POWER PLANT
ISSUE-II : FEB 2005

PLANNING GUIDELINES

FOR

SWITCH MODE POWER SUPPLY (SMPS)

BASED POWER PLANTS

No. GL/SMP-03/02 FEB 2005

This document supersedes the previous document " Planning Guidelines For SMPS Power Plants No. PLG/SMP-01/01 APR 98"

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HISTORY SHEET

S.No.	Name of the Generic Requirements	No. of the Generic Requirements	Remarks
1.	Planning Guidelines for SMPS Based Power Plants	PLG/SMP-01/01 APR 98	First issue
2.	Planning Guidelines for SMPS Based Power Plants	GR/SMP-03/02 FEB 2005	Second issue Since the first issue of this document, GR for SMPS power plants has been revised twice. Many improvements have been made in the GR for SMPS based Power Plant due to which updating of these guidelines has become necessary.

CONTENTS :

References

1.	**GR/SMP-01/05 JAN 2005**	SMPS Based Power Plants.
2.	**GR/BAT-01/03 MAR 2004**	VRLA batteries

PART 1

BASIC THEORY

AND

SMPS SYSTEM CONCEPT

No. GL/SMP-03/02 FEB 2005

1.1Scope

This document covers the basic theory and concept of SMPS technology. It also lays down the necessary guidelines for planning of the SMPS Power Plant for a given telecom equipment and includes :

a) The basic theory and SMPS concept.
b) The fact which shall be taken into consideration while selecting a power plant for a given requirements.
c) SMPS power plant features which shall be verified at the time of procurement and commissioning of the power plant.
d) The guidelines for calculating load with sample calculations for a given system.
e) Guidelines for selecting a power plant and battery along with sample calculations.

1.2 Introduction

The modernisation and expansion of Telecom network, calls for compact, flexible, reliable, easily transportable power plant, having Compatible operating characteristics with respect to telecom equipment. Moreover, with the expansion of network the necessity of centralised control and monitoring of power plants has also become a necessity. SMPS power plants easily fit into the concept.

Conventional Power Plants, utilising SCRs or Ferro-resonant techniques, had serious impediments of massive size, large weight and lower efficiency. These type of power plants did not have the scope for modular expansion, due to which, frequent changing of the power plants with each expansion of the switching/transmission system was a compulsion.

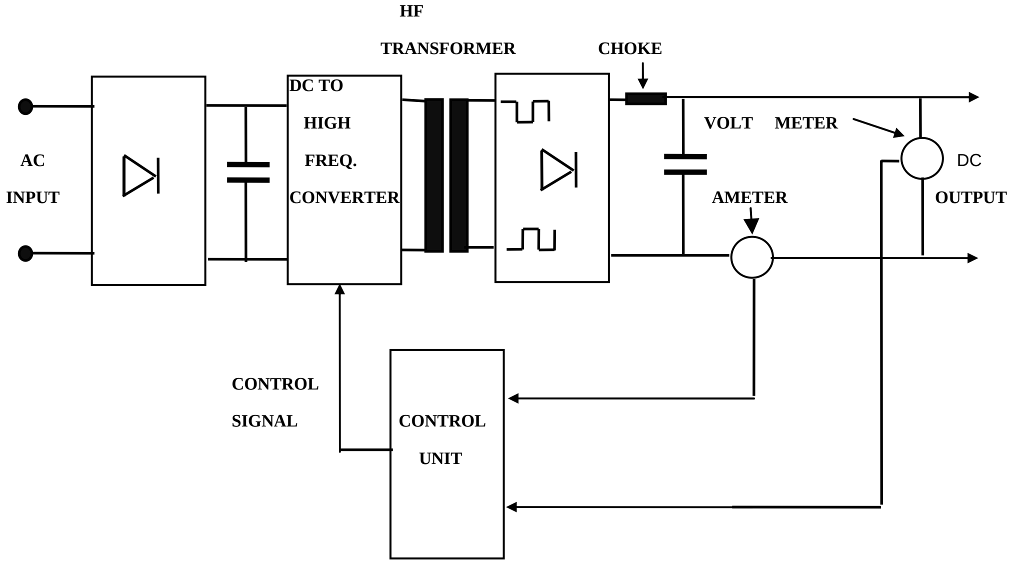
As compared to convention SCR/Thyristor controlled and Ferro-resonant power plants, the operating characteristics such as Transient Response, Power Factor, Efficiency, Total Current Harmonic Distortion and Ripple Noise are markedly improved in SMPS (Switch Mode Power Supply) based power plants. This makes the SMPS based power plants more efficient, economical and safer for the telecom equipment.

SMPS based power plants are compatible with conventional flooded Lead acid as well as VRLA (Valve Regulated Lead Acid) batteries. The SMPS power plants, require small space due to their compactness and can be taken right into switch-room along with VRLA batteries leading to easy management and saving of the valuable space, copper bus-bars and lower voltage drop. It also increases the efficiency of the system and man power.

The batteries (both VRLA as well as flooded Lead Acid) are more prone to temperature. It is a known fact that for every 10 deg Celsius rise in working temperature over the specified ambient temperature the life of the battery is reduced to half. As most of the SMPS power plants employ micro-processor control techniques, the introduction of temperature compensation logic for batteries has become simple and easier.

1.3 SMPS Design : Most of the SMPS power plants design are based on one of the following conversion techniques :

a) Two Stage Conversion SMPS : In these SMPS systems, the conversion of AC to DC is accomplished in two stages as given below :



BLOCK SCHEMATIC - TWO STAGE CONVERSION SMPS TECHNIQUE

i) First Stage conversion :

- The input AC voltage is directly rectified and converter in high voltage DC.

ii) Second Stage Conversion :

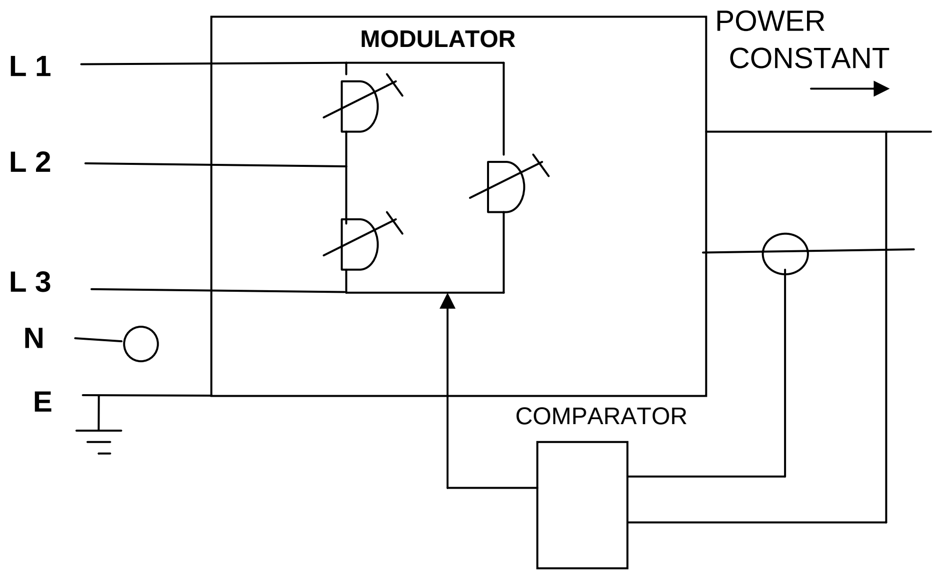
- Rectified high voltage DC is stored in a capacitors.
- High voltage DC is then converted in to a very high frequency AC (20KHz and higher).

Conversion of high voltage DC to high frequency AC is achieved by means of very powerful and fast semi-conductor switching devices.

- High frequency AC is stepped down to the required level by means of a small high frequency transformer.
- Stepped down AC is rectified to DC of desired voltage and filtered by means of high frequency filters.

b) Single Stage Conversion Techniques in SMPS based Power Plants : In this conversion technique :

- The input AC voltage (50Hz) is directly converted into a very high frequency AC(20Kz and above).
- High frequency AC is stepped down to the required level by means of a small high frequency transformer.
- Stepped down AC is rectified to DC of desired voltage and filtered by means of high frequency filters.



BLOCK SCHEMATIC - SINGLE STAGE CONVERSION TECHNIQUE

1.3.1 Output Voltage Regulation in SMPS Power Plants : The regulation of the output voltage in both the above techniques is done by the control circuit, which corrects output voltage to the high speed switching circuit. Generally control circuit generates a fixed frequency by means of a local oscillator. The width of these frequency pulses is adjusted to attain the desired regulation.

The width of the pulses generated by the control circuit are dependent upon the output voltage. Since the output voltage is dependent upon the input voltage and the load current, **any variations in the input voltage or the load current will correspondingly alter the width of the pulses generated by the control circuit and accordingly alter the value of "D", the duty cycle** .

since $V_o = K*V_{in}*D$

Where V_o is the required Output DC voltage, V_{in} is the high frequency stepped down AC voltage, K is a constant corresponding to the shape of the waveform and "D" is the duty cycle. The regulation is achieved through control circuit in the feed-back path.

For example, removed of load or increase in input voltage will give a signal to control circuit to shorten the pulses duration i.e. to correspondingly reduce value of `D' to maintain constant value of $V_o$. Similarly, if the load is increased or the input voltage decreases, the width of pulse would be correspondingly increased i.e. the value of `D' would increase to maintain constant value of V_o. "D" will alter with variations in input voltage and output load to keep V_o constant. That is how regulation is obtained.

The underlying difference between the conventional and the SMPS systems is that while in the former the regulated output voltage is a function of low frequency input AC voltage (50 Hz), in the later case, the output voltage is a function of very high frequency voltage of the order of 20 KHz - 100 KHz due to which response time is very fast.

1.3.2 Salient Features of SMPS Technology :

- SMPS based power plants use very high frequency switching due to which :

- Size of the transformers and chokes is reduced to 10 to 15% of the conventional SCR/Thyristor controlled power plants. This makes the power plant compact due to which a lot of saving in floor area is achieved.

- Being small and light in weight, fit perfectly in modular concept. Up-gradation of the capacity in modular system is easy, simply plugging-in the additional modules adds to the capacity, with the limit of ultimate capacity and does not require the scrapping of existing power plant as in case conventional power plants.

  As the power plant can grow only up-to its rated ultimate capacity, it is therefore very important that future growth is properly assessed and accounted for, while choosing the ultimate capacity of the power plant.

- Being light weight, these power plants, do not require to be installed on ground floor and can easily be taken close to technical room, even in the equipment room itself, which reduces the voltage drop to make the system more efficient. These power plants with VRLA batteries can be installed in the equipment room thus reducing the bus-bar length and the cost.

- These power plants have very high conversion efficiency and consume less power resulting in low operational cost. Conversion efficiency of these power plants are as given below :

a) Single phase power plants :

- At nominal input, output and full rated load shall be better than 89%.
- Other specified Input, output conditions and load between 50% to 100% shall be better than 85%.

b) Three phase power plants :

- At nominal input, output and full rated load shall be better than 90%.
- Other specified Input, output conditions and load between 50% to 100% shall be better than 87%.

- SMPS offer a very improved power factor (near unity) making the system more efficient and make easy to comply with state electricity boards P.F. norms.

- These power plants have a very high reliability and therefore are less prone to faults which results in low operational costs.

- Being menu-driven solid-state system, without potentiometers etc., the system does not require much routine maintenance and reduce the pressure on the maintenance staff.

- Being, microprocessor controlled, menu-driven systems, compatibility with remote supervision and control can easily be achieved.

- All these power plants are provided with Auto float/charge operation to recoup the battery lost capacity faster.

- These power plants are capable of performing over a vide input range as given below :

  a) Single Phase (Nominal230V) : 90V to 300V
  b) Three Phase/4 wire (Nominal 400V) : 320V to 480V

  Thus these power plants fully match the Indian electric commercial supply conditions.

- Since the system is modular in design, the time to replace the faulty module is much less.

1.3.3 System Configuration : SMPS based power plants are composed of :

a) Distribution, Switching, Control, Alarm and Monitoring(DSCA) unit : This unit is composed of two parts :

i) Control, Alarm and Monitoring Part : Control, Alarm and Monitoring part of DSCA unit is modular and for ultimate system capacity. This unit is microprocessor controlled and all the parameters settings, monitoring and control are executed through a menu-driven program. DSCA also provides for :

- Necessary interface for remote supervision and control on RS 485 bus.

- A large number of battery monitoring functions through which the vital battery parameters, like, Voltage and temperature of each individual cell of the battery bank can be monitored. It also provided the monitoring of each battery trickle current. The DSCA will create an alarm in case of any of the parameters is found outside the set limits. All this information is made available to the remote controller site for necessary action and storage.

  - Programmable routine tests such as partial battery discharge test for battery are possible. In this test the battery would be put to load automatically at a pre-set time for the duration as programmed by the in-charge of the system. The DSCA will check some parameters such as voltage, current and conductance of each cell during this discharge test and pass on the information to the remote controller. It will also observe the cells for any abnormal behaviour (mark deviation in cell voltage charging current, temperature and conductance as compared to other cells) during this period and will create an alarm to warn about the abnormal behaviour of the cell with its identity.

  - The power plant circuitry ensures that, in the event of the failure of DSCA unit itself, the power output to the equipment is maintained. The default settings of the individual FR/FC modules will remain intact and the modules will deliver the power to load. In the event of the failure of DSCA the only parameters such as remote monitoring and control of the power plant, Battery monitoring functions, battery path current limiting, and temperature compensation etc shall be affected. **But, in such a case, the battery path current can be manually controlled by switching off some of the FR/FC modules so as to restrict the power availability.**

ii) Distribution and Switching : Distribution and switching part of DSCA shall be for ultimate system capacity. It shall provide for :

- The termination of the batteries and load (telecom equipment).
- The switching and interconnecting devices for batteries, load and input AC.
- Contactors for battery low disconnect and AC input out of range.
- Shunts for meters.

- **Float Rectifiers-cum- Float Chargers (FR/FCs) or Float Rectifier-cum Battery Charger (FR/BC) modules :** FR/FC and FR/BC units are modular and plug-in type rack mountable. The rack for these systems is always supplied, fully pre-wired for the ultimate rack capacity. Simply sliding the module in the slot and plugging input AC connector and DC connector, the DC power can be enhanced. The modules can be added and removed even in the working system, without any interruption to the load. The number of basic FR/FC, FR/BC modules in one system will depend on ultimate system capacity. Various basic modules and their system ultimate capacity are as given below :

Category	Basic Module	Ultimate capacity
1	6.25A (Single phase)	25A
2	12.5A (Single phase)	100A
3	25.0A (Single phase)	200A
4A	50.0A (Three phase)	450A
4B	50.0A (Three phase)	800A
5A	100A (Three phase)	1500A
5B	100A (Three phase)	3000A
6A	200A (Three phase)	3000A
6B	200A (Three phase)	4800A

This composition makes the system flexible to meet any load requirements. Depending on ultimate capacity, basic module rating and number of modules (FR/FC or FR/BC) used for system can be ordered. **It is, therefore, very important that while choosing the power plant it shall be ensured that :**

- The redundancy requirement has been taken care of.

- The future load projections have been fully taken care of while deciding the rating of FR/FC, FR/BC modules and ultimate system capacity.

1.3.4 Classification of SMPS power plants :

The SMPS power plants, depending on their application and battery compatibility, are classified as below :

1.3.4.1 SMPS power plants Classification :

From the application point of view, the SMPS power plants may be classified in to two groups :

a) Low Capacity power plant Systems
b) High capacity power plant Systems

1.3.4.1.1 Low capacity Power plants systems :

These type of power plants are required to provide power to small telecom systems in rural and semi urban areas. These type of power plants may also be used with small telecom systems such as BTS etc. in the urban and metros areas.

- These type of power plants are normally required for the telecom equipments, which work in buildings where roof height is not as per standard telecom equipment room. Therefore rack height of these power plants has been kept lower i.e. 1500mm.

- SMPS power plants based on single phase 6.25A, 12.5A and 25A basic modules and three phase 50A basic modules are envisaged for these applications. Ultimate capacity of these power plants is as given in clause

1.2.3(b)

- Battery back up for these type of systems is high (6 to 72 hours) and depends on the electric supply conditions.

- These types of power plants are normally used with unattended systems.

1.3.4.1.2 Large capacity Power plants systems : These type of power plants cater for large or very large telecom systems. Power plant systems with ultimate capacity of 800A and above are envisaged for this application. These systems cater to high loads with a high potential of growth. The Power Plants for Large Switching Systems which normally grow from 10K to 60K lines or power plants feeding a large number of switching systems and other telecom equipments, in the same building, or the power plants for medium and large Transmission Centers fall in this category.

- SMPS power plants based on 50A, 100A and 200A basic modules are envisaged for these application.

- All these power plants are three phase only.

- Battery back-up for these systems may vary as per specific field requirements, but normally it is 6 hours.

- As these systems are installed in standard telecom technical rooms the rack height of these systems has been specified as 2200mm.

1.3.4.2 Battery Compatibility of SMPS Power Plants : Depending on the compatibility with battery bank , the power plants are classified as under :

1.3.4.2.1 SMPS Power Plants Compatible with Valve Regulated Lead Acid (VRLA) batteries Only : These power plants can only comply with the charging requirements of VRLA batteries.

1.3.4.2.2 SMPS Power Plants Compatible with Both VRLA as well as Conventional Lead acid batteries : These power plants comply with the charging requirements of both VRLA as well as conventional flooded lead acid batteries. In these type of power plants a few Float-cum Boost charger(FR/BC) modules are provided. There is a provision by which one battery and FR/BC modules are isolated from the load and the battery is charged @2.7V/cell, while the other batteries and Float-cum-charger modules remain floated across the load and take care of the load.

1.3.5 SMPS Power Plant, Features for specific battery requirements : The battery is a very important component of the power supply system as it provides the stand-by back-up power to the telecom equipment, when the Power plant is unable to supply power due to failure of AC commercial mains or any other unavoidable reason. The necessary provisions in SMPS power plants have been made to take care of the factors which affect the life and performance of the battery. Some of the features are :

A. **Auto Float/Charge Operation :** Normally the power plant voltage remains at 54V for VRLA Batteries and 52.8 for Flooded lead acid conventional batteries. The float voltage is settable in the range - 48V to -56V.

When the power plant is restored after any interruption, DSCA steps up the power plant voltage to 55.2V for fast recoup of the battery. When the battery is fully charged DSCA reverts the power plant voltage to 54V for in case of VRLA batteries and 52/8V in case of conventional flooded batteries respectively. These two modes of operation are called auto float/charge operation.

The float charge voltage is very essential for proper charging of the battery. It is therefore essential that, at the time of installation and during maintenance, it is ensured that float charge voltages are properly set.

B. **Deep discharge Prevention :** Deeper the battery is discharged, lesser the life of the battery becomes. Discharge of the battery beyond 80% of its rated capacity, drastically reduces the life of the battery. This can be understood by the fact that an exchange battery when discharged to Depth of discharge(DOD) of 20%, may give up to 3000 such cycles. Same battery at 50% DOD, may give about 2000 such cycles and will give only 1400 cycles to 80% DOD. The same battery if discharged to its full rated capacity may give about 600 such cycles only.

C. **Battery Under voltage protection :** DOD of the battery can be easily controlled in SMPS power plants. In SMPS Power plants the voltage during charging of the battery is continuously monitored. When the battery reaches the pre-set voltage, the battery is isolated from the load thus preventing further discharge of the battery. When the Power plant starts to deliver output, the battery gets automatically reconnected to the float bus to get recharged from the power plant and be ready to take load in the case of any interruption in the AC power supply.

At the time of installation of power plant and battery, or the additional battery, the concerned authority shall ensure that the Battery low disconnect voltage has been set as per the battery discharge table supplied by the manufacturer or prepared at the time of QA testing. The voltage corresponding to 80% shall be set to prevent the discharge of battery beyond 80% DOD.

D. **Battery health Check :**

Provision in the power plants has been made to monitor each cell of the battery for voltage and temperature. Provision has also been made to monitor the current, trickle current and battery voltage at set periodicity (programmable). The same shall be made available to centralised control and monitoring system through RS 485. Any abnormality observed during these tests shall be reported through an alarm.

There is also a provision for conducting a partial discharge test for a pre-determined duration and frequency. During this test, the voltage, current, conductance and temperature of each cell shall be recorded. During the recharge of the battery after the above test, all the above parameters except conductance will be recorded by the power plant. Any abnormality observed during discharge and recharge test shall be highlighted by the power plant by creating alarm. All this information shall be made available to the remote site with the information about abnormal behaviour of any of the cells. Frequency and duration of partial test discharge shall be programmable.

This feature in SMPS power plants has been made optional for which the ordering authority shall make a clear mention of it. In case it is ordered, it may be ensured at the time of installation that all the above features are functional. These functions may be programmed as per local requirements.

E. Control of the battery temperature :

The importance of temperature control in VRLA batteries can be very well understood by the well known fact that the life of the battery is reduced to half when working temperature increases by 10 deg C above the specified ambient. The two major reasons for rise in battery temperatures are :

- Increase in ambient temperature
- Increase in battery chemical reaction

Both these factors cab be controlled by SMPS power plants as given below :

a) **By Limiting the Battery Path Current :** In Auto Mode, battery path current limit has been made settable for every individual battery so that the battery path current is restricted to 10% of battery AH capacity.

Therefore, it is essential that :

- **Tendering Authority will give the capacity of the each battery to be used with the system.**
- **At the time of installation of power plant and battery or the additional battery, the concerned authority shall ensure that the battery path current limit has been properly set as per battery capacity.**

b) **Temperature Compensation for Battery :**

A very important fact about battery chemistry is that the chemical reaction in the battery depend on its state of charge and the temperature of its electrolyte. In addition to the above chemical reaction also increases the temperature of the battery. From the above facts it is essential to control the temperature of the battery.

Solution to this problem has been found in battery temperature compensation technique. In this technique, the battery temperature is controlled by slowing down the chemical reaction. The battery temperature is monitored and the output voltage of the rectifier in Float/Charge operation is decreased or increased at the rate of 72mV (3mV/cell, 24 cell battery) per degree increase or decrease in temperature over the set voltage. The output voltage decreases till the open circuit voltage of the battery is reached. The open circuit voltage range is made settable between 2.07V/cell to 2.2V/cell. At this voltage the power plant voltage gets locked and further increase in temperature shall not decrease the voltage further. This voltage shall remain locked till the temperature falls below the value at which it got locked. The output voltage due to decrease in temperature shall increase up to 56.8V. It shall get locked at this voltage and any further decrease in temperature shall not lead to further rise in the output voltage of the power plant. This voltage shall also remain locked till the temperature rises above the value corresponding to this set value. A tolerance +/- 5 mV may be acceptable over the specified rate of 72mV/degree C. The nominal distance between the battery & power plant may be 20 metres. The manufacturer shall provide the necessary sensor and cord for the purpose, with the power plant. Failure of temperature compensation circuit including sensors (including the open or short circuit) shall create an alarm and shall not lead to abnormal change in output voltage. Proper sign-writing shall be made in DSCA and both ends of temperature compensation cord for its easy termination. The battery characteristics are normally specified at 27 deg C.

Power Plant Output Voltage settings for Temperature Compensation :

Output voltages (both Float and charge) of the FR/FC and FR/BC are settable at site. The Float voltages at the time of installation shall be set as given below :

1. Ambient Temperature of 27 Degree Celsius

   i) Flooded conventional Lead acid battery : Float : 2.20V/Cell
   Charge : 2.30V/cell

   ii) VRLA Batteries : Float : 2.25V/Cell
   Charge : 2.30V/cell

2. In the Temperatures range, (-)10 Degree Celsius and 45 degree Celsius, the voltage/cell shall be :

   Specified Ambient Temperature Voltage - (actual ambient temperature - 27)0.003

3. For Temperatures - 10 degree Celsius and lower the voltage shall be set at 2.33V.

4. In case of temperature higher than 45 degree Celsius the voltage shall be set at the open circuit of the battery.

F. Parallel operation of FR/FC, FR/BC modules :

SMPS FR/FC modules shall be capable of operating in parallel with one or more modules of similar type, make and rating, other output conditions remaining within specified limits. The load sharing by these modules shall be within +/- 10% of the average current per FR/FC, FR/BC module in the system (mounted in the same or different racks) when loaded between 50 to 100% of its rated capacity for all working conditions.

At the time of installation and during the maintenance of power plant it shall be ensured that the parallel load sharing feature is fully functional and is working within the limits, as specified above.

G. Protections :

The following provisions have been made for protections against the following :

i) Protections against the lightning and surges : A provision of two stage protection has been made for the protection of the power plant against the lightning and surges. One stage is to be installed at the LT panel while second stage is to be provided in the power plant. This protection has been clearly and elaborately specified in the GR for SMPS based Power Plants No. GR/SMP-01/05 JAN 2005.

At the time of installation, it may be ensured that this protection is properly installed as per the manufacturers instructions. Also, it may be ensured that proper co-ordination between two stages has been provided as per the surge protective device supplier.

ii) Other protections :

Provision has been made for the protections against the input AC under/over voltage, output under/over voltage and overload and short circuit.

At the time of installation, it shall be ensured that all these protection limits are properly set as specified in the GR and are fully functional. Periodically, it may be verified that these limits have not been disturbed. It shall also be ensured that all the monitoring and alarm indications are properly functional.

PART 2

PLANNING OF

SMPS POWER PLANTS

No. GL/SMP-03/02 FEB 2005

2.0 Planning of a SMPS Power Plant :

While planning a power plant for a given site the following important factors shall be taken into consideration :

1. **Present Load :** The present load is required for deciding the rating and number of modules.

2. **Ultimate Load :** Ultimate load is the load of the system when it has grown to its maximum capacity. **Minimum five years growth projection may be taken for the purpose of calculation.**

3. **Battery back-up :** The capacity of the battery bank, depends on the number of hours it is expected to cater the load during the non availability of power plant due to any reason. The capacity of the battery is so chosen that the whole back-up may be met by three batteries (preferably). If feasible, two sets may be installed in the initial stage and one can be added when the need arises. For this purpose, the following input may be essential :

   i) Present Battery back-up
   ii) Ultimate Battery back-up

4. **Redundant capacity requirement :** A provision for few redundant modules (say one or more extra modules, in addition to the calculated capacity) may be made while planning a power plant so that in the event of the failure of some modules, the power plant may work efficiently and without interruption.

5. **System Type : Small Capacity or High Capacity Power Plants** : As explained in Heading Classification'

6. **Battery Compatibility (VRLA only/Both VRLA & Conventional) :** As explained in Heading `Classification'

2.1 General guidelines for planning :

Some of the important points which may be considered for the effective, efficient and economical use of resources, while planning a telecom system power plant, are as given below :

1. Power Plant :

a) While choosing the basic module and system, five years growth projection shall be taken into account.

b) It may be ensured that the capacity of the power plant is such that the power plant is normally not loaded beyond 90% of its rated capacity. **While deciding the power plant ultimate capacity this point shall be taken into consideration.**

Note : System load consists of Equipment load plus battery charging current at 10 hour rate plus any other load (such as inverters etc.) which are to be fed from this power plant.

c) The provision for sufficient number of redundant modules may be made while planning a power plant so that failure of a module does not affect the performance of the system.

Planner may choose a number of redundant modules as per his local requirements. A provision of one redundant module for every five modules in a system, subject to minimum one module per system is suggested. The number of redundant modules may be calculated as below :

If the number of modules calculated for load and battery : Y

Let Y = N*5 + M

Where Y, N & M are natural numbers, as defined below :

Y is the total number of modules required for the system
N is the quotient when "Y" is divided by 5
M is the remainder when "Y" is divided by 5

The number of redundant modules shall be decided as under :

- **If M is greater than or equal to 3, the number of redundant modules shall be N + 1**

- **If M is less than 3, the number of redundant modules shall be N**

d) While deciding the number of basic modules and module ratings (for meeting the projected ultimate load), the available space in the installation area should be kept in mind.

e) Power Plant Category (Low capacity and high capacity) shall be decided with respect to place of installation and ultimate load requirements :

- Whether it is to work with the unmanned equipment such as microwave repeaters or similar application or round the clock supervision is available. At unmanned stations the number of redundant modules should be sufficient to ensure trouble-free continuous working without excessive overloading of power plant.

- Number of FR/FC, FR/BC modules required for battery requirements as per battery back-up. For higher battery back-up, battery capacity will be high and so the number of FR/FC, FR/BC modules.

- Whether the Instrument Room is as per standard Equipment room specification or not standard, low ceiling. For example for a small exchange which is installed in a rented building with low ceiling level, low capacity system may be chosen.

f) The modules used in system configuration shall be of same rating and make to ensure load sharing requirements.

g) The number of modules required for boost charge operation (Conventional battery application only) shall be as per battery capacity. The remaining number of modules working in float/charge operation shall be capable to take care of the load and floated batteries.

2. Battery Bank : The capacity of battery bank shall be calculated on the basis of the following factors :

i) The battery reserve required, 6, 12 , 24, 36 hours or 72 hours as per the electric supply conditions.

ii) Battery shall not be allowed to be discharged beyond 80% of its rated capacity at any time.

iii) The number of batteries in the system shall be minimum two.

3. Standby DG Set : While choosing the DG Set for a particular station, the following factors shall be considered :

a) For Power Plants and UPS systems, AC requirements shall be taken equal to 1.25 times the Ultimate power plant load.

b) The multiplying factor for all the other loads such as Air conditioning, Lighting, Fans etc., which are to be fed from the same DG set, shall be as per equipment specifications.

c) Future projections shall also be taken into account, while selecting the DG set capacity.

d) Type of DG set required, Battery push-button start, or Auto Star t(Ignition requirements to be specified i.e. after what time the engine shall start).

ANNEXUE - 1

Sample Calculations :

1 Load Calculations :

a) Equipment load (C-DOT RAX working on 48V) :

Requirements	Present	Ultimate
Say Continuous load	2A	2A
Anticipated traffic in Erlangs	0.1 Erlang	0.1 Erlang
Off Hook Current	30mA (30 subs)	30mA(480 subs)
Battery back-up (hours)	24 hours	24 hours
Off Hook Current Peak	(0.030*30/10) = 90mA	(0.030*480/10) = 1.44A
Load/day : Continuous	2*24 = 48AH	2*24 = 48AH
Off-hook current/day	(0.030*30/10)*24 = 2.16 Ah	(0.030*480/10)*24 = 34.56 Ah
Total Equipment Load/day	50.16AH	82.56Ah
Instant	**2.09A**	**3.44A**

b) Lighting Load :

Requirements	Present	Ultimate
DC : Number of lights	4	6
Wattage of each light	20W each	4 of 20W 2 of 15W
Peak	**80W or 1.76A**	**80+30 = 110W or 2.42A**
Duration of use	average 4 hour each day	average 4 hour each day
Total load WH	4X20X4 = 320WH	(4X20+2X15)X4 = 440WH
AH	**320/(1.9 X 24)= 7AH**	**440/(1.9X24) = 9.7AH**

c) Inverter Load (if used) :

Requirements	Load
Rating of the inverter	48V/200VA
Conversion Efficiency	90%
Load PF	0.9 absolute
FR/FC system Float voltage	54V
Battery average voltage during discharge	45.6V (24 X 1.9 (average cell voltage during discharge))
Inverter Full load Current for :	Power plant : 4.57A (200/0.9/0.9/54) Battery : 5.41A (200/0.9/0.9/45.6)
Expected “No AC mains” or standby hours i.e. battery back-up (Max)	24
Inverter load for battery (in above case).	((200/(0.9X0.9))X24) =5926WH or 130.0AH

d) Load such as soldering bolts headlights etc. which have not been covered in a) to d) above :

Requirements	Load
For power plant	110W or 2A
For battery @ 2hour/day	220WH or 4.8AH

f) Total Load per day :

Requirements	Present	Ultimate
For power plant :	2.09A + 1.76A + 4.57A + 2A = 10.42A	3.44A + 2.24A + 4.57A +2A = 12.25A
For Battery (in AH)	50.16 + 7 + 130 + 4.8 = 191.96AH say 192 AH	82.6 + 9.7+130.0 + 4.8 = 227.1AH say 227 AH

2. Battery (VRLA) and Power Plants Sizing :

A. Small Capacity Power plant Systems

a) Basic Inputs :

S.No.	Requirements	Present	Ultimate
i.	Equipment Load	10.42A(includes Equipments, Inverters and other loads)	12.25A(includes Equipments, Inverters and other loads)
ii.	Battery Back-up	24 hours	24 hours
iii.	AC Input Range	90 V to 300V Single phase	90 V to 300V Single phase
iv.	Rack Height	1500 mm	1500 mm

b) Battery bank Calculations :

For Present and Ultimate Load :

S.No.	Requirements	Present	Ultimate
a)	Daily load	192AH	227AH
b)	Battery Bank	192/(0.8) = 240AH	227/(0.8) = 284AH
c)	Battery capacity Proposed	2 X 150AH	2 X 150AH
Where 0.8 is the permissible Depth of Discharge			

Conclusion : As the batteries of the same capacity shall only be paralleled, the option available is to choose the two battery of a capacity of 150AH for the composition of the battery bank. Which will be sufficient for both present and ultimate load.

c) Power Plants calculations :

The following calculations may be taken as sample calculation for the designing of SMPS Power plant :

Note : Number and rating of basic module shall be so chosen that the power plant would be capable of meeting the ultimate load requirements and at the same time provide sufficient redundancy.

Calculations

S.No.	Requirements	Present	Ultimate
a)	Equipments load	10.42A	12.25A
b)	Battery Load (charging requirements of two, 150AH batteries as calculated above)	30A	30A
c)	Total Load	40.42A	42.25A
d)	Factor to prevent power plant more than 90%.	45A	47.0A
e)	Power plant configuration for different module ratings : 25A basic module 12.5A basic module 6.25A basic modules	 2 + 1 (Load + redundant units) 2 + 1 (Load + redundant units) Not suitable as ultimate capacity of these power plants is 25A	 2 + 1 (Load + redundant units) 2 + 1 (Load + redundant units) Not suitable as ultimate capacity of these power plants is 25A
f)	Power plant system proposed 25A basic module based system 12.5A basic module based system	 3 modules of 25A of 25A/200A SMPS Power plant system 6 modules of 12.5A of 12.5A/200A SMPS Power plant system	 3 modules of 25A of 25A/200A SMPS Power plant system 6 modules of 12.5A of 12.5A/100ASMPS Power plant system
g)	Proposed battery	2 X 150AH	2 X 150AH

d) Power plant for Flooded Lead Acid batteries :

In case the flooded batteries are selected for the system, the power plant selected shall be compatible with :

- Conventional Lead Acid Batteries.
- FR-BC modules shall be selected as per the battery capacity requirement.
- The power plant shall have a provision, in DSCA unit, for cutting in and out of any of the battery set from float bus to connect it to the boost bus. The number of FR/BC modules shall be calculated as given below :

Capacity of the battery Chosen	150AH(as calculated above)
Charging Current required	15A
FR/BC modules required 25A basic module 12.5A basic module	 1 2

Proposed Power Plant system configuration :

Basic module	Number of FR/FC modules		Number of FR/BC modules	
	Present	Ultimate	Present	Ultimate
25A	2	2	1	1
12.5A	4	4	2	2

Note 1 : Number of FR/BC modules are as per battery AH capacity and will be same for present and ultimate system capacity irrespective of the number of batteries at present and ultimate.

Note 2 : In case redundant unit is faulty defer the boost charging till it is repaired or replaced

B. High capacity Power Plants :

Basic inputs :

S.No.	Requirements	Present	Ultimate
i.	Equipment Load	400A(includes Equipments, Inverters and other loads)	800A(includes Equipments, Inverters and other loads)
ii.	Battery Back-up	6 hours	6 hours
iii.	AC Input Range	320V to 480V Three phase	320V to 480V Three phase
iv.	Rack Height	2200 mm	2200 mm

Calculations :

a) Battery bank Calculations :

S.No.	Requirements	Present	Ultimate
a)	Daily load	2460AH (calculated in the same way as in (1))	4860H(calculated in the same way as in (1))
b)	Battery Bank	2460/(0.8*0.83) = 3705H	4860/(0.8*0.83) = 7319AH
c)	Battery Proposed	2 X 2500AH	3 X 2500AH
Where : 0.8 is the permissible Depth of Discharge : 0.83 is the battery effective capacity @ C/6 discharge			

Conclusion : As the batteries of the same capacity shall only be paralleled, the option available is to choose the two battery of a capacity of 2500AH for the present composition of the battery bank. While one may be added at the later stage whenever required.

Note : It may be ensured that proper cell matching (capacity, voltage and conductance) has been done within the battery bank and also the parallel batteries have also been matched for voltage, capacity and conductance.

b) Power Plants calculations :

The following calculations may be taken as sample for designing SMPS Power plant :

Number and rating of basic module shall be so chosen that the power plant shall be capable of meeting the ultimate load requirements and also provides sufficient redundancy.

Calculations

S.No.	Requirements	Present	Ultimate
a)	Equipments load	400A	800A
b)	Battery Load (charging requirements of proposed 2500AH batteries as calculated above)	250 X 2 = 500A	250 X 3 = 750A
c)	Total Load	900A	1550A
d)	Factor to prevent power plant more than 90%.	1000A	1722A
e)	Power plant configuration for different module ratings : 200A basic module 100A basic module 50A basic modules	 5 + 1 (Load + redundant units) 10 + 2 (Load + redundant units) Not suitable as ultimate capacity of these power plants is 800A	 9 + 2 (Load + redundant units) 18 +4 (Load + redundant units) Not suitable as ultimate capacity of these power plants is 800A
	Power plant system proposed 200A basic module based system 100A basic module based system	 6 modules of 200A of 200A/3000A SMPS Power plant system 12 modules of 100A of 100A/3000A SMPS Power plant system	 11 modules of 200A of200A/3000A SMPS Power plant system 22 modules of 100A of 100A/3000ASMPS Power plant system
	Proposed battery	2 X 2500AH	3 X 2500AH

c) Power plant for Flooded Lead Acid batteries :

In case the flooded batteries are selected for the system, the power plant selected shall be compatible with :

- Conventional Lead Acid Batteries.
- FR-BC modules shall be selected as per the battery capacity requirement.
- The power plant shall have a provision, in Distribution and switching unit, for cutting in and out of any of the battery sets from float bus and connecting it to the boost bus. . The number of FR/BC modules shall be calculated as given below :

Capacity of the battery Chosen	2500AH(as calculated above)
Charging Current required	250A
FR/BC modules required 200A basic module 100A basic module	 2 3

The Power plant configuration shall be as given below :

Basic module	Number of FR/FC modules		Number of FR/BC modules	
	Present	Ultimate	Present	Ultimate
200A	4	9	2	2
100A	9	3	19	3

Note 1 : Number of FR/BC modules are as per battery AH capacity and will be same for present and ultimate system capacity irrespective of the number of batteries at present and ultimate.

Note 2 : In case redundant unit is faulty defer the boost charging till it is repaired or replaced

C. Dimension of LVD Contactor, MCB, Knife fuse assembly and bus-bars/cables for load and battery path with respect to the ultimate capacity of SMPS Power Plants :

The following calculations may be followed :

The basic Inputs for calculation :

1.	The ultimate load	X
2.	Redundancy	10% of ultimate load (0.1* X) - worst option
3.	Battery back-up	6 hours
	Battery capacity	6 hours back-up up to 80% DOD (near available capacity)
4.	Battery effective capacity @ C/6	0.83% as per battery GR.
5.	Safety factor	25% of the load
6.	Power Plant ultimate capacity	U

Calculations :

Load Ultimate	X
Battery capacity @ C/6	6X/0.8/0.83 = 9X
Battery charging current @ C/10	9X/10 = 0.9X
Equipment load and battery load	X + 0.9X = 1.9X …………..(1)
Load factors for power plant	90% (power plant is not loaded beyond 90%)
Redundant modules	10% worst case
Power Plant required for load	U X 0.9 X (10/11) = 0.82U …… (2)
From Equation 1 & 2	0.82U = 1.9X **Therefore X = (0.82U/1.9)= 0.43U say 0.45U**
a) Rating of LVD contactor	**0.45U (minimum**) Where U is Ultimate power plant system capacity
b) Rating MCB/Knife fuse assembly	**0.55U** :Taking a safety factor of 1.25 into account
c) Bus-bars and Cables	**0.7U** : Taking 1.5 as the safety factor because bus-bar/cables do not have any short circuit protection.

All the above calculations are based on the presumption that on some occasions only one battery may be catering the load in emergent conditions. These dimensions of contactor, MCB/Knife fuse assembly and bus-bars for exchange bus, and battery path shall be rated as above. However the common bus-bar/cable used for connecting the FR/FCs and DSCA shall be of the rating for the ultimate system capacity.

D. DG Set :

While Choosing the DG Set for a particular station the following factors shall be taken into consideration :

- Power Plant and UPS requirements shall be taken 1.25 X Ultimate input Load of the power plant.
- Other loads (Air conditioning, Lighting, Fans etc.)with their prescribed multiplying factor. The multiplying factor shall be as per equipment specifications.
- Future projections if any
- Type of DG set - Battery push-button start/ Auto Start(Ignition delay if any).
- Fuel tank capacity(for number of hours).
- Continuous run requirements

Individual load calculations for DG set Sizing :

i. Power Plant :

Power plant Ultimate capacity	Say 800 Amps
Power plant Float Voltage	Say 54 Volts
Power plant Conversion efficiency	Say 85%
Power Plant PF	Say 0.9 absolute
Multiplying Factor	Say 1.25
DG Set capacity for power plant	((800*54)/(0.85*0.9))*1.25 = 70588VA **Say 71KW**

ii. UPS System :

UPS Ultimate capacity	Say 100 Amps
Output Voltage	Say 230 Volts
Inverter Conversion efficiency	Say 85%
FR/FC Unit conversion efficiency	Say 85%
FR/FC Unit PF	Say 0.9 absolute
Multiplying Factor	Say 1.25
DG Set capacity for UPS	((100*230)/(0.85* 0.85*0.9))*1.25 = 44214VA **Say 44KW**

iii. Air Conditioners :

Load of each AC	Say 15 Amps
Number of ACs Ultimate	Say 2
Multiplying Factor	Say 1.5
AC PF	Say 0.8 lag
DG Set capacity for ACs	(15*2*230*1.5)/0.8 = 12937VA **Say 13KW**

iv. Other loads (Lighting, fans, soldering irons etc.) :

Total Load summation of each load	Say 500W
Multiplying Factor	Say 1.2
PF	Say 0.8 lag
DG Set capacity for load	((500*1.2)/0.8 = 750Watts **Say 750W**

v. Total DG Set Requirements :

S. No.	Equipment	Load Ultimate	Multiplying factor	DG Set Requirement
1.	Power Plant	800A	1.25	71KW
2.	UPS	100A	1.25	44KW
3.	ACs	15*2	1.50	13KW
4.	Other accessories	500W	1.20	750W
		Total		128.75 KW
Nearest Available capacity may be chosen				

ANNEXUE - 2

Technical Requirements to be specified in the Tender Document.

After short listing the requirements of the system, the Tendering Authority shall furnish the following information in the Tender Document in addition to the GR No. GR/SMP-01/05 JAN 2005 for Power Plant, GR/BAT-01/03 MAR 2004 for VRLA battery, GR/BAT-02/01 JUN 2003 for VRLA batteries for high rate of discharge (UPS) application, relevant BIS specification for conventional Lead Acid Batteries, GR/UPS-01/02 for UPS systems, GR/INV- for inverters etc..

1. Regarding Power Plants and Battery :

a)	Application	Low capacity or High capacity as per GR for SMPS Power plants No. GR/SMP-01/05 JAN 2005
b)	AC Input	Single or Three Phase
c)	Rack Height	1500mm or 2200 mm
d)	Power plant category as per GR No. SMP-01/05 JAN 2005	Refer Clause 1.2.3 (B) of this document.
e)	Basic Modules Rating	6.25A/12.5A/25A/50A/100A/200A
f)	Number of basic modules including redundant units	Present Ultimate
g)	Power plant battery compatibility	VRLA or both VRLA and Convention flooded
h)	Battery Back-up in hours	6 hours/12 hours/24 hours/36 hours/72 hours/any other value
i)	AH Capacity of battery proposed	
J)	Number of batteries proposed	Present Ultimate
k)	Remote monitoring Features	Required/Not Required
l)	Battery Health Check Feature	Required/Not required

Important Notes :

1. **Load shall include equipment load, battery load at C/10 rate of charge and other load (inverter etc.) if any.**
2. **While choosing the power plant the user shall ensure that the redundancy requirement has been taken care of.**

2. Regarding inverters :

a)	Inverter System capacity ultimate	
b)	Rating of basic inverter	
c)	Number of inverters	Present Ultimate
d)	Efficiency of the inverter system under worst operating condition	

Note : Inverter load is for planning the power plant and battery.

3. Regarding UPS System :

a)	UPS System capacity - ultimate	
b)	Rating	Basic inverter : FR/FC Module :
c)	Number of Basic Inverters	Present Ultimate
d)	Number of FR/FC modules	Present Ultimate
e)	Efficiency of the inverter system in the worst operating condition	
f)	Efficiency of the inverter system in the worst operating condition	

Note : FR/FC efficiency is essential for deciding the rating of DG set.
Inverter Efficiency is essential for deciding the battery requirements.

4. Regarding Air Conditioners :

a)	Rating of the Air Conditioners	
b)	Number of Air conditioners Ultimate.	
c)	Power consumption of all ACs	

Note : This is essential for deciding the rating of DG set.

5. Regarding Other loads :

Loads such as Fans lights, Soldering Irons etc.. All the ultimate loads shall be considered for the purpose.

6. Regarding DG Set :

DG set shall be decided for the Ultimate load and shall include the load of power plant, UPS, ACs and other loads :

a)	Rating of DG set in KWs.	
b)	Auto Start or battery Start	Required/Not Required
c)	Delay in case of auto start	
d)	Run time	

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