

# OVERCOMING CHALLENGES AND STREAMLINING ASSEMBLY FOR BATTERY INTERCONNECT DESIGNS

## 1.0 Overview of Battery Challenges for EV Makers

Electric vehicle manufacturers face several over-arching challenges regarding battery assembly and battery cell interconnect designs. Some of the key challenges include:

- **COST:** One of the primary challenges is the high cost of battery assembly and cell interconnect designs. Batteries are expensive to manufacture, and the cost of raw materials like lithium, cobalt, and nickel has been increasing in recent years.
- **PERFORMANCE:** The performance of the battery pack is critical to the success of the electric vehicle. Manufacturers must design the battery pack to deliver the required power and energy density for the vehicle's intended use and driving range requirements.
- **SCALABILITY:** Electric vehicle manufacturers must be able to scale up battery production to meet the rapidly growing demand for electric vehicles. This requires the development of efficient manufacturing processes and supply chain management.
- **STANDARDIZATION:** Battery cell interconnect designs and battery pack designs are not standardized across different manufacturers. EV makers need both customizable solutions and the ability to maintain interoperability across their different EV models.
- **DURABILITY:** Battery packs must be designed to last for the lifetime of the vehicle, which can be challenging given the stresses and strains that the batteries are subjected to during normal use. Manufacturers must ensure that the battery packs are durable and reliable over the lifetime of the vehicle.
- **SAFETY:** Battery safety is a critical concern for electric vehicle manufacturers. The battery pack must be designed to withstand impact, temperature changes, and other extreme conditions without causing a fire or explosion.

This Applications Note focuses on how new innovations in battery interconnect technologies are enabling OEMs and Tier 1 suppliers to optimize the design and assembly processes for EV batteries to overcome today's challenges and to create a sustainable EV battery technology foundation going forward.

## 2.0 The Interplex Cell-PLX™ Battery Interconnect System

As a leading design partner and supplier to automotive OEMs and Tier 1s, Interplex has been at the forefront of co-innovating with our customers as they navigate the transition from conventional internal combustion engine (ICE) vehicles to new generation electric vehicles. Optimizing EV battery design and assembly is just one of many key areas where we are playing a key role.

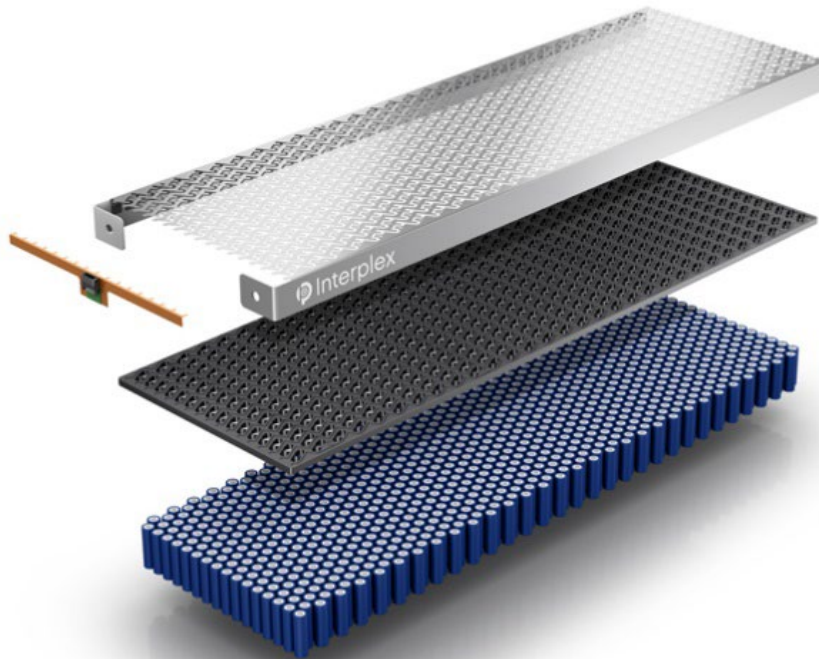


*Figure 1 - Interplex is the battery interconnect supplier for some of the world's largest EV manufacturers.*

The [Cell-PLX™](#) advanced custom battery interconnect system from Interplex consists of a lightweight, ultra-flat, robust current collector assembly that helps EV makers overcome the challenges of customizing reliable battery interconnects.

Battery designs for EVs are complex and requirements vary widely by manufacturer and specific application. However, they all require robust mechanical and electrical component systems which perform the basic required functions to connect and integrate the battery pack.

Battery modules typically consist of a large number of individual cells grouped together and connected to current collector plates for gathering the specified power output levels. The number of cells connected in a specific configuration and power output of each cell are the determining factors for delivering the required output for the battery module.



*Figure 2 - Cell-PLX™ consists of an ultra-flat current collector achieved with Interplex's high-precision engineering.*

Cell-PLX™ is specifically designed to enable battery manufacturers across the entire spectrum of applications to have a single robust, customized solution that addresses the full range of design requirements.

Cell-PLX™ enables a variety of different customized battery modules to be designed and manufactured for connecting cylindrical and prismatic Lithium-ion battery cells. These application-specific modules provide power to various electric vehicles, trucks, solar energy stations, boats or other sources needing electric power.

### 3.0 Key Aspects of Cell-PLX™ Architecture

Understanding different attachment processes to support specific application requirements, Cell-PLX™ battery interconnect systems are designed to provide a permanent, reliable, robust and safe solution to connect EV battery cells and provide electric power to the vehicle.

Designed for highly scalable manufacturability to meet specific customer requirements, Cell-PLX™ provides:

- Robust laser welded or wire bond solutions for attachment to the cells.
- Customization to meet any power outputs and configurations.
- High-speed, high-precision, high-volume manufacturing capabilities.
- Optimized package design to accommodate vibration environments.
- Integrated Safety Monitoring.
- Scalable Modular designs.
- Design options for Aluminum, Copper, Nickel, performance plastics, and dielectric layers.

### 3.1 Support for Different Cell Form Factors

Cell-PLX™ battery interconnect system can be optimized for EV makers' specific requirements including seamlessly accommodating for different battery cell form factors such as cylindrical or prismatic cells.



*Figure 2 - Cell-PLX™ supports cylindrical and prismatic cell form factors.*

#### Cylindrical Battery Cell Designs:

Individual plastic housings or lamination methods hold the cells in position to enhance mechanical integrity and assure proper alignment. High precision die cutting, stamping, and assembly processes provide excellent positioning of dielectric and current collector layers, with options for precision integration of voltage, current and temperature sensing functionality.

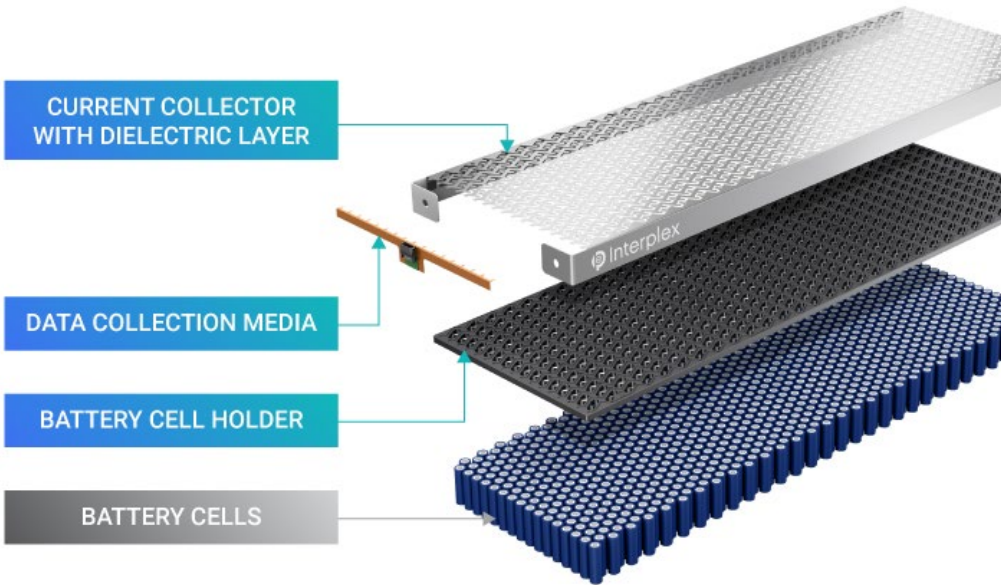


Figure 3 - The current collector can be as long as 1600mm and as thin as 0.2mm, with options for cold or hot lamination.

### Prismatic Battery Cell Designs:

For prismatic cells, Cell-PLX™ battery interconnect system can be integrated with plastic carrier trays, end plates and side plates to provide positional integrity. In addition, Cell-PLX™ can accommodate integration of flex printed circuits (FPCs) to provide sensing functionality within the current collector assembly.

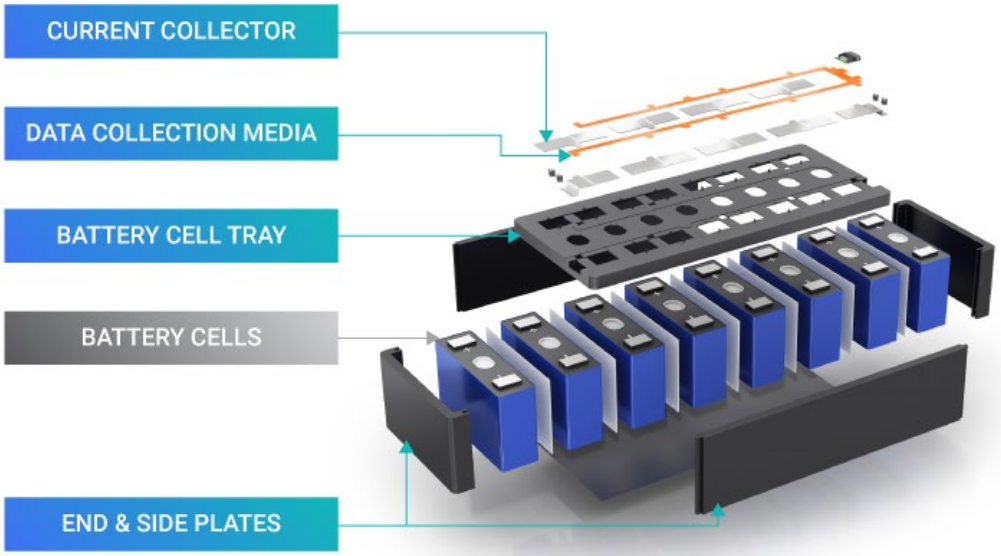


Figure 4 - Aluminum/copper current collector transfers current from the prismatic cells to the rest of the battery pack.

During the Cell-PLX™ battery interconnect assembly process, the top and bottom current collectors, control board interconnects, dielectric layers, cell holders and individual cells are all brought together in

a highly efficient and robust manner that supports high-volume manufacturing and can be adapted for virtually any battery size, power requirements and configuration.

#### 4.0 Optimizing Current Densities with U-Turn Technology

With the introduction of our new patented U-Turn design technology, Interplex has now further expanded the Cell-PLX™ technology to address another key issue, which is the tendency for EV batteries to develop hot-spots within the current flows across collector plates.

U-Turn technology addresses this issue and mitigates internal hot-spots by providing excellent current density spread and uniform distribution of current density throughout the entire battery module. By reducing stress on the individual battery cells, U-Turn enables optimal battery performance and increases EV range, while also improving battery lifespan.

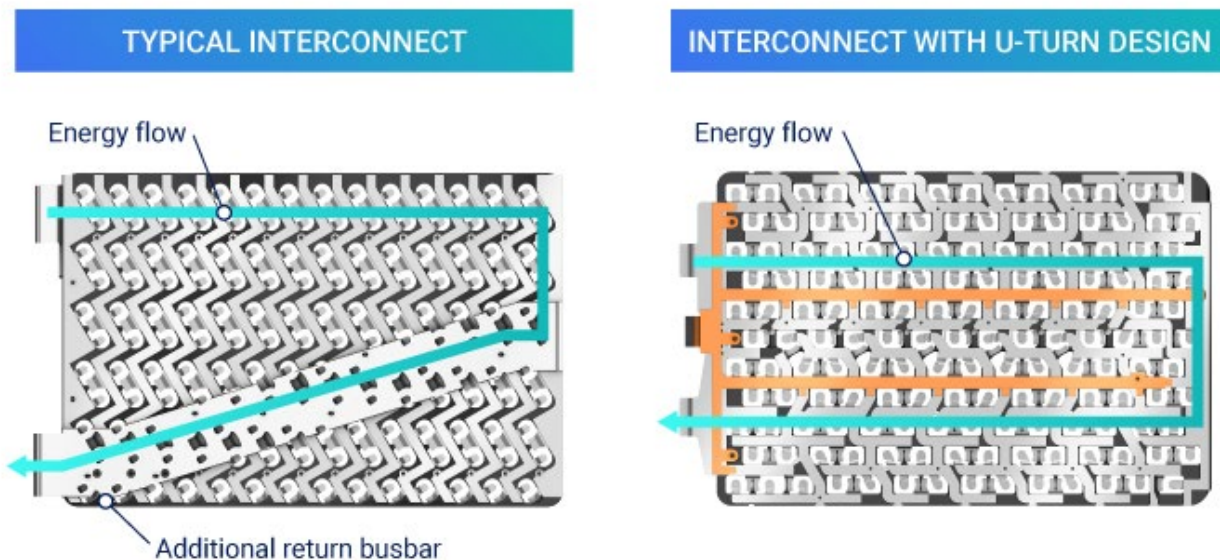


Figure 5 - With U-Turn, the energy flow is markedly better organized as it moves from the positive to the negative terminal via a single conductor layer.

Interplex achieves this evenly distributed power spread with U-Turn by leveraging our proven, precision, high-volume manufacturing methods that ensure each Cell-PLX™ metal plate has a consistent thickness, even for very large battery interconnects.

#### KEY BENEFITS OF U-TURN DESIGN:

- Provides even spread of current throughout the battery.
- Eliminates current bottlenecks that cause temperature spikes.
- Distributes uniform current density across the battery.
- Elimination of hot spots prevents degradation of battery life.

## 5.0 Battery Interconnect Design Use Cases

In addition to pioneering new innovative technologies for the e-Mobility sector, Interplex is a proven leader in how we work with EV makers and Tier 1 suppliers to address the fast-moving, dynamic challenges associated with the major transition to scalable and sustainable EV production.

Our experienced design teams provide an end-to-end capability that enables EV makers to start at inception with an understanding of the various alternative approaches and to evaluate forward-looking tradeoffs to help avoid any dead-ends or re-starts that drive up costs and delay time-to-market.

### **FOLLOWING ARE BRIEF USE-CASE SUMMARIES OF EXAMPLE PROJECTS:**

#### **BATTERY INTERCONNECT SYSTEM FOR THE WORLD'S LEADING EV MANUFACTURER**



### **CHALLENGE:**

The customer needed a comprehensive battery interconnect solution to reduce the overall manufacturing cost and reduce the weight of the battery while improving reliability and performance. The project was on a tight schedule, with multiple design iterations surfacing throughout the project. Each design iteration came with evolving requirements and challenges that required Interplex engineers to respond and problem solve with speed and agility.

**RESULTS:**

To address multiple design iterations and moving targets on design requirements, Interplex engineers surfaced new innovations in multiple engineering disciplines (such as “U-Turn” technology) to design an excellent density spread solution on a large piece of aluminum that is thinner than all the previous solutions. These innovations were done while operating on tight schedules.

We have been supporting them for over 2 years and our solutions do not have a single quality incident that occurred with mass production, and we’ve had zero late deliveries.

**BOTTOM LINE:**

The Interplex team quickly solved multiple design complexities and delivered high quality production, resulting in 0 PPM and 100% on-time delivery.

**BATTERY INTERCONNECT SYSTEM FOR AN AMERICAN AUTOMOTIVE STARTUP****CHALLENGE:**

The customer was a new entrant in the EV market and needed a supplier with design knowledge, R&D support and experience on manufacturability. Based on their initial requirements and design, the customer was unable to find a supplier who could produce their solutions reliably.



## RESULTS:

Interplex engineers worked with the customer's team from the early-stage design stage, providing the engineering support to improve designs, propose materials and ensure manufacturability using computer aided simulation and analysis.

We leveraged our core technology of Cell-PLX™ to accommodate their entire EV product lineup and enabled efficient production processes and lower overall costs. For 2 years now, we have been reliably supporting their high-volume operations, with zero quality incidents.

## BOTTOM LINE:

The Interplex team helped resolve early-stage design issues and supported transition to production with 0 PPM and 100% on-time delivery.

## BATTERY INTERCONNECT SYSTEM FOR RAPIDLY GROWING AMERICAN EV MANUFACTURER



*Image via [Mike Mareen](#)*

## CHALLENGE:

The customer's initial current collector assembly design was largely different from other EV OEMs and featured a unique insert molded part. Producing this design proved to be a challenge, as their supplier faced multiple issues with production, which affected their overall manufacturing goals and go-to-market timeline.

## RESULTS:

Interplex engineers conducted a design for manufacturability (DFM) study on the customer's design to identify the problems and surfaced a new design for the complex profile of the plastic mold. We introduced new tooling and manufacturing processes that ensured consistent quality of the battery components.

To exceed expectations on quality, we used computer aided simulation to optimize the design further and avoid any possible defect which is traceable to the design phase. The results of our intervention were significant, with higher yield, less wastage and zero quality issues to date. Today, we are supporting the customer with 2 production lines.

## BOTTOM LINE:

The Interplex team identified the root cause of engineering issues and then delivered consistent quality with 0 PPM and 100% on-time delivery.

## 6.0 Cell-PLX™ Specifications Overview

Cell-PLX™ has been designed to provide full conformance with all applicable standards that are currently used within the automotive industry and to provide the built-in flexibility for adapting to any new EV-related standards as they evolve and are adopted.

### BELOW ARE KEY STANDARDS THAT CURRENTLY APPLY TO THE CELL-PLX™ TECHNOLOGY:

- ISO 16750-2 and 3; Electrical and Mechanical loads
- ISO 16750-4 and -5; Climatic and Chemical Loads
- USCAR 2-6; Performance Specifications for Automotive electrical Connector Systems
- IEC 60664-1 Insulation coordination for equipment within low voltage systems

## TECHNICAL SPECIFICATIONS

### Material Specifications:

- Current Collectors: AL1000 Series, C1000 Series, Nickel
- Dielectric Layers: PET, PI
- Battery Cell Holder: PPA, PC/ABS, Nylon 6, PA66, PBT (Operating Temperature  $\leq 130^{\circ}\text{C}$ )
- Surface Treatment of Current Collector: Nickel plating option for anti-corrosion and welding

- > Flammability Rating: UL 94 V-0 for battery cell holder and dielectric layers

**Mechanical Specifications:**

- > Battery Cell Types: Cylindrical, prismatic
- > Battery Module Connection Types: Nut/bolt, pin/socket, custom configurations possible
- > Current Collector Sizes (Length): 100mm – 2500mm
- > Current Collector Thickness: 0.17mm – 3mm
- > Cell Terminal Thickness: 0.125 – 0.3mm  
(Laser Weld: Terminal thickness <0.3mm; Wire Bond: Various thicknesses possible)
- > Cell Terminal Positional Tolerance: ±0.127mm
- > Dielectric Layer Thickness: 0.1 – 0.3mm (Pressure-sensitive and thermal-activated adhesive)

**Performance Specifications:**

- > Battery Pack Voltage: Up to 800V and higher
- > Battery Module Capacity: 50 – 400A
- > Battery Module Energy: 0.60 – 48kWh
- > Module-to-module Connections: <400A, off-shelf or customized
- > Current Density: <15A/mm<sup>2</sup>, maintaining <60°C with cooling
- > Dielectric Strength of Insulation Materials: <7.5kV/0.025mm, ASTM D149
- > Dielectric Continuous Use Temperature: <220°C
- > Voltage Sense Line: Flex printed circuit at <2A, 50V
- > Temperature Sensing: 4.7kΩ at 25°C, thermistor placement
- > Overload Condition: <200% for 10s without degradation

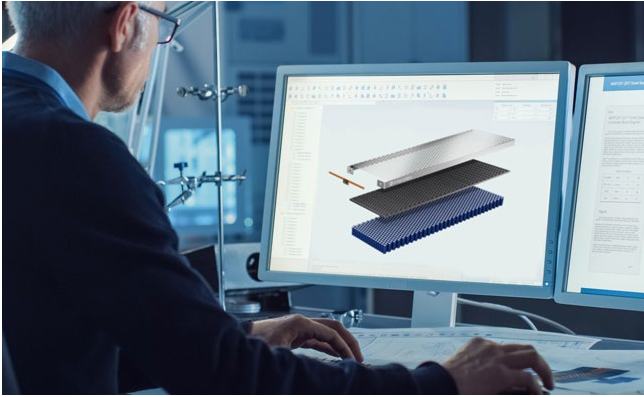
All specification values indicated herein are within a typical value range; actual specifications depend on end applications and requirements.

## 7.0 Summary

Interplex has long been a recognized leading innovator in the EV sector and has already transformed the options available to battery designers with the Cell-PLX™ battery interconnect system that provides a single robust, customized, cost-effective solution to address the full range of requirements across the entire spectrum of EV applications.

Cell-PLX™ provides options for high speed, robust laser weld attachment from collector plates to the cells, thereby enabling efficient production processes, lower manufacturing costs, and high-volume operations. This gives battery designers an interconnect solution that is very thin and light to fit into tight spaces and weight constraints, while also being extremely robust.

In the constantly evolving and highly competitive EV market, fast responsiveness and rapid product development cycles are critical for success. That’s why, in addition to offering highly adaptable technologies, Interplex engineering teams also have the knowledge, commitment and agility to go stride for stride with the customers’ internal product development groups.



Over many decades of working with leading automotive manufacturers as well as with the whole spectrum of new EV makers, Interplex has found that it is our strong commitment to the relationship that makes the most difference for success. Virtually every new engagement with an EV manufacturer has quickly evolved from an initial design success to explorations of other Interplex technologies and partnering opportunities.



Across all these different programs, a key ingredient has been the Interplex commitment to responsiveness and quality. We consistently rank at the highest levels in customers’ quality monitoring and rating programs.

Another important factor that underpins all these successful relationships is the global logistics, manufacturing, and support capabilities that Interplex provides our customers worldwide. EV manufacturers often need the ability to manufacture in specific countries, either to meet local government mandates and/or to optimize supply chain logistics.

**REQUEST A CONSULTATION WITH THE INTERPLEX BATTERY SYSTEMS TEAM.**

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