

Tech Byte 31: Power Distribution Management For Dual Bus UPS Systems

How to prevent human error from defeating dual bus redundant power distribution designs in datacenters and computer rooms

Introduction

Dual bus redundant UPS designs have become the defacto standard for powering critical IT equipment in computer rooms and datacenters. What makes this design so attractive is the complete isolation between the two distribution paths from sub-station(s) to the actual dual power plugs on the IT equipment. This design, when implemented properly, ensures that any one fault or failure at any point in the electrical distribution system can NOT compromise **both buses**. The critical IT infrastructure, at minimum, must be able to survive any single failure. By accomplishing this “fault-tolerance”, datacenters with dual bus redundant UPS protection experience the highest levels of critical load availability.

However, the theoretical effectiveness of the dual bus redundant UPS design is based on a large assumption. The assumption is that the system will be utilized and managed properly. If not, the dual bus system CAN be defeated, meaning there is a way to compromise the critical load given a single failure, if the owner does not manage the use of the system to enable it to work as designed. To understand how the dual bus redundant UPS system can be defeated and how to best prevent this from happening, this tech byte will begin with a basic overview of a dual bus system, and then offer options for successful power distribution management practices .

Let us begin with a brief review of dual bus redundant UPS systems. To the right, a Tier 4 UPS and power distribution system is depicted in the image from Uptime Institute’s Tier Classification whitepaper. As can be seen, two paths of power are preserved from the utility transformer all the way down to where the IT load is connected. In theory, we should be able to put our finger on any single point on this schematic to indicate a fault location, and at least ONE source of UPS power must still be able to reach the IT equipment.

For the UPS equipment, the size of each UPS would be based on the total IT design load. So if the IT load were say 800kW, then BOTH UPS systems would be 800kW. This allows the infrastructure to lose either UPS bus and still have the capacity to maintain the connected load (assuming all connected loads have access to BOTH UPS buses thru dual cords or source switching).

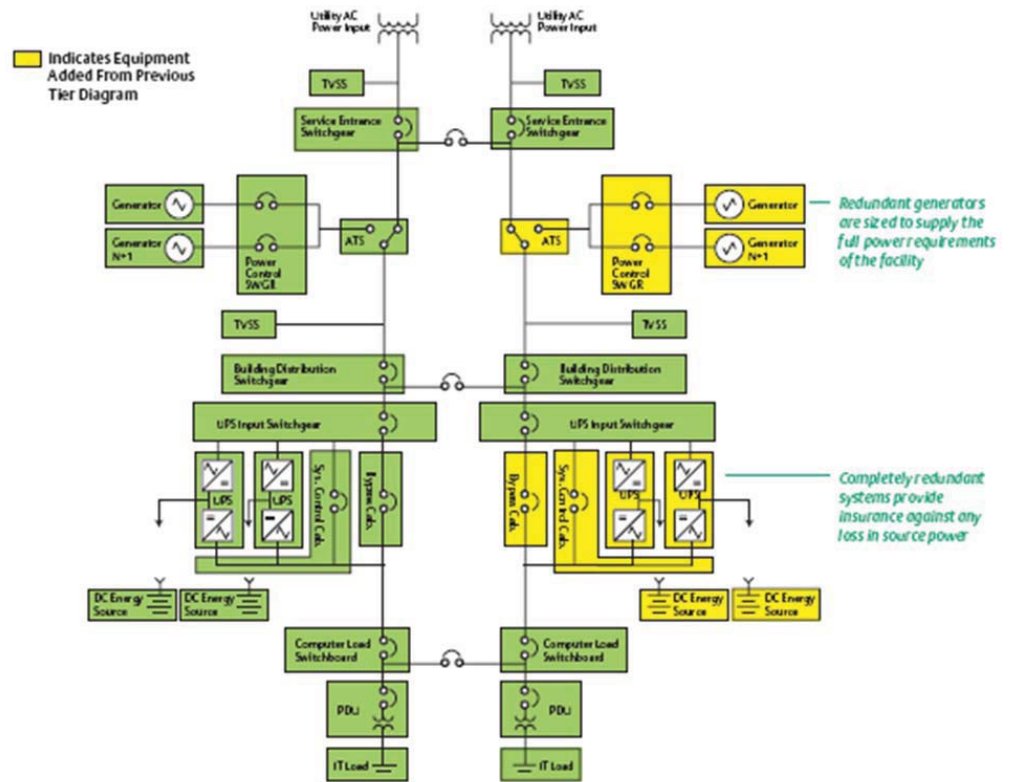


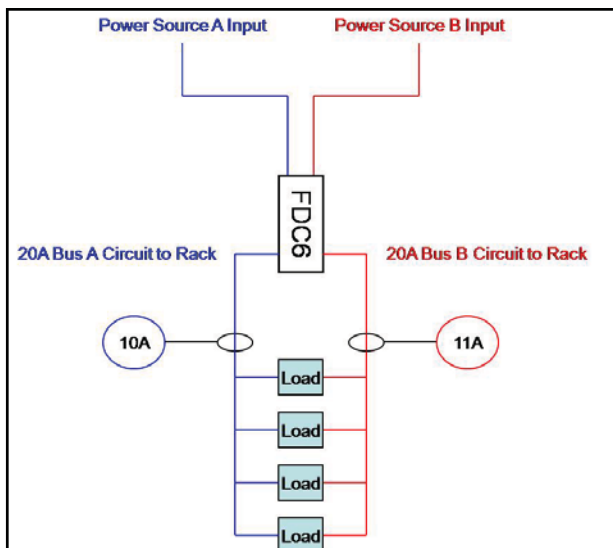
Figure A—Uptime Institute’s Tier 4 Infrastructure Example

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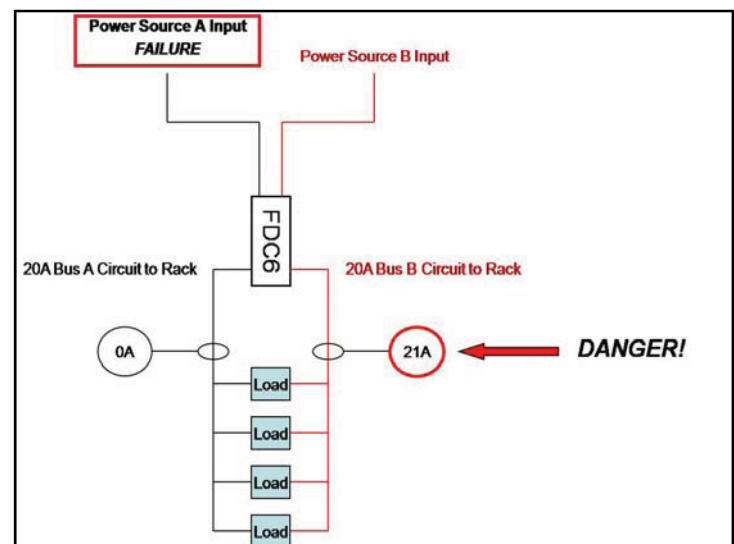
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A real world potential problem enters into the equation when we realize that each 800kW UPS in a dual bus system is inherently limited to half load during NORMAL operation, if either UPS is to carry the entire load during an emergency loss of the other UPS bus. Likewise, the power distribution is also limited. Let us evaluate the power distribution down at the connectivity level. Each piece of IT equipment will most often have two power cords. In preserving the dual bus redundant design strategy, one cord will connect to a Rack PDU powered by UPS bus “A”, and the other cord will connect to a rack PDU powered by UPS bus “B”. Each of these two rack PDUs will be fed by an upstream branch circuit breaker, properly sized for the connected rack PDU. Let’s say for this particular example that these circuits are each fed from a 20A (80% rated) breaker.

Typically, dual cord IT equipment will SHARE their total power demand between BOTH input power cords, when both are available. To make this painfully clear, this means that a total amp draw of 12A would be split 6A on rack PDU “A”, and 6A on rack PDU “B”. So what then happens if we are not actively managing the amount of current draw on EACH rack PDU? Let’s take a look at the example shown in Figure B below to the left. In this example, you can see that during normal operation, everything seems to be ok. All equipment is connected properly and drawing from both UPS buses. However, this system is designed to ensure continuity of the connected load even with a failure of one bus. So what will happen in this example if perhaps we lose bus “A”?



**Figure B — Dual Bus Distribution
Normal Operation**



**Figure C — Dual Bus Distribution
Single Bus Failure Operation**

Bad news. Although we went thru the design efforts and additional costs of deploying a high availability, dual bus redundant UPS system, we were able to defeat it in this case by not managing it properly, as illustrated in Figure C. Branch circuits can NOT be any more than half loaded in a dual bus design with dual cord connected equipment. All of the load current will transfer to one side in the event of the other’s failure. This circuit will, in due time, overload and trip unless we are fortunate enough to recover the second bus before we get to that point.

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A second real world problem has to do with IT equipment installation. The assumption is that with the dual bus redundant UPS system, both cords of the dual input IT hardware will ensure its uptime if one bus were to fail. This assumption also assumes that the IT personnel connect the IT device's power cords correctly. One cord has to go in bus "A" rack PDU, and the other cord must be plugged into bus "B" rack PDU. Figure D below is a picture of the rear of an IT enclosure with dual power strips. What is to prevent the IT folks from using either of these rack PDUs, or using the same rack PDU for each plug? It is NOT AT ALL unheard of to see many devices have BOTH plugs connected to the same PDU. This human error scenario is another way in which a dual bus redundant UPS system can be defeated.

Many IT individuals have their expertise in information technology, not in power distribution systems. They may not have a solid understanding of how the power infrastructure is designed and how it should be utilized. Further, it is common for many IT professionals to believe that the purpose of dual corded devices is that it protects against a loss of one of the internal power supplies in the IT device itself. Within this mindset, it then is understandable why some IT individuals may not see anything wrong with plugging both power cords into the same rack PDU.

Lastly, personnel may come and go over the life of the electrical infrastructure supporting a datacenter. Are new employees going to be trained on the power and UPS design and how to properly deploy IT equipment in the datacenter space? The original staff of the datacenter may be very fluent in proper utilization of the datacenter, but over time, these individuals may move on, inviting a new staff into the space that may not share this knowledge base.

Because of these reasons, a focus on on-going management of the datacenter is as important as the day one design focus. We must design a system that will offer high availability, but we must also give the owner the tools to ensure it stays that way over time. Depending on the owner's comfort level and operational procedures in the datacenter, there are a variety of suitable options for managing the use of the dual bus redundant system. Let us visit a few of these options and discuss the advantages of each.

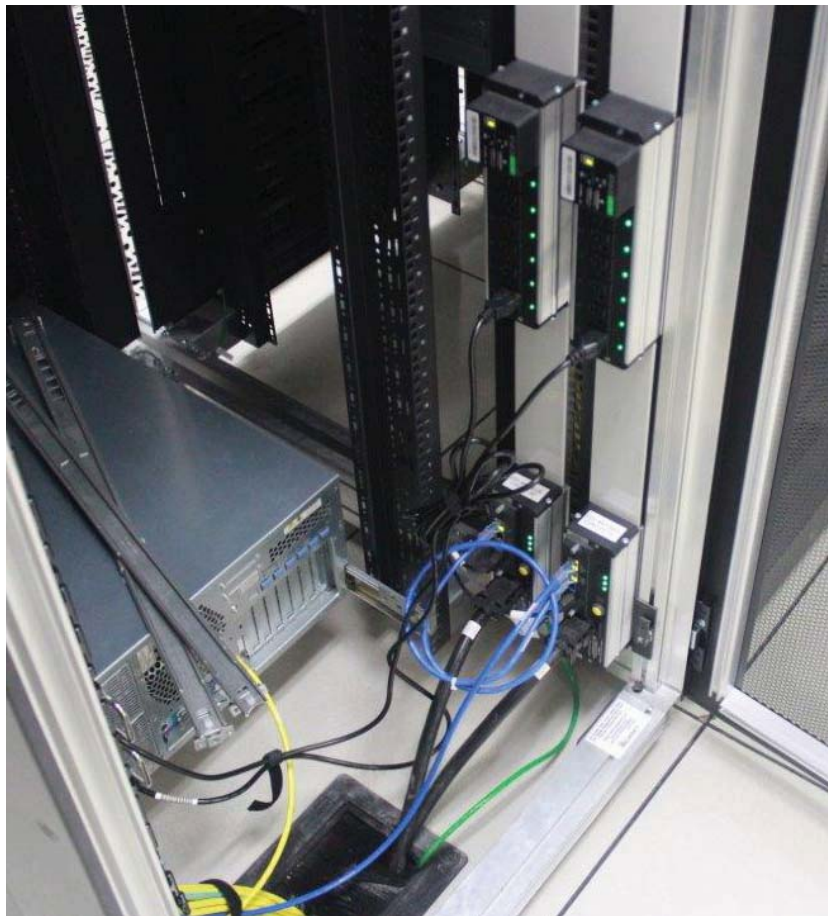


Figure D — Typical IT Enclosure with Dual Rack PDUs

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We will discuss four solutions in this paper. In each, we will define their capabilities as either “passive” or “active”.

A *passive* system will be one that does not take direct action to prevent the undesirable outcome, nor does it prevent the mismanagement that leads to the undesirable outcome. A passive system is one that informs the customer that a potential problem is looming. It is then the customer’s responsibility to take corrective action in response.

An *active* system is one that directly prevents the mismanagement from taking place, or it performs an action to prevent the undesirable outcome.

Dual Bus Redundant UPS Power Management

Option #1 - *Active* Management

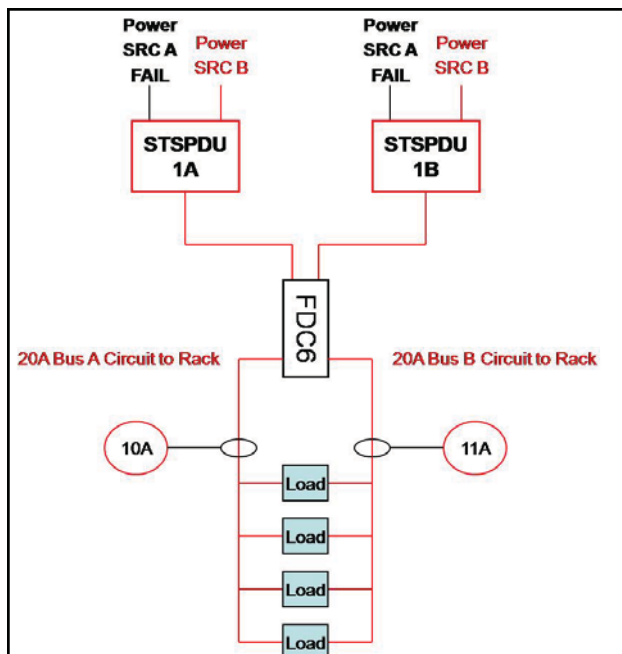


Figure H: System with STS Components
Loss of One UPS

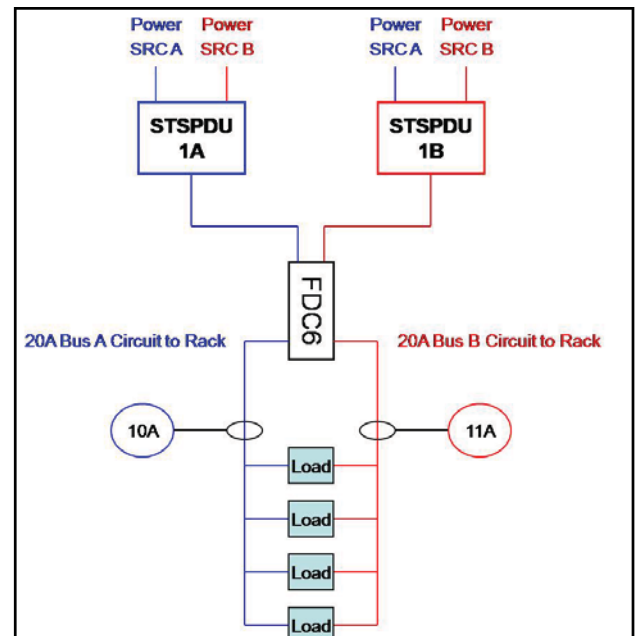


Figure G: System with STS Components
Both UPSs Available

The first option at a customer’s disposal would be an “active” power management system. This system would protect against both of the real world problems detailed earlier in this paper. It would do so not by *preventing* the improper connectivity of the equipment, but by eliminating the undesirable outcome of improper connectivity during the loss of a UPS bus. In this way, this active management strategy would ensure that we do not encounter circuit overloads in the event of a bus outage, and we would not experience IT equipment outages due to a bus failure and both IT power cords being plugged into the same rack PDU.

This active management system involves the use of Static Transfer Switches (STSs) being installed downstream of each UPS system. This system is described in great detail in *Tech Byte 20: The Benefits of Power Switching in Dual Bus UPS Systems*. In brief, the static transfer switches introduce the availability of BOTH UPS systems onto both of the power distribution paths. Essentially each rack PDU can be sourced by either UPS bus. If one UPS bus fails, the STS that was being sourced by that UPS will instantly transfer to the other UPS. The transfer occurs so quickly that it is invisible to the connected load.

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Figure G illustrates how the static transfer switch system operates. All static transfer switches are fed by both UPS systems. In normal operation of a system with only two STSs, each STS will have a different preferred UPS source. In the event of one source failure, as shown in Figure H, the STSs both source from the remaining UPS system. In this way, the branch circuits are always powered, preventing all the current from moving to one of the two feeds to a given rack. By constantly powering both rack PDUs, this system also protects against both equipment input cords being plugged into the same rack PDU.

On top of this, the STS system also TRIPLES the MTBF to both IT cords. This system offers the best in active management and increased connected load availability.

Dual Bus Redundant UPS Power Management

Option #2 - *Passive* Management With *Active* Connectivity Control

The next available option for management of the dual bus redundant UPS system would be a combination passive / active approach, utilizing Smart Rack PDUs. There are a variety of “Smart PDUs” available today. However, that does not mean they all share the same features and characteristics. The Smart PDUs that would qualify for option #2 must have these distinct features:

1. They must have the capability to monitor and manage real time power draw at the branch level
2. They must have the ability to provide user adjustable thresholds for alarming when a branch circuit exceeds a maximum current draw (which for a dual bus system would be 50% of the continuous current rating of the branch circuit). They must include the interface to send alarms to the proper personnel.
3. They must have the ability to control receptacles by locking them on or off. This allows for an administrator to approve of a location for a new IT device install, and only permit certain receptacles being turned on for that device’s purpose. The administrator could then ensure that only one receptacle was turned on in each rack PDU. All other unused receptacles would be turned off. This would prevent the installer from plugging both IT device cords into the same rack PDU, as long as the administrator allocated the receptacles properly.



Scalable Design Allows Onsite Configuration To Fit Immediate IT Equipment Needs.

The Liebert MPX Adaptive Rack PDU features essential characteristics to support fast-paced, growing data centers.

Hot Swappable Output Power
Deploy easily to get IT equipment online quickly

Receptacles & Modules
May be remotely controlled and metered, providing operator flexibility and allowing increased site security

Rack PDU Card (Liebert RPC)
Mounts in the Power Entry Module and provides upgradable network communications, sensor and local display interface

Input Power

- May be reconfigured to support changing power needs, single and three phase input.
- Can be positioned for top or bottom rack entrance.

Liebert Power Monitoring Capabilities

The operation of Liebert MPX can be monitored using:

- Liebert RPC Rack PDU Card.
 - Liebert Nform Monitoring System.
 - Liebert SiteScan® Web Centralized Monitoring System.
 - Secure Web/SNMP Interfaces.
 - Liebert RPC-BDM Local Display Module.

For more information, see page 18.

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An example of this type of Smart Rack PDU is Liebert's MPX product. This rack PDU is not only scalable and completely configurable by the customer, it offers the monitoring and management feature, as well as the receptacle control. As you can see on the receptacle module on the previous page, the arrow is pointing to the green LED that indicates whether or not the associated receptacle is on or off. This feature allows the owner to manage device installation.

The monitoring and management of this MPX Smart PDU is accomplished through a web interface shown below. In the interface, the customer can customize alarm set points to indicate when branch circuits have reached (or are approaching) a maximum current draw, which for dual bus UPS systems would be 50% of the continuous branch circuit current.

The screenshot displays the Liebert PDU Explorer web interface. The top navigation bar includes 'monitor', 'control', 'configure', and 'support'. The left sidebar shows 'Rack PDU Information' for HEDRICK MPH1 and 'System Status' as 'Normal Operation'. The main content area is titled 'PDU Explorer' and features a 'Select a PDU to view:' section with two options: '1 MPH Rack PDU' and '2 MPH Rack PDU'. Below this is a table of supported events and their status.

Supported Events	Status
<input checked="" type="checkbox"/> PDU Low Voltage	Inactive
<input checked="" type="checkbox"/> PDU Over Current	Inactive
<input checked="" type="checkbox"/> PDU Low Current	Inactive
<input checked="" type="checkbox"/> PDU Failure	Inactive
<input checked="" type="checkbox"/> PDU Communication Fail	Inactive
<input checked="" type="checkbox"/> PDU Neutral Over Current	Inactive

Dual Bus Redundant UPS Power Management

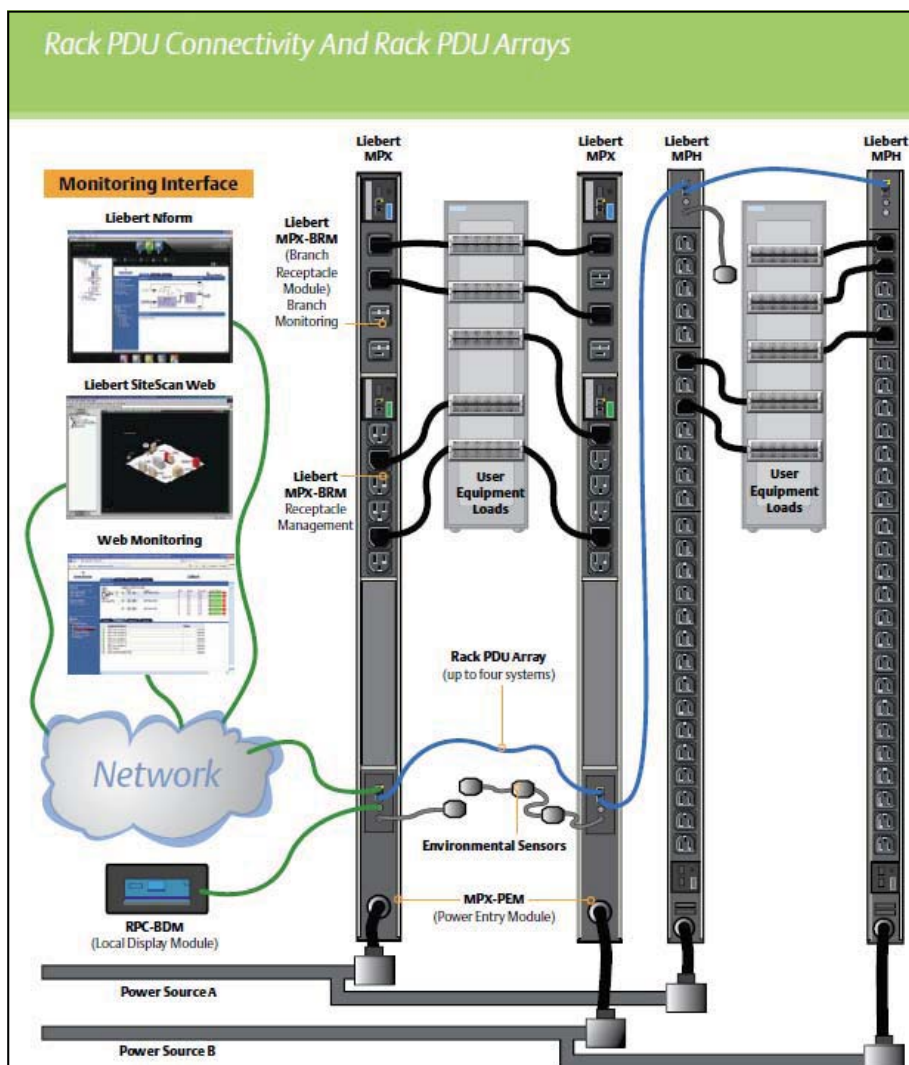
Option #3 - *Passive* Management Thru Rack PDUs

The third option for management of the dual bus redundant UPS system would be a passive approach, utilizing a different style of Smart Rack PDUs. Option 3 would not offer the device connectivity management capability, preventing both IT device cords from being plugged into the same rack PDU, however this option would offer the monitoring and management capability. These Smart Rack PDUs would have these features:

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1. They must have the capability to monitor and manage real time power draw at the branch level
2. They must have the ability to provide user adjustable thresholds for alarming when a branch circuit exceeds a maximum current draw (which for a dual bus system would be 50% of the continuous current rating of the branch circuit). They must include the interface to send alarms to the proper personnel.

An example of this type of Smart Rack PDU is Liebert's MPH product (pictured below to the right). This rack PDU offers the monitoring and management feature, through a web interface, very similar to the MPX. In the interface, the customer can customize alarm set points to indicate when branch circuits have reached (or are approaching) a maximum current draw, which for dual bus UPS systems would be 50% of the continuous branch circuit current. In the image below and to the left, we have an illustration of how the Smart Rack PDUs, customer equipment, and communications interface ties together.



Rack PDU Card (Liebert RPC)

Provides upgradable network communications, sensor and local display interface



Secure Web/SNMP Interfaces

- User configured alarm thresholds
- High alarm and warning; low alarm
- Receptacle state and sequencing configuration
- Electrical metering, volts, amps, kW & kW/hr
- Rack PDU Array—Device consolidation
- PDU Explorer—Intuitive hierarchical interface
- View PDU status by strip or receptacle
- Device Explorer—Browsing by user defined device name



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Dual Bus Redundant UPS Power Management

Option #4 - *Passive* Management Thru Branch Circuit Panel Power Monitoring System

The final option involves a passive management approach utilizing a monitoring system. The previous option utilized Smart Rack PDUs with the capability to monitor the current draw on their respective circuit. This option performs the same function, but at the power distribution branch panel location. Each rack PDU in an IT enclosure is fed from a branch circuit panel somewhere nearby. This could be a wall mounted load center, similar to the breaker panel in a house, or it could be a remote power panel enclosure, designed specifically for computer room power distribution—such as the Liebert FDC (shown to the right). There are products that install inside of these panels that monitor the current draw off from each branch circuit breaker, and provide remote communication and alarming to the administrator. An example of this is the Liebert LDMF branch circuit monitoring system.

The Liebert LDMF utilizes branch circuit sensor modules and individual current transformers (CTs) to monitor current. In addition, the Liebert LDMF monitors options like subfeed and output circuit breakers and provides a full array of power parameters and alarms. The LDMF system can communicate this information and alarm messages to a Building Management System (BMS).

To illustrate how the system works, let's look at a Liebert Remote Power Distribution Cabinet product, the Liebert FDC, pictured to the right. In the FDC, there are four (4) 42-pole, in-line panelboards. The Liebert LDMF would require a CT strip (shown below) installed in the wiring gutter space of each of the FDC's four panelboards. Each circuit's wires would feed through its dedicated CT hole, and then terminate on the branch breaker. These CT strips would then communicate data to the logic boards that would also be housed in the FDC. The logic boards would have remote communication capability to then speak to a BMS system.

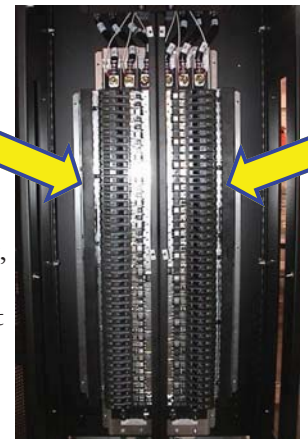


Liebert FDC Cabinet



Liebert LDMF CT Strip

CT Strip installed in panelboard gutter space. One (1) per in-line panelboard.



Liebert FDC Interior

With the Liebert LDMF, the customer would have the ability to set alarming on each branch circuit, to indicate when the current draw has exceeded the pre-set amount. This would allow them the management assistance to prevent overloading a dual bus circuit. However, this solution would not prevent the customer from plugging in both cords of a dual cord device into the same Rack PDU.

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In conclusion, on-going management of a datacenter's power infrastructure is critical to preserving a high availability design. Options exist to provide the necessary management, but it needs to be a more frequent discussion between owner, consultant, and product suppliers at the design stage. This will assist in facilitating a management atmosphere that will lend itself best to each unique customer's business and personnel needs, and result in better availability performance of a dual bus redundant UPS system.



Keeping Business In Business



Liebert STS2 Static Transfer Switch

- Designed for use at 480V
- (2) Inputs fed from the output of (2) independent UPS systems
- (1) Output feeding to downstream power distribution units

Liebert STS2PDU Static Transfer Switch Power Distribution Unit

- (2) 480V Inputs fed from the output of (2) independent UPS systems
- (2) 480V to 208/120V Step Down Transformers
- (1) Static Switch Assembly
- Integral output power distribution options



Liebert MPH Smart Rack PDU

- Monitoring and Management of Power
- Option for Receptacle Control
- 1-Phase and 3-Phase Offerings



Liebert MPX Smart Rack PDU

- Monitoring and Management of Power
- Option for Receptacle Control
- Scalable / Modular for Change Management
- 1-Phase and 3-Phase Offerings