



# How to Choose the Right Onboard Charger for Your Battery Pack: 5 Critical Design Considerations

This paper provides a practical guide to selecting the right onboard charger (OBC) for your battery pack. It outlines the key electrical, system-level, and integration considerations that impact charging performance, safety, reliability, and long-term battery health in Industrial Electric Vehicle (IEV) applications.

## Contents

How to Choose the Right Onboard Charger for Your Battery Pack: 7 Critical Design Considerations.....	1
INTRODUCTION .....	2
1. BATTERY VOLTAGE & CURRENT REQUIREMENTS.....	2
2. HOW LONG WILL MY BATTERY TAKE TO CHARGE? .....	4
3. METHOD OF CHARGING CONTROL .....	5
4. POWER LEVEL SELECTION: 720W–1200W.....	7
5. MECHANICAL & THERMAL INTEGRATION.....	8
CONCLUSION .....	10
Frequently Asked Questions .....	10

## INTRODUCTION

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An onboard charger (OBC) is a power conversion device installed inside an electric vehicle that converts AC input into controlled DC output for battery charging.

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As electrification accelerates across industrial vehicles such as AGVs, forklifts, cleaning machines, aerial work platforms, and utility vehicles, selecting the right onboard charger becomes a critical design decision.

Unlike off-board chargers, an onboard charger is permanently integrated inside the vehicle. Therefore, it must meet not only battery requirements but also mechanical, thermal, electrical, and communication constraints of the overall system.

Delta Electronics provides onboard charger solutions ranging from 720W to 1200W, supporting both plug-and-play and communication-based architectures for industrial electric vehicle applications.

When selecting an onboard charger, engineers must evaluate multiple system-level parameters to ensure optimal performance, safety, and long-term reliability.

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In practice, onboard charger selection is a multi-dimensional engineering problem involving electrical compatibility, thermal constraints, and system integration.

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The following critical design considerations should be carefully assessed: battery voltage and current requirements, charging time estimation, charging control methodology, power level selection, and mechanical and thermal integration.

### 1. BATTERY VOLTAGE & CURRENT REQUIREMENTS

One of the primary criteria when selecting an onboard charger is the battery's voltage range. Selecting an onboard charger begins with verifying compatibility between the charger output range and the battery pack operating window. Every battery pack defines a minimum operating voltage, nominal voltage, and maximum charging voltage. The onboard charger

must be capable of operating across this entire range while maintaining stable regulation in both constant-current (CC) and constant-voltage (CV) regions.

For lithium battery systems, the maximum pack voltage is determined by the number of series-connected cells and the maximum allowable cell voltage:

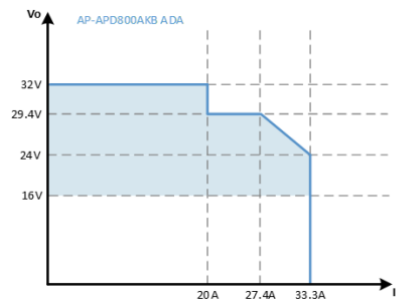
$$V_{pack,max} = N_{series} \times V_{cell,max}$$

If the charger cannot reach the required CV voltage, the battery will never achieve full state of charge. Conversely, exceeding voltage limits introduces safety risk and accelerated degradation.

Charging current selection must also align with the battery's allowable C-rate:

$$I_{charge} = C_{rate} \times Capacity_{Ah}$$

Improper current selection may lead to overheating, lithium plating, or reduced cycle life.



**Fig-1:** Charging curve of Delta AP-APD800AKB ADA. Figure 1 illustrates the relationship between output voltage ( $V_o$ ) and output current ( $I_o$ ) during the charging process. The charger initially operates in constant-current mode until the battery voltage reaches its maximum threshold, after which it transitions into constant-voltage mode where current gradually tapers.

Technical Criteria	Design Consideration
Maximum Voltage	Must exceed battery pack maximum voltage
Current Rating	Must align with allowable C-rate
Regulation Mode	Stable CC and CV operation required
Safety Margin	Include tolerance for temperature variation

Table 1. Voltage & Current Selection Summary

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Proper voltage and current matching is essential to ensure full battery utilization while avoiding overvoltage risks and premature degradation.

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## 2. HOW LONG WILL MY BATTERY TAKE TO CHARGE?

One of the most common questions is: “How fast can I charge my battery?” A simplified estimation of charging time can be calculated as:

$$\text{Charging Time (hours)} = \frac{\text{Battery Energy (Wh)}}{\text{Charger Power (W)}}$$

Example:

A 1000 Wh battery charged with an 800 W charger would theoretically take:

$$1000/800 = 1.25 \text{ hours}$$

### *Efficiency Impact*

In practical systems, charger efficiency ( $\eta$ ) typically ranges from 92% to 95%. Therefore, the effective charging time becomes:

$$t_{\text{real}} = \frac{E_{\text{battery}}}{P_{\text{charger}} \times \eta}$$

Assuming 93% efficiency:

$$t = \frac{1000}{800 \times 0.93} = 1.34 \text{ hours}$$

This still represents only the constant-current phase approximation.

### *CC–CV Tapering Effect*

Most lithium battery systems employ a Constant Current–Constant Voltage (CC–CV) charging profile. During the initial CC phase, the battery charges at a fixed current. Once the pack reaches its maximum voltage threshold, the charger transitions to constant-voltage mode, and current gradually decreases.

In the CV phase, charging current typically follows an exponential decay:

$$I(t) = I_0 e^{-kt}$$

Charging termination commonly occurs when current drops below 0.05C to 0.1C. Because current tapers significantly above approximately 80% State of Charge (SoC), the final 20% of charging can account for 25–40% of total charging time. This tapering behavior is intentionally implemented to protect battery health and prevent overvoltage stress.

### *System-Level Influences*

Beyond electrical efficiency and charging profile behavior, several real-world factors further extend charging duration:

- Battery chemistry and allowable C-rate
- Ambient temperature effects on charge acceptance
- Cable and connector voltage drop
- Internal battery resistance growth with aging
- Parasitic loads active during charging
- BMS-imposed current limitations

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In real-world applications, actual charging time is typically 15–40% longer than ideal calculations due to efficiency losses and CC–CV tapering behavior.

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## 3. METHOD OF CHARGING CONTROL

There are two common approaches to battery charging control:

### *3.1 Plug-and-Play Charging*

Plug-and-play charging refers to a control architecture in which the charger operates based on a predefined and fixed charging profile without real-time communication with the battery pack. Once the battery is connected, the charger automatically initiates charging according to preset voltage and current parameters.

Because no communication interface such as CAN or RS485 is required, system integration is straightforward. The charger does not depend on protocol matching, firmware coordination, or BMS-driven parameter updates. This simplifies electrical design and reduces development

effort, making plug-and-play charging particularly suitable for lead-acid batteries and lithium packs with fixed charging specifications.

However, the absence of dynamic feedback also limits adaptability. The charger cannot respond to real-time battery conditions such as temperature variation, state-of-charge changes, or aging-related internal resistance increases. As a result, charging behavior remains constant regardless of battery health or environmental conditions, which may reduce optimization potential in advanced lithium battery systems.

### 3.2 Communication-Based Charging

Communication-based charging incorporates real-time data exchange between the charger and the Battery Management System (BMS). Through communication protocols such as CAN or RS485, the BMS continuously transmits allowable voltage and current limits, battery temperature data, and fault status to the charger.

This architecture enables dynamic control of charging parameters. Instead of operating with a fixed profile, the charger adjusts output current and voltage according to real-time battery conditions. As a result, charging can proceed at the maximum safe rate permitted by the battery, improving efficiency while maintaining strict safety margins.

In addition, communication-based control enhances system intelligence and diagnostics. Fault conditions such as overtemperature, cell imbalance, or abnormal voltage can be detected immediately, allowing the charger to reduce output or terminate charging to prevent damage. This adaptability is particularly important in lithium battery systems, where precise control directly impacts safety, performance, and long-term cycle life.

Technical Criteria	Plug-and-Play Charging	Communication-Based Charging
Applicable Battery	Lead-acid, simple lithium packs	Lithium systems with BMS
System Complexity	Low	Moderate to High
Safety Adaptability	Fixed limits	Dynamic control
Diagnostics Capability	Limited	Real-time monitoring

Integration Effort	Minimal	Protocol coordination required
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Table 4. Charging Control Comparison

Although communication-based charging introduces additional integration complexity, including protocol alignment and software validation, it provides superior flexibility and is generally preferred for modern industrial electric vehicle applications using lithium battery technology.

#### 4. POWER LEVEL SELECTION: 720W–1200W

Selecting the appropriate power level for an onboard charger directly impacts **charging time, system infrastructure requirements, thermal design constraints, and overall system cost**. Engineers should evaluate charger power levels based on **vehicle duty cycle, available charging time, and system limitations**.

Mid-range power solutions, such as 720W and 800W, provide a balanced approach between charging performance and system complexity. These chargers are well-suited for standard industrial electric vehicle applications where moderate charging speed is sufficient. They enable reliable overnight charging while maintaining manageable AC input requirements and simplified thermal design.

Higher power chargers, such as 1200W, enable significantly shorter charging time and are particularly suitable for applications that rely on opportunity charging during short operational breaks. However, increased output power results in higher AC input current and greater heat generation, which places stricter requirements on wiring, protection devices, and thermal management within the vehicle enclosure.

Selection Criteria	Mid Power (720–800W)	High Power (1200W)
Charging Time	Moderate	Shortest
Typical Use Case	Overnight / standard operation	Opportunity charging
AC Input Requirement	Moderate	High

Thermal Design	Manageable	More demanding
System Cost	Balanced	Higher
Battery Size Suitability	Medium battery packs	Medium to large packs

Regardless of the selected power level, system designers must verify that the AC input source can continuously support the required input current, that cables and connectors are properly rated for both electrical and thermal loading, and that sufficient heat dissipation is ensured inside the vehicle enclosure to prevent thermal derating or long-term reliability issues.

Delta Electronics provides onboard chargers in the [720W](#), [800W](#), and [1200W](#) power classes, enabling system designers to select the optimal solution based on application-specific requirements. This portfolio supports a wide range of industrial electric vehicle use cases, from standard overnight charging to high-demand opportunity charging scenarios.

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Charger power selection should be aligned with operational duty cycle rather than maximizing power output.

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## 5. MECHANICAL & THERMAL INTEGRATION

Because onboard chargers are installed inside vehicles, designers must evaluate:

- **Mounting orientation:** The installation orientation affects natural convection and heat dissipation performance. Improper mounting may restrict airflow paths or create heat accumulation zones, leading to higher internal temperatures and potential power derating.
- **Vibration resistance:** Industrial electric vehicles often operate in harsh environments with continuous vibration and mechanical shock. The charger must be designed to withstand these conditions without degradation in electrical connections or component reliability over time.
- **IP rating:** Ingress Protection (IP) rating defines the charger’s ability to resist dust and moisture. In applications such as cleaning machines or outdoor vehicles, insufficient sealing can lead to corrosion, short circuits, or premature failure.

- **Cooling method (passive vs active):** Passive cooling relies on heat sinks and natural convection, while active cooling uses fans or forced airflow. Passive designs offer higher reliability and lower maintenance, whereas active cooling may be required for higher power density but introduces additional failure points.
- **Available airflow:** Even with passive cooling, adequate airflow within the vehicle enclosure is necessary to remove heat effectively. Poor airflow management can result in thermal buildup, reducing efficiency and potentially triggering thermal protection or derating.

Delta's onboard chargers are designed with these integration challenges in mind and feature:

- **Industry-standard form factor:** A standardized mechanical footprint simplifies system integration and reduces redesign effort across different vehicle platforms, enabling faster time-to-market.
- **Passive cooling design:** By eliminating the need for internal fans, passive cooling enhances system reliability and reduces maintenance requirements, particularly in dusty or high-vibration environments.
- **High reliability components:** The use of industrial-grade components ensures stable performance over a wide temperature range and extended operational lifetime under demanding conditions.
- **Robust mechanical construction:** The charger housing and internal structure are designed to withstand vibration, shock, and environmental stress, ensuring consistent performance in real-world industrial applications.

Passive cooling improves system reliability by eliminating moving parts such as fans, reducing maintenance and failure risk.

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Thermal management is a key reliability factor, as excessive temperature directly impacts efficiency, performance, and component lifetime.

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Delta [MOOV<sup>on</sup> 720W Onboard Charger](#)

## CONCLUSION

Choosing the right onboard charger for your battery pack requires a holistic evaluation of:

- Battery voltage range
- Charging current requirements
- Charging time expectations
- Battery chemistry
- Communication protocol
- Power infrastructure
- Mechanical and thermal constraints
- Integration flexibility

A properly selected onboard charger not only ensures safe and efficient charging but also enhances overall vehicle reliability and long-term battery performance. Delta Electronics' onboard chargers provide flexible, customizable, and reliable solutions tailored for Industrial Electric Vehicle applications. [Contact us](#) for more information.

## Frequently Asked Questions

### **1. How do I determine the correct charger power for my battery pack?**

The charger power should be selected based on required charging time, battery capacity, and system constraints. A higher power charger reduces charging time but increases AC input current and thermal requirements.

Engineers should evaluate duty cycle, available charging window, and infrastructure limitations to determine the optimal power level.

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## **2. Can I use a higher power charger to charge my battery faster?**

Not always. Charging speed is limited by the battery's allowable current (C-rate) and BMS constraints. Even if a higher power charger is used, the battery may restrict charging current to protect safety and longevity. Oversizing the charger beyond the battery's acceptance capability may not provide additional benefit.

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## **3. Why does charging slow down after 80% state of charge?**

Most lithium batteries use a constant current–constant voltage (CC–CV) charging profile. After reaching the maximum voltage, the charger switches to constant voltage mode, and current gradually decreases to prevent overvoltage and reduce stress on the cells. This results in slower charging during the final 20% of capacity.

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## **4. What is the difference between plug-and-play and communication-based charging?**

Plug-and-play charging uses a fixed charging profile without real-time feedback from the battery, making it simple and cost-effective.

Communication-based charging uses a Battery Management System (BMS) to dynamically control charging parameters, improving safety, efficiency, and battery life, especially for lithium battery systems.

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## **5. Do I need communication (CAN/RS485) for lithium batteries?**

In most modern lithium battery systems, communication with the BMS is recommended or required. It allows the charger to adjust voltage and current dynamically based on battery conditions, ensuring safe operation and optimal charging performance.

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## **6. How accurate is the charging time estimation formula?**

The basic formula  $t = \frac{E}{P}$  provides only an ideal estimate. Real charging time is typically 15–40% longer due to efficiency losses, CC–CV tapering, temperature effects, and system-level constraints such as BMS current limits and parasitic loads.

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### **7. What happens if the charger voltage is too low or too high?**

If the charger voltage is too low, the battery will not reach full charge. If it is too high, it may cause overvoltage conditions, leading to safety risks, battery damage, or reduced cycle life. Proper voltage matching is critical.

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### **8. Why is thermal management important for onboard chargers?**

Onboard chargers generate heat during operation due to power conversion losses. Without proper thermal management, excessive temperature rise can reduce efficiency, trigger derating, and shorten component lifetime. Thermal design is especially critical in enclosed vehicle environments.

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### **9. When should I choose a 1200W charger instead of a 720W or 800W charger?**

A 1200W charger is suitable when fast charging or opportunity charging is required. If the application allows longer charging time (e.g., overnight charging), a 720W or 800W charger is often sufficient and may simplify thermal design and reduce system cost.

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### **10. Does higher charging current reduce battery life?**

Yes. Higher charging current increases internal temperature and electrochemical stress, which can accelerate battery degradation. Selecting an appropriate C-rate is important to balance charging speed and long-term battery life.

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### **11. What role does the BMS play during charging?**

The Battery Management System monitors cell voltage, temperature, and overall battery health. It communicates with the charger (in communication-

based systems) to set safe charging limits and protect the battery from abnormal conditions.

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## **12. Can one charger work with different battery types?**

In some cases, yes—if the charger supports configurable charging profiles and communication protocols. However, the charging algorithm must always match the specific battery chemistry requirements to ensure safe and efficient operation.