Seven steps to selecting the right high-density dc/dc converter

Topology, input and output needs, agency approvals, and cost are some factors for designers to consider

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High-density dc/dc converters give the designer enormous flexibility in meeting today's complex power requirements. But how does the designer choose the right converter? Considering seven key criteria—topology, input and output choices, accessories, delivery, application support, agency approvals, and cost of ownership—will ease the selection process.

When considering these factors, designers should make sure their approach makes the most sense for the task at hand. The power solution may need to be quick and inexpensive or it could require long life and flexibility.

The selected power supply architecture—centralized, scalable, or distributed—might suggest a converter having particular attributes. Maybe the level of investment or involvement will be the determining factor: will the engineer design at the component level, use higher-order assemblies, or go for a full custom solution? Are there especially demanding electrical, mechanical, or thermal requirements?

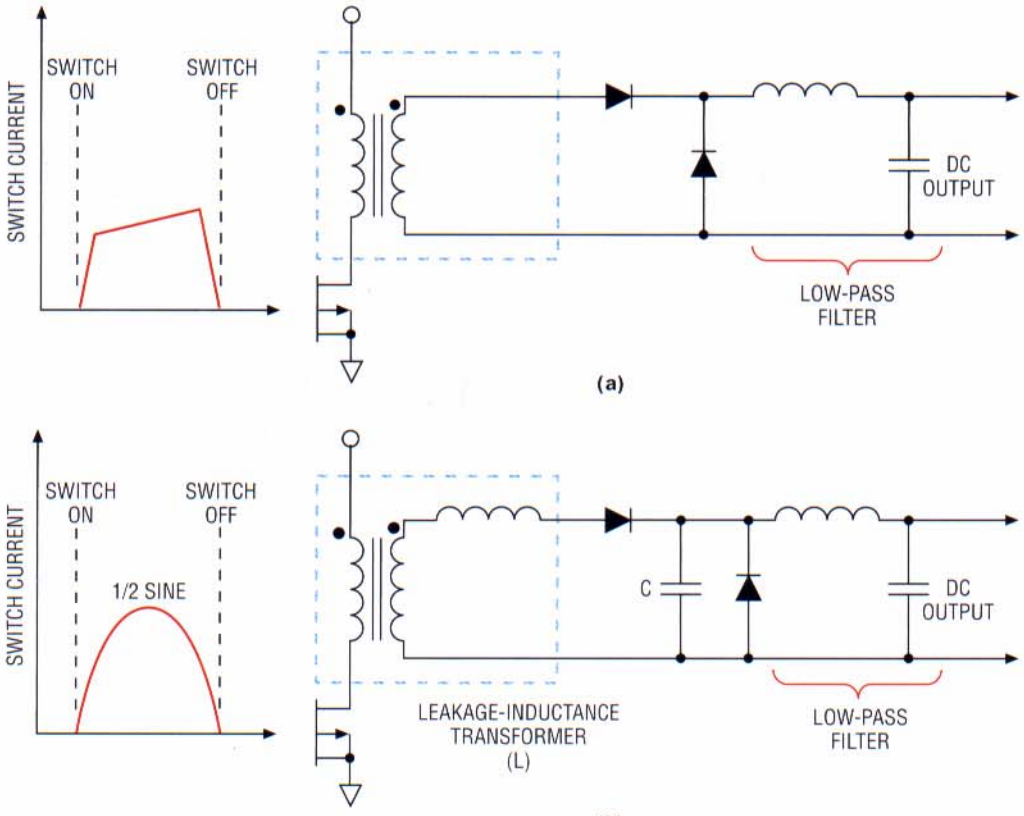

Fig. 1. Although PWM converters (a) are simpler in design than ZCS converters (b), they inherently sacrifice efficiency for greater operating frequency.

1. Topology

In certain instances, topology does matter. Although many topologies are used in dc/dc converters, they can be grouped into two primary classes: pulse-width modulation (PWM) and

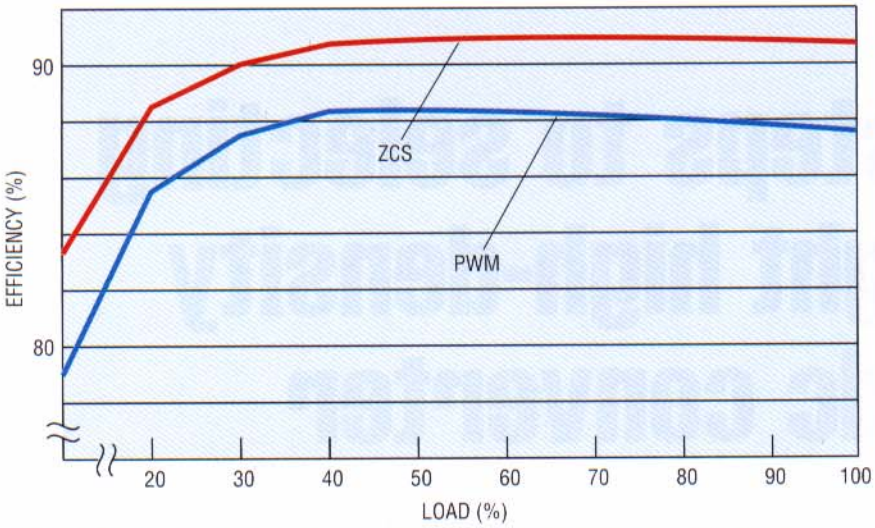

Fig. 2. ZCS converters have essentially constant efficiency from 20% load to full load while the efficiency of PWM units begins dropping off below full load.

quasi-resonant designs, such as zero-current switching (ZCS).

Of the two, PWM has a somewhat simpler design, but this technique inherently trades off efficiency against operating frequency. Each time the switching element makes and breaks current flow during its brief turn-on and turn-off transitions, heat is generated. *Figure 1* shows the current-switching waveforms and circuit topologies of PWM and ZCS.

Power dissipation due to switching losses increases directly with operating frequency until it becomes a dominant loss factor. Efficiency declines rapidly, resulting in a frequency barrier that limits achievable power density in conventional converters.

ZCS converters overcome the frequency barrier by implementing a forward converter switching at zero current. Each switch cycle delivers a packet of energy to the converter output, with switch turn-on and turn-off occurring at zero current. ZCS results in an essentially lossless switch. ZCS converters can operate at frequencies in excess of 1 MHz, with efficiencies greater than 80%.

The most dramatic improvement in efficiency is at light loads: ZCS units have essentially constant efficiency from 20% load to full load, while the efficiency of PWM units begins dropping off below full load. This is important if the load is dynamic or operation at low loads is anticipated. *Figure 2* compares the efficiency of PWM and ZCS converters against percentage of load.

Other advantages of ZCS converters include power densities up to twice that of PWM converters, resulting from the smaller size of reactive components (capacitors and magnetics) used at higher frequencies. Also, ZCS converters exhibit significantly reduced levels of conducted and radiated noise.

2. Input and output considerations

Some manufacturers offer a wide range of input voltage, output voltage, and output power. For those who need a range of inputs and outputs, or need something beyond the common choices, this flexibility has definite value. *Figure 3* compares the offerings of two typical manufacturers in terms of input voltage, output voltage, and output power levels; one is fully populated, the other is limited.

The modular dc/dc converter implies a building-block approach. However, the building-block approach works best with products from only one manufacturer. For example, a designer can't take an EMI filter from one manufacturer and a module from another and expect everything to work together

In addition, it's not uncommon for a manufacturer with a product designed for one market—say, a telecom central office—to want to sell that product in another market. The ability to replace a 48-V-input high-density converter with a 72-V-input converter—while maintaining the same pinout, footprint, and electrical performance—can be very valuable.

3. Build or buy accessories?

Power architects using high-density dc/dc converters often build their own circuit elements using discrete components. Some companies just offer dc/dc converter modules and, typically, a relationship with a value-added reseller who will put the pieces together.

Other suppliers offer all the complementary products and accessories that allow the building-block concept to flourish. These include ac front ends, EMI filters, output filters, heat sinks, sockets, common-mode chokes, differential-mode chokes, Y capacitors, and application manuals that take the designer step by step through the process of creating a stable, reliable power system design.

A broad inventory of accessories makes power system design easier electrically, mechanically, and thermally. For example, it's a big benefit when a manufacturer can guarantee meeting the Bellcore spec when the designer uses that manufacturer's filter and dc/dc converter combinations. If designers want to add hot-plug capability, they simply add an input attenuator module. Three modules can take care of all the issues for EMI and hot plugging.

4. Timely delivery

Timely delivery is important to everybody. Ask about delivery lead times, of course, but also ask about how the products are manufactured and qualified. Does the manufacturer have ISO 9000 registration? Does it have a wide variety of standard modules in stock? Can it modify standard products or respond quickly to the need for small quantities for

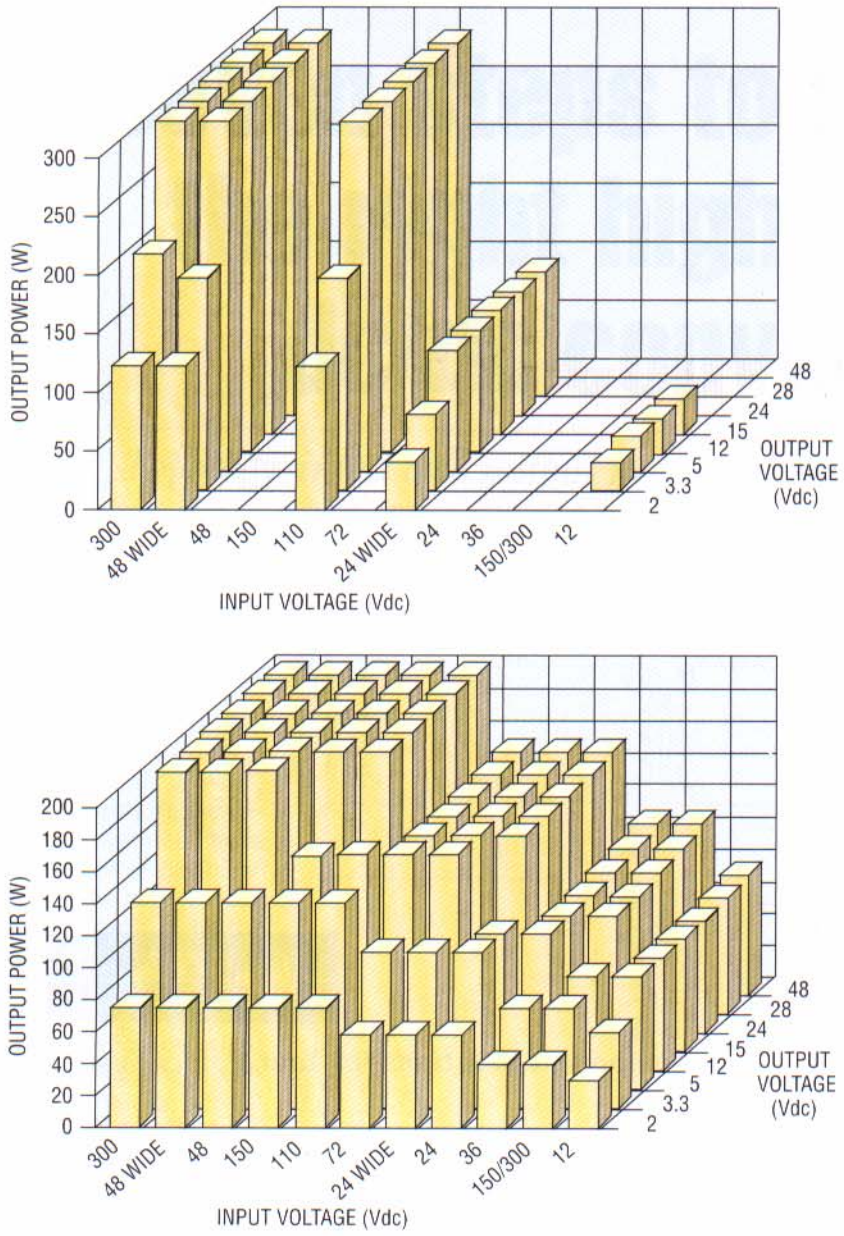

Fig. 3. Input and output voltages and output power levels can vary widely from one manufacturer to another, as shown by this comparison of product offerings from two different converter manufacturers.

prototyping?

Most manufacturers of modular dc/dc converters are especially sensitive to designers who are under time-to-market pressure. The manufacturers make various standard products available off the shelf.

Time-to-market is a primary reason for using a modular converter. That's true regardless of quantity. Timely delivery is just as important to the buyer of two modules for prototyping reasons as it is for the buyer of thousands of modules for a production run.

5. Application support

Designers should look for a converter from a company whose application engineers are available and committed to help achieve a successful design. The engineer can provide technical support that is very specific to a customer. For instance, the customer may have an EMI requirement, but no place to mechanically fit the supplier's available filter module. In such a case, the converter manufacturer's application engineers can often work with the customer (recommending components and designs) to produce a discrete design arranged to fit the available space.

6. Agency approvals

Agency approvals are required for a system, but they are not required for power modules embedded within a system. Some suppliers, as a result, do not ensure that their converters meet the appropriate standards. Those that do, however, are providing their customers with an advanced starting point, greatly simplifying and streamlining the system approval process.

7. Cost per watt or cost of ownership?

The cost per watt for high-density converters is coming down, and it's a valid comparative parameter for high-density converters. But it's often not as important as total cost of ownership. Designers have to consider the available design and development resources and the total budget. Costs for design and development time should be included in any comparison. The cost impact of quality and reliability should also be a factor.

On the other hand, if designers buy high-density converters based only on selling price, it could mean that corners have been cut on the design. It may end up costing more in the long run in the form of more field service, reduced reliability, higher replacement costs, and possible damage to the reputation of the designer's company. All these factors affect ownership costs. EP