High Efficiency UPS
Operating Modes

A Hedge for Uncertain Data Center Utility Costs

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Caveat!
No one UPS is all things to all people!

- What is Your Overall Data Center Strategy?
  - Redundancy WITHIN the data center vs. redundant DATA CENTERS
  - Bricks & Mortar vs. Containerized or other pre-fab
  - New construction or renovation/expansion of existing sites
  - Criticality of the data

- Efficiency
- Flexibility
- Availability
- Maintainability
- Expectations, training, and competence of operators
  - Safety
- Regional conditions, regulatory environment, plus energy availability and costs
- WHAT WILL THE FUTURE LOOK LIKE?
The Need for Energy Efficiency

- Efficiency and cost containment are among the top concerns of data center managers
  - 2010 DCUG report: 44% of Data Center Managers cited it as their top concern

- 5-6% of a data center’s utility cost goes into powering the uninterruptible power supply (UPS)
  - Typical Enterprise UPS operate at 92% - 94% efficiency
    (Legacy <90% efficient, new technology > 95% efficient in double conversion)
  - Example: Utility costs of $700,800 to power the IT
  - $67,000 goes to UPS operation (losses)

- Energy saved reduces cooling load (1 watt to cool 3 watts)

Ex: A 5,000 sq ft data center, 800 kW of IT @ 10 cents per kwhr
First: What Limits UPS Efficiency?

- Losses occur during the conversion of current

<table>
<thead>
<tr>
<th>Loss Category</th>
<th>Typical Loss Range</th>
</tr>
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<tbody>
<tr>
<td>Rectifier (AC-DC) Losses</td>
<td>1.8% - 2.5%</td>
</tr>
<tr>
<td>Inverter (DC-AC) Losses</td>
<td>1.9% - 3.5%</td>
</tr>
<tr>
<td>Cooling / Controls etc.</td>
<td>0.7% - 1.8%</td>
</tr>
<tr>
<td><strong>TOTAL LOSSES:</strong></td>
<td><strong>4.4% - 7.8%</strong></td>
</tr>
</tbody>
</table>
Efficiency Improvement Opportunity

- Ability to improve the efficiency of the UPS
  - By literally bypassing the inverter and rectifier
  - Shutting off unneeded systems (inverter and/or rectifier, fans, etc.)
    - Switch over to “standard operating mode” when conditions arise

- Significant efficiency gains, especially at high loads
- 2% to 8% improvement
- Increased UPS efficiency translates to lower power bills
- 8% gain translates to $xxxx per year in savings

What’s New?
- Multi-modal UPS’s with sophisticated control algorithms
- Intelligent Paralleling

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![Graph showing efficiency improvements](image)
Three Modes of UPS Operation
(as defined by IEC 602040-3)

VFI: Voltage & Frequency of the output is Independent of the input voltage
- Double Conversion UPS
- Highest level of power conditioning
- **Efficiencies up to 96%**

VFD: Voltage & Frequency of the output is Dependent on the input voltage
- Off-Line UPS
- No power correction (volts in = volts out)
- **Efficiencies up to 99%**

VI: Voltage of the output is Independent of the input voltage
- Line interactive UPS
- Corrects sags, harmonics, input PF, & swells but not frequency
- **Efficiencies of 96% to 98%**
When to Use or Not Use High Efficiency Modes

Three General Approaches

- Based on Utilization
- Based on Site History vs Equipment Tolerances
  - ITIC, IEC, or CBEMA Curves
  - Control Algorithms which manage total power quality
- Avoid based on advanced knowledge of known risk
  - storms, when running on generator

Server Utilization in Virtualized Environment

Power Disturbances vs. Equipment Tolerances

Opportunities for High Efficiency Operation
Risks

- There is a tradeoff between efficiency and availability
- Misunderstanding of UPS performance specs can lead to availability or efficiency results below expectations
- Excessive use of contactors and breakers
  - Shorten the expected useful life and lead to failures and outages
  - Many devices were not designed to operate in this manner
Best Practices

- Consider UPSs which offer multiple operating modes including double conversion.
- Utilize your high efficiency modes when conditions are right:
  - When power quality conditions permit
  - During non-critical times of data center operation
  - When known risk factors are NOT present
- Be aware of conditions that result in high rates of battery cycling and understand how the UPS you choose behaves under those conditions:
  - Impacts choice of UPS and/or battery plant.
- Use advanced control techniques for optimal and automatic UPS mode selection:
  - A UPS which learns and knows when it can safely operate in high efficiency modes
- Look for a UPS which can use the inverter as an active filter while operating in high efficiency (VI) mode
- Utilize a continuous duty static switch instead of momentary duty.
Other Considerations

- When figuring your true savings, use a weighted average taking into account a mixed mode of operation.
- Request the efficiencies for each of the operating modes.
  - EnergyStar will soon release guidelines for efficiency for the various modes.
- There are efficiency advances being made in power distribution as well as UPS.
  - High Efficiency Transformers (TP1)
  - 4-Wire Transformer Free Distribution
- Understand the tolerances of your load.
  - CBEMA (8 ms), IEC(10 ms), or ITIC (20 ms) Compliant
- Understand what power quality tolerances will be maintained in the high efficiency modes.
  - Voltage level to the critical load
  - THDi?
  - Input PF?
Intelligent UPS Paralleling (aka “Circular Redundancy”)

- UPS efficiencies follow a curve; typically less efficient when load <50% of capacity
- When deploying multi-module UPS, loading is often not optimal for efficiency
  - Example:
    - Two 600 kW UPS modules (capacity system) are supporting a 400 kW load, each one is operating at about 33% of its capacity.
    - But, peak efficiency is at 67%
    - Result: 1.4% loss of efficiency
UPS High Efficiency Modes of Operation, “Intelligent Paralleling”

- Stand-by unit idled
- Schedule based on load operations
- Distribute operations to all modules

3 Units @ 25% Load = 91.5% Efficiency
2 Units @ 38% Load = 93.5% Efficiency
Optimizing Multi-Module Operating Efficiencies

Intelligent Paralleling

- Firmware intelligence
- Increases the efficiency of a multi-module system by idling unneeded inverters or whole modules
- Maintains user programmed levels of capacity and distributes off-time equally between modules
- Increases capacity on demand
- Maintains battery charging at all times
  - Several methods used
Intelligent Paralleling + High Efficiency Operating Modes

Optimized Efficiency Levels

![Graph showing efficiency levels over load](image_url)

<table>
<thead>
<tr>
<th>System data</th>
<th>AC/AC efficiency VFI mode @ nominal input conditions with resistive load</th>
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</thead>
<tbody>
<tr>
<td></td>
<td>(%)</td>
</tr>
<tr>
<td>- 25% load</td>
<td>(%)</td>
</tr>
<tr>
<td>- 50% load</td>
<td>(%)</td>
</tr>
<tr>
<td>- 75% load</td>
<td>(%)</td>
</tr>
<tr>
<td>- 100% load</td>
<td>(%)</td>
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</tbody>
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AC/AC Efficiency VFD mode

![Image of EMERSON CLORIDE Trinergy](image_url)
# Summary, Efficiency (AC)

<table>
<thead>
<tr>
<th>Technology</th>
<th>UPS</th>
<th>PDU Transformer</th>
<th>Server</th>
<th>End-to-End Efficiency</th>
</tr>
</thead>
<tbody>
<tr>
<td>Legacy (VFI Only)</td>
<td>Legacy 90%</td>
<td>Legacy 97%</td>
<td>Legacy 84%</td>
<td>73%</td>
</tr>
<tr>
<td>Today - Standard Mode</td>
<td>VFI (Dual Conv.) 94.5%</td>
<td>EPA TP1 98.5%</td>
<td>Today 92%</td>
<td>85.5%</td>
</tr>
<tr>
<td>Today – High Efficiency Modes</td>
<td>VI (Line Interactive) 97%</td>
<td>EPA TP1 98.5%</td>
<td>Today 93%</td>
<td>89%</td>
</tr>
<tr>
<td>VFD (Static Bypass)</td>
<td>99%</td>
<td>No PDU Xformer 100%</td>
<td>Next Gen 95%</td>
<td>94%</td>
</tr>
</tbody>
</table>

**End-to-End includes UPS, PDU and Server from input to 12Vdc**
Conclusions

- High Efficiency Modes and Intelligent Paralleling capabilities provide cost-effective approaches to reducing current and future energy costs.
- Some UPSs can still manage power quality while delivering significant power savings.
- There will be some tradeoffs between availability and efficiency, so consider all the factors in making your decision.
Thank You!

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