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# Lithium-ion Battery Pack Charging Interfaces and Challenges

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# Li-ion Market Trends

- Need for safe & portable power is increasing worldwide
- Lithium-ion (Li-ion) batteries are used in almost every market segment including medical, consumer electronics, military, automotive, etc.
- Over the last few years, motive applications that have traditionally been powered by lead-acid batteries are adopting Li-ion battery technology.

# Why Li-ion?

- Users are starting to see the advantages in using Li-ion batteries over the traditional lead acid packs, such as:
  - Longer runtime
  - Maintenance free
  - Faster Charging
  - Better insight to battery's key parameters such as State of Charge (SOC), State of Health (SOH) etc.
- But, there are **charger considerations** that need to be made when making the switch from lead-acid to lithium-ion.

**Increased Run Time**

**Zero Maintenance**

**Battery Intelligence**

**Quick Charging**

**Reduced Weight**

**Long Lifespan**

**Lower Total Cost of Ownership**

# Charger Types

- Type of charger dependent on Li-ion battery pack behavior
  - Standalone charger (No communication)
  - Intelligent chargers (Closed Loop Communication)
- Li-ion battery packs exhibit (2) types of behaviors:
  - Lead Acid replacement (Power terminals live)
  - Smart Battery (Power terminals live after activation)

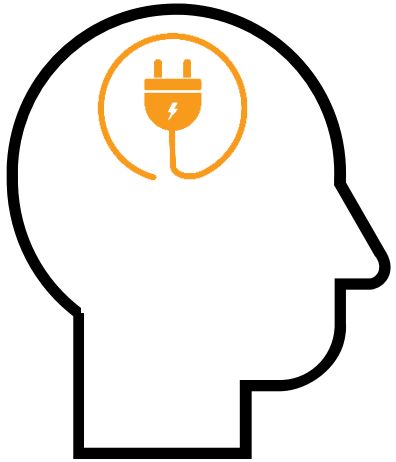
**Standalone**
*for Lead Acid Replacement*

**Intelligent**
*for Smart Batteries*

*Image Source: Delta-Q Technologies*

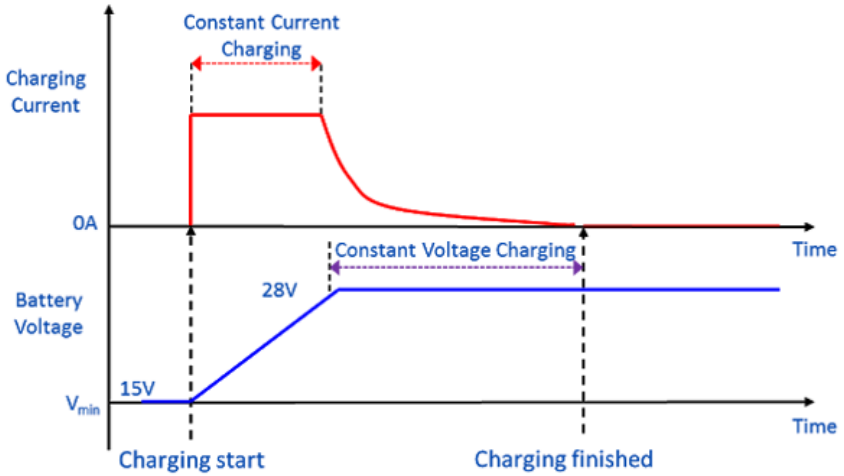
# Common Li-ion Charging Concerns

- Charger Compatibility
- Unable to Charge Battery
- Charger Fails to Stop Charging
- Stackable Chargers & Charging Beyond Limits
- Communication Issues



# Charging Compatibility

- **Charging Lead Acid w/ Li-ion charging algorithms**
  - Max charge voltage much higher for Li-ion batteries (48V vs 58V)
- **Charging Li-ion w/ Lead Acid charging algorithms**
  - Charger must perform Constant Current / Constant Voltage (CCCV) profile
  - Max charge voltage & current should align with battery chemistry & spec requirements
  - Charging to terminate according to taper current of the cell
  - Safety concerns could arise if the charge voltage and/or current exceeds cell spec
- **Why special charging profiles / algorithms matter?**
  - Algorithms are tapered according to the battery pack chemistry & overall design



# Battery Unable to Charge

**Issue:** Battery pack fails to charge; charger looks for battery terminal voltage before it starts charging.

**1:** A smart battery turns off the terminal voltage and enters SLEEP mode when the user inactivates WAKE and ‘Charge Enable’.

**Solution:** Charger needs to activate ‘Charge Enable’ to enable charge mode, which gets the terminals to be alive

**2.** When cell voltage is critically low, pack enters a power saving mode to prevent further cell discharge

**Solution:** In this mode, pack requires a charge voltage to bring it out for this mode and enable charging; Charger needs to account for this mode of the battery pack

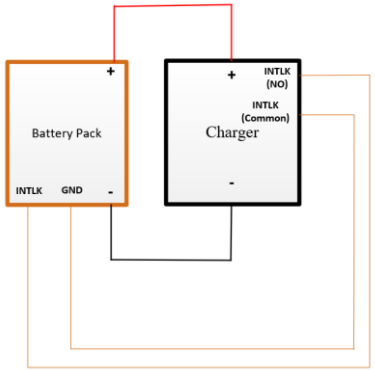
# Charger Fails to Stop Charging

**Issue:**

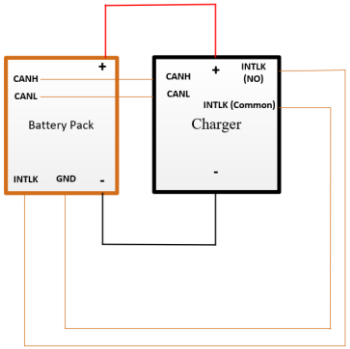
- The charger does not stop charging the battery according to the battery spec.
- This results in cell over voltage fault; which if not taken care by a BMS could end in a safety event.

**Solution:**

- Standalone Charger
  - Proper charge termination conditions need to be defined & programmed in the charger & battery pack algorithm
- Intelligent Charger
  - Upon successful completion of the handshaking, the pack controls the charger by sending max charge & voltage details
  - The pack terminates charging using commands via electronic communication standards (CANopen or J1939)




Stand Alone Charging




Intelligent Charging

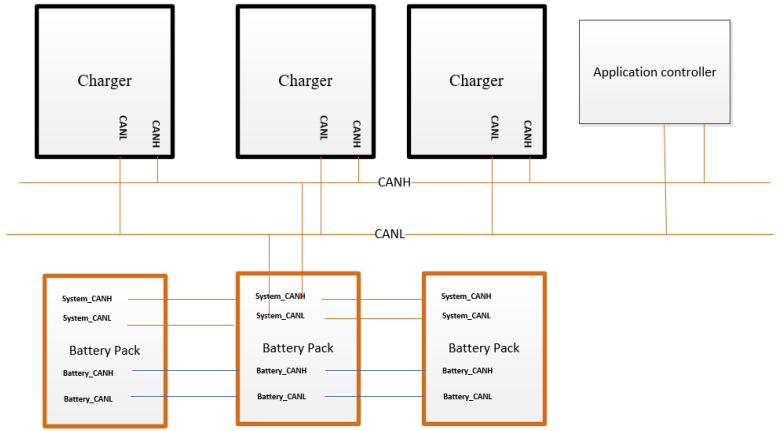
# Stackable Charging

**Stackable charging** is when multiple chargers are connected in parallel to charge battery packs.

**Issue:** If one pack enters charge protection, total current is supplied to the remaining packs, which could result in an **over current charge protection** in the remaining packs, eventually stopping charging.

**Solution:** Intelligent Charging

- Inventus Power's virtual battery feature identifies the number of packs connected. The data from all batteries is consolidated by the master pack.
- This communicates with the master charger from the charger system and adjusts the current accordingly.



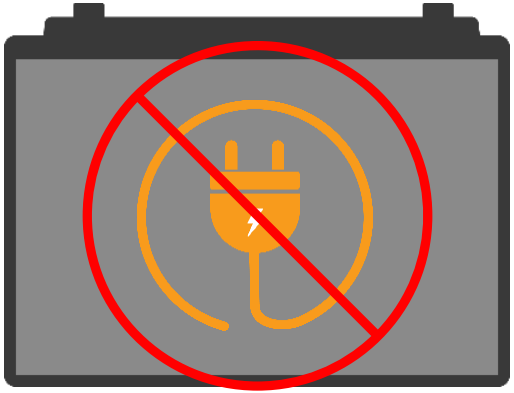
# **Communication Errors –** *only in Intelligent Charging*

**Issue:**

- Charger baud rate of charger is different from baud rate of battery pack
- Mismatch of communication protocols (CANopen / J1939) between charger & pack
- Message structure is different between the charger & battery pack

**Solution:**

- Charger allows adjusting of baud rates to match with that of the battery pack
- Firmware for intelligent charger needs to account for the right protocol to communicate with the battery pack
- Messaging structure within battery pack BMS is published in a specification for which the charger firmware accounts for



# Conclusion

- Solutions for charging issues can be addressed by both the Battery Management System (BMS) & the Charger
- Inventus Power has partnered with many OE chargers to develop specific charge algorithms for both smart charging & standalone charging
  - Ease of Compatibility – can reflash software in the field
  - Charging algorithms have been tested & verified with our U1LiFePRO & PROTRXion batteries in various markets
- We continue to venture into new partnerships with charger companies to ensure a smooth transition from traditional lead acid batteries to Li-ion batteries for our customers.

# THANK YOU!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### Product Showcase

**Thursday 9/16, 12:00 pm**