APPLICATION NOTE

Point-of-Load Power Solutions for Low Voltage Applications

DC-DC CONVERTERS AND ACCESSORIES

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Introduction

Modern digital electronics present a challenge to designers of power systems for critical reliability applications in military, avionics, and space programs. The latest high performance FPGAs, ASICs, and processors require increased high performance from the power supply. Typical requirements include low voltages, high currents, tight regulation, fast transient response, and even supply voltage sequencing. These requirements present an even greater challenge to the military designer who does not have access to the latest new components but instead must choose from a limited set of high reliability power converters and discrete components.

VPT's High Efficiency Reliability Optimized (HERO) Power System includes a set of hybrid DC-DC converters that offer a new solution to the low voltage problem, and allow the military designer to assemble the smallest, most reliable, and most efficient system possible.

The 28V Distributed Power Bus

The typical 28V military power bus is governed by MIL-STD-704 for aircraft, MIL-STD-1275 for vehicles, or by specific system or program requirements. The normal steady state voltage can vary significantly, and the transient voltage can vary from the teens to the forties under disturbances, transients, and surges. The simplest way to construct a power system is to convert the 28V into regulated load voltages, 5V, 12V, and 15V for example, and bus the load voltages to different loads or subsystems. This centralized approach has several drawbacks including cumbersome distributed wiring for multiple voltages, poor regulation, and transient response at the load, and lack of configurability or easy upgradeability.

Distributed 28V Meets Low Voltage

The typical high performance digital board may require several different voltages, 5V and below. For example, each FPGA or DSP will require one voltage for the I/O circuitry and another to power the processor core. A typical FPGA might require 3.3V for the I/O and the 1.2V for the core. Multiple FPGAs with different core voltages can result in several voltages ranging from 5V down to 1.2V or lower on a single board.

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There are several ways to generate the required low voltages. The first, shown in Figure 1, is to use and isolated DC-DC converter for each voltage. VPT offers a variety of isolated DC-DC converters which operate from the unregulated 28V power bus. They each have a wide input voltage range, input transient capability, and are available in various power levels with various fixed or trimmable outputs including 1.9V, 2.5V, 3.3V, 5.0V, 5.2V, 12V, and 15V.

The efficiency of isolated 28V input hybrid DC-DC converters has in the past been mediocre. A typical hybrid DC-DC converter might be 84% efficient for a 12V output model, 80% efficient for a 5V output model, and 72% efficient for a 3.3V output model. Below 3.3V the efficiency drops rapidly. The overall efficiency of the system show in Figure 1 is 63.3%. The total power dissipated is 14.6W. This low efficiency creates a problem for the modern digital board. It results in wasted power, excess heat which must be dissipated, and higher overall operating temperatures. A better solution is needed.

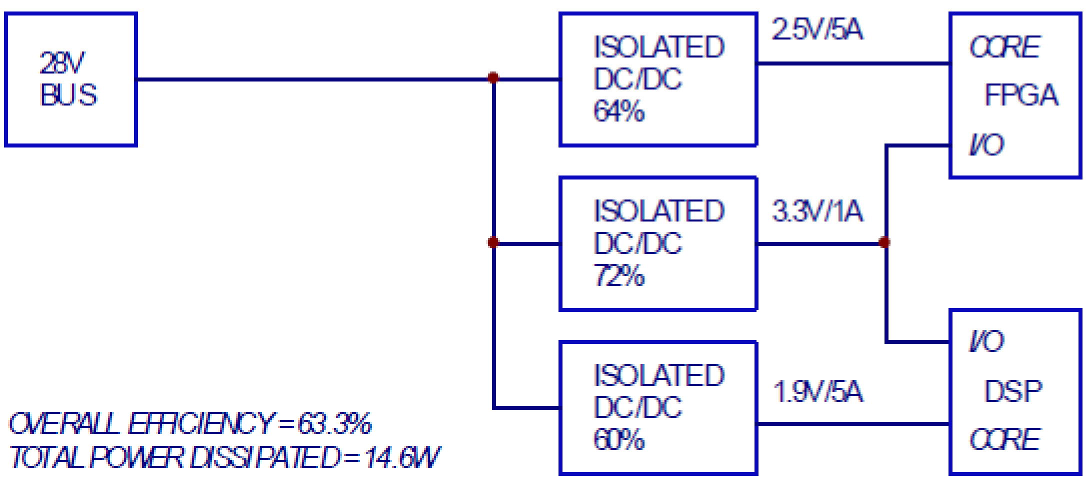

Figure 1. Low Voltage Application Using Isolated DC-DC Converters.

The HERO Power System

VPT's HERO Power System is comprised of two components: a high efficiency isolated hybrid DC-DC power converter and a smaller hybrid point-of-load converter built to military specification for hi-rel use.

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The DVHR High Efficiency Isolated DC-DC Converter

The first step to an improved high reliability low voltage system is a better isolated DC-DC converter. To meet this need, VPT has introduced the DVHE2800S series of high efficiency isolated DC-DC converters as a component of the HERO Power System. A wide input range, 500V of isolation, and compatibility with VPT's standard EMI filters allow the DVHE2800S to drop into almost any 28V application. Hermetic hybrid packaging and rated operation over the full military temperature range, -55ºC to +125ºC, meet the strict environmental and reliability requirements dictated by most military and avionics systems.

The DVHE2800S maintains preferred features for easy incorporation into system designs. Patented magnetic feedback circuitry eliminates optocouplers and their accompanying problems. Low input and output noise simplifies board design and eliminates the need for additional capacitors in most applications. Full undervoltage lockout circuitry, overcurrent and short circuit protection are standard. The input voltage range is 16V to 40V continuous, with transient capability of 50V for 1 second. The package footprint is 1 inch by 2 inch and is available both with and without mounting flanges.

Single low voltage outputs are available: 1.9V, 2.5V, 3.3V, and 5.0V, each trimmable, at up to 50W of output power. Using advanced synchronous rectification techniques, the DVHE2800S achieves efficiencies of up to 90% for the 5V output, 88% for the 3.3V output, 86% for the 2.5V output, and 84% for the 1.9V output. Output transient response is optimized with fast response times for demanding digital loads.

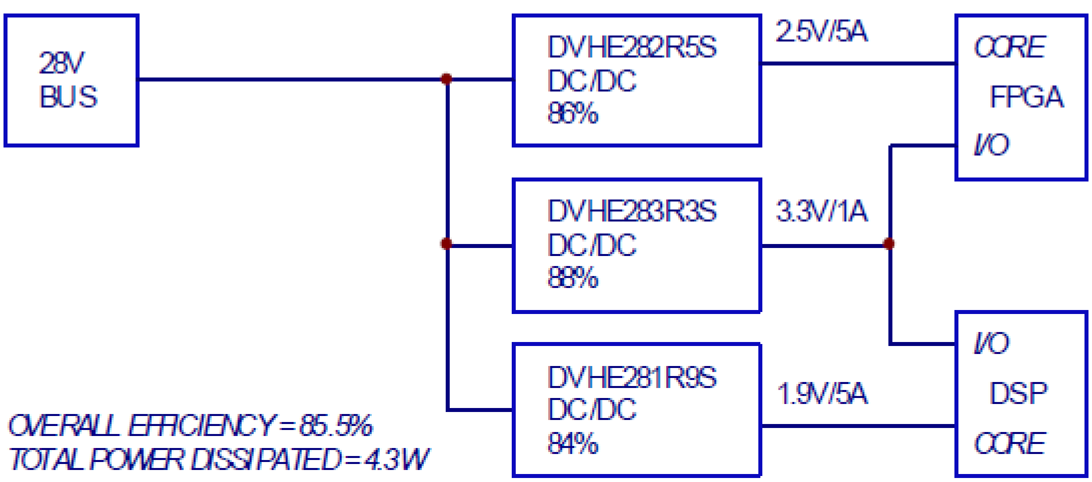

Figure 2. Low Voltage Application Using the DVHE2800S Series.

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Replacing a standard isolated DC-DC converter with a DVHE2800S series DC-DC converter can reduce power losses by 3 to 4 times. The application from Figure 1 can be reconfigured in this manner as shown in Figure 2. The overall efficiency is improved from 63.3% to 85.5%. The total power lost in the power converters is reduced from 14.6W to 4.3W. This reduction in power losses will be accompanied by reduced operating temperatures and increased reliability. The total current drawn by this application would be 1.1A at 28V input, down from 1.4A, over a 20% reduction.

The Post Regulator Approach

The second method commonly used to develop several low voltages, shown in Figure 3, is to use post regulators. One isolated DC-DC converter is used, typically the highest voltage needed, 3.3V, 5V, or 12V. The lower voltages are then down regulated from the main voltage. The post regulator can be either a linear regulator or a non-isolated buck converter. This technique is especially attractive when several different voltages are needed. The post regulators can be placed directly at the load for the best performance.

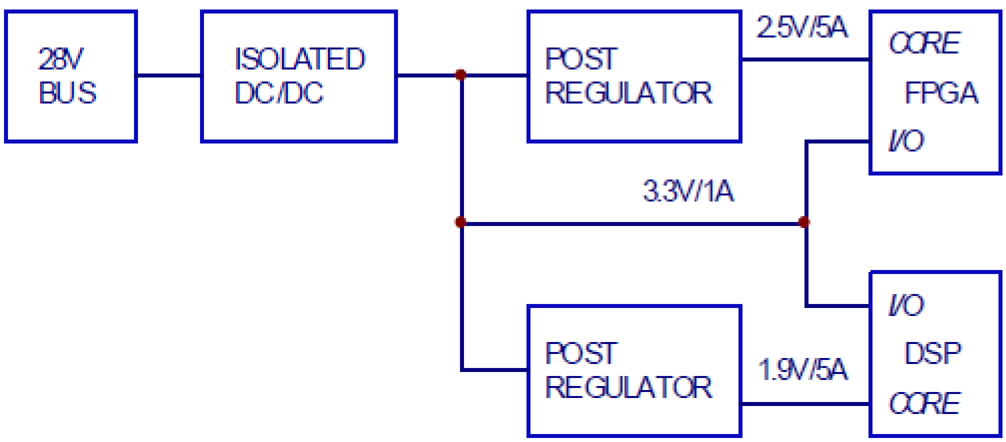

Figure 3. Low Voltage Application Using Post Regulators.

A linear regulator can be used to develop a lower voltage from a higher one. The power dissipated in the linear is equal to the current multiplied by the voltage drop across it. For example, the linear regulator supplying 3.3V at 1A from 5V is 66% efficient and will dissipate 1.7W. The linear regulator supplying 1.2V from 5V is only 24% efficient. For this reason, linear regulators are generally only recommended for low currents, typically 1A or less.

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The non-isolated synchronous buck converter schematic is shown in Figure 4. This is a switching circuit which can be used to develop a low voltage from a higher one. This circuit can achieve much higher efficiency than the linear regulator. For the military or hi-rel designer, it is not a simple drop-in circuit like the linear regulator. The synchronous buck must be built from discrete components: PWM controller, MOSFETs, capacitors, power inductor, etc. These components are not usually rated for the military temperature range or widely available in hermetic packages. So a compromise must be made and reliability must be sacrificed for performance. The risk and design effort is increased, since the buck converter must be redesigned or at least the printed circuit implementation must be redesigned for every new digital card that requires it.

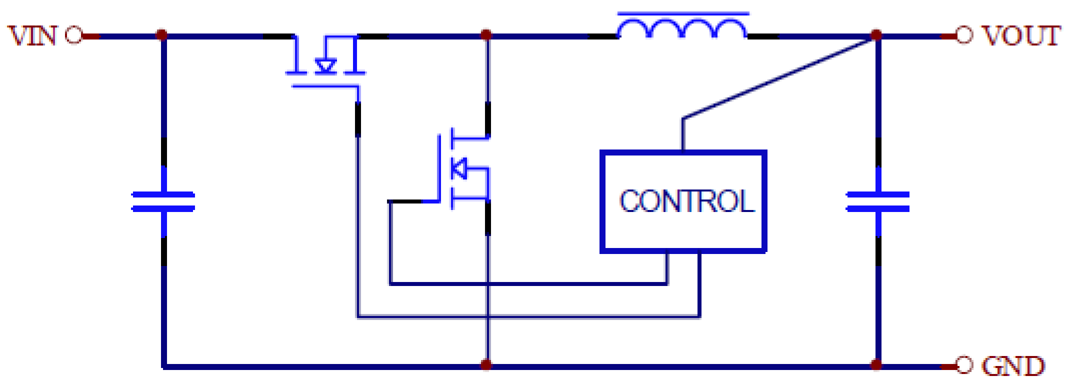

Figure 4. Non-Isolated Synchronous Buck Schematic.

The DVPL High Efficiency Point-of-Load Converter

To eliminate the compromise and allow the most efficient and most reliable system possible, VPT has introduced the DVPL0505S “point-of-load” DC-DC converter. The DVPL is a high efficiency non-isolated synchronous buck converter, built with hermetic hybrid technology and rated over the full military temperature range, -55ºC to +125ºC. Only 1” x 0.8” in size, the DVPL can be located as close as possible to the load for the best performance. The DVPL operates from a fixed 5V or 3.3V input and with one external resistor, outputs 5A at any voltage from 3.3V down to 0.8V. The efficiency is typically 90 to 97%, and is optimized over a load range of 1A to 5A.

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The HERO Low Voltage Solution

With the HERO Power System's new set of high reliability, high efficiency DC-DC converters available, digital power systems no longer have to suffer from compromises of efficiency, performance or reliability. The system of Figure 3 can be improved as shown in Figure 5 by dropping in the DVHE and the DVPL as the post regulator. The design task is simplified, with a few hybrid blocks replacing many various discrete components. The reliability is increased, with the entire power circuitry being hermetically sealed and rated for the full military temperature range. The bill of material is reduced, with only two part types required to generate three voltages.

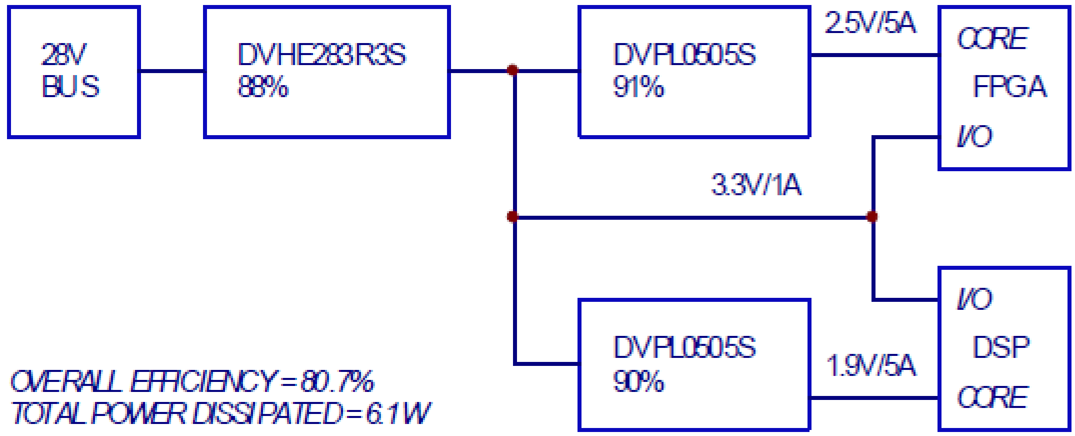

Figure 5. Low Voltage Application Using the HERO Power System.

The HERO 5V Distributed Bus

The next progression is to realize that only one isolated converter may be needed for several digital boards. Instead of wiring the unregulated 28V to every board, and then adding the required EMI filter and DC-DC converter on each board, it could be simpler to isolate only once. One EMI filter, the DVMC28 or DVMD28, and one isolated converter, the DVHE2805S, could generate a 5V regulated bus with 90% efficiency. The 5V could be bussed to the various digital load boards, where point-of-load converters, the DVPL0505S, would convert to 3.3V and below for FPGAs, etc. The final conversion would take place directly at the load for best performance. This type of optimized system is shown in Figure 6.

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The distributed low voltage bus is often chosen to be 5V or 12V. Both are frequently used, but in the past, 12V has been chosen for two reasons: the isolated converter has been more efficient with 12V output than with 5V output, and distribution losses can be less with 12V. The availability of the DVHE2800S DC-DC converter with 90% efficiency at 5V output tips the scales back in favor of the 5V bus. The DVHE is more efficient than any currently available 12V output hybrid DC-DC converter. The distribution losses can still potentially be lower for a 12V system, but the distances involved are usually small and so they tend to be a small portion of the total losses and not a driving factor. The synchronous buck converter will also operate more efficiently at 5V input, since it will have a better conversion ratio than at 12V input. With both ends of the power conversion being more efficient, 5V is the recommended low voltage bus.

The circuit of Figure 6 is significantly more efficient than that of Figure 5. This is counter intuitive, since an additional regulator was added to the 3.3V power path. The first reason is that the DVHE isolated converter is more efficient at 5V than at 3.3V. The second is that the DVPL non-isolated converter is also more efficient at 5V input, due to it having a better internal gate drive voltage.

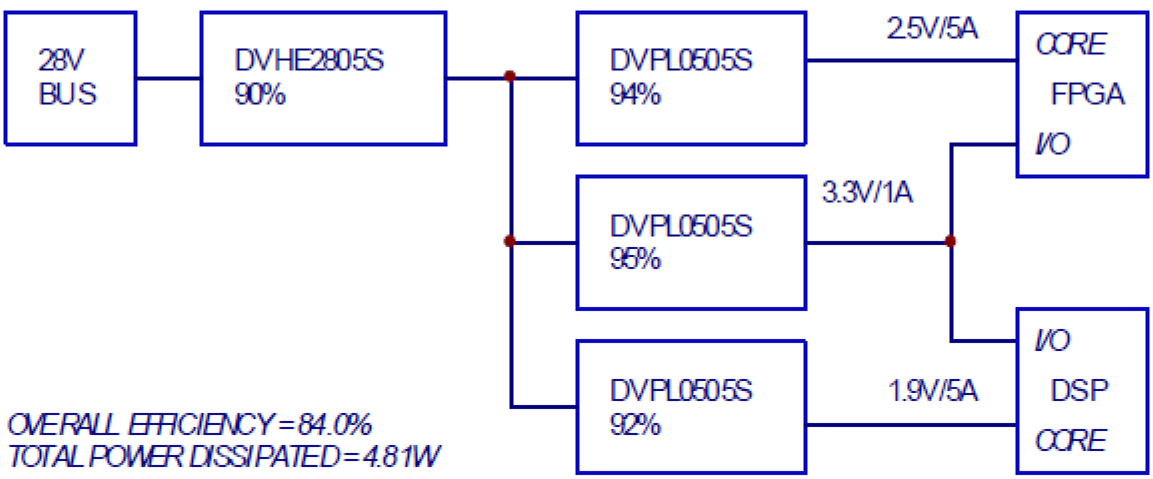

Figure 6. Low Voltage Application Using the HERO Power System Distributed 5V Bus Approach.

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Low Voltage Flexibility

Complex FPGAs and processors often add additional strict requirements on the supply voltages. Often one voltage may not exceed another, or two voltages may not differ from each other by more than a certain amount. These requirements are often met by tying voltages together with Schottky diodes, or by controlling the turn on and turn off sequence of the various voltages, often referred to as power sequencing. Power sequencing is difficult with isolated converters, due to long turn on delay times and primary referenced enable signals.

To greatly simplify this task, the DVPL0505S converter includes a TRACK input. The TRACK input can be used to accurately sequence the turn on and turn off of several converters. The TRACK input can also be used to implement voltage tracking, whereby several voltages follow the same startup curve until they reach their respective regulation points.

Conclusion

The lack of high reliability high efficiency DC-DC converters has long been a stumbling block for the military power designer, causing increased design effort and compromises between reliability and performance. Comprised of the DVHE series of high efficiency isolated DC-DC converters and the DVPL high efficiency point-of-load converter, the HERO Power System eliminates this impediment. Overall system efficiency is greatly improved while maintaining the highest reliability and simplicity. The elements of the HERO Power System can be arranged and configured to meet almost any low voltage power need with optimum performance.

Contact Information

For further information about any of VPT's products, policies, or programs contained herein, or to request a quotation or place orders please contact your sales representative or the VPT Inc. Sales Department at:

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