

## Tech Byte 20: The Benefits of Power Switching in Dual Bus UPS Designs

### Achieve Higher System Availability, Increased Protection Against Human Error, and Incorporate a Safety Net Against Circuit Overload Due to Improper Power Management

#### Introduction

Dual bus uninterruptible power supply architectures have long been recognized as the preferred redundancy design for supporting mission critical applications. However, a dual bus design represents only the foundation, or the basic building blocks that a unique, customer-focused power infrastructure is built upon. Beyond selection of the dual bus configuration, many additional decisions must still be made in regards to the functionality and capabilities of the power infrastructure hardware and monitoring technology. These decisions will be based upon the customer's expectations of performance in the following areas, just to name a few:

- **Availability expectations:** Availability performance can still be improved based on technology selections within a dual bus UPS system
- **Maintainability:** The degree of desired maintainability will further affect the dual bus design as we attempt to allow for more maintenance capabilities while not compromising the redundancy integrity as seen by the connected load.
- **The degree of predictive analysis:** Many monitoring technologies exist that can identify performance degradation, allowing for advanced notification of pending problems. This capability greatly reduces downtime for repair and unexpected compromising of system redundancy.
- **The level of automated management:** Although a dual bus design offers the highest theoretical critical bus availability, it can be defeated in real world use if the system is not managed properly. There are technologies that can assist in facilitating management for customers that are not comfortable managing this on their own. This topic will be a focal point of this paper.

One of the most common sources of confusion in the field of uninterruptible uptime is what constitutes a reliable computer room or data center. All too often, reliability is in the eye of the beholder - what is acceptable to one person or company can be inadequate to the next. Competing companies with computer rooms of radically different infrastructure capabilities are all claiming to deliver high availability. With the continuously increasing pressure on high availability comes an increased demand for computer hardware reliability. Information technology customers expect availability of "Five Nines" or 99.999%.

Tier Requirement	Tier 1	Tier II	Tier III	Tier IV
Source	System	System	System	System + System
System Component Redundancy	N	N+1	N+1	Minimum of N+1
Distribution Paths	1	1	1 normal and 1 alternate	2 simultaneously active
Compartmentalization	No	No	No	Yes
Concurrently Maintainable	No	No	Yes	Yes
Fault Tolerance (single event)	No	No	No	Yes

Unfortunately, the substantial investment a business frequently makes to achieve Five Nines in its computer hardware and software platforms is likely to be insufficient unless matched with a complementary site infrastructure that can support their availability goals. The Uptime Institute developed a four-

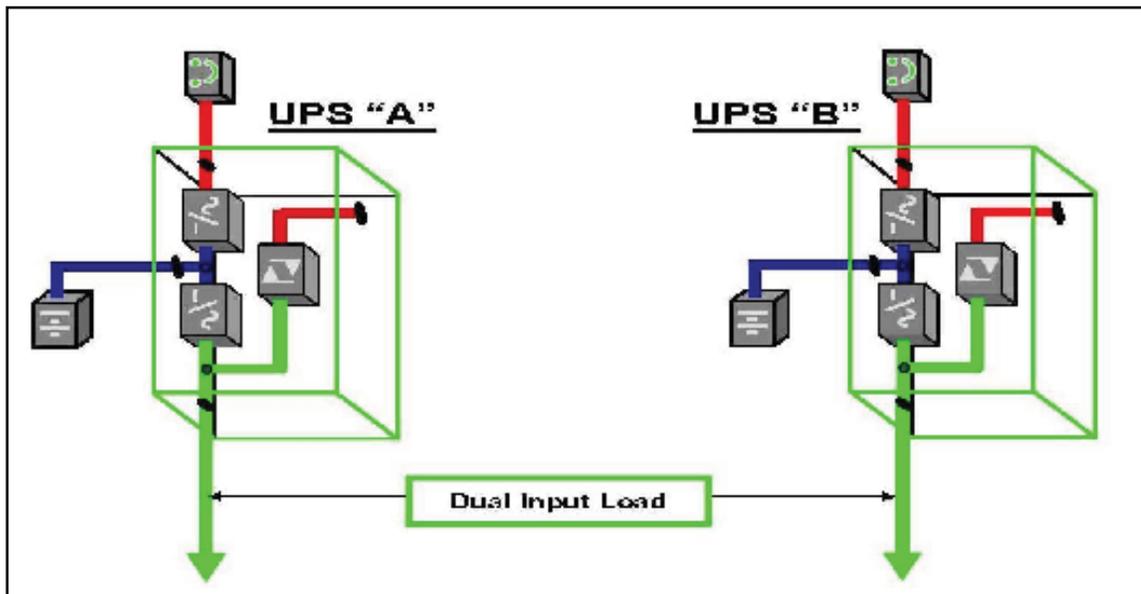
*Figure A—Uptime Institute's Datacenter Tier Classification Requirements*

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tiered classification approach to site infrastructure functionality that addresses the need for a common benchmarking standard. A basic overview of the Tier levels is shown in Figure A on the previous page. As you can see in this figure, Uptime classifies a fault tolerant system with the highest availability performance to be a system with two simultaneously active power sources feeding the critical load equipment. This type of system architecture is referred to as "Dual Bus" or "Distributed Redundant" architecture.

The distributed redundant configuration requires a complete change in UPS design approach. This change is best reflected in a recent Uptime Institute survey of data-processing center downtime. According to survey results, 79% of electrical infrastructure failures that interrupted critical load operation occurred between the UPS output bus and the critical load. ***The emphasis of critical-power-system designers needs to shift from building a bullet-proof UPS system to creating a fault-tolerant UPS and power distribution system.*** This transfers the importance of power maintenance



**Figure C — Basic Dual Bus UPS System Rendering**

from the output of the UPS to the input terminals of the load equipment. Distributed redundancy means creating dual, full-capacity UPS system busses and redundant power-distributed systems. This eliminates as many single points of failure as possible, all the way up to the load equipment's input terminals. To provide fault tolerance, you must provide some method of allowing the load equipment to receive power from *both UPS power busses*. You should design the two ac-power sources to be as independent as possible to eliminate common failures. Switching between the two power sources needs to be break-before-make for the same reason. You can devise several distributed redundancy power configurations. Keep in mind, however, that redundancy needs to be as close to the load as possible to achieve its goal - keeping power available at the load-equipment level.

Uptime Institute classifies this design as a Tier 4 UPS design architecture. Figure C above provides a basic UPS configuration illustration of this distributed redundant architecture. Both UPS modules operate in an independent, redundant fashion, supplying two paths of power to the load.

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This industry accepted practice of deploying dual, independent, and redundant UPS systems is clearly the best method for ensuring conditioned, uninterruptible power is delivered virtually continuously to business critical connected loads. It provides true fault tolerance, defined by the ability of the system to withstand any single failure at any point in the system between utility input and load connection, and still provide a source of conditioned power to all connected loads. However, this design architecture offers this high availability in theory, and **requires proper utilization practices and/or management technology to ensure it is used properly**. In essence, a dual bus UPS system can be unintentionally defeated if the user is not diligent in managing the use of the UPS infrastructure. The main reasons it can be defeated are improper load management, human error during installation of the connected loads, and a internal load power supply failure.

Also, the dual bus architecture can be enhanced to offer higher levels of critical bus availability and fault tolerance, beyond what the basic architecture offers.

Both of these concerns of load management and system availability can be addressed by the integration of dual bus power switching. For enhanced load management and increased availability, a distributed redundancy configuration would not only provide two, independent UPS systems, but also incorporate fast power switching mechanisms (Static Transfer Switches) downstream of the UPSs. This ensures that even during a bus fault, that power from one of the UPS

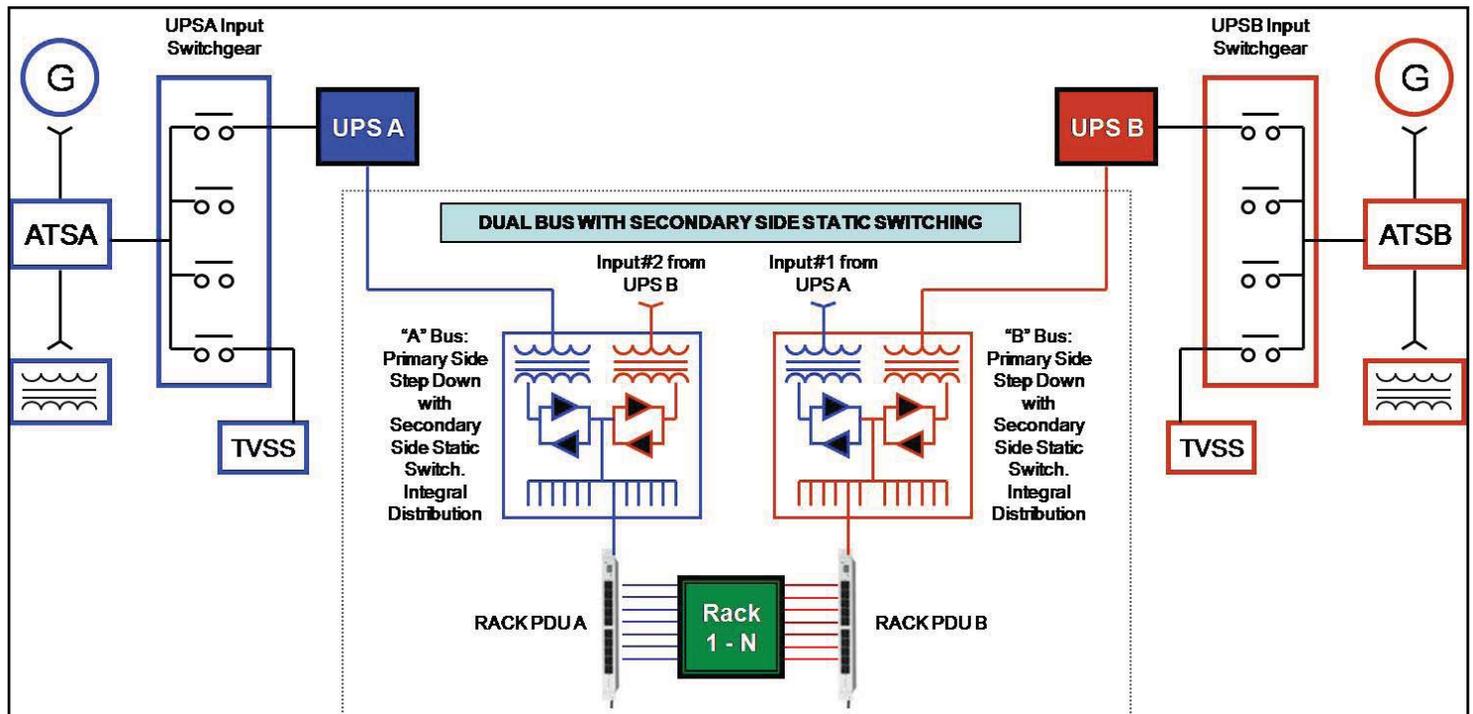


Figure D — Basic Dual Bus UPS System Rendering

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systems still reaches BOTH inputs of the dual corded load equipment. This protects against significant, real world problems which we will discuss below.

The Static Transfer Switch (STS) normally operates with one input feed from each of the two UPS system outputs. If the preferred UPS source of a particular STS fails, the STS then transfers the load to the other available UPS source in approximately a 1/4 cycle - meaning the connected load never knew that power was disturbed.

In Figure D on the previous page, you can see that if the blue UPS bus goes down, all the STS systems would switch over to the red bus, and provide red bus power to each of their respective distribution circuits.

The STSs offer other benefits as well. For example:

- They provide additional tolerance against human error during a UPS bus failure mode or maintenance mode, where system redundancy has been compromised. With one UPS bus down, the system could still tolerate an accidental breaker opening downstream, as the STSs would maintain two paths of power to each dual cord device.
- STS equipment also protects against human error in load connectivity, or computer power supply problems. As a rule of thumb, a loss of one UPS bus can result in a loss of 3% - 8% of connected dual cord loads. **The most typical reasons are both load power cords being erroneously plugged into the same UPS bus when the device was originally deployed, and a failed power supply in the load device.**

They also offer inherent load balancing across the distribution circuits. It is more prevalent today to see dual corded devices that share their power draw from each power cord. This can present a potential problem for IT managers as they add load to each individual circuit.

***It is important to note that any one circuit can not be loaded above half load when feeding dual corded devices.*** The reason is that in a bus failure, all the load that was previously shared between two distribution circuits is quickly transferred onto one circuit.

It is likewise important for users to remember that although two (2) UPS systems are present in a dual bus system, the design intent is for the two (2) UPS systems to operate in a redundant configuration. This means that two (2) 100kVA UPSs, configured in a dual bus design, provide a TOTAL capacity of 100kVA. In normal operation, when both UPS systems are available, there will be nothing to prevent overloading the total system beyond 100kVA, or overloading shared power distribution in the same fashion. The infrastructure can handle the condition as long as BOTH UPS systems are available.

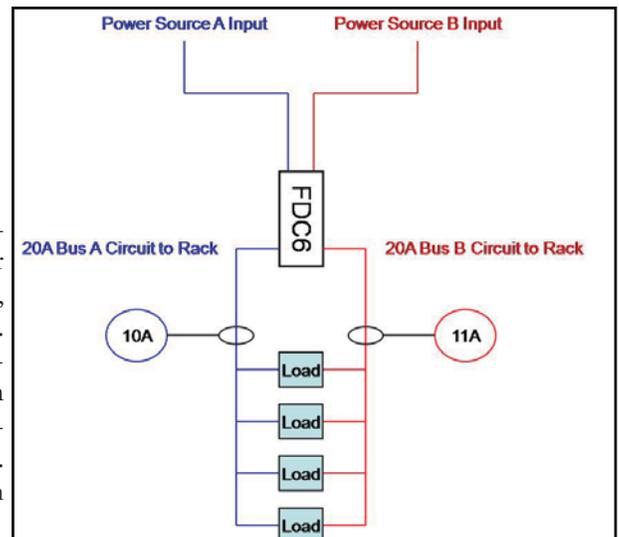
The problem arises when one UPS becomes unavailable, through maintenance or some sort of failure. At that point, the user pays the price for improper power management in their computer room because capacity limitation does come into play at the UPS level and the branch circuit level. All of the system load will transfer over to ONE of the UPS busses. If that total load exceeds 100kVA, the clock begins to tick, as the system is now in overload and likewise, branch circuits can

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This is a detail that many times gets overlooked, and distribution circuits are loaded up beyond the half load point. Without the STS systems, it would be critical to focus on this detail, and manage how the load is distributed onto the power distribution infrastructure. Take this example:

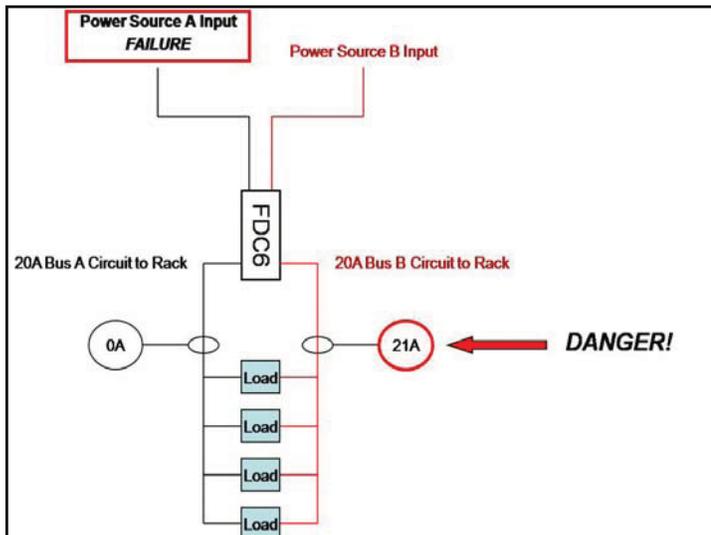
A dual bus UPS system in Figure E is feeding downstream panelboards on the FDC remote distribution cabinet. On two particular 20 amp circuits, each fed from a different UPS system (A or B), there is currently only 10 amps and 11 amps of load, respectively. Because each individual circuit is 20 amps, it can be incorrectly assumed that plenty of capacity is still available on either circuit. In fact, these two circuits would collectively overload one of the circuits in the event of a UPS failure, as can be seen in Figure F. Twenty-one amps would accumulate onto one of the circuits with the loss of the opposite circuit. This is an overload condition.



**Figure E: Both UPSs Available**

As you can see in these diagrams, the benefit of Dual Bus redundancy has been defeated because of the lack of required power management.

There are two main approaches to address the issue of power management in a Dual Bus UPS system. First would be to incorporate sophisticated monitoring equipment, configured to alarm and notify an administrator when branch circuits reach a predetermined load level. This solution would still require attention and due diligence on the part of the administrator. This person must properly set up alarm thresholds, configure notifications, and then require that all equipment changes in the computer room space gain prior authorization before installation.



**Figure F: Impact of a Single UPS Bus Failure**

The second approach would be to incorporate a safety net that would work to ensure that both circuits remain powered even in the event of a single UPS bus failure. This approach involves the use of STS systems. We will repeat the scenario from the previous page, only we will introduce the STS systems in the power distribution.

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Now, *with* the STS systems, the previous course of events will not happen, because even with a UPS bus failure the STSs will ensure that both distribution circuits remain powered. The distributed redundant system with two different STS designs is shown in Figure G.

As can be seen in this figure, both UPS sources are brought to each Static Switch Unit. With the loss of either UPS power source, the static switches will transfer to the available source and provide power to both circuits.

In Figure H, UPS “Power SRC A” has failed, causing static switch system “1A” to transfer from the failed source to UPS “Power SRC B”. This transfer takes place virtually instantaneously, so the connected equipment does not know that an interruption took place. Because of this, the downstream distribution circuits are able to continue sharing the load current and an overload situation is avoided.

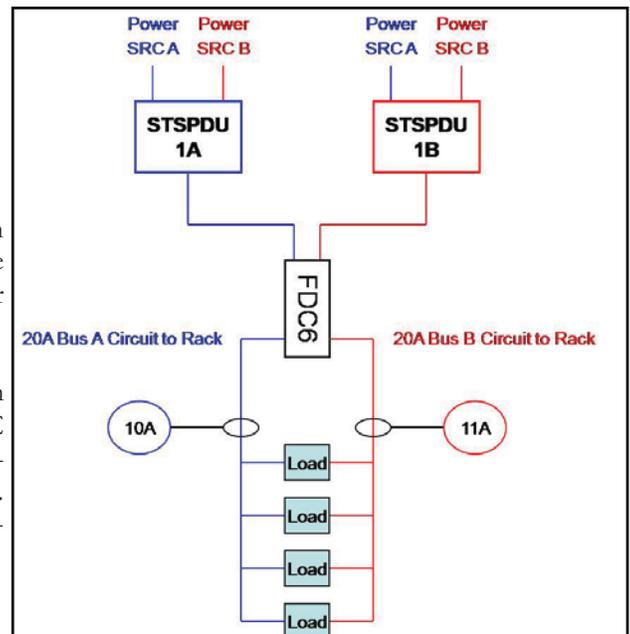


Figure G: System with STS Components

### Conclusion

As you can see in this paper, it is important to balance expectations of critical bus availability attainment with real world practicality. Although we can estimate theoretical values of expected availability as we look at a design on a schematic level, there are no guarantees that these expectations will be met in reality without proper utilization from day one through the useable life of the system. A dual bus system is the best design that can be implemented to achieve high levels of critical bus availability. However, it is simply a framework upon which a specific customer begins to create their tailored uninterruptible power infrastructure. Because all customers have unique applications, resources, and staff training practices, there are no one-size-fits-all solutions.

Ideally, a customer would identify their expertise, manpower, and process limitations, in regards to managing their UPS and power infrastructure. From there, they would choose the proper

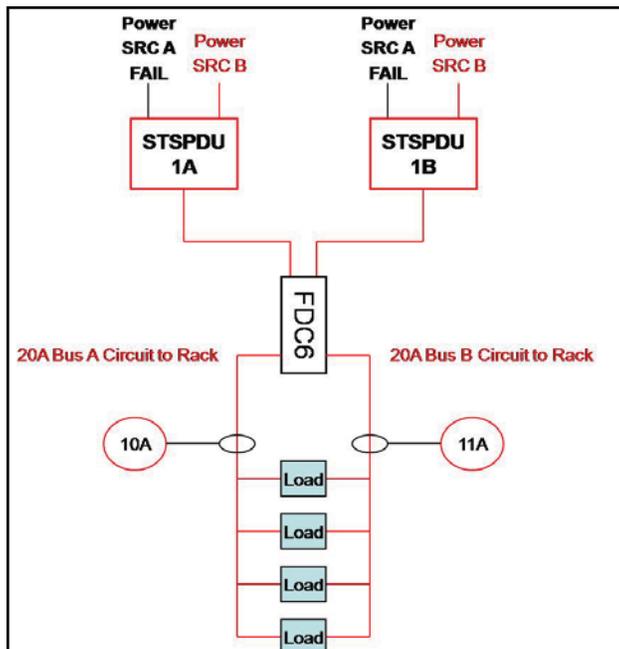


Figure H: System with STS Components

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technology that will allow them to achieve their availability expectations while incorporating a level of additional processes, procedures, and training that is acceptable to them.

Dual bus power switching offers a higher level of tolerance from unexpected failures and also offers a safety net to protect against improper load balancing. Utilizing these devices in a dual bus architecture is one way to customize your UPS and power infrastructure to better meet your unique needs.

Here are some Liebert power switching products that offer these benefits we have discussed:



### **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

Link to the STS2 information page at Liebert.com:

[http://www.liebert.com/product\\_pages/Product.aspx?id=75&hz=60](http://www.liebert.com/product_pages/Product.aspx?id=75&hz=60)



### **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

Link to the STS2/PDU information page at Liebert.com:

[http://www.liebert.com/product\\_pages/Product.aspx?id=83&hz=60](http://www.liebert.com/product_pages/Product.aspx?id=83&hz=60)



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