FOCUS ON TELECOM

Powering carrier-grade systems

By Paul Kingsepp and Lazar Rozenblat

Most of today's embedded computing systems are high availability systems. Their downtime is expected to be less then 0.001%, which is just a few minutes a year. Powering such systems is not a trivial task and requires special powering schemes. Such schemes should use highly reliable power supplies, and if a failure of one of the supplies does occur, it should not affect the entire system. An operator should get a warning of a failed power supply and should be able to replace it without powering down the entire system or causing any errors or glitches.

Bus architectures and form factors

Embedded systems use various bus architectures and form factors, and are subjected to a number of standards. These standards impose specific requirements to power supplies for these systems. Among today's most popular bus architectures used in embedded computer systems are VMEbus and CompactPCI. While power for VMEbus systems is not governed by a power supply specific standard, power supplies for CompactPCI are governed by a specific standard.

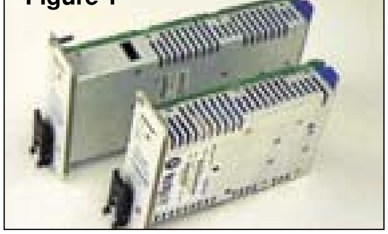
Typically, VMEbus systems have utilized a wide variety of power supply types, initially hard-mounted and wired *shoebox* types, whereby the power supply is mounted in the chassis and hard-wired to the backplane. As an increasing amount of VMEbus systems are being designed for telecommunications applications, there is also an increasing need for redundant, pluggable power supplies for these systems. Currently, there are no specified connectors, form factors, etc. for power supplies used in VMEbus systems. Many system integrators however do utilize pluggable power supplies to allow for some level of hot-swap capability, and ease of maintenance. One of the drawbacks of not having a standard for VMEbus power supplies is that there is generally no commonality between various power supply vendors' products.

The PICMG Power Interface Specification, PICMG 2.11, however, governs power supplies for CompactPCI. This article details the mechanical form factors for CompactPCI power supplies, as well as pertinent operational parameters that power supplies must provide. The largest market for CompactPCI systems is in telecommunications. The need for equipment in that market to be operational basically 100% of the time mandates that redundant, hot-swappable equipment be utilized not limited to power supplies.

Compliance issues

These specifications, however, cannot satisfy all applications. There are systems being generated that use basic CompactPCI architecture and form factor but have variations from PICMG specifications. For example, some systems use voltages other then specified in PICMG, such as 2.5V. Other systems may use a different form factor. For example, the European ETSI standard requires that all connections to the rack be made from the front. In order to comply with this requirement, the rear transition module has to be moved to the top leaving more room for the cards. This led to the creation of Condor's 200W 3U 220 mm deep version of CompactPCI power supply shown in Figure 1.

Figure 1



In addition, power supplies designed for use in embedded computer systems must also comply with a large number of different market-driven requirements not necessarily detailed in the specific power supply standards. Power supplies to be used in systems to be marketed in Europe must include conformance to the Low Voltage Directive (LVD) and carry the CE marking (although technically a power supply as a component is not supposed to have a CE mark). The systems which the power supplies are used in must comply with the EMC directive EN55022 as well, although the systems' standards (such as PICMG) generally do not specify whether they have to meet Class A or Class B requirements. Power Factor Correction, more specifically related to harmonics, is also a requirement for European marketed power supplies.

Embedded systems designed for telecommunications use must also be NEBS compliant especially those that will be used at or connected to the equipment of Regional Bell Operating Companies. While NEBS is not specifically relevant to the power supply, and power supplies will not claim compliance to NEBS, power supplies must not be an impediment to allowing a system in which they are used to become NEBS compliant. This means that power supply design must take the NEBS requirements into consideration. These requirements include shock, vibration, EMI, flammability, specific temperature operating range to name a few.

Regardless of form factor and specific electrical requirements, the most important electrical features for power supplies in embedded systems are current sharing and ability to hot-swap. These are the key operational parameters that allow high reliability fault tolerance required for today's embedded systems.

Current Sharing (CS)

High availability systems use at least one extra power supply so that failure of one supply does not power down the system. For such operation, the supplies obviously have to share the load currents. When one power supply fails or is removed from the rack, the remaining power supplies should take over its load. Most embedded systems allot separate pins on power connectors for forced current sharing. For example, the CompactPCI standard allots three pins for current sharing on +5V, +3.3V, and +12V outputs. The respective pins are then paralleled on the backplane, which let power supplies share information about their currents. Methods that use a separate connection for current sharing (so-called single-wire current sharing) generally assure the best voltage regulation (typically better then 1%). However, they also have some drawbacks:

- Cost of an additional current sharing control circuit per each output increases the overall cost of the power supply.
- Fault in the current sharing bus (such as accidental short on backplane) will cause shift in output voltage of all paralleled power supplies and may even drive this voltage out of acceptable tolerance.
- Power supplies from different manufacturers may not necessarily share the load since there is no unified standard for current sharing bus.

Although most systems allocate current share pins, the standards do not mandate any particular method of current sharing. To increase reliability of the systems and eliminate the possibility of a single point of system failure due to current sharing connection, Condor DC Power Supplies employs an automatic current sharing method (called *droop* method) that does not require any current sharing bus. With this method, the output voltage of each power supply depends on its current. As the output current of one power supply increases, its output voltage slightly decreases in order to force the other supplies to take more current. If all supplies are adjusted to the same voltage at a given load and have the same Voltage vs. Current slope, they will share the load with high accuracy. Implementation of such a method may be done by injecting a replica of load current into the feedback loop shown in Figure 2, a block diagram of power supply with droop current share scheme. Since a current sensor is usually present in any supply anyway for current limit, such implementation requires just one extra resistor Rdroop. This resistor injects a replica of output current into the feedback divider that senses output voltage V_{out}. The resulting signal is then compared to the reference V_{ref} and controls the duty cycle of pulse-width modulator (PWM). Droop method has the following advantages:

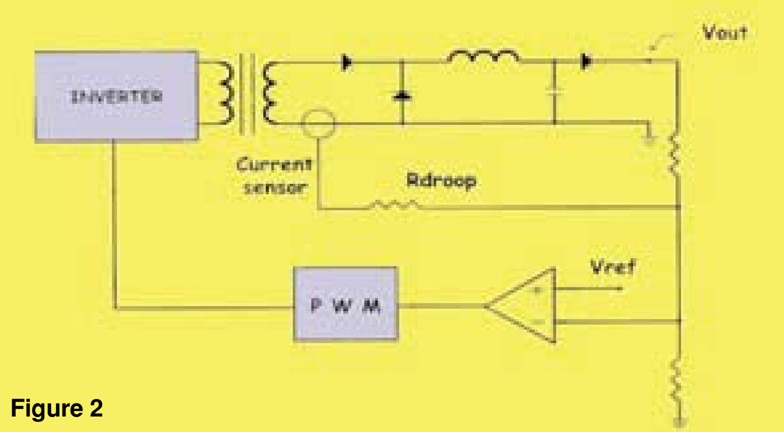


Figure 2

- Current share scheme will not introduce a single point of failure
- Fewer components, thereby increasing system reliability and reducing its cost
- Improved load transient performance
- Power supplies may share the load with supplies that use single wire methods (provided it is adjusted accordingly)

Contrary to a common misconception, droop method can assure sufficient accuracy of current sharing and fair regulation. For example, the series of Condor's CompactPCI quad output supplies shown in Figure 1 feature ±2% typical load regulation and better then 10% accuracy of current sharing on all four outputs.

Load transients

Power supplies for today's embedded systems have to face load steps. They may be caused by inserting or retracting power supplies or the system's modules, or by rapid load changes. Ever-reducing output voltages demand improved power supply transient performance. Because every power supply has a finite response time there always will be sudden deviation of its output voltage upon step load change. The magnitude of the initial deviation is a function of the high frequency output impedance of the power supply which mainly depends on the equivalent series resistance (ESR) and equivalent series inductance (ESL) of its output capacitors. While the method of sharing cannot control the magnitude of the initial voltage deviation, it may affect the maximum voltage excursion DV from the nominal value. Figure 3 shows output voltage deviation for different current share methods: A) without droop and B) with droop. Let us see how it works. With droop share

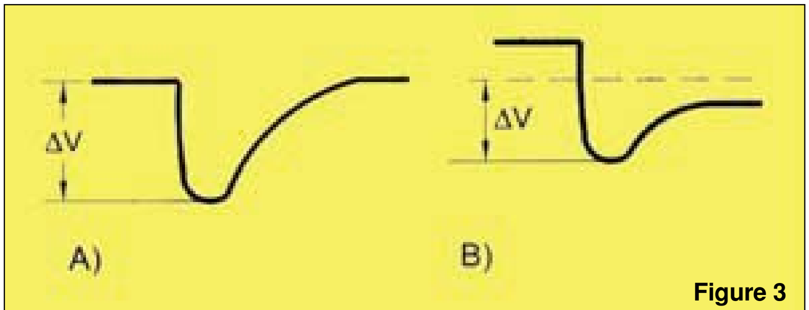


Figure 3

method the steady stead output voltage increases at light load. When the load to the power supply rapidly increases, the voltage dip occurs, but it starts at an initially higher voltage level. Likewise, output voltage slightly reduces at high loads. When a load rapidly reduces, output voltage *jump-starts* at lower level. In other words, droop regulator always presets the steady stead voltage opposite to the direction of the voltage transient thereby reducing the maximum voltage deviation from nominal value.

We mentioned above that the droop method could be accomplished by adding just one resistor to the circuit. Now we see that this single resistor not only provides current share, but also improves transient performance of the power supply. The described method was implemented on the series of Condor's power supplies for embedded computer systems, such as CPCI/DPCI series for CompactPCI and TMX and SPH series for VMEbus systems.

Paul Kingsepp *is a Director of Marketing at Condor DC Power Supplies. He is Condor's representative to the PCI Industrial Computer Manufacturer's Group (PICMG) Executive Committee, and is an active member of PICMG's Power Interface Subcommittee. He has worked in the power supply industry over 16 years.*

Lazar Rozenblat *is a Manager of the R&D group at Condor DC Power Supplies. He has worked for Condor (previously Todd Products) for eleven years and has more then 16 years of power supplies' design experience. Lazar received The Engineer Degree (equivalent to MSEE) in 1977 from the Leningrad Electrotechnical Institute for Electronic Communications (LEIS).*

For more information on powering embedded computer systems, contact:

Condor DC Power Supplies
50 Emjay Blvd
Brentwood, NY 11717
Tel: 631-231-3366
FAX 631-231-3473
E-mail:
Paul_Kingsepp@condordc.com or
Lazar_Rozenblat@condordc.com
Web site: www.condordc.com