**ABBREVIATIONS**

CPP - Captive Power Plant

UPS - Uninterrupted Power Supply

MCC - Motor Control Centre

MLDB - Main Lighting Distribution Board

HRSG - Heat Recovery Steam Generator

ENC - Energy Centre

PTA - Pure Terephthalic Acid

PX - Paraxylene

PFY - Polyester Filament Yarn

PSF - Polyester Staple Fibre

FDY - Fully Drawn Yarn

LAB - Linear Alkyl benzene

UTL - Utilities

HT - High Tension

LT - Low Tension

HVSB - High Voltage Switch Board

SLD - Single Line Diagram

DCPS - Direct Current Power Supply

AC - Alternating Current

FIB - Fibre

DCS - Distributed Control System

1.1 General:

1.1.1 Sources of power:

MSEB - Contractual demand of 15 MVA

GTG - 2 x 30 MW

STG - 1 x 24 MW

DG - 2 x 4.1 MW & 2 x 2.5 MW

1.1.2 Distribution:

MSEB power is received at 100 KV level.

RIL - PG Complex is divided in three load centres, viz. PTA Complex, Fibre Complex and LAB Complex. Power is distributed at 22 KV level to each of these complexes. Other voltage levels used are 11 KV, 6.6 KV and 433 Volts.

11 KV level is used for distribution in PTA complex fed to various step-down transformers and one HT Motor.

6.6 KV level is used for 6.6 KV HT Motor supply and 6.6 kV distribution.

433 V level is used for LT Motors.

From 433 V side of transformer, power is fed to Power Control Centres (PCC) / Power and Motor Control Centres (PMCC). From PCC, there are outgoing feeders to Motor Control Centres (MCC). Individual motor receives power from MCC through motor feeder.

For critical loads, Uninterrupted Power Supply (UPS) systems are used for critical loads like DCS, motor control, boiler auxiliaries and instrument controls.

For breaker controls and some motors, DC supply is used, which is available from DC power supplies.

1.2 Power distribution network :

1.2.1 100 kV main Receiving Substation :

RIL, PG complex receives MSEB power through 2 Nos. 100 kV overhead lines, coming from Apta and Patalganga substations at our 100 kV main receiving station.( See SLD-1)

Depending upon the load requirement of the consumer, MSEB decides the supply voltage.

Advantages of going for High Voltage Level are :

1) Less possibility of line faults

2) High reliability.

This 100 kV voltage is stepped down through 3 nos. 100 / 22 kV, 32/40 MVA transformers. Theses transformers are connected to the 22 kV switchboard at 100 kV substation. From this switch board, 2 feeders each are taken to 22 kV switch boards at LAB complex and Fibre Complex.

Also, there is one tie feeder between the 22 kV switch board at 100 kV sub station and 22 kV switch board at Energy Centre (captive power plant) in PTA complex.

1.2.2 Captive Power Plant (CPP):

The captive power plant is situated at Energy Centre in PTA complex. It consists of 2 nos. 30 MW Gas Turbine Generator sets (GTG) with Heat Recovery Steam Generators (HRSG) and a 24 MW Steam Turbine Generator set (STG). There are 3 nos. 70 tonnes / hr each boilers which along with 2 nos. Horses, supply steam for power generation and process plants.( See SLD-1).

GTG 1 and GTG 2 are connected to 22 kV switch board section A and C respectively at Energy Centre through 11/22 kV, 53 MVA step-up generator - transformers.

There are 3 nos., 22/11 kV, 15 MVA transformers TAO, TAO & TAO which connect the 22 kV switch board to the 11 kV switch board where STG is connected. (Section - B)

Also, there are 3 nos., tie feeders between 22 kV switch board at Energy Centre and 22 kV switch board at Utility substation. Thus power is fed from CPP to Fibre complex. There is an interconnection between 11 kV bus at Energy Centre and 6.6 kV bus at Utility sub station through 15 MVA Zig-Zag transformer which connects STG & DG to fulfil normal power requirement at HVSB # 2 bus.

1.2.3 PTA Complex :

PTA complex consists of PTA plant, PX plant and Energy Centre. These plants get power from Energy Centre 11 kV Bus. ( See SLD- 2)

Voltage is stepped down by 11 / 6.9 kV, 6.6kV / 433 V & 11kV / 433 V transformers for use in HT & LT drives and other loads.

1.2.3.1 Energy Centre:

All loads of Energy Centre are connected to 11 kV bus.

6.6 kV switch board - B at Energy Centre receives power from 2 nos., 10 MVA, 11 kV / 6.9 kV transformers TB1 & TB2. On this switch board various HT drives of Energy Centre (13 nos.) & PTA plant are connected (4 nos.).

On this 6.6 kV switch board - B, feeder from DG bus at Utility is connected as a source of emergency power. In case of total power failure, critical drives and lighting get this power. Transformers TD1 ( 2 MVA, 6.6 kV / 433 V) supplies this emergency power to various critical loads of Energy Centre through PCC - D.

For LT distribution at Energy Centre - Boiler House, there are 2 nos., 11 kV / 433 V, 2 MVA transformers, TD2 & TD3. LT side of these transformers connected to PCC-D which further feeds MCC 11, 12, 13 and 14 feeding to various loads of boilers and STG auxiliaries. Also transformers TD4 and UAT supply auxiliaries of GTG 1 and GTG 2 respectively.

For LT distribution at Energy Centre - Offsites, transformers TJ1, TJ2 and TJ3 (11 kV / 433 V, 2 MVA) feed PCC-J. From this PCC, MCC UT 1 through UT 7 are fed. These give power to Demineral Water Plant, Compressor house, Effluent treatment plant, Water treatment plant, Cooling water plant, Chilled water plant etc.

For DC distribution, there are 125V, 110V and 50V chargers with battery back up. 125 / 110 DC is used for electrical breaker control and DC motors. 50 V DC is used for instrument controls.

For DCS and other critical control supplies, there are 3 nos. UPS systems. (For GTG2 and Boiler / STG UPS - output voltage is 110 AC. For GTG1 output voltage is 3, 415V AC stepped down to 110VAC for distribution.)

1.2.3.2 PX Plant:

There is a 6.6 kV, 350 MVA switch board - C at PX plant, which gets power from 11 kV Energy Centre switch board through 2 nos., 11 / 6.9 kV, 10 MVA transformers TC1 & TC2. Various HT drives (13 nos.) are connected on this switch board.

For LT distribution, there are 6 nos; 2 MVA, 11 KV / 433 V transformers namely TG1, TG2, TG3, TH1, TH2 & TH3 connected to PCC G and PCC H. Transformer TH4, (6.6 KV/ 433 V, 2 MVA) fed from 6.6 KV switchboard -B at ENC supplies emergency power for PX plant.

There is 110V DC charger with battery backup for DC distribution. For critical loads such as DCS, 110V ac UPS system is provided.

1.2.3.3 PTA Plant:

HT motors (4 nos., 6.6 KV & one 11kV) in PTA Plant receive power from Energy Centre.

LT loads at PTA receive power through 7 nos., 2 MVA, 11 KV / 433V transformers TE2, TE3, TE4, TF1, TF2, TF3 and TK1 connected to PCC-E, PCC-F and PMCC-K.

Transformer TE1 (2 MVA, 6.6 kV / 433 V) fed from 6.6 KV switchboard - B at ENC fulfils emergency power requirement at PTA.

There are 110V and 50 V DC chargers with battery backup. Also 110V AC UPS system for critical power supply is provided.

1.2.4 LAB Complex :

LAB complex consists of Front End, Back End, A3, B1, B2 & B3 tank farms and MVWSS.

LAB Complex receives power at 22 kV level through 2 Nos. 22 kV feeders from 100 kV substation. ( See SLD - 3) This is stepped down through 2 nos., 22 / 6.9 kV, 15 MVA, zigzag transformers TRP 1 & 2 and connected to 6.6 kV, 350 MVA switch board LAB - back end which is divided in three sections. From this switchboard there are 9 nos., 6.6 kV motor feeders. Also there are feeders to 8 nos., 6.6 kV / 433 V, 2 MVA transformers, TRP 3 thro' TRP 10 which feed LT loads in LAB Complex.

From this switchboard there is one feeder to MVWSS switchboard (located in Guest house area). This MVWSS switchboard receives power from Energy Centre 6.6 kV switchboard-B section-1.

From 6.6 kV switchboard LAB back end, there are 2 feeders to 6.6kV switchboard LAB-front end. There are 18 nos., 6.6 kV motor feeders from this switchboard.

A-3 tank farm, which comes under LAB plant, receives power from PSF plant (PCC # 11-13).

1.2.5 Fibre Complex :

Fibre Complex consists of Utilities, PFY - I, FDY, PSF & PFY - II plants.(See SLD - 4 )

1.2.5.1 Utilities Plant:

Fibre complex receives power from 22 kV switch board at 100 kV s /s through 2 nos. 22 kV feeders connected to 22 kV switch board namely HVSB # 1 at the utilities substation. This switch board is also connected to Energy Centre 22 kV switch board by 3 nos. tie feeders through which the CPP power is available to Fibre complex. from the 22 kV switch board HVSB # 1 there are feeders to 4 nos., 22 / 6.6 kV, 10 MVA transformers TR 21 thro' TR 24 which feed power to 6.6 kV switch boards namely HVSB # 3 and HVSB # 4. HVSB # 5 receives power from both HVSB # 3 and HVSB # 4.

From HVSB # 3, 4, 5 various HT motors (29 nos.) at Utilities are fed. Also there are 10 nos., 6.6 kV / 433 V, 2 MVA transformer feeders which feed LT loads in PFY, PSF and FDY plants.

There are 4 nos DG sets (2 x 2.5 MW - DG 1 & 2, 2 x 4.1 MW - DG 3 & 5 ) connected to 6.6 kV switch board HVSB # 2. From 6.6 kV switch board HVSB # 2, there are 6 nos., 6.6 kV / 433 v, 2 MVA transformer feeders for PSF and PFY-1 plants.

There are feeders to PTA complex (6.6 kV switch board- B at Energy Centre) and LAB complex (6.6 kV switch board at LAB) so that DG power is available to the critical drives in case of total power failure.

Also, there is one small, 430 V, 315 kVA, lighting DG in utilities substation which supplies critical lighting load in Fibre Complex in case of complete power failure in Patalganga complex.

From 22 kV switch board, HVSB # 1 there are feeders to 12 nos., 22 kV / 433 v, 2 MVA transformers which supply power to LT loads in PSF, PFY - I, PFY - II, FDY, and Utilities plants.

1.2.5.2 PFY I Plant:

This plant receives power from 6.6 KV switchboard HVSB # 2 (TR 11, 13, 14, 16), HVSB # 3 (TR 12) and HVSB # 4 [(TR 15 and TR 16 (Spare)] (see SLD - 4).

Transformers TR 11, 12 and 13 supply power to PCC # 11-13. Transformers TR 14, 15 & 16 supply power to PCC # 14 - 16.

PCC # 11 - 13 supplies power to both MPP 1 (CP 1) and MPP 2 (CP 2 and CP 3). PCC # 14 - 16 supplies power only to MPP 2.

From PCCs, power is fed to DC drives, DCPS and UPS.

1.2.5.3 FDY Plant:

FDY Plant gets power from HVSB#5 through 3 nos., 2 MVA, 6.6 KV / 433 V transformers TR 28, 29 and 30. They supply power to PCC # 28-30.

From this PCC, there are feeders to MCC 1A, 1B, 2, 3, common MCC A, common MCC B, and Emergency DB. These MCCs supply power to various UPS, DCPS, Inverters and heaters.

1.2.5.4 PSF Plant:

PSF Plant gets power from HVSB#1 through transformers TR 1, 2 and 3 which are connected to PCC# 1 - 3. This PCC supplies power to Draw machines 1 - 4, balers 1 - 4, MCC 103 & 104 and non critical loads of CP4, CP5 & spinning. Also, one feeder goes to A3 tank farm.

Critical loads of CP4, CP5, UPS., MCC 21 - 24 are fed from PCC # 17 - 19 which receives power from TR17, 18 & 19 (TR 17 & 19 supplied from HVSB#2 and TR18 from HVSB#3.)

Transformers DL1 (fed from HVSB # 3) and DL 2 (fed from HVSB # 4) supply power to PCC-DL1 and PCC-DL2 respectively. These PCCs supply power to DC drives of DM 1-4.

Transformers DL3 and DL4 are fed from HVSB # 5 and are connected to PCC # DL3 - 4. This PCC feeds power to Draw machines - 5 and Baler - 5.

1.2.5.5 PFY II Plant:

PFY II receives power from HVSB # 1 through transformers TR 25, 26 and 27. These are connected to PCC # 25 - 27. All spinning machines and MCC 101, 102 are supplied from PCC # 25 - 27.

**NORMAL AND EMERGENCY LOADS**

2.1 Normal Loads:

It is the power requirement of the plant when it is running with full production. It includes drives, lighting and heater loads.

2.2 Load Restriction:

MSEB imposes load restriction when generation is not available to supply the entire load of the grid. In case of isolated operation load restriction is imposed when captive generation level cannot cope up with the load demand.

Whenever there is a shortfall of power, the plants are asked to restrict the load. Some nonessential loads such as comfort air conditioners, extra lighting (without affecting production and fulfilling safety requirements) are switched off.

If there is additional requirement to reduce load, some process loads are also switched off which do not affect main production. In some cases throughput may be decreased to give power relief.

2.3 Emergency Load:

When there is a total power failure, (i.e. the captive generators as well as grid supply is not available) all processes / utilities will come to halt and there will be total darkness.

Personnel safety- Central Control Rooms, passages, staircases, emergency exits, parts of switch rooms, etc. should get power immediately for lighting for personnel safety requirements.

Safety of Machinery -Failure of some drives like lubricating oil pump, may damage equipment. Some processes involve slurry. When agitators, heaters go off due to loss of power, the slurry may get solidified and the pipe line involved may have to cut to normalise the process. To avoid this, power is made available to these drives. Thus, the plant will be in a safe-hold condition.

Production loss - Also, there are some drives due to failure of which the normalisation of plant after resumption of power gets delayed.

The power required for these lighting and drive loads is called emergency power.

The emergency lighting is fed from emergency lighting distribution boards. Only these DBs get emergency power supply.

For the individual plants, lists of such drives and heaters are made. These loads only shall receive emergency power. Some of them shall start automatically and rest shall have to be started manually.

The emergency power shall be made available from DGs. One DG will start automatically after total power failure. The emergency power shall be released automatically / manually as per priorities already decided. Emergency power to entire complex shall be made available after starting other DGs, in stages.

During emergency power operation, the plant personnel should act in very disciplinary manner. Drives should be made on only when clearance is given. Any extra load on DGs may affect their stability and may result in loss of emergency power to entire complex. This may result in further delay in start up, monetary losses and personnel / equipment safety may be endangered.

|  |  |  |  |
| --- | --- | --- | --- |
| **Normal And Emergency Loads** | | | |
|  |  |  |  |
|  |  |  |  |
|  |  |  |  |
|  | **Normal** | |  |
|  |  | **Final after** |  |
| **Plant** | **Existing** | **Debottlenecking** | **Emergency** |
|  | (on Aug 97) | (By Dec 97) |  |
|  |  |  |  |
| PTA | 8.5 | 8.8 | 2.26 |
|  |  |  |  |
| PX | 5.0 | 6.5 | 0.35 |
|  |  |  |  |
| EC | 6.5 | 7.5 | 0.89 |
|  |  |  |  |
| LAB | 7.0 | 7.4 | 1.00 |
|  |  |  |  |
| UTL | 16.5 | 18.3 | 0.89 |
|  |  |  |  |
| PFY-I | 6.0 | 6.0 | 0.21 |
|  |  |  |  |
| PFY-II | 1.5 | 1.5 | 0.11 |
|  |  |  |  |
| PSF | 3.6 | 4.5 | 0.16 |
|  |  |  |  |
| FDY | 1.3 | 2.0 | 0.39 |
|  |  |  |  |
| **TOTAL** | **55.9** | **63.1** | **6.25** |
|  |  |  |  |

**CPP Operations**

3.1 Introduction:

Electricity is the heart of any industry. It is required for drives, for heating apparatus, for illumination, etc.

Further, in a process industry with continuous operation, uninterrupted electric power is of great importance. An interruption of electricity for fraction of a second may cause huge amount of losses.

a) Whole plant may be shutdown and has to be restarted. This amounts to production loss.

b) Loss due to generation of waste - as the process gets interrupted, off spec production will result.

Thus, there is a need for reliable electric power source.

3.1.1 Source of power:

Normally, industries receive power from the State Electricity Boards.

The advantage of taking power from State Electricity Board is that there is very little impact of loading on load throw off of any particular industrial load on the grid due to its huge network of large number of generators.

Generally the industries receive power at 22 KV level and above.

3.1.2 Why Captive Power Generation?

Though the State Electricity Board supply is available, many industries go for their in-house power generation, called generally as "Captive Power Plant (CPP)". The reasons to go for captive power plants are:

3.1.2.1 Improvement in reliability of overall power system:

The captive power generation may be operated in parallel with the State Electricity Board supply. Whenever State Electricity Board supply fails, the captive power is still available for running the plants and lighting loads. Depending upon the size of the CPP, whole plant is run on the captive power, otherwise, part of the plant or only critical loads are run on captive power. When State Electricity Board supply resumes, remaining equipments are started and the production is normalised.

With captive power, there is increase in safety, the critical drives continue to run thus reducing the plant start up time and hence reducing the production loss.

3.1.2.2 Economies of operation:

Day by day, as the government industrial policies are becoming more and more liberalised and deregulated, it is becoming comparatively easy for the industries to set up their own power generating units. With the new technologies evolving, it is also becoming economically viable.

The combined cycle power plant gives better efficiency as well as the steam generated in the waste heat recovery steam generator can be used in the process.

3.1.2.3 Use of available fuels ( by products):

In chemical processes, various intermediate products are generated. Also, the unused part of raw materials (like Naphtha used in Paraxylene manufacturing process, only certain component of the raw Naphtha is used in the process. Remaining is not useful for the process and has to be given back to the supplier) can be used as fuel in boilers and gas turbines, which comes out to be economical.

3.1.2.4 Use of excess steam:

Chemical processes require steam for heating. The excess steam generated can be used in steam turbine generator to produce power.

From the above illustration, we can say that captive power generation is becoming more and more popular in industries.

3.2 Parallel Operation / Isolated Operation:

3.2.1 Introduction:

For the industries having their captive power plants (CPP), there are two alternatives of operation:

a) Run the captive power plant in parallel with the State Electricity Board supply (hereafter called as grid supply),

b) Run the captive power plant in isolation.

3.2.2 Advantages and disadvantages:

Isolated Operation

1. Voltage and frequency can be easily controlled and kept at required constant level.

2. No voltage fluctuation.

3. No fluctuation in frequency. With a steady frequency, drives run at constant speed hence process parameters remain stable.

Parallel Operation

1. Voltage and frequency are governed by the grid. CPP has no control over these parameters as its capacity is negligible as compared to size of the grid.

2. Voltage fluctuation due to voltage dips caused by faults in the grid, sudden loss of major power station. During voltage dips, some drives may trip on undervoltage. Certain contactor may drop out due to undervoltage.

3. Frequency fluctuates depending upon the load and power generation balance. Sudden drop / rise in frequency is due to tripping of major power station / tripping of major load respectively. Motors already running near full load may trip upon sudden / slow increase in frequency.

Isolated Operation

4. Power factor controlled by load itself.

5. With new combined cycle power plant technologies with better efficiency, cost of power generation per unit is less.

6. When one of the generating units fails / trips, the remaining units may not take up the load hence load shedding may have to be initiated and causes production loss.

7. No effect of grid faults in CPP.

8. CPP may become unstable during starting of heavy loads like very large motor of the range of few MW rating.

Parallel Operation

4. As voltage changes, the power factor changes as the reactive power generation varies. Hence, the power factor control requires additional efforts.

5. While operating in parallel, certain energy from grid is consumed. Due to two part tariff with maximum demand charges, the average unit cost is higher. Anyway, the unit cost of grid supply is higher than CPP unit cost at present.

6. Even if one generating unit or total CPP fails, strong grid can take up the load easily without affecting the loads.

7. For any grid fault / loss of grid, CPP may feed the fault and hence CPP may become unstable. In this condition islanding has to be resorted.

8. Grid is capable of taking any heavy load start.

**NORMAL AND EMERGENCY OPERATION**

4.1 Normal Operation:

When all the generators in the Captive Power Plant are available (i.e. 2 GTGs and 1 STG), they are be so run as to have zero or negligible (< 0.5 MW) draw from MSEB grid. The generation levels of individual generators are kept at such levels that optimum balance of steam / power is met.

The target is to have maximum generation on GTGs (with HRSG in line for respective GTG) and balance load on STG. Apart from HRSGs, 2 Nos. Borsig boilers generate steam required for STG and process plants. The loading of boilers should be maintained such as to arrive at minimum cost of generation of steam and power.

PTA complex receives power from GTGs (through transformers TA # 1,2,3) and STG; distribution being done from 11 kV switchboard at EC.

LAB complex receives power from 22 kV switchboard at 100 kV s/s which is connected to 22 kV EC bus.

Fibre complex receives power from 22 kV switch board at utilities which is connected to 22 kV switchboard at EC and from Zig-Zag transformer which is fed from 11 kV bus at EC.

The diesel generators are kept 'off ' and shall be a source of emergency power in case of total power failure.

4.2 Emergency Operation:

In case of total power failure, DGs will have to be started for the emergency power requirement.

For this purpose, DGs are always be kept in 'ready to start ' condition.

After complete power failure, all drives shall stop and will be started automatically after resumption of emergency power as per priority.

**Active & Reactive Power Control**

5.1 Introduction:

In a Power System, there are various types of load such as :

a) Motors

b) Heating and lighting loads

c) Electronic devices

The active power is the one which contributes for doing the work either in the mechanical form to drive loads or in the form of light and heat. It is measured in KW.

Reactive power is required for the magnetisation of electrical equipments in the network. It is measured in kVAr. It does not contribute the work.

5.2 Active Power Control:

Active power is a direct function of the fuel input to the drive of the generator, which may be a turbine or engine. For increasing / decreasing the active power output of a generator, the fuel input to the prime mover has to be increased / decreased.

The control of fuel input is either manual or automatic.

There are different conditions of operation of generators,

1) Only one generator running in isolation,

2) Two or more generators running parallel (in isolation with the grid),

3) One or more generators running in parallel with grid.

5.2.1 Single generator operation:

The load on the generator governs the active power output of the generator. Whenever the load changes, the frequency changes for the same input to the prime mover. This is because output is more at reduced rpm and vice versa. To maintain operating frequency, the input fuel is varied. This may be done manually. But this will require continuous watch on frequency. Hence, automatic frequency control is provided which monitors the frequency continuously and whenever its value goes beyond prefixed band, a signal is given to governor to change the fuel input to the drive. This mode of operation is called as "Isochronous" Mode.

5.2.2 Two or more generators running parallel (in isolation with the grid):

5.2.2.1 Master - Follower Scheme:

When there are more than one generator running parallel in a network, but in isolation with the grid, the Master - Follower scheme is used. One generator acts as Master and others "Follow" it. Whenever the load changes, the frequency changes accordingly. This change is sensed by the Master generator first and the additional load is distributed to follower units in proportion to their capacities.

*Advantages of Master-Follower scheme:*

1. Single point control of active power.

2. Increase in load is distributed in proportion to the capacity of individual generators.

*Disadvantages of Master-Follower scheme:*

1. In case of fuel starvation to Master generator, its generation decreases and bus frequency also decreases. Cascade effect of the above is that entire bus may collapse. Hence, the master follower scheme won't be active below a specified generation level of master generator. The operator shall, in such case, change the selection to other generator as "Master".

5.2.2.2 Droop mode:

There is another method of operation in which the changes in load will be shared by the generators running in parallel as per their governor characteristics. If their capacities and characteristics are exactly matching, the additional load will be equally shared.

5.2.3 One or more generators running parallel with a grid:

When one or more generators are running parallel with grid, they follow grid voltage and frequency. This is due to very high inertia of the grid as large number of generators are connected in the grid. Hence it is called as ' Infinite Bus ', having little or no effect on its voltage and frequency with changes in excitation and mechanical input to the generators in Captive Power Plant.

Hence, a change in excitation of generator connected to grid shall result in change in its reactive power. A change in mechanical input ( fuel) shall result in change in its power output ( MW ).

5.2.4 Active Power Control in Gas Turbine Generator:

Various modes of operation in GTG are described below:

a) Preselect mode:

Selection of this mode is normally resorted to when we are operating in parallel with the grid. The machine load will be at a preselect value irrespective of any changes in the grid frequency. The magnitude of power which can be selected is within the machine capability. Any external load control signal ( command to increase or decrease the speed ) will bring out the machine from the preselect mode of operation and takes it into "droop mode". In this mode of operation, machine follows grid frequency. If it is steady, there is no change in active power output. But if frequency decreases or increases, the generator tries to follow it and accordingly active power output increases or decreases. Hence it is advisable to select the machine to preselect mode.

b) Base load mode:

This is the most economical mode of operation when HRSG is also in operation. This is basically a temperature control. The machine will be loaded to its maximum capability within its permissible temperature of exhaust gases. The output of the machine goes on varying as per the changes in the ambient temperature.

c) Peak load mode:

This is also a temperature control mode of operation similar to base load but the exhaust gas temperature set value will be at a higher value. This is not a regularly recommended mode of operation as it will be overstressing the machine.

d) Droop mode:

This is the mode of operation when machine is running in parallel with the grid. The increase and decrease in grid frequency will decrease or increase the generation of the machine. Similarly, in isolation, if the load increases, the frequency falls and vice-versa. Here also, the load which the machine can take is limited to base load capacity.

e) Isochronous mode:

Selection of this mode is normally resorted to when the machine is operating in isolation with the grid. This is basically a constant speed control which keeps the machine operating frequency at preset value. Again, this is applicable as long as the machine is operating within the base load capacity.

Normal mode of operation when operating in parallel is preselect mode at a specified generation.

When islanded from the grid due to any grid abnormalities, islanding signal is given which will bring the generator out of the preselect mode to droop mode. After the machine is in droop control mode, it may manually be taken to isochronous mode.

5.3 Reactive Power Control:

Major part of the industrial loads is the motor load ( nearly 95%). In industry, squirrel cage induction motors are largely used. This inductive load requires a large amount of reactive power depending on the rated power factor of the individual motor.

Reactive power pulsates sinusoidally about average value zero.

As the average value over a cycle is zero, this power does not contribute to drive the load.

**Inductive load is treated as sink of reactive power and capacitive load is treated as source of reactive power.**

Large reactive power means larger complex power hence the higher rating of machines. Also large reactive power means higher line current hence higher I2R losses. Also the generator terminal voltage sags if the reactive power requirement is higher and non compensated by appropriate increased in generator excitation. Hence, State Electricity Boards impose penalty on lower power factors. This is because for the same amount of active or useful power required by the industry; the rating of transformers, transmission line and generators needs to be on the higher side. Also, the loss in transmission and distribution is more as the line current is higher with lower power factor.

Controlling the reactive power means nullifying or minimising the effect of inductive reactive power by addition of leading reactive power at various stages of a power system network so that power factor at any given bus is controlled near unity.

Sources of leading reactive power are:

1) Power factor improvement capacitors,

2) Synchronous motors running on over excitation mode,

3) Generator running on over excitation mode,

4) Synchronous condensers.

Reactive power control is done in two stages. Primarily, the capacitor banks are installed at various load centres to compensate the lagging reactive power requirement at that load centre. This improves the power factor at that load centre and reduces the line losses.

The balance reactive power requirement is met with either from grid or generated by captive generators. To maintain grid power factor above 0.9, the reactive power of captive generators is controlled. This is second stage of reactive power control.

When all the power is drawn from the grid, the active and reactive power requirement decide the power factor at which the power system operates. Power drawal from MSEB at a power factor less than 0.9 imposes penalty. Thus, in order to fulfil this requirement, power factor improvement of the system is necessary. As in an industry, most of loads are having lagging power factor, capacitor banks are provided which compensate for the lagging reactive power by supplying leading reactive power.

When the captive power plant is running in isolation, the reactive power requirement of the load has to be fulfilled by generators themselves. Production of active and reactive power of a generator is guided by its capability curve. Exceeding the limits of the capability curve will lead to temperature rise of the machine beyond acceptable limits. Hence, the additioinal reactive power requirement is catered by installation of capacitor banks.

When captive generators are running in parallel with grid, reactive power is controlled by increasing or decreasing the excitation current of the machines. This is done with the help of Automatic Voltage Regulator (AVR). Increase in generator VAR output leads to poor power factor of the machine and vice-versa. The total VAR requirement of the system is met by the generators, installed capacitors and the balance requirement is met by the grid.

**Introduction**

Cables are basically an insulated conductors which carry / transmit electric power, data, signals etc., from one end to another. In old days the above job was done through over head lines with bare uninsulated conductors which poised problems to electrical safety. As the technology developed various types of cables have come into use and they are like Cotton / cloth covered, Rubber Insulated, Paper Insulated, PVC Insulated, PVC sheathed, and presently XLPE cables. Also depending upon the service various types of cables are developed like Mining, Crane duty, Heat resistant, Shielded Telecommunication, Computer Application, Co-axial, Welding, etc., for specific application.

Cables are also made of steel armouring to protect against mechanical damage. Cables are also classified based on voltages it is being operated. Various standards are drawn up for manufacturing cables depending on their duty, voltage, environment (Hazardous, Heat zone, Mining) and also standards for their installation in under ground installation (either directly in trenches or buried with sand and brick bedding) or in Air.

Once the layout of electrical equipment is prepared cable selection is done based on their duty, application, voltage etc., and necessary precautions are taken to see that minimum voltage drop is maintained and losses are kept to minimum after considering the due derating factors for type of laying (air / ground), grouping, load factor etc. One should always keep abreast of the new development in cables so as to select right cable manufacturing technology as in long run it will help in saving in losses and also enhances the life span.

Transporting power through overhead lines which is totally exposed to corrosive dust pollution's atmosphere and rough weathers like lighting poses frequent breakdown due to problems faced like bird faults, failures of disc insulator etc. Though we can overcome the above problems in cables but still cable end termination's and straight and tee joints form weak points for breakdown. Therefore, right selection of cable end termination, straight or tee joints are to be selected and with perfection these termination's are to be carried out to avoid any failures. Such problems are more predominant as we go to higher voltages.

Unlike in overhead conductors where routine inspection is done to check up for failure of hardware, sealing etc., in cables it is not necessary. Once cables are laid and properly installed we can forget about the installation. But it is advisable to check once in a while the heating of cable, end termination, megger values etc.

Though initial cost is very much on higher side for cables when compared to overhead transmission keeping in view of electricity safety, area lost under the transmission lines, thefts of power (In case of State Electricity Board) and aesthetic point of view, cables shall still be economical on a broader perspective.

The enclosed module gives a brief account of various aspects in selection, laying, testing and maintenance of cables.

**3.6.6 XLPE Cables (Cross Linked Polyethylene)**

**3.6.6.1 Properties and Advantages :**

The excellent thermal properties of XLPE cables permit maximum continuous conductor operating temperature of 900 C and short circuit temperature of 2500 C. Moreover, it has very low dielectric loss which does not vary much over the entire operating temperature range.

These characteristics, along with the low dielectric constant make XLPE cables particularly suitable for high voltage applications. Given below are additional outstanding features.

High Continuous Current Rating :

Its ability to withstand higher operating temperature of 900 C enables much higher current ratings than those of PVC or PILC cables.

High Short Circuit Rating :

Maximum allowable conductor temperature during short circuit of 2500 C is considerably higher than for PVC or PILC cables resulting in greater short circuit withstand capacity.

High Emergency Load Capacity :

XLPE cables can be operated even at 1300 C during emergency, therefore in systems where cables are installed in parallel, failure of one of two cables will not bring down the system capacity because the remaining cables can carry the additional load even for longer duration until repairs / replacements are carried out.

Low Dielectric Losses :

XLPE cables have low dielectric loss angle. The dielectric losses are quadratically dependent on the voltage. Moreover, these losses occur continuously in every charged cable whether it carries load or not. Hence use of XLPE cable at higher voltages would result in considerable saving in costs.

Charging Currents :

The charging currents are considerably lower permitting close setting of protection relays.

Easy Laying and Installation :

Low weight and small bending radii make laying and installation of cable very easy. The cable requires less supports due to low weight.

High Safety :

High safety against mechanical damage and vibrations.

**3.6.6.2 Applications :**

Because of the excellent mechanical and electrical properties XLPE cables are being used extensively in all power stations and in industrial plants. They are ideally suited for chemical and fertiliser industries where cables are exposed to chemical corrosion or in heavy industries where cables are exposed to chemical corrosion or in heavy industries where severe load fluctuations occur and for systems where there are frequent over voltages. Cables can also be used at higher ambient temperature on account of their higher operating temperature. There excellent installation properties permit the cable to be used even under most difficult cable routing conditions and also in cramped conditions e.g. City distribution network. Single core cables due to their excellent installation properties are used in power stations, sub stations and industrial plants with advantage.

**3.6.6.3 Construction :**

XLPE cables are manufactured and tested in accordance with IS : 7098 (Part II) - 1985. Its salient constructional features are as under :

Conductor :

The conductors made from electrical purity aluminium wires, are stranded together and compacted. All sizes of conductors of single or three core cables are circular in shape. Conductor construction and testing comply to IS 8130 - 1984.

Cables with copper conductor can also be offered.

Insulation :

High quality XLPE unfilled insulating compound of natural colour is used for insulation. Insulation is applied by extrusion process and is chemically cross linked by continuous vulcanisation process.

Shielding :

All XLPE cables rated above 3.3 kV are provided with both conductor shielding and insulation shielding. Both conductor and insulation shielding consists of extruded semi conducting compound.

Additionally, insulation is provided with semi-conducting tape and non-magnetic metallic tape screen over the extruded insulation.

Conductor shielding XLPE insulation and insulation shielding are all extruded in one operation by a special process. This process ensures perfect bonding of inner and outer shielding with insulation.

Inner Sheath

(Common Covering) :

In case of multi-core cables, cores are stranded together with suitable non-hygroscopic fillers in the interstices and provided with common covering of plastic tape wrapping. As an alternative to wrapped inner sheath, extruded PVC inner sheath can also be provided.

Armouring :

Armouring is applied over the inner sheath and normally comprises of flat steel wires (strips) for multi core cables. Alternatively, round steel wire armouring can also be offered. Single core armoured cables are provided with non-magnetic armour consisting of hard drawn flat or round aluminium wires.

Outer Sheath :

A tough outer sheath of heat resisting Tropodur (PVC) compound (Type ST2 as per IS 5831) is extruded over the armouring in case of armoured cables or over non-magnetic metallic tape covering the insulation or over the non-magnetic metallic part of insulation screening in case of unarmoured single core cables. This is always black in colour for best resistance to outdoor exposure. The outer sheath is embossed with the voltage grade and the year of manufacture. The embossing repeats every 300/350 mm along the length of the cable.

XLPE cables are manufactured under advanced manufacturing and testing facilities. The cables are type tested and routine tested in accordance with IS 7098 (Part II) - 1985.

The following tests are carried out as on every length of cable manufactured :

a) Conductor resistance test.

b) Partial discharge test.

c) High voltage test.

d) Insulation resistance.

e) Bending test.

f) Heating cycle test.

g) Dielectric power factor test.

h) Impulse withstand test.

**3.6.6.4 Test Voltages** **:**

The following test voltage is applied between conductor and screen / armour (IS 1255 - 1983) :

\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

**Voltage rating of Cables Test voltage**

3.8 / 6.6 kV (E) 12 kV (rms) for 5 minutes

6.35 / 11 kV (E) 17 kV (rms) for 5 minutes

11 / 11 kV (UE) 28 kV (rms) for 5 minutes

12.7 / 22 kV (E) 32 kV (rms) for 5 minutes

19 / 33 kV (E) 48 kV (rms) for 5 minutes

\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

**A) Conductor Resistance Measurement :**

This is generally taken on whole cable drum. During test, current flow is proportional to electrical resistance of conductor, heat loss in cable in turn depends on this resistance. Resistance of the conductor is of utmost importance from system design point of view, which is measured during this test.

In order to achieve consistency in quality, in addition to above tests, rigorous quality control measures are effected at every stage of production. Accordingly, every batch of raw materials and in process cables are tested to check for their physical and electrical properties.

To carry out testing and quality control programme, the manufacturing plant has physical, chemical and electrical laboratories which are recognised by the Department of Science & Technology, Government of India. Our R & D facility is recognised as an in-house R & D unit by the Department of Science & Industrial Research, Ministry of Science & Technology, Government of India.

Besides standard types, these laboratories also possess special equipment for precision testing and quality control particularly for XLPE cable such as Insertion Tensile Testing Machine, Melt Index Tester, Differential Scanning Calorimeter, Infra-red spectrograph, Oscillating Disc Rheo meter, Micro tomes, Blown File Extruder.

**Partial Discharge Detection in Finished Cables :**

This is a modern PD detection equipment where the discharge magnitude can be directly read on a calibrated meter. The detector is associated with 50 kV noise-free transformer, discharge-free transformer, discharge-free capacitor and suitable matching units. Besides, specially designed corona free terminators are used for testing purposes.

Special Features of Partial Discharge Detector Laboratory

The presence of partial discharge of even minute magnitude is not desirable in XPLE cables and hence a highly sensitive detector has been employed with the help of which discharges as low as 5 pc/cm can be detected. The noise from supply source is prevented by providing isolating transformer and low pass filters. The complete equipment is housed in a specially shielded room to prevent external noise that would otherwise interfere with the measurements.

**B) Partial Discharge Test :**

This is the test for insulation and is carried out for the partial discharge occurring in screened electric cables due to voids which remain unnoticed in the normal high voltage tests and could be harmful to the life of insulation. Test is carried out as per the relevant standards. Partial discharge observed should be with permissible limits at 1.5 time the test voltage. Not only the insulation but the semiconductor layer also should have homogeneous coating surrounding, otherwise small voids and deep impression in that may create larger partial discharges. Similarly, if the metallic foil over semi-conducting layer is not tight enough then it gives use to higher level of discharges.

**C) High Voltage Test :**

The insulation material in cable is used to isolate the conductors from one another and from ground and also provides mechanical strength. The insulation has to withstand the voltage imposed on it in service. This is evaluated by applying higher voltage stress to the insulation for a short duration. The cable has to withstand the applied voltage without breakdown for specified period. Thus high voltage test confirms the specified voltage rating of cable.

**D) Insulation Resistance :**

Any insulating material in cable should naturally have maximum resistance in order to establish its dielectric properties. This insulation resistance is measured between the phases or phase and ground. Decrease in the insulation resistance indicates impurity and imperfection in cable insulation. This test evaluates quality of insulation.

**E) Bending Test :**

This test condition simulate bending stresses for the cables which are always there during handling and installation of cables. It is carried out as per the relevant standard. After the test the cable sample should be thoroughly examined for physical damage or cracks on the sheath. Immediately after this again partial discharge test is to be carried out. During manufacturing if overlapping of metallic screen is not tight and smooth, then in bending test it may open out. Partial discharge test after this of course establishes the satisfactory performance of cable during bending operation, without any physical damage.

**F) Heating Cycle Test :**

In actual service cables undergo cyclic heating and cooling resulting in expansion and contraction which may cause either mechanical distortion or degradation of screen which may lead to failure of cable by initiation of high dielectric loss of higher partial discharges. Hence after this test, the sample is to be subjected to dielectric factor test and partial discharge test. As it is subjected to cyclic heating and cooling with specified temperature limit, the performance of cable under actual service conditions is tested. Measuring of partial discharge level and dielectric power factor after the test tells us about mechanical displacement of metallic screen and homogeneity of insulation.

**G) Dielectric Power Factor Test :**

Dielectric power factor of any insulating material should be as small as possible in order to have less heating of dielectric. If the cable insulation contains impurities and voids then this value may be higher. This test should be done as a function of voltage. Then the sample is heated by passing current up to a desired value and again this tan delta measurement should be done. These should be within limits which ensures more purified insulating material.

**H) Impulse with Stand Test :**

Because of the nearby lightning strokes, the cable insulating material in H.V. cables may be subjected to transient over voltages. So for insulation design and manufacturing process of cable, the withstand ability with transient over voltages is established by this test. When the specified impulse voltage is applied no breakdown of insulation should occur and the dielectric material must be able to withstand transient over voltages ensuring reliability of cable insulation.

***GENERAL CONSTRUCTION OF CABLES***

**3.1 CONDUCTORS**

The conductors of power cables are normally made from electrical purity aluminium, and those of control cables are of annealed high conductivity copper. However, copper conductor power cable can also be supplied. All conductors conform to IS:8130-1984.

A point to be noted here is that for conductors for fixed installation (Class 1 and Class 2), IS:8130 - 1984 specifies only the minimum number of wires and the maximum d.c. resistance of the conductor at 200 C for a particular cross-section; the diameter of the wire is not specified.

Normally, aluminium conductors up to size 10 sq. mm. are solid circular in cross section, and sizes above 10 sq. mm. are stranded. In case of single core and twin core cables up to 50 sq. mm., they are circular in cross section while for 3 core and 4 core cables, conductors of cross section 25 sq. mm. and above are normally sector shaped.

11 kV PVC insulated cables are designed with cores having round compacted stranded conductors.

**3.2 INSULATION**

The conductors are insulated with the high quality PVC base compound. Cables with Heat Resisting Insulation are also available for maximum operating conductor temperature of 850 C for 1.1 kV grade cables.

The insulation and outer sheath compounds shall be conforming to IS:5831 - 1984 as per the requirement of IS:1554 (Part 1 and 2) of 1988.

**3.3 CORE IDENTIFICATION**

1. **Colour Scheme** :

Cores are identified by colour scheme of PVC insulation. The following colour scheme is normally adopted :

1 core - Red, Black, Yellow, Blue or Natural (non-pigmented)

2 core - Red and Black

3 core - Red, Yellow, and Blue

4 core - Red, Yellow, Blue and Black (also 3-1/2 core) (reduced neutral core is black)

5 core - Red, Yellow, Blue, Black and Grey

For cables having more than 5 cores :

Two adjacent cores (counting and directional) in each layer are coloured blue and yellow respectively and the remaining cores are grey.

Alternatively cores with number printing can be offered. For 11 kV PVC/XLPC cables, cores shall be identified by means of number printing tape.

1. **Inner Sheath :**

For all cables having two or more cores, a common covering (inner sheath) is applied over the laid up cores either by extruded sheath of un-vulcanised rubber/PVC compound or wrapping of plastic or proofed tapes. Single core cables do not have inner sheath.

1. **Armouring :**

For multi-core cables, armouring is applied over the inner sheath. In case of cables where fictitious diameter over the inner sheath does not exceed 13 mm., the armour consists of galvanised round steel wires; above this size, normally the armour is of galvanised formed steel wires.

Armouring of PVC mining cables consists of galvanised round / formed steel wires, but wherever necessary, a few tinned copper wires / strips are also included to meet the resistance requirements of armouring for mining cables as specified in IS:1554 (Part 1 & 2) 1988.

For single core armoured cables, non magnetic armouring is provided.

1. **Outer Sheath :**

Outer sheath of PVC is extruded over the armouring. In case of multi-core unarmoured cables, over the inner sheath, whereas, in case of unarmoured single-core cables, it is extruded over the insulation. This is always black in colour for best resistance to outdoor exposure. Any other colour can be available on request.

The manufacturer's name and trademark along with the year / year code of manufacture are embossed on the outer sheath; additionally in the case of LT cables, the word 'ELECTRIC' and in the case of HT cables, the voltage grade is also embossed. In case of LT cables with Heat Resisting Insulation, the word "HR 85" is also embossed. In the case of mining cables, the word MINING is added in the embossing script. The embossing script repeats in such a way that every meter of the cable be are the same script.

**Procedure for Power System Operation at Utility(Fibre).**

**2.11.1 INTRODUCTION**

**The purpose of this procedure is to instruct and make aware the concerned people about the various operations to be done for the smooth functioning of the Power System.**   
**The procedure describes various activities involved in generation, receipt and distribution of power.**

**2.11.2 PROCEDURE**

**Fibre Utilities (Power) receives, generates and distributes power to PFY, FDY, PFY II , PSF plants and Utilities. In addition to this, it supplies emergency power to PTA, LAB, PFY, FDY, PSF and PFY II plants in the event of power failure in the respective plants.**

**2.11.2.1 22 kV SYSTEM**

**Fibre Utilities (Power) receives power at its 22 kV High Voltage Switch Board HVSB # 1 from 22 kV Switch Boards of**   
**(a) 100 kV Substation through two incoming feeders viz. Incomer # 1 & Incomer # 2.**   
**(b) Energy Centre through two incoming feeders viz. Tie # 1,Tie # 2 & Tie # 3**

**All the incoming feeders are normally kept ON so as to Import or Export the Power from the HVSB # 1 bus depending upon In-house generation at E/C. HVSB # 1 is divided in Three bus sections viz. HVSB # 1A, HVSB # 1B, HVSB # 1C. All the three bus sections are normally run in parallel with each other.**

**The power received at 22 kV Switch Board is distributed at 22 kV level to PFY II, PSF Plants and Utilities.**

**These plants are equipped with transformers to step down the distributed voltage of 22 kV to the users' level of 415 Volts.**

**2.11.2.2 6.6 kV SYSTEM**

**The power received at 22 kV Switch Board is stepped down to 6.6 kV level by 4 nos. of 10 MVA transformers TR # 21,22,23 and 24.**

**TR # 21 and TR # 22 are connected to 6.6 kV High Voltage Switch Board HVSB # 3. TR # 23 and TR # 24 are connected to 6.6 kV High Voltage Switch Board HVSB # 4. HVSB # 5A is connected to HVSB # 3B through Incomer # 1 of HVSB # 5. Similarly HVSB # 5B is connected to HVSB # 4B through Incomer # 2 of HVSB # 5. HVSB # 5A and HVSB # 5B are normally run in isolation with each other by keeping Incomer # 1 & & Incomer # 2 ON and Buscoupler between HVSB # 5A & 5B OFF.**   
 

**HVSB # 3 and HVSB # 4 feed the 6.6 kV motors of Utilities. From these two**

**Switch Boards standby transformers of PFY, PSF & FDY plants and transformers DL1 and DL2 of PSF plant are fed. HVSB # 5A & 5B also feed 6.6 kV motors of**

**Utilities. In addition TR # 28 & TR # 30 of FDY and TR # DL3 & TR # DL4 of PSF**   
**are also connected to these bus.**

**Fibre Utilities has 2 nos. of 2.5 MW and 2 nos. of 4.1 MW Diesel Generating sets. These generators generate at 6.6 kV level and are connected to High Voltage Switch Board HVSB # 2. Power generated by Diesel Generators is distributed to PFY and PSF plants and Utilities. These plants are equipped with transformers to step down the voltage to 415 Volts. DGs are synchronised and taken out of line as per SOP No. UTIP/PDN/1111 and UTIP/PDN/1112 respectively.**

**From HVSB # 2 supplies the critical loads of PFY and PSF plants and Utilities. From this bus one no. emergency feeder is provided for individual PTA and LAB plant. These two feeders automatically come into operation and supply emergency loads to the respective areas in the event of power failure in those areas.**

**HVSB # 2 is connected through EC incomer to 11 kV bus (Turbo Generator of Energy Center is connected to this bus) of Energy Center via zigzag transformer located at Energy Center.**

**Diesel Generators on HVSB # 2 can be run in parallel with 11KV bus of Energy Centre. They can also be run in parallel with MSEB supply at HVSB # 3 through tie feeder LA or with HVSB # 4 through tie feeder LB. Normally the Diesel Generator sets are kept as Standby, DG set No. 1 & 2 come in line automatically to supply emergency loads of HVSB # 2 in the event of Total Power Failure. Readiness of Auto Standby DG sets is ensured through "DG operators Checksheet", Format No. UTIP/PDN/R-1158. Starting of DG 1 & 2 by simulation of Auto scheme is checked once in a week.**

**At HVSB # 2 all the three supplies i.e. MSEB, TG/GT(from E/C) and DG can be paralleled.**

**Paralleling of HVSB # 2 with HVSB # 3 and HVSB # 4 are done as per SOP No. UTIP/PDN/1113 and UTIP/PDN/1114 respectively. Deparalleling operations are**

**done as per SOP NO. UTIP/PDN/1115 and UTIP/PDN/1116 respectively.**

**Paralleling & Deparalleling of HVSB # 2 with E/C Incomer is done as per SOP**

**No. UTIP/PDN/1138.**

**2.11.2.3 DECOUPLING AND LOAD SHEDDING**

**LA and LB Tie feeder breakers are equipped with frequency based Decoupling Logic.HVSB # 2 gets isolated through the operation of this logic, when running in parallel with either HVSB # 3 or HVSB # 4, by opening of LA/LB Tie breakers in the event of abnormality in MSEB.**

**HVSB # 2 gets isolated from Energy Centre, when 11 kV breaker of EC feeder at Energy Center is tripped on frequency based load shedding logic at Energy Center or by tripping of 6.6 kV breaker on frequency based load shedding logic at Utilities Substation.**

**The outgoing feeders from HVSB # 2, except emergency feeders and TR#19 feeder, are equipped with Under Frequency Load Shedding scheme. In the event of power deficit at HVSB # 2, followed by decoupling or while running in isolation, Under Frequency Load Shedding scheme gets activated and feeders are tripped off as per predetermined priorities so that stable operation is regained.**

**TR#23/24 & DL#1/2 are tripped on the load shedding logic derived for whole complex.These load shedding settings are decided and circulated by CES depending upon In-house Generation & Priorities of the plants.**

**2.11.2.4 415 VOLT SYSTEM**

**In Utilities LT distribution is done from 2 nos. of 415 Volts Switch Boards viz. PCC # 4-6 and PCC # 7-9. Each of these PCCs are fed by 3 nos. of 2 MVA transformers connected to HVSB # 1, out of which 2 nos. are normally loaded and the third one remain standby. From these PCCs, power is fed to Motor Control Centres (MCCs) and Lighting Distribution Boards situated at different locations.**

**11 nos. of MCCs are fed from these 2 nos. PCCs. 2 nos. of MCCs namely MCC # G1 and MCC # G2 are fed from PFY plant. 5 nos. of MCCs namely MCC # 2,**

**MCC # 21, MCC # 22, MCC # 23 and MCC # 24 are fed from PSF plant.**

**1 no. 160 kW Emergency Diesel Generator, generating voltage 415 Volts, is connected to MLDB # 2 through Auto Mains Failure Scheme and automatically comes into operation in the event of power failure to supply emergency lighting loads of PSF and PFY plants and Utilities.**

**2.11.2.5 415 VOLTS UPS SYSTEM**

**UPS system in Utilities is used for Control Supply of Dow Boilers 1 to 4, Thermax Dow boiler & a Distributed Control System. There are two modules of UPS each is of 60 kVA rating & delivers output at 415 Volts level. Both run in 1+1 configuration i.e. in parallel with each other. The input sources to both modules are separate, but their bypass supply is common from third source. Each module is backed up by a 150 Ampere Hour capacity battery set separately.**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Electrical Equipment database** | | | |  |
|  |  |  |  |  |
| **SN** | **DESCRIPTION** | **UOM** | **Remarks for filling up the data** | **Patalganga** |
| **1** | **Outdoor switchyard equipments** |  |  |  |
| a | Outdoor circuit breakers | Nos | No of breakers installed in outdoor switchyard | 7 |
| b | Current transformer | Nos | No of CTs installed in outdoor switchyard | 27 |
| c | Potential transformer | Nos | No of PTs / CVTs installed in outdoor switchyard | 12 |
| d | Isolators (with and without earthing switch) | Nos | No of Isolators installed | 13 |
| e | Lightning Arrestors | Nos | No of LAs installed for line and transformer | 27 |
| f | NGR | Nos | No of NGRs | 7 |
| g | EHV Cable | Mtrs. | Apprx. Qty in mtrs | 183 |
| **2** | **Generators** |  |  |  |
| a | Gas Turbine Generators | Nos | No of GTGs | 2 |
| b | Steam Turbine Generators | Nos | No of STGs | 1 |
| c | DG sets (HV) | Nos | No of DG sets with generating voltage more than 415 V | 4 |
| d | DG sets (LV) |  | DG set with generating voltage of 415V or less | 3 |
| **3** | **Transformer** |  |  |  |
| a | Grid transformer | Nos | Transformers installed for grid connectivity | 3 |
| b | Power Transformer | Nos | Transformer with rating more than 2.5 MVA | 22 |
| c | Generator transformer | Nos | Transformer connected directly with Generator | 3 |
| d | Distribution transformer | Nos | Transformers with rating less than 2.5 MVA | 72 |
| e | Unit transformer | Nos | Special transformer for equipment (e.g. Rectifier transformer, Transformer for VSD, etc.) | 23 |
| f | Reactors | Nos | No of Reactors installed | 5 |
| **4** | **Switchgear** |  |  |  |
| a | HV Panels | Nos | Incomer, bus coupler, outgoing feeder, PT panel should be considered separately as one panel each. | 299 |
| b | LV Panels | Nos | Each Incomer, bus coupler, Motor feeder, outgoing feeder (SFU / breaker) should be considered as one number each. | 4658 |
| **5** | **Motors** |  |  |  |
| a | LV Motors (above 0.37 kW) | Nos | Provide all LT motors. Do not consider fractional HP motors less than 0.37 kW (e.g. spinning motors, air curtain motors, etc.) | 4085 |
| b | HV Motors | Nos | Al HT motors to be considered | 92 |
| c | DC motors | Nos | All DC motors to be considered | 31 |
| d | Any other special motors | Nos | If applicable | 6 |
| **6** | **Cables** |  |  |  |
| a | HT cables | Mtrs. | Approx. Qty of 6.6 kV, 11 kV, 22kV & 33 kV cables installed for trasformer, motor, tie feeders, etc. | 92901 |
| b | LT cables | Mtrs. | Approx. Qty of LT cables installed for trasformer, motor, tie feeders, etc. | 755500 |
| c | Control Cables | Mtrs. | Approx Qty of control cables | 801000 |
| **7** | **UPS** |  |  |  |
| a | Power UPS | Nos | No of UPS system installed to feed power to large loads (motors, etc.) UPS system with parallel redundant system should be considered as one UPS system | 2 |
| b | Control supply / Instrument supply UPS | Nos | UPS system installed to feed power to instrument load, control power to various process loads UPS system with parallel redundant system should be considered as one UPS system | 16 |
| **8** | **AC / DC Drives** |  |  |  |
| a | LV Drives | Nos | No. of AC variable frequency drives excluding derives for spinning motors & fractional HP motors in polyester plant. | 628 |
| b | DC drives | Nos | No. of DC Drives excluding drives for spinning motors & fractional HP motors in polyester plant | 51 |
| c | HV Drives | Nos | No. of HV drives | 0 |
| **9** | **Capacitors** |  |  |  |
| a | HT Capacitors banks | set | No of HT capacitor banks including reactor and other accessories | 0 |
| b | LT capacitors banks | set | No of LT capacitor banks | 36 |
| **10** | **Battery chargers** | Nos | No of Batterycharger / DC supply systems. Consider Float / Float cum boost charger as one system | 17 |
| **11** | **Battery sets** |  |  |  |
| a | Ni Cd cells | Nos | Total No of battery cells in battery banks for UPS, DC supply systems, etc. | 6243 |
| b | Vented Lead Acid cells | Nos | Total No of battery cells in battery bank for UPS, DC supply systems, etc. | 837 |
| c | VRLA batteries | Nos | Total no. of battery cells in battery bank for UPS, DC supply systems, etc. | 463 |
| d | SMF Batteries | Nos | Total No of battery cells in battery bank for UPS, DC supply systems, etc. | 58 |
| **12** | **Soft Starters** |  |  |  |
| a | HT soft starter | nos. | Demag compressor motor starter |  |
| b | LT soft starter |  | motor starter |  |

**In case of failure of One module, another module takes up the whole connected**

**load. On simultaneous failure of both incoming sources, both battery sets come in**

**line without interruption of supply to load. In case of failure of both UPS modules along with their battery banks, Load continues to get supply as STATIC BYPASS SWITCH changeovers from UPS to Bypass supply.**

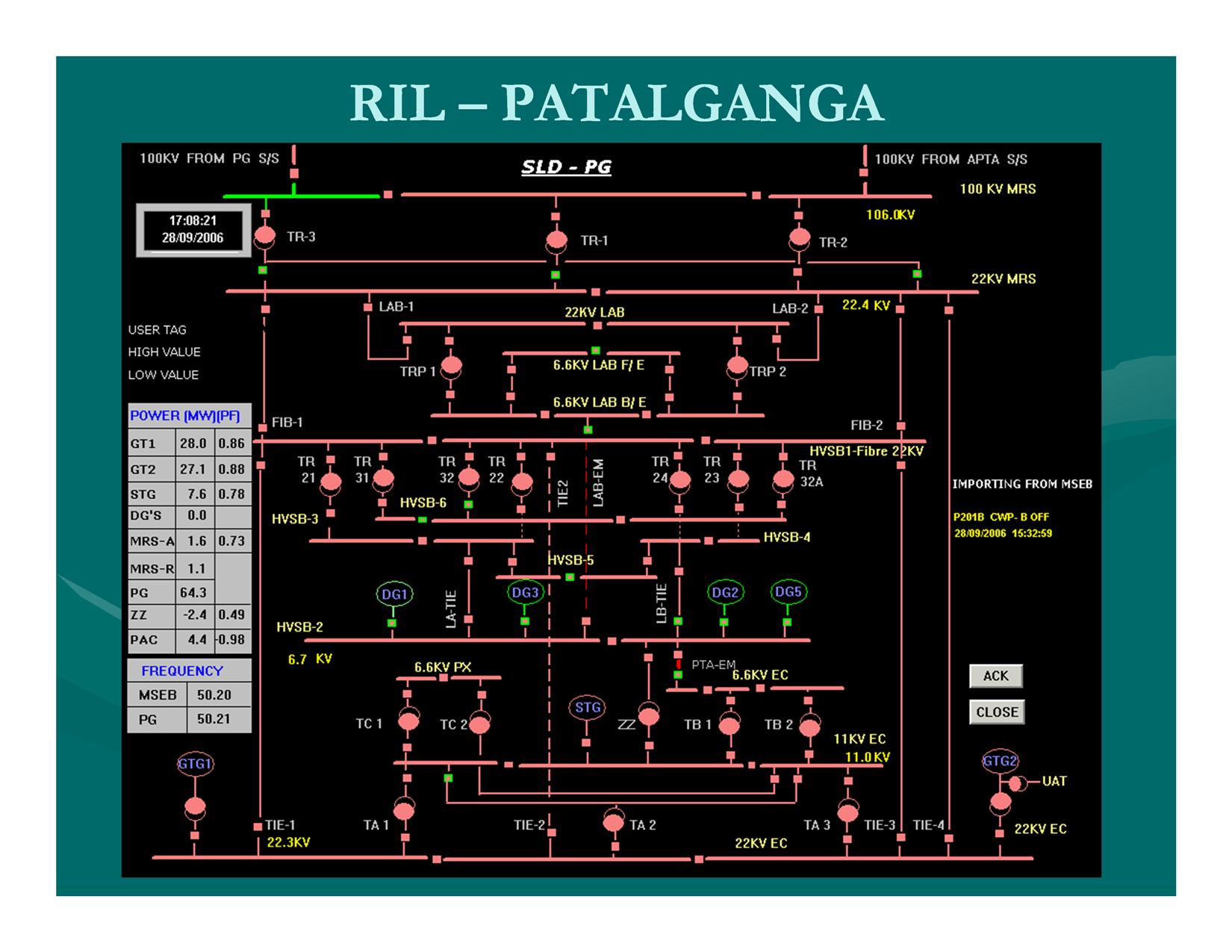
**The shutdown of UPS module/s is carried out as per SOP No. UTIP/PDN/1150.**

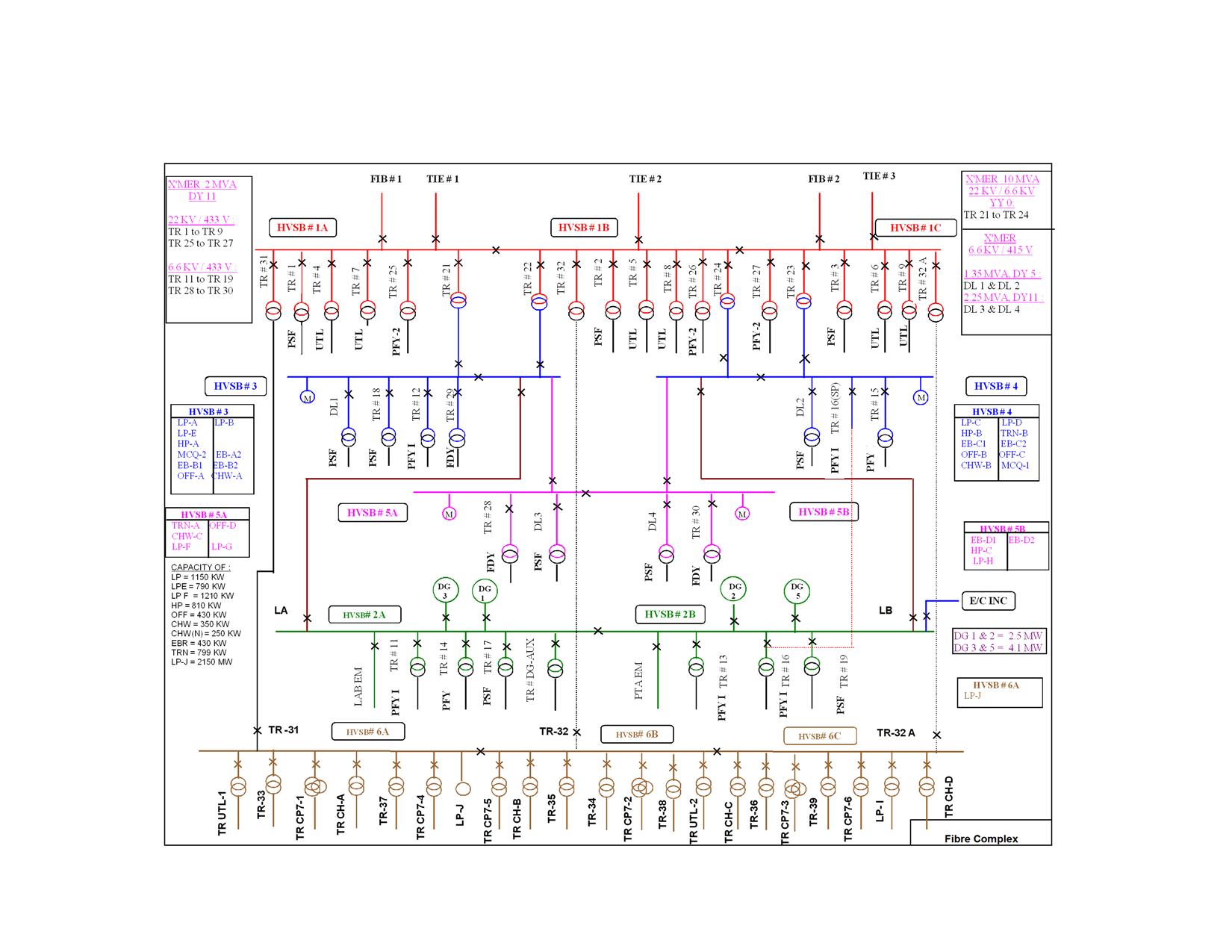
**The UPS module/s is/are taken in service as per the SOP No. UTIP/PDN/1151.**

**2.11.2.6 110 VOLT DC SYSTEM**

**Substation and DG house are equipped with 1 set of battery and battery charger each. The set located at Substation supplies the power required by control and protection circuits of 22 kV and 6.6 kV Switch Boards and PCCs. The set located at DG house supplies the power to the control and protection circuits of DGs.**

**The total load can be put on any one of the sets by on-load changeover.**

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