इरिसेट IRISET

S 9

POWER SUPPLY FOR SIGNALLING

Indian Railways Institute of
Signal Engineering and Telecommunications

SECUNDERABAD - 500 017

S 9

POWER SUPPLY FOR SIGNALLING

VISION:	TO MAKE IRISET AN INSTITUTE OF INTERNATIONAL REPUTE, SETTING ITS OWN STANDARDS AND BENCHMARKS
MISSION:	TO ENHANCE QUALITY AND INCREASE PRODUCTIVITY OF SIGNALLING & TELECOMMUNICATION PERSONNEL THROUGH TRAINING

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INDIAN RAILWAYS INSTITUTE OF
SIGNAL ENGINEERING & TELECOMMUNICATIONS
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CHAPTER – 1: SECONDARY CELLS

1.1 Cells which store Electrical Energy and supply on need are called secondary cells. Because of their ability to store energy, they are also known as “Storage Cells” or “Accumulators”. They work on reversible chemical reactions.

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 (Please refer Annexure-IV)

(Use of Maintenance free secondary cell [as per spec. No. IRS:S 93/96(A)] is permitted with IPS in 25KV RE area for signaling application in terms of Railway Board’s letter No. 2010/SIG/SG/2/VRLA Battery Dt.20.12.2010.)

(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 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. Ideally 80AH = 8 Amp Current X 10 Hours. *See also Depth of Discharge.*

Cell capacity can be selected depending upon the load current and backup time required. Flooded type Lead Acid Cells are available with standard capacity ratings of 40AH, 80AH, 120AH, 200AH, 300AH, 400AH and 500AH for Signalling applications.

1.6 Depth of Discharge (DOD) of the cell

Since secondary cell should not be fully discharged (i.e 100 %) due to Technical considerations i.e Increase in Internal Resistance with increase in discharge, High Charging current for next charging, Life of cell, etc, there is a limit laid down on extent of discharge which is known as Depth of discharge (DOD) which is stated as a percentage of the ampere-hour capacity.

Due to variations during manufacture and aging, the DOD may vary over time or number of discharge cycles. Depth of Discharge permitted as follows.

Flooded type Lead Acid Cell - 70%, LMLA cell - 80% , VRLA cell - 50%.

1.7 Assessment of required Capacity of a Secondary Cell

$$C = \text{Required Capacity of the Cell} = \left[\frac{\text{Load current X Backup time required}}{\text{Depth of Discharge permitted}}\right]$$

Eg: If the load current is 10A and the backup time required is 10Hrs then the recommended Capacity of the Cell is

$$C = \left[\frac{\text{10A X 10 Hrs}}{0.70}\right] = 142\text{AH}$$

$\approx$ 200AH(nearest available higher capacity of the cell)

1.8 Self discharge of the cell

Self-discharge is a phenomenon with internal chemical reactions reducing the stored charge of the battery without any connection between the electrodes. Self-discharge decreases the shelf-life of batteries and causes them to have less charge than expected when actually put to use. How fast self-discharge occurs is dependent on the type of battery. Storing batteries at lower temperatures reduces the rate of self-discharge and preserves the initial energy stored in the battery.

1.9 EFFICIENCY OF THE CELL

It is expressed in following 3-ways.

1.9.1 Ampere – Hour Efficiency

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

$$\%\text{ of A.H. efficiency} = \left[\frac{\text{Amp-hour discharge}}{\text{Amp-hour charge}}\right] \text{X100}$$

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.

1.9.2 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.

1.9.3 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.

$$\text{Watt - Hour efficiency} = \text{AH efficiency X} \left[\frac{\text{Average voltage during dicharge}}{\text{Average voltage during charge}}\right]$$

It is always less than A.H. efficiency and varies between 70% to 80%.

1.10 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'.

There are two basic types of batteries available. The flat pasted plate heavy duty type and the "tubular" type as per the design of the positive plate. In general, the negative plates are identical in both types. The essential difference is that in the flat plate design, the positive plate is a rugged lead alloy grid which is filled with a specially compounded paste active material whereas in the "tubular" design the positive plate is composed of a series of parallel tubes filled with lead oxide. Tubular batteries are more efficient because it uses less lead than the flat plate design.

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]

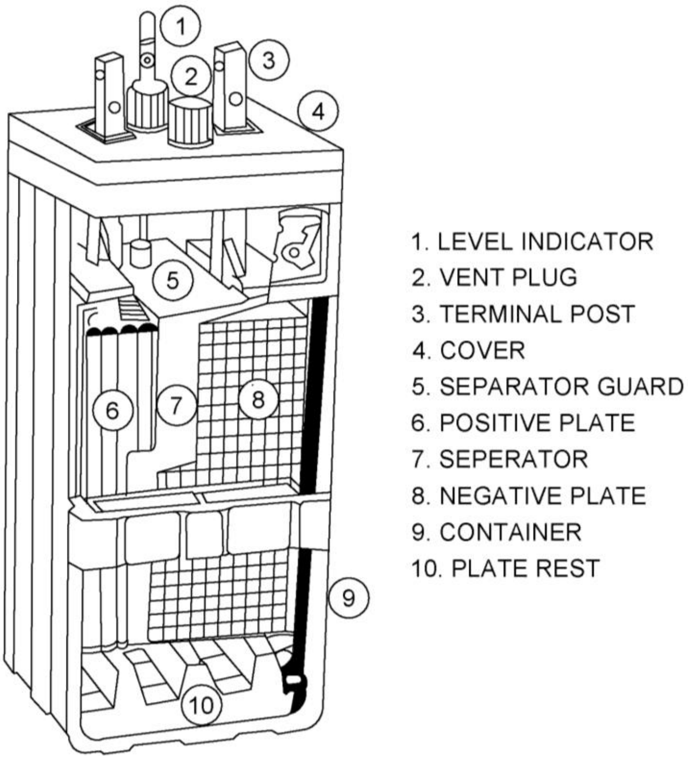


Fig: 1.1 CUT SECTION VIEW OF A CELL

Fig: 1.2 ARRANGEMENTS OF CELLS IN BATTERY ROOM

1.10.1 CHEMICAL REACTIONS

During discharging:

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

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

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

During charging:

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

During Charging and Discharging:

$$\underset{\text{(Anode)}}{PbO_2} + \underset{\text{(Cathode)}}{Pb} + \underset{\text{(Electrolyte)}}{2H_2SO_4} \underset{\text{Charging}}{\overset{\text{Discharging}}{\rightleftarrows}} 2Pb\,So_4 + 2\,H_2O$$

(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) When the battery is charged the positive and negative active materials, which have been turned into Lead Sulphate, 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.

(c) When the battery charging approaches its final stage, the charging current is consumed solely for electrolytic decomposition of water to Oxygen gas from positive plate and Hydrogen gas from negative plate **leading to loss of water**. 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) Electrolyte level should be maintained 12mm to 15mm above the plates.

1.10.2 Importance of Specific gravity of the Electrolyte

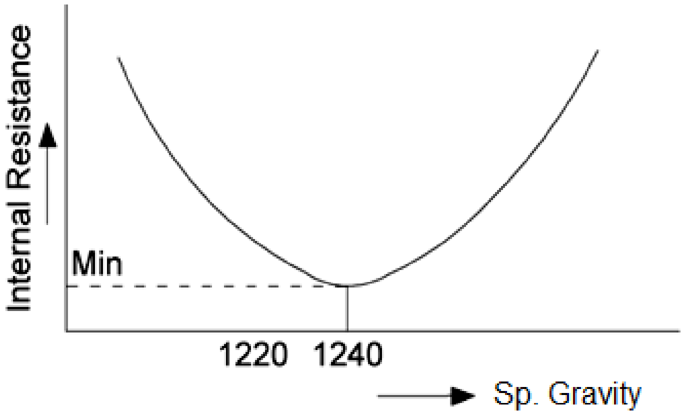


Fig: 1.3

1	Voltage & Specific Gravity of Fully charged cell	2.2 V , 1215 (1210 $\pm$ 5) at 27^{0}C
2	Voltage of Discharged cell	1.8 V , Sp Gravity 1180
3	conductivity of the electrolyte is High at Sp. Gravity (Internal Resistance is minimum)	1240 at 27^{0}C
4	Temperature α	$\frac{1}{\text{Specific Gravity}}$
5	Change in Sp. Gravity	0.7 per ^{0}C
6	Specific Gravity at T^{0}C	Sp. Gravity at 27^{0}C – [(T-27) X 0.7]

1.10.3 CHARGING OF SECONDARY CELL

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

(b) For good performance of a battery, manufacturer's instructions must be strictly followed for preparation of electrolyte and the initial and subsequent 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 (IS 266) and distilled water (IS 1069) in the ratio as given below:

Sp.gr. of Conc. H_2SO_4	**Required Sp.gr. of solution Dil. H_2 SO_4**	**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.

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

(iv) The level of the electrolyte should be 12 mm 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 ‘-‘ to avoid short circuit circulating current.

(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 ± 5
- If the Sp. Gravity of a cell after charging does not improve to 1210 ± 5, then a small quantity of the electrolyte is taken out and is replaced with higher (1400) Sp. Gravity 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 reduces 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 are indicating the electrolyte level in proper position.

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

Battery Charging mode	**Voltage**	**Current**
Float mode	2.25 V/Cell adjustable from 2.12V to 2.3V/cell	-
Boost mode Equalising Charging	2.4 V /Cell	10% of AH
Initial Charging mode	2.7 V/ Cell.	4% of AH

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.

1.10.4 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.

(j) Batteries in the bank should be given continuous numbering.

1.10.5 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 grease 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 assess the battery condition and also provides the discharge cycle.

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

(l) Equalisillng charge shall be given, as they drop the voltage due to Internal Resistance.

(m) Do not allow the batteries to overcharging, excessive gassing and heating.

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

(o) Defective cells should be replaced.

(p) When a cell is completely discharged or dead, it gives no voltage but offers a very high Internal Resistance causing voltage to drop across it which is in opposition to main Voltage in the circuit. This is usually referred as Reverse Polarity of a cell. Thus a dead cell must be immediately removed from circuit to avoid voltage drop.

(q) Syringe type Hydrometer having a scale with one-division represents 5 units of Sp. Gravity shall be used.

(r) Voltmeter used should have internal resistance of at least 1000 Ω.

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

1.11 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).

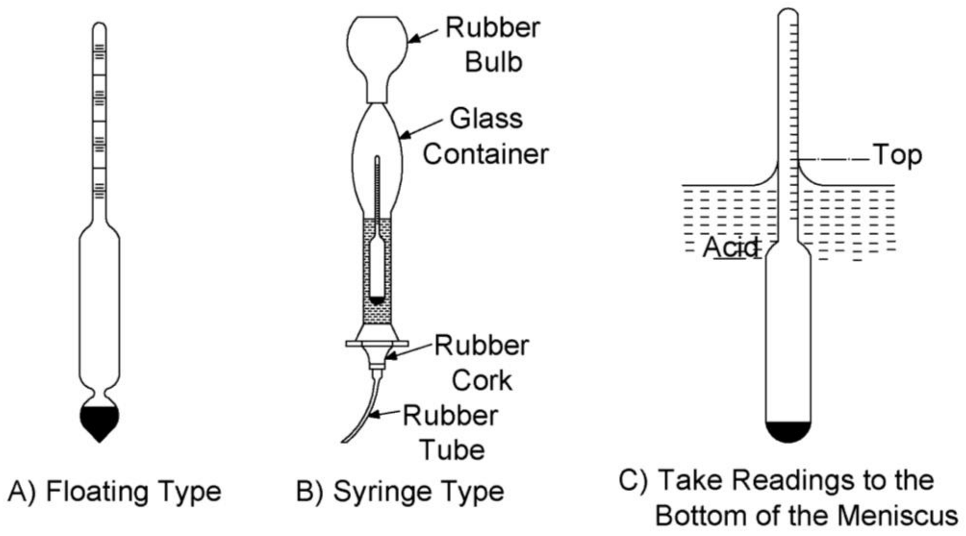


Fig: 1.4 HYDROMETER

1.12 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. If 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."

(f) Don't keep the dead cell in the battery bank. If you keep using a battery with one dead cell, the dead cell will be reversed (charged backwards by the current flowing through it from the other cells) and damaged.

1.13 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 than normal during Float Charging

Possible reason is: Float voltage is high.

1.14 PROFORMA OF 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											

1.15 Life of a Secondary Cell

Codal life of a secondary cell is 4 Years.

1.16 Limitations of Conventional Lead Acid Cells

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

(b) During charging cycle corrosive acid fumes are given out by the batteries which will affect other equipment if kept in the same vicinity and hence they are to be kept in separate room with proper ventilation / exhaust fan.

To address above limitations, two more variants of Lead Acid Cells have been developed namely (a) VRLA cells – Details in Annexure-…. (b) Low maintenance lead cells- Details in next chapter.

* * *

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 by reducing gas formations thus reducing topping up frequency.

(b) Low Maintenance Lead Acid Tubular Cells are made of robust PPSFM (Polypropylene Structural Foam Molded) 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°C.

(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. Codal life of a secondary cell is 4 Years.

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

<u>Reaction at positive electrode</u>

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

<u>Reaction at negative electrode</u>

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

<u>Oxygen Recombination step at Negative electrode</u>

$$Pb + H_2SO_4^- + H^+ + ½\,O_2 \underset{\text{Charge}}{\overset{\text{Discharge}}{\rightleftarrows}} PbSO_4 + H_2O$$

<u>Overall Cell Reaction</u>

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

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 dropping 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 / Initial charging shall be started only 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 2.65V to 2.75V per 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 temperature of electrolyte should not go beyond 50°C during charging. If found, discontinue charging and allow the batteries to cool down to 40°C.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 has 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 – 2.20 V/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. (Pilot Cells are selected out of every 60 Cells)

(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 the specified, then 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°C

(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

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

C_a = actual capacity at 27°C

C_t = Observed capacity at t°C

R = variation factor at given rate of discharge.
(0.43 for 0.1C discharge)

t = average room temp. in °C

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) for preventing corrosion of terminals

(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 ventilation & 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 RDSO approved list of firms for manufacture and supply of electrical signalling items: as on 31st December 2013

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

APPROVED UNDER PART: I	APPROVED UNDER PART: II
1. M/s Exide Industries Ltd.	1.M/s Bharat Battery Mfg. Co. Pvt. Ltd.,
2. M/s Southern Batteries Pvt Ltd,	2.M/s CELTEK Batteries Pvt. Ltd.,
3. M/s Lead Acid Batteries Co. (P) Ltd.,	3.M/s Exide Industries Ltd.
4. M/s Bharat Battery Mfg. Co.Pvt.Ltd.,	4.M/s Southern Batteries Pvt Ltd,
5. M/s Mysore Thermo Electric Pvt. Limited	5.M/s Power Build Batteries Pvt. Limited.
	6.M/s United Lead Oxide Product Pvt. Ltd.,

* * *

CHAPTER – 3
BATTERY CHARGER - SELF REGULATING TYPE

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 (effective from 02-08-2005)

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 AC Input voltage goes below 160V AC or goes above 270V AC use of a separate AC voltage stabilizer 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 output 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 is provided to indicate that the AC supply is out of range (160 to 270V).

(h) Red LED indication shall appear with audible alarm (re-settable) when no output voltage is available although AC supply is available.

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

(j) It generates start DG set non-resettable alarm when the battery voltage falls to 1.90V/cell, in both auto and manual mode of working.

(k) If the current across battery terminals increases by 8% to 12% of the rated current, the output voltage of the charger shall automatically change to 2.4V/Cell (Boost 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 rated current value. The output current during boost charging shall be maintained constant (within ±5% of the selected value) with input voltage varying between the limits and the DC terminal voltage varying from 1.8V to 2.4V/cell. If there is no output voltage, the indication LED against “Auto” mode will start flashing with an audible alarm.

(l) The charger output 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 12V, 24V, 36V, 48V, 60V, 110V & 120V are recommended.

(t) The charger of 12V, 24V, 60V & 110V output shall have a provision for charging number of cells as mentioned below. LED indications are provided on the charger for indicating the no. of cells selected.

In this table, n = V/2, where V= Rated output voltage of the charger.

Rated Output Voltage	Provision for charging No. of cells n, (n+1), (n+2)
12	6,7,8
24	12,13,14
60	30,31,32
110	55, 56, 57

(u) The charger unit has separate battery and load terminals for all ratings. All wire terminations are provided with spring washers, locking washers etc to avoid cases of loose connection.

(v) This unit is electronically protected against reverse polarity, short circuits, over voltage, over load and surge voltages.

(w) Chargers are provided with means of protection against spikes in line voltage by providing line surge suppressor (Metal Oxide Varistors) on input side. For chargers meant for Telecom/Axle Counter/SSI applications, Radio Frequency Interference, Electro Magnetic Interference filters are also be provided both on input & output sides.

(x) The charger has soft start feature whereby on energisation, the output voltage is build up slowly in less than 30 seconds, eliminating all starting surges.

(y) In case any fault occurs within the charger, the output DC voltage in Auto mode shall not exceed 2.4 volts/cell.

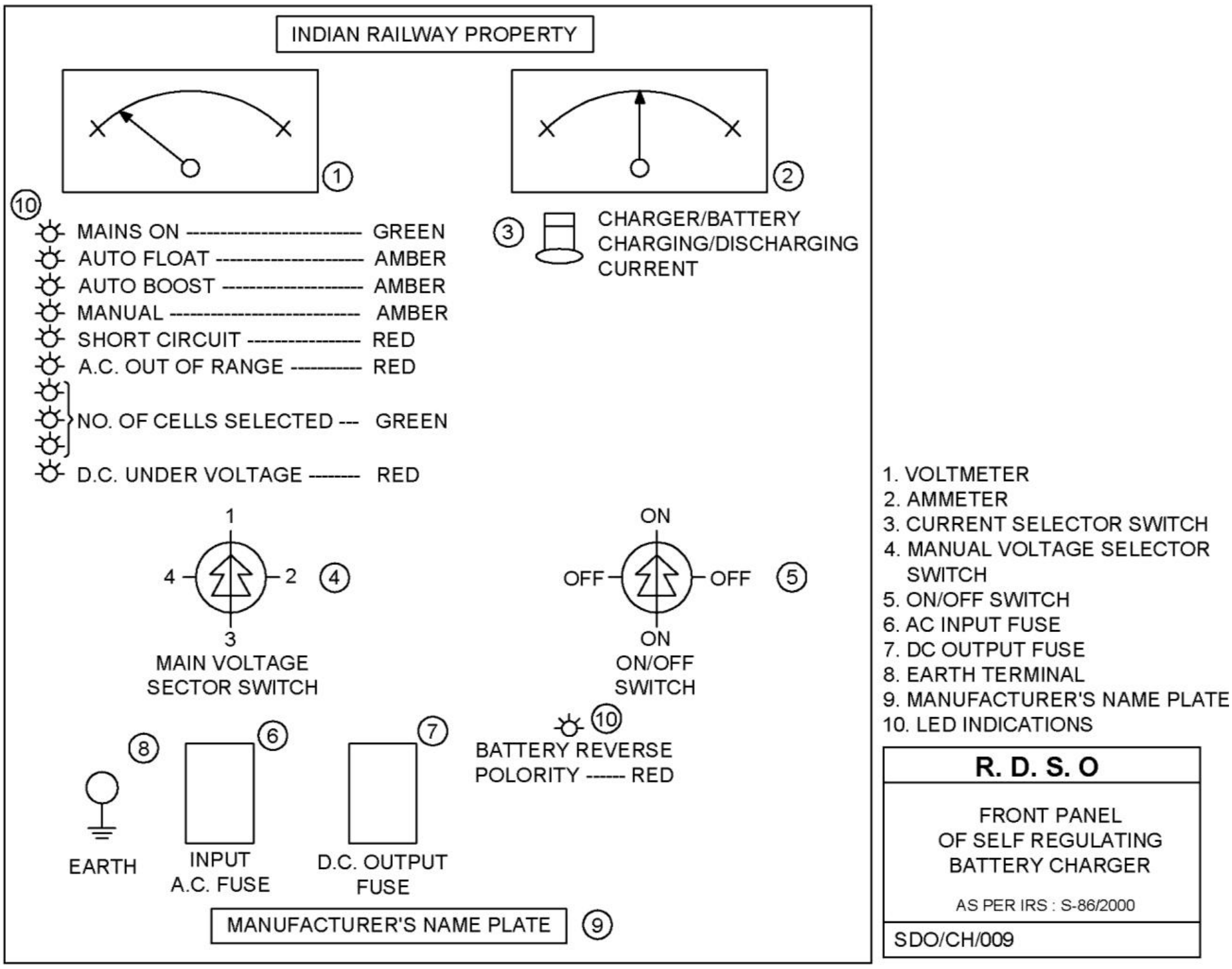


Fig: 3.1 Front view of Self Regulating type Automatic Battery Charger

3.2 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 Control card 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 mounted inside the charger and 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 such as n, n+1, n+2 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 Control card used to adjust the output voltage from 2.12V/cell to 2.3V/cell in the Float mode of working.

Sl. No	Controls, Indications and Protections	Description
7	Current Set Potentiometer	This is a single turn potentiometer mounted on the Control card 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	Green 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.
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 (High Rupture Capacity) fuse provided on the output side to protect the equipment from any possible ‘Over Load’ or ‘Short Circuit’ conditions.

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. Automatic / Manual mode working block diagram is shown in figure 3.2

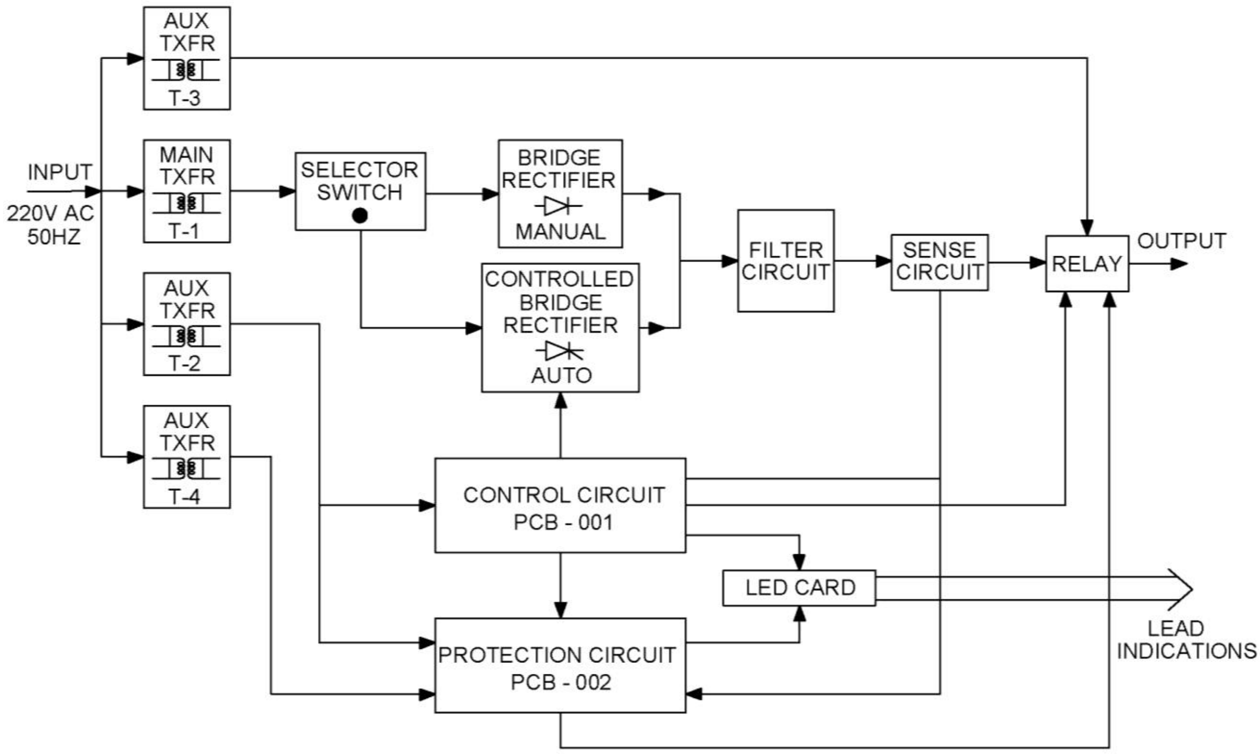
3.2.1 AUTO MODE OF WORKING

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 2.12 V/cell to 2.3 V/cell by a potentiometer called “Voltage Set Potentiometer” provided on the Control Card.

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 Control Card, to deliver the 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 by sensing the battery charging current drawn through the battery terminals. If the current drawn by the battery is more than 8 to 12 percent of the set charging current (C/10), then the charger automatically switches to Boost mode of operation. 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(C/10). Once this condition is satisfied the charger will switch back to the Float Mode of operation automatically.



BLOCK DIAGRAM 0F AUTOMATIC/MANUAL MODE CHARGER WORKING

Fig.No.3.2

3.2.1.1 ADJUSTMENT FOR AUTO MODE OF OPERATION

(a) Adjustment for Auto Float mode of operation

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

(ii) Adjust the output voltage to the required value by voltage adjust potentiometer (2.15V/cell).

(b) Adjustment for Auto Boost mode of operation

(i) Adjust the current control potentiometer to C/10 of the Battery AH capacity.

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

(iii) 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 changes to float charging mode when the battery becomes fully charged.

Eg: For 120AH cells, if the current drawn by the battery is more than 1Amp (8 to 12% of C), then the charger automatically switches to Boost mode of operation. Battery charger will be in Boost mode till the battery charging current is up to 600mA. As soon as battery charging current is less than 600mA (3 to 5% of C) the charger will change over from Boost mode to Float Mode.

3.2.1.2 INSTALLATION AND MAINTENANCE INSTRUCTIONS (AUTO MODE)

Various Front panel control, switches and indications are given in Sketch No. SDO/CH/ 009 enclosed. i.e. in Fig .3.1 for the charger output current rating is less than 50A.

(a) INITIAL COMMISSIONING:

(i) 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.

(ii) Set the Mode selector switch in “Auto” position provided inside the charger.

(iii) 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.

(iv) 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. C10 rate of charging). The use of current control potentiometer Is explained by the followed example.

(v) Eg: 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. 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 charging current) will not exceed 10A. Therefore overcharging of batteries can be avoided by making use of the Current control pot.

(vi) If the AH capacity of the batteries is matching with the charger output current rating, the Current Control pot shall be kept at “100% position”

(vii) Connect batteries across the battery terminals. 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 C10 rate and battery voltage builds up to 2.4V/Cell. This happens after the batteries have almost got fully charged.

(viii) In this mode of working Manual voltage Selector switch is ineffective and therefore need not be touched.

(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 Technician - Signal)

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

(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 may be kept in position 1, 2 or 3 depending on load/battery charging requirement.
- Failure of Auto mode will be immediately informed to SSE(Signal), who in turn will check up the charger as soon as possible.

(d) ROUTINE MAINTENANCE

(i) During the visit of Technician (Signal) 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 above, changeover the battery charger to Manual Mode and report the failure to SSE(Signal).

(ii) The Technician (Signal) will check the tightness of the connections to battery and load terminals provided inside the charger 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, then Technician (Signal) shall not disturb the control switches of the charger.

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

(i) Fuses

- Rectifiers/SCR fuse
- Condenser fuse

(ii) Alarms (Audio & Visual)

- Main fuse blown
- Output fuse blown
- SCR/Rectifier fuse blown
- Overload/Short circuit
- 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 Technician (Signal) on duty to silence the buzzer/hooter. The visual indication will continue till the fuse is replaced or the fault rectified.

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 Auto / Manual Mode Selector Switch mounted in side of the charger. 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.

When the Auto / Manual 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. The DC output voltage in the Manual mode is achieved through a separate Full Wave Bridge Rectifier.

In this mode the output DC voltage is controlled by the 3 - position 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.

3.2.3 INSTALLATION AND MAINTENANCE INSTRUCTIONS (MANUAL MODE)

(a) Connect Earth terminal 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 to “ON” position, Indication Main ON (Green LED) will glow.

(b) Change Mode selector switch provided inside the charger to manual position. The charger comes into Manual mode and indication amber LED glows.

(c) Change Manual Voltage selector switch to first, second or third position as per the No. of cells connected to the charger.

(d) Connect the load across the load terminal; the output voltage should be 2.25V per cell with the load connected across the load terminal.

(e) Initial setting in manual mode is to be done by the SSE(Signal) depending on the load connected. Technician (Signal) of the station should closely monitor the battery charger as per instructions of the SSE(Signal).

(f) 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.

3.3 Codal life

Codal life of a Battery Charger is 10 Years.

3.4 RDSO approved list of firms for manufacture and supply of electrical signalling items: as on 31st December 2013

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

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

APPROVED UNDER PART: I	APPROVED UNDER PART: II
1. M/s Electric Industries	1. M/s Sree Chand Elect, Industries (P) Ltd.
2. M/s Ex-Servicemen Electrical Industries	2. M/s General Auto Electric Corporation
3. M/s General Auto Electric Corporation	3. M/s Electro Star
4. M/s Ultra Electronics Pvt. Ltd.	4. M/s Mani Electronics
5. M/s Electro Star	
6. M/s Mani Electronics	
7. M/s Cosine Comm. & Electronics (P) Ltd.	

* * *

CHAPTER – 4: FERRO RESONANT TYPE AUTOMATIC AC 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.

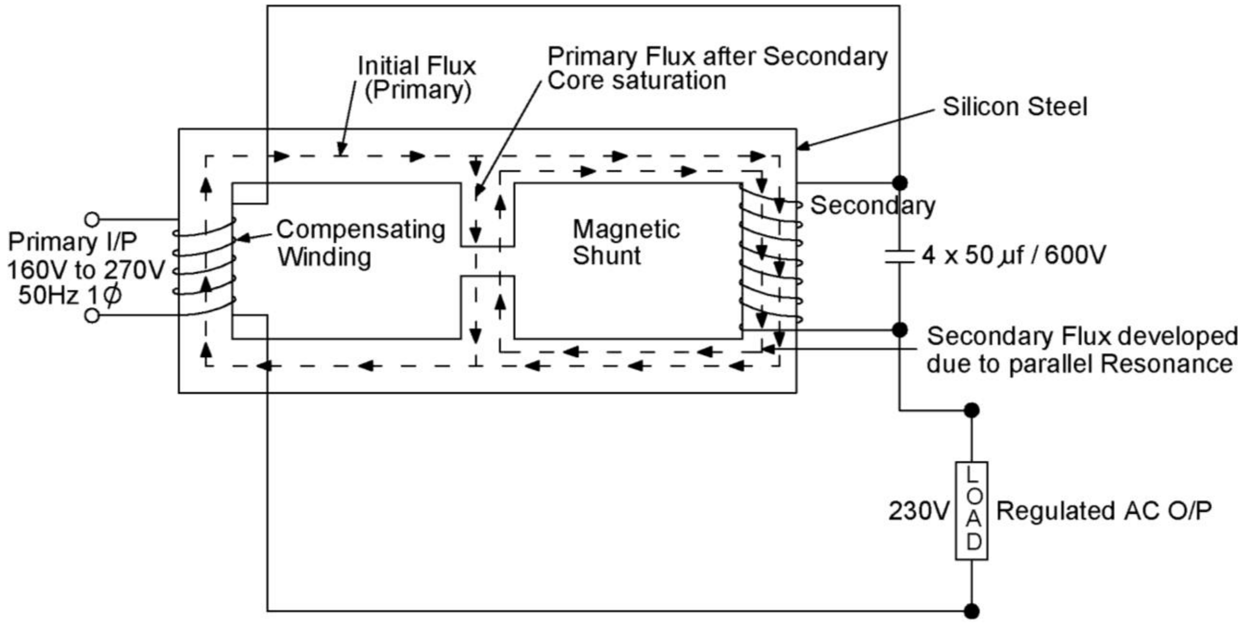


Fig: 4.1

At resonance, the capacitor increases the secondary voltage drastically. This resultant secondary magnetic flux (due to capacitance current flowing in the secondary winding) is added to the magnetic flux flowing through secondary core due to the primary voltage. Hence **flux addition** takes place **in the secondary core** causing secondary saturation.

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 to provide magnetic isolation. 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 thereby increasing induced voltage on secondary.

Hence regulation is taking place with compensating winding.

With compensating winding, the input 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 thereby 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.

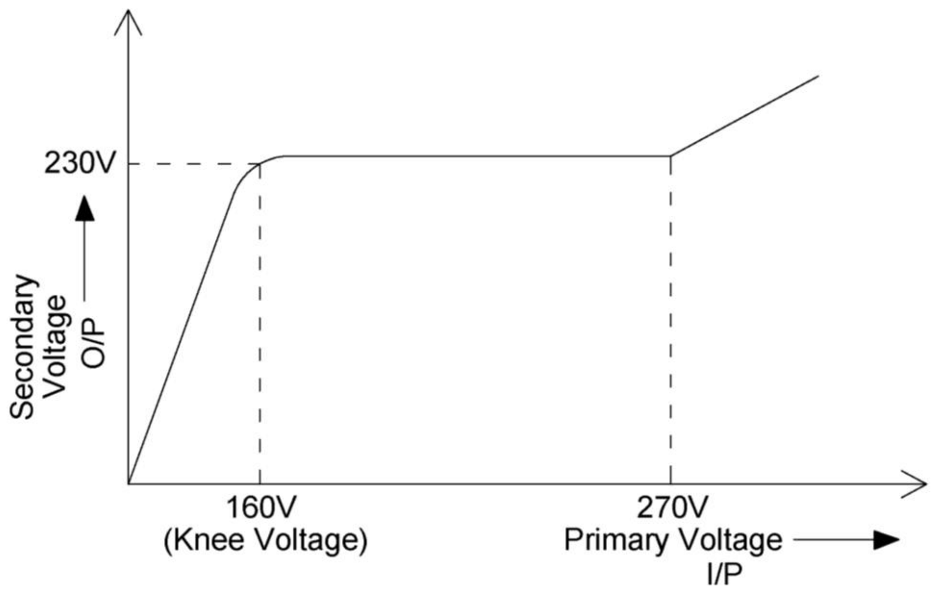


Fig: 4.2

4.3 FEATURES

(a) Robust in construction.

(b) No moving parts.

(c) It's O/P Voltage=**230V ± 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 ± 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 without 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% for 1% 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 ± 1 Hz ---	± 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/660V A.C 36mfd/660V A.C 10mfd/660V A.C	For Saturation of main transformer.

4.7 RDSO approved list of firms for manufacture and supply of electrical signalling items: as on 31st December 2013

ITEM: POWER SUPPLY EQUIPMENTS– VOLTAGE REGULATOR-FERRO RESONANT

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

APPROVED UNDER PART: I	APPROVED UNDER PART: II
1. M/s Apple Systems Pvt. Ltd.	1. M/s Mani Electronics
1. M/s Starvision Power Systems	2. M/s Electro Star
2. M/s Electro Star	

* * *

CHAPTER – 5
INTEGRATED POWER SUPPLY SYSTEM

(RDSO/SPN/165/2012)

5.1 INTRODUCTION

A typical 4 line station requires power supplies of 24 V DC(5 Nos), 12 V DC (5 Nos), 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?

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. Thus the SMPS based Integrated Power Supply (IPS) system is meant to give continuous supply to both AC & DC signalling circuits.

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 %.

Switched-mode power supply Technology:

Switched-mode power supplies (SMPS) are basically DC-to-DC converters, operating at frequencies in the 20KHz and higher region. Basically, the SMPS is a power source which utilizes the energy stored during one portion of its operating cycle to supply power during the remaining segment of its operating cycle.

Switched-mode power supplies operate at much higher levels of efficiency (generally in the order of 75% to 80%), thereby reducing significantly the energy wasted in the regulated supply. The SMPS does significantly in the ripple regulation. It is able to maintain a higher degree of regulation.

The advantages of SMPS are low weight and small size, high efficiency, wide AC input voltage range and low cost.

- Low weight and small size are possible because operation occurs at a frequency beyond the audible range; the inductive elements are small.

- High efficiency because, for output regulation, the power transistor is switched rapidly between saturation and cut-off and therefore has little dissipation. This eases heat sink requirements, which contributes to weight and volume reduction. Conventional linear regulator supplies may have efficiencies as low as 50%, or less, but efficiencies of 80% are readily achievable with SMPS.

- Wide AC input voltage range because the flexibility of varying the switching frequency in addition to the change in transistor duty cycle makes voltage adaption unnecessary.

- Low overall cost, due to the reduced volume and power dissipation, means that less material is required and smaller semiconductor devices suffice.

Switched-mode power supplies also have slight disadvantages in comparison to the linear regulators, namely, somewhat greater circuit complexity, tendency to RFI radiation, slower response to rapid load changes, and less ability to remove output ripple.

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/165/2012. The specification supersedes the earlier specification No. RDSO/SPN/165/2004 with Amendment-5. It 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

IPS for medium size station in RE/Non-RE area (Internal, External)

IPS for interlocked L.C gate in RE/Non-RE area

IPS for IBS in RE/Non-RE area

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 backup 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 (Pulse Width Modulation) 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 Rectifier 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 Rectifier cum Boost Charger (FRBC) Panel

This is for Charging 110 V DC battery bank. It consists of SMR / FRBC modules and Supervisory & Control Unit. FRBC modules of 110V/20Amp rating are provided as per standard configuration. FRBCs are suitable for operating in parallel on active load sharing basis with one or more modules of similar type, make and rating. The current sharing shall be within ± 10% of the individual capacity of each FRBC in the system when loaded between 50 to 100% of its rated capacity. The number of FRBC modules as required for meeting a particular load are housed in (n+1) parallel configuration in a single rack where ‘n’ is the actual required number, n+1 is the hot standby arrangement in the FRBC modules.

The SMPS based FRBC should be based on High Frequency (20 KHz and above) Switch Mode techniques. Resettable Fuses are provided to protect the module against failure of control and sensing circuit.

SMR/FRBC delivers the current to Inverters, DC-DC Converters and also to Battery Bank for charging. **Supervisory & Control Unit**, which controls and monitor the complete system. It has various indications on the panel reflecting the working of the panel.

Class B & C Protected AC 230 V Mains is connected to FRBC modules. FRBC has suitable time delay to avoid hunting during switching ON and OFF of the system. The module is disconnected at 150V and reconnected at 170V. The FRBC module has forced cooling and only DC fan is used. Switching ON and OFF the cooling fan shall be temperature controlled. In case of fan failure the module has automatic protection to switch off the module above 70°C and restore automatically with reduction in temperature to protect from fire hazard.

Auto Float and Boost Charge Mode

Float voltage of each rectifier module shall be set as given in the following table:

No. of Cells	Auto Float mode Voltage		Auto Boost mode Voltage	
	VRLA Cells	LMLA Cells	VRLA Cells	LMLA Cells
55	123.8 V	118.25 V	126.5 V	133.1 V
1	2.25 V	2.15 V	2.3 V	2.42 V

The FRBC module should have a range from 2.0 to 2.3V/Cell in float mode & 2.2 to 2.5V/Cell in boost mode to meet the requirement of VRLA as well as conventional/ LMLA batteries.

The DC output voltage shall be maintained within ± 1% of the half load pre-set voltage in the range 25% load to full load when measured at the output terminals over the full specified input range.

In auto boost charge mode, FRBC shall supply battery and equipment current till terminal voltage reaches 2.3V (VRLA battery) /2.42V (Low Maintenance battery) per cell and shall change over to Auto Float mode after a defined delay of 0, 1, 2, 4 hours adjustable, to be set as per battery manufacturer's specification.

Current Limiting (Voltage Drop)

The current limiting (Voltage Droop) is provided for Float/Boost Charge operation. The float/boost charge current limiting is continuously adjustable between 50 to 100% of rated output current between 2.0 V to 2.5 V/Cell. The float and boost charge current limit adjustment is provided on the front panel.

The FRBC modules are fully protected against short circuit. It is ensured that short circuit does not lead to any fire hazard. It will resume normal function automatically after the short is removed. In case the problem still persists, it is not be possible to switch ON and it is possible to switch ON again only after removal of fault/ cause by pressing a reset push button. The maximum short circuit current shall not exceed 105% of their rating. The tripping OFF of such a faulty module will not affect the normal working of other modules. Battery path current is automatically controlled by the input current in such a way that input current will not exceed the set limit. The set limit is adjustable anywhere between 75 to 100% of full load input current. Provision is also be made for full utilization of power when DG set is operated.

Soft Start Feature

Slow start circuitry is employed such that FRBC module output voltage shall reach its nominal value slowly within 10 to 20 seconds, eliminating all starting surges. The maximum instantaneous current during start up shall not exceed the peak value of the rectifier-input current at full load at the lowest input voltage specified.

Voltage Overshoot/Undershoot (with battery disconnected)

The FRBC modules are designed to minimise output voltage overshoot/undershoot such that when they are switched ON, the DC output voltage is limited to ± 5% of the set voltage and return to its steady state within 20 milli seconds for any load of 25% to 100%. The modules are designed such that a step load change of 25% to 100% or vice-versa shall not result in DC output voltage overshoot/undershoot of not more than ±5% of the set value and return to steady state value within 10 millisecond without resulting the unit to trip.

Electrical Noise

The FRBC modules are provided with suitable filter on the output side. A resistor is provided to discharge the capacitors after the FRBC module has stopped operation and the output is isolated.

The psophometric noise with a battery connected across the output should be within 5 mV, while delivering the full rated load at nominal input (230V single-phase supply). The peak-to- peak ripple voltage at the output of the rectifier module without battery connected shall not exceed 300mV at the switching frequency.

5.6.2 A.C DISTRIBUTION PANEL

It is made of ON-Line inverters with (1+1) modular technology with hot standby arrangement & CVT (Constant Voltage Transformer) / AVR (Automatic Voltage Regulator) and set of step down transformers to feed un-interrupted, stabilized supply for Signals.

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 fails then the stand-by inverter comes 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.

Class B & C Protected AC 230 V mains is extended to the separate CVT and its output is fed to set of step down transformers in order to give Stabilized 110V supply for DC Track circuits. Since separate batteries are provided for each DC Track Circuit in Location Box along with Track Feed Battery Charger, un-interrupted power supply from IPS is not required and only stabilized supply is sufficient for DC Track Circuits.

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.

The DC-DC converter for Axle Counters, EI and Data loggers are optional. Purchaser has to specify whether optional DC-DC converters are required or not. For 60V operated metal to metal relay installation, the ratings of DC-DC converter for relay internal & relay external shall be 60-66V /5A in lieu of 24-32V /5A modules.

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% DOD 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 % DOD 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.	See Remark column	90% DOD	-	*110VDC Input supply will be cut-off to all the DC-DC converters, except to Block Tele DC-DC converters*
5.	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.
6	Stop Generator	FRBC change over to float mode	GREEN	Audio / Visual Alarm.

Note: DOD – Depth of discharge of battery bank.

Audio alarm in case of 1, 2 & 3 shall be of one type of tone and there shall be different tone for the case of 4 & 5 cases. In 1, 2 & 3 conditions, the visual LED indication will remain lit until fault is cleared or the DG set is started as the case may be until reset push button is pressed. In case of 4th condition, if fault is not cleared, the LED will continue to glow, even if reset push button is pressed.

5.6.5 POTENTIAL FREE CONTACTS

Following potential free contacts shall be provided for extension of alarms at remote place:

(a) Inverter 1 fail

(b) Inverter 2 fail

(c) FRBC fail

(d) DC-DC converter fail

(e) Mains fail

(f) Call S & T staff

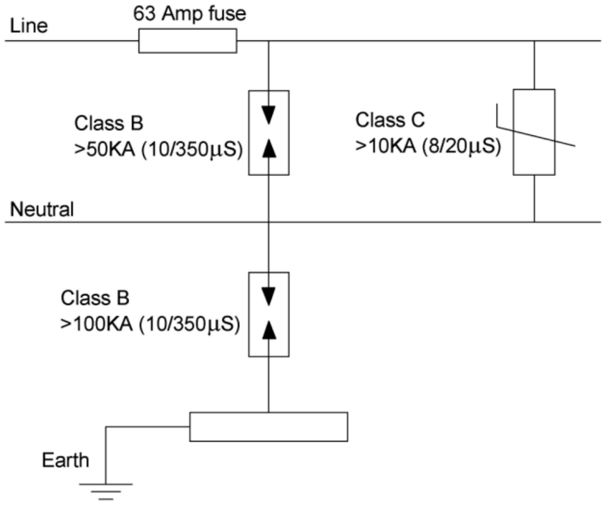
(g) Battery low (50% Deep discharge)

Note: Using above potential free contacts, the status and alarms can be extended to a central monitoring office (like Test rooms in Divisions) using networked Dataloggers.

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 2 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 Ω. 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



Connection of Lightning Arrestors

The power line of electronic signalling equipment shall have Class B & C type 2-stage protection in TT configuration. Stage 3 protection is also required for protection of power/signalling/data lines. Class B & class C type protection devices shall preferably be pluggable type to facilitate easy replacement. Manufacturer will provide Stage1 & Stage 2 protection along with the IPS. These are described below.

Stage 1 protection (Power line protection at Distribution Level) 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. They shall be arc chopping spark gap type voltage switching device.

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.

Stage3 protection (Protection for power /signalling/data lines) is of Class D type. All external Power/signalling/data lines (AC/DC) shall be protected by using this Class D type device. It consists of a combination of Varistors/suppressor diodes and Gas Discharge Tube with voltage and current limiting facilities. *(Note: IPS manufacturer will provide the Stage3 protection on demand.)* The device for **power line protection** shall be of Class D type. This shall have an indication function to indicate the prospective life and failure mode to facilitate the replacement of failed SPDs. This shall be thermal disconnecting type and equipped with potential free contact for remote monitoring. These devices for **Signalling/Data line protection** shall preferably have an indication function to indicate the prospective life and failure mode to facilitate the replacement of failed SPDs. If the device has any component which comes in series with data/ signalling lines, the module shall have "make before break" feature so that taking out of pluggable module does not disconnect the line.

If power 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 (Class C) type shall be used at such locations for power supply lines and Stage 3 protection for signal / data lines.

Note:

1. Coordinated type Class B & C arrestor shall be provided in a separate enclosure in IPS room adjacent to each other. This enclosure should be wall-mounting type.

2. Length of all cable connection from input supply and earth busbar to SPDs shall be minimum possible. This shall be ensured at installation time.

3. Stage 1 & Stage 2 (Class B & C) protection should be from the same manufacturer/ supplier. IPS manufacturer shall provide Stage 1 & Stage 2 protection along with IPS. Stage 3 protection shall be got provided by Railways separately.

4. The cross sectional area of the copper conductor for first stage protection shall not be <16 mm^2 and for second stage shall not be < 10mm^2.

5. Batch test report of OEM should be submitted by the manufacturer /supplier of Lightning & Surge protection devices to the IPS manufacturer at the time of supply of these devices. Copy of the same shall be submitted by IPS manufacturer to RDSO at the time of acceptance test of IPS system.

5.8 FEATURES

(a) SMR/FRBCs 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, where ‘n’ is the actual required number of charger modules.

(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) 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) and for other circuits (n+1) configuration.

(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 measures may be adopted:

(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 health of IPS through Dataloggers using potential free contacts.

(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.

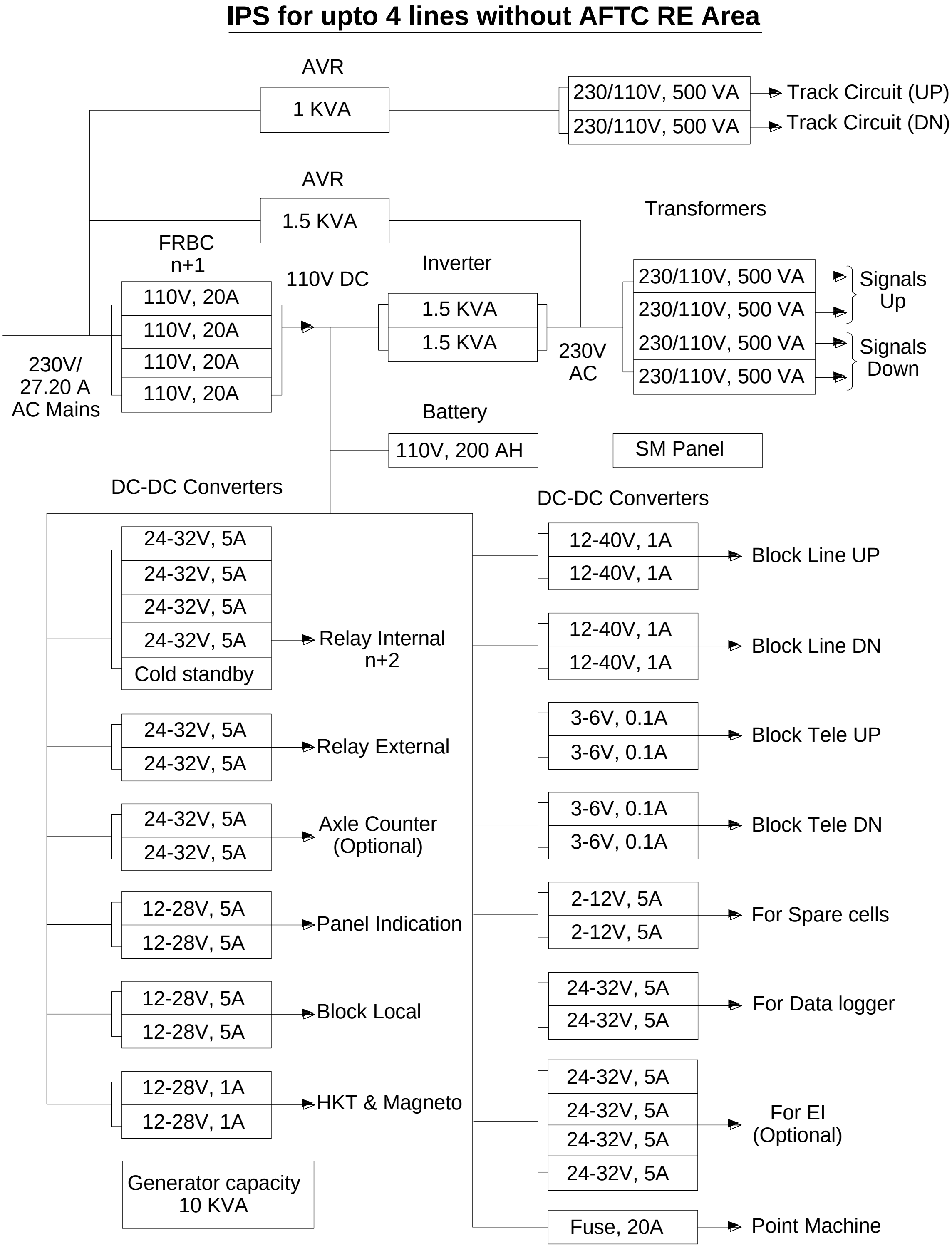
(d) In railways having end Goompties, Mini IPSs are provided at Goompties with 24 V DC-DC convertors at Goompties (Note: 110 V Battery bank is at the center which is extended to Goompties through Power cable).

(e) IPS pre-commissioning check list is already circulated and it is also mentioned at the end of this chapter. This check list is to be compiled before commissioning of IPS.

(f) “SMS” alert system to concerned maintainer has been installed in some zonal railways using CUG cell phones.

5.12 SMPS based IPS block diagrams & details of the system as per RDSO specification RDSO/SPN/165/2012 is shown as below

5.12.1 BLOCK DIAGRAM OF IPS USED IN RE AREA UP TO 4 LINES WITHOUT AFTC



Note: i) For 60V metal to metal relay circuit, the rating of DC-DC Converter for relay internal and external shall be 60- 66V/5A

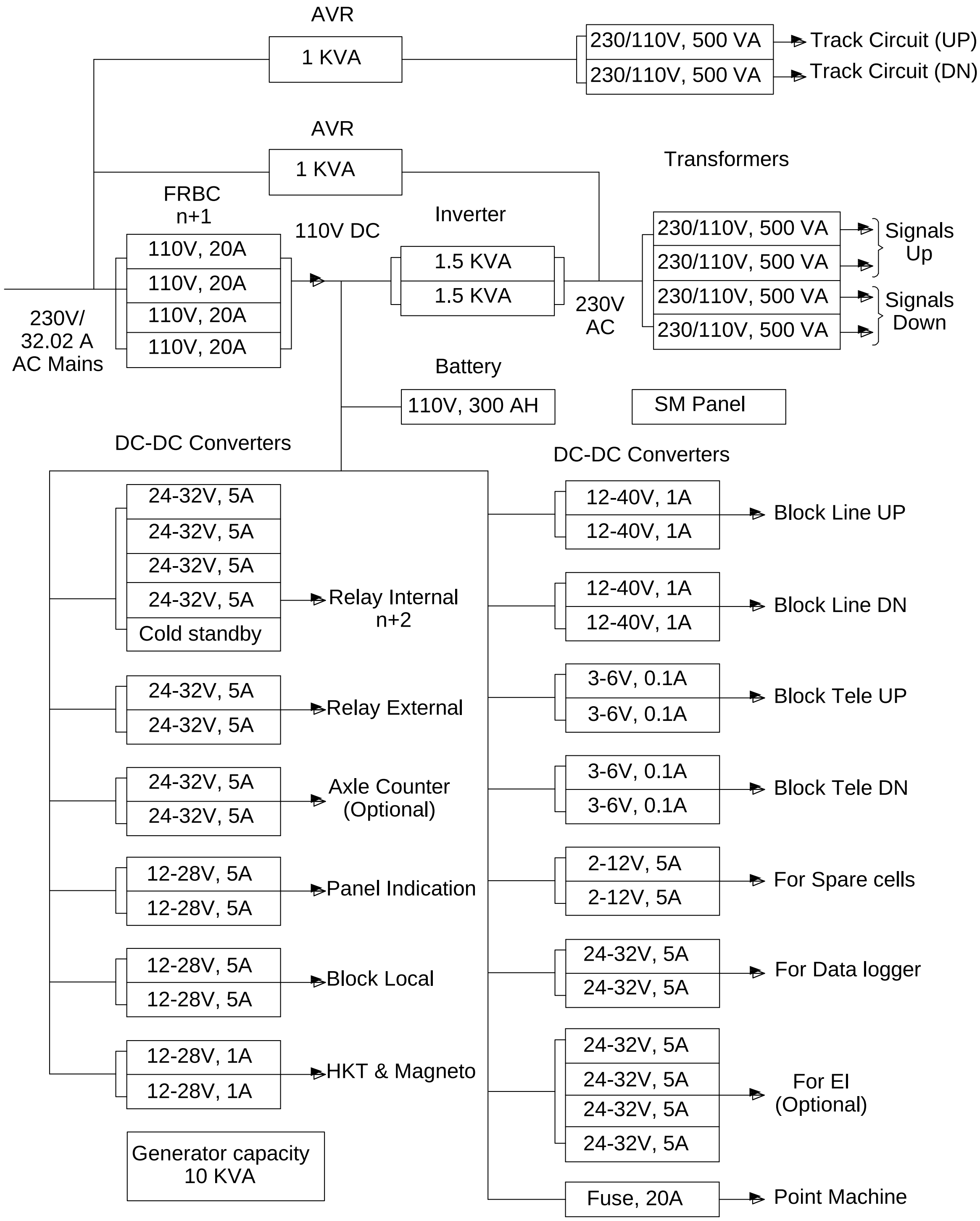
ii) Depending upon type of block instrument, the DC-DC converter for block line may be taken as 12-40/1A or 40-100V/1A or 100-150V/1A.

iii) SMR shall be in n+1 configuration, DC-DC converter for internal circuit shall be in n+ 2 configuration & for other circuits in n+1 configuration.

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



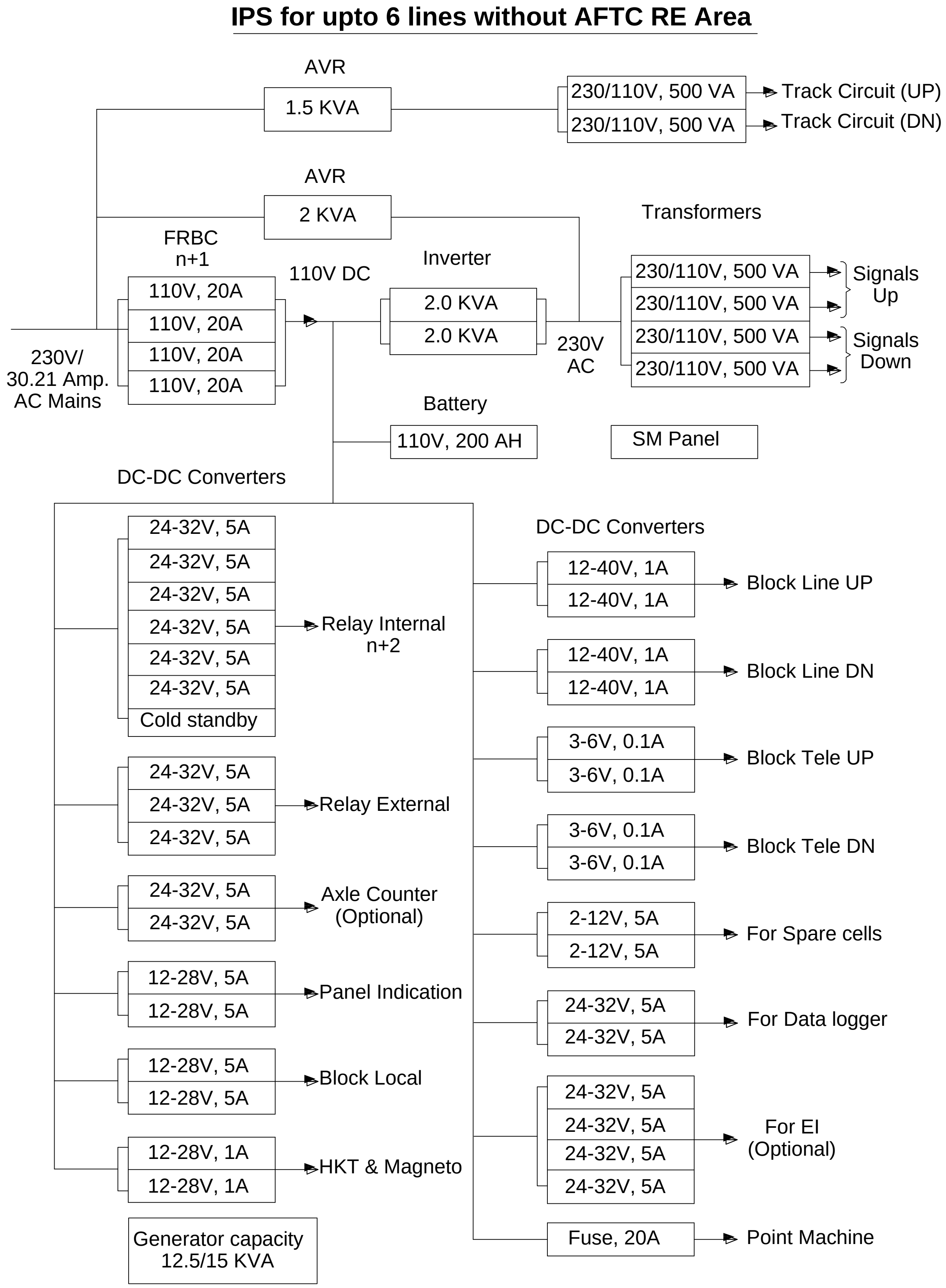
Note: i) For 60V metal to metal relay circuit, the rating of DC-DC Converter for relay internal and external shall be 60- 66V/5A.

ii) Depending upon type of block instrument, the DC-DC converter for block line may be taken as 12-40/1A or 40- 100V/1A or 100-150V/1A

iii) SMR shall be in n+1 configuration, DC-DC converter for internal circuit shall be in n+ 2 configuration & for other circuits in n+1 configuration.

Fig: 5.2

5.12.3 BLOCK DIAGRAM OF IPS USED IN RE AREA UP TO 6 LINES WITHOUT AFTC



Note: i) For 60V metal to metal relay circuit, the rating of DC-DC Converter for relay internal and external shall be 60- 66V/5A.

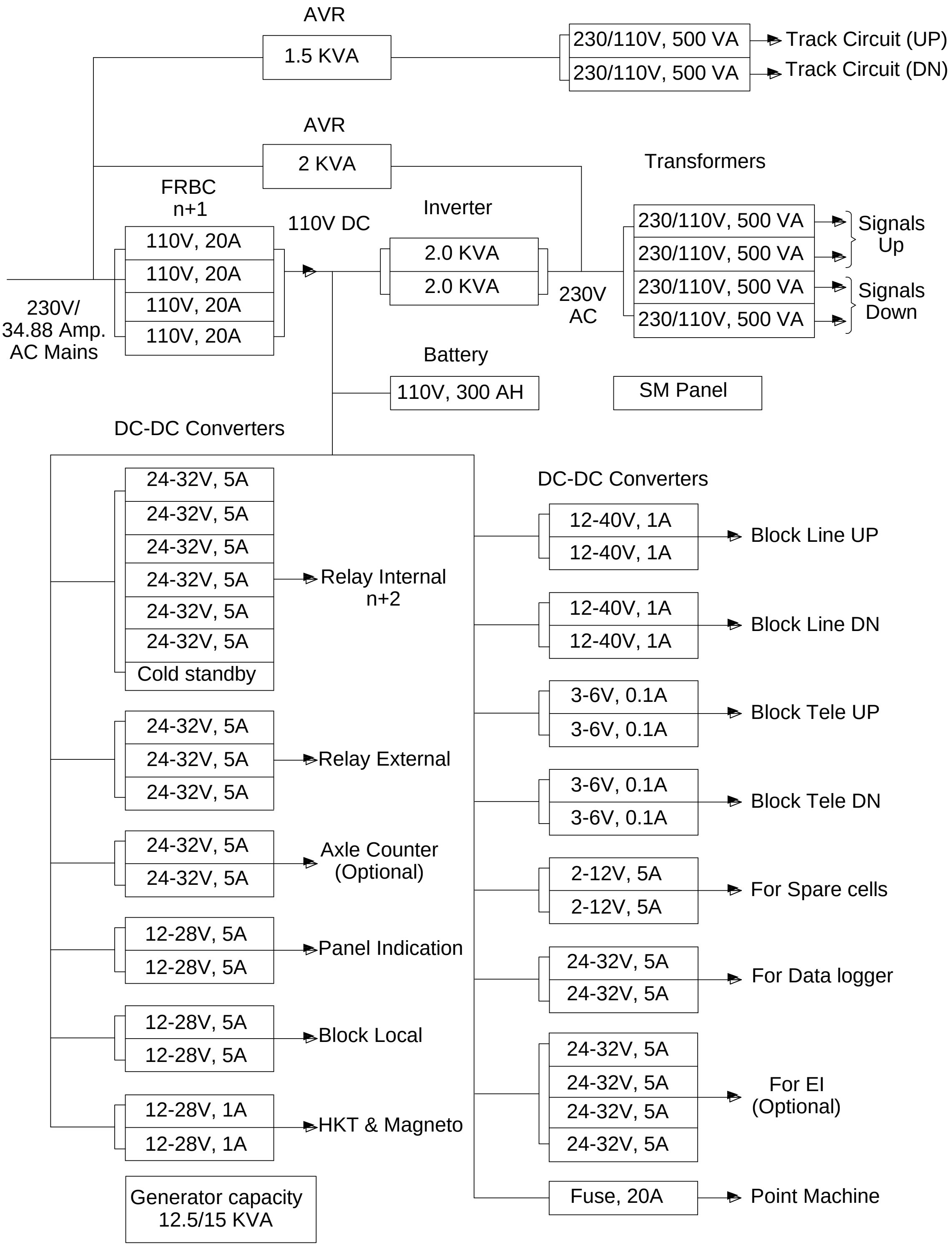
ii) Depending upon type of block instrument, the DC-DC converter for block line may be taken as 12-40/1A or 40- 100V/1A or 100-150V/1A

iii) SMR shall be in n+1 configuration, DC-DC converter for internal circuit shall be in n+ 2 configuration & for other circuits in n+1 configuration.

Fig: 5.3

5.12.4 BLOCK DIAGRAM OF IPS USED IN NON-RE AREA UP TO 6 LINES WITHOUT AFTC

IPS for upto 6 lines without AFTC Non - RE Area



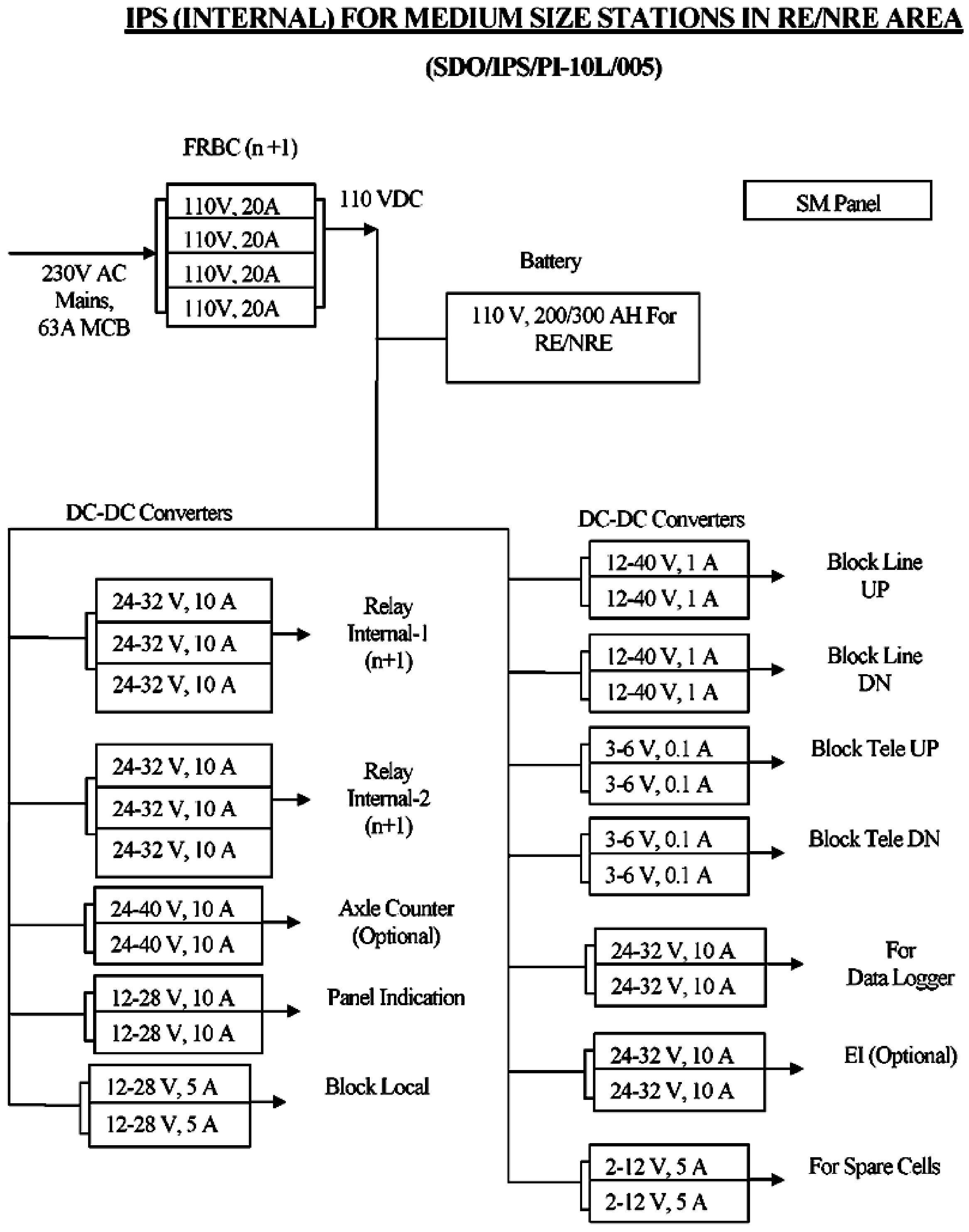
<u>Note</u>: i) For 60V metal to metal relay circuit, the rating of DC-DC Converter for relay internal and external shall be 60- 66V/5A.

ii) Depending upon type of block instrument, the DC-DC converter for block line may be taken as 12-40/1A or 40- 100V/1A or 100-150V/1A

iii) SMR shall be in n+1 configuration, DC-DC converter for internal circuit shall be in n+ 2 configuration & for other circuits in n+1 configuration.

Fig: 5.4

5.12.5 BLOCK DIAGRAM OF IPS (INTERNAL) FOR MEDIUM SIZE STATIONS IN RE/NON-RE AREA



Note: i) For 60V metal to metal relay circuit, the rating of DC-DC Converter for relay internal and external shall be 60- 66V/5A

ii) Depending upon type of block instrument, the DC-DC converter for block line may be taken as 12-40/1A or 40- 100V/1A or 100-150V/1A

iii) SMR shall be in n+1 configuration, DC-DC converter for internal circuits shall be in n+ 2 configurations & for other circuits in n+1 configuration.

Fig: 5.5

5.12.6 BLOCK DIAGRAM OF IPS (EXTERNAL) FOR MEDIUM SIZE STATIONS IN RE/NON-RE AREA

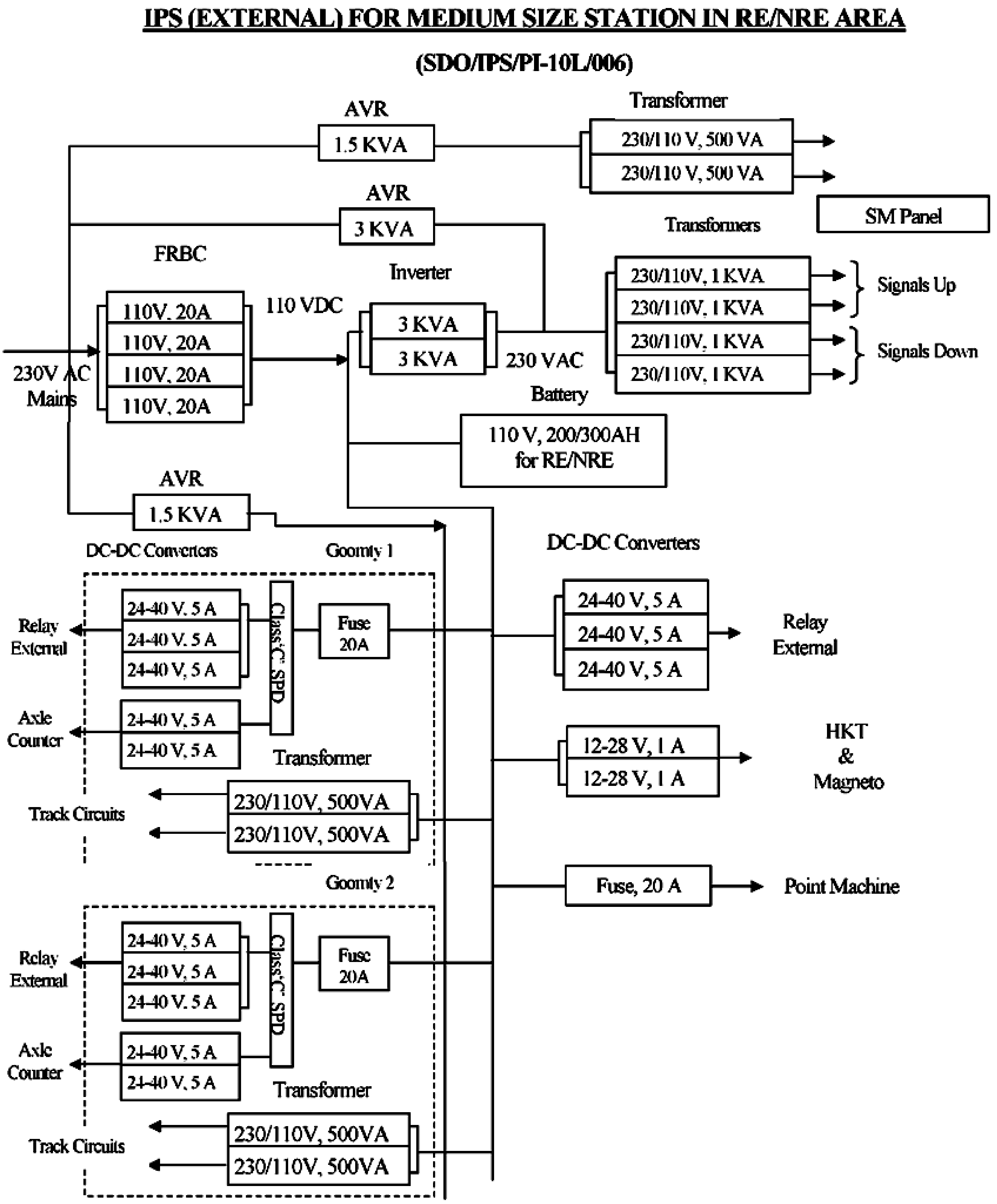


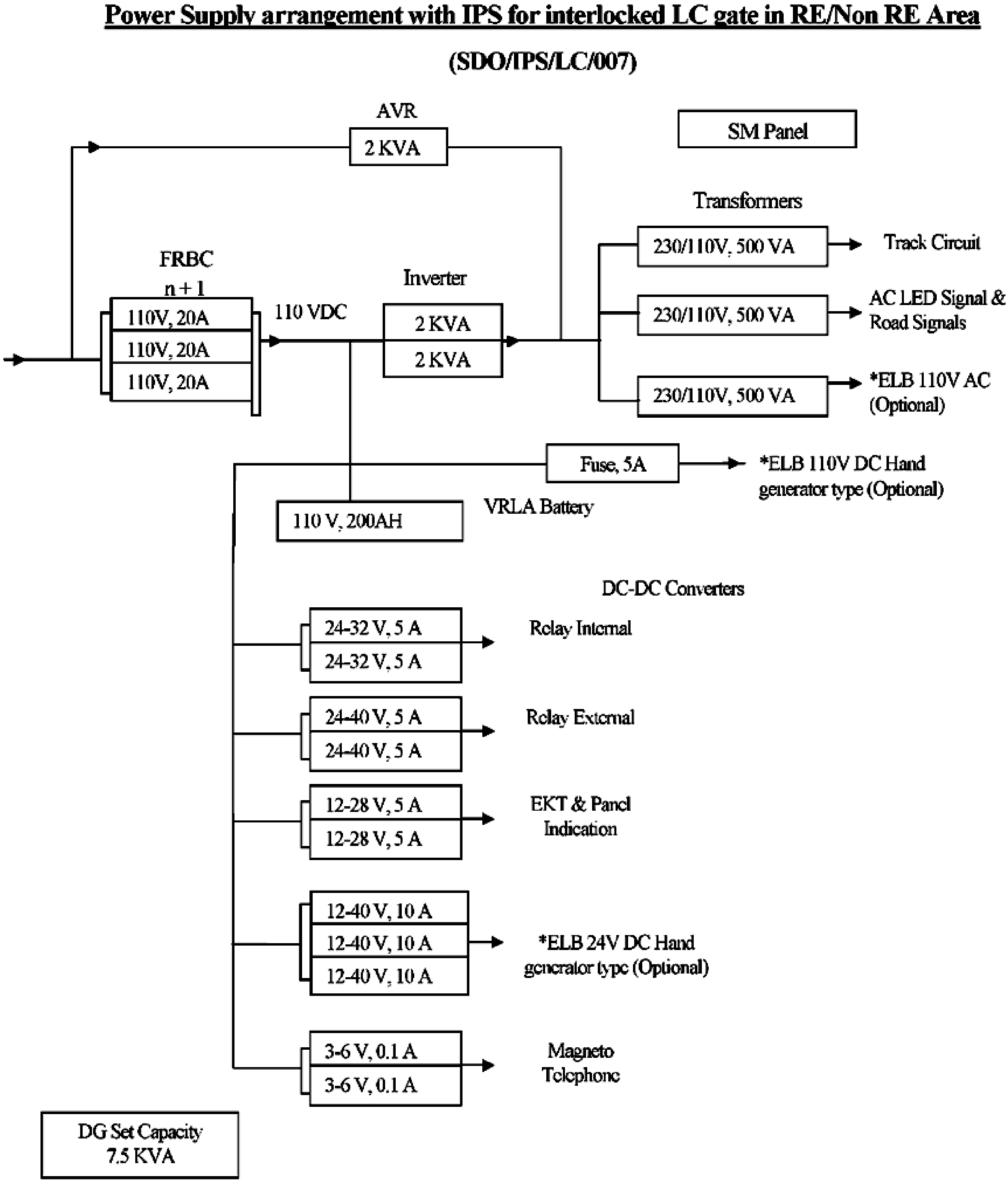
Fig: 5.6

Note: i) In case goomty arrangement is not planned, rating of DC-DC converters for Relay External. AVR and Transformer for track circuits shall be suitably increased at central location in IPS (external)

ii) DG set capacity for medium size station shall be 20 KVA.

iii) SMR shall be in n+1 configuration, DC-DC converter shall be in n+ 1 configuration.

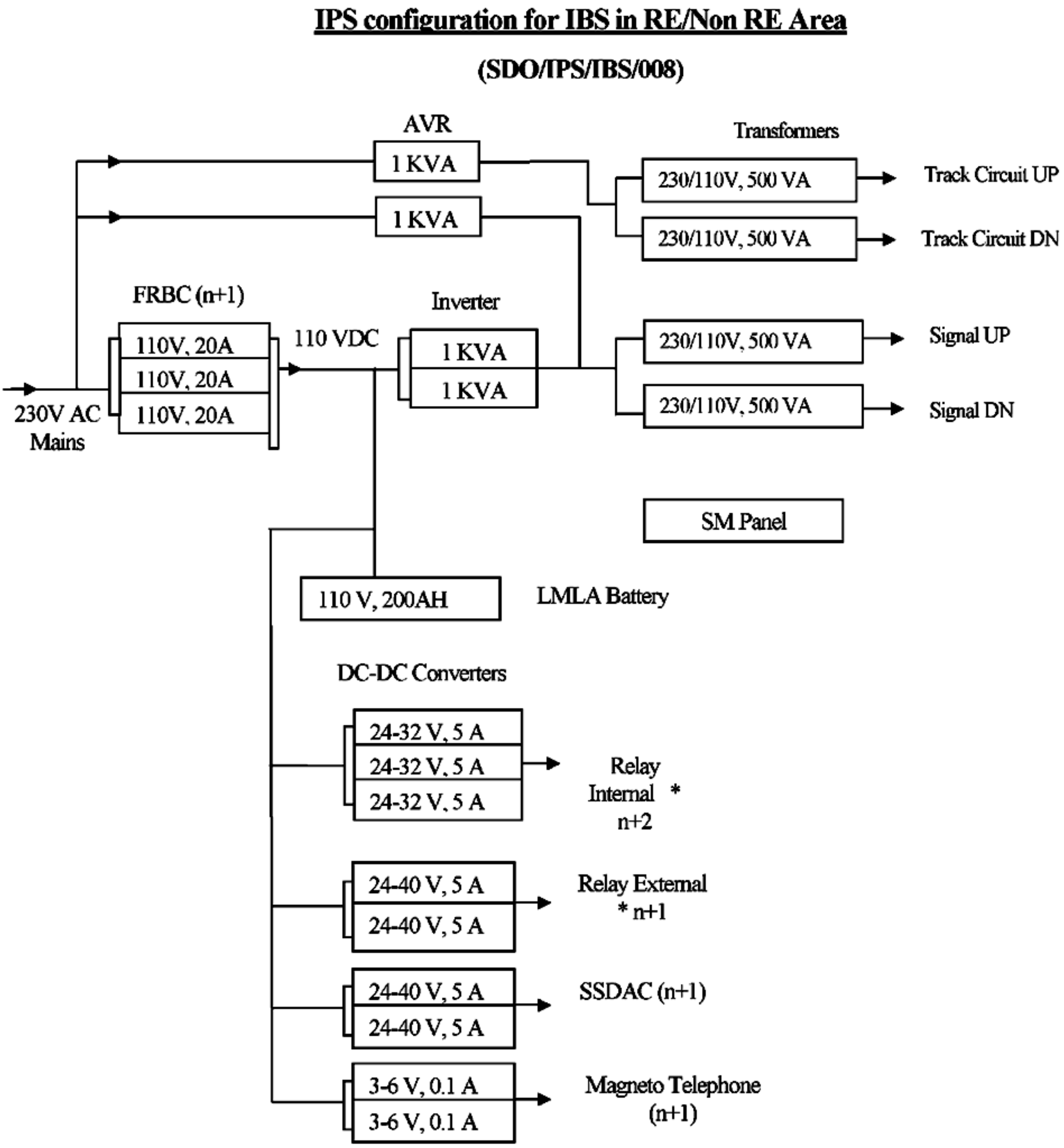
5.12.7 BLOCK DIAGRAM OF IPS FOR INTERLOCKED L.C GATE IN RE/NON-RE AREA



Note: * Only one type of ELB (24V DC/110 V DC/110 V AC) shall be used.

Fig: 5.7

5.12.8 BLOCK DIAGRAM OF IPS FOR IBS IN RE/NON-RE AREA



Note: * Wherever required 60-66V/5A DC-DC converter modules may be used instead of 24-32V/5A or 24-40V/5A depending upon Relay type.

Fig: 5.8

5.13 Pre-Commissioning Check List of SMPS based IPS System

1. STATION DETAILS

Zonal Railway		Number of main signals	
Division		Number of shunt signals	
Station Name		Number of point machines	
IPS Make		Number of Axle Counters	
RE/Non RE		Number of Track Circuits	
No. of lines / Roads		Type of Track Circuit (AFTC/DC)	
Power availability hours / day		Number/Type of Indoor relays	
DG set rating		Number/Type of outdoor relays	
Type / capacity of battery (LM/VRLA)		Interlocking (RRI/SSI)	

2. PRE-COMMISSIONING REQUIREMENTS

Sl. No.	ITEM	Specified Value/provision	Measured Value / Observation	Remark (OK/Not OK)
A	**Ambience of IPS Room**			
A1	Availability of working space for maintenance.	1 m (min.) from sides and rear. 2 m (min.) in front of the IPS		
A2	Provision of flooring to ensure proper cleaning.	Pucca floor/ Ceramic tiles		
A3	Provision of forced ventilation	Fresh Air fans with dampers		
A4	Arrangement for protection against dust.	(i) Tight closing of doors & windows; use gaskets if necessary. (ii) Washable dust filters on windows. (iii) Provision of double door or entry through adjoining room to reduce dust ingress		
A5	Provision of Ventilators	As per RE Drg. No. RE/Civil/S-129-2001 (Annexure-I).		

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Sl. No.	ITEM	Specified Value/provision	Measured Value / Observation	Remark (OK/Not OK)
B	**Batteries**			
B1	Installation of secondary cell as per para 16.6 of SEM Pt.	Installed in separate room / apparatus case. Acid proof flooring and tiles Exhaust fan Initial charging as per instruction of battery manufacturer Use of battery grade sulphuric acid conforming to IS: 266. Use of distilled or de-mineralised water conforming to IS: 1069		
B2	Storage period of VRLA batteries for IPS	Less than 03 months (If the battery is being stored for more than 3 months, freshening charge should be given once in 3 months as given below. The charging current should be 10% to 20% (max.) of rated capacity:- Float Charge @ 2.25V/cell for 24 hours Boost Charge - @ 2.30V/cell for 15 hours)		
B3	Measured capacity of battery after capacity test on batteries.	Rated AH		
B4	Feeder cable from battery to charger 120AH 200AH 300AH	 10 sq.mm copper 16 sq.mm copper 25 sq.mm copper		
B5	Availability of Spare cell in charged condition at site	05 Nos.		
C	**Commercial/AT Supply**			
C1	Availability of commercial supply (Ref: RB letter No. 2002/SIG/SGF/3 dt. 24.6.03).	More than 6 hours in 24 hours with least fluctuations (Note: Nominal incoming AC supply shall be 230V, 50Hz single phase AC. The specified AC voltage range for IPS is 150V-270V.)		

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Sl. No.	ITEM	Specified Value/provision	Measured Value / Observation	Remark (OK/Not OK)
C2	Voltage drop in input feeder at full load.	Less than 30 volts		
C3	Provision of sources of power supply as per para 16.2 of SEM Pt. II.	**RE Area** Power supply drawn from AT Up/Dn/ Commercial supply/ Genset with auto/ manual changeover facility in the control panel. On double/multiple line sections, at least one AT is available to ensure power supply in the event of power block. On single line sections where power supply is drown from a single AT, a DG set of suitable capacity has been provided In big yards, a DG set of adequate capacity in addition to supply from AT's and local source **Non RE Area** Power supply drawn from commercial feeder. In addition two standby diesel generators have been provided		
C4	Size of input feeder cable as per TI Directorate's note no. TI/PSI/Project/CLS/01 dt. 04.01.02.(Annexure II) from Auxiliary Transformer (AT) / Distribution transformer to IPS room for 5 KVA AT 10KVA AT 50KVA AT	 2X25 sq.mm Al 2x70 sq.mm Al 2x300 sq.mm Al		

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Sl. NO.	ITEM	Specified Value/provision	Measured Value / Observation	Remark (OK/Not OK)
C5	Sanctioned Commercial feeder load (KVA)=S			
	General Electrical Lighting load (KVA)=L			
	Balance available for Signalling Load(KVA) = S-L 4 Line Non-RE 4 Line RE 6 Line Non-RE 6 Line RE	 7.4 KVA 6.25 KVA 8.1 KVA 7.0 KVA		
C6	MCB/ Changeover switch (Ref: RB letter No. 2004/SIG/SGF/3 dt. 25.3.2004.	63 Amp of Merlin Gerlin (Telemecanique) / Siemens, Schneider or ABB.		
D	**DG Set supply**			
D1	Provision of adequate capacity DG set (without AFTC) 4 Line Non-RE 4 Line RE/6 Line RE 6 Line Non-RE with AFTC in yard	 10 KVA 10 KVA 12.5/15 KVA At least 25 KVA		
D2	Checking of DG set at 5KW dummy load: Waveform Voltage Regulation Frequency	 Sinusoidal within 3% 50Hz ± 5% from no load to full load		
D3	Proper termination of earth and neutral.	Good workmanship		
E	**Earthing**			
E1	Earth resistance of earthing arrangement.	Less than 2 Ohm (without adding water prior to measurement) Preferably maintenance free earth.		
E2	Extension of earth to equi-potential bus bar.	Provided		

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Sl. No.	ITEM	Specified Value/provision	Measured Value / Observation	Remark (OK/Not OK)
E3	Connection of individual equipment to equipotential bus bar: - IPS racks - DG sets -Surge protection devices	with individual copper insulated cable of size 4 Sq.mm 4 Sq.mm 16 Sq.mm		
F	**Lightning & Surge Protection**			
F1	Provision of lightning & surge arrestors (As per Cl. 3.12 of RDSO/SPN/ 165/ 2004 Ver 2)	One set		
G.	**Instruction Manual**			
G1	Instruction Manual consisting of Layout drgs., Circuit/ System diagram, PCB Layout etc. (Ref: Cl. 7.1 of RDSO/SPN/165/ 2004 Ver 2)	Two sets		
H	**Training**			
H1	Imparting on job training to SE/SSE/JE and ESM	3 days		

3. IPS LOAD DETAILS

N= Number of modules provided in hot standby

Sl. No.	ITEM	Specified Value/provision	Measured Value / Observation	Remark (OK/Not OK)	
				OK	Not OK
1.	Signalling Equipment load (KVA)	80% of the DG Set capacity provided at station			
2.	Relay internal 24-32V/5A	5 *(N-2) Amp			
3.	Relay external 24-32V/5A	5 *(N-1) Amp			
4.	Axle counter 24-32V/5A	5 *(N-1) Amp			
5.	Block local 12-28V/5A	5 *(N-1) Amp			
6.	Panel Indication12-28V/5A	5 *(N-1) Amp			
7.	HKT/magneto 12-28V/1A	1 *(N-1) Amp			
8.	Block UP 12-40V/1A	1 *(N-1) Amp			
9.	Block DN 12-40V/1A	1 *(N-1) Amp			

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Sl. No.	ITEM	Specified Value/provision	Measured Value / Observation	Remark (OK/Not OK)	
				OK	Not OK
10.	Block Tele UP 3-6V/0.1A	0.1*(N-1) Amp			
11.	Block Tele DN 3-6V/0.1A	0.1*(N-1) Amp			
12.	Data logger 24-32V/5A	5 *(N-1) Amp			
13.	SSI 24-32V/5A	5 *(N-2) Amp			
14.	Load on each Signal Tx UP	500 VA			
15.	Load on each Signal Tx DN	500 VA			
16.	Load on Inverter 4 Line 6 Line	 1.5 KVA 2.0 KVA			
17.	Load on Signalling AVR 4 Line 6 Line	 1.5 KVA 2.0 KVA			
18.	Load on Track Tx UP DN	 500VA 500VA			
19.	Load on Track AVR 4 Line 6 Line	 1.0 KVA 1.5 KVA			
20.	High voltage disconnect	275 V			
21.	Low voltage disconnect	160V			
22.	Battery capacity	300/200AH			
23.	Battery charging current	30/20A =Y			
24.	Total Current drawn from FRBC at 110 V after one hour of discharge.	20* (N-2) Amp=X			
25.	Current drawn from FRBC at 110 V when battery is in float condition	X-Y			
26.	Input feeder current at full load 4 Line Non-RE 4 Line RE 6 Line Non-RE 6 Line RE	 32 Amp 27.2 Amp 35 Amp 30.2 Amp			
27.	Input feeder voltage at full load	160 Volts (Minimum)			
28.	Functioning of dynamic current control	Operational			
29.	Supply fuse	63 A			

Signature of Manufacturer's Representative | Signature of Railway Supervisor

<table>
<tr><th rowspan="2">Sl. No.</th><th rowspan="2">ITEM</th><th rowspan="2">Specified Value/provision</th><th rowspan="2">Measured Value / Observation</th><th colspan="2">Remark (OK/Not OK)</th></tr>
<tr><th>OK</th><th>Not OK</th></tr>
<tr><td>30.</td><td>Working of Status Monitoring Panel (Para 4.10 of spec.)
DOD 50%
60%
70%

Stop DG Set</td><td>

RED & Audio alarm
RED & Audio alarm
RED & Audio alarm till DG is started

GREEN & Audio alarm</td><td></td><td></td><td></td></tr>
<tr><td>31.</td><td>Call S&T due to failure of any module</td><td>RED & Audio alarm</td><td></td><td></td><td></td></tr>
<tr><td>32.</td><td>Changeover inv. 1 to 2 and vice versa</td><td>Inverter failure</td><td></td><td></td><td></td></tr>
<tr><td>33.</td><td>Changeover inv. to CVT and vice versa</td><td>Both inverter fail</td><td></td><td></td><td></td></tr>
<tr><td>34</td><td>DC-DC Converter for spare cells 2-12V, 5Amp</td><td>02 Nos.</td><td></td><td></td><td></td></tr>
<tr><td>35</td><td>Temperature compensation</td><td>Provided for VRLA battery</td><td></td><td></td><td></td></tr>
</table>

4. Performance Monitoring of IPS

Sl. No.	ITEM	Specified Provision	Observation	Remark
1	Monthly calculation of MTBF / MTTR and sending it to Zonal Railways for onward transmission to RDSO.	As per Annexure-III		

Signature of IPS Manufacturer's Representative Name Designation Date	Signature of Railway Supervisor Name Designation Date

5.16 Codal Life

Codal life of IPS system is 15 years.

5.17 IMMEDIATE ACTION PLAN FOR PREVENTING SIGNAL INCIDENCES DUE TO LIGHTNING EFFECT

(Ref: Railway Board's L. No: 2011/Sig/SF/1 dated:19-08-2011)

Increasing signal incidences due to lighting has been a cause of concern. Failures of IPS modules or their resetting cases are prominent during lighting. To improve the reliability of signaling equipment as well as availability of signaling, detailed discussions/meeting was held with Railways and with RDSO wherein the various measures were proposed to be taken immediately. These measures are summarized as under:

Integrated Power Supply (IPS) for signaling gears at stations:

(a) Availability and intactness of class 'B' & 'C' SPDs which are being supplied along with IPS in a separate wall mountable box shall be checked and provided wherever not available.

(b) The equi-potential bonding of indoor signaling equipments including IPS racks should be provided in the power and EI rooms and connected to low resistance earth of less than 1Ω as per RDSO scheme.

(c) The length of cables from SPD to earth bus bar and from equipment to earth bus bar should be shortest possible without any bends.

(d) The size of cable from SPD to earth bus bar should be minimum 16 sq.mm copper cable and the size of cable from equipment to earth bus bar should be minimum 10sq.mm copper cable.

(e) All connections from equipment or SPD to earth bus bar shall be using exothermic welding.

(f) In order to achieve low resistance of less than 1Ω, multiple earth pits may be provided. This should be checked at the time of installation.

(g) Type sketch indicating SPDs for indoor signaling equipments at station is shown in Annexure-VIII Fig. No.8.

5.18 RDSO approved list of firms for manufacture and supply of electrical signalling items: as on 31st December 2013

ITEM: POWER SUPPLY EQUIPMENTS – SMPS BASED IPS

Spec No.: RDSO/SPN/165/2012

APPROVED UNDER PART: I	APPROVED UNDER PART: II
1. M/s Statcon Power Controls Ltd.,	1. M/s Medha Servo Devices Pvt. Ltd.
2. M/s Amara Raja Power Systems Pvt. Ltd.,	2. M/s Shukila Power Electronics Pvt. Ltd.
3. M/s HBL Power System Ltd.	

* * *

CHAPTER – 6: POWER SUPPLY ARRANGEMENTS

6.0 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.

A well designed power supply scheme to be provided at every signalling installation to provide high availability of power by deriving power from as many sources as feasible at a place.

6.1 SOURCES OF POWER SUPPLY

6.1.1 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 backup of suitable capacity may be provided as main/standby source of power supply wherever feasible. Details may be seen in Annexure-III

6.1.2 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.

6.3 AUXILIARY TRANSFORMERS (AT)

In RE area, for making the reliable power supply arrangements for Signals 25 KV/240V Auxiliary Transformers (AT) are provided to ensure reliable 240V AC supply at signalling installations.

Standard ratings of these ATs are 5KVA, 10 KVA, 25 KVA and 50 KVA.

(a) 5KVA ATs at IBH stations and Level Crossing gates.

(b) 10KV ATs at stations for signalling loads for 3 to 4 lines.

(c) 25KVA ATs at medium size stations (RRIs) having approx. 6 to 10 no. of lines

(d) 50KVA ATs for big stations (major RRIs) having more than 10 no. of lines.

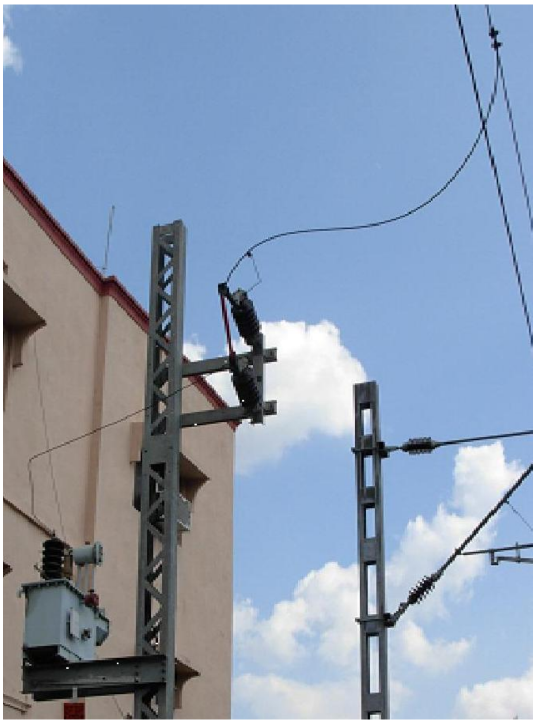


Fig: Auxiliary Transformer (AT)

6.4 SCOPE

6.4.1 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.

6.4.2 Responsibilities of Electrical and S&T Departments.

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

The following provisions shall be made, keeping in view as many sources as feasible to provide redundancy..

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

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

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

6.5.2 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.

6.5.3 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.

6.5.4 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 KM 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 KM 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.

6.5.5 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 KM away from the station. Wherever interlocked level crossing gates are located within 2 KM 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.

6.5.6 AUTOMATIC BLOCK SIGNALLING INSTALLATIONS

(a) INSTALLATIONS WITHIN 2 KMS FROM THE STATION

Power supply to all signals within 2 KM 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 KM, 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.

6.6 MAIN / STANDBY SUPPLIES

6.6.1 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.

6.6.2 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.

6.7 POWER SUPPLY ARRANGEMENTS / AUTO CHANGE OVER etc

6.7.1 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.

6.7.2 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.

6.8 TELECOMMUNICATION INSTALLATIONS

6.8.1 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 2 KM, separate ATs will be provided by Electrical Department.

6.8.2 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.

6.9 TYPES OF LOAD PERMISSIBLE on Auxiliary Transformer Power Supply

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.

6.10 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.

6.11 SCHEMATIC DIAGRAMS

The schematic diagrams for various types of installations are shown in fig. 6.1 to 6.8. 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.

All cables from changeover switch to signalling installations should be maintained by S&T department.

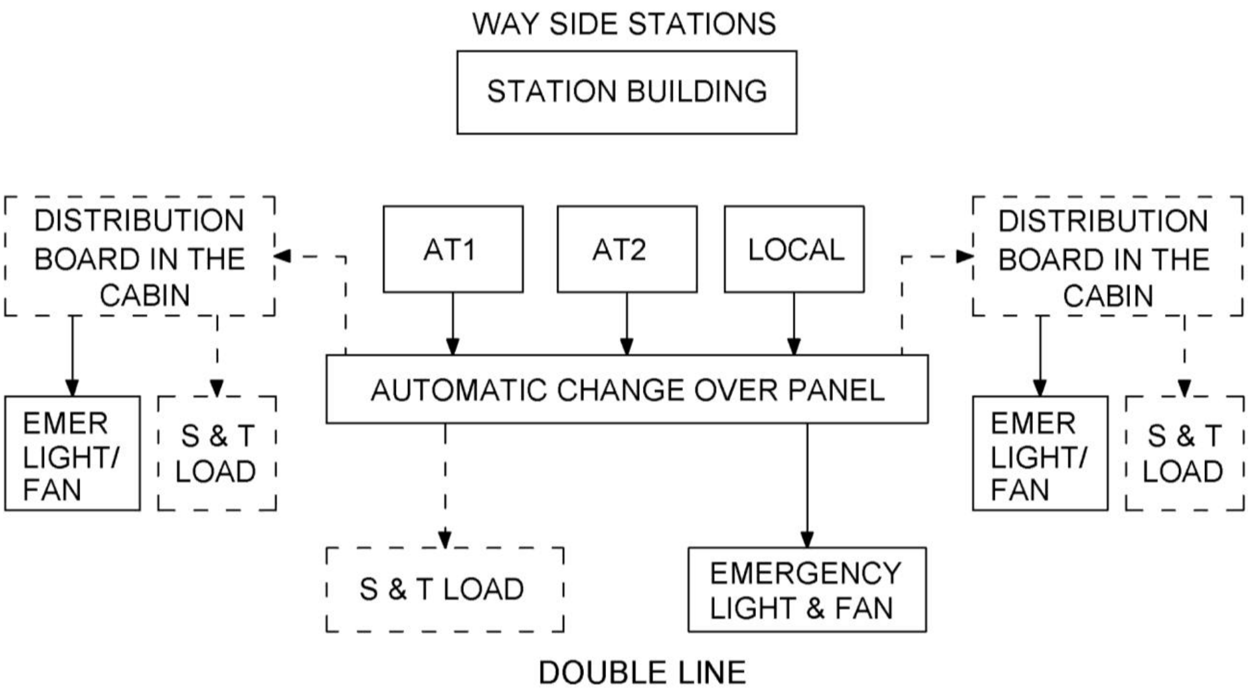
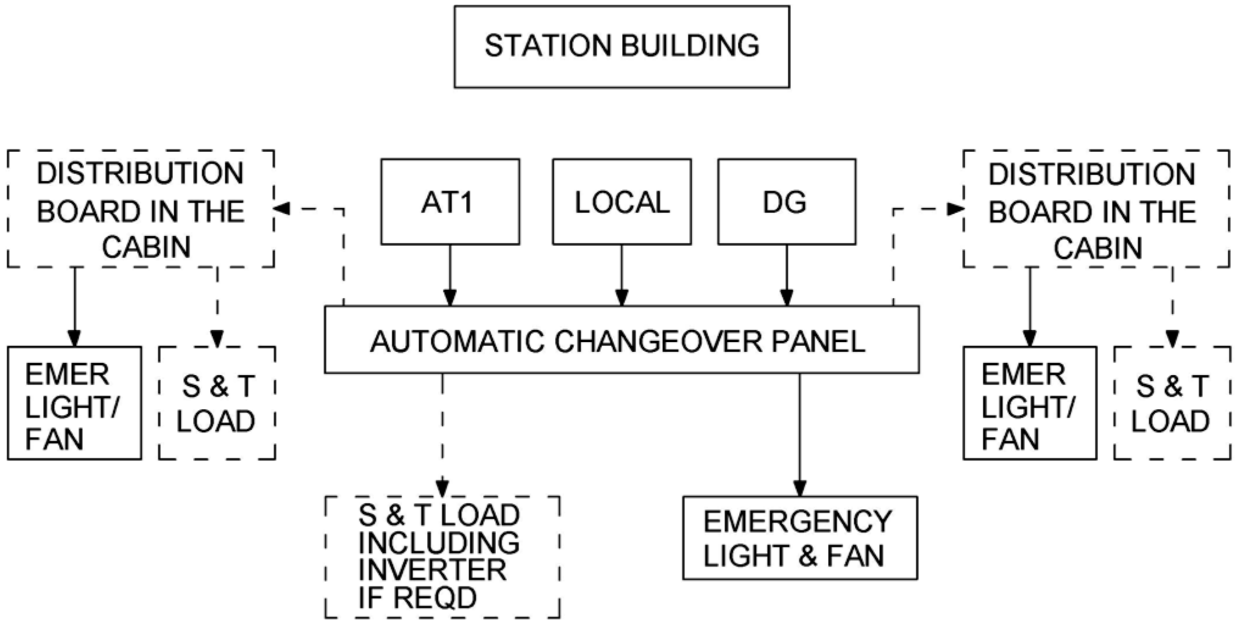


Fig: 6.1

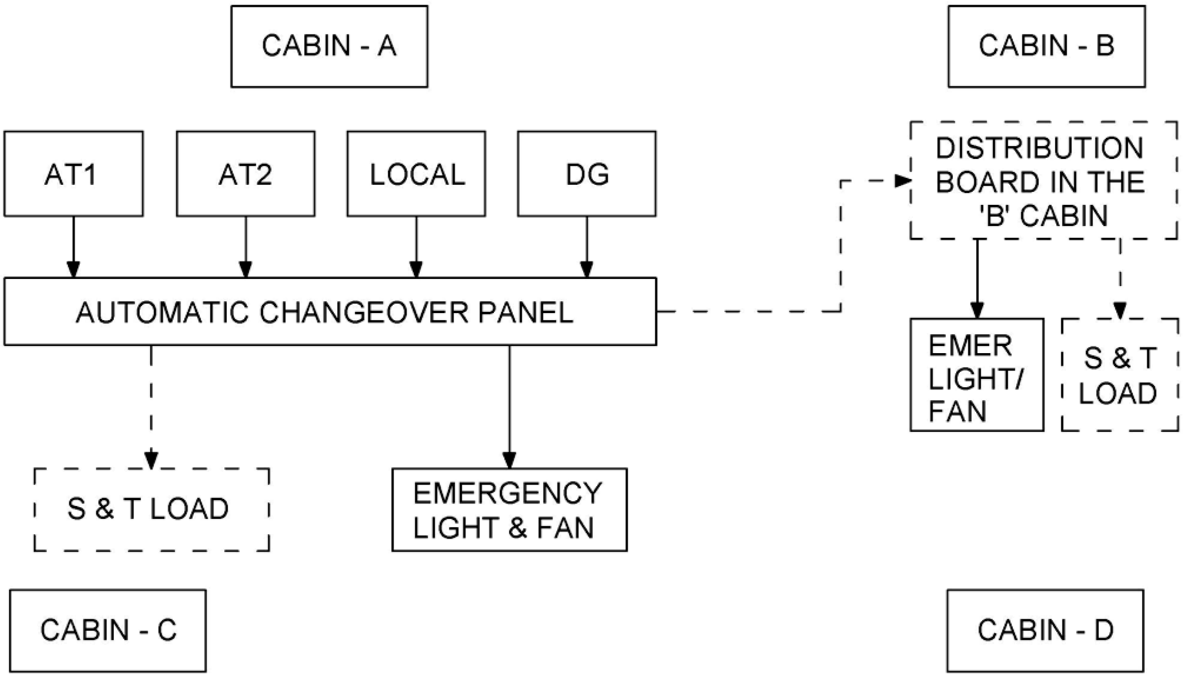


SINGLE LINE

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

Fig: 6.2

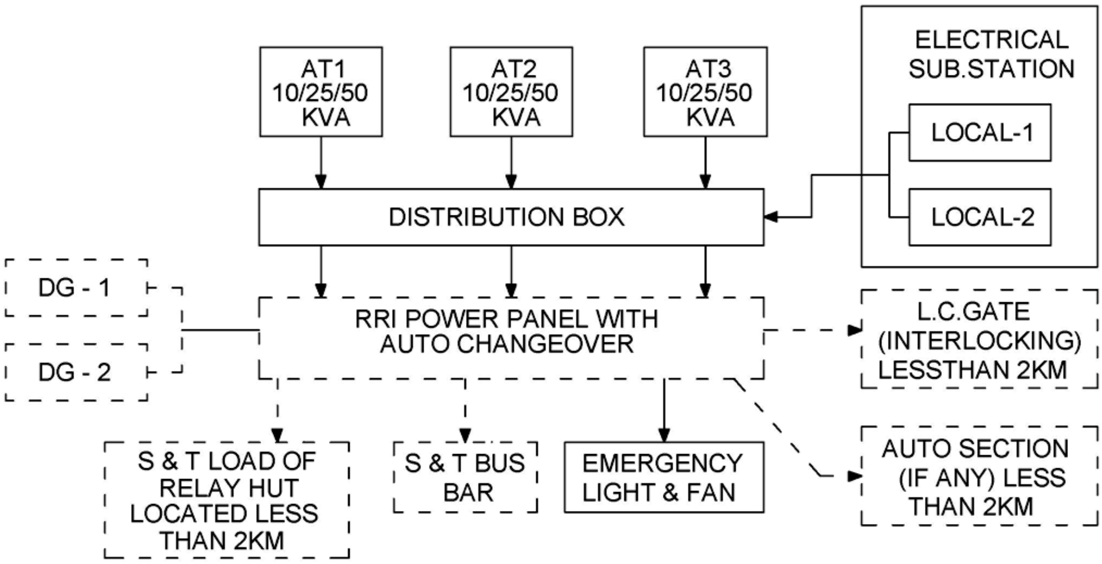
ANNEX-2



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

MULTI CABIN

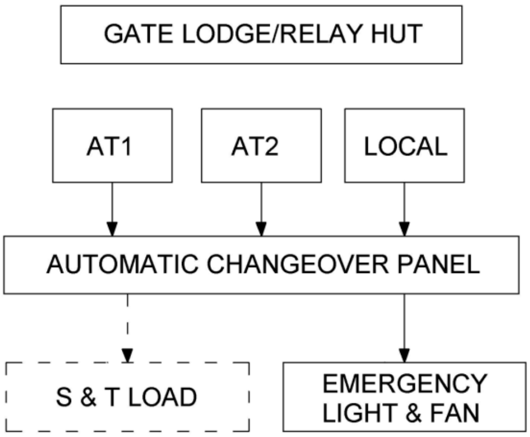
Fig: 6.3



FOR RRI CABIN

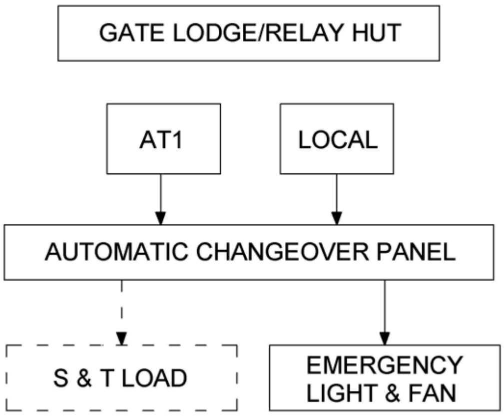
Fig: 6.4

LEVEL CROSSING GATES / IBH



DOUBLE LINE

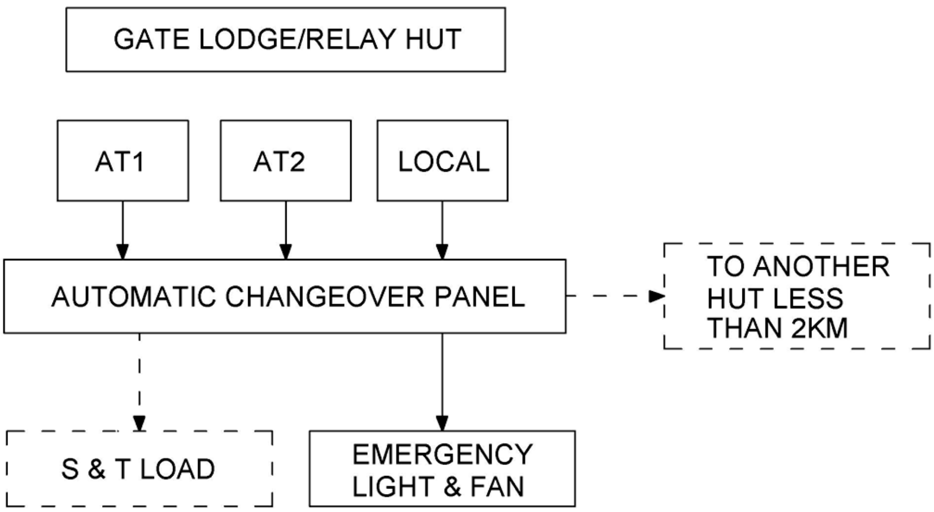
Fig: 6.5



SINGLE LINE

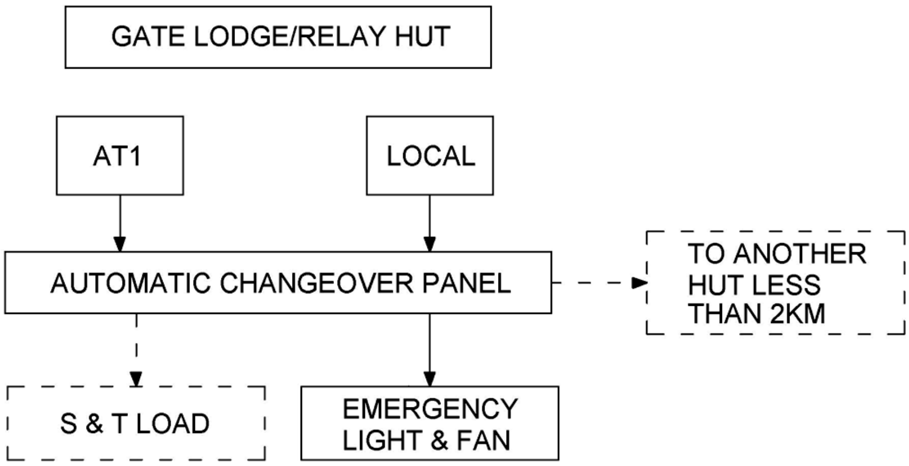
Fig: 6.6

AUTO HUT/RELAY HUT



DOUBLE LINE

Fig: 6.7



SINGLE LINE

Fig: 6.8

6.12 POWER SUPPLY ARRANGEMENTS AT RRIs

6.12.1 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

6.12.2 REDUNDANCY OF SOURCE

(a) State Supply (with separate substation)

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

(c) Diesel Generators – 2 Nos.

6.12.3 SELECTION OF SOURCES

(a) Automatic

(b) Manual

6.12.4 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)

6.12.5 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

6.12.6 MANUAL CHANGEOVER SWITCHES – in the Equipment Room

(a) Chargers 6 pole

(b) Transformer 4 pole

(c) Stabilizer 8 pole

(d) Two 4 Pole switches

6.12.7 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.

6.12.8 SIZING OF THE CELLS AND CHARGERS

(a) CELLS

(i) Low maintenance battery

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

(iii) 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.

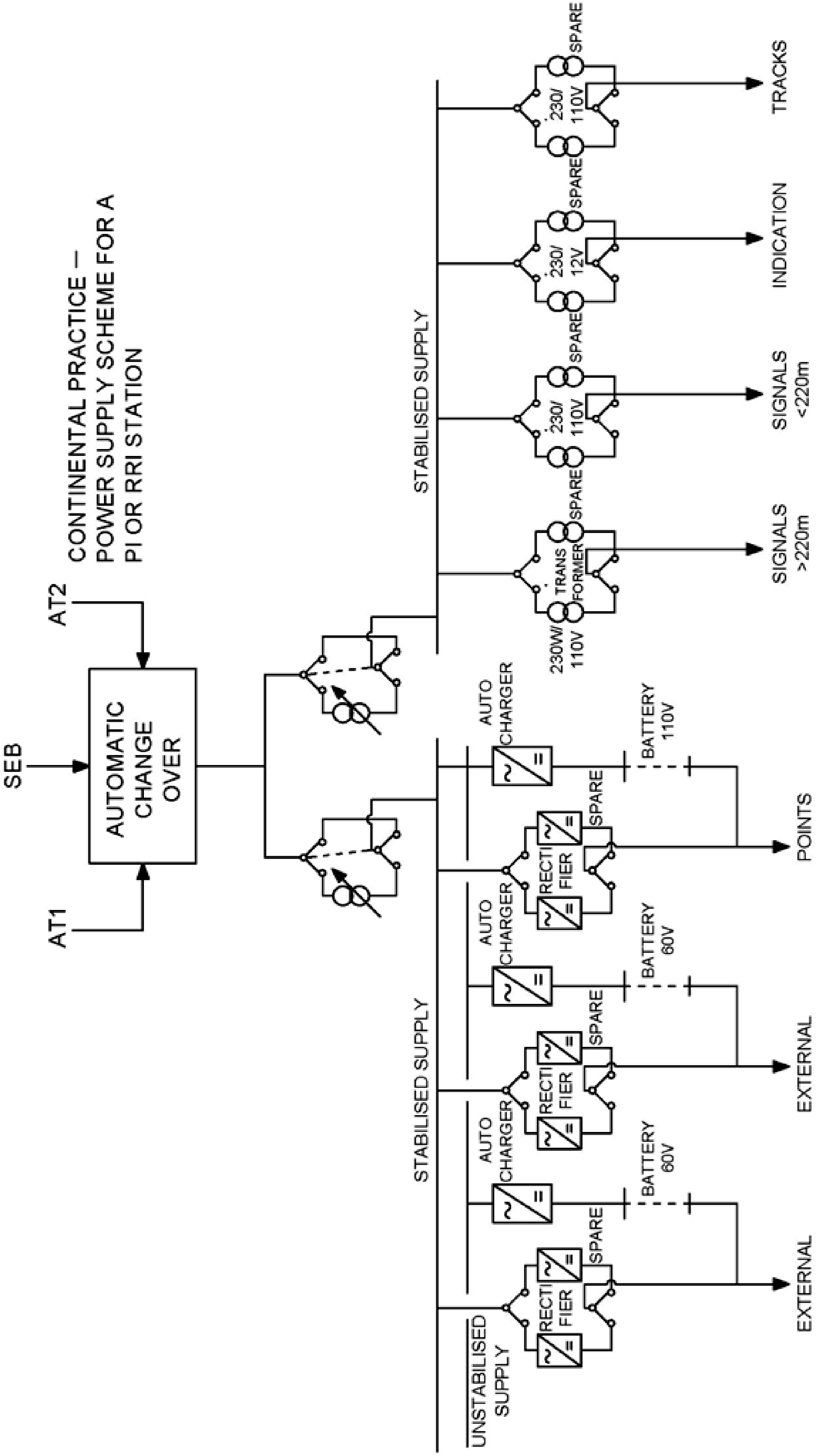

CONTINENTAL PRACTICE –
POWER SUPPLY SCHEME FOR A
PI OR RRI STATION
SEB
AT1
AT2
AUTOMATIC
CHANGE
OVER
STABILISED SUPPLY
230W/
110V
TRANS
FORMER
SPARE
230/
110V
SPARE
230/
12V
SPARE
230/
110V
SPARE
SIGNALS
>220m
SIGNALS
<220m
INDICATION
TRACKS
UNSTABILISED
SUPPLY
STABILISED SUPPLY
AUTO
CHARGER
BATTERY
110V
RECTI
FIER
SPARE
AUTO
CHARGER
BATTERY
60V
RECTI
FIER
SPARE
AUTO
CHARGER
BATTERY
60V
RECTI
FIER
SPARE
POINTS
EXTERNAL
EXTERNAL

Fig.6.9

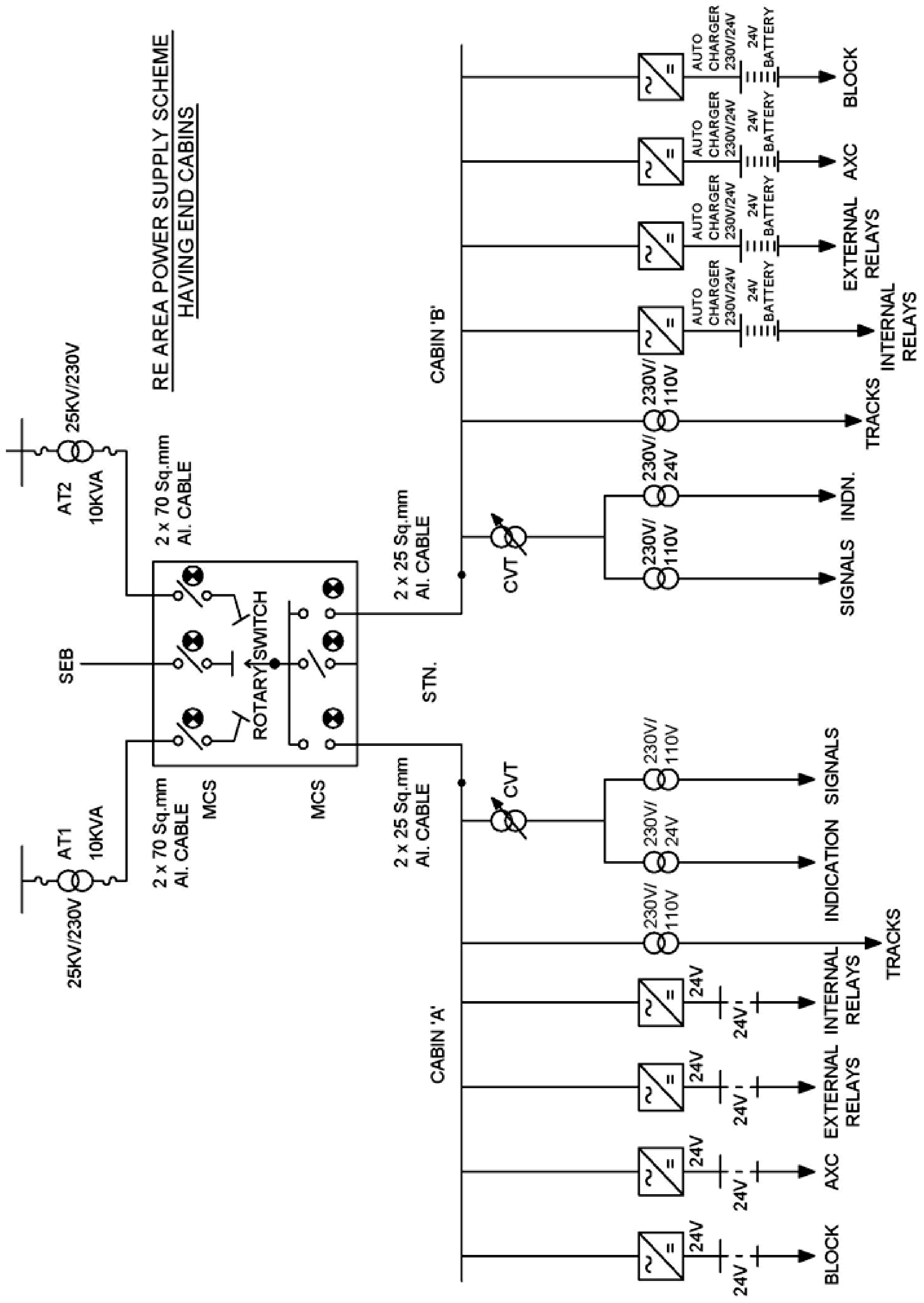

RE AREA POWER SUPPLY SCHEME
HAVING END CABINS
25KV/230V
AT2
10KVA
2 x 70 Sq.mm
Al. CABLE
SEB
AT1
10KVA
25KV/230V
MCS
ROTARY SWITCH
MCS
STN.
2 x 25 Sq.mm
Al. CABLE
CVT
CABIN 'B'
CABIN 'A'
230V/
110V
230V/
24V
AUTO
CHARGER
230V/24V
24V
BATTERY
24V
SIGNALS
INDN.
TRACKS
INTERNAL
RELAYS
EXTERNAL
RELAYS
AXC
BLOCK
INDICATION

Fig.6.10

6.13 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 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.

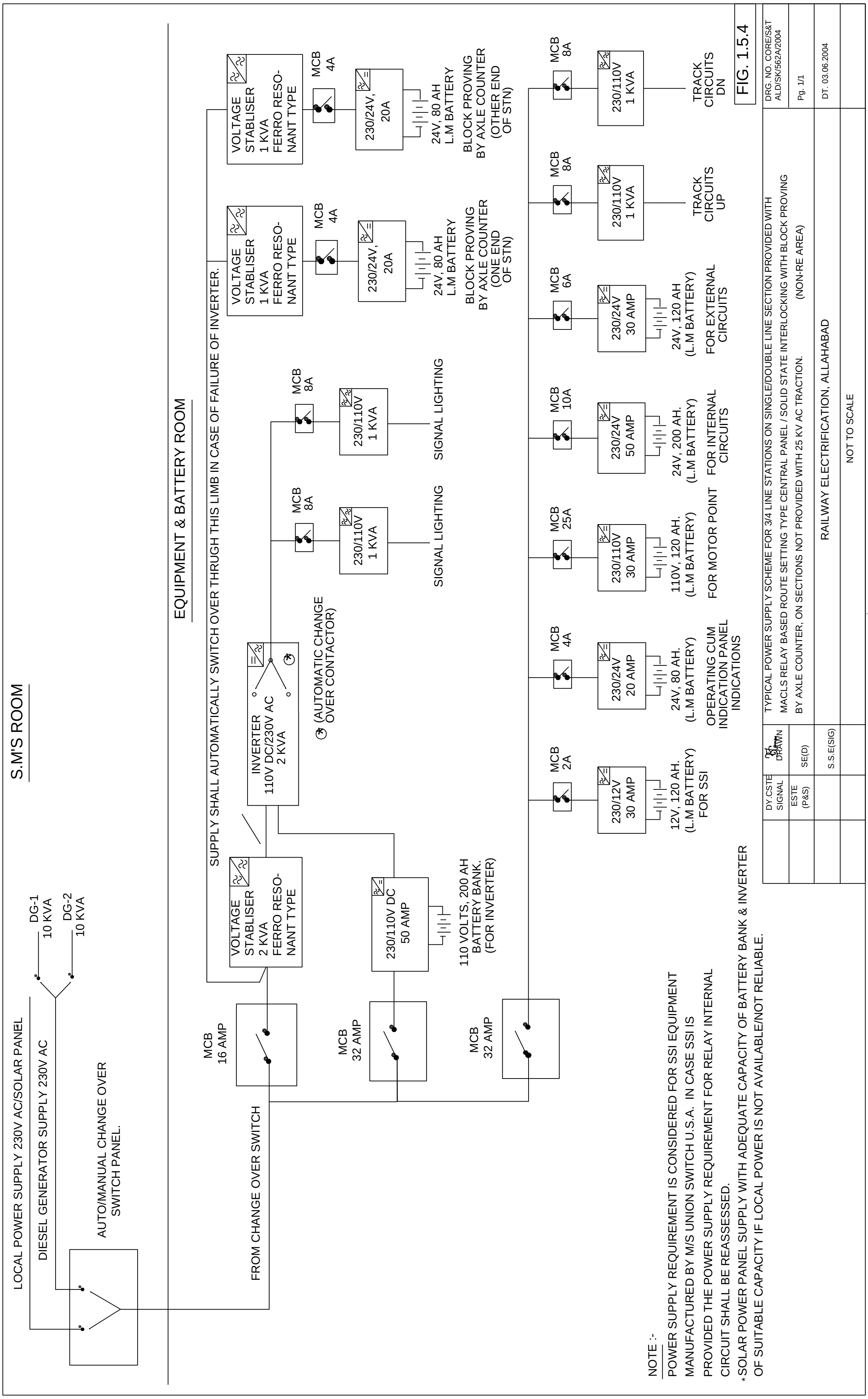
A Ferro resonant Voltage Stabilizer of 2 KVA capacity shall be connected to 230 V AC Local power supply through 16 Amp MCB. This shall be utilized to provided stabilized power supply for signal lighting.

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.



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.

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. Track feed chargers should be monitored using potential free contract available in the charger. Industrial grade rectifier element should be provided for improving the quality. Two chokes should be provided in parallel at the feed end. Sliding type variable resistance should be replaced with Disc type variable resistance. Disc type variable resistance should be provided in parallel at feed end. Self restoring type PPTC (Polymeric Positive Temperature Coefficient) fuses to be provided. (Ref: Railway Board's L. No: 2011/Sig/SF/1 dated:19-08-2011)

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, 500 ma, (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.

6.14 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.

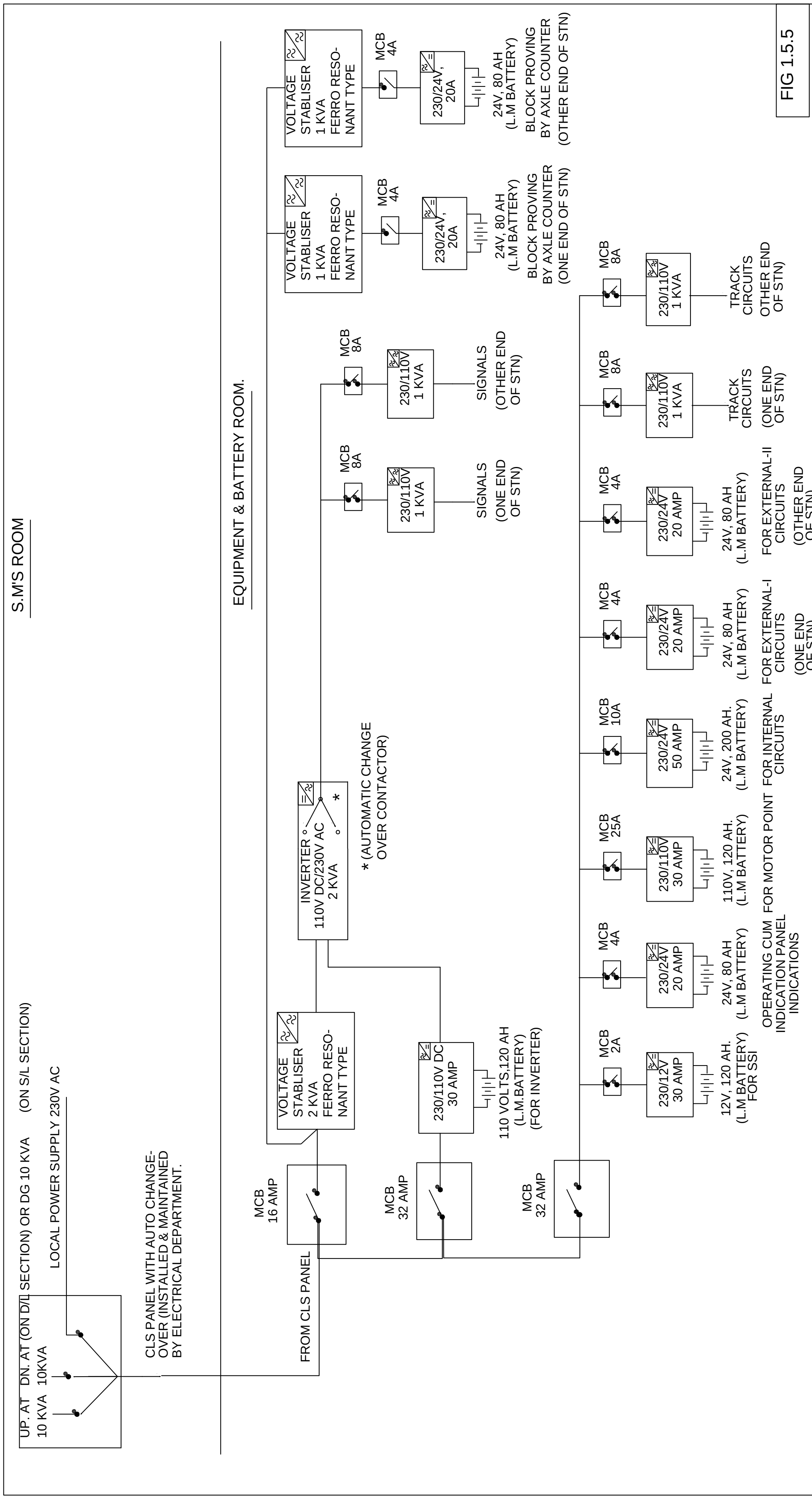
On stations on single line section or on double line section, an Inverter of 110V DC/230V AC, 2 KVA capacity supported with battery bank of 110V, 120AH Low Maintenance cells shall be provided and connected for on line operation. A battery charger of 230V AC/110V DC, 30 Amp shall be provided to charge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



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	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)	DRG. NO. CORE/S&T ALD/SK/563A/2004
ESTE (P&S)	SE(D)		Pg. 1/1
	S.S.E(SIG)	RAILWAY ELECTRIFICATION, ALLAHABAD	DT. 03.06.2004
		NOT TO SCALE	

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.

6.15 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

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

Due to provision of voltage stabilizer, the signalling load is normally of constant VA type i.e. if the voltage decreases the current will increase correspondingly. The input voltage range of the voltage stabilizer is 160-270V. Considering this the optimum cable sizes for different types of ATs are worked out and are given as follows:

Source of power supply (AT/Local)	Size of cable
5 KV 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

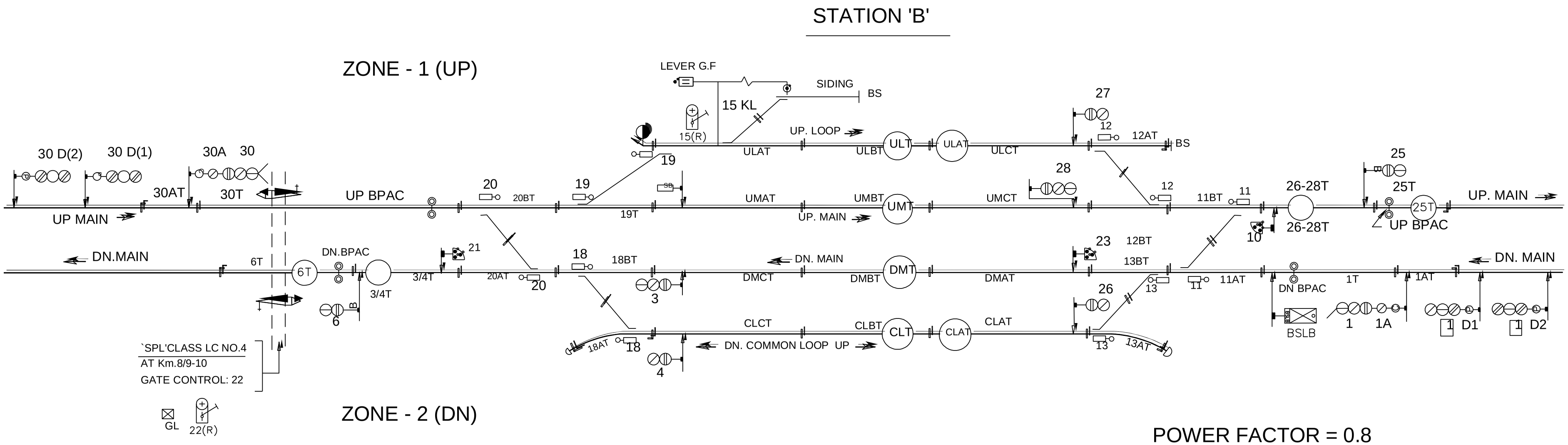
Table: Source of Power Supply verses Type of Cable

The taps of ATs should be judiciously kept so that the available voltage is maintained in the range of 160-270 V, which is the input voltage range of signalling voltage stabilizer.

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

* * *

CHAPTER – 7: POWER SUPPLY LOAD CALCULATIONS



TOTAL NO. OF SIGNALS = 13
SH SIGNALS = 2, Co ON SIGNALS = 2
TOTAL NO. OF SIGNAL ROUTES = 27
ASSUME Q-SERIES RELAYS ARE USED.
ASSUME 18 RELAYS ARE USED PER ROUTE
QN1 = 60 mA, QNA1 = 120 mA; (IN CASE OF K50 = 30mA)

BACKUP TIME CONSIDERED:
RELAYS = 10 Hrs, POINTS = 6 Hrs,
TRACK CIRCUITS = 48 Hrs,
BLOCK INSTRUMENTS = 48 Hrs.

Cell Capacity in AH	Recommended capacity of Battery Charger as per spec.
40	10 A
80	20 A
120	30 A
200	40 A
300	60 A
400	80 A
500	100 A

POWER FACTOR = 0.8
DG SET Factor of safety = 1.3

CHARGER EFFICIENCY FACTOR

12V up to 40 A = 60%
< 500 W = 65%
> 500 W = 70%
TRACK FEED BATT. CH = 50%

TRANSFORMER EFFICIENCY FACTOR

110 / 12 V CLS Tx = 80%
230 / 110 V Tx = 85%
230 / 24 V Tx = 85%
FRVS = 85%

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

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

For Power Calculation
Transformer / Charger Efficiency = $\dfrac{\textbf{Secondary Watts / VA}}{\textbf{Primary Watts / VA}}$ **Power Factor =** $\dfrac{\textbf{Watts}}{\textbf{VA}}$
Six Steps in order are as under:
1. Make a Schematic of Power Distribution. –DC, AC for ease. Study assumptions given. Assume others if not given.
2. Calculate Max Load in watts for each Limb (AC/DC). And then do as under for each limb as under.
3. For DC load: (a) Assess Secondary Cells Capacity in AH for DC load as per Back up & DOD for each limb.   (b) Assess Charger Current Rating (Boost Current +Load Current).   (c) Select suitable Rating among standard Ones.   (d) Assess Primary VA (for assessed Secondary load) after accounting for Efficiency.
4. For AC Load: (*Load of each lamp is in watts. TC charger also gives watts only)   (a) As per AC load, Assess Transformer 230/110 V Capacity required for each limb of AC.   (b) Select suitable Transformer (*Max load not to exceed 75% of rated Capacity)   (c) Assess Primary VA after accounting for Efficiency.
5. Application of Power Factor   Since all loads (both DC/AC) assessed so far are in Watts they are to be converted to **<u>VA for which</u>** Power Factor to be used.   (a) **ONLY once in each Limb –** Both for DC charger & AC transformer.   (b) Once applied in each limb , load is in VA and there is no need to apply again for same limb.   (c) If applied on 230 V side equipment, then it automatically applies to all its branches.   (d) Assess VA on 230 V AC Side.
6. Total them on 230 V AC side.

The maximum load is considered when reception signals are taken off for 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

$$\text{Capacity of the Cell } C = \left[\frac{\text{Load current X Backup time required}}{\text{Depth of Discharge permitted}}\right]$$

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

Recommended Capacity of the battery charger = 30A (as per Battery charger Spec.)

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

$$\text{TOTAL LOAD in VA} = \left[\frac{\text{Voltage X Current}}{\text{Power Factor X Efficiency}}\right]$$

$$= \left[\frac{\text{Voltage X (Boost charging current of the cell+Load Current)}}{\text{Power Factor X Efficiency of charger}}\right]$$

$$= \left[\frac{110\text{V X (12A+0A)}}{0.8 \text{ X } 0.7}\right] = 2357 \text{ VA ----- (A)}$$

7.2.2 Relays

Total No. of Signal routes = 27

Consider 18 Relays per route are used.

Total No. of Relays used = 27 X 18 = 486 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 486 = 486 X 0.75 = 365 Internal relays

Total No. of External relays used = 25% of 486 = 486 X 0.25 = 121 External relays

7.2.3 Relays Internal

Total No. of Internal relays = 365

Assume 60% relays are in pickup condition.

No. of picked up internal relays = 365 X 0.60 = 219 relays

Each QN1 relay takes 60 mA Current.

Internal relays Load Current = 219 X 60mA = 13.14 A

$$\text{Capacity of the Cell } C = \left[\frac{\text{Load current X Backup time required}}{\text{Depth of Discharge permitted}}\right]$$

$$= \left[\frac{13.14A \text{ X } 10 \text{ Hrs}}{0.70}\right] = 188 \text{ AH}$$

$\approx$ 200AH (nearby available capacity of the cell)

Recommended Capacity of the battery charger = 40A (as per Battery Charger spec.)

$$\text{TOTAL LOAD in VA} = \left[\frac{\text{Voltage X Current}}{\text{Power Factor X Efficiency}}\right]$$

$$= \left[\frac{\text{Voltage X (Boost charging current of the cell+Load Current)}}{\text{Power Factor X Efficiency of charger}}\right]$$

$$= \left[\frac{24V \text{ X } (20A+13.14 \text{ A})}{0.8 \text{ X } 0.7}\right] = 1420 \text{ VA ----- (B)}$$

7.2.4 Relays External

Total No. of External relays = 121

Assume 60% relays are in pickup condition.

No. of picked up External relays = 121 X 0.60 = 73 relays

Each QNA1 relay takes 120 mA Current.

External relays Load Current = 73 X 120mA = 8.76 A

$$\text{Capacity of the Cell C} = \left[\frac{\text{Load current X Backup time required}}{\text{Depth of Discharge permitted}}\right]$$

$$= \left[\frac{8.76 \text{ A X } 10 \text{ Hrs}}{0.70}\right] = 125 \text{ AH}$$

$\approx$ 200AH (nearby available capacity of the cell)

Recommended Capacity of the battery charger = 40A (as per Battery Charger spec.)

$$\text{TOTAL LOAD in VA} = \left[\frac{\text{Voltage X Current}}{\text{Power Factor X Efficiency}}\right]$$

$$= \left[\frac{\text{Voltage X (Boost charging current of the cell + Load Current)}}{\text{Power Factor X Efficiency of charger}}\right]$$

$$= \left[\frac{24V \text{ X } (20A + 8.76 \text{ A})}{0.8 \text{ X } 0.7}\right] = 1232 \text{ VA ----(C)}$$

7.2.5 Up side block Instrument

Load Current = 0.5A

$$\text{Capacity of the Cell C} = \left[\frac{\text{Load current X Backup time required}}{\text{Depth of Discharge permitted}}\right]$$

$$= \left[\frac{0.5 \text{ A X } 48 \text{ Hrs}}{0.70}\right] = 34 \text{ AH}$$

$\approx$ 40 AH (nearby available capacity of the cell)

Recommended Capacity of the battery charger = 10A (as per Battery Charger spec.)

$$\text{TOTAL LOAD in VA} = \left[\frac{\text{Voltage X Current}}{\text{Power Factor X Efficiency}}\right]$$

$$= \left[\frac{\text{Voltage X (Boost charging current of the cell + Load Current)}}{\text{Power Factor X Efficiency of charger}}\right]$$

$$= \left[\frac{\text{24V X (4A + 0.5 A)}}{\text{0.8 X 0.65}}\right] = \text{207.69 VA} \cong \text{208 VA ----- (D)}$$

7.2.6 Down Side Block instrument

Load Current = 0.5A

$$\text{Capacity of the Cell C} = \left[\frac{\text{Load current X Backup time required}}{\text{Depth of Discharge permitted}}\right]$$

$$= \left[\frac{\text{0.5 A X 48 Hrs}}{0.70}\right] = \text{34 AH}$$

≈ 40 AH (nearby available capacity of the cell)

Recommended Capacity of the battery charger = 10A (as per Battery Charger spec.)

$$\text{TOTAL LOAD in VA} = \left[\frac{\text{Voltage X Current}}{\text{Power Factor X Efficiency}}\right]$$

$$= \left[\frac{\text{Voltage X (Boost charging current of the cell + Load Current)}}{\text{Power Factor X Efficiency of charger}}\right]$$

$$= \left[\frac{\text{24 V X (4A + 0.5 A)}}{\text{0.8 X 0.65}}\right] = \text{207.69 VA} \cong \text{208 VA -------- (E)}$$

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

= 2357 + 1420 + 1232 + 208 + 208

= 5425 VA - (F)

7.3 A.C LOAD CALCULATIONS

7.3.1 Zone-1 Signals

Route indicator lamps = 5 (25W each)

Shunt Signal lamps = 2 (25W each)

Total lamps = 7

$$\text{LOAD in VA} = \left[\frac{\text{Total lamps X Wattage of each lamp}}{\text{Power Factor}}\right]$$

$$= \left[\frac{\text{7 X 25W}}{0.8}\right] = \text{219 VA ----- (1)}$$

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

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

$$\text{LOAD in VA} = \left[\frac{\text{Total lamps X Wattage of each lamp}}{\text{Power Factor X efficiency of signal lamp transformer}}\right]$$

$$= \left[\frac{7 \text{ X } 33\text{W}}{0.8 \text{ X} 0.8}\right] = 361 \text{ VA ----- (2)}$$

Zone-1 Signals load

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

= (1) + (2)

= 219VA + 361 VA = 580 VA

Rating of the 230V/110V Signal transformer

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

= 580 VA X 1.5 = 870 VA

≅ 1 KVA (nearest higher rating available)

Note: 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.

230/110V AC Signal transformer efficiency = 85%

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

$$= \left[\frac{\text{Load on secondary side of the transformer}}{\text{Efficiency}}\right]$$

$$= \left[\frac{580 \text{ VA}}{0.85}\right] = 682 \text{ VA ------ (3)}$$

7.3.2 Zone-2 Signals

Route indicator lamps = 5 (25W each)

Shunt Signal lamps = 2 (25W each)

Total lamps = 7

$$\text{LOAD in VA} = \left[\frac{\text{Total lamps X Wattage of each lamp}}{\text{Power Factor}}\right]$$

$$= \left[\frac{7 \text{ X } 25\text{W}}{0.8}\right] = 219 \text{ VA ----- (4)}$$

Main Signal aspects = 8 (33 W each) (for Distant Signal HG & HHG are considered)

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

$$\text{LOAD in VA} = \left[\frac{\text{Total lamps X Wattage of each lamp}}{\text{Power Factor X efficiency of signal lamp transformer}}\right]$$

$$= \left[\frac{8 \text{ X } 33\text{W}}{0.8 \text{ X} 0.8}\right] = 412 \text{ VA ----- (5)}$$

Zone-2 Signals load

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

= (4) + (5)

= 219VA + 412 VA = 631 VA

Rating of the 230V/110V Signal transformer

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

= 631 VA X 1.5 = 947 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

$$= \left[\frac{\text{Load on secondary side of the transformer}}{\text{Efficiency}}\right]$$

$$= \left[\frac{631 \text{ VA}}{0.85}\right] = 743 \text{ VA ----- (6)}$$

7.3.3 Zone 1 Track Circuits

Total No. of track circuits in Zone 1 = 15

Load on each Track circuit = 0.5A

$$\text{Secondary cell capacity on each Track Circuit} = \left[\frac{\text{Load current X Backup time required}}{\text{Depth of Discharge permitted}}\right]$$

$$= \left[\frac{0.5\text{A X 48 Hrs}}{0.70}\right] = 34 \text{ AH}$$

≈ 40 AH (Nearby available capacity of the cell)

$$\text{LOAD in VA} = \left[\frac{\text{No.of track Ckts.X Voltage of Tack circuit X (Boost charging I+load I)}}{\text{Power factor X efficiency of Track feed Battery Charger}}\right]$$

$$= \left[\frac{15 \text{ X } 6\text{V X } (4\text{A}+0.5\text{A})}{0.8 \text{ X } 0.5}\right] = 1012.5 \text{ VA}$$

Rating of the Zone – 1

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

= 1012.5 VA X 1.5 = 1519 VA

≅ 2 KVA (Nearest higher rating available)

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

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

$$= \left[\frac{1012.5\text{VA}}{0.85}\right] = 1191 \text{ VA ---- (7)}$$

Zone – 2 Track circuits

Total No. of Track circuits in Zone-2 = 16

Load on each Track circuit = 0.5A

$$\text{Secondary cell capacity on each Track Circuit} = \left[\frac{\text{Load current X Backup time required}}{\text{Depth of Discharge permitted}}\right]$$

$$= \left[\frac{\text{0.5A X 48 Hrs}}{0.70}\right] = 34 \text{ AH}$$

≈ 40 AH (Nearby available capacity of the cell)

$$\text{LOAD in VA} = \left[\frac{\text{No.of track Ckts. X Voltage of Tack circuit X (Boost charging I+load I}}{\text{Power factor X efficiency of Track feed Battery Charger}}\right]$$

$$= \left[\frac{\text{16 X 6V X (4A+0.5A)}}{\text{0.8 X 0.5}}\right] = 1080 \text{ VA}$$

Rating of the Zone – 1

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

= 1080 VA X 1.5 = 1620 VA

≅ 2 KVA (Nearest higher rating available)

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

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

$$= \left[\frac{\text{1080 VA}}{0.85}\right] = \text{1271 VA ----- (8)}$$

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 - 4 Nos. (3 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 13(Main) + 2 (Shunt) + 2 (Co-ON) = 17

Total No. of Indication lamps used for Pts, Signals & T/Ckts = 40+36+4+28+17 =125

Misc. indication (15% of above) = 125X 15/100 = 19

Total No. of Indication lamps used = 125 + 19 = 144 ≅ 150 lamps.

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

$$= \left[\frac{\text{No.of lamps X Wattage}}{\text{Power factor}}\right]$$

$$= \left[\frac{150 \text{ X } 1.2\text{W}}{0.8}\right]$$

$$= 225 \text{ VA.}$$

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

= 225 VA X 1.5

= 337.5VA

≅ 0.5 KVA

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

$$\text{Load on primary of the Indication Transformer} = \left[\frac{\text{Load on secondary side of the transformer}}{\text{Efficiency}}\right]$$

$$= \left[\frac{225 \text{ VA}}{0.85}\right] = 265 \text{ VA ---- (9)}$$

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

= 682VA + 743VA + 1191VA + 1271VA + 265 VA

= 4152 VA

7.4 FERRO RESONANT VOLTAGE STABILISER (FRVS)

FRVS efficiency = 85%

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

$$\text{FRVS I/P LOAD} = \left[\frac{\text{Load on secondary of FRVS}}{\text{Efficiency}}\right]$$

$$= \left[\frac{4152 \text{ VA}}{0.85}\right] = 4885 \text{ VA ---- (10)}$$

FRVS rating = 4885 VA (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 on FRVS I/P

= (F) + (10)

= 5425 VA + 4885 VA

= 10310 VA

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

= 10310 VA x 1.3 = 13403 VA

$\cong$ 15 KVA

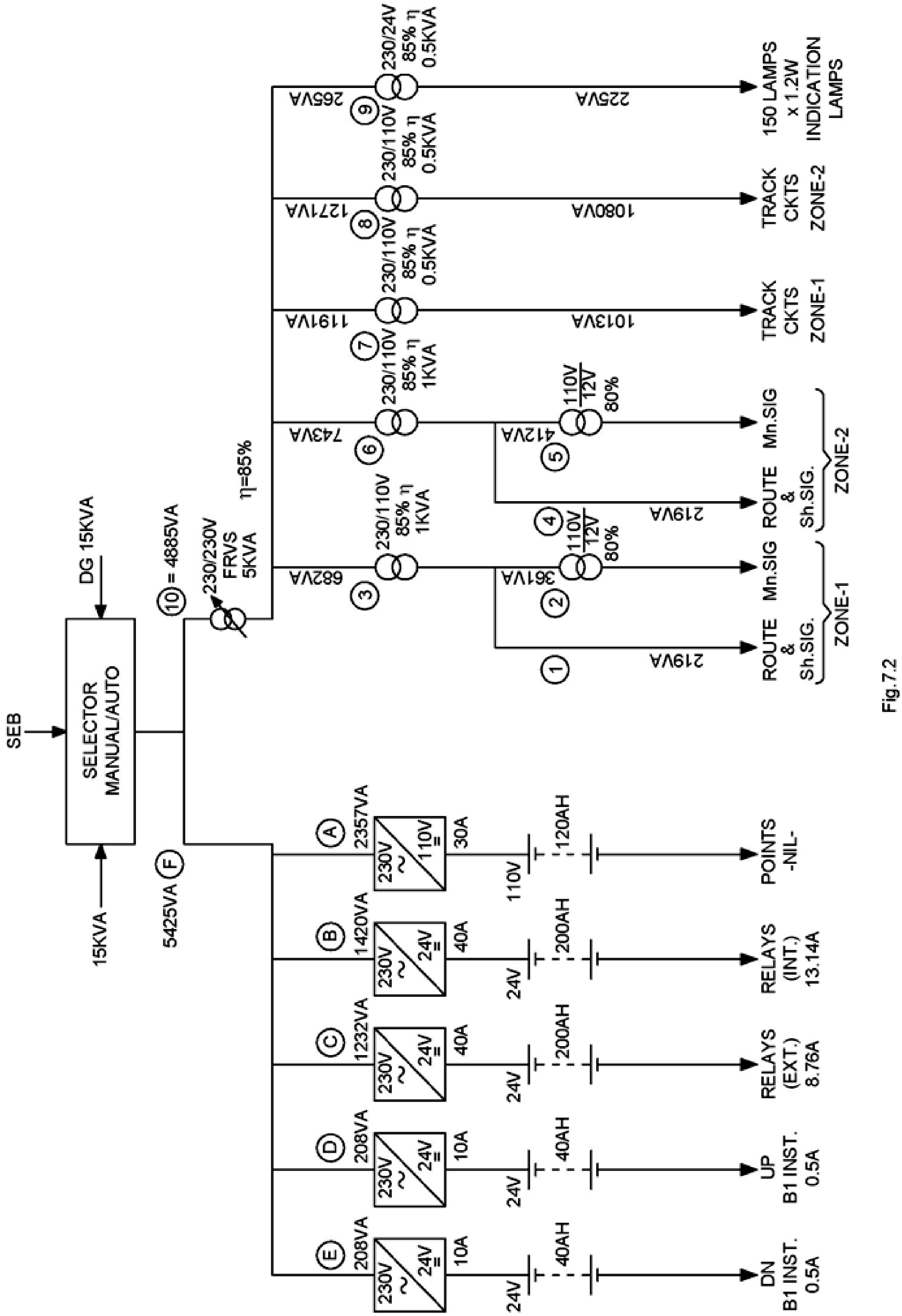

SEB
SELECTOR MANUAL/AUTO
DG 15KVA
15KVA
5425VA F
10 = 4885VA
230/230V FRVS 5KVA
η=85%
1 219VA
2 361VA
3 682VA
4 219VA
5 412VA
6 743VA
7 1191VA
8 1271VA
9 265VA
230/110V 85% η 1KVA
230/110V 85% η 1KVA
230/110V 85% η 1KVA
230/110V 85% η 0.5KVA
230/110V 85% η 0.5KVA
230/24V 85% η 0.5KVA
110V/12V 80%
110V/12V 80%
1013VA
1080VA
225VA
ROUTE & Sh.SIG.
Mn.SIG
ZONE-1
ROUTE & Sh.SIG.
Mn.SIG
ZONE-2
TRACK CKTS ZONE-1
TRACK CKTS ZONE-2
150 LAMPS x 1.2W INDICATION LAMPS
A 2357VA
B 1420VA
C 1232VA
D 208VA
E 208VA
230V ~ 110V =
230V ~ 24V =
30A
40A
10A
110V
24V
120AH
200AH
40AH
POINTS -NIL-
RELAYS (INT.) 13.14A
RELAYS (EXT.) 8.76A
UP B1 INST. 0.5A
DN B1 INST. 0.5A
Fig.7.2

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.

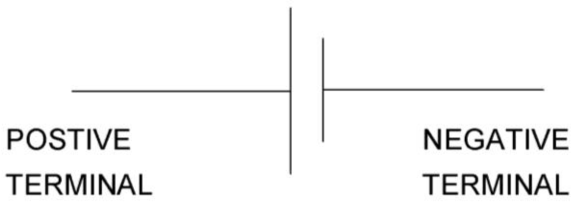
3. IONS

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, safety factor and backup time required.

Required capacity of cell = I_{Load} 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).

$$\% \text{ polarisation} = \left[\frac{E - V}{E}\right] X\ 100$$

% polarisation of a cell shall not be more than 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)

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

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

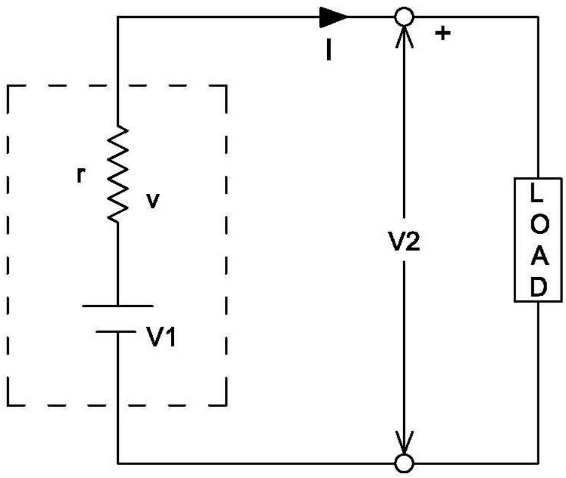


Fig: 1.3

$$V1 = v + V2$$

$$v = V1 - V2$$

$$\text{Internal resistance} = \left[\frac{v}{I}\right] \Omega$$

$$= \left[\frac{V1 - V2}{I}\right] \Omega$$

$$= \left[\frac{V_{\text{No Load}} - V_{\text{Load}}}{\text{Circuit current}}\right] \Omega$$

"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:

(a) Dry Cells.

(b) Wet Cells.

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.

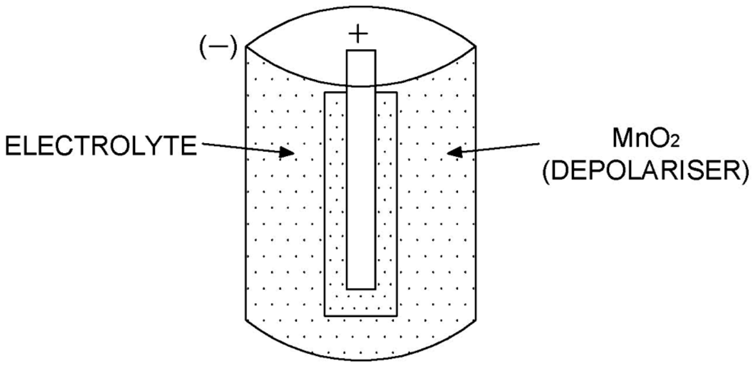


Fig: 2.1

(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.

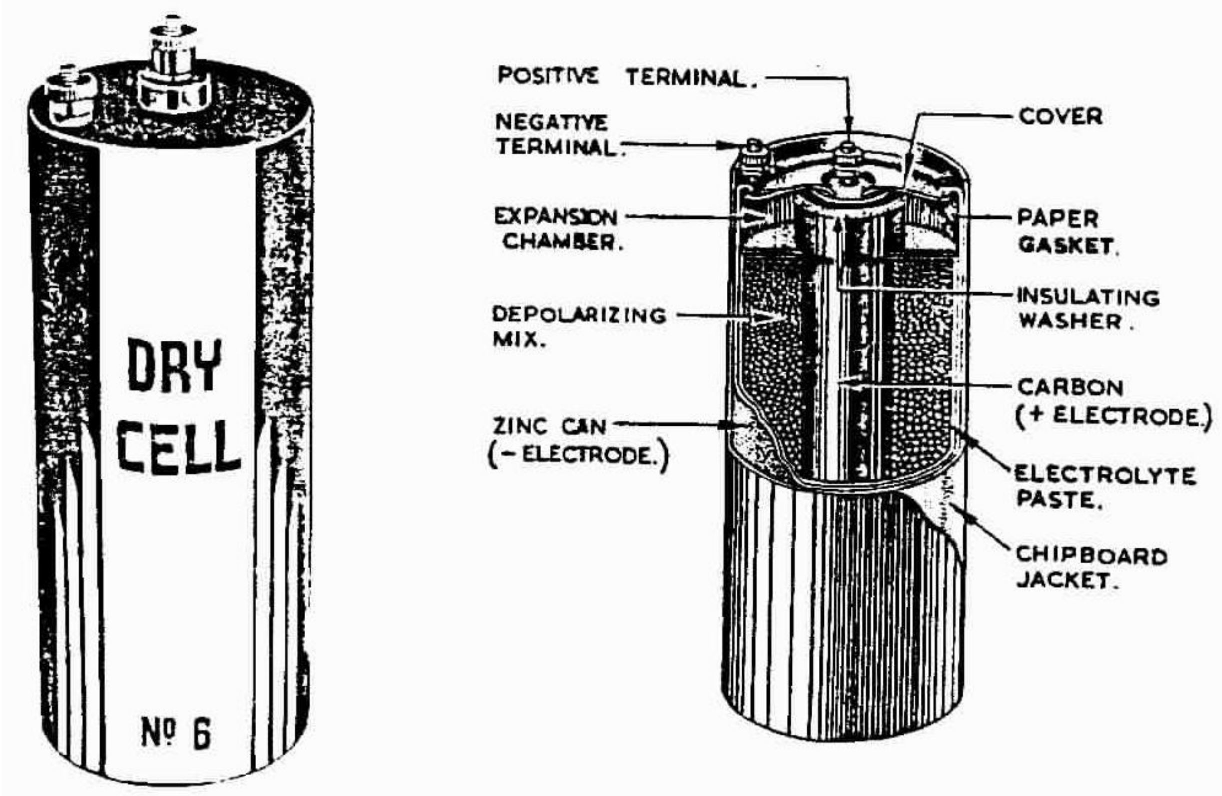


Fig: 2.2 6I DRY CELL – SECTIONAL VIEW

(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

Air Depoliriser (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	LECLANCHE DRY	LECLANCHE WET	AIR DEPOLARISER 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.

6. RDSO approved list of firms for manufacture and supply of electrical signalling items: as on 31st December 2013

ITEM: POWER SUPPLY EQUIPMENTS - PRIMARY CELL - SITEL

(DRY LECLANCHE TYPE)

Spec No.: IRS: S-95/96 with Amendment 1.

APPROVED UNDER PART: I	APPROVED UNDER PART: II
1. M/s Fintech Associates	**-NIL-**
2. M/s Indian Batteries	
3. M/s Industrial Carbon India	
4. M/s Spark Electronics	
5. M/s Vijay Electronics	

* * *

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 (Ni-Fe) 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) or LIB

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)

The sun light incident on earth contains power approximately 6000 times power required for all activities of Earth. It is clean, green & perennial energy source. Materials used in solar cells are – Gallium Arsenide, Cadmium Telluride and Crystalline Silicon. Among them Crystalline Silicon is common and cheap for civilian applications.

(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.

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

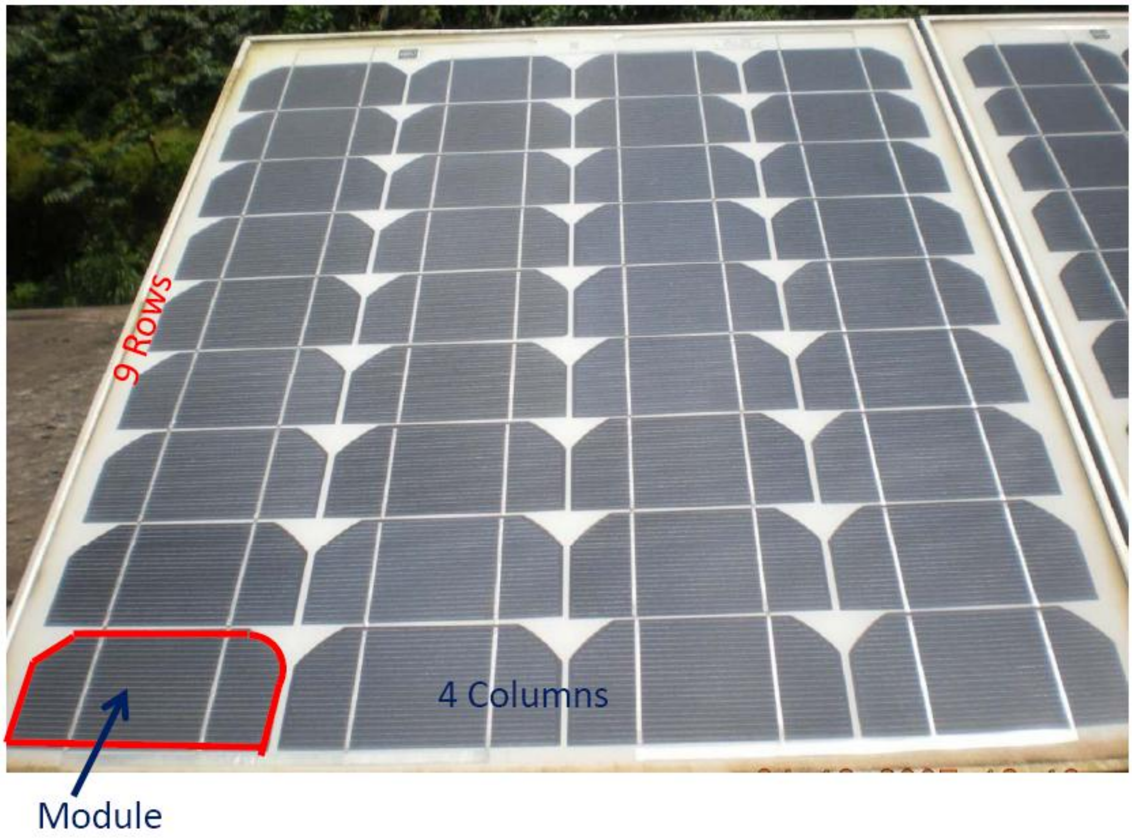
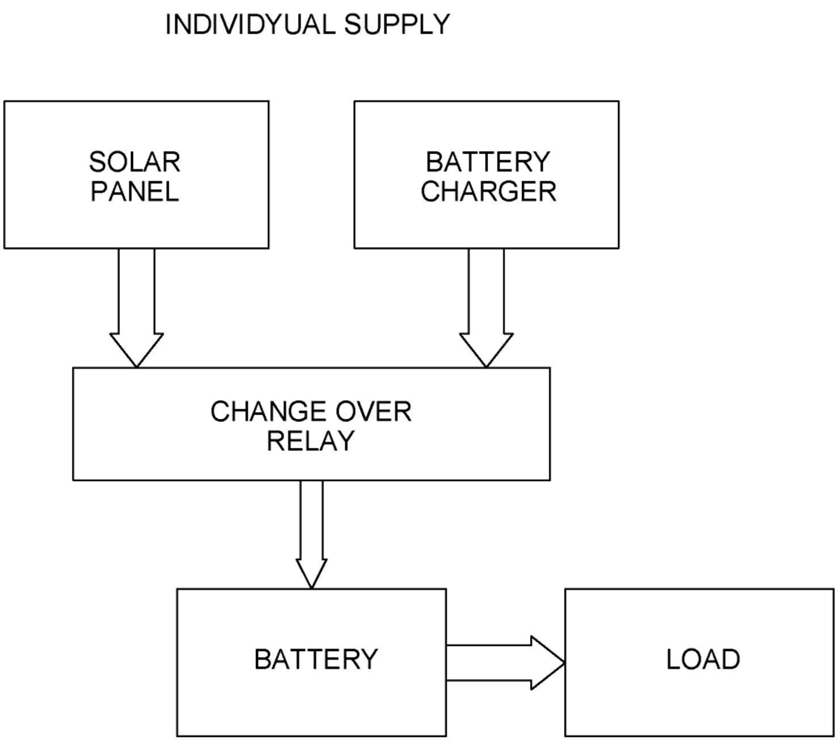


Fig: Solar Panel

(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 various companies & subsidized by Govt.

(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.

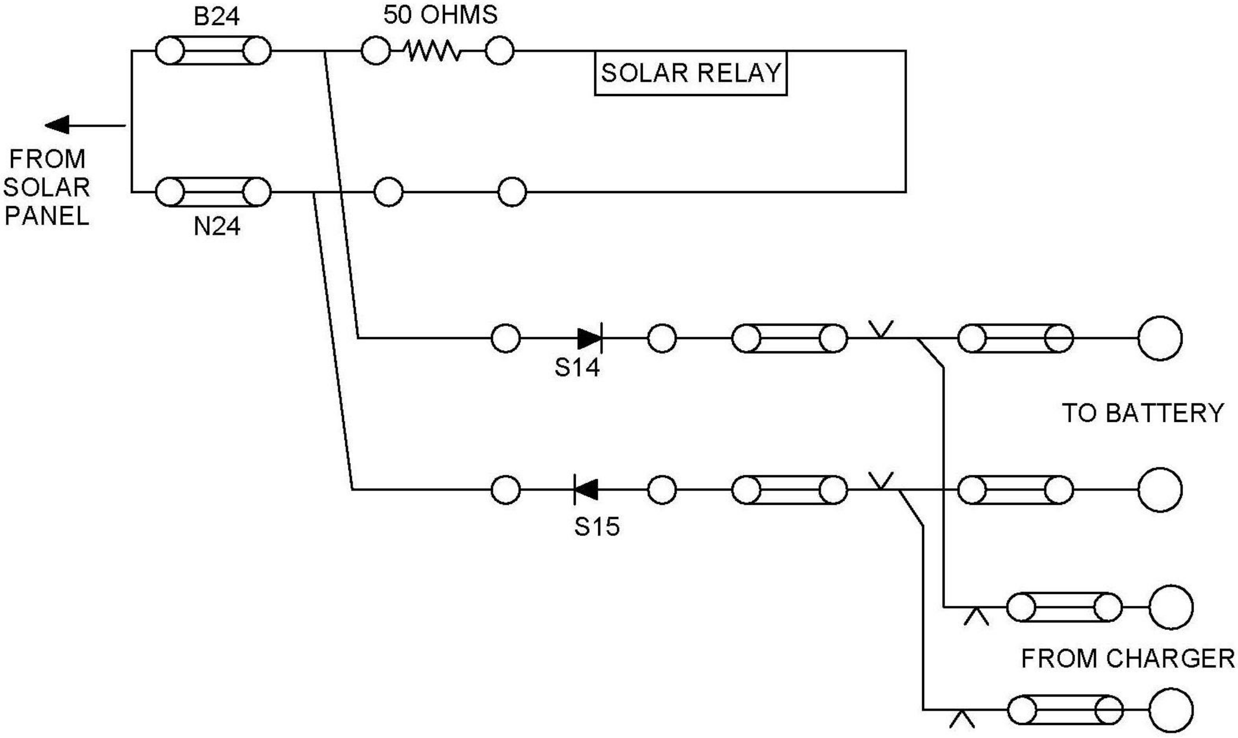


(l) Secondary cells for different circuits namely Internal, External, Point etc were charged through front contact of the Change Over Relay (SOLAR RELAY) with solar supply.

(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:

(a) The solar panels to be earthed

(b) The series connecting diode should be of minimum 25 Amp rating.

(c) Fixing of the panel should such a way that maximum sunlight falls throughout the day

(d) The change over relay may be minimum 25 Amp rating or QBCA1

Load at PADIL station:

Supply	Load	Battery
INTERNAL	12Amps ---- (6A)	200AH
External	5Amps ---- (8A)	120AH
Point	3Amps ---- (7A)	300AH
Block	2Amps ---- (5A)	80AH

Operational Life of Solar Panel

The solar photovoltaic modules are highly reliable, light-weight and have a long operational life.

10 years life at 90% output.

25 years life at 80% output.

* * *

Annexure - IV: VALVE REGULATED LEAD ACID BATTERIES (VRLA)

IRS Specification No. S 93/96(A)

1 Valve Regulated Lead Acid batteries works on the principle of the "Oxygen recombination".

These are available in two types.

(a) Gelled electrolyte type.

(b) Absorbed electrolyte type.

While the basic electrode reactions remains same as in conventional flooded cells. With conventional flooded batteries, during charging oxygen and Hydrogen gases evolves and water is lost from the cell.

2 In VRLA Cells

(a) In case of Gelled Electrolyte type batteries; the oxygen gas generated at the +ve plate is transported in the gas form through the gelled electrolyte, which develops a fissured structure that permits the diffusion of oxygen, to the negative plate and it is consumed at negative plate.

(b) In case of absorbed electrolyte type: the oxygen gas generated at positive plate is transported in the gas form through a highly absorbent and porous 'glass separator' to the negative plate and it is consumed at negative plate. This micro-porous glass separator is not completely saturated with electrolyte and thus the empty space available allows an access of oxygen to the negative plate.

3 The oxygen gas reacts with the negative plate (sponge Lead) to form 'Lead Oxide (PbO) which in turn reacts with H_2SO_4 (sulfuric acid) to form water (H_2O) i.e. The oxygen gas gets reduced at the negative plate surface, thereby effectively suppressing the evolution of Hydrogen. This results H_2O is formed. This is known as oxygen recombination principle.

The Oxygen recombination principle can be shown by the following mechanism.

(a) Reaction at positive plate:

$$H_2O \longrightarrow \tfrac{1}{2} O_2 + 2H^+ + 2e^- \quad ----- \quad (1)$$

(b) Reaction at negative plate:

$$Pb + \tfrac{1}{2} O_2 \longrightarrow PbO \quad ----- \quad (2)$$

$$PbO + H_2SO_4 \longrightarrow PbSO_4 + H_2O \quad ----- \quad (3)$$

To reaction (1)

$$PbSO_4 + 2H^+ + 2e^- \longrightarrow Pb + H_2SO_4 \quad ------ \quad (4)$$

To reaction (3)

To reaction (2)

(c) The total reaction at Negative plate

$$\tfrac{1}{2} O_2 + 2H^+ \longrightarrow H_2O$$

Thus, the combination technology makes the battery virtually maintenance free.

(i) Since there is no net evolution of gas, these cells do not lose any water under normal operation. Therefore, no topping up is required. This makes the battery as maintenance free.

(ii) Under normal operating conditions an equalizing charge is NOT required. It is required when non-uniformity in voltage has developed between the cells.

(iii) Fully charged cell voltage = 2.2 V

(iv) End Point Voltage = 1.75V

(v) Under constant voltage type charging, at 27^0C

(vi) Boost charge Voltage = 2.3V/Cell (For 16 Hrs)

(vii) Float Charge Voltage = 2.25 V/Cell and charging current should be limited to 20 % of Its AH capacity.

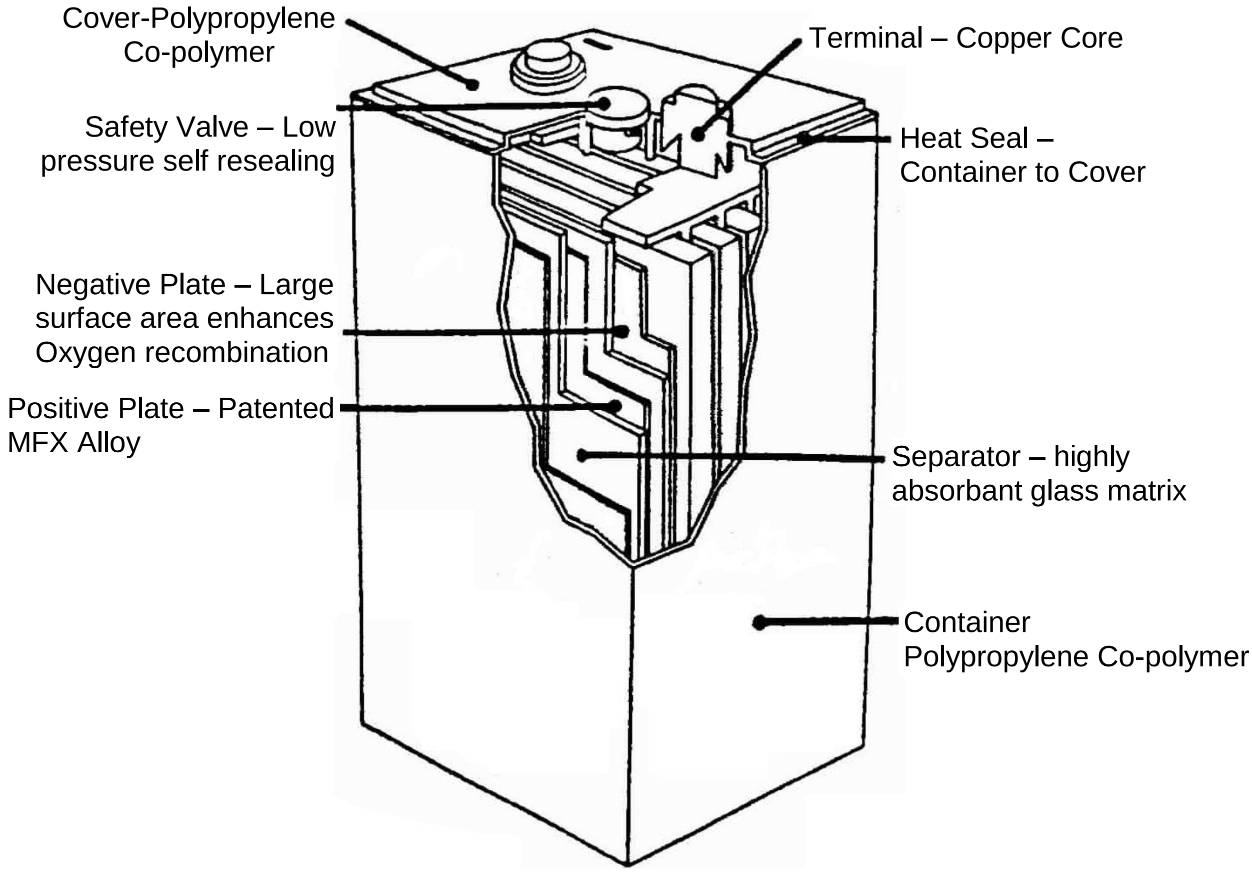


Fig: 4.1 POWER STACK CELL

4 SPECIAL DESIGN FEATURES OF VRLA BATTERIES

(a) Starved Electrolyte

The electrolyte is immobilised by using highly absorbent glass mat separators, which are designed to hold sufficient electrolyte to meet all performance requirements.

(b) Oxygen Recombination

The battery works on oxygen recombination principle. Recombination efficiencies are in excess of 99%.

(c) Explosion resistant safety vents

VRLA batteries operate at a slight positive pressure within the cell. Cells are fitted with a unique low pressure self-resealing safety valve which releases the gases when the internal pressure within a cell exceeds 6 psi and reseals again at low pressures. The constant positive pressure in the cells prevents accidental ingress of external air, which would otherwise result in a self-discharge at the negative plate. The safety valves are also fitted with a porous plastic disc, which prevents external sparks from entering the cell. This makes the safety valve explosion proof.

(d) Hermetic heat seal

The battery jar and cover are hermetically sealed automatic machines. Additionally, the total absorption of electrolyte in the separators and the use of pressure regulated valves make it spill proof and leak proof.

(e) Superior alloys

VRLA batteries use high corrosion resistant alloys such as low antimonial lead, a lead calcium or lead-Cadmium for the positive grids. Negative grids are made from a lead-Cadmium alloy, which is universally accepted, as the best available maintenance free alloy. Among the positive grid alloys, the low antimony alloy exhibits good deep discharge capability but has poor float or maintenance free characteristics. The lead calcium alloy, while being a good maintenance free alloy (low float currents) is poor in deep discharge cycling. When compared to these alloys the lead-cadmium alloy has both good maintenance free characteristics, as well as deep discharge cycling capability. In these Batteries, this superior lead cadmium alloy in the positive grids and the lead-calcium alloy in the negative grids are used.

(f) Copper insert terminals

VRLA batteries have highly conductive copper inserts in terminal resulting in very good power characteristics. Inter cell connections are made by using high purity, lead coated copper strip connectors and heavy duty stainless steel bolts which are resistant to sulphuric acid.

(g) Modular steel trays

VRLA batteries in the Power Stack range are assembled in modular steel trays in horizontal configuration. This lends flexibility in assembling the system one module above the other.

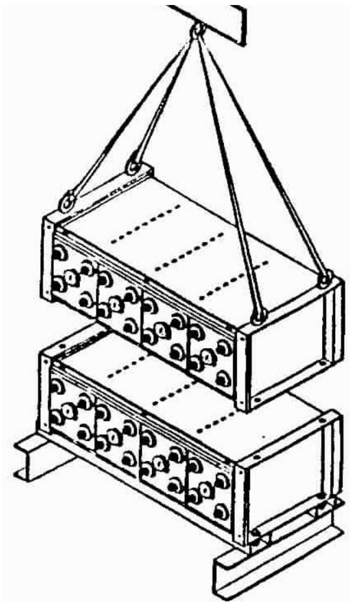


Fig: 4.2

5 CHARGING

5.1 CAUTION

(a) Use insulation equipment such as gloves, shoes and eye protectors.

(b) Tools like wrenches etc. should necessarily be insulated.

(c) Do not put tools or other equipment over the battery.

(d) Always work with the battery ungrounded.

(e) Be sure the charger is turned off before making electrical connections between the battery and the system.

(f) Connect battery positive terminal to charger positive terminal and battery negative terminal to charger negative terminal.

(g) Be sure that all connections are as per General Arrangement Drawing and are firm to 10 Nm torque before turning on the charger.

5.2 FRESHENING CHARGE

The battery system may require an initial charge if the voltage per cell drops to 2.1 Volts while the battery is in storage prior to installation. In order to give an initial charge to the battery, the following instructions have to be observed.

(a) Set the connected charger in constant potential mode.

(b) Set the voltage to 2.3 volts X No. of cells with a current limit of 0.2C Amps max.

(c) After attaining the required voltage for three consecutive hours, the system has to be switched to float mode (2.25V per cell) and the load may be connected to it.

5.3 EQUALISING CHARGE

This type of charging is to be done for every 6 months or if the variation in cell voltage on float/charge (min to max) is more than 0.1 V, whichever is earlier. The procedure is as follows.

(a) Discharge all the cells up to 1.75V/cell and bypass the cells that are reached early to 1.75V and continue the discharge till all the cells reaches to 1.75V

(b) Charge the cells for 21 hours with a voltage setting of 2.3V per cell in constant potential charging. The current limit should be 0.2 C Amps.

(c) Repeat the procedure till it reaches its rated capacity.

5.4 CONSTANT VOLTAGE CHARGING

Only constant voltage charging shall be followed for charging the battery system. The following instructions have to be observed while charging the battery. Constant potential chargers that can supply DC current with RMS ripple current less than 3% should be used.

5.5 RECHARGING DETAILS FOR THE DISCHARGED BATTERIES

Charging must be carried out at constant potential with the current limited to 0.2C amperes. (Where C refers to the numerical value of the nominal capacity of the battery) Charge in boost mode at a charge voltage of 2.3 volts per cell for a period 16 hours followed by charge in float mode at a float voltage of 2.25 Volts Per Cell for a period of 72 hours before connecting the load. The duration of charging varies with the depth of discharge.

Example: For a 48V, 400AH battery having 24 cells, charging must be carried out in boost charge mode at a voltage of 55.2V + 0.1 for a period of 16 hours followed by charge in float mode at 54V + 0.1 V for 72 hours. The maximum current limited to 80 Amperes (400 X 0.2 = 80).

(a) Charging should be done after every discharge and the battery should be maintained in charged condition by keeping it connected to the charger in float mode.

(b) The charging duration referred to above relates to an ambient temperature of 27°C. Batteries located in areas having very low ambient temperatures (below 15°C) will require the charging time recommended above to be doubled in order to fully charge the battery.

CAUTION

(i) Use only constant potential charging.

(ii) Voltage to be set exactly to the value specified.

(iii) Ensure tight connections.

6 PERFORMANCE OF BATTERIES

6.1 MONITORING

The performance of the batteries is to be monitored during operation at monthly intervals in order to detect and correct abnormalities, if any. The battery voltage on float, individual cell voltage on float, torque of the terminals and cleanliness of the battery are to be monitored.

Use only Calibrated Digital Voltmeters with accuracy $\pm$ 0.05 volts. Maintain a record of the total battery voltage and the individual cell voltages using the service record formats.

6.2 EFFECT OF TEMPERATURE

A lead acid battery is an electrochemical device. Heat accelerates chemical activity; low temperature slows it down. Normal battery operating temperature is 27^0C. Lower than normal temperature has the opposite effect and reduces capacity. In general, at proper float voltage, a battery in a cool location will last longer than one in a warm location.

***Note**: No temperature correction is required when operating at 27^0C. If the operating temperature is above 27^0C, it is recommended that the float voltage should be reduced by 3 mv/^{0}C rise in temperature/cell.*

7 ADVANTAGES OF VRLA BATTERIES

(a) Improved and reliable service life due to low antimony lead/ lead cadmium alloy used in positive plates.

(b) No separate battery room required, as they are compact in design.

(c) No topping up with distilled water and no measurement of specific gravity of electrolyte.

(d) Ideally suited for deep discharges and partial discharges as well.

(e) 80% reduction in installation time as they are delivered in ready to use conditions.

(f) Tremendous space savings as they occupy 40% less space.

(g) Less floor loading as they weigh 30% less.

(h) High charge acceptance by virtue of very low internal resistance.

(i) Very low self-discharge of 0.5 to 1% of capacity per week.

(j) Rugged in construction as they are mounted in MS racks.

(k) Can be installed in horizontal direction without any leakage of electrolyte, as the electrolyte is totally absorbed by the spun glass separator.

(l) No spillage of electrolyte.

(m) No acid proof flooring required by virtue of their sealed construction.

(n) Can be installed in the close proximity of sensitive electronic equipments, as they do not emit any hazardous gasses.

7.1 OTHER ADVANTAGES INCLUDE

(a) Less wear & tear of electrical of electrical components due to higher average discharge voltage of 1.95 volts per cell at C10 discharge rate.

(b) Uniform discharge currents.

(c) No stratification of electrolyte due to wicking action of highly absorbent separators and horizontal mounting of cells.

(d) No post corrosion as there is no acid mist.

(e) Environment friendly as they do not emit any hazardous gasses.

(f) Cell covers and jars hermetically heat-sealed.

(g) Can operate under extreme climatic conditions (-40° C to +55° C)

(h) Lower recurring costs because no distilled water addition and no periodic equalising charges.

7.2 DISADVANTAGES

(a) With every 10° C rise in temperature, the capacity gets reduced by half. So, these cells are not preferred for outdoor applications.

(b) They are more costlier than conventional / LMLA cells.

8 BATTERY CARE

8.1 DO'S

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

(b) Store the batteries in a cool and dry location.

(c) Charge the batteries within six months if they are under storage.

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

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

(f) Keep the battery area clean and dry.

(g) Monitor the charge and the float voltages of the charger at monthly intervals and adjust if required.

(h) Check the tightness of all the electrical connections at monthly intervals.

(i) Check compatibility of the charger before commissioning the battery.

(j) Maintain monthly service record as per enclosed format.

(k) Provide adequate ventilation and illumination.

(l) Ensure the cell orientation & connections are as per the General Arrangement Drawing.

(m) Contact company personnel for additional help and guidance.

8.2 DON'TS

(a) Do not expose the packed batteries to rain.

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

(c) Do not exceed the storage period without charging the batteries.

(d) Do not install the batteries in rooms with varying temperature pockets due to sunlight or ventilation ducts.

(e) Do not short-circuit the battery or cells during assembly.

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

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

(h) Do not make tap connections.

(i) Do not tamper with the cell vents.

(j) Do not keep the batteries in discharged condition.

9 SAFETY PRECAUTIONS

Only authorized and trained personnel familiar with standby battery installation, preparation, charging and maintenance should be permitted to access the battery.

The following instructions are to be followed for the safety of the operator and also of the battery system.

(a) Do not touch un-insulated battery connectors or terminals.

(b) Isolate the battery from the charger while working on the battery.

(c) All tools used for installation should be insulated to avoid accidental shorting of connections.

(d) Ensure that connections are made as per general arrangement drawing enclosed.

(e) Do not attempt to move the installed battery without removing the connectors.

(f) Do not expose the battery to open flame or sparks.

(g) Keep the battery clean and dry.

(h) In case of accidental contact with acid, wash the affected area with a continuous flow of water for 15 min., and consult a doctor immediately.

(i) Do not install batteries in a sealed cabinet or enclosure since explosive gases may be released under abnormal conditions.

(j) Use a suitable lifting device in handling the battery to prevent damage.

10 RDSO approved list of firms for manufacture and supply of electrical signalling items: as on 31st December 2013

ITEM: POWER SUPPLY EQUIPMENTS - SECONDARY CELL – MAINTENANCE FREE

Spec No.: IRS: S-93/96(A) with Amd. 1 (To be used with IPS in 25 KV RE area for signalling application as per Railway Board's letter No. 2010/SIG/SGF/2/VRLA Battery Dt. 20.12.10)

APPROVED UNDER PART: I	APPROVED UNDER PART: II
1. M/s HBL Power System Ltd.	1. M/s Exide Industries Ltd.
2. M/s Amara Raja Batteries Ltd.,	2. M/s Microtex energy Pvt. Ltd.,

* * *

Annexure- V: FUEL CELLS

A **fuel cell** is an electrochemical cell that converts a source fuel into an electrical current. It generates electricity inside a cell through reactions between a fuel and an oxidant, triggered in the presence of an electrolyte. The reactants flow into the cell, and the reaction products flow out of it, while the electrolyte remains within it. Fuel cells can operate continuously as long as the necessary reactant and oxidant flows are maintained. Fuel cells are different from conventional electrochemical cell batteries in that they consume reactant from an external source, which must be replenished – a thermodynamically open system. By contrast, batteries store electrical energy chemically and hence represent a thermodynamically closed system.

1. HISTORY :

The principle of the fuel cell was discovered by German scientist Christian Friedrich Schönbein in 1838. Based on this work, the first fuel cell was demonstrated by Welsh scientist William Robert Grove in the February 1839. In 1955, W. Thomas Grubb, a chemist working for the General Electric Company (GE), further modified the original fuel cell design by using a sulphonated polystyrene ion-exchange membrane as the electrolyte. Three years later another GE chemist, Leonard Niedrach, devised a way of depositing platinum onto the membrane, which served as catalyst for the necessary hydrogen oxidation and oxygen reduction reactions. GE went on to develop this technology with NASA and McDonnell Aircraft. This was the first commercial use of a fuel cell. In 1959 British engineer Francis Thomas Bacon successfully developed a 5 kW stationary fuel cell. In 1959, a team led by Harry Ihrig built a 15 kW fuel cell tractor, using potassium hydroxide as the electrolyte and compressed hydrogen and oxygen as the reactants.

Many combinations of fuels and oxidants are available. Some are given below.

(a) Fuels include hydrocarbons and alcohols.

(b) Oxidants include chlorine and chlorine dioxide.

  (i) A hydrogen fuel cell uses hydrogen as its fuel and oxygen (usually from air) as its oxidant.)

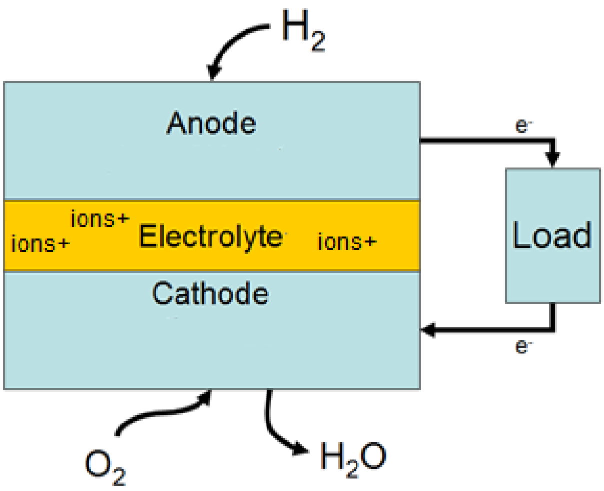
  (ii) In addition to this pure hydrogen type, there are hydrocarbon fuels for fuel cells, including diesel, methanol and chemical hydrides. The waste products with these types of fuel are carbon dioxide and water.

(c) **Proton exchange fuel cells**

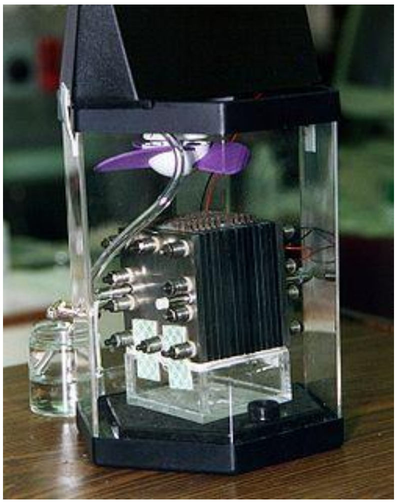
(d) **SOFC**: Solid oxide fuel cell

(e) **MCFC** : Molten carbonate fuel cell

Fuel cells come in many varieties; however, they all work in the same general manner. They are made up of three segments which are sandwiched together: the anode, the electrolyte, and the cathode. Two chemical reactions occur at the interfaces of the three different segments. The net result of the two reactions is that fuel is consumed, water or carbon dioxide is created, and an electrical current is created, which can be used to power electrical devices, normally referred to as the load. At the anode a catalyst oxidizes the fuel, usually hydrogen, turning the fuel into a positively charged ion and a negatively charged electron. The electrolyte is a substance specifically designed so ions can pass through it, but the electrons cannot. The freed electrons travel through a wire creating the electrical current. The ions travel through the electrolyte to the cathode. Once reaching the cathode, the ions are reunited with the electrons and the two react with a third chemical, usually oxygen, to create water or carbon dioxide.



A block diagram of a fuel cell



Direct-methanol fuel cell. The actual fuel cell stack is the layered cube shape in the center of the image

A typical fuel cell produces a voltage from 0.6 V to 0.7 V at full rated load. To deliver the desired amount of energy, the fuel cells can be combined in series and parallel circuits, where series yields higher voltage, and parallel allows a higher current to be supplied. Such a design is called a *fuel cell stack*. Further, the cell surface area can be increased, to allow stronger current from each cell. Fuel cells do not operate on a thermal cycle. As such, they are not constrained, as combustion engines are, in the same way by thermodynamic limits, such as Carnot cycle efficiency. The laws of thermodynamics also hold for chemical processes (Gibbs free energy) like fuel cells, but the maximum theoretical efficiency is higher (83% efficient at 298K in the case of hydrogen/oxygen reaction) than the Otto cycle thermal efficiency (60% for compression ratio of 10 and specific heat ratio of 1.4). The efficiency of a fuel cell is dependent on the amount of power drawn from it. Drawing more power means drawing more current, this increases the losses in the fuel cell. As a general rule, the more power (current) has drawn, the lower the efficiency. Most losses manifest themselves as a voltage drop in the cell, so the efficiency of a cell is almost proportional to its voltage. A typical cell running at 0.7 V has an efficiency of about 50%, meaning that 50% of the energy content of the hydrogen is converted into electrical energy.

2. PROTON EXCHANGE FUEL CELLS

On the anode side, hydrogen diffuses to the anode catalyst where it later dissociates into protons and electrons. These protons often react with oxidants causing them to become what is commonly referred to as multi-facilitated proton membranes. The protons are conducted through the membrane to the cathode, but the electrons are forced to travel in an external circuit (supplying power) because the membrane is electrically insulating. On the cathode catalyst, oxygen molecules react with the electrons (which have traveled through the external circuit) and protons to form water — in this example, the only waste product, either liquid or vapor.

3. SOFC: SOLID OXIDE FUEL CELL

A solid oxide fuel cell (SOFC) is extremely advantageous "because of a possibility of using a wide variety of fuel". Unlike most other fuel cells which only use hydrogen, SOFCs can run on hydrogen, butane, methanol, and other petroleum products. The different fuels each have their own chemistry. For methanol fuel cells, on the anode side, a catalyst breaks methanol and water down to form carbon dioxide, hydrogen ions, and free electrons. The hydrogen ions move across the electrolyte to the cathode side, where they react with oxygen to create water. A load connected externally between the anode and cathode completes the electrical circuit. Below are the chemical equations for the reaction:

Anode Reaction: $CH_3OH + H_2O \rightarrow CO_2 + 6H^+ + 6e^-$

Cathode Reaction: $\frac{3}{2}O_2 + 6H^+ + 6e^- \rightarrow 3H_2O$

Overall Reaction: $CH_3OH + \frac{3}{2}O_2 \rightarrow CO_2 + 2H_2O$ + electrical energy

At the anode SOFCs can use nickel or other catalysts to break apart the methanol and create hydrogen ions and CO_2. A solid called yttria stabilized zirconia (YSZ) is used as the electrolyte. Like all fuel cell electrolytes YSZ is conductive to ions, allowing them to pass from the anode to cathode, but is non-conductive to electrons. YSZ is a durable solid and is advantageous in large industrial systems. Although YSZ is a good ion conductor, it only works at very high temperatures. The standard operating temperature is about 950^{o}C. Running the fuel cell at such a high temperature easily breaks down the methane and oxygen into ions. A major disadvantage of the SOFC, as a result of the high heat, is that it “places considerable constraints on the materials which can be used for interconnections” . Another disadvantage of running the cell at such a high temperature is that other unwanted reactions may occur inside the fuel cell. It is common for carbon dust, graphite, to build up on the anode, preventing the fuel from reaching the catalyst. Much research is currently being done to find alternatives to YSZ that will carry ions at a lower temperature. Solid-oxide fuel cells produce exothermic heat from the recombination of the oxygen and hydrogen. The ceramic can run as hot as 800 degrees Celsius. This heat can be captured and used to heat water in a micro combined heat and power (m-CHP) application. When the heat is captured, total efficiency can reach 80-90% at the unit, but does not consider production and distribution losses.

4. MCFC : MOLTEN CARBONATE FUEL CELL:

Molten carbonate fuel cells (MCFCs) operate in a similar manner, except the electrolyte consists of liquid (molten) carbonate, which is a negative ion and an oxidizing agent. Because the electrolyte loses carbonate in the oxidation reaction, the carbonate must be replenished through some means. This is often performed by recirculating the carbon dioxide from the oxidation products into the cathode where it reacts with the incoming air and reforms carbonate.

Unlike proton exchange fuel cells, the catalysts in SOFCs and MCFCs are not poisoned by carbon monoxide, due to much higher operating temperatures. Because the oxidation reaction occurs in the anode, direct utilization of the carbon monoxide is possible. Also, steam produced by the oxidation reaction can shift carbon monoxide and steam reform hydrocarbon fuels inside the anode. These reactions can use the same catalysts used for the electrochemical reaction, eliminating the need for an external fuel reformer MCFC can be used for reducing the CO_2 emission from coal fired power plants as well as gas turbine power plants.

5. FUEL CELL APPLICATIONS

Fuel cells cannot store energy, but in some applications, such as stand-alone power plants based on discontinuous sources such as solar or wind power, they are combined with electrolyzers and storage systems to form an energy storage system. The overall efficiency (electricity to hydrogen and back to electricity) of such plants (known as *round-trip efficiency*) is between 30 and 50%, depending on conditions. While a much cheaper lead-acid battery might return about 90%, the electrolyzer / fuel cell system can store indefinite quantities of hydrogen, and is therefore better suited for long-term storage. Fuel cells are very useful as power sources in remote locations, such as spacecraft, remote weather stations, large parks, rural locations, and in certain military applications. A fuel cell system running on hydrogen can be compact and lightweight, and have no major moving parts. Because fuel cells have no moving parts and do not involve combustion, in ideal conditions they can achieve up to 99.9999% reliability. In western countries, some urban transport buses use these cells. Japan has used them in Railway shunting engines.

* * *

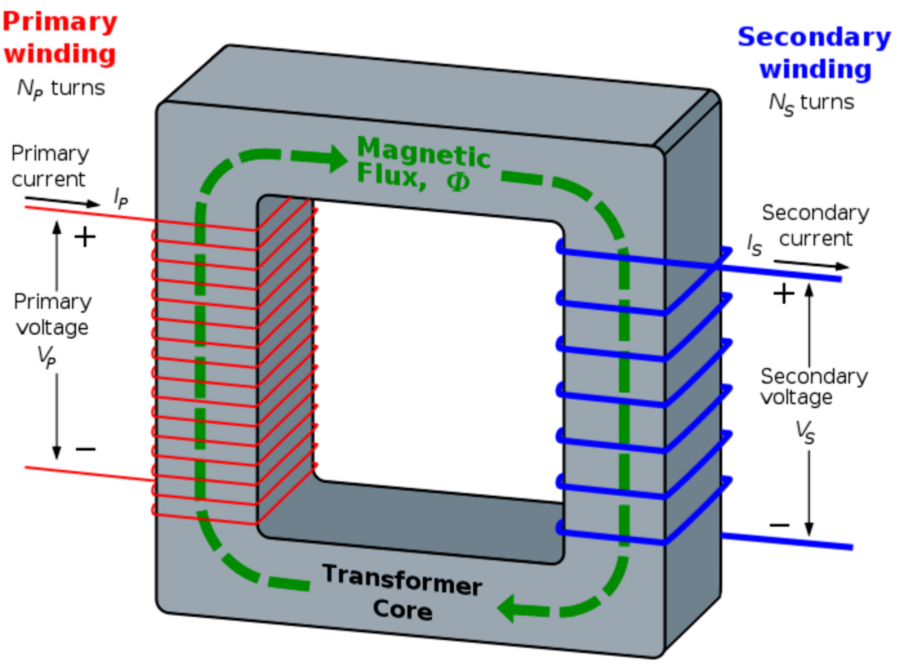
Annexure- VI : Transformer 230/110V

IRS: S -72/88 with Amendment-2

1. TRANSFORMER

A transformer is a device which is use to convert high AC voltage to a low AC voltage and vice versa. Transformer step up or step down the input source voltage without change in its frequency.

Transformer works on the principle of mutual induction of two coils. When current in the primary coil is changed the flux linked to the secondary coil also changes. Consequently an EMF is induced in the secondary coil.



In an ideal transformer, the induced voltage in the secondary winding (V_s) is in proportion to the Primary voltage (V_P) and is given by the ratio of the number of turns in the secondary (N_s) to the number of turns in the primary (N_P) as follows:

$$V_S / V_P = N_S / N_P$$

$$V_S = V_P \times (N_S/N_P)$$

Whenever voltage (VP) is applied to primary winding, results in mutually induced e.m.f secondary winding. This induced e.m.f is anti phase with V_P and its magnitude is proportional to the rate of change of flux and the number of secondary turns.

POWER FACTOR:

The **power factor** of an AC electric power system is defined as the ratio of the real power (also known as active power) P in watts flowing to the load to the apparent power S in volt-amperes (VA) in the circuit, and is a dimensionless number between 0 and 1.

If φ is the phase angle between the current and voltage, then the power factor is equal to the cosine of the angle,|Cos φ| , and:

$$|P| = |S|\ |\cos \varphi|$$

Efficiency of Transformer:

Efficiency of Transformer = Output power / Input power

= Output power / (output power + Core loses)

$$\text{Efficiency} = \left[\frac{\text{Output Power}}{\text{Output Power + Copper Loss + Core Loss}}\right] \text{X } 100$$

$$\text{Efficiency} = \left[\frac{V_S\, I_S\ \text{X PF}}{(V_S\, I_S\ \text{X PF}) + \text{Copper Loss + Core Loss}}\right] \text{X } 100$$

Where, PF= Power Factor, V_S= Secondary Voltage and I_s= Secondary Current

Core losses are caused by two factors: hysteresis and eddy current losses. Hysteresis loss is that energy lost by reversing the magnetic field in the core as the magnetizing AC rises and falls and reverses direction. Eddy current loss is a result of induced currents circulating in the core. Efficiency of the 230/110V, 50Hz, 1φ transformer used for signalling applications is not be less than 85%.

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)

Select nearest higher rating which are: 1 KVA, 2KVA, 3 KVA, 4KVA and 5 KV

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?

$$\text{The Load on 230V side of transformer in VA} = \left[\frac{\text{Load on secondary}}{\text{Efficiency of Transformer}}\right]$$

$$= \left[\frac{\text{Load on secondary in VA}}{0.85}\right]$$

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.

(i) 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.

(j) 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.

$$\text{Output current of the 230/110V Transformer at Full Load} = \left[\frac{\text{Transformer rating}}{\text{Nominal output Voltage}}\right]$$

$$= \left[\frac{1000\text{ VA}}{110\text{ V}}\right]$$

$$= 9.090\text{ A}$$

Efficiency of the Transformer = 0.85

$$\text{Input current at Full Load} = \left[\frac{\text{Transformer rating}}{\text{Nominal output Voltage X Efficiency of the Transformer}}\right]$$

$$= \left[\frac{1000}{230 \text{ X } 0.85}\right]$$

$$= 5.11\text{ A}$$

(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)

RDSO approved list of firms for manufacture and supply of electrical signalling items: as on 31st December 2013

ITEM: POWER SUPPLY EQUIPMENTS – TRANSFORMER – 230 / 110 V

Spec No.: IRS: S- IRS:S-72/88 with Amd. 2

APPROVED UNDER PART: I	APPROVED UNDER PART: II
1. M/s Electro Star,	1. M/s Ultra Electronics Pvt. Ltd.,
2. M/s Ex-Servicemen Electrical Industries,	2. M/s Mani Electronics,
3. M/s General Auto Electric Corporation,	3. M/s Apple Systems Pvt. Ltd.,
4. M/s Sree Chand Elect, Industries (P) Limited,	4. M/s Electro Star,
5. M/s Mani Electronics	

* * *

Annexure-VII
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. Diesel Generator shall be air cooled silent genset, Single Phase, 230 V output, Diesel Engine as per RDSO Specification RDSO/SPN/193/2005 with acoustic proof enclosure, panel & push button start assembly, remote operation panels and anti vibration mounting of engine/ alternator along with low maintenance battery of 12V 80AH (capable of providing 20 starts without recharging) as per IRS:S-88/93. Push button starting arrangement is to be provided. For Railway signalling applications based on no. of lines RE/Non-RE area, with/without AFTC generators of 7.5KVA, 10KVA, 12.5KVA and 15KVA are used.

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. Codal life of the DG set is 10 Years.

* * *

Annexure-VIII
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 more 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.

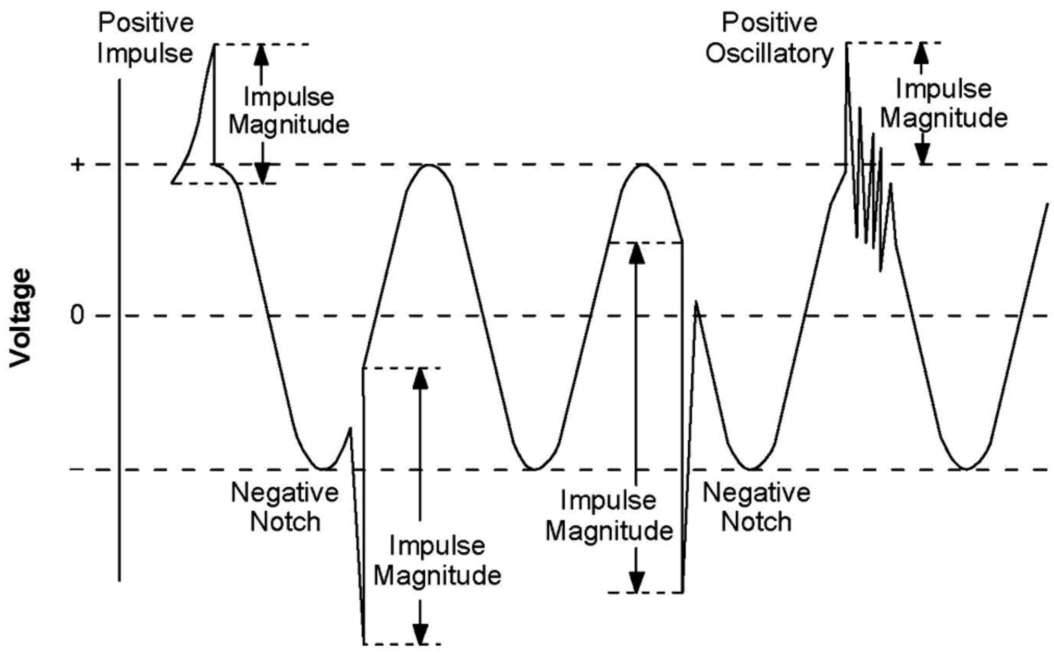


Fig.1: Effects of Voltage Transient on an AC Sine Wave

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.

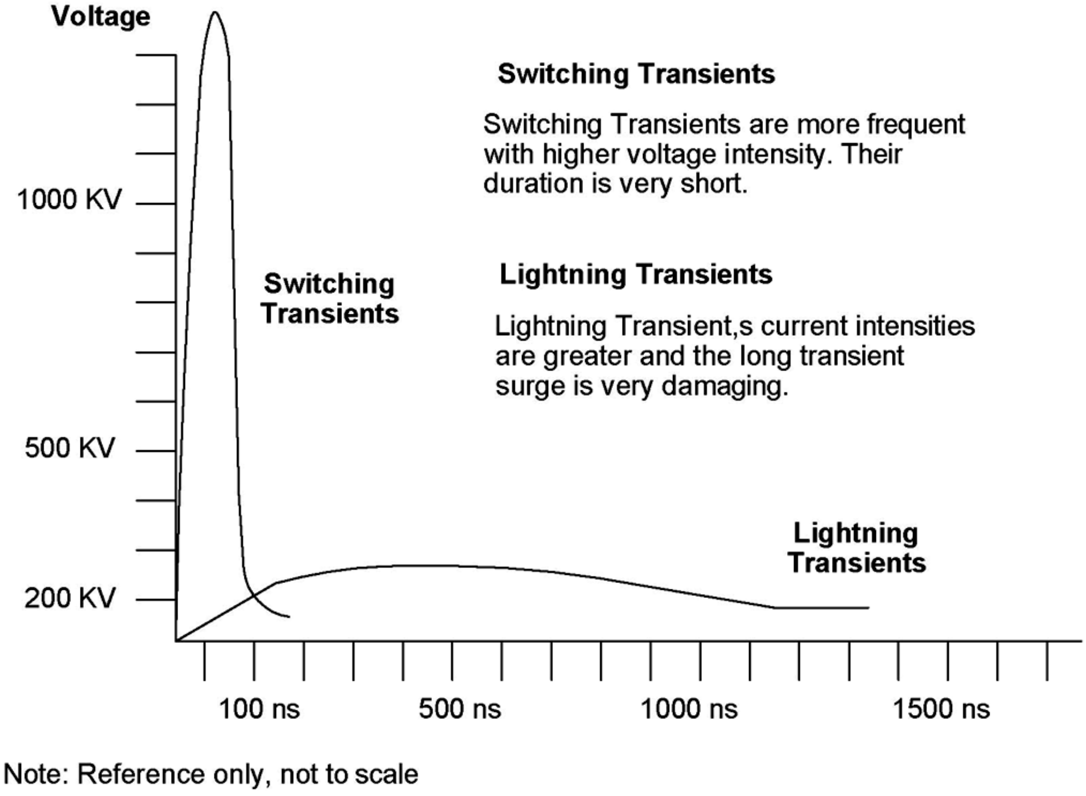


Fig.2: Characteristic Values of Transients

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 µsec 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. The “time to half value” of a typical lightning strike is 350µsec. Duration of 350µsec along with a high peak current will cause damage in almost all semiconductor based protection devices.

Comparison of lightning test currents

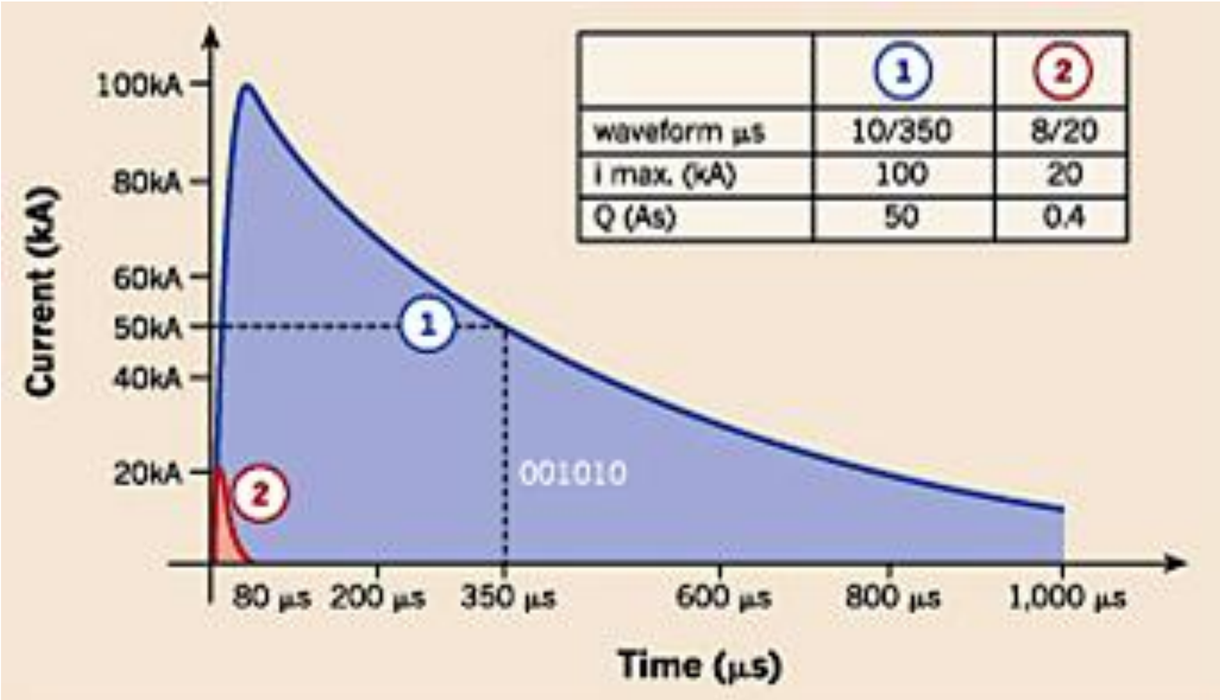


Fig.3: Comparison of lightning test currents

According to the new testing requirements, the 10/350µsec waveform is to be used for protection against direct lightning currents while the 8/20µsec waveform is useful only for protection against indirect lightning effects.

Above diagram shows that a 100kA 10/350µsec impulse delivers 125 times as much discharge in amps as a 20kA 8/20µsec pulse and use of an MOV protector for a 100kA 10/350µsec pulse would require about 2,500kA 8/20µsec MOV capability.

The 10/350 µsec has a longer decay time than the 8/20 µsec impulse. The result is that SPDs tested to the10/350 µsec must be robust enough to handle direct lightning strike energy. A comparative factor of 10 is accepted by the IEEE standards to compare 8/20 µsec testing to the 10/350 µsec testing. In other words, an SPD rated to 50kA 10/350 µsec could be considered to have a rating of 500kA 8/20 µsec.

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 structure housing sensitive electronics equipments thus has two major subsystems:

(a) External Protection subsystem

(b) Internal Surge Suppression subsystems.

3.1 EXTERNAL PROTECTION (Stage - 0 or 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. ESE (Early Streamer Emission) device or Air rods or Mesh method shall be used for Class-A protection and it is provided on roof top of the buildings.

Main components of the external protection system are:

(i) Strike Termination (Air 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.”

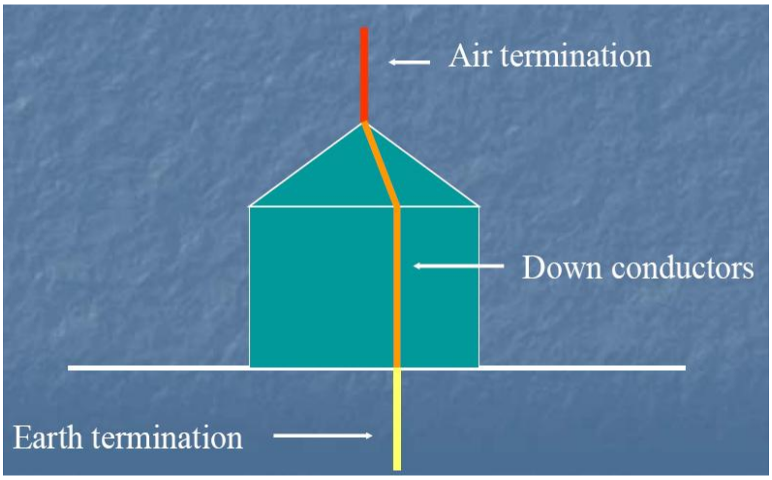


Fig.4: Air termination and Down Conductor

(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.

Down conductor shall be cable rated for HV (50 sq.mm cross section of stranded copper conductors) for structures of 80m or high. (If 60 or more lightning days in a year). Other places 40mm x 6mm MS flat shall be provided which should insulated from the building.

(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.

3.2 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.

Stage 1 protection (Power line protection at Distribution Level) 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. They shall be arc chopping spark gap type voltage switching device.

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.

Stage3 protection (Protection for power /signalling/data lines) is of Class D type. All external Power/signalling/data lines (AC/DC) shall be protected by using this Class D type device. It consists of a combination of Varistors/suppressor diodes and Gas Discharge Tube with voltage and current limiting facilities. *(Note: IPS manufacturer will provide the Stage3 protection on demand.)* The device for **power line protection** shall be of Class D type. This shall have an indication function to indicate the prospective life and failure mode to facilitate the replacement of failed SPDs. This shall be thermal disconnecting type and equipped with potential free contact for remote monitoring. These devices for **Signalling/Data line protection** shall preferably have an indication function to indicate the prospective life and failure mode to facilitate the replacement of failed SPDs. If the device has any component which comes in series with data/ signalling lines, the module shall have "make before break" feature so that taking out of pluggable module does not disconnect the line.

If power 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 (Class C) type shall be used at such locations for power supply lines and Stage 3 protection for signal / data lines.

Note:

1. Coordinated type Class B & C arrestor shall be provided in a separate enclosure in IPS room adjacent to each other. This enclosure should be wall-mounting type.

2. Length of all cable connection from input supply and earth busbar to SPDs shall be minimum possible. This shall be ensured at installation time.

3. Stage 1 & Stage 2 (Class B & C) protection should be from the same manufacturer/ supplier. IPS manufacturer shall provide Stage 1 & Stage 2 protection along with IPS. Stage 3 protection shall be got provided by Railways separately.

4. The cross sectional area of the copper conductor for first stage protection shall not be $<16\ mm^2$ and for second stage shall not be $< 10mm^2$.
5. Batch test report of OEM should be submitted by the manufacturer /supplier of Lightning & Surge protection devices to the IPS manufacturer at the time of supply of these devices. Copy of the same shall be submitted by IPS manufacturer to RDSO at the time of acceptance test of IPS system.

For correct functioning the Lightning and Surge Protection devices proper EARTHING arrangement is required.

Sl	Description	Class A	Class B	Class C	Class D
1	Protection Devices	ESE, Air rods, Mesh method	Spark Gap principle	Metal Oxide Varistor (MOV) (Thermal disconnecting type)	Transzorbs (suppressor diodes) & GD Tubes
2	Max Protection Level	>100KV	≤ 2.5KV	≤ 1.5KV	≤ 1.2KV
3	Response Time	>100 n.sec	≤ 100 n. sec.	≤ 25 n. sec.	≤ 25 n. sec.
4	Installation	On roof top of the Buildings	Main Power Supply Distribution Box at the entry of the input 230V AC in Power/Eqpt room	Sub-Power Supply Distribution Box at the group equipment	at the individual equipment
5	Application in S&T	On top of Building	IPS	IPS	Computers, Transzorb Diodes in Microlok II Ssdac

Class A Device ESE Device	Class B Device Spark Gap	Class C Device MOV
		
Class 'D' Devices – Supressor Diodes and GD Tubes		
		

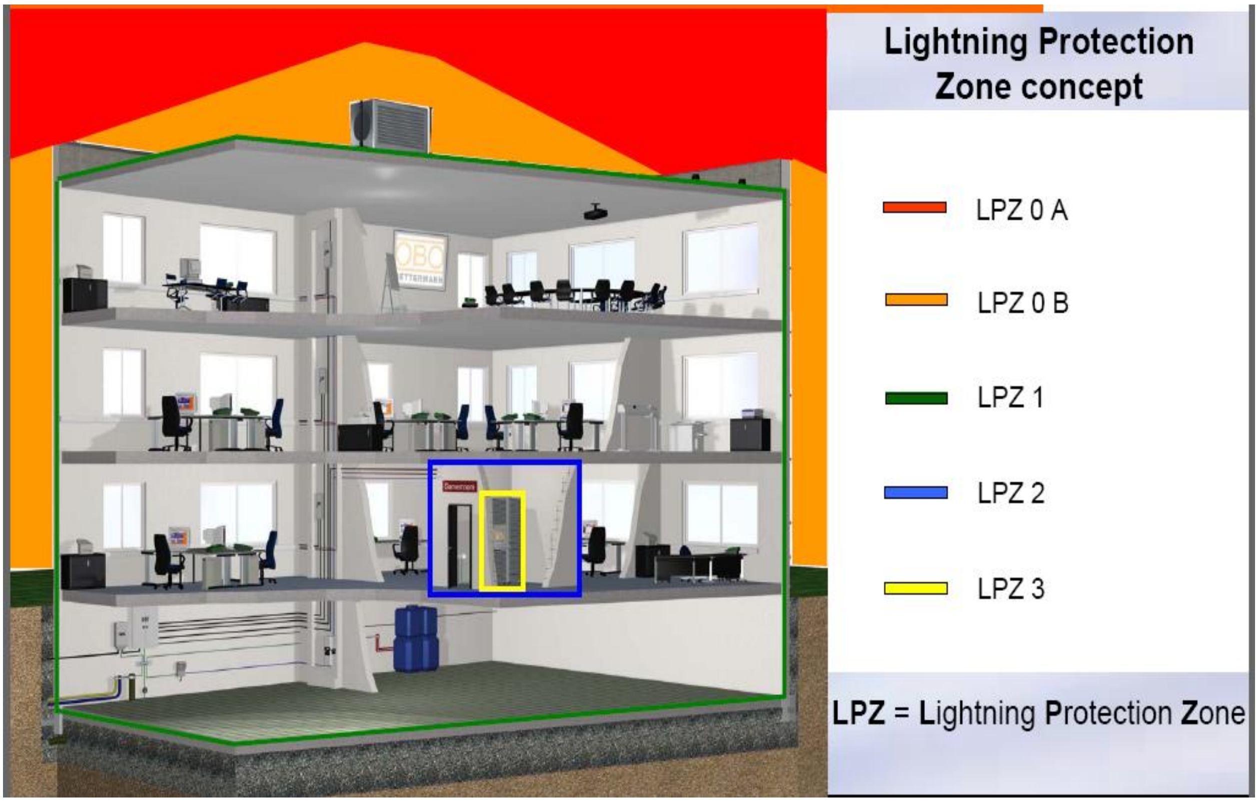


Fig.5: Lightning Protection Zone Concept According to IEC 61312-1 & IEC 62305-4

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)

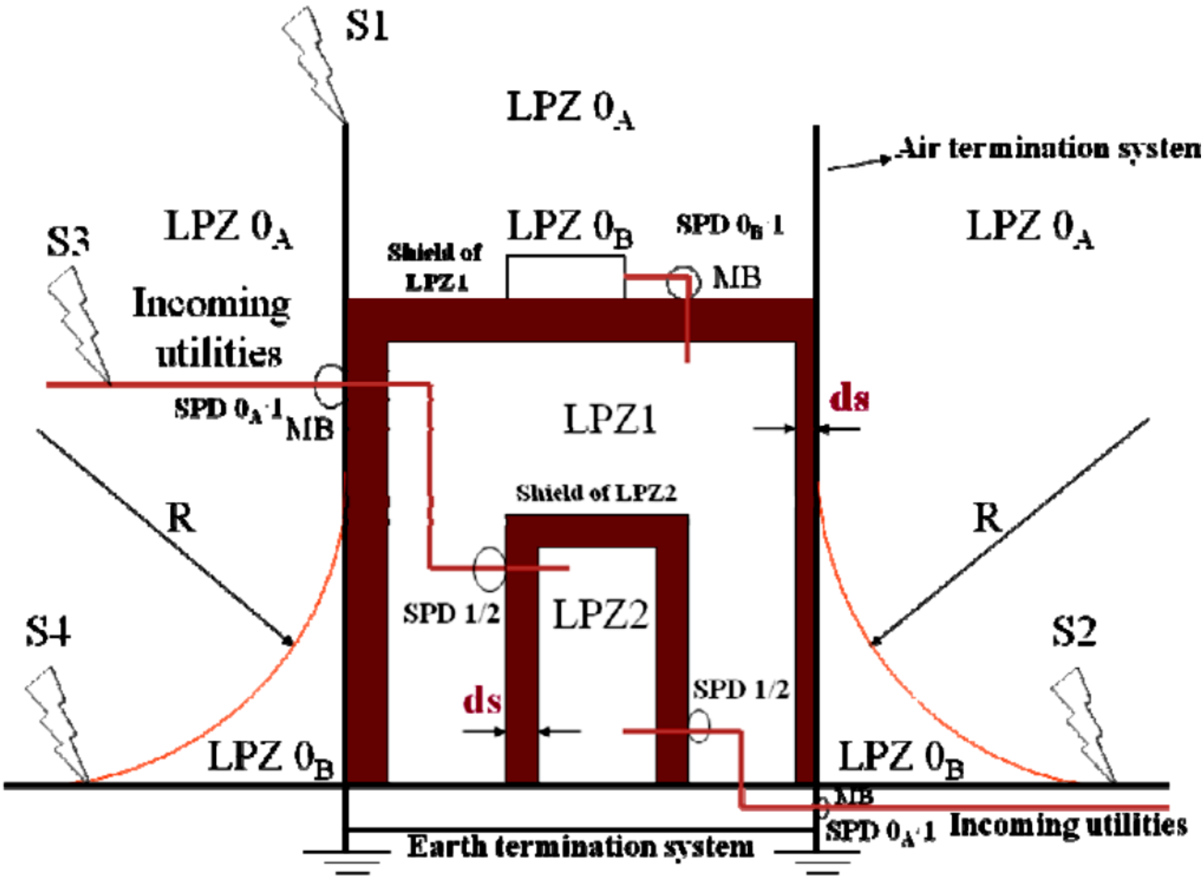


Fig.6: Lightning protection zones

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

Location of earth to be chosen in the following order:

(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. up to 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 Equi-potential Earth Busbar and its connection to equipments & Surge protection devices in the Equipment room:

4.7.1 EQUI-POTENTIAL EARTH BUS BARS

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 bus bars located in individual rooms shall be termed as Sub equi-potential bus bars (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.

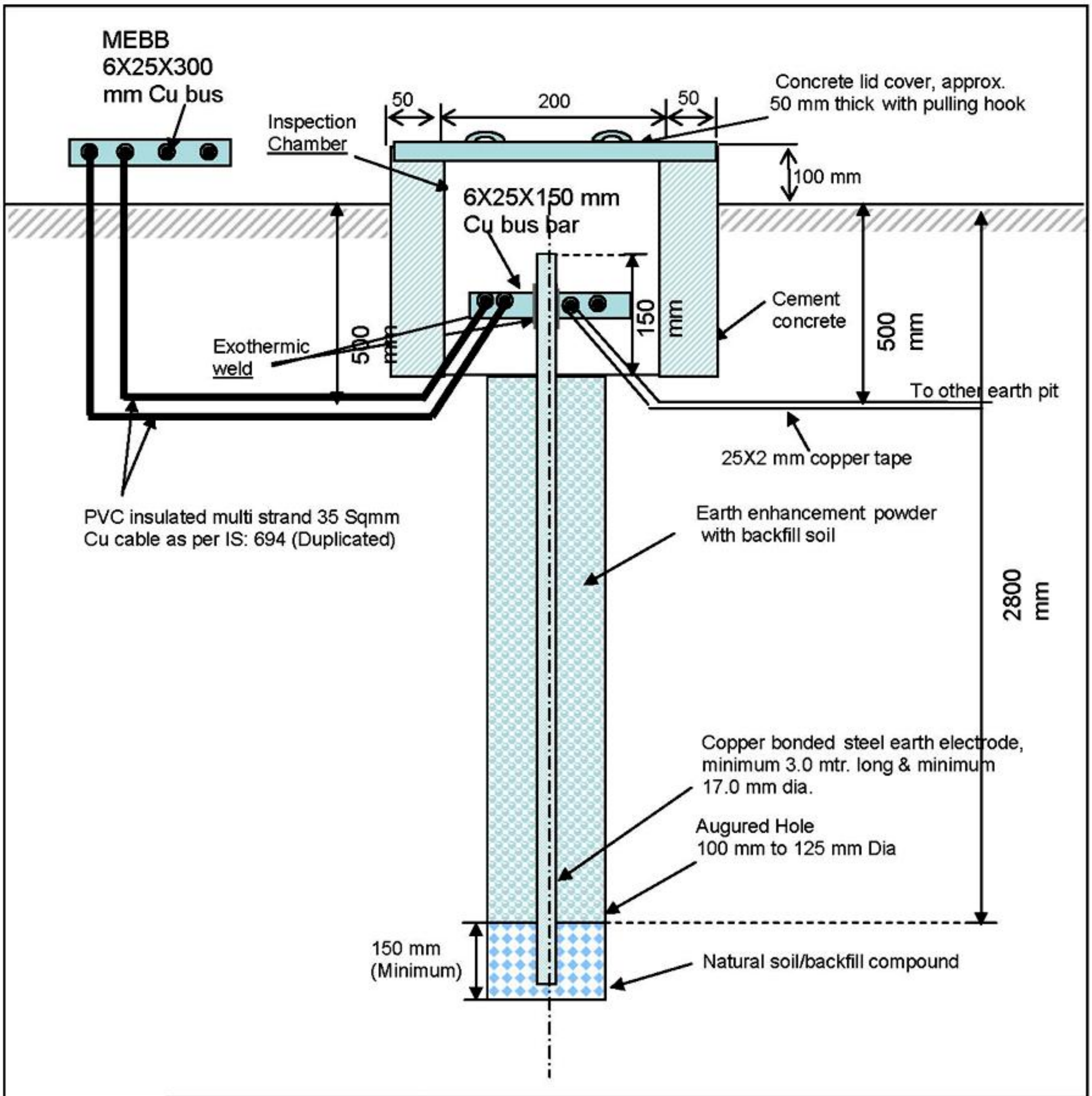
4.7.2 BONDING CONNECTIONS

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 equi-potential bus bar and earth electrode shall be as given below.

Component/Bonding	Material	Size
Main equi-potential earth busbar (MEEB)	Copper	300X25X6 mm (min.)
Sub equi-potential 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	16 sq.mm
MEEB to main earth electrode	Multi-strand single core PVC insulated copper cable as per IS:694 (Duplicated)	35 sq.mm
Main earth pit to other earth pit in case of loop earth	Copper tape	25 X 2 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

Fig.7: Typical installation of earth for S&T Installations

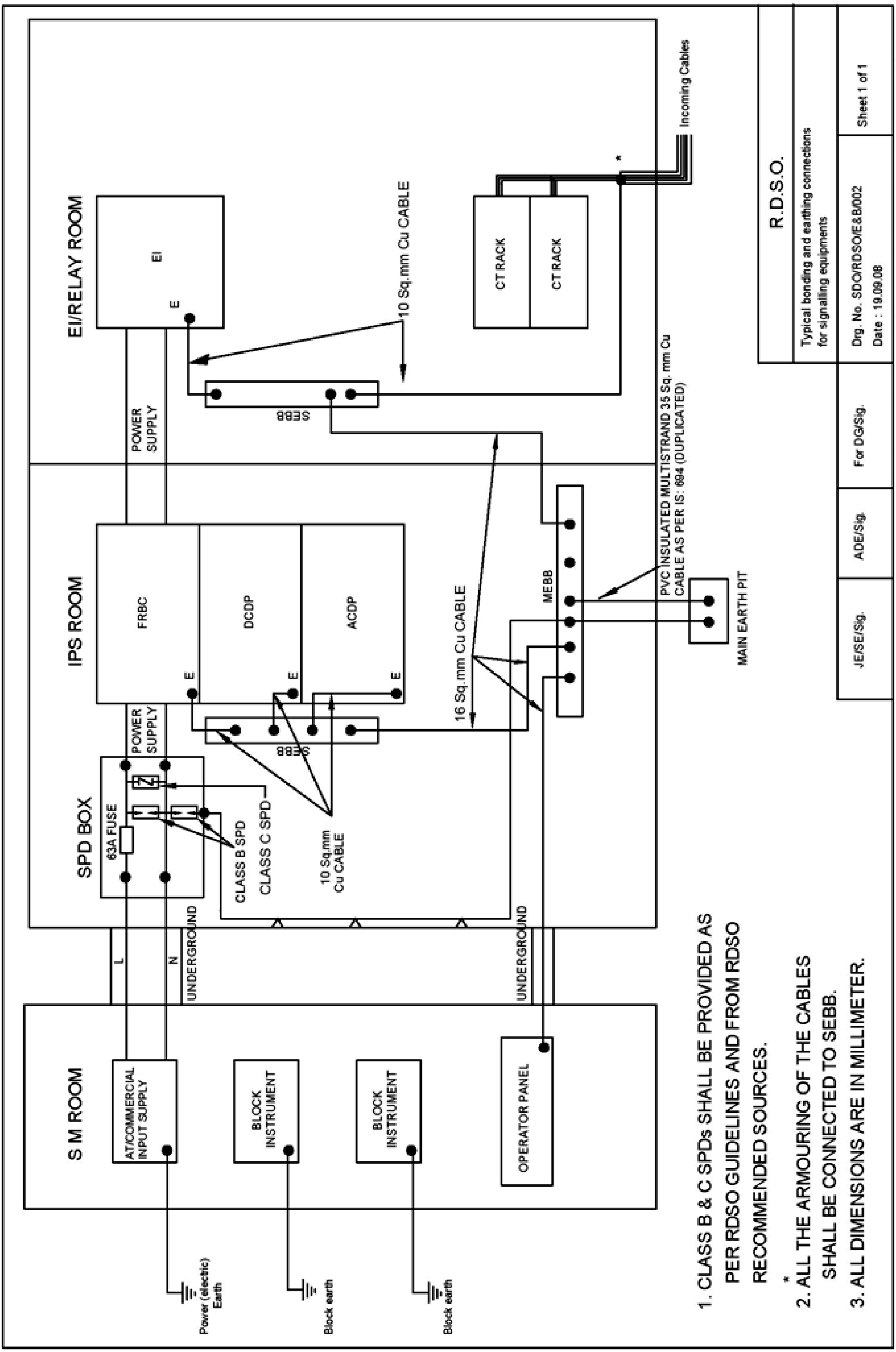
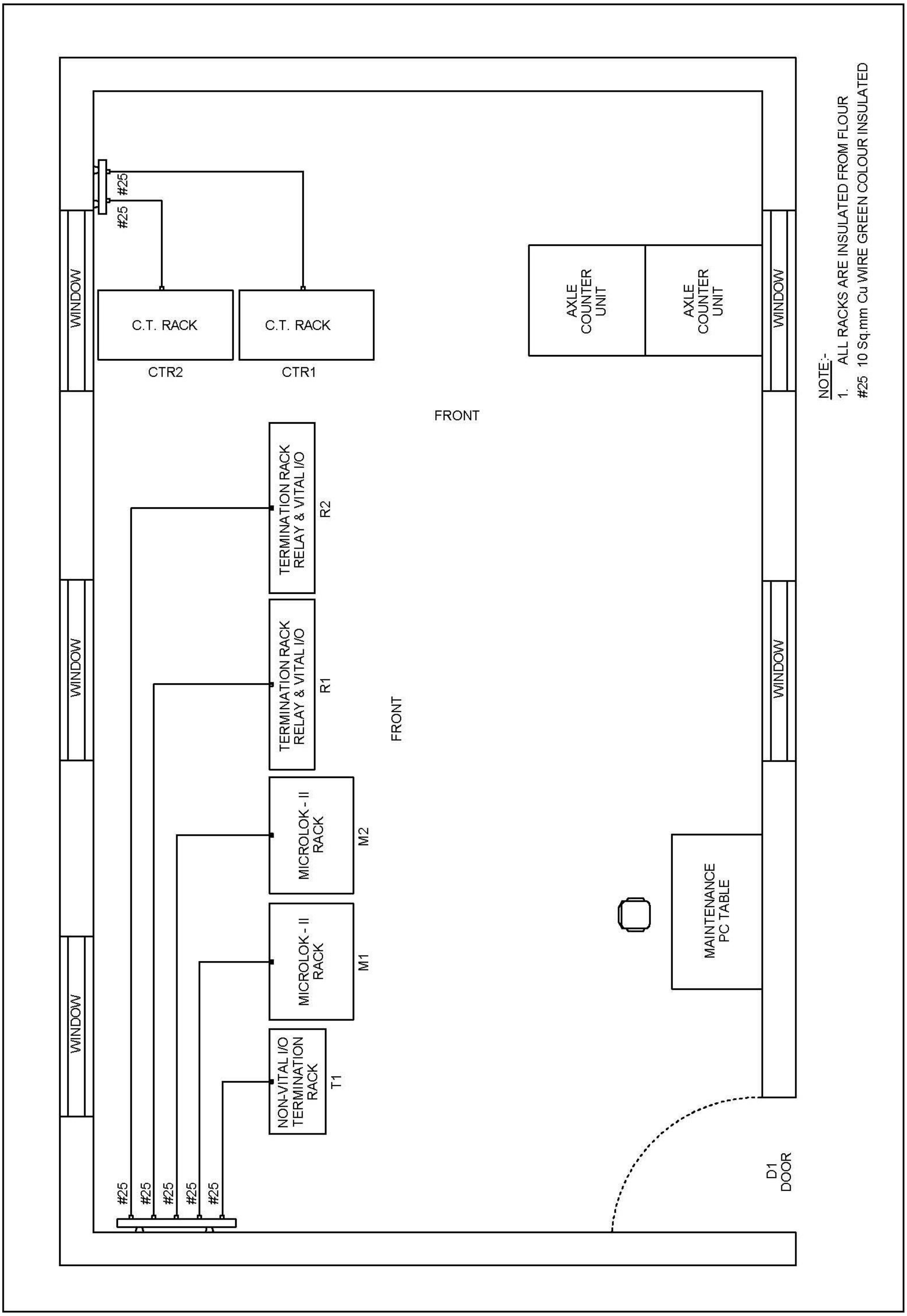
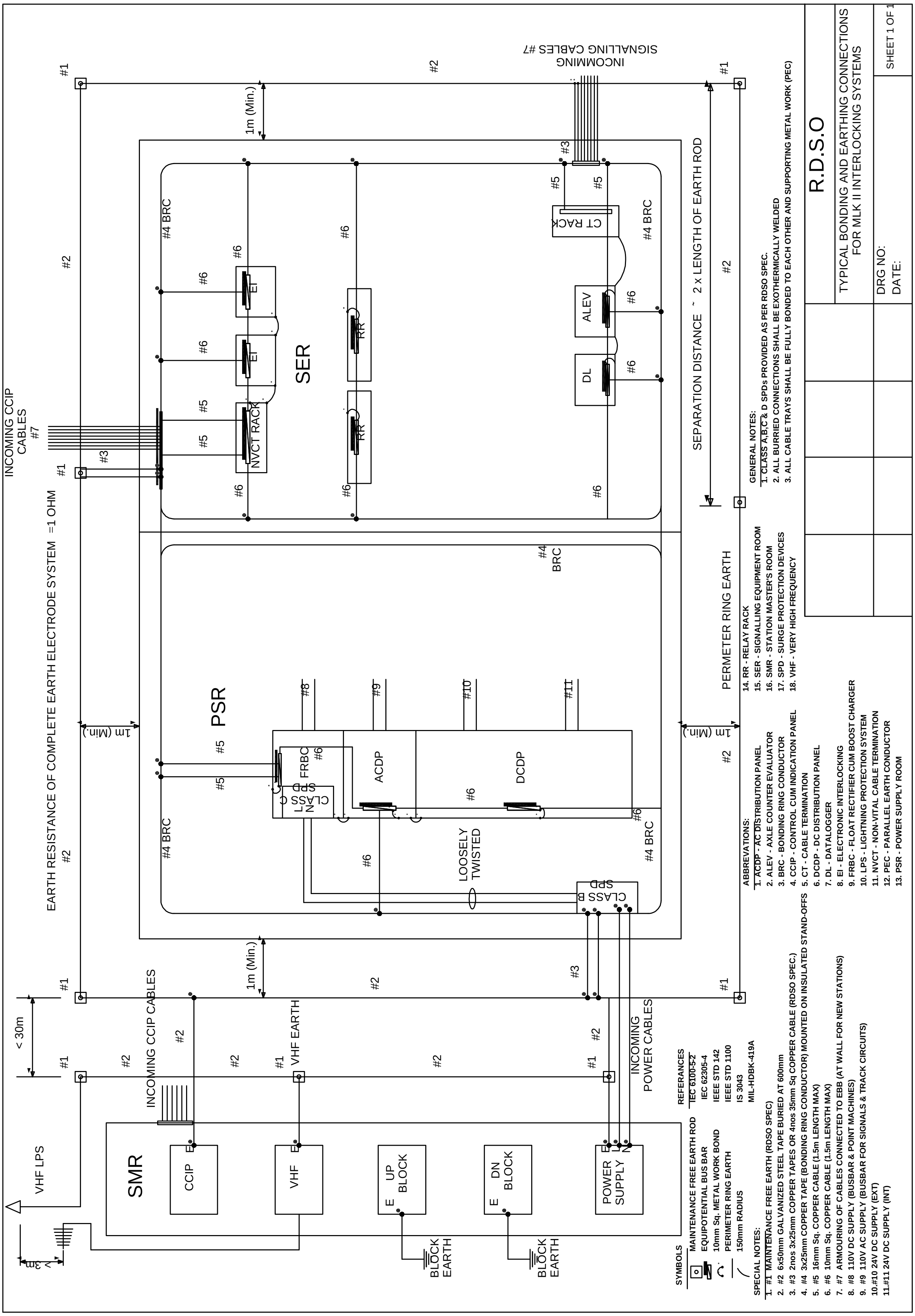


Fig.8: Typical Bonding and Earthing connections for signalling equipments

4.8 RACK EARTHING

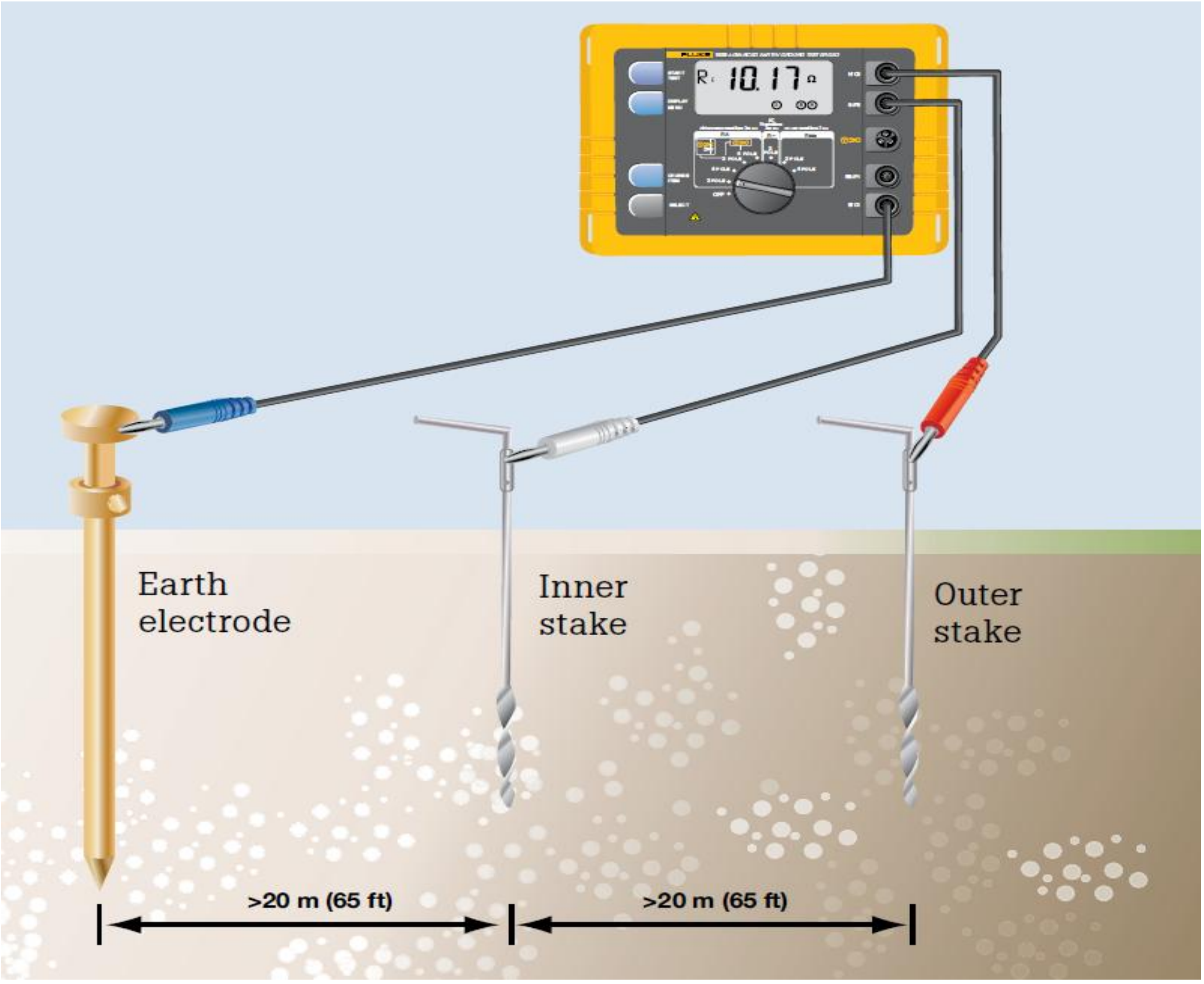


4.9 PERIMETER EARTHING



4.10 Earth Resistance Measurement Procedure

To test soil resistivity, connect the Earth resistance Tester as shown below.



The Fall-of-Potential test method is used to measure the ability of an earth ground system or an individual electrode to dissipate energy from a site.

First, the earth electrode of interest must be disconnected from its connection to the site. Second, the tester is connected to the earth electrode. Then, for the 3-pole Fall-of-Potential test, two earth stakes are placed in the soil in a direct line away from the earth electrode. Normally, spacing of 20 meters (65 feet) is sufficient.

A known current is generated by the Earth resistance tester (Fluke 1625) between the outer stake (auxiliary earth stake) and the earth electrode, while the drop in voltage potential is measured between the inner earth stake and the earth electrode. Using Ohm's Law (V = IR), the tester automatically calculates the resistance of the earth electrode.

Connect the Earth resistance tester as shown in the picture. Press START and read out the Earth Resistance (R_E) value. This is the actual value of the ground electrode under test. If this ground electrode is in parallel or series with other ground rods, the R_E value is the total value of all resistances.

PLACING OF THE STAKES:

To achieve the highest degree of accuracy when performing a 3-pole ground resistance test, it is essential that the probe is placed outside the sphere of influence of the ground electrode under test and the auxiliary earth. If you do not get outside the sphere of influence, the effective areas of resistance will overlap and invalidate any measurements that you are taking. The table is a guide for appropriately setting the probe (inner stake) and auxiliary ground (outer stake). To test the accuracy of the results and to ensure that the ground stakes are outside the spheres of influence, reposition the inner stake (probe) 1 meter (3 feet) in either direction and take a fresh measurement. If there is a significant change in the reading (30%), you need to increase the distance between the ground rod under test, the inner stake (probe) and the outer stake (auxiliary ground) until the measured values remain fairly constant when repositioning the inner stake (probe).

Depth of the ground electrode	Distance to the inner stake	Distance to the outer stake
2m	15m	25m
3m	20m	30m
6m	25m	40m
10m	30m	50m

* * *

Annexure IX
Supply, Installation & Commissioning and AMC of IPS

1. Supply, Installation & Commissioning of IPS being procured through stores contract (Ref: RDSO letter No. STS/E/IPS/Genl. Dated: 03-01-2006)

The competent authority has taken decision that since IPS is being procured only through stores contract and IPS systems are being delivered by the manufacturers at the consignee stores, the responsibility of IPS manufacturers shall be limited to supply of IPS and later on its commissioning at site when the site is ready as per pre-commissioning check list issued by RDSO. Transportation, installation, wiring etc. and any other civil works involved shall be responsibility of works contractor executing the work at the station.

The detailed break-up of supply and commissioning portion coming under IPS manufacture shall be as given below.

A. <u>Supply portion at the stores (Responsibility of IPS supplier)</u>

1. Supply of IPS as per indenting configuration along with the surge protection devices (on a separate wall mountable SPD box) and status Monitoring panel.
2. Supply of 110V battery bank and wooden rack along with its all accessories.
3. Supply of minimum spares as per Annexure-II of the specification or as indented by the railway.
4. Supply of tool kit containing all type tools required for maintenance of IPS.
5. Supply of exhaust fan 12'' size.
6. Supply of copper cable of suitable dia as per IS: 694 and grade 1100V for connecting IPS to Battery bank (distance to be given by Railways at the time of indenting) as given below –
   a) For 120AH battery – 10Sq.mm
   b) For 200AH battery – 16Sq.mm
   c) For 300AH battery – 25Sq.mm
7. Supply of 12 core, 1.5sq.mm signalling cable as per IRS:S 63/2007 with amdt for connecting IPS to status Monitoring panel in Station Master's room (distance to be given by Railways at the time of indenting).
8. Supply of Use's Instruction Manual.

B. <u>Installation & Wiring (Responsibility of IPS supplier)</u>

1. Installation of IPS as per Specification.
2. Electric wiring and bringing AC input supply up to IPS.
3. All wiring /ducting from/to IPS and Relay room, Battery room & station master room.

C. <u>Commissioning of IPS (Responsibility of IPS Supplier)</u>

1. Charging the battery as per battery manufacturer's guidelines (power for battery charging shall be arranged by the Railways).
2. Interconnecting all the modules / racks of IPS (including 230V AC input supply and commissioning of IPS).
3. Checking the working of all modules of IPS along with all indications/alarms.
4. The provisions given in pre-commissioning checklist shall be jointly verified by the IPS manufacturers and Railways.
5. Training of maintenance staff on operation and maintenance of IPS.

2. Terms and Conditions for Annual Repair contract (ARC) of IPS system

(Ref: Annexure-II of RDSO Letter No. STS/E/IPS/Genl. Dated:13.06.2008)

A. SCOPE

ARC covers repair of all defective IPS modules including status Monitoring panel & LPD/SPD box in the contract period.

B. SCHEDULE OF ACTIVITY FOR REPAIR OF DEFECTIVE MODULES

(i) Railway should procure & keep min. 10% spares of all modules or 01 DC-DC Converter module each for critical circuits, 01 SMR, 01 Inverter, 01 AVR & 01 transformer module at the station where IPS is installed and further 10% spares of each module based on total population in the division at suitable/central location.

(ii) As soon as a module becomes defective, it shall be taken out of IPS by the ESM/SI and sent to suitable/central location in the division. Adequate care shall be taken so that modules are not physically damaged during transportation.

(iii) All the defective modules shall be collected from the specified location as mentioned above by the firm's representative every month for repair. These defective modules shall be returned back duly repaired in not more than two months period.

In case, the some defective modules cannot be repaired & returned in the two months period, firm shall provide spare modules in its lieu in order to maintain proper functioning of IPS. These spare modules shall be taken back whenever defective modules are returned back after repair.

(iv) Warranty of repaired modules shall be min 12 months. If any module fails within the warranty period, it shall repaired by the firm free of cost.

(v) In order to have proper accountal, a record book shall be maintained at the central location mentioned above in which details of modules handed over for repair, returned after repair along with dates and serial no of modules shall be jointly recorded by the authorized Railway representative and the firm's representative.

C. PENALTY

Penalty shall be charged for lapse on the part of the firm as given below and it should not be less than the agreement cost of annual repair contract per day –

(i) Firm's representative does not come to the specified location in due monthly visit for collection of defective modules or return of repaired modules.

(ii) Firm does not return the defective module after repair in maximum two months period and neither gives a working spare module in its lieu.

D. PAYMENT

Firm shall raise monthly based on the no. of modules repaired as per record available in the record book. Payment shall be done after deducting any penalty charges for lapse on the part of the firm as given above.

E. OTHER ITEMS

(i) The installation shall also be jointly checked by the Railway & firm's engineer as per pre- commissioning checklist before commencement of ARC and any deficiency noted in the installation shall be got rectified by the Railway beforehand separately.

(ii) A mobile number, Landline phone number, Fax number of the firm's engineer shall be given by the firm at the commencement of AMC for communication in case of any need.

(iii) Damages/ failures of IPS modules due to direct lighting strike, flood, earthquake, sabotage, theft, civil /industrial unrest are not covered under warranty of ARC.

NOTE:

1. Railways should assess probable quantity of IPS modules of particular firm which can get defective during contract period based on average no. of modules got defective during last 2 years and then process for ARC in the following suggested format:

Sl. No	Description of work	Assessed Quantity	Rate
1	Repair of following modules of IPS installed as per RDSO/SPN/165/**2000** (a) SMR (b) Inverter (c) DC-DC converter (d) AVR/ CVT (e) Transformer (f) Status Monitoring panel (g) LPD/SPD box		
2	Repair of following modules of IPS installed as per RDSO/SPN/165/**2004** (a) SMR (b) Inverter (c) DC-DC converter (d) AVR/ CVT (e) Transformer (f) Status Monitoring panel (g) LPD/SPD box		

2. Contract should include provision that rate of repair of various modules shall remain same even for variation of quantity by ±25% during the contract period.

3. Any other terms & conditions may be given by Railways as per practice being followed.

4. The contract can be for one to three years.

* * *

Annexure X
COMPARISON BETWEEN VARIOUS TYPES OF LEAD ACID CELLS

Sl. No.	Item	Conventional Lead Acid Battery	VRLA (MF) Battery	LMLA Battery
1	Requirement of a Battery Room	Yes	Not required	Yes
2	Charging Requirement	Requiring regular Float and Boost charging and equalize charging (up to 2.7V /cell) once in 3 to 5 months. 2.7V. 2.4V, 2.25V	Requires simple Float/ Boost Charging 2.3V, 2.25V	Requires less frequent boost charging 2.15 to 2.2V
3	Topping up and maintenance	Requires once in a week	Maintenance free	Requires topping up once in a month.
4	Aging factor	Approx. 1.5 to 2% decay in capacity due to aging per year.	Same as Tubular LA Battery	Does not decay due to aging for first 5 years. As a matter of fact its AH capacity goes up for first 5 years.
5	Storage	Can be stored in dry uncharged condition for many years.	Can be stored at max. 25deg. C and still needs to be charged in store within 3 to 5 months.	Same as Tubular LA Battery
6	Working Condition	Can be used at Normal Indian ambient temp.	Should be installed in AC room. The capacity reduces to half for every 10deg. C rise in temp. above 27degC	No effect of temp. at all.
7	Life of the Battery	Works up to 7 to 9 years in normal environmental conditions. 4 to 5 years/Sign.	Works for 3 to 5 years if storage and temperature conditions are met.	Works for 20 years minimum. Life found between 25 to 30 years.
8	Depth of discharge	Can be discharged up to 80%	Should normally used up to 50% DOD only. 80% is external limit.	Same as Tubular Lead Acid Battery.
9	Cost	Low cost	Approx. 2 times costlier than Tubular Lead Acid Battery.	Approx. 2 times costlier than Tubular Lead Acid cells. But a lower AH battery can be used.

Sl. No.	Item	Conventional Lead Acid Battery	VRLA (MF) Battery	LMLA Battery
10	Initial Charging	2.7V / Cell at I=4%AH (for 35 hours)		At 10% up to 2.4V & 5% →2.7V/ cell --- total 60 Hrs. Constant current
11	Boost or Equalizing charging	2.4V/cell at 10% of AH	2.3V/cell (for 16 hrs)eq. for every 6months ±max20% of AH	12.5% of AH for 10 to12 Hours.
12	Float charging	2.25V/cell (2.12 to 2.3V adjustable)	2.25V/cell for 72 Hrs Imax <20% of AH	2.15 to 2.2V/cell
13	V Max	2.2V	2.2V	
14	V min	1.8V	1.75V	1.85V
15	Safety Valve	-	Opens at 6 PSI and closes automatically.	-
16	Anode (+ve)	PbO2	Lead-Cadmium alloy	Low Antimony PbO2
17	Cathode (-ve)	Pb	Lead Calcium alloy (Large are for more oxygen recombination)	Low Antimony Pb
18	Maintenance	15 days		
19	Life cycle	-	5000 cycles at 20% DOD 1500 cycles at 80% DOD	-

* * *

Annexure XI
FUSES

Fuses shall be of an approved type. Normally Non-Deteriorating type, Indicating type of low voltage Non-Deteriorating type, Cartridge type fuses shall be used. When fuse is not provided with fuse blown of indication, additional indication circuit may be provided.

At the time of commissioning of any signalling installation, the normal load current of every circuit shall be measured and recorded. These recorded values shall be checked with the theoretically obtained values. Fuse of correct capacity which should be not less than 2.5 times the rated current, shall be provided. (As per SEM Part II para: 19.87.2)

When there is a case of fuse blowing off, the concerned circuit current shall be measured and compared with the original recorded value. If there is a variation, action shall be taken to locate and remove the defect before a new fuse is inserted.

The following are the guidelines for providing minimum fuses in relay circuits, power equipment, batteries and power distribution panel shall be followed in all new works. Auditing of existing installations shall be done to identify and remove redundant fuses.

(Ref: NORTH EAST FRONTIER RAILWAY Technical Circular No. 01/2007)

1. Indication Non-deteriorating fuses of approved type shall be used.
2. Busbar terminal blocks shall be approved type.
3. Use of Bare/Loose wires as fuses is prohibited. Sufficient spare fuses shall be made available soon after commissioning.
4. Signaling circuit shall be designed with minimum fuses following **principle of one fuse one signal / function**. In existing installations fuse affecting more than one signal or function in **all external circuits** shall be identified and provided with two parallel fuses for each signal / function.
5. All the important circuits including slot, external control and signal lighting fuses at locations shall have two parallel fuses.
6. LED indications to be provided for all types of fuses. Preferable the circuit shall be such that blowing of a fuse shall glow the LED indication and bring standby fuse into the circuit.
7. At the time of commissioning of any signaling installation, the normal load current of every circuit shall be measured and recorded. These recorded values shall be checked with theoretically obtained values. (SEM Part-II para 19.87.2)
8. Fuse of correct capacity, which should be not less than 2.5 times the rated current, shall be provided. (SEM Part-II para 19.87.2)
9. Fuses shall be of suitable rating as per para 5 above and rating of the fuses shall be written on fuse block.
10. Fuses for point machine working with parallel operation shall be 10Amps.
11. For installations with WAGO / Phoenix terminals, type of fuses shall be as required by fuse holders of such makes.
12. When there is a case of fuse blowing off, the concerned circuit shall be measured and compared with the original recorded value. If there is a variation, action shall be taken to locate and remove the defect before a new fuse is inserted. (SEM Part-II para 19.87.3).

13. For signal lighting circuits fuses need not be provided for NX path.
14. No fuses shall be provided at the input or output of battery bank.
15. Power distribution panel shall be provided, where IPS is not provided.
16. MCBs shall not be used in input to power supply equipment. Existing MCBs, if any shall be replaced.
17. Power equipments shall have only one fuse at the input and one fuse at the output. Both input and output fuses shall be provided as per guidelines given in para 8. Duplicate power equipment shall be connected through programme switches of sufficient capacity in power supply panels. Programme switches shall have 9 terminals to make input and output contacts used for power equipment wiring are parallel as per the wiring diagram.
18. The periodicity of replacement of all kind of fuses shall be 3years. All sections in a division shall be divided into 3 groups so that each year replacement is due for only 1/3rd part of the division. Sections of SSE under ASTE/DSTE shall be grouped for this purpose.

Use of Non-deteriorating fuses in signaling circuits:

(Ref: Southern Railway CSTE L.No.SG.199/V/2/71, Dated: 25.11.2010 and S&T circular No: 13/2000 vide L. No. SG.190/P of 11.08.2000)

In partial modification to the circulars issued by this office on the subject, it has been decided to standardize the capacity of fuses used in the various signaling circuits keeping in view the protection to the equipments, standard fuses available in the market and also to avoid failures due to small fluctuations in power supply voltage.

The capacity of fuses used should be **2A, 4A, 6A, 10A, 16A & 20A**. While the minimum capacity of fuses used to be 2A even in circuit like energizing single shelf type line relay other circuits may be so combined where permissible such that the capacity of fuses is double that of the working current of the circuit and are within the range of fuses mentioned. The capacity of fuses for the point operating circuit should be 16A. For power circuits only HRC (High Rupturing capacity) fuses should be used with proper capacities.

However these instructions are not applicable to special type fuses like bottle type fuses in Automatic Main Failure (AMF) Panel, indication type fuses in Siemens groups etc.

For LED signals the instructions issued vide Southern Railway CSTE L. No. SG.199/V/2/85, Dated: 27.07.10 holds good. In this letter, it is advised that the LED signal units which are not provided with HMUs and the units which are having defective HMUs and are by passed may be provided with 600mA fuses to protect Current Regulator and LED lighting signal units in the absence of HMU as advised vide Railway Board's letter No.2005/Sig/SGF/12 (LED) of 09.06.10.

HRC (High Rupturing capacity) Fuses are available with the rating of 0.63A, 1.6A, 1A, 2A, 3A, 5A, 6A, 10A, 16A & 20 Amperes.

Indicating type of Low Voltage Non-Deteriorating Fuses are available with the rating of 0.4A, 0.6A, 1.6A. The rated voltage of the fuse shall be 250V DC or AC 50Hz.

Non-Deteriorating type of Low Voltage Fuses are available with the rating of 1A, 2A, 4A, 6A, 10A, 16A & 20A. All these fuse fittings will be deemed to be rated for 240V AC/DC.

Maintenance of fuses: (Ref: CAMTECH hand book - CAMTECH/2000/S/FUSE)

Fuses need special care from its supply to installation and further their maintenance for perfect working till the life span. Extra maintenance is not required for fuses. At the time of maintenance of any circuit or instrument following observations shall be made for maintenance of fuse:

- Remove the dust and corrosion of fuse blocks.
- Check for tightness of fuse links.
- In the areas where pollution, salinity and humidity is very high, it observed that after some period the characteristics deteriorates rapidly e.g. fuses of 6A, 1.6 A & 0.63 A are start blowing at 5A, 1.2 Amp & 0.4 Amp respectively. Therefore in Mumbai division of Central Railway a process is adopted to replace important fuses after every monsoon and rest after every two years.
- Due to chemical reaction, at the surface of the fuse link, metallic ends and contact points a very high oxide/chloride layer is deposited. It becomes a reason of fuse disconnection. In such areas practice of regular cleaning of surface is adopted.
- Precautions should be taken while removing fuse link from fuse holders in case of glass type fuses. Glass fuse should be removed from ends. Never remove glass fuse by holding glass, it may cause broken fuse.
- Now Indian Railways have gone one step ahead in maintenance of fuses by introducing Fuse monitoring units.

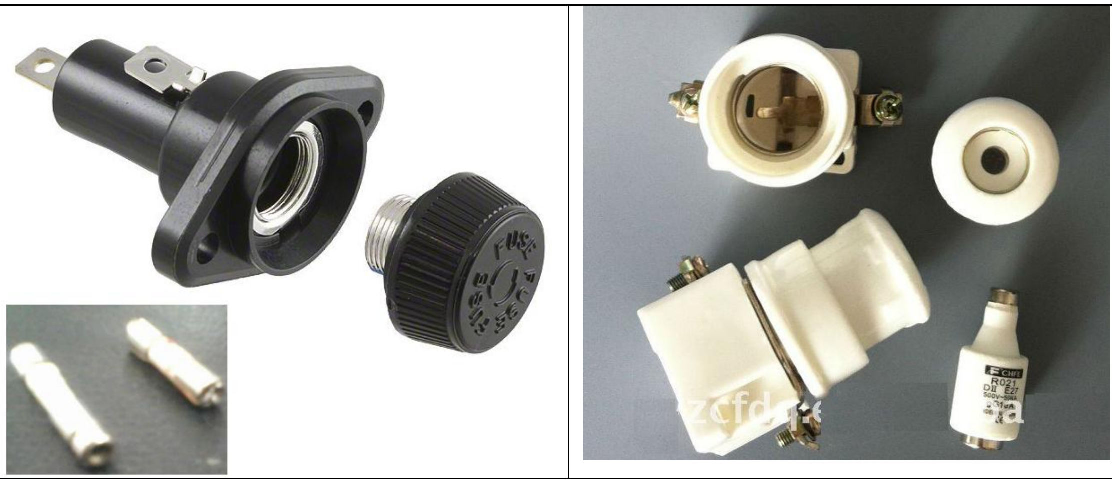


Fig: ND TYPE FUSE

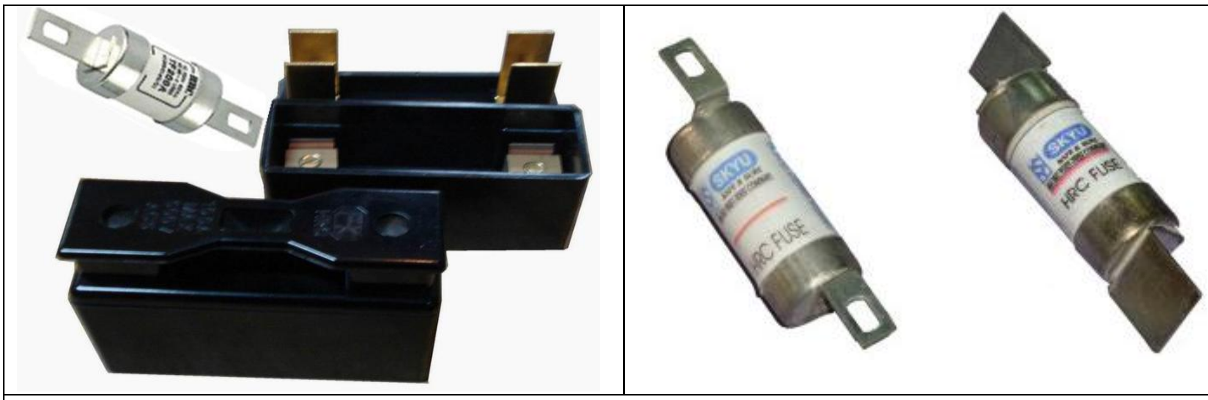


Fig: HRC FUSE

Fuse Monitoring Units in RRI:

Fig: Fuse Monitoring Unit installed in RRI

The fuse monitoring systems continuously monitor the status of various fuses provided in railway signalling installations. The system indicates status of the fuses by visual indication displayed on the panel. An audio / visual indication is activated in case of failure of any fuses.

* * *

Annexure XII
Earth Leakage Detector
(RDSO/SPN/256/2002)

Earth Leakage Detector is used to detect earth fault in the signalling cables and circuits. An audio-visual alarms is activated when the insulation reaches the preset value, which can be adjusted through a potentiometer for insulation value of 2K Ώ to 1M Ώ. It is suitable for working on 110V/230V AC.

Display of 12 - Channel ELD – Front View (1Basic + 2 Add on units)

The basic unit comprised of 4 channels, for use on signalling circuits of 110V AC/DC and/or 60V/24V/12V DC as per requirement. If the detector is required for less number of channels, dummy plates are provided. For More than 4-channels, say 8, 12 or 16-channels, add-on units of 4-channels are attached to the Basic unit. The individual detecting circuit unit is plug-in type unit.

Earth Leakage Detector has twin indicating arrangement in 19 inch sub rack. The first is analogue display of Leakage current on a DC meter calibrated to represent equivalent resistance in the meter circuit from infinity to nearby dead short (about 500Ώ or Zero) resistance. Under this extreme condition the current has been limited to 500Micro-Amps by insulation resistance meter. The second indicating arrangement is by way of lighting of Red LED, labelled 'FAULT' with initiation of audible alarm which operates as per adjusted leakage limit. This second arrangement is for facilitating the operational safety of Railway Signalling System by alerting the Maintenance Staff to take suitable measures to avoid any chances of signalling mishap.

A common audio alarm circuit is provided to all the detecting circuits. Individual visual indication e.g., Red light on the plug in units, is provided for each detecting circuit. The leakage detecting relay is provided as individual for all detecting circuits. Any value between 2KΏ to 1MΏ can be set through a lockable potentiometer to generate a leakage indication / alarm. When the lower limit of the leakage resistance is crossed, the visual indicator as well as audio alarm comes. A push button switch is provided to MUTE the alarm buzzer. The buzzer may be extended to remote location (like SM room) through potential free contacts and remote acknowledgement is also possible. Individual fault indication also can be extended through potential free contacts. The detecting relay, normally remain energized and get de-energised when the earth fault is detected. The relay, once de-energised, shall remain in that condition until it is reset. A RESET push button is provided to re-energise the detecting relay after an earth fault has been rectified. Each RESET operation shall be recorded by a counter.

It has a provision to measure insulation resistance of individual cable pair with respect to ground when the pair is de-energized. For this purpose, cable insulation resistance meter is provided to read the insulation resistance of the bus bar up to 10 MΏ. A suitable rotary switch is provided to connect the insulation resistance measuring meter to any of the circuits one by one, where multiple detecting circuits are used. All channels of ELD and Insulation Tester have a common Meter.

The detector can measure the leakage resistance in 'hot' condition, i.e. when the cables are powered. The disconnection of Earth or AC bus bars shall result into fault condition. Cable Insulation is tested only in OFF line condition.

On line System Insulation of signalling system with respect to Earth:

Insulation of Power supply + Insulation of Control circuits + Insulation of Cables + Insulation of loads (all in parallel) = Leakage Resistance

In practical case insulation of control circuit is very high in respect to others.

To understand this property, let us take an example.

Let insulation of power supply(w. r. t Earth) = Rp

Let insulation of one cable pair (w. r. t Earth) = Rc

Let insulation of one load (any) (w. r. t Earth) = Rs

Total insulation of (pair + load) = 1/Rc+1/Rs , Let it = R1

If we have 99 such circuits in our system then its insulation resistance can be represented as R1, R2, R3, - - - - - - R99.

Let all are same and have an insulation value of 100MΩ. When all such circuits are working on common power supply (called bus bar with 100MΩ value), they all are in parallel and equivalent parallel IR, will be

$1/R = 1/Rp+1/R1+1/R2+- - - - - 1/R99.$

$1/R = 1/100+1/100+- - - - - - 1/100$ (100 times)

$1/R = 100 / 100$

$R = 1M\,\Omega$

This value of Insulation Resistance in parallel is called as **ON LINE SYSTEM INSULATION or LEAKAGE RESISTANCE.**

RANGE OF LEAKAGE DETECTION:

As per experience manufacturer suggests:

- In small station (3line) > 1 M Ω
- In medium station(5 / 6 line) > 500KΩ
- In big stations (RRI) > 100KΩ
- In Large stations > 20 K Ω
- Minimum safe limit (as per RDSO is 2KΩ)

How ELD Indicates Leakage

- ELD constantly monitors & measures Leakage Resistance of Bus Bar with respect to Earth in on-line condition.
- Leakage Resistance can be read on meter.
- When Leakage Resistance value drops below reference value, fault is detected; which is either announced as **audio** and/or visual **alarm**.
- Fault can be recorded by counter / Data logger.
- Reference value can be set anywhere between 1M to 2K (Factory setting on 2K).

Cable Insulation Tester in ELD

- ELD Detects low insulation or leakage resistance in Bus Bar.
- However, Cable Insulation Tester can be used to identify leaky pair/load in that busbar.
- Cable Insulation Tester is an off-line testing instrument with in-built special features as per RDSO SPN 256/2002.
- Cable Insulation Tester is used for detecting leaky pair/load.
- Cable Insulation Tester can measure directly on Cable Termination (CT) Rack.
- Insulation of cable pair + load is measured without disconnection when pair is in un-energized condition.
- Unit isolates itself in presence of any supply.

Advantages:

- User can continuously monitor the leakage resistance of cables and devices when everything is under operation.
- User can select any minimum value of particular power cables or supply point to get alarm.
- The individual monitoring channels are independent to each other so no influence of other monitoring lines.
- On-line dial display of the leakage resistances with good accuracy.
- Separate insulation resistance measuring terminals for ready use like megger.
- Individual visual display for each channel.
- Compatible to any voltage line monitoring (12V, 24V, 60V & 110V AC/DC).

- Modular architecture for easy maintenance and better serviceability.
- Assists in predictive maintenance.
- 'Busbar Presence' indication as ready information about the power availability.
- Remote fault indication and acknowledgement.

The faults which can be detected by the system:

- Any part of the cables of a power line if touched to earth.
- Any device if 'shorted' to earth internally, but line-to-line impedance is remained unaltered.
- Any power source is partially or totally 'shorted' to earth.
- Insulation resistance of any side (live or neutral, positive or negative) of a line power line if drops below acceptable level.
- Battery bank if gets partial conductive path to earth through thin layer of electrolyte surface deposit.

The faults which may occur in the detector:

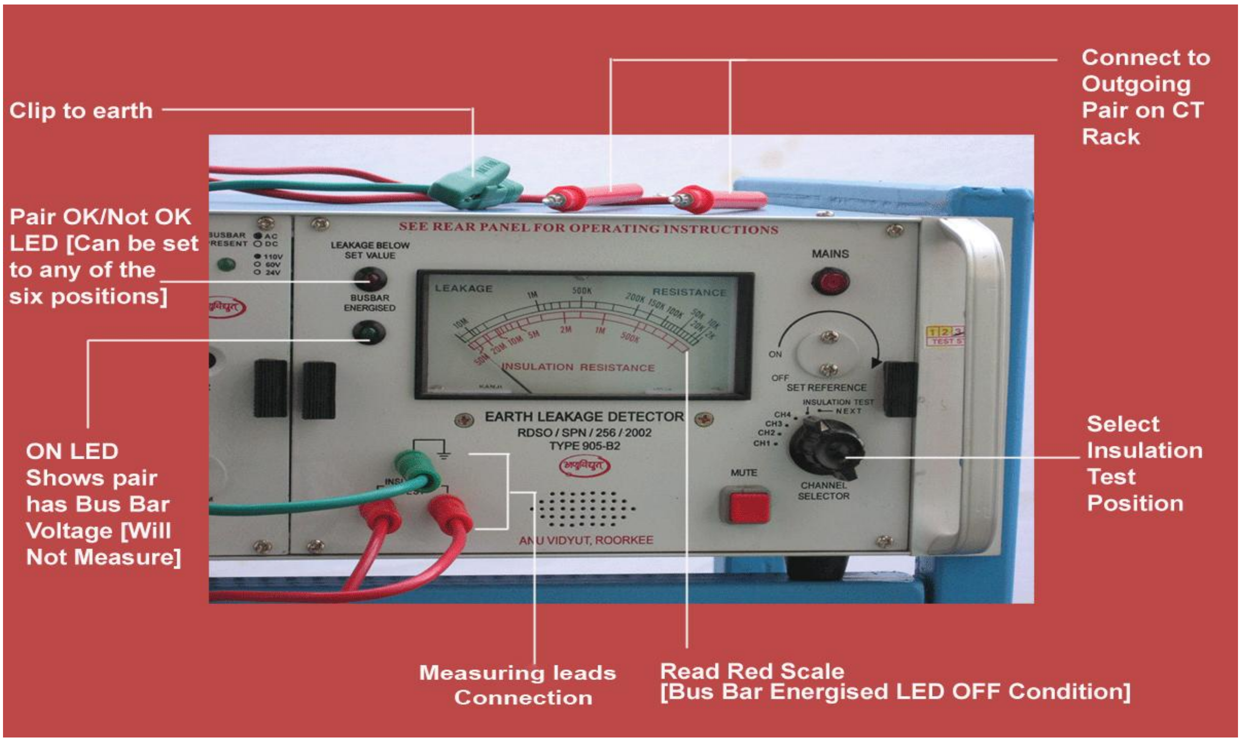
- As such the detector is rugged in design and hence the chance of failure of the detector is very less.
- There are varistors at the input along with the current limiting fuses. The failure of the varistors are probable is high voltage is fed to the inputs. In these cases, the fuse and defective varistors must be replaced.

Installation Procedure:

- Fix the Earth Leakage Detector (ELD) at an appropriate place.
- Connect the Mains power cable to AC input points, 110V or 230V AC as applicable.
- Connect reference earth to all E1 points.
- If it is a case of unshielded cable keep the 10Ω resistor between E1 & E2.
- If it is a case of shielded cable, remove the 10Ω resistor.
- Connect cable shields to E2 points.
- Connect 'Live' or 'Positive' wire to 'Bx/+' point.
- Connect 'Neutral" or Negative wire to 'Nx/-' point.
- Check the glow of 'Busbar Present' LED to ensure the connection of the power cables.
- Select the channel you want to set the alarm point by the channel selector switch.
- Open the 'Ref. Adj.' cover and turn the pot clockwise with the help of a screwdriver and set the value (upper scale) you want to fix for that particular channel.
- Check, in this condition, the yellow LED 'Set Ref' is glowing on that particular channel only.
- Now open the 'Set Reference Pot' cover and turn the pot in clockwise direction with the help of a screwdriver.
- Turn the pot until the alarm appears.

- Now turn the pot in anticlockwise direction small amount (say half turn).
- Press the 'Reset' switch.
- The alarm and the 'Fault' LED glow should go off.
- Again turn the pot slowly to the point when the alarm just appears.
- If require repeat the few previous steps for the best adjustment.
- In similar manner, adjust for all the remaining channels, where the set point may be different as per requirements.
- Turn the 'Ref. Adj.' pot anticlockwise to detain 'Off' position.
- Cover all the pot covers.
- Your system is ready for use.
- If you want to see the leakage resistance value, turn the channel selector to desired channel.

PROCEDURE TO MEASURE INSULATION RESISTANCE:



ELD with Built-in CIT Unit

- Keep the channel selector switch in 'INSULATION TEST' Position (5^{th} position of Channel Selector).
- Connect the measuring leads as shown in fig.
- Touch Red leads to Green lead, meter needle will move fully towards right side and Green LED (Busbar energised) glow momentarily and Red LED (Leakage below set value) start glowing. It shows that instrument is working OK.
- Now connect Green clip firmly on the earth and start touching Red prods to the out going cable pair on CT rack.

- If the pair is energised, Green LED will start glowing and meter will not show any reading. Connect to another pair, if Green LED does not glow and meter shows a reading (RED SCALE), this is the insulation of the pair + Load + Power supply with respect to earth.
- By repeating this procedure we can find earth resistance value of all pairs. In case any energised pair is to be measured, either take permission (follow safety rules) and remove both links and measure the insulation else conditions may by created by suitable operations to reenergize the pair and then test it. In this way we can measure insulation without any disconnection in the field and find low insulation pair very easily.
- After detecting low insulation pair / pairs, next step would be taken as per routine of railways working (Meggering of that pair).

Use of Earth Leakage Detector (ELD) for testing of Cable insulation:
(Ref: RDSO Letter No. STS/E/ELD/Vol.III Dated: 11-10-2011)

RDSO has done testing in RDSO lab as well as at one of the installations using ELD equipment of the two approved RDSO firms for ELDs. The various observations of the testing are as under.

(a) The insulation tester can be used to measure and detect core to earth fault on cable termination rack without Disconnection of either load or power supply.

(b) In case of non-energized signaling cable pair, the equipment will indicate the earth resistance value of combined signaling cable pair, load, as well as of power supply.

(c) In case, if the cable pair is engersied, the equipment has auto cut off facility and it will cut off itself and will not show any measurement.

(d) For measurement of energized signaling cables, conditions has to be made for these signaling cables to be in non-energized condition and then the same may be tested by this equipment. For example if a point is normal, the NWKR will be energized, hence, point can be made reverse and then NWKR pair can be tested.

Following precautions shall be taken very strictly while carrying out the testing by this equipment:

(a) Since the equipment connects voltage on to the signaling cable, it is necessary that short duration of block (10 to 15 minutes) is taken so as to ensure that no untoward situation arises.

(b) It is also necessary that this testing should be one under supervision of competent signaling supervisor only.

This testing will not be able to detect core to core fault or break fault of the cable core which can only be detected by regular cable testing. However, since large number of cable faults are due to earth fault on the cable core, the same can be detected using this equipment.

USE OF INSULATION TESTER (ON CT RACK ONLY)

In earth leakage Detector provision for insulation tester also exists. This insulation tester is provided with a facility to auto cut-off in case of testing pair energized. Using this facility earth leakage can be checked in signaling circuits. It is important to note that this can be without disconnecting the links of cable pair, however in such condition the low earth leakage is shown not only in signaling cable pair being tested but also load as well as in power supply. i.e if insulation noted is low ,then low insulation may be either in cable pair or in load or in power supply and that needs to be identified and located by open line staff.

When measuring earth leakage resistance using this equipment, cable pairs are to be tested as per methodology. However for the cable pairs which are powered ON, conditions needs to be made that they are not powered ON and then these cable pair should also be tested. For example if RG circuit is powered ON, then same should be de energized by lighting Yellow lamp through following standard process of signal lowering and when RG is not powered ON then only its earth leakage valve can be checked.

It is very important that earth leakage measuring is carried out using this equipment with supervisor of adequate knowledge, however in no circumstances it should not be carried out below SSE(Signal) level of supervisor.

During the time of testing though disconnection are not needed to be made at cable termination Rack, in compliance to GR and SR, suitable blocks of 5 to 30 minutes depending upon availability shall be taken and testing should be done only in blocks ensuring that no train operation is being carried out during the process of testing.

Block circuit and Axle counter circuits which use relays, whose pick valve is near 10ma, shall **not** be tested by this equipment by this equipment under any circumstances.

RDSO approved list of firms for manufacture and supply of electrical signalling items: as on 31st December 2013

ITEM: ELECTRONIC SIGNALLING EQUIPMENTS – ELD – MULTI CHANNEL

Spec No.: RDSO/SPN/256/2002

APPROVED UNDER PART: I	APPROVED UNDER PART: II
1. M/s Anu Vidyut,	Nil
2. M/s Urban Tekno-Systems Pvt. Limited	

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Annexure XIII
IPS

IMPROVEMENT DONE IN DESIGNS

- Provision of auto changeover arrangement of Inverters using Static switch with changeover time less than 60 ms instead of present relay/contactor based changeover arrangement with changeover time of approx. 200-250ms.
- Provision of keeping signal CVT in continuously ON condition so that in case of any failure of changeover arrangement, signal supply can be extended through CVT to prevent blanking of signals
- Removal of all MOVs at PCB level in modules
- Provision of class 'C' SPDs in common and differential mode for relay external, axle counter, point machine circuit and at Inverter output
- Alarm & indication provided in case 110V Battery gets disconnected from circuit

IMPROVEMENT IN EXISTING SYSTEM

- Application of RTV silicon sealant to all power devices so as to make it weather proof, dust proof and sealed
- Replacement of Electrolytic capacitors working more than 06 years being overage
- Modifications in circuits of SMR, Inverter & DC-DC Converter modules for preventing failures of power electronic components i.e. MOSFET & IGBT as per action plan vide this office letter dt. 02.12.11

DESIGN IMPROVEMENTS IN PROGRESS

- Provision of resettable fuses in control cards
- Provision of Isolation Transformer/Line conditioner Unit at the input to avoid failures due to input supply fluctuations.
- Manual Bypass of LVDS in IPS after successful field trail (with LMLA batteries only).
- Development of inverters with synchronized sine wave output to avoid problem of higher order harmonics
- Isolation of defective DC-DC converter unit in case of variable, noisy and low output voltage due to failure of components regulation, feedback and aging of components etc
- In case of malfunctioning of DSA and either of the SMRs, working of SMR should not be affected

ACTION TO BE TAKEN BY RAILWAYS

- Replacement of old 2000 version IPS on priority
- Work order to be given to firms for modification as per action plan in out of warranty /out of AMC IPS
- Provision of Maintenance free earthing as per RDSO/SPN/197/2008
- Provision of Dust free and well ventilated IPS rooms
- Provision of adequate capacity of DG Sets in Non-RE area.
- Feeder strengthening in Non-RE area.

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 latest Amendment.
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 latest Amendment.

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)

   A) 10mV B) 50mV C) 100mV D) 200mV

8. Chargers used for Axle counter installations, the peak to peak noise voltage shall be less than 50mV. (B)

   A) 10mV B) 50mV C) 100mV D) 200mV

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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