



Peter Oliver, CEO Switch Vehicles

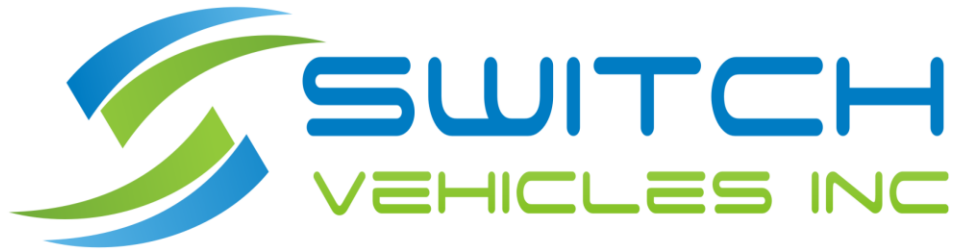
Baudielo Ibarra, Certified Instructor



# Electric Vehicle Safety In Two Sections

First Section – General EV Safety Considerations – Baudelio

Second Section – Working with Lithium - Peter



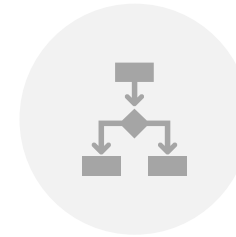
# General EV Safety Considerations

Baudelio Ibarra

# Safety considerations when working with and around Hybrid/electric vehicles



OPERATION – START(ON), STOP(OFF) AND FUNCTION



DEPOWER PROCEDURES-  
NORMAL OFF MODE AND  
DEPOWER FOR SERVICE



ENVIRONMENTAL  
PRECAUTIONS- LOCATION OF  
WHERE VEHICLE WILL BE  
WORKED ON






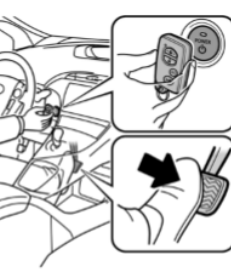
PERSONAL PROTECTIVE  
EQUIPMENT-GLOVES,  
SAFETY GLASSES ETC..

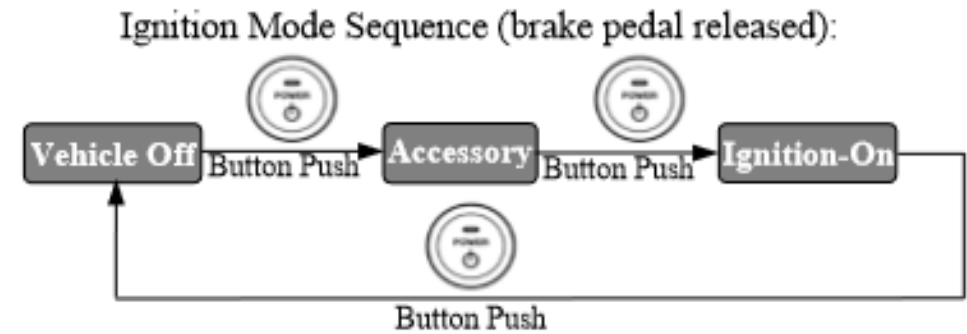


SPECIAL TOOLS AND  
EQUIPMENT- METERS, HV  
SHEPARD'S HOOK ETC..

# Become familiar with the Operation

Ignition Mode	Power Button Indicator Light
Off	Off
Accessory	Amber
Ignition-On	Amber
Brake Pedal Depressed	Green
Vehicle Started (READY-ON)	Off
Malfunction	Blinking Amber

	
<p>Power Button with Integral Status Indicator Light</p>	<p>Ignition Modes (Brake Pedal Released)</p>
	
<p>Starting Sequence (Brake Pedal Depressed)</p>	<p>Smart Key Recognition (When Smart Key Battery is Dead)</p>





Orange cables be alert



## BAS Systems

45



Motor / Generator

Note: three phase AC cables are not orange – 42 volts max

- The GM BAS [Belt-Alternator-Starter] system uses an intermediate voltage motor [42 volts] that is driven by the multi-rib belt
- The hybrid motor supplies additional torque to the crankshaft when operating under load and functions as a starter during start-stop operation

Image courtesy of General Motors Corp



Vehicle manufactures have used color coding as a means to identifying electrical systems



### What Do the Colors of Cables Mean?

Hybrid electric vehicles are equipped with plastic conduit to cover and protect the electrical cables. This plastic conduit is color coded to help identify the potential risk. The colors and their meaning include:

- **Black**—12-volt cable. Not a shock hazard but can power airbags and pretensioners.
- **Red**—12 volts
- **Blue**—42 volts. Not a shock hazard but could maintain an arc if the circuit is opened. Is used for some electric power steering systems and mild hybrid vehicles such as the GM Belt-Alternator Starter (BAS) system.
- **Yellow**—42 volts. Not a shock hazard but could maintain an arc if the circuit is opened (cut). Usually used for electric power steering.
- **Orange**—144 to 600 volts or higher. Shock hazard and could cause severe burns or death. ● **SEE**

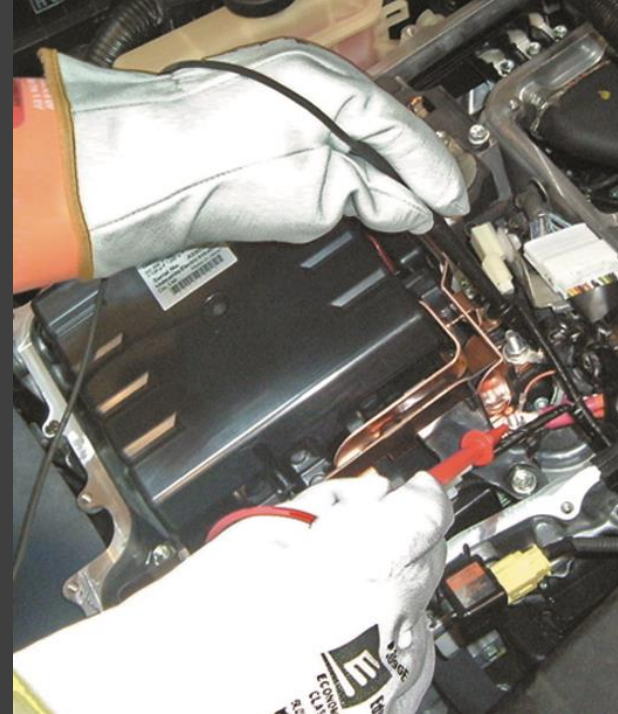
**FIGURE 18-5.**

8/19/2019

## Voltage

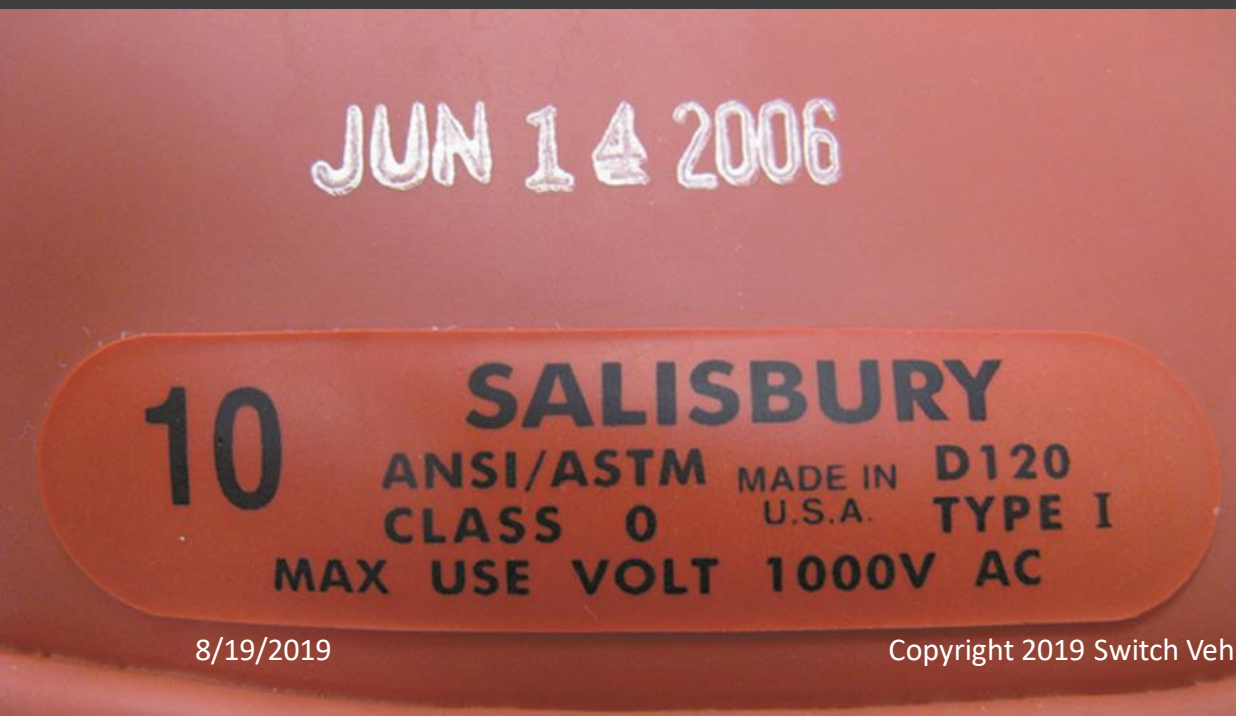
- Low – 0 to 29 volts
- Medium -30 to 59 volts
- High voltage- 60 volts and higher





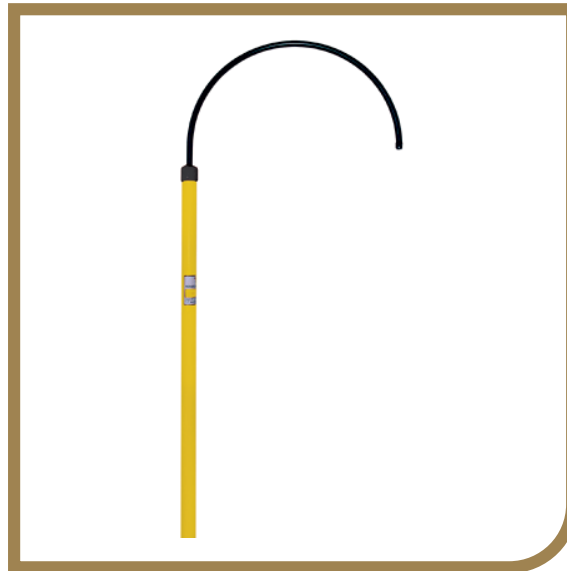
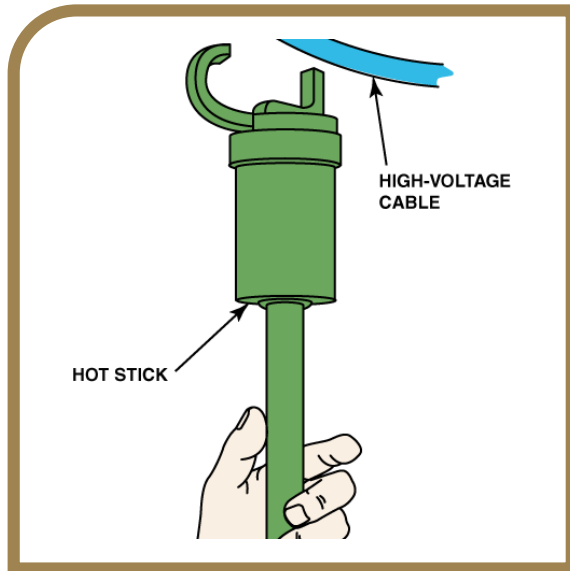
# Gloves must be inspected before use

- Class "0" gloves
- Certification every six months
- Keep clean and protect from abrasions





If Air can come out electricity can  
come in.



# Emergency equipment

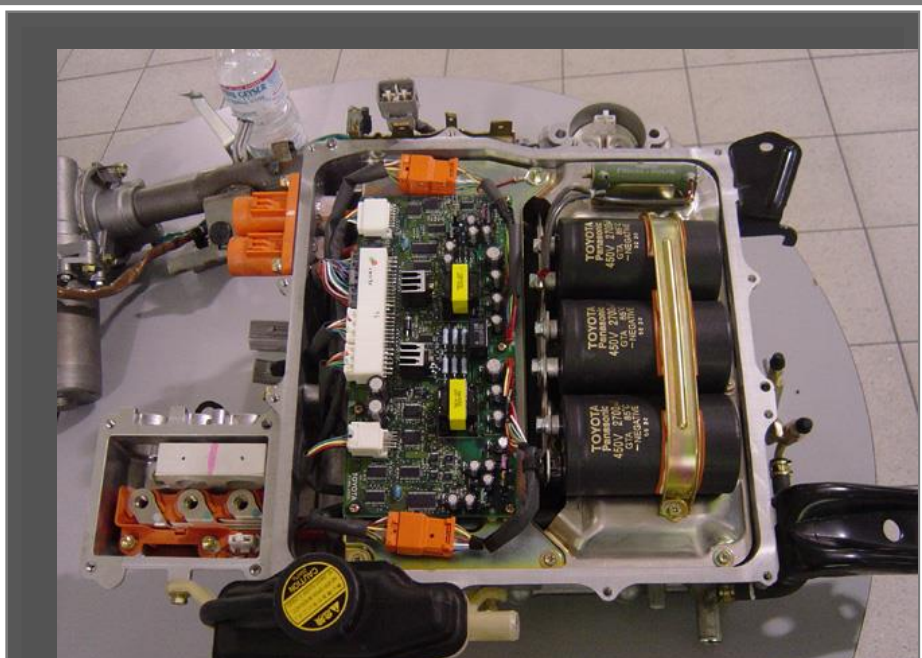
---

- Hot stick- used to move live wires
- Shepard's hook- used to move live people

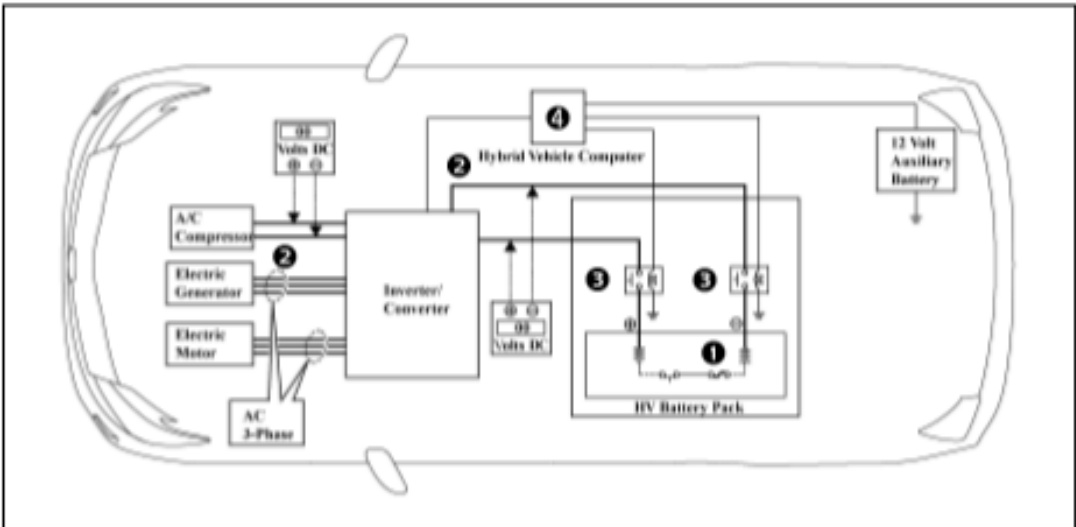


Properly rated meter  
must be used

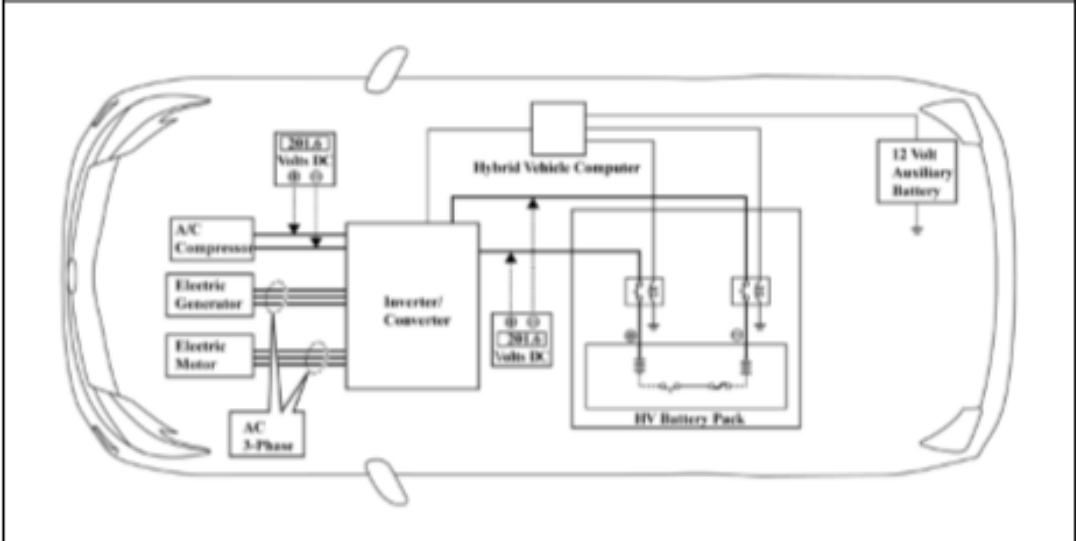




- Capacitors can be packaged in metal cylinders or in brick shaped packs
- Since there is very little heat produced in the capacitor they are normally located at the top of the inverter assembly



High Voltage Safety System – Vehicle Shut Off (READY-OFF)



High Voltage Safety System – Vehicle On and Operational (READY-ON)



Q & A

Baudelio Ibarra



Peter Oliver

# Working with Lithium





What are the challenges?

Thermal events

Protecting investment

Protecting workers (students)

Replacing bad cell in pack

Others?



# Thermal Events



Cell chemistry determines thermal stability

Energy density

Lithium Cobalt

vs.

Lithium Iron Phosphate



Primary Causes of Thermal Runaway?

# Thermal Events

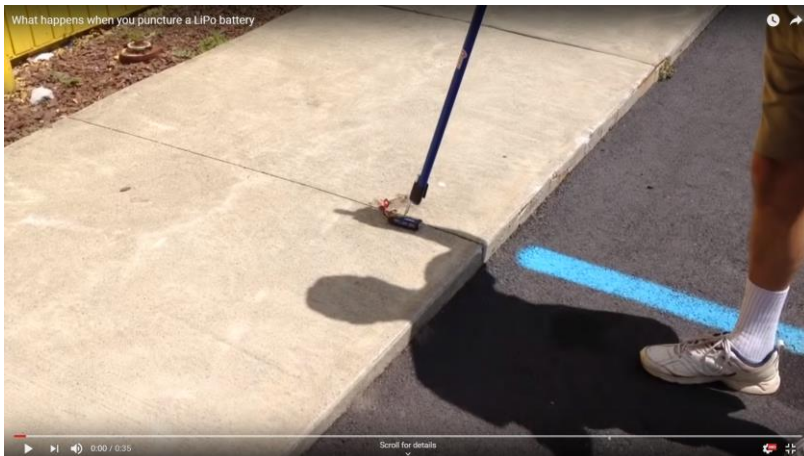
Cell chemistry determines thermal stability

Energy density

Lithium Cobalt

vs.

Lithium Iron Phosphate



## Primary Causes of Thermal Runaway?

Over discharge – Over Charge – Puncture



Protecting investment  
Protecting workers (students)  
maybe drivers too?  
Passengers?

Battery Management  
System (BMS)

Start with a balanced pack?

Say what? All batteries or  
cells at the same state of  
charge

Some say: "Top balancing",  
others say "Bottom Balancing"

Protecting investment  
Protecting workers (students)  
maybe drivers too?  
Passengers?



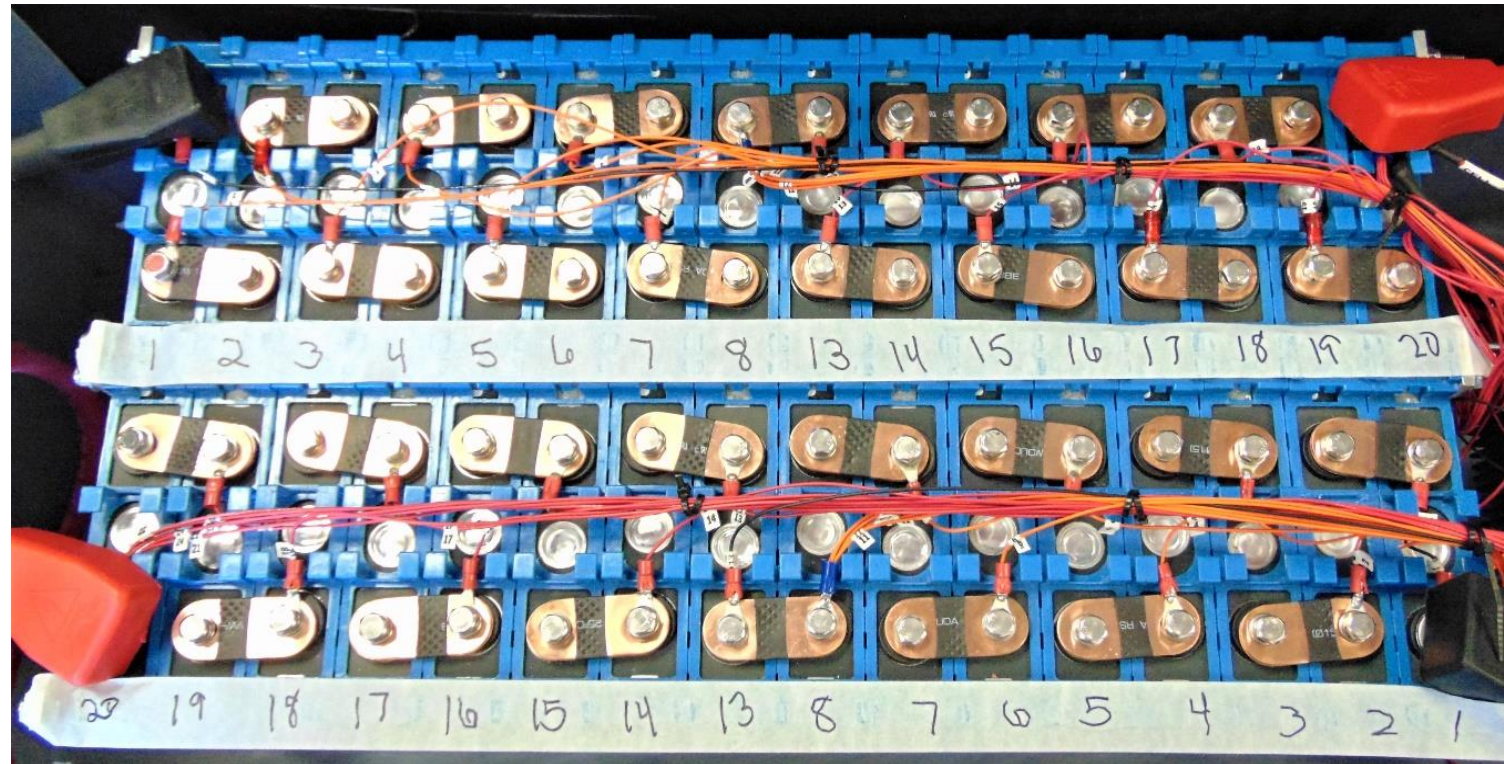
# Battery Management



Lead acid, lithium or any battery chemistry should be installed after balancing and all batteries should be at the same state of charge (SOC)

BMS will then be programmed to monitor cells and watch for over charge, (turn off charger), or over discharge, (inform the driver and shut off the vehicle.) There are other steps but this is essentially it.

# Three examples of how BMS connects



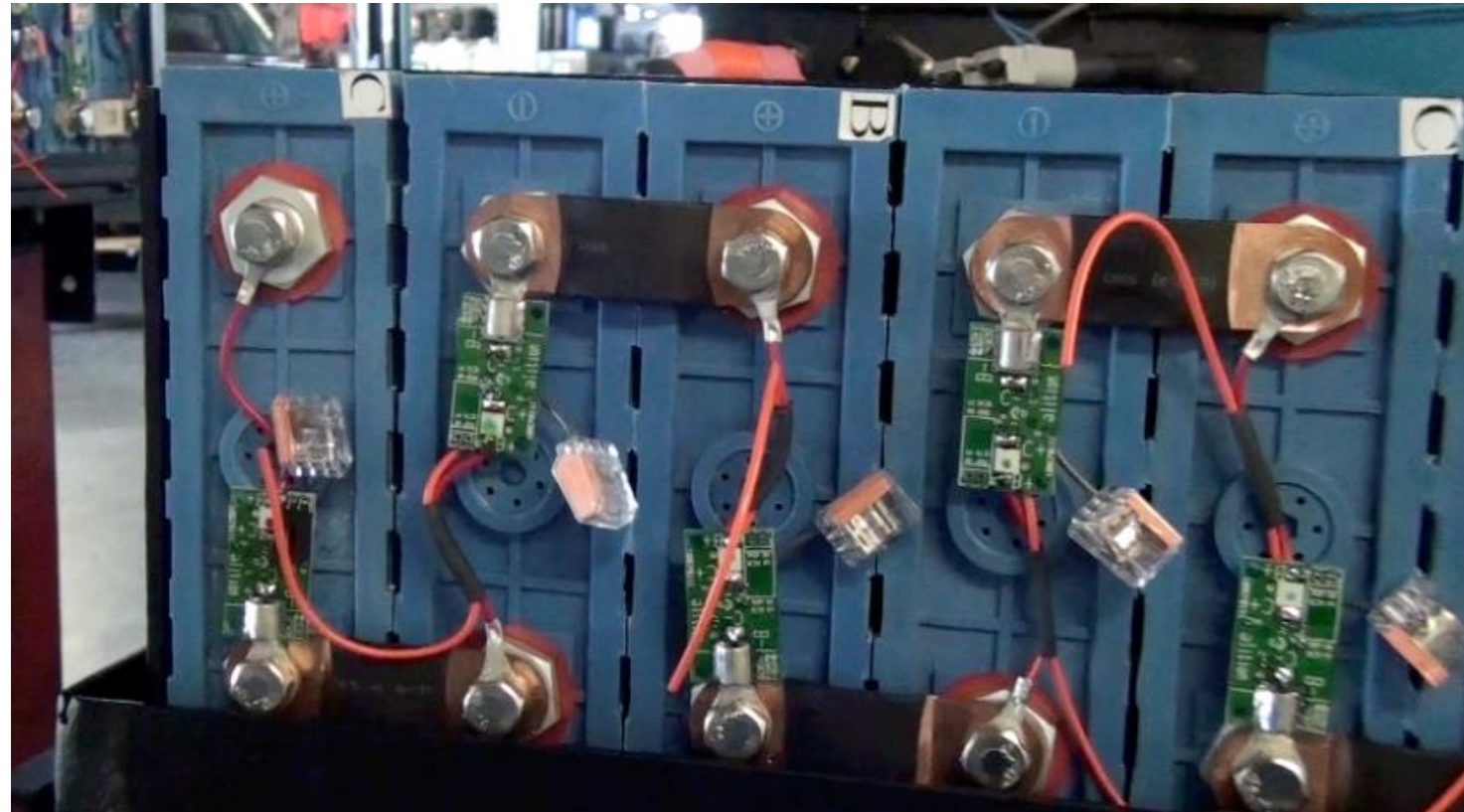






*Optima Blue Top AGM Sealed Lead Acid Batteries with PCHC-12V-2A Power Cheqs Installed in a Corbin Sparrow*

# BMS Sensors and Wiring



## Replacing bad cell in pack

A bad cell can limit the range of the entire pack.

It will run out of energy or become hot (another data point the BMS monitors along with internal resistance) or internal resistance will increase.

The vehicle will register “Out of Fuel “ prematurely.





# Replacing bad cell in pack

Remember the first step in assembling or installing your traction battery?

Charge all cells to the same SOC.

How do we do that with some installed and one not?



# Replacing bad cell in pack

Charge the traction battery to “Full”

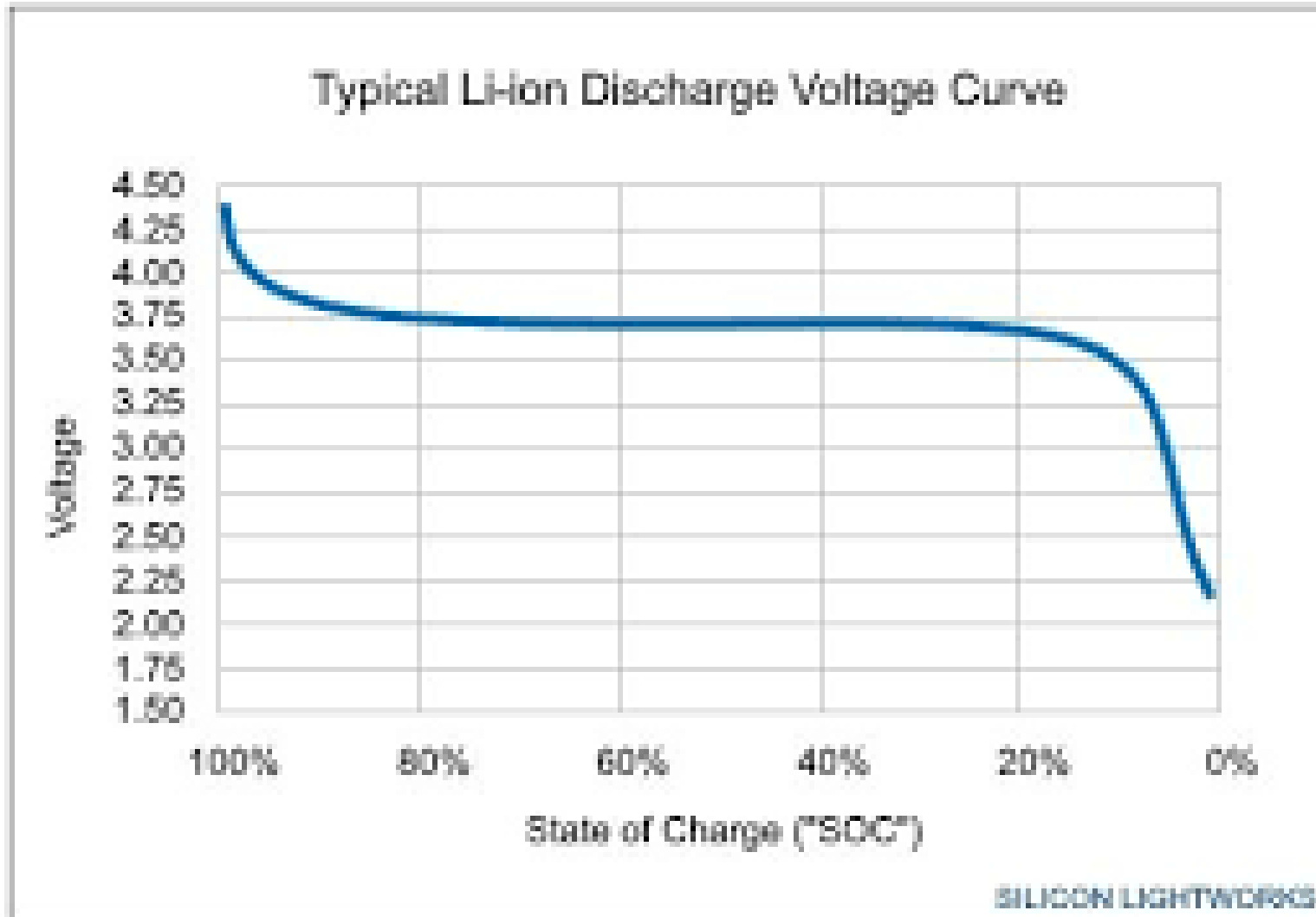
Measure cell voltages

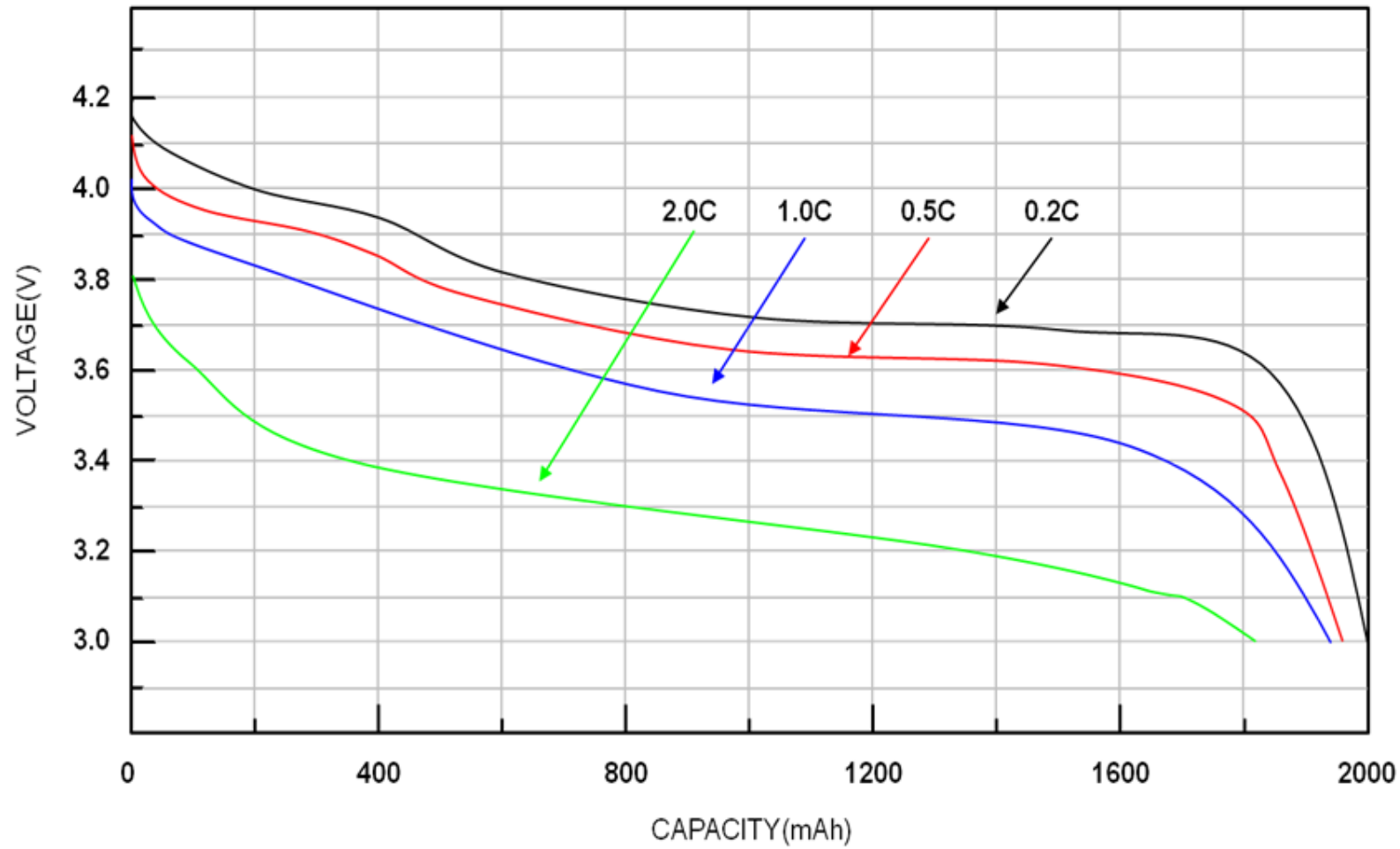
Charge the new cell to the same voltage + .10 to .20 more. Why?

see next slide

There are safety procedures for working on the traction battery, follow all of them and remove the bad cell and replace it with the new cell.

Charge the pack and monitor status.





# The SWITCH, a vehicle for education!



Q and A?

Peter Oliver

Baudelio Ibarra

[www.theswitchlab.com](http://www.theswitchlab.com)

707-827-0107



Sport Switch Three-Seater