High Efficiency Server

Power Solutions for Data Centre and Cloud Computing Applications Move Closer to Production

High efficiency cabinet or rack-level architecture power solutions are necessary to improve the overall power efficiency of systems that perform the increasing number of data centre and cloud computing applications. Power architectures such as IDT's coolRAC include an AC/AC PSU front end, backplane, AC/DC Synchronous Rectifiers, and DC/DC VRM. Such systems demonstrate near 90% overall efficiency.

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Since introducing an initial concept one year ago, IDT has now completed the first system-ready prototypes of its coolRAC components. These include a 480VAC 3-phase input/50VAC output PSU Silverbox, 300W 50VAC input/5VDC output Synchronous Rectifier, and a 5VDC input/1VDC output Voltage Regulator Module (VRM). A 3.6kW Server Power Demonstration System shows the functionality of the power conversion components in a server-like application. This article describes IDT's coolRAC demonstration system and its performance in supporting the global need for higher efficiency in data centre and cloud computing applications.

Picture 1: coolRAC Demonstration System

The coolRAC Demonstration System consists of a 20U 19" standard rack, two PSU Silverboxes, and six power blades (five with 5V loads and one with VRMs and 1V loads). The backplane was designed to show that a low cost two-layer, two ounce copper PCB backplane was sufficient to supply the required power at high efficiency for this demonstration. A LabVIEW interface was used to monitor power at critical points in the system and to control the PSU and blade system configuration and power levels.

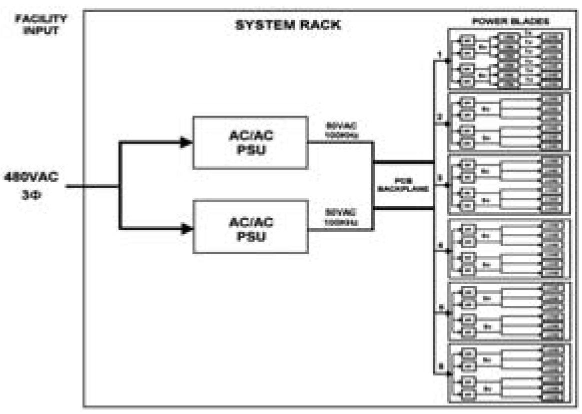

Figure 1: Demonstration System Block Diagram

VRM

Beginning at the end of the power chain, or the point-of-load conversion, the core voltage conversion is done by a VR12.x Intel standard or equivalent, 6-phase PWM Buck controller. It is widely known that if the input voltage to the controller is reduced from 12V to 5V a significant boost in efficiency can be realised. The efficiency boost achieved versus the typical 12VDC to 1.0VDC conversion is ~3%. The 5VDC to 1VDC VRM was designed using coupled inductor technology. In addition to high efficiency, this approach significantly reduces the need for output bulk capacitors and reduces overall solution size.

The point-of-load conversion could also be achieved using a Voltage Regulator Down (VRD) implementation if the board area and the design expertise are available. The coolRAC demonstration system utilises six VRMs on one of the power blades in order to show the overall system efficiency, to the 1VDC output of the VRM. The efficiency of all six VRMs running in parallel on this blade is over 95%

Synchronous Rectifier

The 300W Synchronous Rectifiers (SR) should reside as close to the load (i.e. processor, memory, ASIC, etc) as possible. This is recommended in order to minimize the I2R losses, and to achieve the highest efficiency possible, on the 5VDC (SR output) bus. The SR converts the 50VAC 100KHz backplane voltage to 5VDC at 98% efficiency. The SR configuration is centre tap with secondary side control using a 10:1:1 transformer ratio.

Backplane

Backplane losses are very low using a 50VAC 100kHz AC distribution voltage - typically less than 1%. Also, 50VAC is overall much safer than technologies such as 400VDC or 48VDC distribution. 50VAC was chosen as a safe operating level that also provided very low losses on the backplane. For higher power solutions, additional layers of copper can be added, the backplane voltage can be increased, or a combination of the two can be implemented.

Power Supply Unit/Silver box

The Front-end PSU Silver box was designed for 3.6kW maximum output power. This power level provides a building block for satisfying the power requirements of much larger systems and is similar to the power level of PSUs for 12VDC and 48VDC architectures. The Vienna 3-phase rectifier PFC front-end, using power MOSFETs provides a .99 power factor at full power. IDT's coolRAC technology allows for current sharing between multiple PSUs and provides power supply redundancy. Both the PSUs and the power blades are Hot-Swappable – a 'must have' for this type of application. The input voltage to the PSU is 480VAC 3-phase, which is readily available in data centre and cloud computing environments. The output is 50VAC 100KHz and the form factor will be somewhat smaller than standard 12V or 48V silver boxes. The 50VAC 100KHz output current waveform is sinusoidal and therefore unlikely to cause problematic system EMI issues. Voltage ripple is a very low 260mVpp. Crucially, the implementation of high efficiency server power solutions in data centres should not require a modification to the existing building infrastructure, as is the case for High Voltage DC distribution.

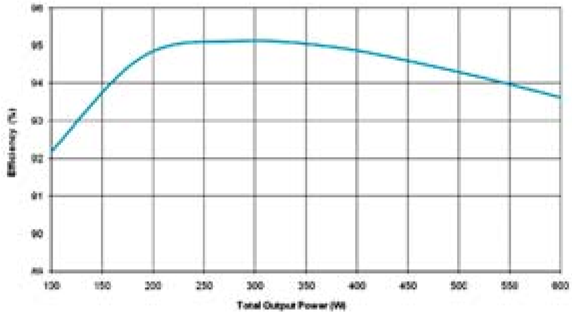

Figure 2: VRM Blade Efficiency (All six VRMs on Blade 1)

Depending on the region of the world 480VAC, 380VAC, 220VAC, 208VAC are already available in data centres.

The closest comparison to the legacy 12VDC and 48VDC PSUs and the coolRAC PSU is to look at the efficiency from 480VAC to the 5VDC output of the SR. One should then factor in the distribution losses of the legacy architectures. The coolRAC efficiency from 480VAC to 5VDC (includes silverbox, backplane losses, and SR) is over 94%. When typical backplane losses in legacy systems are taken into account this is equivalent to 80Plus Titanium level efficiency.

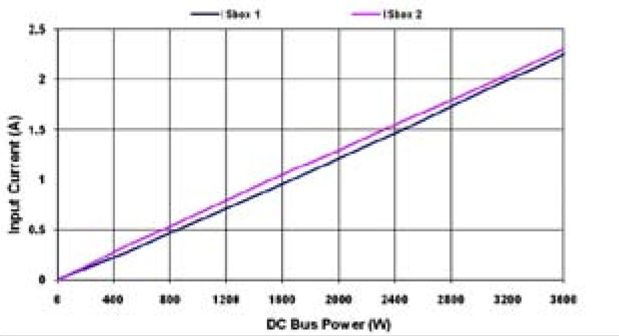

Figure 3: Current sharing <4% across the load range

Overall System

The net effect of having a high efficiency VRM, SR, backplane, and front-end is overall efficiency from 480VAC to 1VDC of almost 90%.

Typical server systems today have an overall efficiency that ranges from around 70% to 85%. Most use 220VAC and a 12VDC or 48VDC backplane distribution voltage. The replacement of all existing servers with higher efficiency architectures could save a 12MW data centre approximately $1M per year in electricity costs for power and cooling. The worldwide power consumption for data centres is

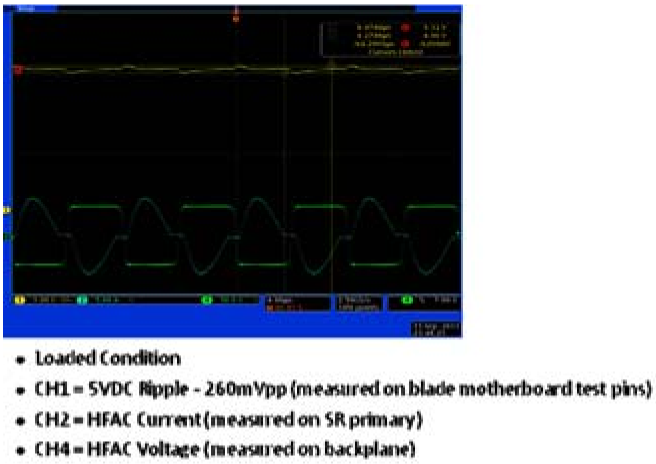

Figure 4: CH2 (Blue) is 50VAC Generator Output Waveform

equivalent to seventeen 1GW power plants (Koomey, Lawrence Berkeley National Laboratory-2007). Assuming a 10% average system power saving implemented worldwide, this would be equivalent to a savings of 141 12MW data centres or in monetary terms, $141M per year.

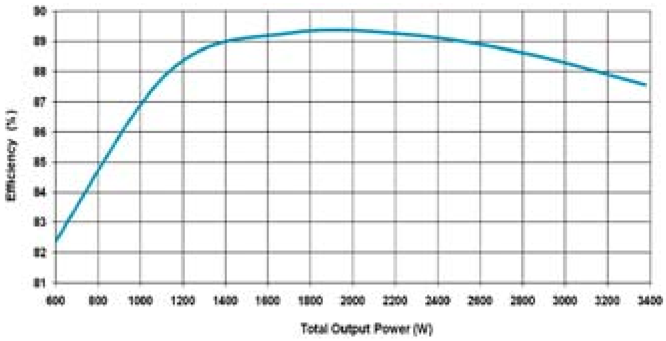

Figure 5: Total System Efficiency from 480VAC to 1VDC

Conclusion

Barring a significant downturn in the world economy, data centre power consumption is expected to increase by 19% over the next 12 months and will continue to increase in the foreseeable future. Market drivers include cloud computing, video and music file sharing, mobile data, and social networking applications.

The potential costs savings that can be achieved with the use of high efficiency server power solutions is extremely high. The higher efficiency also results in the ability to add additional computing resources for the same amount of overall power and cooling. It is common that utilities will charge a significant kilowatt-hour price premium if the allotted power usage for the data centre is exceeded. High efficiency server power solutions allow data centre managers the ability to meet both their power budgets and computing resource requirements.

Architectures such as IDT's coolRAC provide a very attractive option for lowering the cost of operating a data centre and provide improvement to key performance metrics, including gigaflops/watt, that show the effectiveness of power delivery. Such architectures provide a straightforward and cost effective approach to improving power efficiency, meeting today's challenges and positioning for further enhancements.

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