STREAMLINING POWER SUPPLY DESIGN TO OPTIMIZE SWAP-C AND ACCELERATE TTM

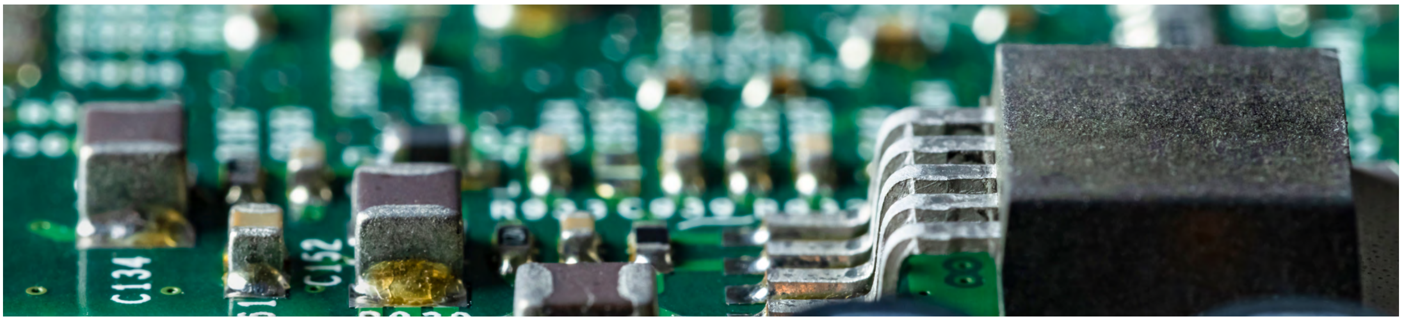
Power supply solutions also tend to be some of the most expensive components in the system bill-of-materials (BOM).

WHITEPAPER: 07/2025

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES



INTRODUCTION

There are many compelling reasons to optimize the design process—particularly for the power supply subsystem, which is often viewed as a necessary inconvenience rather than a direct contributor to high-value system features. Power supply solutions are also among the most expensive components in the system bill of materials (BOM). These factors, combined with the confidence that comes from reusing a qualified design block or a commercially available power module, strongly motivate the adoption of a leverage/reuse strategy across successive projects

A REVIEW OF THE TYPICAL POWER SOLUTION DESIGN PROCESS

To fully understand the motivations behind leveraging or reusing power supply solutions, it's useful to briefly examine the typical design process and pinpoint the gaps and opportunities that drive these strategies. Whether you're a direct power stakeholder or a recipient of power supply design services, if the generalized process outlined below aligns with your experience, you're likely not alone in that perspective.

R_x The "Official" Power Supply Design Process

Step 1: All system stakeholders (*typically minus the Power stakeholder*) get together and architect a system.
Step 2: Determine system power budget by summing maxima of all major loads in the system.
Step 3: Confirm feasibility with the Mechanical/Thermal stakeholder.
Step 4: Provide power budget, volumetric constraints, and project timeline to Power Stakeholder.
Step 5: Magic?!? (*i.e. — forget physics and reality*)

Figure 1: The "Official" Power Supply Design Process, courtesy of PowerRox

The figure above outlines the typical high-level steps a team might follow to progress from concept to establishing a system power budget and defining physical or environmental constraints. While not an "official" process – there's a bit of humor involved – it still reflects a lot of real-world truth. The "magic" segment refers to the unrealistic demands that stem from overinflated power budgets, which can call for efficiencies, densities, or transient responses that are either impractical for the product class or simply unattainable, even with state-of-the-art (SOTA) technology.

A key takeaway is that while power stakeholders are expected to meet these outputs, they are often excluded from the process that generates the inputs. Given that power engineering is a specialized discipline requiring a multidisciplinary background—typically built through years of hands-on experience – it's surprising how rarely these stakeholders are consulted early on. This is especially problematic given that power subsystems are often the primary gatekeepers to optimizing system size, weight, power, and cost (SWaP-C). Since no electronics function without power, performance and reliability must also be added to that list.

To make matters worse, the project timeline is usually built around an idealized, flawless development cycle – often shortened by 10% to improve time-to-market (TTM) over the previous generation – layering even more pressure on top of these already unrealistic expectations.

Now comes the negotiating process. Engineers are trained to be problem solvers, so when faced with a list of challenging problems, the kneejerk response is to start digging into solutions (i.e. – Is there an existing part that can meet this power density and footprint? Should airflow go from front-to-back or back-to-front to meet the system thermal envelope? And so on...). Even this initial step is an opportunity to pause and examine the system budget—and how it came to be.

For instance, how often are all loads (especially the larger ones) drawing their maximum currents simultaneously? Many subsystems are intentionally designed to operate in antiphase with others (e.g. – the classic examples of compute vs. memory power demands or sleep/wake/transmit operating cycles), so it's rare that the sum of maxima – often taken from datasheets already reflecting unrealistic maximums with added safety margins – makes sense as an aggregated power budget.

Consider every touch point in that power budget from inception to finalization. Each stakeholder is likely to add their own margins to satisfy their specific guidance, and these layers accumulate quickly. Those added layers of "fat" can cost significant money and engineering resources when designing for scenarios that are truly unrealistic, even under extreme corner-case modeling.

Another key point in the fight against overinflated system power budgets is recognizing where the biggest opportunities for optimization lie. Start by identifying the largest, most demanding loads in the system, and consult with the critical stakeholder(s) who best understand what those loads actually require in terms of power. Whenever possible, gather real characterization data. This process often opens the door to implementing intelligent power management (IPM) techniques, such as aggregating lower-voltage power rails, load sharing or shedding, and short-term power allocation.

IPM is defined as a "combination of hardware and software that optimizes the distribution and use of electrical power in computer systems and data centers" [1]. While the term originated in the context of data centers, its applicability is broad, as IPM is more of a design mindset than a specific solution. For example, shifting the power subsystem architecture mindset from "always on" to "always available" can produce paradigm-shifting results in the final system design. Achieving this will require extensive collaboration with both internal team members and external vendors.

In other words, it is often far simpler, faster, and more cost-effective to invest the effort into reducing the system power budget to a realistic summary of worst-case, maximum power loading (from each individual power supply's perspective), rather than pouring that effort into trying to bend physics – or available components – to meet unrealistic expectations. Given the constant pressures around time and cost reduction, this approach allows for a much smoother negotiation process among team stakeholders and helps establish a pragmatic balance between time, cost, and quality.

These inevitable tradeoffs are tightly linked, no matter how much we wish they weren't, as illustrated in the figure below. For example, a product may be optimized for any two of time, cost, or quality – but rarely all three at once.

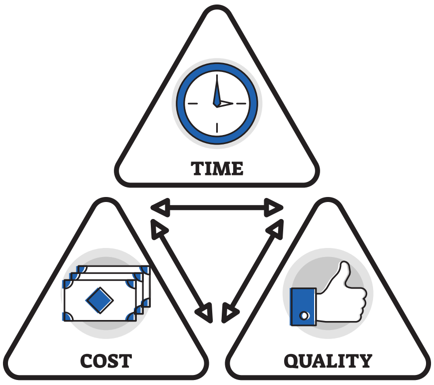


Figure 2: The Time/Cost/Quality Triangle

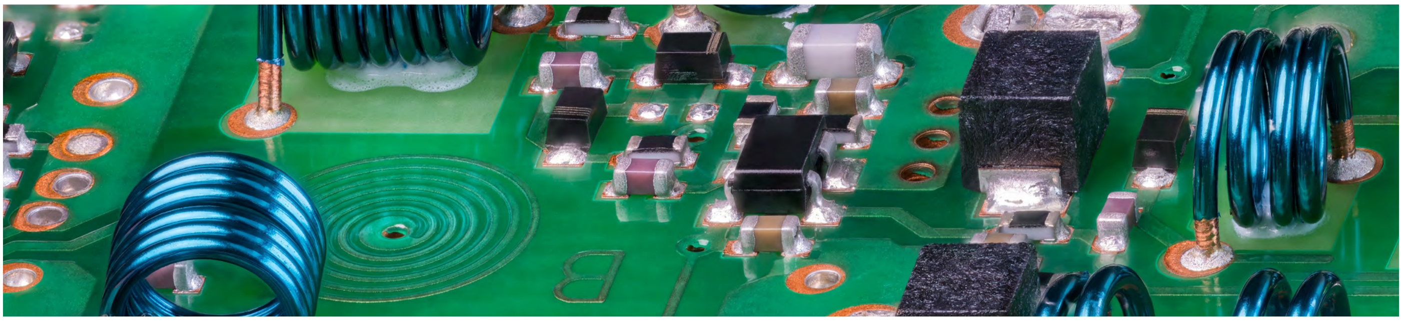
Articulating the difference between leverage and reuse is important when communicating with program managers or external vendors, as each term can imply something very different – even though they are often used interchangeably. Miscommunication here can lead to negative program or solution impacts.

Leverage refers to taking an existing solution and tweaking minor aspects (e.g. – passive component values, signal/logic/comparator thresholds, cosmetics, form factors, etc.) to optimize it for a similar, though not identical, use case. In this context, "semi-custom" is a commonly used synonym for leverage.

This distinction becomes particularly important when speaking with a component vendor about a "fully custom" design (i.e. – built from the ground up) versus a "semi-custom" design, which typically involves modifications to a commercial off-the-shelf (COTS) solution. The differences between the two can have significant implications in terms of quoted price (both component and non-recurring engineering, or NRE) and lead time.

Direct reuse refers to taking an existing design and copying it exactly. In effect, this is comparable to purchasing COTS (commercial off-the-shelf) components, though there can be some gray areas – since certain fixed designs are intentionally created with flexibility in mind. For example, reusing power bricks with a wide input voltage range or programmable output can support various applications.

It's also common to leverage a part family, particularly when dealing with power modules designed for standardized footprints. This allows for optimizing specific module characteristics – such as input/output voltage range, power density, current handling, pinout, and filtering – to better suit the application.



In general, common criteria for determining whether a case qualifies as leverage or reuse come down to a test of three key characteristics: form, fit, and function (i.e. – aesthetics, mechanical/thermal compatibility, and electrical/communicative performance). This is another area where careful negotiation and detailed discussions with team partners and solution providers pay big dividends, as some organizations have very strict definitions for adhering to form/fit/function.

For example, taking the exact same power supply and changing its ENABLE or POWER ON signal logic from positive to negative (high-level turn-on vs. low-level turn-on) may seem too minor to shift from direct reuse to heavy leverage – but that single change might trigger a full new round of qualification testing, just like a new product (e.g. – new part numbers to manage and all that comes with it), thereby placing it in the leverage category.

Even more seemingly trivial is changing a word, statement, or value on a printed label of a power brick. But if that label relates to safety – or if it affects part number formatting or unique identification stored in EEPROM – then new regulatory compliance testing may be required and/or manufacturing processes adjusted. This would break the form/fit/function criteria.

Having survived the process of negotiating the system power budget, one can now confidently focus on proposing solutions to make that budget a reality. Given the time and cost pressures, the initial effort will typically focus on known-good solutions or subcircuits (a.k.a. – macros), which is where leverage and even direct reuse become highly valuable. It's important to ensure that what's being leveraged or reused are solid, proven solutions – not just recycled out of operational pressure (with one exception noted below).

This highlights the importance of allocating time and resources for the things we often claim "we don't have time/resources to address." Blind reuse also carries forward any bugs or shortcomings from the original design. In fact, some organizations with strict adherence to form/fit/function requirements may even demand that a second-source component intentionally mimic a known bug or defect to maintain backward compatibility during multisourcing (NOTE: Multisourcing is a topic worthy of its own deep dive and should be carefully evaluated for its pros and cons before implementation – though that is outside the scope of this white paper).

Neglecting iterative improvements from one product generation to the next can significantly impact operational efficiency. On the other hand, reusing a proven, trusted design with well-understood performance characteristics can greatly accelerate development (i.e. – the platform design approach). There are many well-established, reliable power vendors available to support this strategy – especially when using COTS power modules.

If a design team is working on multiple system developments concurrently and/or in rapid succession, they are likely to develop a go-to toolbox of power solutions, sub-blocks, or product families suited to a range of standard application scenarios. This toolbox often includes pre-built, pre-qualified, and pre-tested power modules – whether developed in-house or sourced from a power supply vendor.

Naturally, this strategy supports optimization of all SWaP-C factors, as previously discussed, but its primary value lies in mitigating risk – particularly in critical, high-reliability, or high-volume deployments. For example, while an isolated power supply for a SiC driver can be constructed using a transformer driver, transformer, rectifier, and LDO, a ready-made DC/DC module (such as RECOM's RxxP1503D with asymmetric output voltages optimized for gate driver performance) not only accelerates the R&D phase but also consolidates multiple components into one BOM item. This significantly reduces the chance of an error that could damage an expensive SiC transistor.

STREAMLINING THE SYSTEM DESIGN PROCESS

Know your team stakeholders

This extends well beyond the core engineering team directly involved in system development. It should also include program managers (PMs), supply chain owners, manufacturing personnel, and even the software/firmware (SW/FW) designers. Though it may seem counterintuitive, some of the most important stakeholders to engage early on are the marketing and sales teams – along with anyone who has direct contact with customers or end users. It's far better to negotiate compromises and make informed decisions early, rather than have them dictated later in a top-down manner without input from power solution stakeholders – as highlighted at the beginning of this white paper. Avoid the "if we build it, they will come" mindset. If market requirements and customer potential are not clearly understood before initiating a new project, the risk of product failure increases significantly.

Know your technology

Don't wait until design kickoff to start thinking about conducting an industry survey – either to get a sense of the latest advancements or to refresh outdated information used in previous projects. Inviting vendors to provide technology or roadmap updates can be an excellent way to quickly gain an overview and tap into vendor resources to consolidate proposed solutions. This may even give you a head start on competitive analysis. Leveraging the support of motivated external partners to survey the vast industry landscape can save significant time and effort – and reduce the risk of missing out on state-of-the-art (SOTA) technologies. Most vendors will welcome the opportunity (and maybe even throw in lunch) for early engagement in potential developments.

NOTE: Always consider the source of any information and approach it critically. This underscores the importance of developing strong, working relationships with key vendors and service providers. In high-stakes development projects, a "customer is always right" mindset doesn't always lead to the best engineering outcomes. A collaborative relationship that shares some level of risk often increases the chances of success for everyone involved

Plan ahead of, during, and after project completion

Plan ahead of, during, and after project completion! Take time to review a "design playbook" or collection of learnings (a.k.a. – best practices, golden nuggets, etc.) before diving too deep into project or product definition. Often, the most recent issues from the last project are the ones that get overlooked because the team was under pressure to get the product out the door.

Don't hesitate to schedule team meetings multiple times throughout the project – ideally once per major phase or milestone – especially for reviews related to Design for Anything (DFx), safety/compliance (including powerline and electromagnetic interference or EMI compatibility), and user experience. The last point – user experience – deserves emphasis, especially since most design engineers aren't trained to consider aspects like look, feel, or general usability and comfort from the end user's perspective. After a costly and painful project delay caused by an engineer picking the wrong shade of black from 1,000 Pantone options, the importance becomes much clearer.

After the high-fives and champagne that come with project completion, be sure to hold a thorough post-mortem session to capture key learnings, bugs, risks, best practices, optimization opportunities, and process gaps – while they're still fresh in everyone's minds. DOCUMENT this clearly and extensively!

Beware of the "sprint" trap. When each task is constrained by tight time limits, longer-term or more complex design issues often get pushed aside – creating a "design backlog" that can significantly impact the final quality of the product.

IMPLEMENTING PRAGMATIC LEVERAGE/REUSE TRADEOFFS IN POWER SOLUTIONS

There has been extensive discussion so far on the general motivations for adopting a leverage/reuse strategy for power supply solutions and subsystems. But how does a designer identify and evaluate the many tradeoffs and implications of a single power rail implementation? The four key project objectives – scope, quality, cost, and time – define the product or development effort. These must be weighed against four primary constraints – performance, competitiveness, effort, and viability – which drive the negotiations and [sometimes uncomfortable] tradeoffs that ultimately shape the final product. This complex relationship is summarized graphically in the figure below.

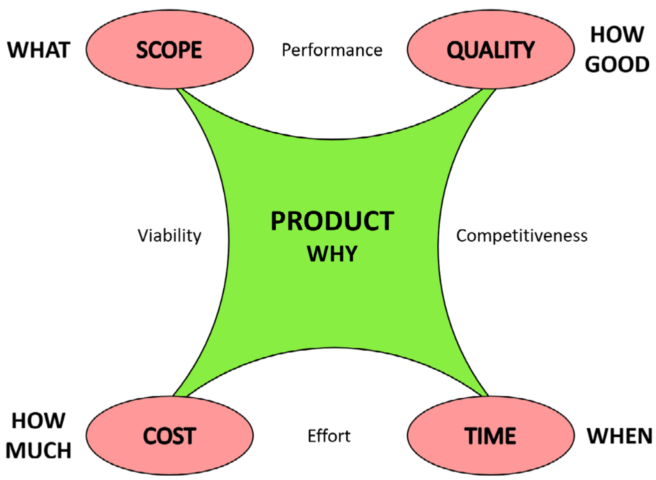


Figure 3: The Key Objectives & Constraints Tradeoff Tetrad

While volumes have been written on each and every topic outlined here (even specific to the more niche topic area of Power), a reasonable summary table is offered below as a more succinct starting point, as well as to make digestion of this white paper more manageable.

TRADEOFFS OF PROS & CONS ASSOCIATED WITH LEVERAGE & DIRECT REUSE STRATEGIES, BY STAKEHOLDER		
STAKEHOLDER	**PROS**	**CONS**
Power	– Opportunity to improve all aspects of SWaP-C factors – Known, reliable, qualified design – TTM – Reduced NRE $ – Reduced BOM $ – Manage multiple projects concurrently – Vendor/Supply Chain consolidation – Process/repository for design best practices – Reduced program schedule, time to initial power up – Known form/fit/function – Enhanced vendor relationship	– Multiple risk of design weakness – Upfront cycles to establish qualified design blocks – Engineering Change Order (ECO) risk management – Multisourcing qualification – Assurance of supply risk – Quality escapes from similar, yet different designs – Can be forced to incorporate known defects (i.e. – backward compatibility) – Can be forced to implement insufficient component thermal margins – Managing multiple unhappy customers/returns concurrently if major field issue
System Electrical Engineer	– Opportunity to improve all aspects of SWaP-C factors – Faster schematic/layout reviews – Increased confidence in power subsystem – Increased familiarity with power characteristics, debug capabilities – Known, reliable, qualified design – TTM – Reduced NRE $ – Reduced BOM $ – Manage multiple projects concurrently – Process/repository for design best practices – Reduced program schedule, time to initial power up – Known form/fit/function – Enhanced vendor relationship	– Multiple risk of design weakness – Upfront cycles to establish qualified design blocks – ECO risk management – Multisourcing qualification – Quality escapes from similar, yet different designs – Can be forced to incorporate known defects (i.e. – backward compatibility) – Can be forced to implement insufficient component thermal margins – Managing multiple unhappy customers/returns concurrently if major field issue
Mechanical / Thermal Engineer	– Opportunity to improve all aspects of SWaP-C factors – Known thermal/airflow impedance characteristics – Known form/fit – Faster computational fluid dynamics (CFD) simulations, reusable models – Known, reliable, qualified design – TTM – Reduced NRE $ – Reduced BOM $ – Manage multiple projects concurrently – Process/repository for design best practices – Enhanced vendor relationship	– Multiple risk of design weakness – Upfront cycles to establish qualified design blocks – ECO risk management – Multisourcing qualification – Risk if not designed/qualified for bidirectional airflow – Can be forced to implement insufficient component thermal margins

TRADEOFFS OF PROS & CONS ASSOCIATED WITH LEVERAGE & DIRECT REUSE STRATEGIES, BY STAKEHOLDER		
Program Manager	– Opportunity to improve all aspects of SWaP-C factors – Known form/fit/function – Enhanced vendor relationship – Predetermined subsystem blocks for system partitioning – Known, reliable, qualified design – TTM – Reduced NRE $ – Reduced BOM $ – Manage multiple projects concurrently – Process/repository for design best practices – Reduced program schedule, time to initial power up	– Multiple risk of design weakness – Upfront cycles to establish qualified design blocks – ECO risk management – Multisourcing qualification – Lack of familiarity/understanding of leverage/ – reuse requests – Quality escapes from similar, yet different designs – Can be forced to incorporate known defects (i.e. – backward compatibility) – Managing multiple unhappy customers/returns concurrently if major field issue
Software / Firmware Engineer	– Process/repository for design best practices – Increased familiarity with power characteristics, debug capabilities – Faster, simplified regression testing – More efficient memory utilization	– Bugs from changes not communicated – Confusion on sufficient qualification process – Field FW upgradeability – ECO risk management – Multisourcing qualification – Lack of familiarity/understanding of leverage/ reuse requests – Can be forced to incorporate known defects (i.e. – backward compatibility)
Component Engineer	– Known, reliable, qualified design – Reduced BOM $ – Enhanced quality modeling capability – Manage multiple projects concurrently – Process/repository for design best practices – Supplier quality auditing efficiency – Streamlined Quality Management System (QMS) – Component portfolio consolidation – Known form/fit/function – Enhanced vendor relationship – Increased familiarity with power characteristics, debug capabilities	– ECO risk management – Multisourcing qualification – Quality escapes from similar, yet different designs – Managing multiple unhappy customers/returns concurrently if major field issue – Extend lifetimes of less desirable vendor relation-ships
Manufacturing / Process Engineer	– Supplier quality auditing efficiency – Streamlined QMS – Enhanced quality modeling capability – Known form/fit – Reduced BOM – Process/repository for design best practices	– Multiple risk of design weakness – Upfront cycles to establish qualified design blocks – Quality escapes from similar, yet different designs – ECO risk management – Multisourcing qualification

TRADEOFFS OF PROS & CONS ASSOCIATED WITH LEVERAGE & DIRECT REUSE STRATEGIES, BY STAKEHOLDER		
Supply Chain	– Increased component volume pricing leverage – Component portfolio consolidation – Multisourcing support – TTM – Reduced BOM $ – Manage multiple projects concurrently – Enhanced vendor relationship	– Multiple risk of assurance of supply – ECO risk management – Multisourcing qualification – Lack of familiarity/understanding of leverage/ reuse requests – Managing multiple unhappy customers/returns concurrently if major field issue – Extend lifetimes of less desirable vendor relation-ships – Increased vendor pricing negotiation leverage
Marketing	– TTM – Reduced BOM $ – Reduced/reused new product training materials – Portfolio consolidation – Enhanced brand awareness due to commonality – Opportunity to improve all aspects of – SWaP-C factors	– Leveraged risk of damage to brand awareness – ECO risk management – Lack of familiarity/understanding of leverage/ reuse requests
Sales	– TTM – Increased profit margins – Reduced new product training – Portfolio consolidation – Improved product familiarity – Enhanced product satisfaction due to commonality – Simplified customer communication	– Managing multiple unhappy customers/returns concurrently if major field issue – Major field returns are very costly – ECO risk management – Lack of familiarity/understanding of leverage/ reuse requests

Table 1: Stakeholder Tradeoffs of Pros & Cons Associated with Leverage & Direct Reuse Strategies Table

SUMMARY & CONCLUSIONS

As has been clearly demonstrated over the course of this white paper, practical leverage/reuse goes far beyond simply cutting and pasting from one project to the next. Defining a specific process and strategy for leverage/reuse is a major enabler of a cleaner design process and puts a team on the path to continuous improvement in operational efficiency – which can translate into profits both directly (i.e. – NRE, TTM, value engineering, etc.) and indirectly (i.e. – improved performance/reliability, reduced warranty costs, customer/brand recognition, etc.). When performing a thorough assessment of operational efficiency – particularly in engineering design projects – it can be surprising how costly it is for an organization to neglect the very issues it claims it "cannot afford" to address.

Achieving this kind of utopian process goal requires an extraordinary effort to open frequent and comprehensive lines of communication with all types of stakeholders, both internal and external to the development. Knowing and communicating with all team stakeholders is essential – so the earlier the engagement in the development process, the better. Utilize vendors and suppliers to stay informed on technology and the competitive landscape, and identify those with product families that enable simpler leverage/reuse while maintaining design flexibility.

Find the right balance between the pressure to move too quickly with cut-and-paste solutions – just to stay off the critical path of the development timeline – and the need to extract maximum return on investment (ROI) from prior efforts and learnings. Though it may seem counterintuitive, it's often better to leverage an existing solution (even one with known "bugs") than to waste resources on a brand-new, unproven redesign.

If no stakeholder can clearly explain or justify the rationale for leveraging or reusing a product, component, circuit, or solution, there's a strong chance it lacks solid justification. Don't be afraid to challenge the status quo just because "...we've always done it that way."

If a standard power supply solution cannot be sourced off-the-shelf – and the project volume or cost constraints don't justify a fully custom design – consider a semi-custom solution. This refers to a standard power supply that has been modified by the manufacturer to meet the project's specific requirements. Most commercial power supply vendors offer this type of service. One key advantage is that many existing safety and regulatory certifications remain valid, significantly accelerating time-to-market (TTM).

For further discussion on the advantages of semi-custom solutions, refer to this RECOM blog.

KONTAKT:
RECOM Power GmbH
E-Mail: info@recom-power.com
www.recom-power.com