

CompactPCI power supplies: The key to a reliable system



By Aaron Applebaum

CompactPCI power supplies are to a redundant system what automobile tires are to a car. At first (and even second) glance boring, and uninspiring, however absolutely critical to the safety and reliability of the vehicle. Correct tire size, equal and maintained inflation pressure, wheel balance, and tread depth all help insure a safe road journey. Likewise, paying attention to critical power supply characteristics insures that a redundant system operates all the time and in particular maintains overall system operation when a failure occurs in one or more of the subcomponents. This article examines CompactPCI power supplies as standalone parts and in a system environment context to identify the important features that contribute to total redundant computer system reliability. There may be some overlap in the classifications, but this scheme allows a dual view of CompactPCI supplies in the power supply context and in the system context as a whole.

CompactPCI power supplies' system characteristics can be broadly defined as:

- System thermal considerations
- Hot swap insert and hot swap remove
- Current share capabilities
- IPMI bidirectional communication on I2C bus

CompactPCI power supplies have standalone characteristics that target:

- Mechanical size
- Power supply efficiency
- Power supply power output and power derating
- Electrical power quality
- Unit cost

System characteristics of CompactPCI power supplies

Thermal considerations

One of the frequently overlooked characteristics of a system is the thermal

considerations of the system as a whole. Typically the heat generating components and the heat removing components of the system have to be in balance, or the result will be overheating and a shortened system life.

There are two types of heat generating components in a system, the power supplies and the load. The heat removing components in the system are the active cooling elements (in most cases these are cooling fans) and the passive cooling elements, which are represented by the physical construction of the entire system. Logic tells us that the more efficient the power supplies (and the loads) are, the less waste heat (that needs to be removed) is generated. Therefore power supply manufacturers strive to maximize the efficiency of the supply. In addition the more air that is pumped through the system, the greater the cooling effect – both on system components and on the power supply. The brute force approach of air cooling has two disadvantages, the first being increased acoustical noise due to higher fan speeds, and the second is increased power supply output power consumption, as a result of the stronger fans. What is frequently overlooked in thermal planning is the total airflow path through the system. If the supplies are built as square closed *brick types* this frequently will obstruct the flow of air through the system, thus inhibiting the overall cooling effect of the fan. Figure 1 shows a brick type power supply. On the other hand CompactPCI supplies that are built with the entire system construction in mind allow an unobstructed airflow, thus maximizing the cooling effect of the entire system. Maximizing the cooling effect of the entire system also lowers the overall temperature in the chassis and increases the reliability of the entire system. Figures 2 and 3 show LV Power's Maxi Air and Power Machine power supply units, respectively, which are designed to enable unobstructed airflow. From a design point of view it is also important to plan sepa-

rate cooling paths for the power supplies and for the load boards. Both the physical construction of the power supply and the thermal cooling path(s) must be taken into account when designing the system.



Figure 1

Hot swap

The *raison d'être* of a redundant system is to allow the system to continue to function normally during the insertion/extraction or failure of a component or a power supply. Nonetheless adding or subtracting a supply from a common bus is a powerful event due to inrush current or dynamic loading on one or more supplies. Often a voltage spike is generated on one or more of the output rails. This spike may in some cases cause a general reset of the entire system, and in some severe cases may even cause damage to the CPU boards. Although the maximum magnitude of the voltage spike is clearly defined on the CompactPCI specification, it is surprising how many manufacturers frequently violate this important parameter.

Current share

The current share function is meant to allow two or more supplies to work in parallel on the 5V, 3.3V, and 12V current rails. The CompactPCI specifications state that the current share accuracy needs to be within 10% under conditions where the supply is fully loaded for a 1 + 1 configuration, and within 20% where the supply is half loaded. The reason for this is that if one supply is taking most of the load, and the other is running cool the reliability of both suffers. If the *hot* working supply fails, then the jolt of the full load being transferred to the cool supply is likely to cause it to fail as well, which will lead to an overall system failure. The

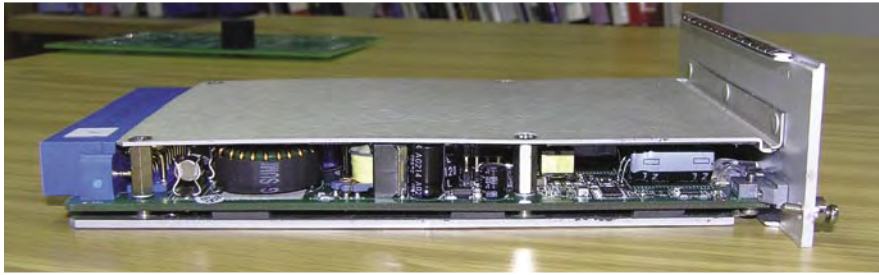


Figure 2



Figure 3

current share accuracy requirements of the CompactPCI specification are frequently violated, especially if the current sharing is implemented using the droop method. Variances of 30% to 70% on load sharing are not uncommon.

A much better implementation is the active master-slave method of current sharing, which permits very high current share accuracy between supplies, allowing an even load and uniform heating between supplies. Examples of companies that are using this method are Tracewell and LV Power.

IPMI bidirectional communication on I2C bus

The IPMI, or Intelligent Protocol Management Interface, is a communication protocol between any part of the system and the outside world. The CompactPCI specification is incorporated in this protocol, which also applies to power supplies.

Until recently few if any power supply manufacturers have implemented the IPMI protocol into the power supply. At best what was available was the possibility of transmitting the physical geographical address of the power supply over the I2C bus. This situation created a reality where the system as a whole had a large *blind spot* in regards to the operation of the power supplies in the system. A few manufacturers have now rectified this situation by fully implementing the IPMI specification into the power supply (as

originally defined by the CompactPCI specification), thus allowing the integration of the supply as a true IPMI system peripheral component.

As such the power supply is now able to communicate various types of information over the system. It can do this with or without power from the power supply itself. In a situation where the power supply does not supply power to the IPMI circuitry, the circuitry maintains active operation via an auxiliary feed. The type(s) of information and commands that are accessible can be broadly summarized as follows:

- Event information – from supply to system
- Sensor thresholds – bidirectional
- Command information – from system to supply
- Miscellaneous data – from supply to system

Event information from power supply sensors Voltage/current /temperature/voltage feed fail

In any case where a sensor reaches a predetermined set threshold an IPMI Event is generated. The Event data is then transferred from the sensor to the system via the I2C bus. The system control circuitry receives the event information and can react to it in any way in accordance with the overall system requirements.

The power supply reports the voltage levels on each of the output rails to the system. The output voltage is split into six threshold levels (three for overvoltage and three for undervoltage). The output currents and temperature sensors are split into three levels for overcurrent and overtemperature. If the input power to the supply is interrupted (feed fail) or the voltage input to the supply falls under the allowable input voltage, the power supply reports the loss of input power to the system.

Sensor thresholds

The default levels of the sensors whether they are voltage, current, or temperature are set by the power supply manufacturer and stored in the power supply IPMI circuitry. These thresholds also can be changed by the system.

Command information

There are more than 50 commands that the system uses in order to address the supply, either locally or from a remote location via the Internet. The most important groups of commands that are used by the system are those that read sensor information, and vary predetermined threshold settings and those that are used to turn the power supply on or off.

Miscellaneous information

The name of the power supply manufacturer, supply serial number, supply hardware revision, and supply software version are all stored in the IPMI circuitry of the power supply. This data is transmitted to the system when the system issues a command for the information.

Additional IPMI implementation information available at www.intel.com/design/servers/ipmi/spec.htm.

Standalone characteristics of CompactPCI power supplies

Mechanical size

The mechanical size of CompactPCI power supplies is a function of the available space in the chassis and the power (watts) required. Typically the supplies come in two height form factors, 6U and 3U. Width is generally two slots. Obviously the more power output that can be obtained from a given size form factor, the better the supply. This is because the CompactPCI chassis size is fixed at 21 slots. The more slots that can be used for system functionality (rather than power

conversion), the more cost efficient the system is as a whole. However the size criteria becomes even more important when the (N+1) redundancy requirement of power in a CompactPCI system is taken into account. A 3U x 2-slot 350W supply uses half the space of a 6U x 2-slot 350W supply. In usable space the savings are 3U x 2 slots. However in a minimum configuration of (1+1) supplies for a 350W system, the space savings grow to two times 3U x 2 slots, unlike current solutions that are 6U x 2 slots in size. In another example of a loaded system of 1050W (N = 3 + 1) the space savings grow to four times 3U x 2 slots. For a fully loaded 21-slot system, this accounts for 19% of the usable space! Companies that realize the importance of high-density CompactPCI supplies in overall chassis utilization include Jasper, Tracewell, and LV Power.

Power supply efficiency

The overall power supply efficiency is perhaps one of the most important characteristics of merit for the supply. A high efficiency supply saves electricity (money) for the overall operation of the system. However far more important is the fact that a *low* efficiency supply generates waste heat, which must then be removed from the system by use of strong fans that by themselves generate heat and consume power.

For example, if a loaded system of 1050W is using a supply that is 70% efficient that means there is 30% of waste heat or 315W that needs to be removed. If the same system were using supplies that were 85% efficient, the waste heat generation would be reduced to 158W (half the previous amount). It is worth noting that the power supply manufacturers that produce the smallest supplies are almost by definition the most efficient manufacturers, simply because it is not possible to produce a high power small supply that is inefficient.

Power supply power output and power derating

Power supply derating characteristics allow some manufacturers to *fudge* the

real usable power output ratings of the power supply. The output power rating of a supply is meaningless if the operating conditions in which it was tested are not clearly stated. Specifically both the ambient temperature and the cooling requirements in linear feet per minute (lfm) or cubic feet per minute (cfm) need to be stated. Above 40°C some supplies start to derate heavily between 0.5W to 3W/per degree C. It is important to have the derating chart in order to make comparisons. Typical power specifications are given at 400 lfm (which is abundant airflow). Some of the better manufacturers are now starting to specify power outputs at 300 lfm and even below. The manufacturer should have a graph of output power at several different airflows. The CompactPCI system operating specifications are specified up to an ambient of 50°C so the best manufacturers will specify their supplies at full power rating with no derating up to an ambient of 50°C at a defined airflow.

Electrical power quality

The CompactPCI specifications define the minimum noise and ripple allowed to be 50mV_{pp}. The line load regulation is specified at +4% and -2%. This is generally quite sufficient for digital applications. However, this may cause problems in some analog front-end capture systems. Check actual figures. Noise and immunity specifications EN55022 and 47CFR,P15 SubB:01, ICES-003:97 are classified at Class A. Some manufacturers have improved on these specifications and are offering Class B noise and immunity as standard. All things being equal, it is always much preferable to select a Class B certified product over Class A because of the lower level of interference caused by Class B certified products.

Output voltage sequencing means that when the supply is first turned on, a fixed predetermination on which voltage comes up first is set. The CompactPCI specification does not predetermine output voltage sequencing. Nonetheless some manufacturers will set a predetermined sequencing. The output voltages on other manufacturers' products will come up at random, requiring expensive controllers and control-

ler implementation at the system level. By specifying the desired turn on/off sequence from the power supply manufacturer, it is possible to save this expense.

High inrush current from a cold start is frequently a power supply killer. It is the highest stress point possible on the supply; therefore good design dictates that the inrush current be controlled. CompactPCI specifications state a requirement for input inrush current suppression. Inrush current suppression should also be controlled by active means and not rely on unreliable passive components such as NTC for one time inrush current suppression.

Unit cost

Industry prices for CompactPCI power supplies vary greatly, from \$0.50/W in the very low end to \$1.50/W for top of the line product. What is most important is to make true apples to apples comparisons. Several products that are advertised as 250W units are in fact no more than 80W units after temperature derating and airflow requirements are factored into account. Other products that are advertised as CompactPCI supplies do not meet even basic CompactPCI specifications for hot swap or current share. As always the buyer beware adage is correct here, so it makes sense to kick the tires a few times before buying.

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