New Xbox: Power Design a Win for ON—and for Discretes

iSuppli teardown analysis reveals a plethora of discrete FETs

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Microsoft Corp.'s brand-new Xbox 360 debuted in November, sporting more processing power than any video-gaming console to date, and in turn requiring more current from the DC/DC sections to supply those processors.

There has been a lot of speculation in the power-supply world about the design of the next generation of video-game consoles. Rumor has it that a certain company will be supplying a phalanx of converter modules to Sony for its upcoming PS3 release next year. Thus, iSuppli Corp.'s Teardown Analysis Service has been waiting anxiously to crack open this first new console from Microsoft to see what its power-management strategy is.

A peek under the hood of the new Xbox 360 reveals that the buck converters that supply the current to the console's powerful new microprocessor and graphics chips are laid out on the board in discrete form using venerable TO-252 (D-Pak) power MOSFETs. All of the layout and thermal management was achieved on the main circuit board, with no hybrid or integrated packaging, and no heatsinking.

ON inside

iSuppli is estimating that 10 million Xboxes will be sold in 2006, every one containing seven buck converters and each using some combination of 22 D-Pak 20V MOSFETs to do the bulk of the DC/DC conversion, plus a few linear regulators and LDOs thrown in for good measure. In the Xbox 360 dissected by iSuppli, ON Semiconductor has the bulk of that MOSFET business—by far.

ON Semiconductor won most of the controller and IC business as well. In the Xbox 360 analyzed by iSuppli, ON's NCP5425DB dual sync buck controller, its NCP5331FTR2 2-phase controller/driver and a half-dozen of its LDOs were found. That leaves only a half dozen or so other parts to be shared among fellow Xbox 360 suppliers Philips, Vishay, Analog and Samsung. Figure 1 presents

Figure 1. Photo of the XBox 360 motherboard, showing the CPU and GPU chips being literally surrounded by D-Pak MOSFETs that are supplying their power.

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These findings bring up several issues that are of interest to designers and strategic procurement people who are in the decision chain for similar projects.

Discretes, or modules?

The first issue is the overall project-management decision of whether to use discretes or complete converter modules in a design.

One of the areas of great excitement in the industry now is the number of suppliers entering the DC/DC module business. For system designers who face space or time constraints, and who can meet their cost requirements using off-the-shelf DC/DC converters, this is an attractive route to take. With just a few clicks at the right website, a converter design can be mostly completed and optimized for space.

Conversely, if a designer has time and resources, and a huge production volume to amortize costs over, it may make sense to spend a lot of effort to drive every last little bit of cost out of the power supply by optimizing a custom design. And, generally speaking, if a designer has enough space to work with, he can employ lower power-density discrete designs to minimize his costs.

That certainly appears to be what Microsoft has done here, freeing up space in the main console by moving the AC/DC section outside the box and by providing enough circuit board to allow traditional low-cost discrete packaging and assembly techniques.

Discrete advantages?

Second, there's the question whether a designer can capitalize on what "going discrete" potentially offers.

Cost and second-sourcing likely are key considerations in which discretes might have a potential advantage. Certainly for Microsoft, which like other game-console manufacturers loses money on each console shipped, achieving the absolute minimum cost that can be achieved in any given form factor is a key criterion. Likewise for Microsoft's equipment assembly subcontractors, which have operating margins in the neighborhood of 1 percent, any costs that can be driven out must be driven out. Given the very high volumes on these products, it can thus confidently be presumed that Microsoft put a critical eye on the subject of DC/DC point of load conversion.

In the face of this scrutiny, discrete D-Paks apparently have been deemed to be Microsoft's best option in this form factor. That is a strong statement for similar applications, and it issues a significant challenge to any technologies that wish to succeed in this market. In power, cost is still king.

Having said that, second-sourcing is also a significant criterion on projects that are not even as large as the Xbox 360, and strategic procurement groups often will dictate that multiple sources be specified in order to ensure reliable supply and to encourage competition for the socket. Despite the existence of the DOSA and POLA alliances, DC/DC converter modules for the most part have not really been truly second sourced (i.e., functionally swappable).

So in theory at least, commodity discretes should have an advantage in this area. However, according to an ON Semiconductor spokesperson—although Microsoft intended to have multiple sources for the power FETs, and even though in theory it is possible to have multiple sources for D-Pak power FETs—it is looking more and more like ON will in fact be the sole source for the Xbox 360.

It remains to be seen whether this is an artifact of something non-technical—e.g., limited supply from other suppliers, or better pricing from ON, or other terms—or of something technical, such as "other parts don't switch correctly in our circuit," etc. The point here is that if second sourcing is one of the desired benefits in going with discretes, good technical due diligence is required in order to ensure that multiple vendors' parts actually do work as fungible alternatives in a converter design.

Getting Technical

And then there are the definitely technical considerations: How much performance can be delivered, and how?

In the case of the new Xbox, in going with discrete D-Paks, Microsoft's power designers took a nifty building-block approach to spec'ing transistors in which the number and type of D-Paks used is varied according to the needs of the load. Some of the converters use two FETs (one per switch), one optimized for switching and the other for conduction. Others use three FETs (two in parallel for the conducting FET). Still others use four FETs—two in parallel for each switch—and on some, FETs optimized for switching were nonetheless used for conduction in order to minimize the cost.

This is a good example of cooperation between engineering and procurement to optimize the bill of materials. The Microsoft power designers managed to facilitate probably four or five different regulator ratings on the board using only two FET part numbers and effectively minimizing their cost.

Even the thermal management is an exercise in wisdom in overall costs. If you realize that only 10 to15 percent of the heat in the system is coming from the power MOSFETs, it definitely looks inappropriate to spend a tremendous amount of money thermally managing them. And Microsoft doesn't.

The heat from the power MOSFETs is conducted through heavy traces into the large, openly-laid-out main circuit board—which just happens to be directly in the path of the main cooling air stream that comes in to cool the fully-heatsinked processor chips that are generating the real bulk of the heat in the box.

So overall, the regulator functions accomplish their job at an apparently good cost point. The only questionable design decision iSuppli noticed in the Xbox 360 was that a large amount of output cap was used, a traditional but expensive practice. Given some of the latest fast-responding controller chips, this looks like a brute-force approach that perhaps could have been improved upon, but that is speculation. This may still have been the lowest-cost route and Microsoft has plenty of space available in the box.

In summary

There are a limited number of products such as the Xbox 360 that are both high-cost and high-volume, products for which the pressure to optimize for the application conditions are at their absolute maximum. And in the face of that pressure to optimize, tried-and-true discrete power devices have won the day in this video game console, suggesting that there's probably quite a bit of life left in them yet.

It will be interesting to see how the other game consoles' power sections have been designed.

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