DC/DC Converter Modules Replace Discrete Designs

The decision to 'make or buy' a DC-DC converter has never been straightforward with many factors to consider. More low power applications can now be satisfied with new generations of low cost modules.

Paul Lee, Director of Business Development, Murata Power Solutions, UK

Your new product design requires a processor, so do you design one and then find board space for two billion transistors? Would you buy a 100 mW resistor in an SOIC-8 package? Frivolous examples but they illustrate the extremes where the decision to buy a module or achieve a function with discrete components is easy. For DC/DC converters, the decision is often quite difficult with their particular combination of size, dissipation, isolation, EMC and electrical performance specifications.

The argument for buying is easier at higher power levels: 'state of the art' bus converters for distributed power applications can achieve 600 W output in a quarter brick format utilizing a 14 layer board in heavy copper. This would be hugely difficult to implement discretely in a motherboard for the same performance. At lower powers such as 1 W there is a very large market for simple isolated converters which typically power isolated data interfaces or generate low power 'spot' voltages for analogue circuitry such as -5 V for an op-amp rail (Figure 1). Today, these converters can be bought as surface-mount or through-hole modules from reputable sources for about $2 in volume. However, many users feel that in volume they can design and implement the converter themselves from basic theory and device application notes at lower total cost.

Of course the cost comparison is not simply between the bought-in module and the BOM cost of the discrete design. Taking an example of a 1 W isolated converter which could be implemented with ten discrete components, other direct cost factors include the placement/inspection cost of ten components versus one, purchasing overhead for ten components from perhaps five manufacturers, including specialist magnetics, versus one module supplier and the stores handling/inspection/stocking/picking overhead for perhaps eight different component types including specialist magnetics versus one module.

The costs of testing functionality and isolation would also need to be included. Then you would need to consider the indirect extra costs. These would include the cost to board area – a discrete design is unlikely to be smaller, cost to skyline - a surface mount module with embedded magnetics can be very low profile and the specialist power circuit design, product qualification and overhead. There are a number of other indirect costs such as PCB design and overhead, design support cost, ongoing certification and inspection costs if agency approved and the costs associated with multiple supplier monitoring, QA and control.

If the transformer and other magnetic components are also designed and manufactured 'in-house' then all the above considerations apply again for these parts with would include multiple wire types and gauges, insulation, hardware and cores. The transformer in the above example would typically have a minimum of six windings with wire down to 0.07 mm gauge on a core of 4 mm diameter

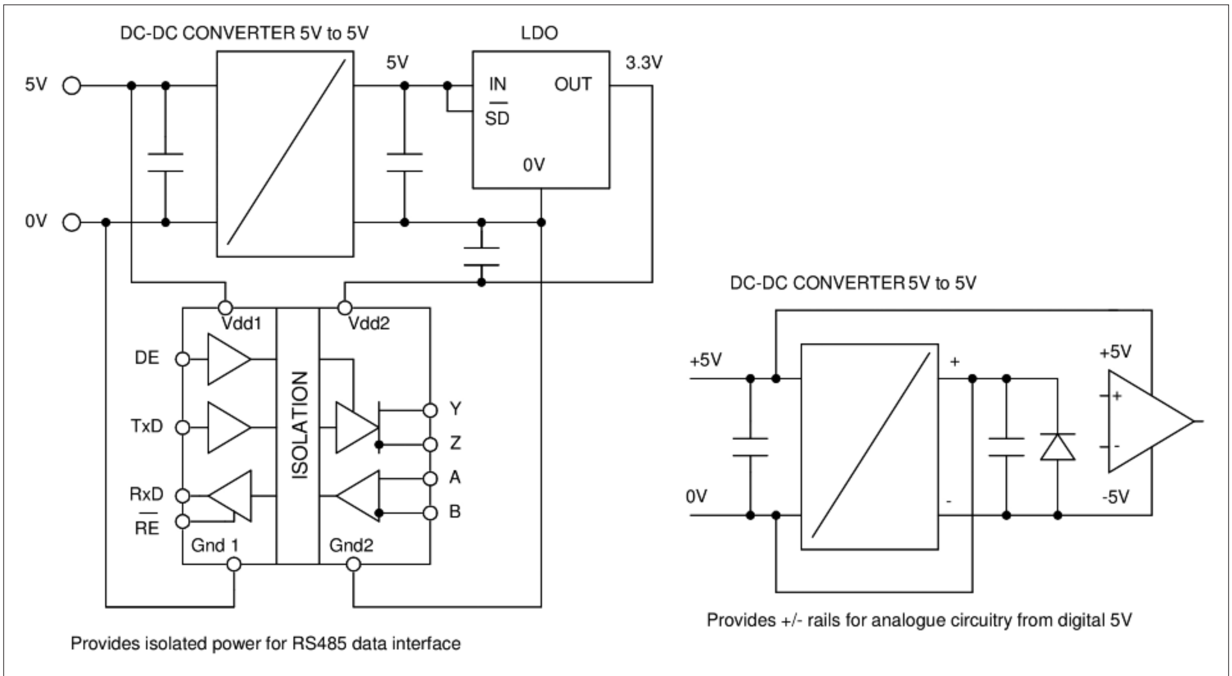

Figure 1: Typical applications for isolated DC/DC converters

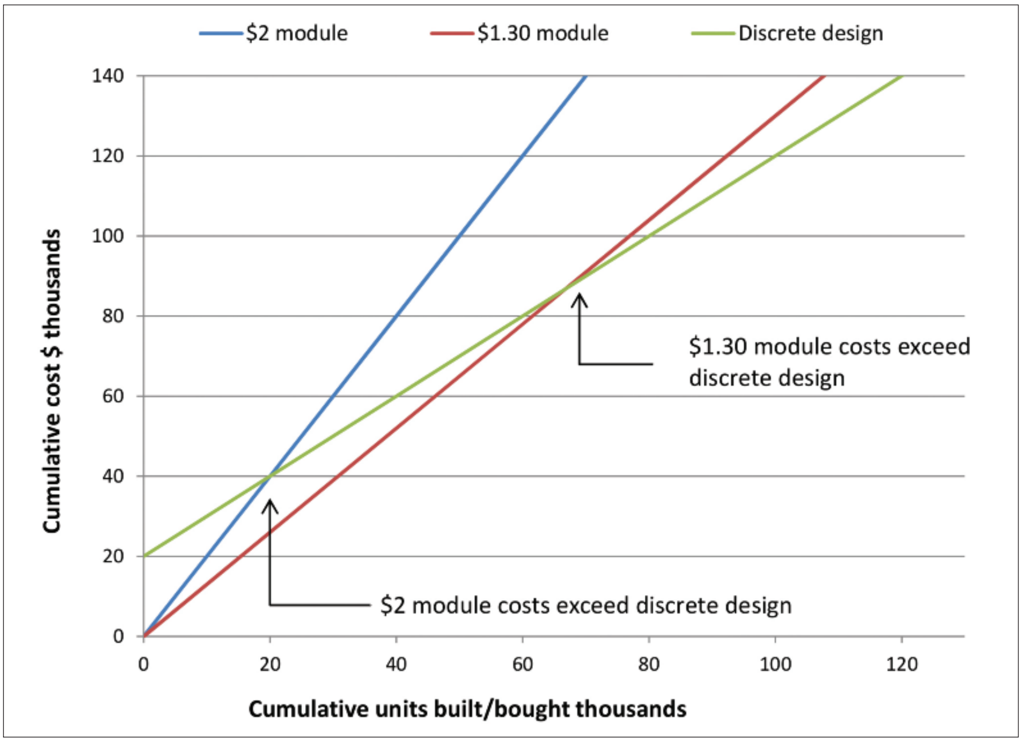

Figure 2: Example of crossover points make or buy for DC/DC converters

requiring specialist techniques and equipment to wind. Of course, if available, the magnetic part could be bought in, but could be as expensive as a complete DC/DC module.

Circuit and magnetics design are not trivial despite, and perhaps because of, the minimal component count. The example given of a 1 W converter is a self-oscillating push-pull circuit which relies on careful selection of transistor gains and biasing along with deliberate cyclic saturation of the transformer ferrite core operating outside of its normal data sheet parameters. To be viable, the completed design must have high efficiency with low noise on inputs and outputs while maintaining reliable isolation, accurate output across its load range and even with a degree of overload protection. A lot to get right with just 10 discrete components!

Speed to achieve a solution is a factor with even a simple converter requiring many weeks of design, documentation and qualification over all prospective operating and environmental conditions. If the converter forms any sort of safety barrier, the costs and time to achieve agency rating are measured in thousands of dollars and months with ongoing costs for inspections and re-certifications.

All of these costs and associated overheads and delays need to be compared with the simplicity of purchasing a proven, reliable module and also saving the 'opportunity cost', the value of the time that could be used elsewhere in core business and the value of a quicker time to market and earlier sales.

There may be some volume at which your company can afford to become a DC/DC converter manufacturer, keep the design in-house and write off the design costs. However, new 1 W converter module designs are pushing out the make/buy volume crossover point. At much lower costs than equivalent older products and with performance advantages, the differential between make and buy may now be down to a few cents, if anything, perhaps moving the crossover point out by fivefold or more.

To put some figures into an example, let's say that the total time taken to implement a discrete design is eight man-weeks. This would include time for a design engineer, support technicians, drawing office, production engineer, component engineer, qualification engineer, EMC engineer, management and probably more functions. If the average burdened employment cost of these staff is $50/hour then the one-off cost is about $15,500. Add prototyping materials, tooling, external agency costs and disposables, this figure could easily approach $20,000. If the direct cost of a discrete design is $1, comprising BOM, placement, component sourcing, handling, test and ongoing design support, then the gain over buying a $2 bought-in DC-DC converter pays off the design costs after building about 20,000 units. If the bought part is now closer to $1.30, the pay-off quantity is close to 70,000 units. An unexpected further cost

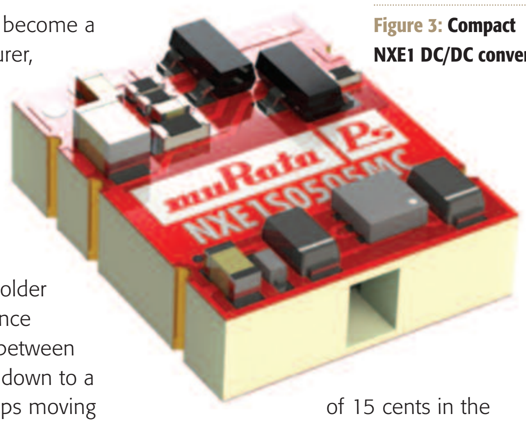

Figure 3: Compact NXE1 DC/DC converter

of 15 cents in the discrete design doubles the payback quantity again. This is all without factoring in the value of opportunity cost, quicker time to market and convenience of a warranted 'fit and forget' module (Figure 2)

.Latest low cost products on the market also offer significant performance improvements over previous generations. An example is the NXE series having the additional advantage of patent-pending embedded magnetics giving completely repeatable performance and lower profile than typical discrete parts. The NXE with proprietary 'inspectable land grid array' (iLGA) package is also pin-compatible with the 1 W industry standard footprint enabling existing users of DC/DC converter modules to upgrade and realize the benefits as well.

Perhaps the 'make or buy' decision is now a little easier at lower powers and the day is closer when product designers would no more design DC/DC converters discretely than they would a logic gate or op-amp.