Optimizing Power Conversion in High-Reliability Rugged Embedded Systems

an Elma Electronic White Paper

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Supplying power for today's highly mobile, highly rugged embedded computing environments goes well beyond a mere power supply unit (PSU). While an integrated PSU is key to system operation, dense electronics are demanding more power than can reasonably be supplied from just one power source.

Because many embedded systems are now being used in a much wider variety of harsh and space-constrained applications, SWaP (size, weight and power) is a critical factor in every design element. The advent of smaller systems brings with it the use of embedded systems in mobile and remote locations, where power may not be readily accessible, so alternate power sources must be considered.

Systems need methods of sustaining a reliable, and independent, power source to ensure continued operations. Many of the applications where SFF rugged systems are used have a degree of criticalness to them, whether that be loss of life (avionics, medical) or detrimental effects of a work stoppage (power plants, transportation, military and defense), in the event of a power failure.

Power More with Less

SWaP optimization quickly becomes a design dilemma when it comes to the power needed to supply these intense systems. Operation must continue, but balancing a limited power source with the power-hungry, denser system of today has presented quite a conundrum for embedded designers developing systems for rugged and mobile applications: how to supply consistent, reliable power in applications where

limited, or in some cases no, alternate power source is available.

Instead of adding a larger unit or incorporating multiple PSUs in a single system, new design methodologies are being implemented.

Some are focused on converting energy generated by an alternate source into new forms of power that can meet the demands of these highly integrated, dense computing structures—even if they are mobile, rugged, compact, etc. Others are helping condition and balance load requirements to stabilize a steady stream of power within the system itself.

Common Power Challenges

With the increased demand on systems today, power challenges exist in almost every installation. For systems in remote locations and harsh environments, some aspects can be amplified, due to the nature of the installation and the application. Keeping these in mind will ensure that the proper power solution is incorporated into your application.

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Fluctuation. When a system is in a remote location, power needs can be subjected to fluctuating demands. The same supply needs to accommodate a system running at full load that sometimes only has standby or much lower power requirements. How can power needs be balanced to avoid over- as well as under-voltage?

Reliability. In military, defense, medical and transportation applications especially, the need for reliable power is synonymous with user safety, as the loss of power means the potential loss of life. What safeguards should be in place to ensure a power supply remains steady?

Low Maintenance. Installing embedded systems in remote locations mandates the least maintenance requirements possible. Repairs for things such as calibration or wear-and-tear can't be part of the equation. What elements can the PSU include so it can operate continuously with limited user intervention?

Efficient operation. Making what is installed work better and more cohesively is the driving principle behind the concept of energy re-harvesting. The power conversion unit needs to improve the operation of what is already installed. How can the system do more with less?

Repurposing for a Purpose

Energy efficiency is the key to minimizing energy losses. Values, like peak and average energy requirements, can significantly influence the design and efficiency of a PSU as well as the detailed power consumption profiles, which allow the PSU to be adapted to the power needs of the application.

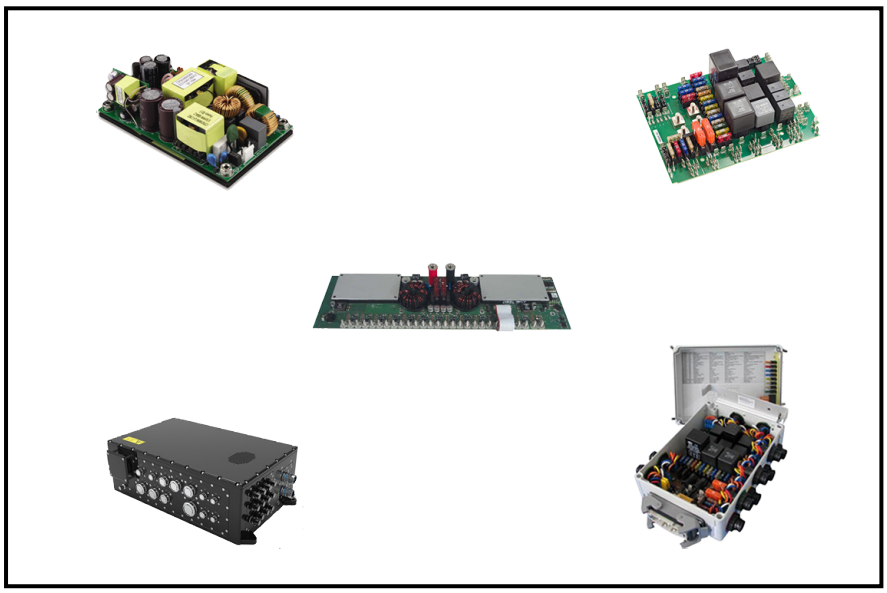

Figure 1:
More power in smaller packages is one of the SWaP goals. Sample of Elma power solutions shown.

In terms of improved efficiency, system designers are employing methods that enable power from one area of an application to be repurposed and supply power to a system in another part of the application. That power is also being conditioned and balanced through embedded power conversion units to ensure the supply is stable and steady. An added benefit is less heat generation, since the system does not need to add another PSU.

These types of technology innovations are very important when designing a power supply. Equally as important is the knowledge of all the power-related parameters of the application, such as energy requirements, energy losses, system requirements, power balancing, design topologies and efficiency.

Solving Specific Power Problems

No matter the industry, developments in power conversion technologies have made it much easier to find a useful way to design a system that will work for specific application needs.

At the same time, when developing power supplies for different applications, such as transportation, defense, medical, etc., several areas of focus related to each unique set of circumstances need be taken into account, e.g. normative requirements, environmental requirements, application-specific requirements, safety requirements and service relevant requirements.

Ensuring reliable military communications. For a recent military installation, Elma developed an AC-DC PSU, since most of the equipment, including the direction beam, 2-way radio, etc., is powered by 24 VDC. Because it runs a critical military communications system, this power supply must be very reliable, work in every condition and must be immune to HEMP and lightning. For added system reliability, the PSU simultaneously charges a battery pack and can switch to battery power in case of AC power loss.

Distributing power across railway systems. The high-current 24 VDC power needed to drive railway-wayside motors for points, signaling and communication equipment traditionally means very thick copper cables that limited the span of the wire itself and significantly adds to system cost. To reduce loss in the power distribution, Elma crafted a high-efficiency, compact DC-DC converter with a supply voltage of 800 VDC. Longer distances with thinner cables at reduced costs are now possible.

Meeting regulations of home healthcare equipment. As medical equipment becomes more mobile, technology is being put directly into the hands of the patient, meaning more accountability from medical equipment suppliers. Regulations are continually being updated to ensure patient safety and upcoming IEC standards are mandating even more EMC protection among medical devices. One such standard is IEC 60601-1-11, which applies to devices used by the patient, such as in-home blood pressure monitoring. Knowing these requirements, and staying compliant, is as critical as the equipment itself.

A Design Engineer's Paradise

Choices for standard PSUs are plenty, and many include inherent features and capabilities that provide the flexibility needed to be modified appropriately to meet system requirements. Power supplies are available in various form factors, too: open frame and u-bracket, chassis or DIN rail-mount, plug-in modules, 19" rackmount shelf, PCB-mount and modular, building block configurations.

PSUs also be configured as modular plug-in units for specific uses, as may be needed in VPX and PC/104 systems. For example, Elma's rugged PCI-104-based PSUs can not only serve as the bottom module in any PC/104, PC/104-Plus, PCI-104,

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PCIe/104 or PCI/104-Express embedded system stack arrangement, but these units can also provide power for other small form factor (SFF) embedded computing systems, such as COM Express.

When all application needs are considered, however, the choice may be a custom-engineered solution that is far better suited to the actual requirements, versus a standard product. Not only can specific conditions be addressed, but optimization on several different levels can be achieved with a customized solution. Working with a partner that provides strong integration engineering and production capabilities will also help keep NRE (non-recurring engineering) charges to a minimum as well as help meet high volume production requirements.

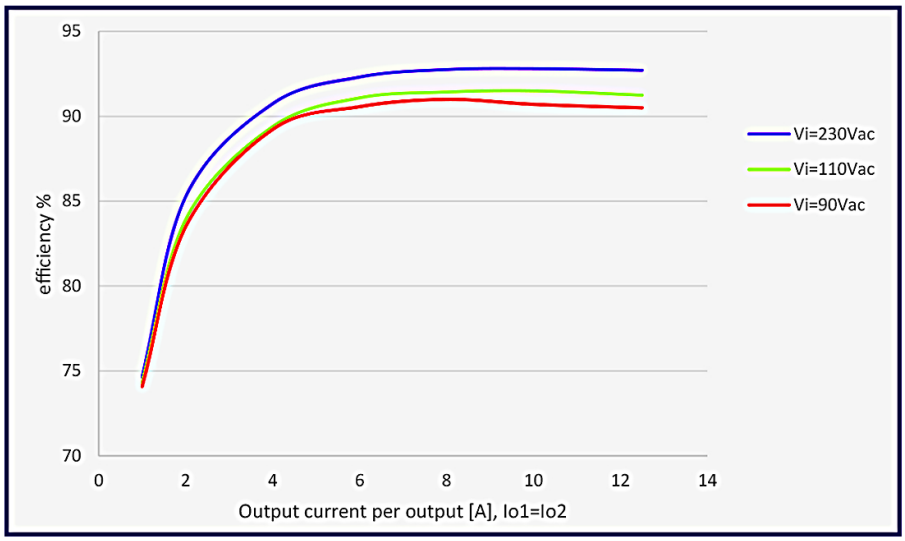

Figure 2:
Power efficiency vs. voltage & input (graph courtesy of Bel Power).

Bottomline, if a state-of-the-art power supplies are required, look for a partner that brings with it a broad set of custom design capabilities for a wide variety of applications as well as knowledge of standard product. That way, you'll have access to up-to-date engineering resources as well as an expansive product choice that will help you meet whatever your application needs might be.

What are Your Power Needs?

As noted above, there are typically two main choices depending on the

application: modify a standard power supply to meet system requirements, or, more often than not, design a fully-custom unit to provide the right match to supplying the needed power within a given application. Knowing what elements to consider for high-reliability systems is a large factor in determining the proper path.

The Balance of Power

The increasing demand for SWaP in mobile and remote embedded systems has brought with it some challenges for embedded system designers. But as components started to shrink in size, integration began happening on a deeper level. Functionality within a given system then grew, but the challenges that arose were met with redefined design principles that weren't even conceived a decade before.

Engineers tasked with making the seemingly impossible task of 'more power, less heat' a reality have been able to improve system efficiencies. This diligence has led to the expansion of embedded systems into applications and markets that had never been considered viable, due to environmental factors, location or computing needs.

Ensuring reliable, high quality power in this new landscape has been no small feat. But thanks to innovative engineering, these compact, high density embedded systems have reliable power in the remote and harsh environments where they are expected to operate.

For more information on Elma's power supplies and solutions, visit **www.elma.com**.

- What approvals, specific standards or industry tests need to be met for safety and EMC compliance?
- Have you defined the dimensions, installation position, cooling and derating requirements?
- Are methods in place to manage signal integrity, noise control and system interference?
- What are the environmental conditions and protections needed to mitigate temperature, moisture, overload, short circuits, shock, vibration, etc.?
- Do you know what the lifecycle of your PSU and the system it will power needs to be?