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The Power of 48 V: Relevance, Benefits, and Essentials in System-Level Applications

Christian Cruz, Staff Applications Development Engineer

Abstract

The demand for efficient and dependable power solutions continues to rise in the ever-changing technological world. The 48 V supply voltage is one voltage level that has received a lot of attention in recent years. While 48 V may not appear innovative at first glance, it is quite relevant, has numerous benefits, and has become an important component in a variety of system-level, industrial, automotive, and communication applications. This article explores the advantages of a 48 V supply voltage through real-world examples and demonstrations.

Introduction

Because of its versatility and compatibility with existing infrastructure, the 48 V supply voltage has become critical in a variety of applications. Historically, power distribution systems depended heavily on the standard 12 V or 24 V levels. However, the increasing power requirements of modern devices and electronics, along with the desire for a more effective system and greater energy economy, have prompted the use of higher supply voltages such as 48 V.

Energy-efficient solutions are in high demand in data centers—for example, where huge supercomputer power is concentrated. The 48 V supply voltage is an appealing compromise between transmission efficiency and conversion losses. Stepping up the voltage reduces power distribution losses, lowering overall energy consumption.

The 48 V supply voltage is also beneficial to the automotive industry, especially in electric vehicles (EVs). The desire for more power-efficient solutions grows as EVs add advanced features and electrically driven subsystems. The 48 V architecture improves energy recovery during regenerative braking and makes it easier to integrate high power components like electric power steering and advanced driver assistance systems.

Benefits of a 48 V Supply Voltage

The benefits of using a 48 V supply voltage range from improved efficiency to greater design choice. These are some of the main advantages:

- Reduced I²R Losses
 - Resistance losses (I²R losses) in power distribution systems can have a major impact on efficiency. When compared to lower voltage systems, the current is lower with the 48 V supply voltage for a given power level. As a result, I²R losses during transmission are decreased, resulting in greater overall system efficiency.
- Improved Power Density
 - In comparison to lower voltage systems, the 48 V supply voltage allows for the use of smaller conductors and components for the same power transfer. This corresponds to increased power density, which allows for more compact designs, particularly in applications where space is limited.
- Enhanced Voltage Regulation
 - Higher voltage levels provide greater voltage regulation by definition, which is critical in applications sensitive to fluctuations. To maintain reliable operation, industrial automation and communication systems frequently demand steady and well-regulated voltage levels.
- Design Flexibility
 - The 48 V supply voltage opens up additional design choices. It permits the integration of numerous subsystems with varying voltage needs. Motors, sensors, and communication interfaces can all coexist in the same system.
- Compatibility with Renewable Energy
 - The 48 V supply voltage matches nicely with the voltage output of solar panels in renewable energy systems such as solar installations. This interoperability makes it easier to incorporate renewable energy sources into current power systems.



Figure 1. Efficient voltage conversion within a system.¹

Essentials of 48 V Supply Voltage Implementation

Certain aspects must be considered during implementation to fully reap the benefits of a 48 V supply voltage. Let's look at these fundamentals through the lenses of system-level, industrial, and communication applications.

Efficient Voltage Conversion

While 48 V is becoming more popular, not all devices and components handle this voltage level directly. Voltage conversion methods that are efficient, such as DC-to-DC converters, need to step down the voltage for subsystems that require lower supply voltages. Refer to Figure 1.

Thermal Management



Figure 2. ADI-BBU module² and quarter brick reference design.

Higher voltage levels in the battery backup unit (BBU) module in Figure 2 and the quarter brick reference design approach may generate greater heat. Thermal management methods like heat sinks, fans, and thermal design considerations are crucial to the longevity and dependability of 48 V components. **Safety Measures**



Figure 3. Galvanic Isolation between 48 V to 12 V in a mild hybrid EV.³

In every electrical system, safety is of the utmost importance. While the 48 V supply voltage is not exceptionally high, it still necessitates adequate safety precautions such as circuit protection, isolation barriers, and grounding to avoid the risks connected with electrical breakdowns. One example of an isolated barrier is the galvanic isolation, demonstrated in Figure 3, between 48 V and 12 V system applications. The ADM2561E was used in the BBU module Modbus[®] communication method to establish isolated communication between the BBU modules and the BBU shelf.

Communication Protocols



Figure 4. Open Compute Project Open Rack V3 architecture.⁴

In modern industrial and communication applications, interoperability is key. Implementing standardized communication protocols ensures seamless data exchange between subsystems operating at 48 V, enhancing overall system efficiency. The Open Compute Project (OCP) is leading the ongoing adoption of new data center architecture. The organization provides a complete architecture design for the 48 V system's power rectifier, BBU, network, storage, and servers. Refer to Figure 4.

Monitoring and Control

Ensuring peak system performance requires constant monitoring of voltage levels, current flows, and temperature in real-time. The adoption of intelligent control systems, on the other hand, allows for the proactive management of these factors. By seamlessly coordinating real-time adjustments, these systems not only anticipate faults but also pave the way for preventative diagnosis, raising system efficiency and dependability to unprecedented levels.

Real-World Applications

The 48 V supply voltage is used in a variety of sectors and technologies. Let's look at some real-world examples that demonstrate its significance:

Telecom Power Systems



Figure 5. Telecom −48 V distribution system.⁵

Telecommunication networks, a cornerstone of modern society, rely on a consistent and reliable power supply. The 48 V architecture emerges as a cornerstone of dependability and efficiency in this domain, altering the landscape of telecom power systems. See Figure 5. These systems, responsible for providing worldwide communication, necessitate a power infrastructure that can withstand regional variances and unexpected outages.

The actual brilliance of the 48 V architecture, however, is reflected in its capacity to overcome geographical limitations. The 48 V architecture remains unaffected in remote hinterlands and disaster-stricken places where traditional power infrastructure may be absent or degraded. It becomes a lifeline for communication services by providing dependable power even in the face of hardship. The intrinsic durability of the architecture ensures that isolated people remain connected when they need it most, providing critical communication during emergencies and promoting rural development through increased connectivity.

Electric Drives in Industrial Automation

Precision and efficiency are critical in the field of industrial automation. Within this dynamic landscape, the 48 V power supply voltage shines brightly, fueling a wide range of critical components, from electric motors and conveyor belts to robotic arms. This voltage level serves as the foundation of power density and control, coordinating flawless operations while simultaneously reducing energy losses and propelling industrial automation to unprecedented levels of performance.

Hybrid Power Systems

The introduction of hybrid power systems has changed energy access in rural and off-grid areas where connecting to the conventional power grid is difficult. These cutting-edge systems seamlessly combine renewable energy sources, primarily solar panels, with modern energy storage banks to provide a dependable and sustainable energy solution. In this scenario, the compatibility of the 48 V supply voltage with solar outputs is critical, efficiently bridging the gap between the energy provided by solar panels and the demands of various applications.

The 48 V supply voltage is in perfect sync with the voltage range produced by solar panels, allowing for efficient energy conversion and distribution. This compatibility eliminates the need for high voltage conversions, which is a major source of energy losses, inefficiencies, and increased costs. The 48 V architecture maximizes energy harvesting by precisely matching with solar outputs, allowing solargenerated power to be channeled directly into the system with minimal loss.

Furthermore, the alignment of the 48 V supply voltage and solar outputs emphasizes the cost-effectiveness of hybrid power system installations. The simplified voltage translation process eliminates the need for sophisticated and costly components, resulting in lower installation and maintenance costs. This cost reduction represents a significant shift for off-grid communities and businesses, making renewable energy both accessible and economically feasible.

Electric Vehicles



Figure 6. A 48 V mild hybrid EV.6

The use of the 48 V design in EVs that was demonstrated in Figure 6 is a strategic step that provides numerous benefits. This voltage paradigm is critical in improving power distribution across the vehicle's subsystems. Aside from its role in power distribution, the 48 V architecture provides access to a slew of novel features, such as regenerative braking, which allows energy to be recovered during braking maneuvers. Furthermore, its integration enables a variety of auxiliary systems vital to occupant comfort and enjoyment, including advanced HVAC (heating, ventilation, and air conditioning) systems and cutting-edge multimedia sets. The 48 V architecture enables this comprehensive approach to EV design, which not only improves energy economy but also improves the whole driving experience by optimizing power use, resource management, and in-cabin amenities.

While using a 48 V supply voltage in system-level applications has several advantages, it is important to understand some of the potential downsides of this system.

Disadvantages to Consider:

Component Compatibility and Availability

Making the switch to a 48 V supply voltage demands careful evaluation of existing system components. Certain pieces may need to be replaced or adjusted as a result of this change. However, one potential issue is the scarcity of components that are compatible with the specified voltage rating. This scenario could result in increased procurement prices and probable delays in the system's smooth integration, underlining the importance of strategic planning and sourcing solutions. See Figure 7.

Design Complexity

Incorporating a 48 V supply voltage frequently ushers in a period of increased design complexities. The implementation phase typically warrants the cautious navigation of complicated design issues, such as precise voltage regulation, thorough heat management strategies, and robust safety standards. This increased complexity has the potential to lengthen development cycles and increase the demand for detailed technical skills, emphasizing the importance of a well-prepared and skilled design team to efficiently traverse these complexities.

Higher Voltage-Related Risks

While 48 V is not exceptionally high, it nevertheless poses possible safety issues, especially if basic safety precautions are not adequately implemented. The increasing voltage level may raise the risk of electrical shock and other hazards, demanding strict safety precautions.

Increased Conversion Losses

Additional conversion steps might result in larger energy losses in systems when voltage conversion is required to power components that need lower voltage levels, such as sensors or low power devices. This reduces some of the energy efficiency improvements made possible by using a 48 V supply voltage.

Limited Adoption in Legacy Systems

In the context of legacy systems designed for lower voltage levels, the switch to a 48 V supply voltage necessitates a realistic assessment. This change may face obstacles that make it both impractical and financially prohibitive. Overhauling existing infrastructure to smoothly support the 48 V standard can be a complex and time-consuming task, requiring significant adjustments and strategic planning to ensure compatibility and optimal performance.

Size and Space Constraints

While 48 V allows for higher power density due to lower current levels, it may not be appropriate for applications with strict size and space constraints. The requirement for additional insulation and safety precautions may demand greater component sizes. Refer to Figure 8.

Increased Electromagnetic Interference (EMI)

Elevated voltage levels provide a significant problem in the form of increased electromagnetic interference (EMI). This interference can disrupt the smooth operation of delicate components and complex communication networks. As a result, the adoption of additional shielding and rigorous filtering techniques becomes necessary to effectively counter and alleviate the negative effects of EMI, ensuring the ongoing performance of key systems.

Scalability Challenges

While 48 V is a reasonable choice for many applications, it may not be the best scalable option in all cases. Some applications, particularly those requiring much greater power levels, may necessitate the use of alternative voltage designs to satisfy their specific needs.

Cost Considerations

Adopting a 48 V supply voltage demands careful consideration of upfront costs such as component replacement, system development coordination, and the implementation of critical safety measures. These initial expenses have the potential to noticeably impact the overall project budget, a dynamic that is dependent on the individual application and sector being addressed. The wise allocation of resources in the face of these potential expenses becomes critical for the endeavor's smooth integration and ultimate success.

Conclusion

The 48 V supply voltage has progressed from a niche option to a critical component in system-level, industrial, and communication applications. Its importance arises from the growing demand for energy-efficient solutions, and its advantages include increased efficiency, power density, and design flexibility. However, effective power





Can Type (H8 mm)



SP-Cap Board Area Saving with a Fewer Number of Components

Figure 8. Capacitor output side circuit mounting consideration.8

conversion, rigorous thermal management, robust safety precautions, standardized communication protocols, and sophisticated monitoring and control systems are required for successful application. As the technological environment evolves, the 48 V supply voltage remains a critical enabler of innovation across multiple sectors, providing a future powered by efficiency and dependability.

Furthermore, the designer or application engineer should examine the benefits of using a 48 V supply voltage in system-level applications that are significant—therefore it's critical to be aware of the potential drawbacks. To make an informed decision about applying this voltage level in a specific application, consider component compatibility, design complexity, safety precautions, energy conversion losses, and associated costs.

Reference

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About the Author

Christian Cruz is a staff applications development engineer at Analog Devices, Inc., Philippines. He holds a bachelor's degree in electronics engineering from the University of the East in Manila, Philippines. He has more than 12 years of engineering experience in the field of analog and digital design, firmware design, and power electronics, which includes power management IC development as well as AC-to-DC and DC-to-DC power conversion. He joined ADI in 2020 and is currently supporting power management requirements for cloudbased computing and system communications applications.



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