A SYSTEMATIC APPROACH TO UPGRADING SYSTEMS

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INTRODUCTION

Standby power systems are widely used throughout the telecom, switchgear and control, and uninterruptible power supply (UPS) applications. Users are often confronted with the task of adding to and/or upgrading their existing DC standby power systems. A description of the issues that challenge the user while planning for the addition is presented.

The basic components of the DC standby power system consist of a lead acid battery, a rectifier/charger and a means to distribute the DC power (telecom application). System upgrades may be required for differing reasons: Telecommunication facilities might add additional load equipment, thus increasing the demand on the DC system; Utility substations may add new circuit breakers and relays, thus increasing the demand on the battery and charger; UPS systems may add additional UPS modules and battery strings for longer run times and reliability.

A systematic approach to upgrading existing systems will allow the user to consider what potential problems may occur. The issues discussed herein are not intended to be comprehensive, but rather focus on some of the more common problems seen in the field. While much of the approach seems obvious and intuitive, it is the discipline of following the systematic approach that will prevent unforeseen problems.

REASONS FOR STANDBY POWER SYSTEM UPGRADE

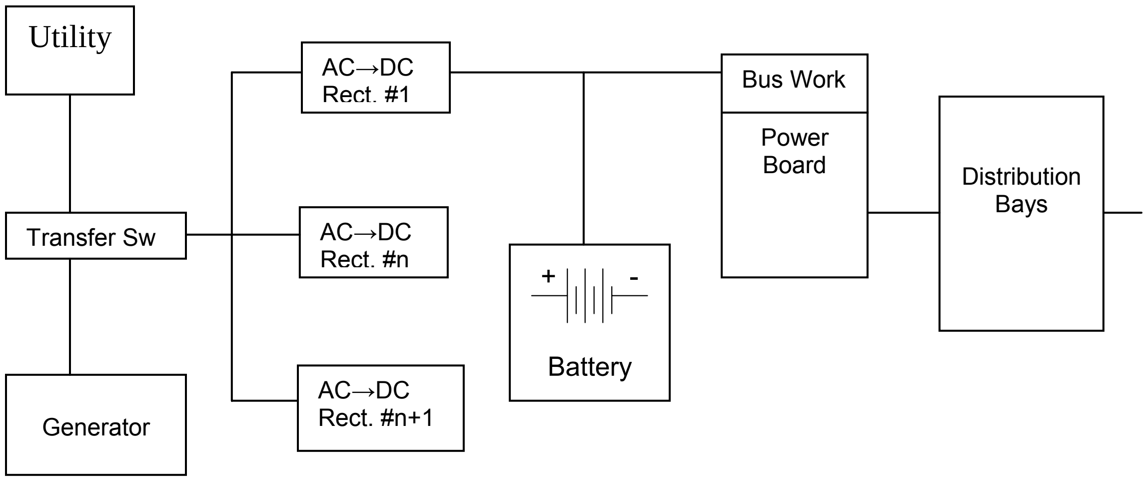
The most common reason for an upgrade to an existing power system is an increase in the load requirements. This can be a planned or unplanned increase not considered in the original system design. Other reasons include: the battery may be at the end of its useful life; difficulty in obtaining replacement parts for the rectifiers, a desire to upgrade to state of the art equipment or to a different technology and topology.

Consider the Existing System

A disciplined approach requires an understanding of the specific engineered parameters of the existing DC standby power system. This can be complicated; often the original design intentions and specifications are incomplete, missing or are no longer appropriate. The general aspects of the existing system design and the specific details for each application will be considered.

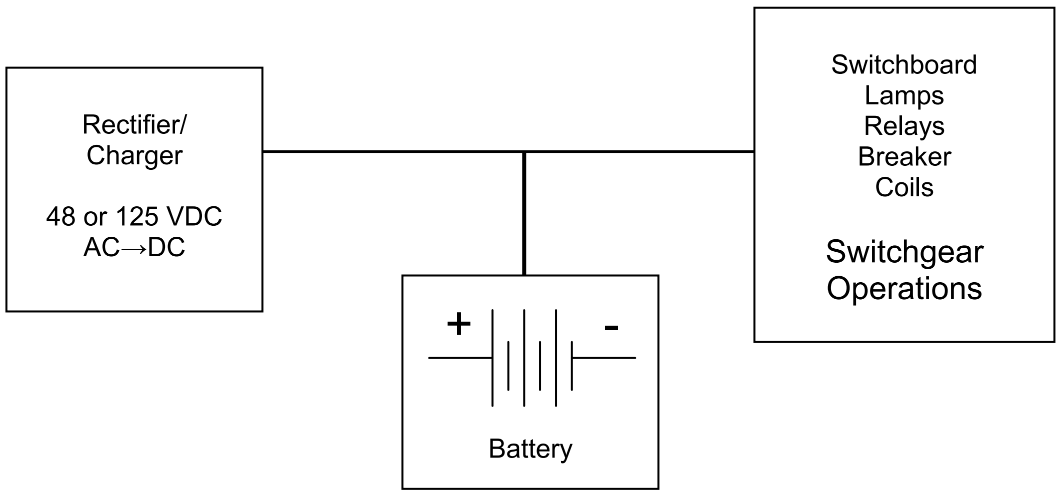
The general aspects of all standby power systems include the maximum output current capability, the footprint and rating of the battery, the number of rectifiers/chargers present and the floor space available for additional equipment.

In the Telecom application, DC power systems will have a maximum current rating. This maximum current rating defines the system capability and must be known in order to determine if the existing system infrastructure is adequate. The rating is based on the current carrying capability of the copper bus work in the power board, termination bus bars or distribution bay. The system can support rectifiers and loads up to the maximum rating of the copper. A well-designed system will not be operating at its maximum capability. See Figure 1.



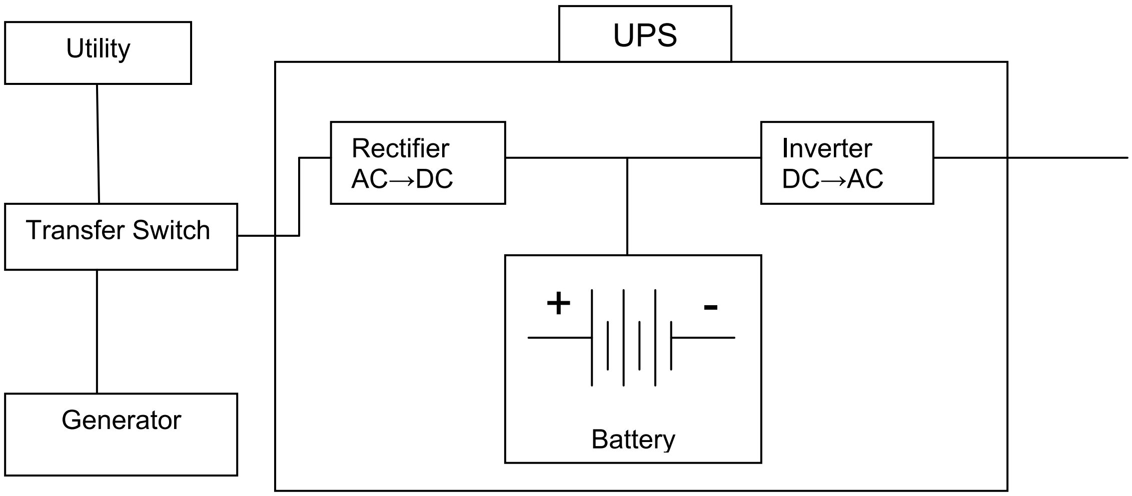
Telecom Application
Basic One Line
Figure 1

In the Switchgear and Control application, DC power systems are defined by the footprint and ampere-hour and one minute rating of the battery. The rectifier/charger is sized to carry the continuous load of the station (1-5 amps, typical) and to recharge a discharged battery within 12-24 hours. The energy to operate the circuit breakers to protect the substation is provided by the battery, not the charger. See Figure 2.



Switchgear and Control Application
Basic One Line
Figure 2

In a typical UPS application, the battery is float charged by the internal charger section of the UPS, which also provides DC power to the inverter section. The battery in the UPS is sized to supply power (kW) to the inverter for a specific amount of time (15 minutes typical) and to a specific end voltage (1.67 volts per cell typical). The inverter provides AC power to the loads. There are variations of this topology; however for the purposes of this discussion, we are concentrating on the battery section of the UPS. See Figure 3.



UPS Application
Basic One Line
Figure 3

Consider the Existing System Engineering Details

The power engineer needs to be aware of the details of the installed system: the physical layout and arrangement of the system may limit expansion. In addition, the floor loading and building infrastructure may limit or require modifications to accommodate the new equipment. The existing grounding scheme must be compatible with the addition or this may be an opportunity to improve what is currently in place. A re-evaluation of the battery load profile should be performed. The use of protective devices in the existing system needs to be reconsidered or recalculated: a short circuit analysis may be in order, the existing cable size and selection criteria should be considered to determine if it is still valid for the addition, the routing method (e.g. conduit, cable tray) of the cable should be assessed for adequacy.

Understand Why the Existing System is Being Upgraded

The reasons for the upgrade can help guide in the selection of the new equipment. An increase in the load being supported by the power system is the most common need for an addition. The power requirements of the load equipment may be changing; for example, an increase in AC loads supported by the DC plant, thus requiring more inverters. The existing power equipment has degraded or aged to the point that it is difficult to find qualified personnel to support it. The philosophy of management and engineering may have changed, thus requiring a different system design and standards.

A typical telecommunications upgrade will include adding new rectifiers to accommodate the increase in load, which can also require additional termination bus work and larger battery systems to support the increased load. Due to the aging power equipment found in many telecommunication sites, the rectifiers and batteries may all be replaced with the latest technologies. This may result in saving valuable floor space and bring the site up to current standards, but should be balanced against system longevity requirements.

A utility substation may require an addition to the existing standby power system due to new equipment installed at the station. The station demand needs to be understood to consider the viability of the battery and charger. A larger battery may be needed and a larger amperage charger or redundant chargers may also be desired.

In the UPS application, the battery strings are typically replaced because they have reached the end of useful life. Factors influencing replacement of the battery are: usage, type, environment and quality of the battery. Parallel strings of batteries can be added for reliability and longer run time. The data center environment is currently struggling with the growth of power hungry servers with critical cooling requirements. This in turn has caused data centers to upgrade the UPS systems, batteries and other infrastructure beyond original design. [1]

Once we have an understanding of what we have in place today and why we need to upgrade, we can begin the systematic approach. We begin with an idea of the end goal, i.e. what the power system should look like and what it should be capable of when we are finished.

Step 1: List Existing Site Conditions and Equipment

Every component in the system should be itemized.

- Rectifiers/chargers - type (technology), model, quantity, age, size, configuration of installation (e.g. load share, spare)
- Batteries – type, model, quantity, age, rating, size, configuration of installation (e.g. parallel strings, disconnects), rack arrangement (e.g. cabinets, 2-tier, 3-tier, stacked modules)
- Power boards/Termination Bus work/Distribution bays – ampacity, size, ratings on copper, meter panels and shunts, low voltage disconnect ratings, breakers/fuses, quantity, type, sizes, availability and landing spaces and hole sizes (type and quantity for cable lugs) of bus work.
- Cabling – size, rating, insulation type, number of conductors, lug type, routing and support (e.g. cable tray, conduit, wire ties, lacing)
- Grounding – ground cable, size, type, termination points, equipment frame safety ground, system power ground (telecom)
- Spill Containment & Safety Equipment – what is in place
- Generator & Automatic Transfer Switch – size, voltage, ratings
- AC Service – capability, single phase, three phase, voltage, sub panels, blank positions
- HVAC System – capability
- Floor Loading/Structural – capability of structure to support additional equipment
- Site Monitoring – what is in place and how is it used
- Review any applicable codes. See if any codes revisions will impact upgrade

Step 2: Analyze Existing Site Conditions and Equipment in Relation to the End Goal

Each item listed above should be analyzed.

- Rectifiers/chargers - new load requirement versus existing capability
  - How many new rectifiers will I need? Can I keep the existing and add on?
  - Do I want/need redundancy and how much design margin should be used?
  - Should the rectifiers load share?
  - What type of rectifier technology do I have/want? (Ferroresonant, switchmode, solid state)?
  - Will the AC service require upgrading to accommodate the new/additional rectifiers?
- Batteries - new back up time versus existing back up time
  - How will the increase in load affect the support time of the existing battery?
  - Is the existing battery viable, does it fit with the overall system design (wet cells vs. VRLA)?
  - A new load profile will need to be calculated (include aging and design margins)
  - Rack arrangement: floor space available and floor loading capability?
  - Does the new system design or load profile require parallel strings? Are disconnects appropriate?

- Power boards/Termination Bus work/Distribution bays - compare existing copper bus work rating in ampacity to new system requirements
    - Can the existing powerboards and/or termination points be utilized? (Is there room to tie in the new rectifiers and battery?)
    - Will the meter panel and/or shunts need to be replaced or upgraded?
    - Will the LVD need to be replaced or removed entirely?
    - Will new distribution (load) circuits be required? What size circuit breakers/fuses and do we need A&B (and C) feeds? Do we need new distribution bays (BDFB/BDCBB)?
    - Where will the new load circuits be located? How will the new cabling be run?
- Cabling – examine existing cabling and routing method (is it adequate?)
    - Calculate and determine the size, type and rating of each cable needed for
        - New load circuits
        - New battery cable
        - New rectifier cable (AC and DC)
    - Layout all cable runs and calculations for allowable voltage drop, protection (circuit breaker/fuse), logistics and method of cable routing.
    - Include the ground cabling
    - Consider compression type, double-hole lugs where possible.
- Grounding – examine existing grounding scheme and methods
    - Follow the NEC, industry practice and standards
    - This may be an opportunity to improve on the system ground network
    - All new equipment must be grounded
- Spill Containment & Safety Equipment – new installations of wet cells typically will require spill containment
    - This may be an opportunity to retrofit existing wet cell battery systems with spill containment
    - The inclusion of spill containment will require additional floor space around battery rack and must be included in design and layout
    - Review of current signage, safety items and PPE (personal protective equipment) in the power and battery rooms
- Generator & Automatic Transfer Switch – review of sizing and rating of generator system
    - Is the generator and automatic transfer switch rated and sized properly to accommodate the new power equipment
- AC Service – review of the AC service
    - Is the AC service in the power room adequate to properly feed the new rectifiers
    - Will new sub-panels be needed
- HVAC System – review the heating, ventilation and air conditioning system
    - Is the HVAC system adequate to accommodate the addition of new rectifiers and batteries?
    - Wet cell batteries need ventilation to limit the accumulation of hydrogen gas.
    - Is the HVAC system capable of cooling the load equipment?
- Floor Loading/Structural – examine the structural capabilities of the existing facility
    - Will modifications be required to the flooring to accommodate the new batteries?
        - A weight spreader plate can be utilized for some modular stacked battery configurations; in some cases, an I-beam can be installed under a battery on a raised floor
    - If suspended overhead cable tray is utilized, consider the structural capability of the roof or ceiling. Will it handle the additional cabling and tray?
    - If conduit is utilized, analyze the method and route of adding new runs.
- Site Monitoring – review what is currently in place and how it is used
    - What is needed for the future?
    - Ethernet/TCP/IP connections, dry alarm contacts, battery & cell monitoring, site parameters
    - New power equipment should be selected with site monitoring requirements.

Step 3: Selection and Specification of New Equipment

The new equipment must be integrated into the existing system. Industry standards and codes should be incorporated into the selection to meet the requirements of the application.

- Rectifiers/chargers – quantity and size based on total requirement (including design margin), future loads, redundancy and battery recharge requirements. Type and model may be dependent upon existing rectifiers and space available.
- Batteries –size for demand profile, include aging and design margins in accordance with IEEE Standards and engineering requirements. If utilizing parallel strings, make sure they have the same float voltage requirements. Specify battery disconnects if needed for the application.
- Power boards/Termination Bus work/Distribution bays – add new as needed for capacity and future growth, in addition to the design margin.
- Cabling – add as needed for interconnecting new equipment to existing and specify lug type
- Grounding –all new equipment additions must be grounded, per industry standards
- Spill Containment & Safety Equipment – add as necessary to meet applicable codes
- Generator & Automatic Transfer Switch – size to accommodate additional equipment
- AC Service – upgrade as necessary and provide proper service to rectifiers
- HVAC System – upgrade as necessary to accommodate the new power equipment and load equipment
- Floor Loading/Structural – accommodate the additional power equipment as needed; specify any structural changes
- Site Monitoring – include as required by the application, must be specified.

PLANNING FOR THE UPGRADE

Installation and maintenance should not be ignored during the specification phase. Be sure to include adequate space to allow and encourage proper maintenance, repair and testing of equipment. The installation procedures should be reviewed and clarified by utilizing a Method of Procedure (a detailed step by step description of the installation process). The installation should be planned so as to minimize risk to the operations, such as maintenance window work, protecting the site with the generator, and bringing in a temporary battery and/or chargers.

MODULAR OPTION FOR UPGRADES

Many power systems designed today are based on a flexible model to accommodate the present and future system needs. They are modular in concept and allow for growth as needed. The power boards and distribution bays can be added as needed for additional distribution. The rectifiers are plug in type which allow for easy installation and growth within the bays. Battery strings can be added as needed to meet the desired back up time as the load increases. Of course, this concept isn't really new; it just makes for an easier implementation. The installation requirements are the same and need to be well thought out. The facility infrastructure should also be designed to account for the future system needs.

SUMMARY

Take a big picture look at your system and attempt to realistically include future loads. Consider where you are today and how you got here. An upgrade to your system should be viewed as an opportunity to improve on what you have and to correct any past mistakes. Due diligence is necessary to avoid the problems often encountered when adding to existing systems. Thoughtful and careful analyses of what your system consists of today, what your needs are, and where you want to be in the future will help prevent many common mistakes.

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