Smart Power Stages with Universal Footprint Address Efficiency

Smart Power Stages with Universal Footprint Address Efficiency and Business Continuity Challenges in Next-Generation Cloud Servers

Shipments of servers to leading cloud service providers currently represent one third of all worldwide server shipments, and this figure is expected to grow to half within the next few years. Maybe this is less surprising if you consider that the 'Top 5' cloud infrastructure services are growing by a minimum of 40% year-on-year, with Amazon and Microsoft leading in market share (Figure 1).

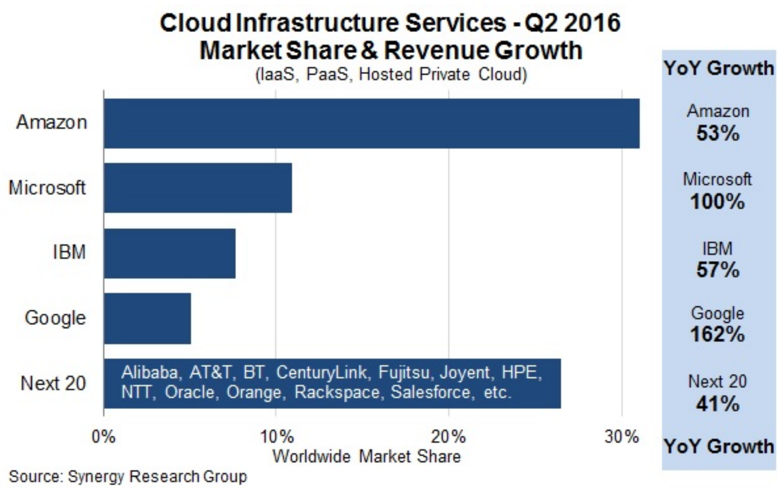

Figure 1: The major cloud service providers are showing significant growth

With more consumers and businesses relying on the cloud for services and data, this growth will continue. Furthermore, the demand for computing power is set to intensify, as more and more cloud providers look to build artificial intelligence (AI) capabilities into their offering. These factors, in turn, impact energy use as chip makers increase their power requirements in CPUs, GPUs, and FPGAs.

As Figure 1 illustrates, currently just a few cloud providers concentrate the majority of cloud infrastructure services. In effect, cloud providers such as Amazon and Microsoft are now the largest utility companies for IT services worldwide. To support these services, they must operate hyper-scale data centers that run millions of servers, each of which requires power to operate. As the computing capacity of these companies increases, so does their power demand.

As a result, managing energy expenses is one of the most critical issues for all data center operators. And the larger the size of the data center, the more critical energy efficiency in power devices becomes.

Energy Efficiency Implications

To illustrate the point, let’s consider the energy efficiency of two different CPU voltage regulators that could be deployed in a server design, as shown by the blue and red curves in Figure 2.

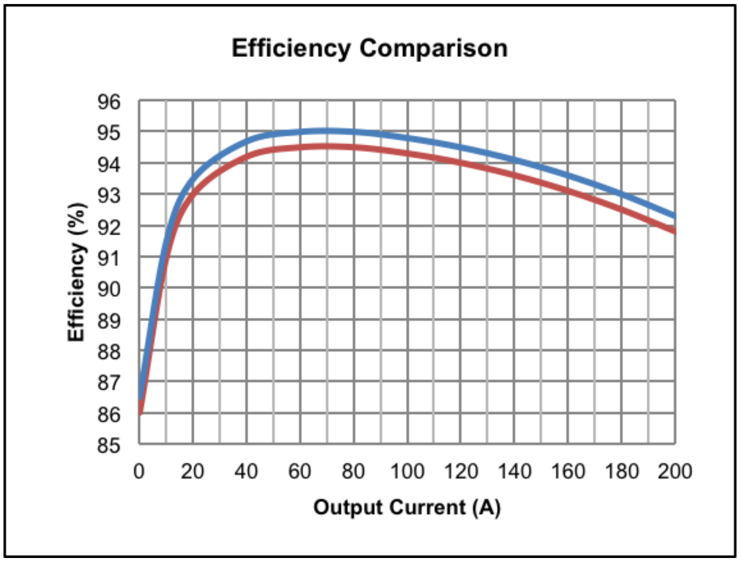

Figure 2: CPU voltage regulators operating with different levels of efficiency

With an efficiency gap of just 0.5% points, choosing the blue voltage regulator to power the server CPUs and memory banks would yield electricity savings of approximately $6 throughout the server's lifetime (based on the assumption that the server is operated for three years and that electricity cost is $0.12/kW-hr).

Clearly, $6 over three years is not enough of an incentive for a company buying just a handful of servers to get involved in the selection of internal power components. However, the perspective of the server buyer changes when we take a look at the operation of a hyper-scale data center. If we assume that such a center could have two million installed servers, then using the blue voltage regulator would generate close to $25M of savings in operational expenses. This high-level estimate includes savings not only from the reduced energy consumption of the installed servers, but also the energy lost in distributing power from the grid to the servers and the cost of cooling the data center facility itself.

This means that greater efficiency in servers is actually a top selection criterion for data center operators.

Business Continuity

In addition to the commercial implications of greater operating efficiency, there is another factor that cloud providers and server manufacturers take very seriously - business continuity.

As top cloud service providers continue to enjoy double-digit growth, any disruption in the supply of the servers on which their business is built can cause significant problems. It is essential, therefore, for server manufacturers to eliminate as many factors as possible that could limit their ability to meet their customers' insatiable appetites for computing power. This includes building flexible power designs around the premise of 'multi-source', such that the ability to satisfy any rapid increases in demand are not disrupted by sudden supply constraints on key components.

Modular Power Solutions

The issues of energy efficiency and the ever-present demands to simplify circuit design and reduce component count have led to the emergence of integrated, modular power solutions. These modules deliver high levels of efficiency and incorporate a variety of integrated capabilities including high-precision telemetry and advanced protection features. More recently, in order to address the multi-source demands of server manufacturers, a growing number of these module solutions now comply with common, 'de-facto standard' footprints.

Take, for example, ON Semiconductor's latest family of Smart Power Stage (SPS) modules, which are supplied in a Power QFN package and are optimized for performance.

As well as exhibiting best-in-class energy efficiencies, these next-generation, ultra-compact, integrated MOSFET-plus-driver power stages support the universal 5 mm x 6 mm footprint that has now been adopted by over 90% of the server market. The family leverages ON Semiconductor's MOSFET expertise, combined with advanced power packaging technology, to deliver high efficiency, high-power-density, and ‘supply-assured’ synchronous buck DC-DC converters demanded by the high-performance servers, storage and telecom systems used in today’s cloud infrastructures.

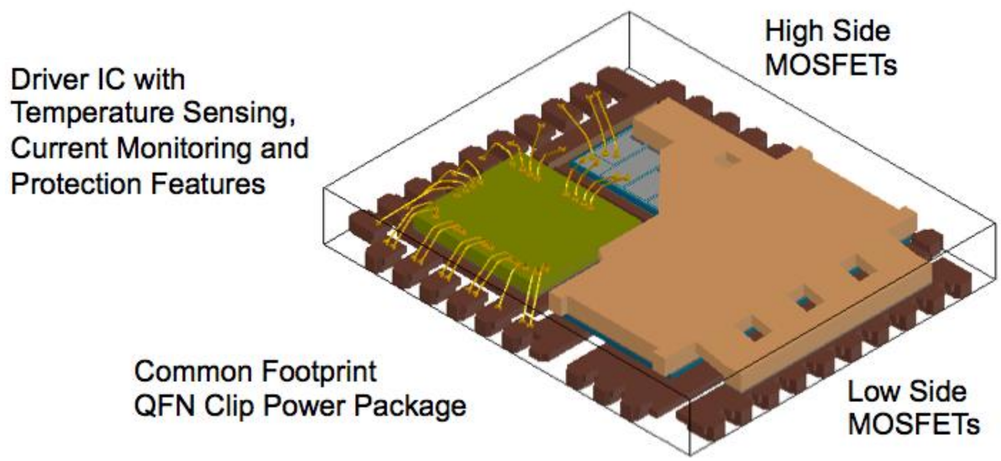

Figure 3: Solid model illustrating 5 mm x 6 mm PQFN package construction

Copper clips, similar to leadframes, replace wire bonding inside the power package. Not only does this approach improve thermal conductivity, but it also reduces the parasitic inductances in the package, improving energy efficiency.

Environment: Minimum Pad, Heat Sink, 200 LFM Forced Air

5 x 6 Package Interconnect	Q_{JA} (°C/W)	(%) Improvement from Wire Package
PQFN Wire	27.1	—
PQFN Clip	23.8	13.9

Figure 4: The Cu clip offers significant improvement in performance

The SPS module range includes a total of eleven devices that offer a range of options and features, allowing designers to select the best possible solution for each application. As Figure 5 shows, three particular devices provide optimized solutions for powering the CPU and memory in servers for cloud applications.

Device	Description	Output Current	Package	Current Monitor	Thermal Monitor
FDMF3180	High Efficiency	70 A_{PEAK}	Universal Footprint 5x6 QFN	Yes	Yes
FDMF3170	Mainstream Performance				
FDMF3172	Lower Current	55 A_{PEAK}			

Figure 5: SPS modules with integrated current and temperature monitors

SPS Features

The SPS portfolio is designed for modern high-performance power solutions, operating up to 1 MHz. With an integrated approach, the complete switching power stage is optimized for driver and MOSFET dynamic performance, system inductance, and power MOSFET $R_{DS(ON)}$.

SPS modules use ON Semiconductor's latest high-performance PowerTrench® MOSFET technology to deliver clean voltage waveforms and reduce ringing, eliminating the need for snubber circuits in most buck converter applications. Under-Voltage LockOut (UVLO) and a catastrophic fault-reporting pin are just two of the features that support designers in integrating safety into advanced designs.

The compact PQFN devices permit extremely dense layouts. As an example, a complete six-phase design can be realized within a 43.4 mm x 16.6 mm space. This includes the power inductors that account for approximately 50% of that space.

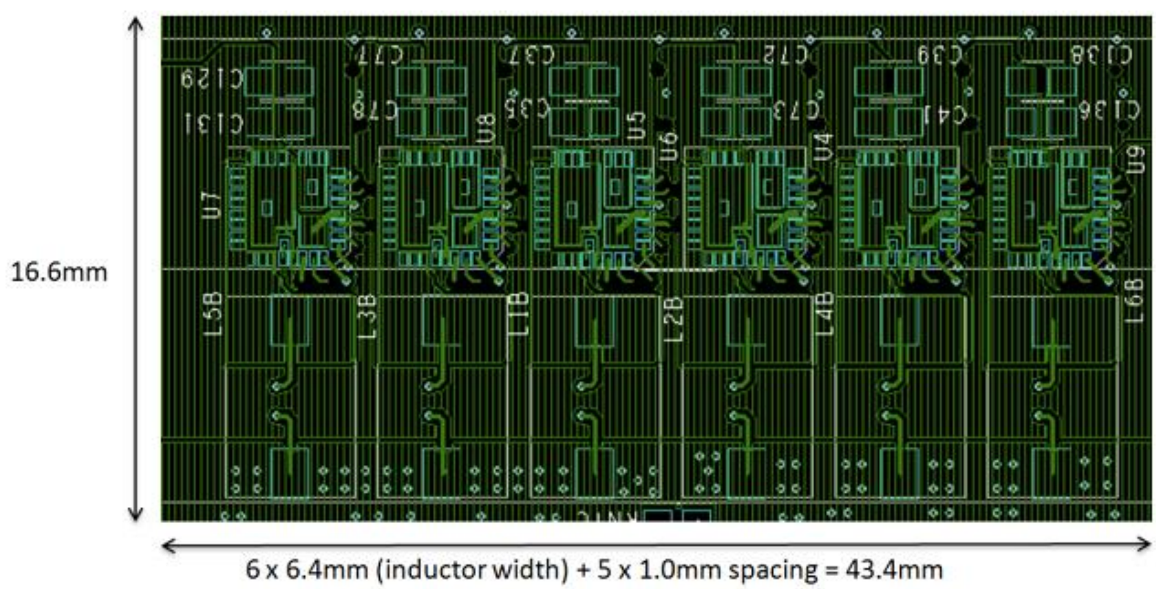

Figure 6: PCB for a high-density 6-phase design using SPS modules

Summary

Given the scale and size of modern data centers, power design is a challenging area where even small gains in efficiency have a huge impact. Incorporating advanced MOSFET and packaging technologies, ON Semiconductor's SPS module solutions represent a significant step in achieving the demanding performance and density requirements of this sector.

Furthermore, because these devices are supplied in a universal 5 mm x 6 mm form factor, server manufacturers not only have the peace of mind of being able to 'multi-source', but also have the flexibility of replacing existing parts to deliver improved performance without costly and time-consuming board re-design.

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