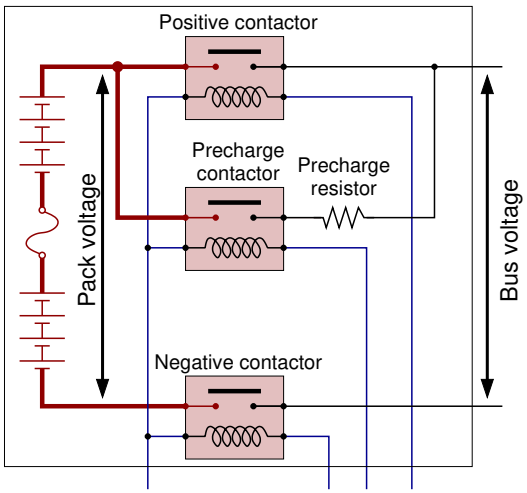
1d: High-voltage contactor control

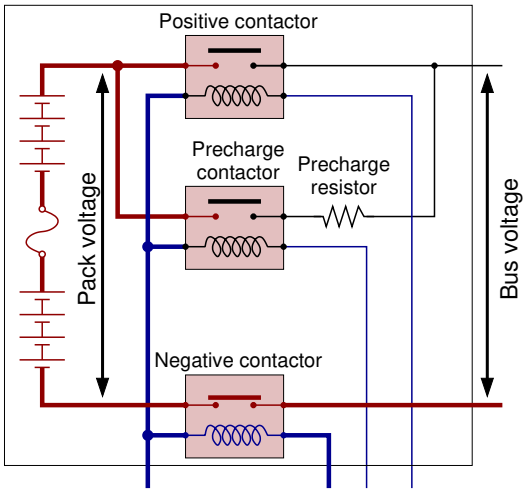
- When not in use, the battery pack internal high-voltage bus is completely disconnected from the load at both terminals
  - Dis/connecting pack at both terminals requires two high-current capable relays or “contactors”
  - A low-voltage/low-current signal activates the contactor, closing an internal switch that connects its main terminals
  - As load is often capacitive, if both contactors were closed simultaneously, enormous current would flow instantly, potentially welding the contactors closed or blowing a fuse
  - So, a third “pre-charge” contactor is used
- In this lecture, we study how the contactors are controlled when the battery pack is connected to the host application

Step 1: Close negative contactor



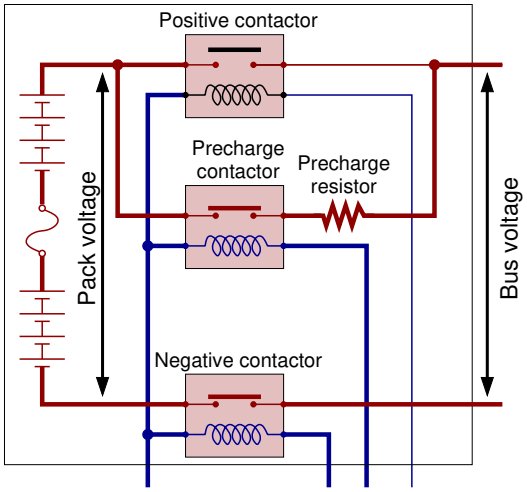
- Contactor wiring diagram is shown to the left
- Pack is initially at rest; all contactors are open
- Then negative contactor activated
  - Connects “–” terminal of the load to “–” terminal of battery pack
- (Thick lines show activated connections)

Step 2: Close precharge contactor



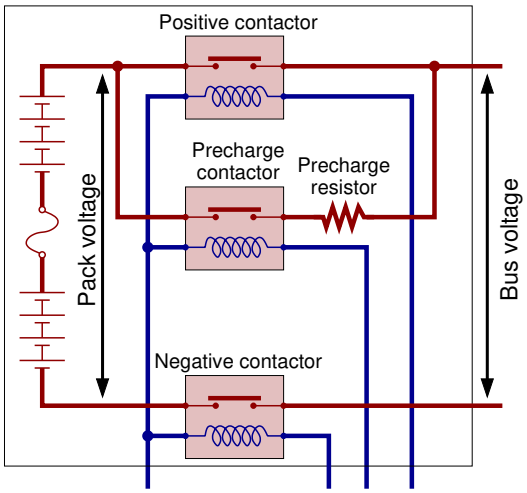
- Precharge contactor activated next
  - Precharge resistor limits current, pack charges capacitive load
  - Resistor temperature is monitored: if too high, load may have short circuit, pack disconnects
  - Bus and pack voltages also monitored: if they don’t converge quickly enough load may have short-circuit fault, pack disconnects

Step 3: Close positive contactor



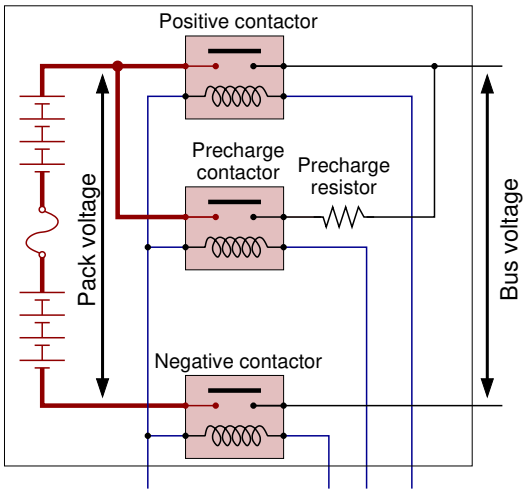
- If bus and pack voltages become "close enough" "quickly enough," then BMS closes/ activates the main "+" terminal contactor
  - Load is now directly connected to pack through low-resistance path
  - Precharge path is still connected

Step 4: Open precharge contactor



- As a final step, after the positive contactor is closed, the precharge contactor may be opened
  - Pack operation commences

Shutdown



- Procedure to follow on pack shutdown not as clear
  - Abrupt disconnect may cause arcing/welding of contactor
  - Could activate precharge path prior to main contactor disconnect, giving current path to prevent welding, but might blow precharge resistor
  - Capacitive load likely stores enough energy to prevent either problem

Summary

- There is a need for care when connecting the battery pack to its load on power-up
- For the common scenario of a capacitive load, a precharge path is needed to charge the load relatively slowly before the main contactor is closed
- This imposes the need for pack and bus-voltage monitoring, precharge-resistor temperature monitoring, as well as the use of three contactors
- Note: clever designs can use pack current sensor instead of pack and bus-voltage monitoring, saving need for additional sensors
- Contactor control on power-down is likely not as critical

Credits

Credits for photos in this lesson

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