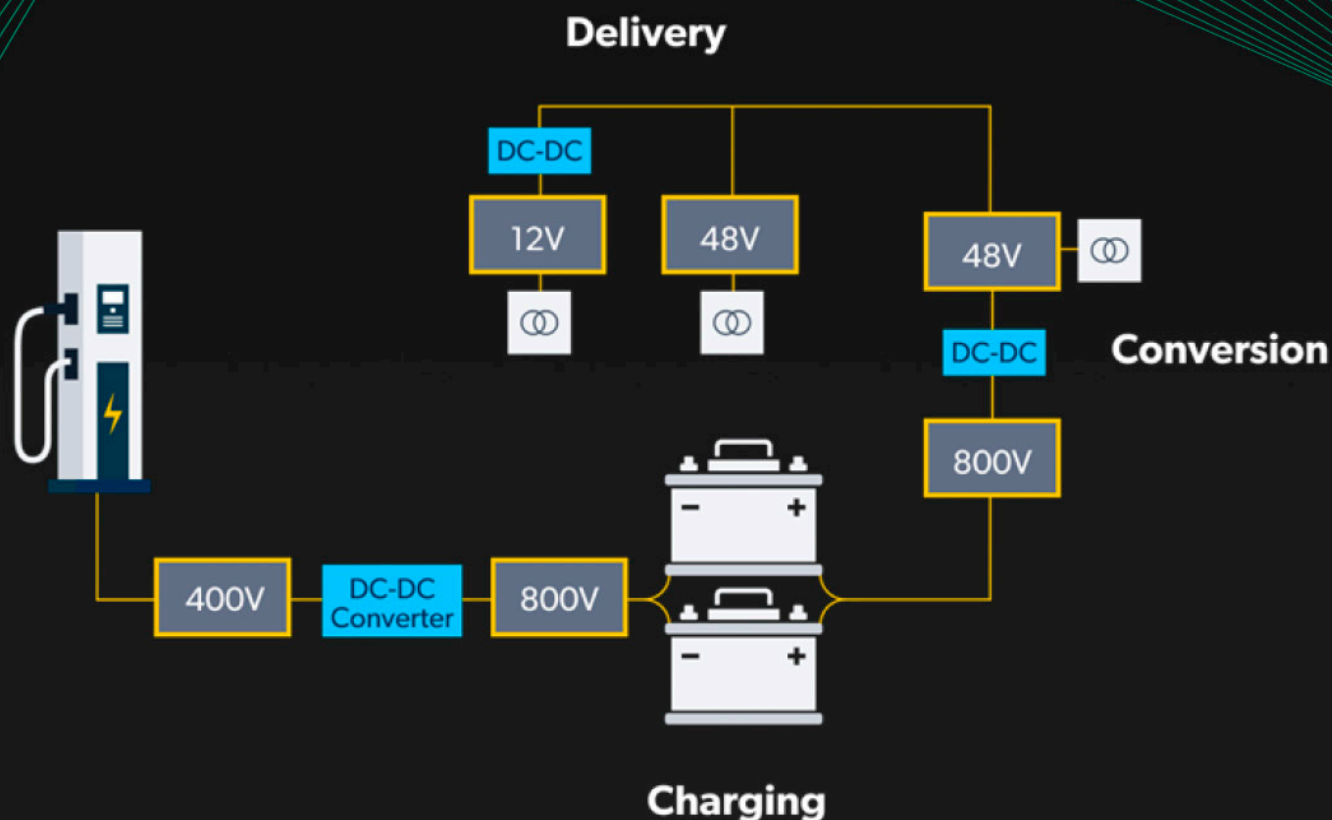


The Future is 48V: How Allegro is Enabling Next-Generation Power Electronics

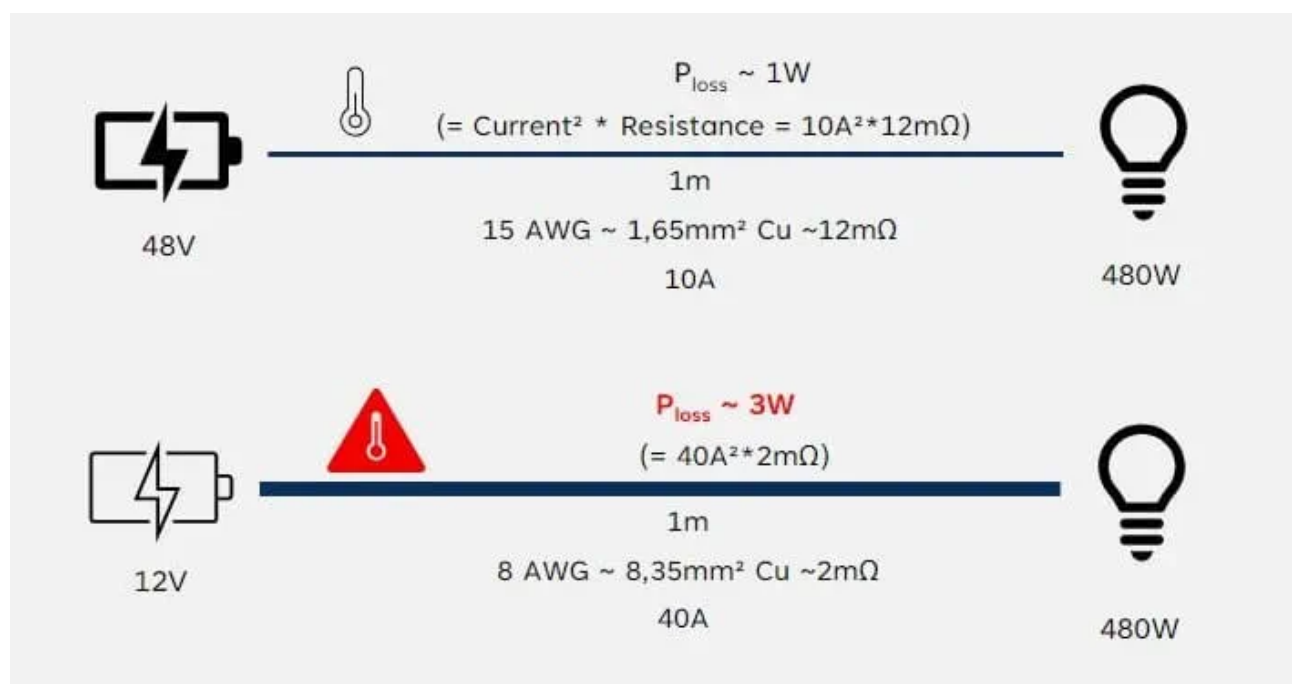


The Future is 48V: How Allegro is Enabling Next-Generation Power Electronics

The world's desire for more power is driving a shift in electrical systems design. Across multiple sectors—from the data centers powering the AI revolution to the automotive industry's embrace of electrification and advanced safety features—the demand for higher power and efficiency is relentless. Traditional low-voltage systems are reaching their limits, struggling to keep pace with the escalating power requirements of modern applications. This challenge is particularly evident in data centers, where the proliferation of AI workloads necessitates robust, high-density power delivery systems. In automotive applications, the integration of sophisticated braking, steering, and other safety functions demands a more efficient and capable electrical architecture. Industrial robotics and the transition towards electric power tools further amplify this trend. The 48V architecture emerges as a solution, offering a pathway to meet growing power demands while minimizing energy losses, and paving the way for a more safe and sustainable future.

Beyond 12V: Why Traditional Systems Struggle with Modern Power Demands

The appearance of the 48V trend indicates that a significant transformation is happening in the power electronics landscape. This shift is driven by the ever-increasing demand for higher power and efficiency across various industries. Traditional 12V systems, once the mainstay of power delivery, are struggling to keep pace with the escalating power requirements of modern applications. The limitations of 12V systems become clear when considering factors like power loss and cable thickness. As power demands increase, so do the currents within a 12V system in a linear fashion ($P = V \times I$). This results in higher power losses along any wiring from the supply source to the load ($P = I^2 \times R$). Practically speaking, if the power demand of the system is doubled, the current will also double, but the power losses will quadruple! These power losses manifest as unwanted heat and reduced system efficiency. Managing higher currents requires thicker and heavier cables which adds weight and cost to system designs.



Why 48 is the Magic Number

48V architecture addresses these challenges by enabling the delivery of higher power levels with lower currents. The same formula $P = V \times I$ can be used to note that by increasing the voltage by a factor of four, the current requirements are reduced by a factor of four. Reduced currents mean less power loss and higher system efficiency. In some cases, the cabling size and weight may be reduced.

Now a common question is: “Why not take the voltage even higher?” If the transition from 12 volts to 48 volts results in four times lower current, wouldn’t a transition from 12 volts to 96 volts result in eight times lower current? The answer to this question is yes; however, there are system safety concerns that must be considered. Underwriters Laboratories (UL) considers voltages higher than 60 volts DC to be dangerous to human lives. Other organizations such as the National Fire Protection Association (NFPA) or Occupational Safety and Health Administration (OSHA) follow this guideline as well. Therefore, any system operating at DC voltages higher than 60 volts must implement special safety measures to isolate the supply voltage from any user interaction. There are significant cost implications to designing a product with these safety measures and for many systems the cost impact is not worth the benefit of further reducing the system current.

Powering the AI Revolution



The increasing demand for artificial intelligence (AI) and machine learning applications has placed significant strain on data center power delivery systems. Traditional 12V systems struggle to efficiently deliver the high currents required by modern AI processors and accelerators. This challenge has driven the adoption of 48V power distribution architectures in data centers.

Several factors contribute to the growing popularity of 48V in data centers. Higher efficiency is critical for these systems since lower losses will save energy costs, and less heat can reduce the requirements for system or environment cooling. Higher power density is also a driving factor, as the output power requirements for a standard server rack power supply are increasing while the form factor remains the same. The transition to 48V allows for smaller cables and connectors.

The 48V trend also applies to cooling fans and pumps in data center systems. Higher voltage provides efficiency benefits as noted above, but it also improves cooling performance. Fans operating at 48 volts can run at higher speeds compared to their 12V counterparts due to the higher voltage supply and therefore can push more air or coolant fluid.

Powering the Future of Automotive Safety



Modern vehicles are equipped with a growing number of electrical components, including advanced driver-assistance systems (ADAS), active safety features, and comfort amenities. These systems require significantly more power than 12V systems can efficiently deliver. 48V systems provide the necessary power capacity to support these features without compromising performance or reliability.

The switch to 48V systems enables the implementation of advanced safety features that were previously limited by the power constraints of 12V systems. For example, electric power steering, active suspension systems, and regenerative braking systems can operate more effectively with 48V, contributing to improved vehicle stability, handling, and overall safety.

Mild hybrid electric vehicle (MHEV) systems are enabled by 48V. These vehicles use a 48-volt battery and electric motor to assist or boost the internal combustion engine (ICE), providing additional power for acceleration and reducing fuel consumption. In some circumstances, the vehicle may operate on the electric motor alone without engine operation. The improved efficiency of MHEVs contributes to lower emissions and reduced environmental impact without requiring major system changes that a full hybrid or battery electric vehicle would necessitate on a vehicle platform. Moving the supply to 48V is necessary for MHEVs to exist; since the electric motor is very high power—up to 25 kW—a higher voltage is needed to operate the motor without thick, heavy cabling.

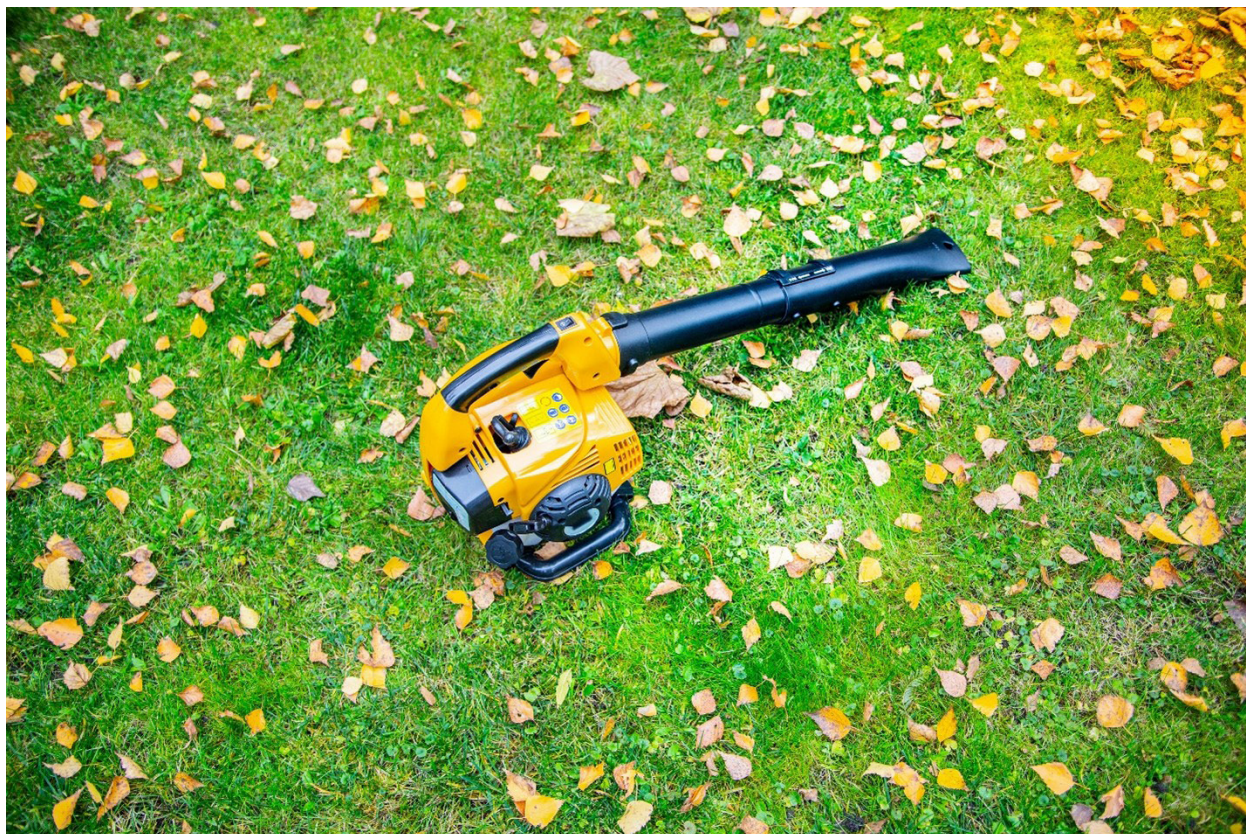
Powering the Switch to Industry 4.0



Conversely, the robotics industry has experienced a reduction in system voltage over the last several years. While high-voltage robots are common in large-scale manufacturing applications, the focus of industrial automation has been on smaller, more mobile tasks. Collaborative robots (“cobots”) and warehouse robots have emerged as new solutions. Reducing the voltage to 48 volts provides a safer operating voltage compared to higher voltage systems, reducing the risk of electrical hazards and improving overall safety for personnel working with or around robots. This is critical for cobots working alongside humans to accomplish a task.

Mobile tasks such as warehouse or logistics automation requires a mobile power supply. These systems are normally battery powered, or at least battery backup-powered if a connection to the main is lost. For these solutions, a 48V system choice is ideal for power distribution and motor drive within the robot.

Powering Engine-less Garden Tools



The shift towards higher voltage batteries in garden tools is driven by the demand to remove the gasoline engine without sacrificing power. High power output allows tools like lawnmowers and chainsaws to handle tougher jobs with ease and speed. A typical gasoline-engine lawnmower has a power rating of 2 to 5 horsepower; this equates to 1.5 to 3.5 watts. A typical 18-volt battery would need to supply 83 to 194 amps in order to be used in the same way. Stacking two 18-volt batteries or using a single 36-volt battery reduces the current draw by half to 42 to 97 amps.

Higher voltage translates to greater efficiency as it enables the use of more powerful motors while drawing less current, leading to longer run times on a single battery charge. This is particularly beneficial for professionals and homeowners with large yards or demanding landscaping tasks. Additionally, advancements in battery technology have led to lighter and more compact high-voltage batteries, making them more manageable and user-friendly.

The higher voltage also allows for a faster motor speed in the case of applications such as leaf blowers. Garden tools are one application example where the power requirements have driven even higher voltage battery solutions, such as 72 volts in some cases.

Allegro Unlocking the Power of 48V

While the benefits of a 48V ecosystem are clear for many applications, making the switch to 48V can be daunting. Moving from a 12V to a 48V system presents several design challenges that engineers must carefully consider. One significant challenge is component availability and compatibility. Many existing components may not be rated for the higher voltage, necessitating a search for suitable replacements. This can impact both cost and design complexity.

Allegro MicroSystems recognizes the challenges faced by engineers when transitioning from 12V to 48V systems and offers a compelling portfolio of solutions to address these issues. Our expertise in power management ICs, motor drivers, and magnetic sensors positions us as a valuable partner in navigating the complexities of 48V designs. We provide a range of components specifically designed and qualified for 48V applications, ensuring compatibility and reliability. Our solutions incorporate advanced safety features and adhere to stringent industry standards. Through our innovative technologies, we empower engineers to overcome the obstacles to 48V system design and unlock the potential of higher voltage applications.

To learn more about Allegro's broad array of sensor and power IC products ready for use in the design of 48V systems, visit allegromicro.com.

Revision History

Number	Date	Description
–	June 10, 2024	Initial release

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