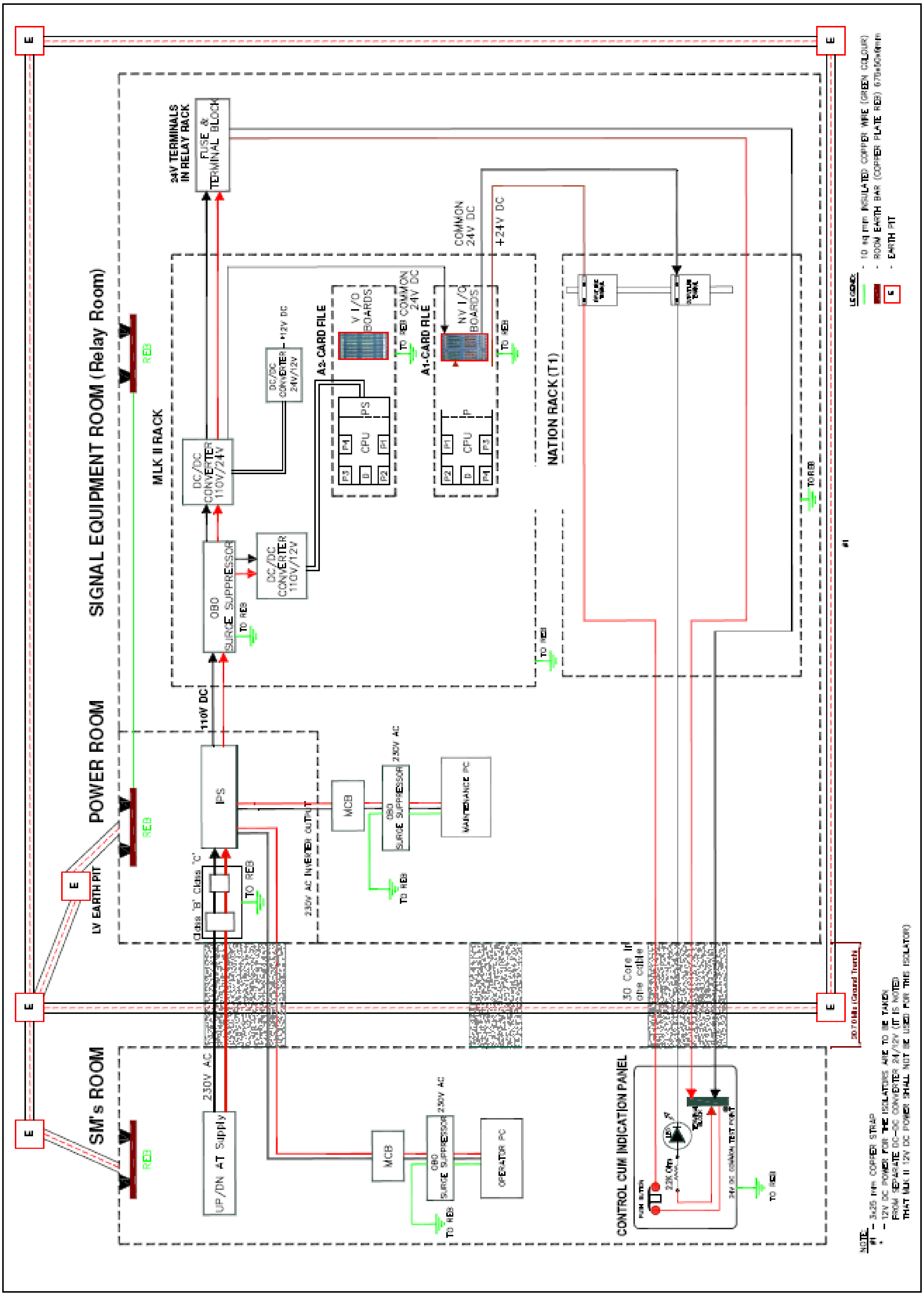
			RDSO Typical installation of earth for S&T Installations	
JE/SE/ Sig	ADE/Sig	For DG/Sig	Drg. No. SDO / RDSO/ E&B/001 Date:	Sheet No. 1 of 1


EI/RELAY ROOM
EI
E
POWER SUPPLY
SEBB
10 Sq.mm Cu CABLE
CT RACK
CT RACK
Incoming Cables
*
PVC INSULATED MULTISTRAND 35 Sq. mm Cu CABLE AS PER IS: 694 (DUPLICATED)
IPS ROOM
FRBC
DCDP
ACDP
E
E
E
MEBB
MAIN EARTH PIT
16 Sq.mm Cu CABLE
POWER SUPPLY
SEBB
SPD BOX
63A FUSE
CLASS C SPD
CLASS B SPD
10 Sq.mm Cu CABLE
CLASS B SPD
CLASS C SPD
L
N
UNDERGROUND
UNDERGROUND
S M ROOM
AT/COMMERCIAL INPUT SUPPLY
BLOCK INSTRUMENT
BLOCK INSTRUMENT
OPERATOR PANEL
Power (electric) Earth
Block earth
Block earth
R.D.S.O.
Typical bonding and earthing connections for signalling equipments
Sheet 1 of 1
Drg. No. SDO/RDSO/E&B/002
Date : 19.09.08
For DG/Sig.
ADE/Sig.
JE/SE/Sig.
1. CLASS B & C SPDs SHALL BE PROVIDED AS PER RDSO GUIDELINES AND FROM RDSO RECOMMENDED SOURCES.
2. *ALL THE ARMOURING OF THE CABLES SHALL BE CONNECTED TO SEBB.
3. ALL DIMENSIONS ARE IN MILLIMETER.

4.8 RACK EARTHING



4.9 PERIMETER EARTHING



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REVIEW QUESTIONS

CHAPTER: 1 - SECONDARY CELLS

Subjective:

1. Write the procedure for Charging the flooded type Lead Acid Battery including preparation of electrolyte, initial charging, boost charging and float charging.

Objective:

1. If the load current is 4A and backup time required is 10Hrs then recommended capacity of Lead Acid Cell is ___________ (C)

   A) 40 AH B) 60 AH C) 80 AH D) 120 AH

2. Maximum permissible load on 120AH capacity Lead Acid cell is ________ (A)

   A) 12 A B) 20 A C) 10 A D) 24 A

3. Voltage of the fully charged lead acid cell is ________ V (B)

   A) 2 V B) 2.2 V C) 2.3 V D) 2.4 V

4. End point voltage of the lead acid cell is _______ V (A)

   A) 1.8 V B) 1.9 V C) 2.0 V D) 2.2 V

5. Specific gravity of the discharged lead acid cell is ____________ in terms of hydrometer reading. (A)

   A) 1180 B) 1200±5 C) 1210±5 or 1220 D) 1240±5

6. Specific gravity of the fully-charged Lead Acid cell is ________ in terms of Hydrometer reading. (C)

   A) 1180 B) 1200±5 C) 1210±5 D) 1240±5

7. If the load current is 8A and backup time required is 10Hrs then recommended capacity of Lead Acid Cell is 80AH (F)

8. During the preparation of electrolyte always add acid to distilled water only, but not water to acid. (T)

9. In Lead Acid cells, electrolyte level should be maintained at 12mm to 15mm above the plates. (T)

10. If the Lead acid cells are continuously used in “FLOAT Charging” then equalising charge must be given once in 3 months. (T)

11. In Lead Acid cells, Boost charging current must given at the rate of C/10 Amp (T)

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REVIEW QUESTIONS

CHAPTER: 2 - LOW MAINTENANCE LEAD ACID CELLS

1. The recommended float voltage of LMLA cell is between 2.15 – 2.20V/cell. (T)
2. In case of LMLA cells, Boost charging current rate is 10% of rated capacity. (F)

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REVIEW QUESTIONS
CHAPTER: 3 - BATTERY CHARGERS

Subjective:

1. Write the Controls, Indications and Protections provided in the Self regulating type automatic battery charger as per Spec No.: IRS: S-86/2000 with Amendment – 4.
2. What are the adjustments required to be done during initial commissioning of the Self regulating type automatic battery charger as per Spec No: IRS: S-86/2000 with Amendment -4.

Objective:

1. Battery charger of 24V can charge maximum ______ no. of cells. (D)

   A) 24 B) 12 C) 13 D) 14

2. Recommended current rating of Battery charger for charging 120AH Lead Acid cell is ________________. (C)

   A) 12 A B) 24 A C) 30 A D) 40 A

3. For charging of 200 AH cells ______________ amp capacity charger is required.(D)

   A) 20 A B) 24 A C) 30 A D) 40 A

4. Boost charging voltage of the lead acid cell is ______ (C)

   A) 2.2 V B) 2.3 V C) 2.4 V D) 2.7 V

5. Initial charging voltage of the lead acid cell is __________ (D)

   A) 2.2 V B) 2.3 V C) 2.4 V D) 2.7 V

6. Float charging voltage of the Automatic battery charger (IRS: 86/200) is adjustable from _________ per cell. (A)

   A) 2.12 to 2.3 V B) 2.2 to 2.3 V C) 2.12 to 2.4 V D) 2.12 to 2.7 V

7. Chargers used for Axle counter installations, the r.m.s ripple shall be less than______.

   A) 10mV B) 50mV C) 100mV D) 200mV (A)

8. Chargers used for Axle counter installations, the peak to peak noise voltage shall be less than 50mV.

   A) 10mV B) 50mV C) 100mV D) 200mV (B)

9. Battery charger working in manual mode, the charger output voltage shall be _____ V per cell. (B)

   A) 2.2 V B) 2.25 V C) 2.3 V D) 2.4 V

10. Battery charger generates low battery alarm when the battery voltage falls to ______ V per cell. (A)

    A) 1.95 V B) 2.0 V C) 2.2 V D) 2.25 V

11. Battery charger generates start DG set non-resettable alarm when the battery voltage falls to 1.90V/cell. (A)

    A) 1.9 V B) 2.0 V C) 2.2 V D) 2.25 V

12. Battery charger isolates battery from the load when the battery voltage falls to ______V per cell. (D)

    A) 2.0 V B) 2.15 V C) 2.2 V D) 1.8 V

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REVIEW QUESTIONS

CHAPTER: 4 - FERRO RESONANT TYPE AUTOMATIC VOLTAGE REGULATOR

SUBJECTIVE:

1. Write the features and drawbacks of Ferro resonant type voltage regulator.
2. Briefly explain the working of Ferro resonant type voltage regulator.

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REVIEW QUESTIONS

CHAPTER: 5 - INTEGRATED POWER SUPPLY SYSTEM

SUBJECTIVE:

1. Draw the functional diagram of IPS used in RE area up to 4 lines without AFTC.
2. Briefly explain the various protections required to be provided for IPS system.

OBJECTIVE

STATE TRUE or FALSE

1. Blanking of signals due to power supply failure can be effectively and economically prevented by using IPS. (T)
2. In IPS system, inverters are configured with (1+1) configuration. (T)
3. All the DC-DC converters except for Relays (internal) of IPS system are used in (N+1) load sharing configuration. (T)
4. In IPS system, Inverter output is used for the load of DC Track circuits. (F)
5. In case of IPS system, normally only one Battery bank is used. (T)
6. An inverter is used in IPS system to convert the A.C. power into D.C. power. (F)
7. DC-DC converters of IPS system for Relays (internal) are used in (N+1) load sharing configuration. (F)
8. SMRs of IPS system are provided with in (N+2) load configuration. (T)
9. In IPS system Inverter-2 will be automatically connected to the load, when Inverter-1 output is failed. (T)
10. In IPS system CVT or AVR will be automatically connected to the load, when Inverter-1 and Inverter-2 output is failed. (T)
11. With IPS System, DG set is not required (F)
12. Class B and Class C arresters are used in IPS for stage1 and stage2 protection. (T)
13. IPS system generates Start D.G set audio-visual alarm with 50% depth of discharge of Battery bank. (T)
14. IPS system generates Stop D.G set audio-visual alarm whenever FRBC / SMR change over to float mode from boost mode. (T)

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