Specifying power supplies for embedded systems

The designer must consider various bus architectures, form factors, and standards

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Most of today's embedded computing systems are high-availability systems, with an expected downtime of less than 0.001%, just a few minutes a year. Powering such systems--not a trivial task--requires special powering schemes.

Embedded systems use various bus architectures and form factors, and are subject to a number of standards, which impose specific power requirements.

VMEbus and CompactPCI are among today's most popular bus architectures used in embedded computer systems. While power for VMEbus systems is not governed by a power-supply-specific standard, power supplies for CompactPCI are.

Typically, VME systems have used a wide variety of power supply types, initially hard-mounted and wired "shoebox" types, whereby the power supply is mounted in the chassis and hardwired to the backplane. As the number of VME systems being designed for telecommunications applications increases, there is also an increasing need for redundant, pluggable power supplies for these systems.

Currently, there are no specified connectors, form factors, and so on for power supplies used in VME systems. One drawback of not having a standard for VME power supplies is that there is generally no commonality between various power supply vendors' products.

Power supplies for CompactPCI, however, are governed by the PICMG 2.11 power interface specification. The need for equipment in telecommunications to be operational basically 100% of the time mandates that redundant, hot-swappable equipment be used.

Compliance is key

These specifications, however, cannot satisfy all applications. Some systems, for example, have a basic CompactPCI architecture and form factor, but deviate from PICMG specifications by using voltages other than specified in PICMG, such as 2.5 V.

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, rear-transition modules have to be moved to the top, leaving more depth for the cards. This has led to the creation of a 220-mm-deep version of a Compact-PCI power supply.

Supplies used in European systems must include conformance to the Low Voltage Directive and carry the CE mark (although technically a power supply as a component is not supposed to have a CE mark). The systems in which the power supply is used must also comply with EMC directive EN55022, although the systems' standards (such as PICMG) generally do not specify whether they must meet class A or class B requirements. Power factor correction, more specifically related to harmonics, is also a requirement for European power supplies.

Embedded systems designed for telecommunications 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 the power supply does not claim compliance to NEBS, a power supply must not be an impediment to allowing a system in which it is used to become NEBS compliant. This means that power supply design must take the system's NEBS requirements--including shock, vibration, EMI, flammability, and specific temperature operating range--into account.

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

Current sharing

High-availability systems use at least one extra power supply so that failure of one supply does not power-down the system. For such an operation, the supplies have to share the load currents.

Most embedded systems allot separate pins on power connectors for current sharing. For example, CompactPCI standard allots three pins for current sharing on +5-, +3.3-, and +12-V outputs. The respective pins are then paralleled on the backplane, which lets the power supplies share information about their currents.

Although most systems allocate current-share pins, the standards do not mandate any particular method of current sharing. To increase the reliability of the systems and eliminate the possibility of a single point of system failure due to current-sharing connection, some manufacturers employ automatic current sharing that does not require any bus.

With this method, the output voltage of each power supply depends on its current. When the output current of one power supply increases, its output voltage slightly decreases 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 versus current slope, they will share the load with high accuracy (see *Fig. 1*).

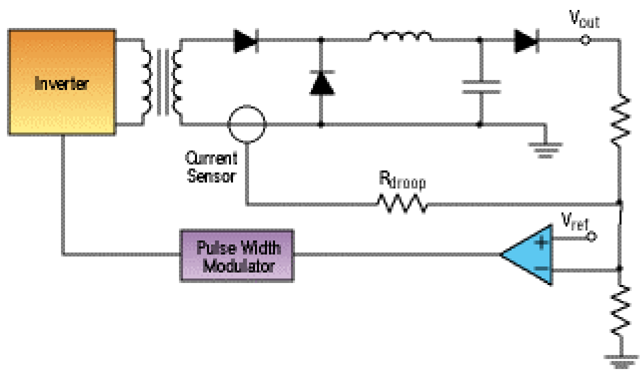
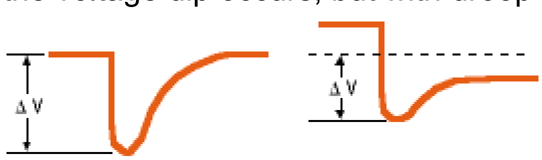


Fig. 1. To increase reliability of power supply systems, automatic current sharing is often used, such as this "droop" current-share scheme.

Load transients

Ever-reducing output voltages demand improved power supply transient performance. Because every power supply has a finite response time, there will always 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 equivalent series resistance and equivalent series inductance of its output capacitors.

While the method of current sharing cannot control the magnitude of the initial voltage deviation, it may affect the maximum voltage excursion ÆV from the nominal value (see *Fig. 2*). When the load to the power supply rapidly increases, the voltage dip occurs, but with droop it starts at an initially higher voltage level.



(a) (b)

Fig. 2. The method of current sharing may affect the maximum voltage excursion delta V from the nominal value, as shown here for sharing without droop (a) and with droop (b).

Likewise, output voltage slightly reduces at high loads. When a load rapidly reduces, output voltage starts at a lower level.