Streamlining The UPS for Peak-shaving Mission-Critical Applications

Introduction

Peak shaving is a technique deployed to compensate the demand of peak electrical power, consumed by typical loads from the utility source. It helps in effective power utilization, subsequently bringing down the penalties for the billing period significantly.

In this paper, we will shed light on how a UPS can help enterprises in reducing the peak power demands of their mission-critical applications. We will also emphasize the benefits of these solutions. Moving forward, the paper includes step-by-step instructions that will help in choosing the appropriate UPS capacity and battery strength to feed the base and peak loads of mission-critical equipment.

Solution Opportunities

Load is the amount of current being drawn by all the components (appliances, motors, machines, etc.). Load is further categorized as base load and peak load, based on the nature of the connected electrical components.

Base Load is the minimum level of electricity demand over a period of 24 hours. The basic purpose of the Base load is to provide power to components that are running round-the-clock perennially.

Peak load is the maximum or the highest demand of electric power over an extended period of time. These peaking demands are often for shorter durations. (Figure A depicts the base load vs. peak load graph)

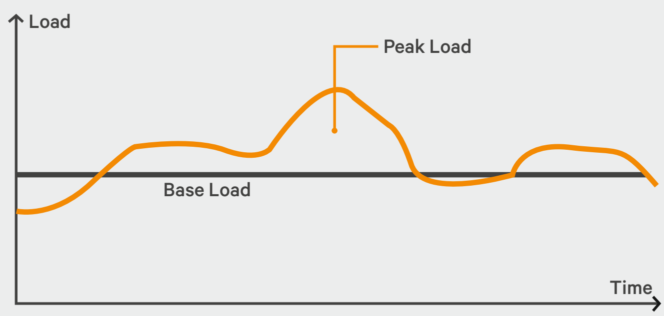
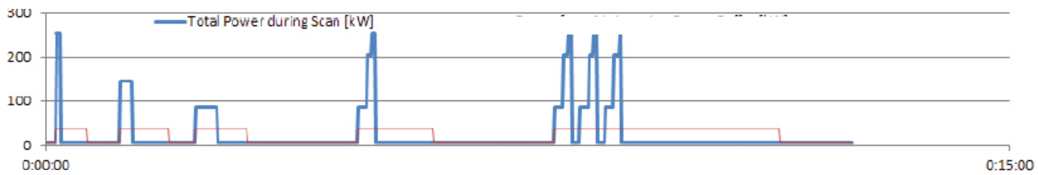


Figure A - Base Load vs. Peak load

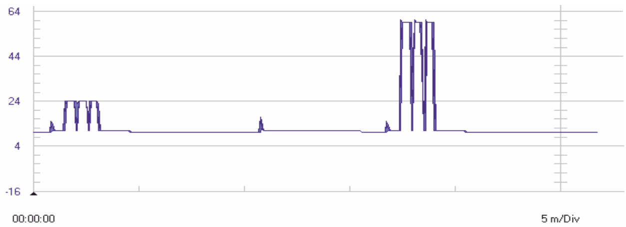
Process industry loads, high-end CT equipment, and plasma machines are some of the few critical applications that demand variable peak power for a short time frame in operating mode. The typical load characteristics of the CT Scan and the induction hardening process are shown in the following graphs respectively :

Healthcare

CT Scan Load characteristics



Process Industry



Induction hardening process Load characteristics

Therefore, to tackle these demands, organizations usually opt for the following solutions:

- Extra-large capacity utility source & its subsequent electrical distribution network
- Load Shedding of non-critical loads
- Peak-sharing methodologies (to avoid the burden on these power utilities)

The preceding techniques are best suited for long duration peak demands. However, in the case of dynamic peak demands, enterprises still have to oversize the capacity of upstream distribution networks (if selected), which accounts for an extremely expensive option.

In contrast, consider if an enterprise wants to add a new load to the existing distribution system where it can support only base demand and not variable peak power demand. In such scenarios, when there are occurrences of un-estimated peak demand, the enterprises are forced to revamp or add additional capacity (as per the requirements) to compensate for the peak demand at the existing upstream distribution side. But this design plan can be extremely tedious to implement in today's complex ecosystems where every minute of uptime matters.

In these situations, the goal is to avoid the installation of additional capacity to support variable peak loads. Instead, a tailored Liebert UPS, in conjunction with batteries, provides fast response and emission-free operation, making it an optimal solution for these critical applications.

Working principle

In this section, we will explain the working principle during Normal Base Load and Peak Load conditions:

Normal Base Load condition

The UPS inverter continuously supplies the critical AC load. The rectifier derives power from the commercial AC source and converts it into DC power for the inverter and battery charger. The battery charger, in turn, keeps the battery in a fully-charged and optimal operating condition. The inverter, on its part, converts the DC power into clean and regulated AC power, which is then supplied to the critical load (conditioned line).

Refer to Figure B to see a schematic illustration of the working principle of a normal Base Load condition:

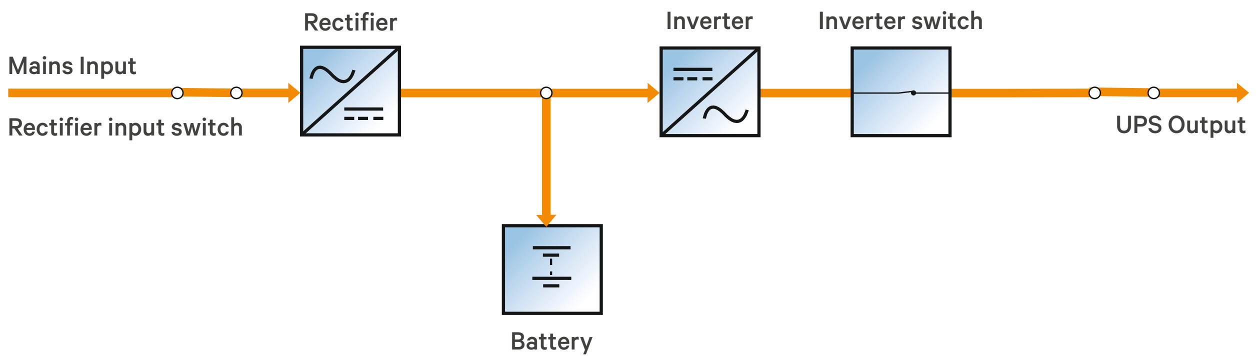


Figure B - Normal Base Load condition

Peak Load condition

Peak loads can be supported in two ways, namely-

- Using Batteries
- Using the Utility + Batteries

Peak Load demand supported by using batteries

By setting an input current limit to the available sanctioned power, the UPS seamlessly transfers the load to the batteries, once the current reaches the pre-defined limit. This method is supported by all Vertiv UPS products. Refer to Figure C to see a schematic illustration of the working principle of the Peak load condition using batteries only:

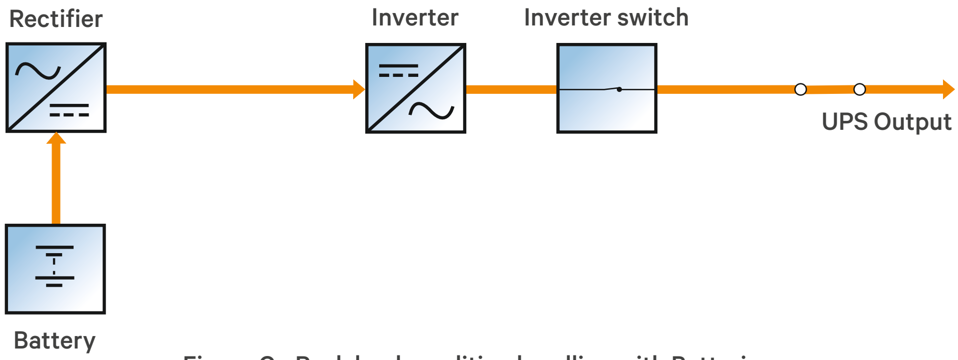


Figure C - Peak load condition handling with Batteries

Peak Load demand supported by a combination of the Utility source & the Batteries

The critical load will be supported by both the utility source as well as the batteries, once it reaches the peak load. Since the utility is working in conjunction with the batteries, the battery backup time can be optimized further. However, remember that this arrangement is not supported by the UPS built on the Vienna rectifier topology. Refer to Figure D to see a schematic illustration of the working principle of the Peak load condition using a combination of the Utility and the batteries:

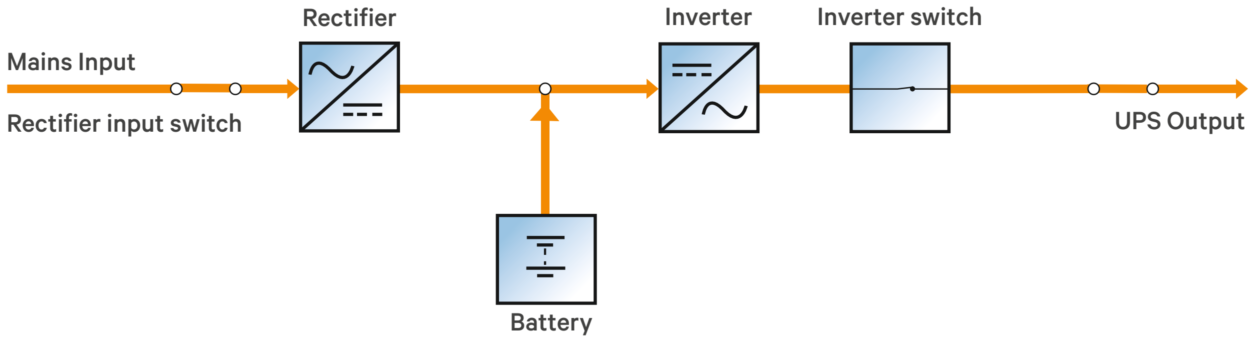


Figure D - Peak load condition handling with Utility + Batteries

Note:

1) *In both the scenarios, the UPS & batteries will be sized for peak power demand.*
2) *Since the bypass source doesn't support peak demand of this capacity, the bypass should ideally be in disabled mode. Therefore, Vertiv recommends that sufficient backup time should be taken into consideration. Vertiv also recommends the installation of a beacon/buzzer for pre-warning alarms for the battery. This will be instrumental for alerts, notifications, and safe shutdown of critical loads.*

Solution Benefits

- Significant cost savings in electricity bills due to reduced peak demand.
- Eliminates the need of an expensive large capacity utility source for peak demand.
- Reduced capital costs in the electrical distribution system.
- Utilities reduce the OPEX associated with the generation of power during the peak period.

Steps to evaluate the Effectual capacity of the UPS & battery

Following are the few factors that have to be considered to conclude the effective capacity of the UPS and battery :

1) Gather information about the points mentioned in the following list:
    - Utility Sanctioned Power
    - DG Power
    - No. of Power interruptions/day/week
    - Source Changeover period
    - Required battery autonomy time

2) Study the critical load behavior – Capture the power demand fluctuations by connecting the power quality analyzers for a certain timeframe depending on the load cycle. Else need to request the OEM to share equipment specifications for further analysis.

3) Capture and analyze the trends for the following:
    - Base Load
    - Peak Load
    - Peak Load Intervals

4) Once all the preceding information is obtained, analyze and calculate the required optimal UPS capacity that caters to the base and peak loads as well as battery charging.

5) Choose the effective capacity and battery types required to support the peak load; also take factors such as frequency and duration into consideration while calculating the appropriate capacity and battery type.

Typical Example to derive right sizing of the UPS & battery autonomy time

Parameters	Value	Measurement units
Input source capacity	250	kVA
Input DG capacity	250	kVA
No of power interruptions per day	1	
Duration of a power interruption	10 to 30	min
Utility to DG Transfer time	1	min
Load peak power	300	kW
Peak Load power factor	0.9	Lag
Load peak real power	333.3	kVA
Peak power duration	5	min
Frequency	3	times in a day
Load Safety shutdown time	5	Min
UPS Capacity = (peak power + safety factor)	400	kVA
Battery Backup time=(Transfer time+(Peak power duration* frequency)+safety shutdown time+safety factor)	21	Min
The Battery type is based upon the number of cycles handled, the battery life, and the recharging period	Lead-acid	

Summary

The UPS Peak Shaving technique is not only tailored to satisfy the requirements associated with peak power demand but also reduces the downtime and operational expenses significantly. This methodology is well-positioned in the following scenarios where maximum savings can be realized :

1. In green field projects, where the enterprise sometimes need to oversize their facility's electrical distribution network to tackle the peak demands of few mission-critical applications.
2. When the existing distribution system doesn't support the addition of new mission-critical applications that have peak demand requirements.

Essential aspects to be considered include a detailed study and analysis of the electrical distribution system as well as the load behavior prior to arriving at the appropriate size of the UPS and the type of battery along with its autonomy period.

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