Multiple power supplies or power converters are used in parallel to increase output power and/or to provide fault tolerance. No matter what method of paralleling is used, current sharing is important because it reduces thermal problems, improves transient response and helps extend the lifetime of all modules in an array.

The two most commonly used approaches to paralleling converters — driver/booster (or master/slave) arrays and DC-coupled single-wire paralleling — have disadvantages. What is needed is an approach that incorporates the best of the traditional approaches to current sharing without any of the disadvantages. An array of intelligent modules with a single AC connection from module to module for current sharing, but with only one module controlling the output at a given time, is such an approach. With the simplicity of a single-wire parallel architecture, the power array would provide excellent transient response under normal and abnormal operating conditions and a high degree of immunity from system noise.

**The Conventional Way.** Most converters can employ the driver/booster array for increased power. Driver/booster arrays usually contain one intelligent module, the driver, and one or more power-train-only modules, the boosters. The driver is used to set and control output voltage, while booster modules are used to incrementally increase output power to meet system requirements. There is only a single control loop, so it has no loop-within-a-loop stability issues, and it has excellent transient response. However, this arrangement does not support redundant operation, nor is it fault tolerant. If the driver module fails, the entire array will come down.

DC-coupled single-wire paralleling involves the paralleling of two or more identical modules, each containing intelligence. Internal circuitry actively adjusts the output voltage of each supply so that all units deliver equal currents. This approach supports a level of redundancy, but it is susceptible to single-point failures that can, at best, defeat current sharing and, at worst, destroy every module in the array. The major reason for this weakness is the single wire, galvanic connection between modules.

**A New Approach to Single-Wire Paralleling.** Zero-current switching DC-DC converter architectures use a unique load share scheme that overcomes these disadvantages. Specifically, this architecture enables an AC-coupled single-wire parallel bus that gives the design engineer a clear edge in power system design, while offering additional functionality.

With this topology, any module can assume control of the array. The module that has the highest output voltage transmits a pulse on the parallel bus to which all other modules on the bus synchronize. Since like zero-current switching converters transfer the same amount of energy on each switching cycle, synchronized converters will inherently share current. If, due to transient events or a module failure, another module’s output voltage becomes higher, it will transparently take command of the array with no perturbation of the output bus.

This capability of synchronous current sharing in democratically-controlled arrays offers power architects new opportunities to achieve simple, non-dissipative current-share control. It provides options that simplify current sharing and eliminate the need to sense the current from each individual module and adjust each control voltage. A pulsed signal also gives designers the option to add capacitors or transformers between parallel pins, providing DC-blocked coupling. Such coupling prevents certain internal or external failure modes from propagating to other modules in the array, thus providing an increased level of fault tolerance. Additional advantages of this architecture include excellent transient response and no loop-within-a-loop control problems.

Using an AC signal at the parallel (PR) pin — a bi-directional port on each module used to transmit and receive information between modules — also provides the system designer with the opportunity to add a level of reliability not previously possible. See Figure 1. Instead of simply connecting all PR pins together, the designer has the option to capacitively couple them and hence to avoid the same potential failure inherent in all DC coupled, single-wire paralleling schemes: the failure of a single module can affect current sharing or even destroy other modules. The addition of a capacitor from each module to the common parallel bus eliminates this failure mode.
Use of a current-share bus transformer (Figure 2) allows arrays of variable-frequency converter modules to current share even if they are widely separated. Modules can be transformer coupled because the current-share signal is a high-frequency pulse. Transformer coupling this pulsed signal provides a high level of common mode noise immunity while maintaining SELV isolation from the primary source. This is especially useful when board-to-board load sharing is required in redundant applications. Since the PR pulse is narrow, a very small, low capacitance pulse transformer can be used.

Figure 1 – Using an AC-coupled single-wire interface, all PR pins are connected to a single communications bus through capacitors. This interface supports current sharing and is highly fault tolerant.

Figure 2 – With a transformer-coupled interface, widely-separated modules or arrays of modules may also be interfaced to load share while providing galvanic isolation between PR pins.