Modules make more sense

Why making like for like comparisons between a power module and a discrete circuit is an invalid approach. By Simopekka Niskanen.

In the early stages of designing a high power, high value product, the development team will decide whether to implement the intermediate power stage and Point-of-Load converters using fully integrated modules or with discrete power components.

When system architects consider this decision, it can be tempting to take a matrix approach; listing the advantages and disadvantages of each. For example, the benefits of using a power module include:

- faster time to market
- small board footprint and low component count
- easy for engineers with limited analogue or power design experience to implement in product designs

However, the drawbacks may include the limited ability to second source the device and, potentially, higher unit cost.

For a discrete circuit implementation, these benefits and drawbacks would be reversed – it would be larger, more complex and would use more components, but those components would readily replaceable and the Bill-of-Material would normally be lower.

If the overriding design consideration is cost, it is likely that the development team would opt for a discrete circuit. If time to market is the most important issue or if power density is a critical factor, the team may favour a module. If the design team has little or no power or analogue expertise, a module will also be the preferred choice.

In reality, the thought process will be more complex. Nevertheless, development teams commonly assume that power modules and discrete power converter circuits which perform the same function are therefore equivalent and can be compared on a like for like basis. This assumption can be flawed.

Why modules perform differently

It might seem odd to suggest that a power module based design would perform differently from a discrete circuit working with the same input and output voltage and current specifications. For example, Intersil’s ISL8273M is an 80A digital power module which operates from a supply rail of 4.5V to 14V, providing a single channel, dual phase output at a voltage programmable from 0.6V to 2.5V. The 18 x 23 x 7.5mm package features a digital power controller IC, MOSFETs, LDOs, inductors and various other power components – the same types of component with which an equivalent discrete power circuit would be implemented.

Because of the way the module is packaged and assembled, its board footprint is smaller than the equivalent discrete circuit. But this is not the only difference and there are three ways in which a module in many cases offers superior performance to a functionally equivalent discrete circuit.

Layout optimisation

Reputable suppliers of power modules have valuable brands to protect and take great pains to provide designers with every assistance to ensure that they work to their highest potential in all conditions.

One way in which they do this is by providing layout guidelines – a blueprint for optimising the thermal and electrical performance of the entire power circuit, including a small number of external components supporting the module. This optimal layout will have been developed and refined after exhaustive testing across the range of operating temperatures and other conditions specified for the module.

Because the manufacturer’s brand stands behind the module, it is important for it to commit the necessary engineering time and resources to this optimisation. By contrast, the economics of product development at OEMs dictate that the same level of layout optimisation...
is normally out of the question. The thermal and board-level design is typically done on a ‘best effort’ basis.

In most cases, this ‘best effort’ will fall short of the optimisation that module manufacturers perform. The thermal performance and layout efficiency of a module-based system can therefore be assumed to be better than that of a discrete circuit.

System reliability
Much the same argument applies to the reliability of a power module, when used within its specified operating conditions.

The reliability argument in favour of modules over discrete power circuits is usually illustrated in terms of component numbers: put simply, this argument states that a system’s Failure In Time (FIT) rate increases in a more or less linear fashion with each increase in the number of components in the system. So, a circuit with 20 components is likely to have a FIT rate around 20 times higher than that of a circuit containing one component.

Of course, a module is not a single ‘component’. Nevertheless, experience shows that power module reliability is better than that of comparable discrete circuits. This is because the module’s construction is less prone to failure than a set of discrete components. For instance, because of its small footprint, it is less affected by any warping of the board. The temperature inside a module is more evenly distributed, because it is smaller, and the moulding compound aids heat distribution. This means the devices inside the module run cooler and more efficiently.

A module also has fewer solder joints; while the dies of active components are directly soldered to the base board of the module, other connections are made by bonding. This means there are fewer solder joints and bonds than in a discrete design and bonds are less susceptible to cracking, bending and other failure mechanisms than solder joints.

But the reliability advantage of modules goes further; because module manufacturers commit time and resources to testing and validating their products – which can include highly accelerated lifetime testing (HALT).

This means the power-system designer can benefit from fully tested, fully documented reliability data about the entire power circuit across all specified operating conditions.

For these reasons, the designer can have greater confidence in the reliability of a module-based power-system design than of a discrete circuit.

A further advantage for module users is that designers have reliability data available from the beginning of the design process. By contrast, testing to establish the reliability of a discrete circuit can only take place after the circuit has been designed and built in prototype form.

Predictable performance
The third way in which a module can be expected to perform better than its discrete equivalent is in predictability of performance. While the performance of a power regulator or power controller IC is normally well documented, this documentation only applies to the IC.

For a module, the documentation applies to the power conversion circuit, meaning module users can implement a system design in full confidence, knowing the electrical performance of the power system will be as predicted by the product documentation.

A discrete circuit is not supported by a manufacturer’s documentation and defects or weaknesses in the performance of a discrete circuit in a given operating condition might elude discovery during the design process. This carries the risk that the real-world performance of the discrete circuit will be worse than that of its module equivalent.

Avoid like for like comparisons
It is certain that, in some cases, a module will perform better – both electrically and thermally, and over a more predictable lifetime – than its discrete equivalent. The assumption that exact comparisons can be made between a module and its discrete equivalent is therefore flawed.

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