

Technical Article

How to optimise multi-output power systems

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Abstract: *Engineering applications in medical, industrial, and laboratory environments often require power systems capable of delivering multiple, tightly regulated outputs. As system complexity grows, so do the challenges associated with space constraints, thermal management, electromagnetic compatibility (EMC) compliance, and safety certification. In this article, Giulio Bocciolini, Senior Product Marketing Manager EMEA, TDK-Lambda, examines the essential engineering considerations in multi-output power system design, the importance of output isolation, and how modular solutions can help engineers overcome these challenges.*

The growing complexity of power system design

The increase in automated equipment used in medical, industrial, and laboratory environments has driven a need for power supplies capable of delivering multiple, precisely regulated voltages. Whether it's a medical robotic system requiring isolated supplies for patient safety or a test bench with sensitive analogue and digital loads, engineers must balance a host of requirements: compactness, thermal management, EMC, and, above all, safety.

Traditionally, three main approaches have been available to meet these needs: deploying multiple single-output AC-DC power supplies, implementing a distributed power architecture (DPA), or adopting modular and configurable multi-output power supplies. Each approach offers its own advantages and trade-offs, particularly in managing heat, noise, compliance, and system flexibility.

Key engineering considerations: thermal, EMC, and safety

One of the most immediate challenges in multi-output power system design is thermal management. Using several single-output power supplies may seem straightforward, but each unit generates its own heat. When these supplies are installed in close proximity, as is often the case in space-constrained applications, the cumulative thermal load can quickly become problematic. This not only risks overheating and leads to power supplies derating but also necessitates additional cooling solutions such as heat sinks or fans, which add complexity and cost. Advanced modular supplies use an internal fan that adjusts its speed based on real-time temperature monitoring, ensuring sensitive components remain cool.

EMC compliance is another critical consideration. Multiple power supplies operating simultaneously can be a significant source of electromagnetic interference (EMI), which can degrade power quality, interfere with sensitive equipment, and complicate compliance with international standards such as IEC/EN 60601-1-2 and EN 55032. The burden of EMC testing, often referred to as 'EMC chamber time', along with the associated engineering effort, can add substantial time and cost to the development process. In contrast, modular power supplies are typically pre-certified for EMC performance, streamlining the path to compliance and reducing the risk of costly redesigns.

Safety certification to IEC/EN 61010-1 and IEC/EN 62368-1 standards is also vital for medical and industrial equipment. In medical applications, where patient protection is non-negotiable, the IEC/EN 60601-1 standard imposes strict limits on earth-leakage current, typically 500µA or lower, depending on the end

equipment. On the one hand, when multiple single-output supplies are used, their individual leakage currents add up, often exceeding this threshold and rendering the approach unviable, even if each unit is medically certified. Modular supplies, on the other hand, are designed with known, low earth leakage values and provide the necessary means of patient protection (MoPP) isolation, including output-to-earth isolation of 1500 Vac, to meet the requirements of patient connected applications.

For laboratory and test environments, compliance with IEC/EN 61010-1 is seen as being highly beneficial, as it simplifies end-equipment certification.

The role of isolation between outputs

Isolation between output voltages is a defining feature of modern modular power supplies, and its benefits extend far beyond compliance. First and foremost, isolation provides flexibility in system design. With fully floating outputs, engineers can configure positive or negative voltages as needed, often using the same part number for different system requirements.

Secondly, isolated outputs can also be connected in series to generate higher voltages, provided that the maximum values of insulation voltages are observed. This capability is invaluable in applications where non-standard voltages are required, or where system requirements may change over time. Furthermore, floating outputs with positive and negative remote sense can compensate for voltage drops in both load wires, improving load regulation and stability for voltage-sensitive loads.

Noise isolation is another key advantage. In systems where one load generates significant electrical noise, isolated outputs prevent that noise from propagating to other, more sensitive loads. This is particularly important in mixed-signal environments or where high-precision measurements are involved. Additional common-mode filtering can be applied to individual outputs as needed, further enhancing system robustness.

Ground loop prevention is a constant challenge in complex systems, especially when multiple loads are referenced to earth ground. Modular supplies with floating outputs make it easier to implement central 'star point' grounding, minimising the risk of noise currents and voltage spikes circulating through the system. This is far more difficult to achieve with non-isolated supplies, where multiple current paths through shared 0 V connections can lead to unpredictable behaviour and increased susceptibility to interference.

Design approaches: solving specific challenges

Each of the three main design approaches handles output isolation and the associated engineering challenges in fundamentally different ways.

Multiple single-output supplies

Deploying multiple single-output power supplies (Figure 1) is often seen as a simple, low-cost solution. Standard units are easy to source, and the upfront investment may be lower than more integrated options. However, this approach quickly runs into limitations: it consumes more space, complicates AC wiring, and introduces cumulative earth leakage and inrush currents that can exceed safety limits. In medical applications, the sum of earth leakage currents can easily exceed the 500 μA threshold, making this approach impractical for anything but the simplest systems. The risk of EMI is higher, and managing multiple part numbers adds logistical complexity.

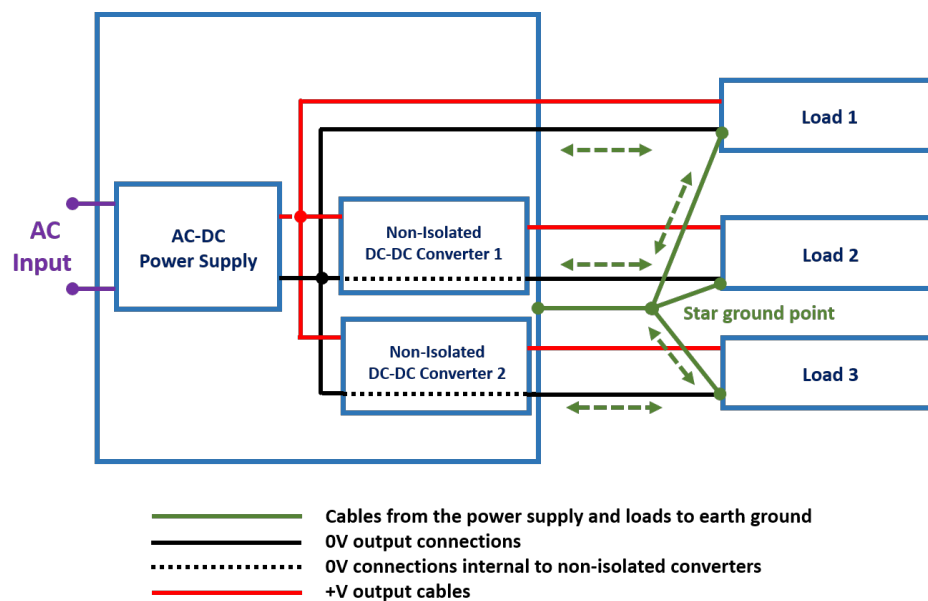


Figure 1: Ground loop challenges with non-isolated outputs and shared 0V connections (Source: TDK-Lambda)

Distributed power architecture

Distributed power architecture (Figure 2) offers greater flexibility by separating AC-DC conversion from point-of-load DC-DC conversion. This can be cost-effective and allows for efficient use of space, as DC-DC converters can be placed close to their loads. However, DPA demands a high level of power system design expertise, as the engineer is responsible for ensuring EMC compliance. At higher powers, mechanical integration and thermal management become more complex. Like the use of multiple single-output supplies, the DPA approach requires sourcing a range of components and may involve coordinating with external electronic manufacturing services (EMS) providers. This adds complexity to the supply chain and increases management

overhead. Additionally, if galvanic isolation is required between different parts of the system, isolated DC-DC converters must be used. These converters are generally larger and more costly than their non-isolated counterparts, which can reduce the overall cost benefits of the DPA method.

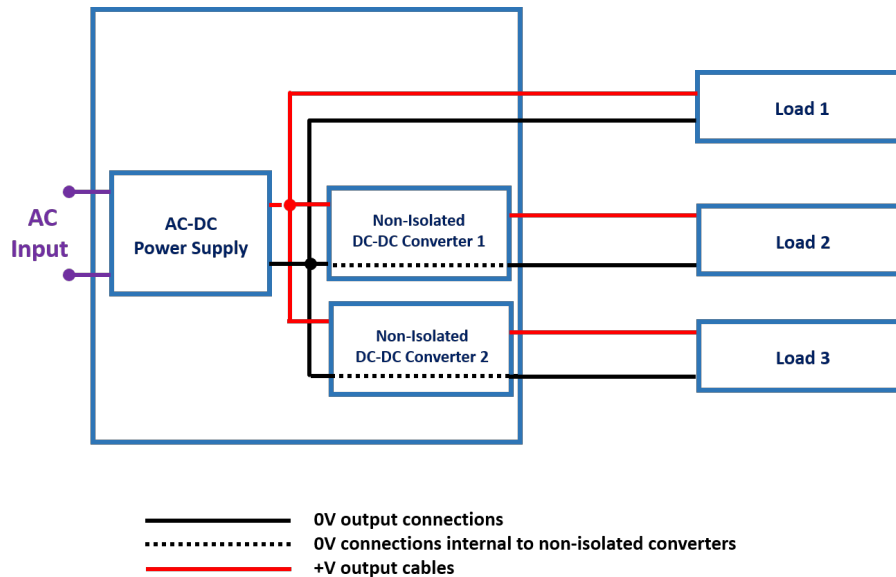


Figure 2: Distributed power architecture using an AC-DC supply with non-isolated DC-DC converters (Source: TDK-Lambda)

Modular and configurable supplies

Modular and configurable power supplies (Figure 3a), such as units in the TDK-Lambda MU series, are compact, available in 1 U (41 mm) high formats, and can provide up to 13 or even 18 fully isolated outputs. They come pre-certified for safety and with tested EMC levels, with known earth leakage and touch current values, and offer a plug-and-play approach that simplifies installation, cabling, and future maintenance. These modern units achieve efficiencies of up to 94 %, reducing heat generation and improving reliability, while intelligent fan control keeps acoustic noise as low as 36 dBA at 80 % load, improving comfort in sensitive environments.

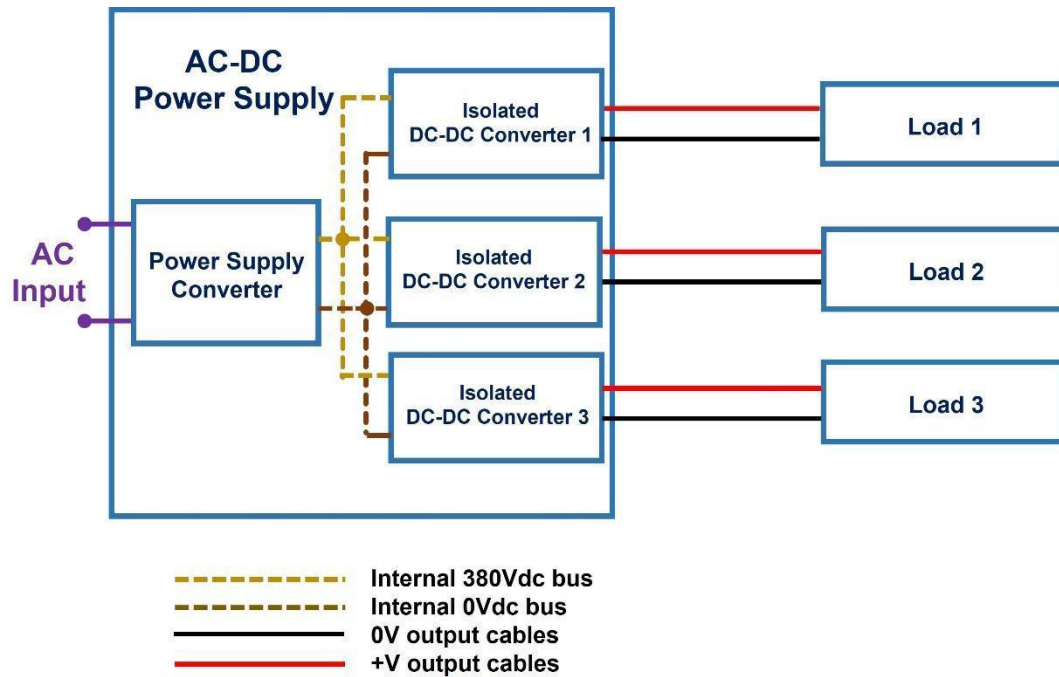


Figure 3a: Modular power supply architecture with isolated DC-DC modules and floating outputs (Source: TDK-Lambda)

The MU6, for example (Figure 3b), delivers up to 1500 W in a compact footprint, with output voltages configurable from 3.3 V to 105.6 V, and includes advanced features such as remote sense, output good signals, PMBus™ communication. With a single part number covering a wide range of configurations, inventory management is simplified, and the path to compliance is greatly accelerated. Also, a unique advantage of the MU Series is full certification to IEC/EN 61010-1, making it particularly valuable for laboratory and test equipment where streamlined compliance is a priority.



Figure 3b: TDK-Lambda MU6 series module (Source: TDK-Lambda)

Conclusion

When evaluating multi-output power system solutions, it is essential to consider the total cost of ownership, including development time, compliance effort, and long-term reliability, rather than focusing solely on component cost.

For teams without deep power expertise, modular and configurable platforms provide a fast, efficient route to robust, future-proof designs. With their fully isolated outputs, pre-certification, and advanced features, they offer a compelling solution for engineers seeking to optimise performance, ensure safety, and streamline design and compliance.

As always, consulting with experienced suppliers can provide valuable guidance and help ensure that your power system not only meets today's requirements but is adaptable for future needs.

For more information, visit <https://www.emea.lambda.tdk.com/landing/en/>

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TDK-Lambda Corporation is aligned for fast responses to any customer need with R&D, manufacturing, sales and service locations in five key geographic regions, namely Japan, EMEA, Americas, China and ASEAN.

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