



# Lunch & Learn

## Battery System Electronics: What you need to know

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# Battery System Electronics: What You Need to Know



If you are moving to a Battery powered design, selecting the right Battery is just the first step.

Learn what you need to do in your device to get the most from your Battery system:

- ▶ Interface
- ▶ Non-Linear Voltage
- ▶ DC System
- ▶ Charging



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# Battery System Electronics: What You Need to Know



## Definitions ...

### ▶ Cell vs. Battery

▶ Cell is a single element

▶ Battery is a collection of cells, often with a connector, etc.

### ▶ Battery Energy = Battery Capacity = How long Battery will run

▶ Amp-Hours or Watt-Hours (has a time component)

### ▶ Power vs. Energy

▶ Power is rate (of current): Usually expressed in Watts = Volts x Amps

▶ Energy is duration of Power: Has a time component, i.e. Amp-Hours, Watt-Hours

▶  $\text{Watt-Hours} = \text{Volts} \times \text{Amps} \times \text{Time}$



# Battery System Electronics: What You Need to Know



## Device Differences: Power vs. Energy

- ▶ Power = High Current, Short Duration
- ▶ Energy = Low/Medium Current, Long Duration

All Devices require Safety electronics – but the architecture will differ.

Fuel-Gauging & Balancing are used when required – not all Devices will need them.



**High Power**

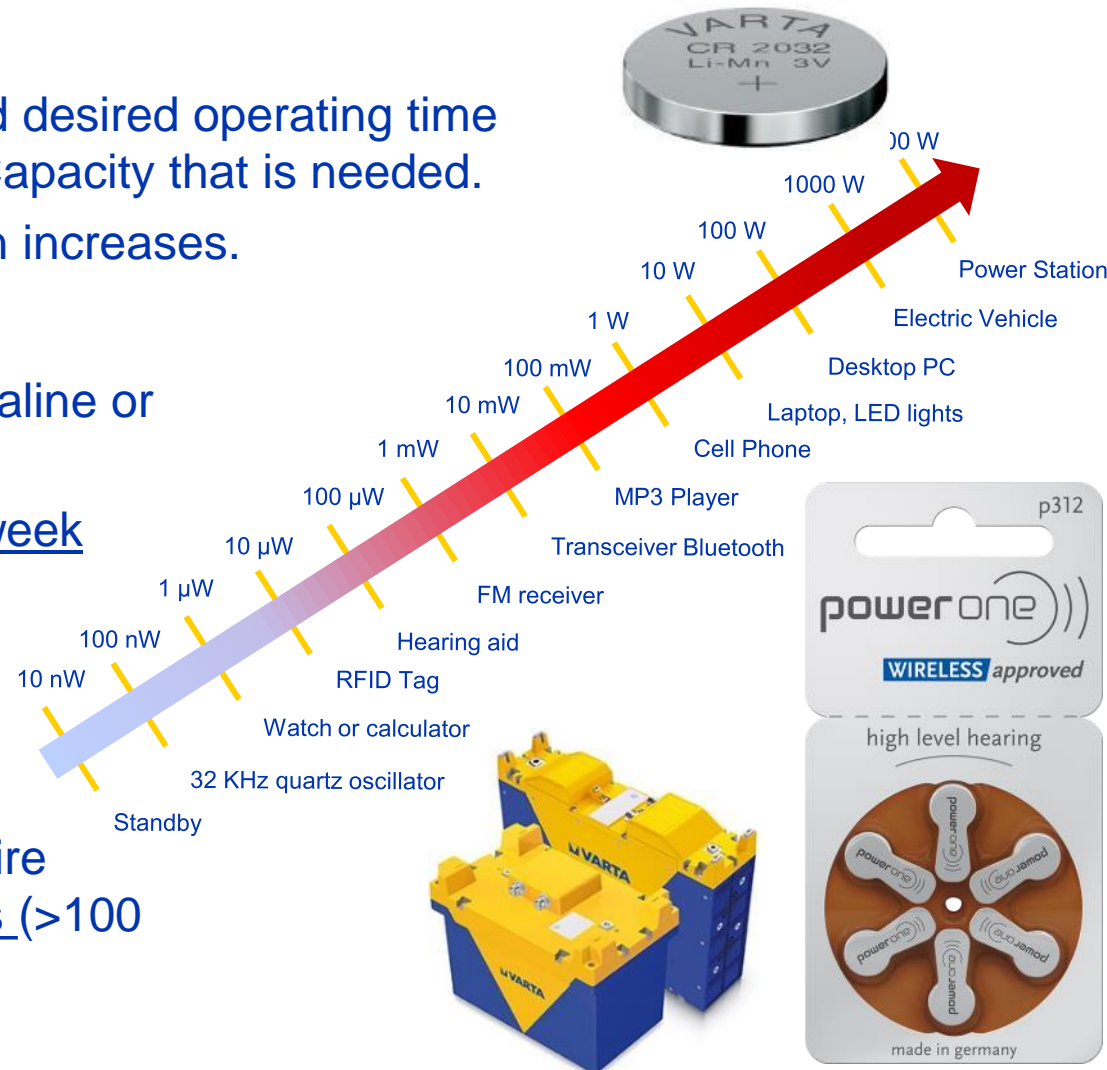
**High Energy**

# Battery System Electronics: What You Need to Know



## What Type of Battery?

- ▶ Power Consumption of the Device and desired operating time determines the amount of Energy or Capacity that is needed.
- ▶ Needs change as Power Consumption increases.
- ▶ Here are some examples:
  - ▶ TV remote control with a primary Alkaline or Lithium Cell lasts a year or more
  - ▶ Hearing-aid primary Cell runs for a week
  - ▶ Bluetooth ear-bud prefers a small rechargeable Cell to run for hours
  - ▶ Cell Phones, Laptops require larger rechargeable Batteries (<100 Wh)
  - ▶ Mobile Robotics (fork-lifts, etc.) require larger rechargeable Battery Systems (>100 Wh)

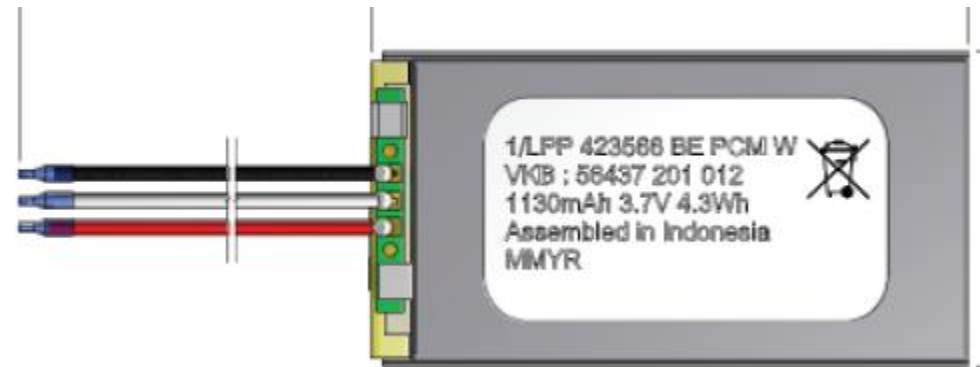
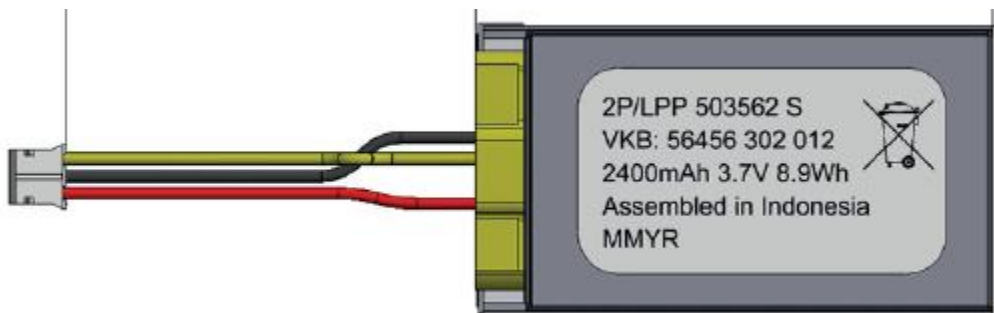


# Battery System Electronics: What You Need to Know



## Interface

- ▶ How your Device & Battery connect:
  - ▶ Fixed or Removable?
  - ▶ Removable: Best to have multiple access options

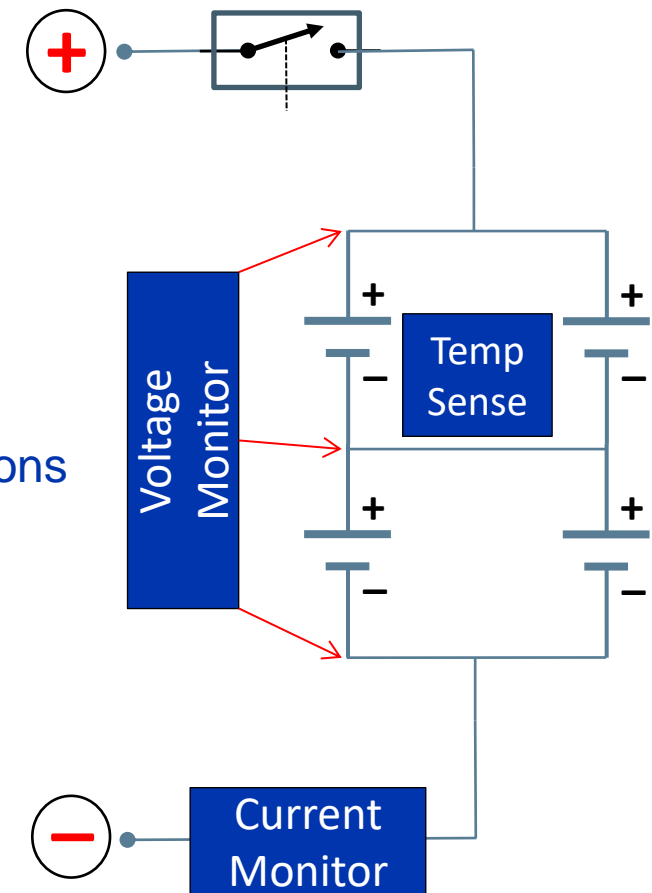
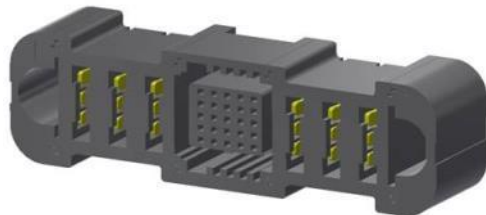


# Battery System Electronics: What You Need to Know



## Interface

- ▶ How your Device & Battery connect:
  - ▶ Fixed or Removable?
  - ▶ Removable: Best to have multiple access options
- ▶ Pinouts:
  - ▶ Power connections (+ & -)
  - ▶ Temperature connection (optional)
  - ▶ Communications connection (optional)
    - ▶ Two or more signal lines typical for communications



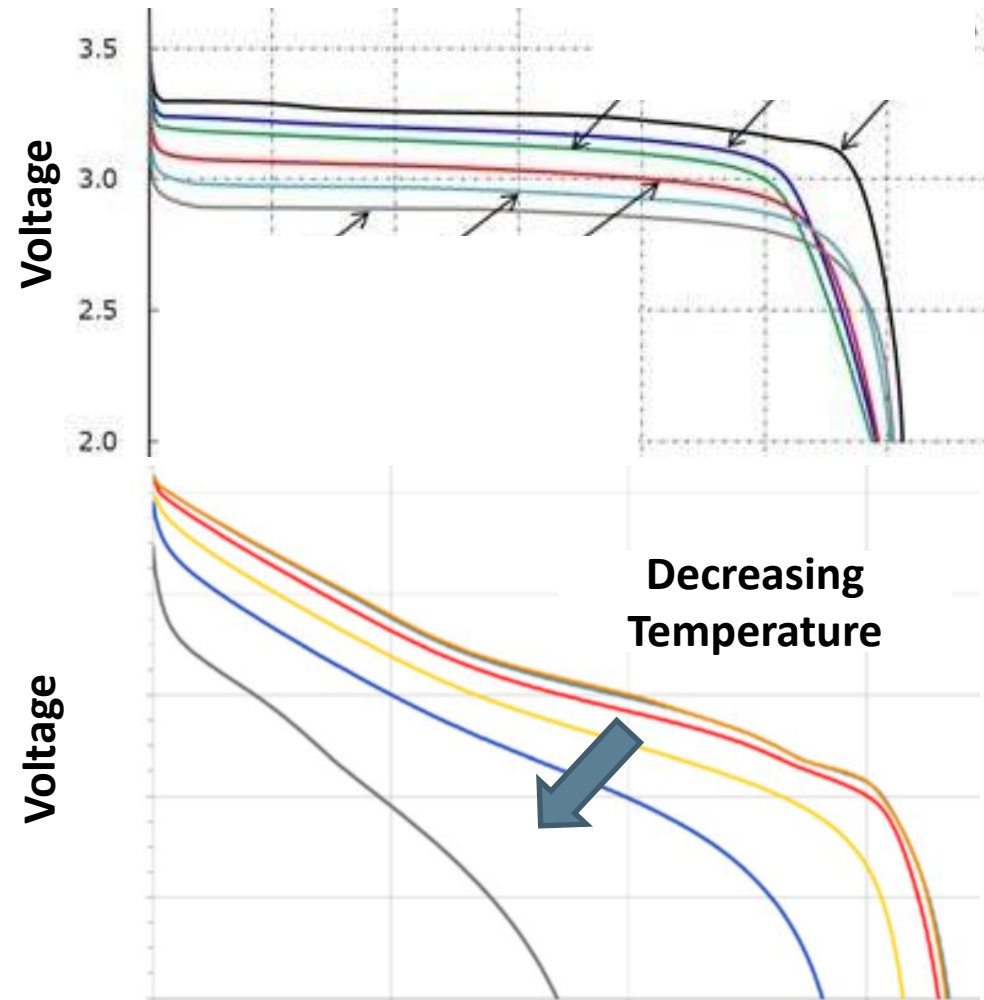
# Battery System Electronics: What You Need to Know



## Non-Linear Voltage

- ▶ A Battery is not really a DC power source:
  - ▶ Voltage varies with Discharge Load, Temperature, & State
  - ▶ Variations can be significant, depending on the chemistry of the Battery...

(Voltages shown are for a single Cell.)





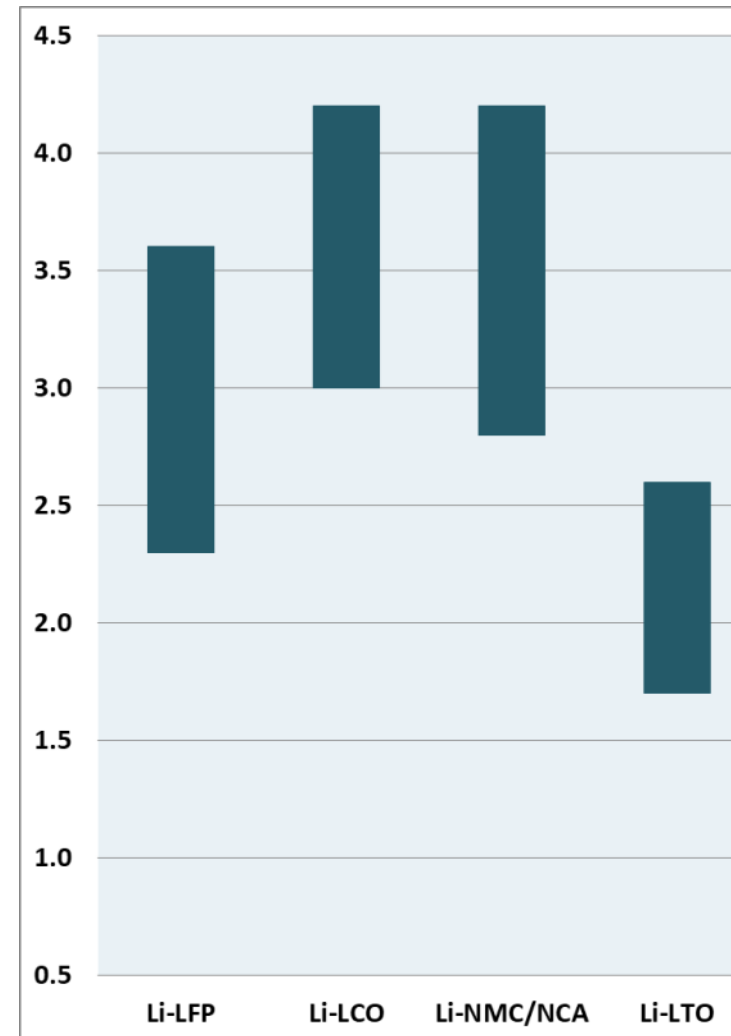
# Battery System Electronics: What You Need to Know



## Non-Linear Voltage

- ▶ A Battery is not really a DC power source:
  - ▶ Voltage varies with Discharge Load, Temperature, & State
  - ▶ Variations can be significant, depending on the chemistry of the Battery...
  - ▶ Voltages differ across chemistry ...

In ALL cases, the voltages shown here are for a single cell. Most battery packs are a collection of multiple cells in series, so the voltages add, but the variation must still be considered.



# Battery System Electronics: What You Need to Know



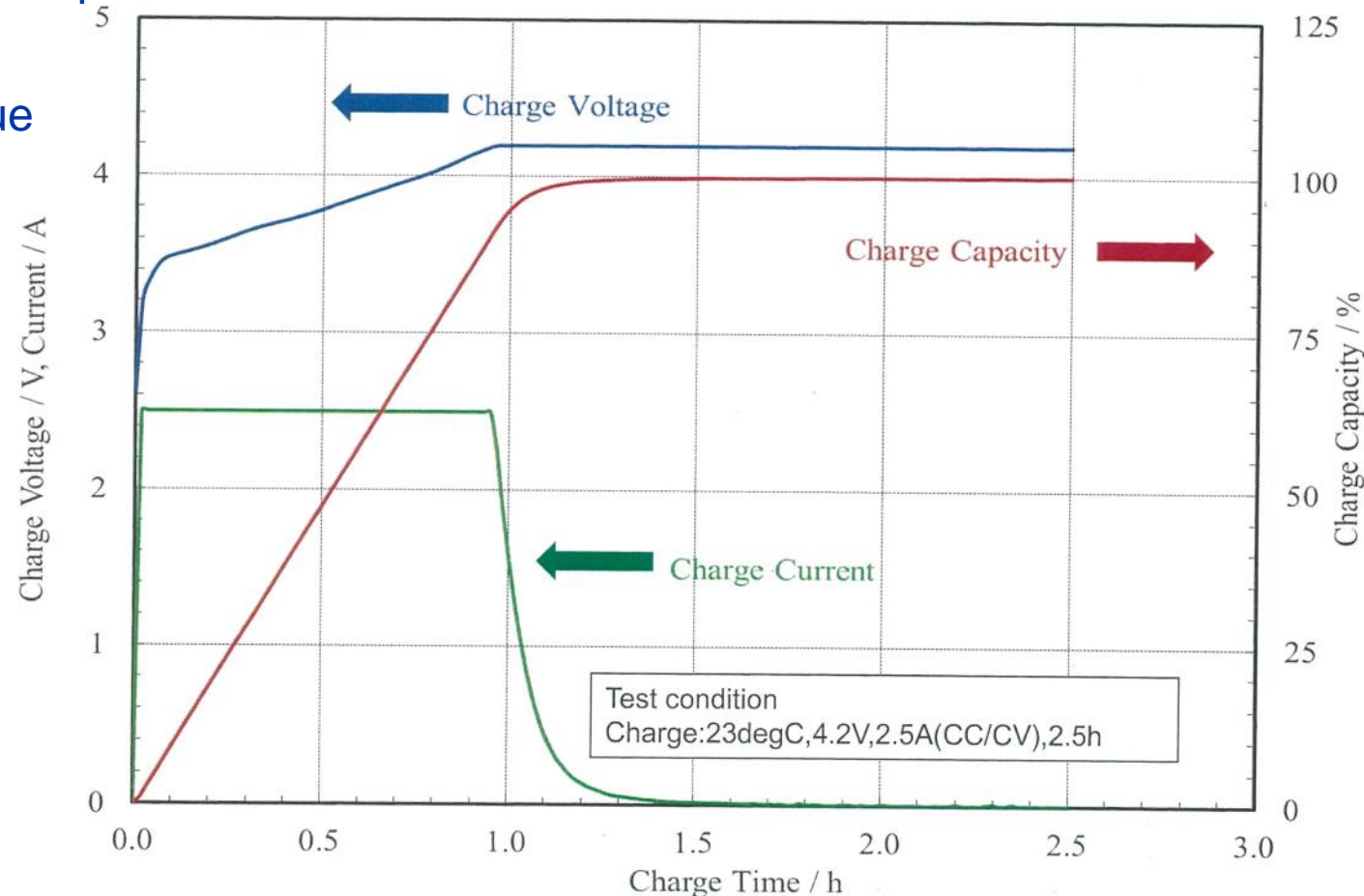
## Non-Linear Voltage

▶ A Battery is not really a DC power source:

▶ Voltage during Charging is quite unique

▶ Voltage rises with constant Charge current.

▶ Then Voltage must be kept fixed by decreasing Charge current.



# Battery System Electronics: What You Need to Know



## DC System

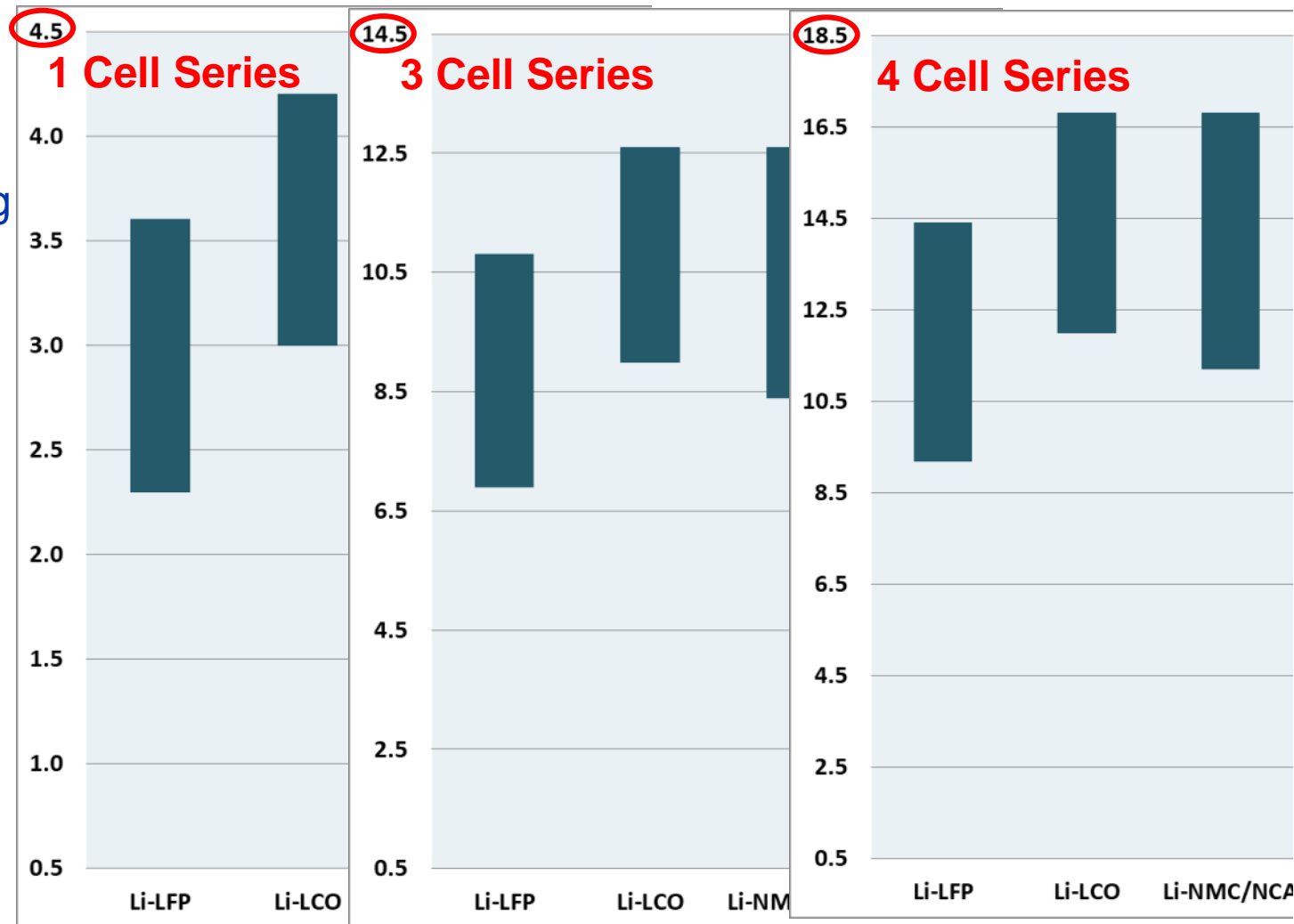
- ▶ Voltage Regulators:  
Beware of total  
Battery Voltage swing

1-Series Cell: 4.2 to 2.5V

2-Series: 8.4V to 5.0V

3-Series: 12.6V to 7.5V

4-Series: 16.8V to 10V



# Battery System Electronics: What You Need to Know



## DC System

- ▶ Voltage Regulators & DC:DC converters:  
Beware of total Battery Voltage swing
- ▶ May need Buck-Boost DC:DC

Example: 3- or 4-series cell systems (i.e. laptop computer)

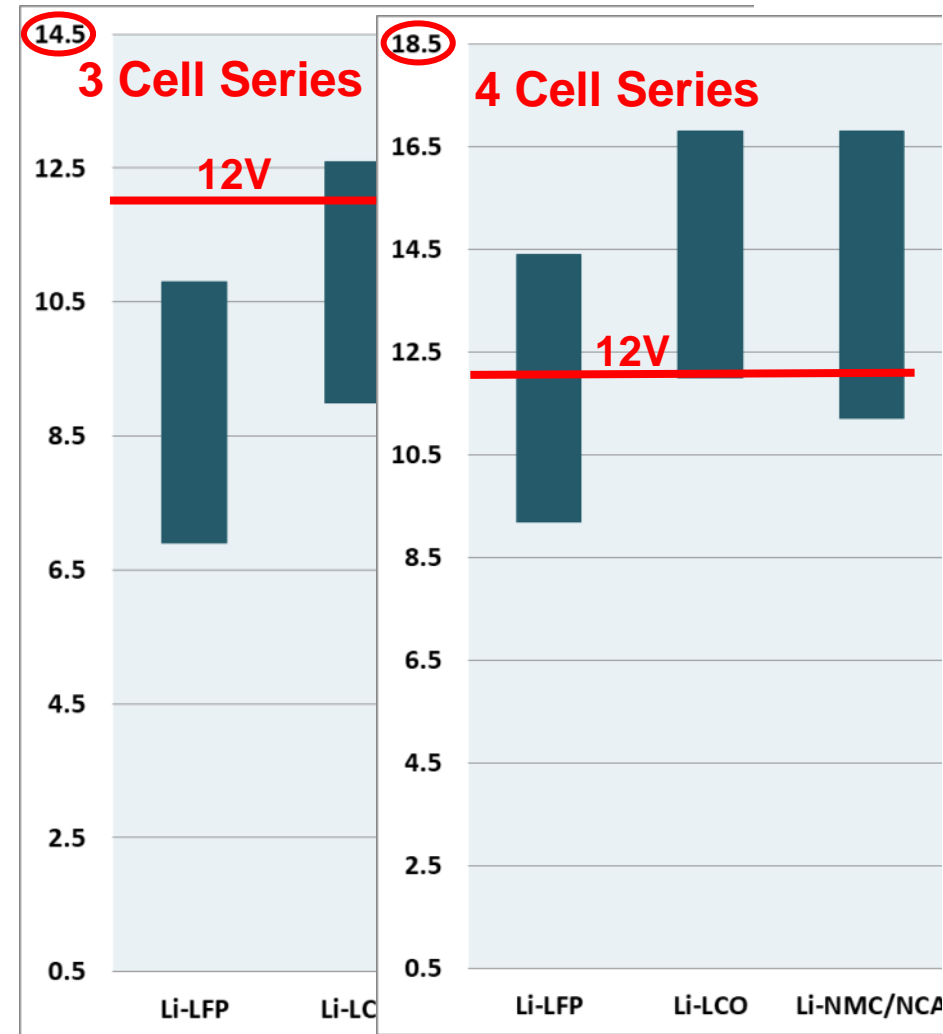
12V System Internal Voltage:

Battery operating voltage crosses 12V

Requires Buck-Boost DC:DC

3-Series: 12.6V to 7.5V

4-Series: 16.8V to 10V



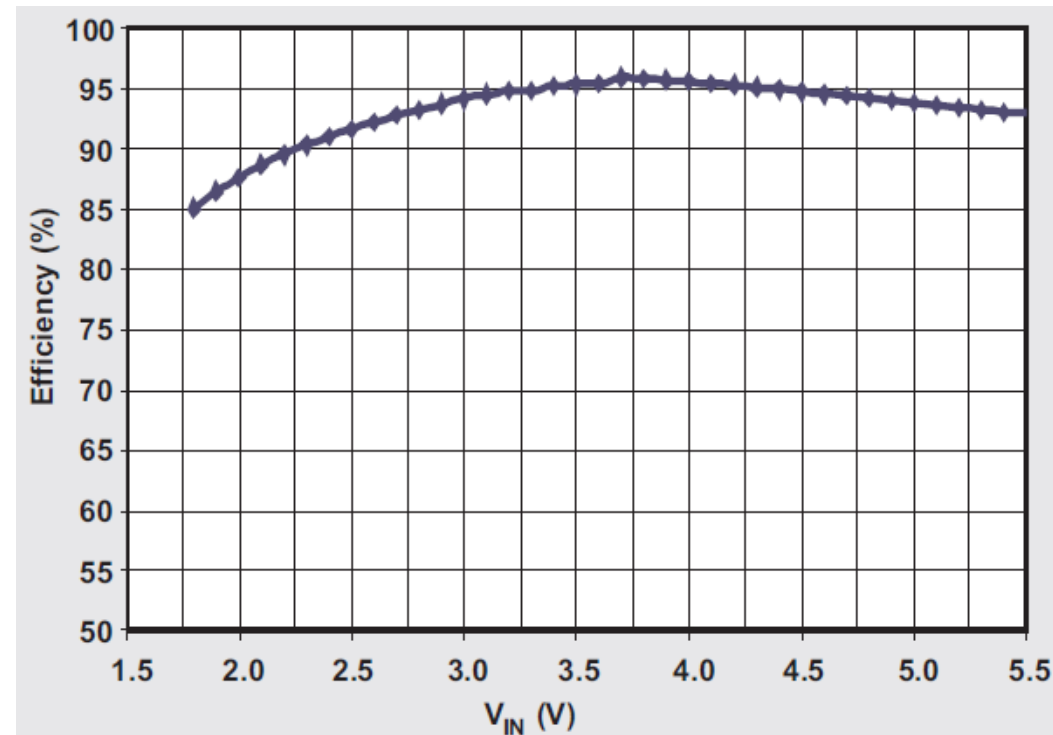
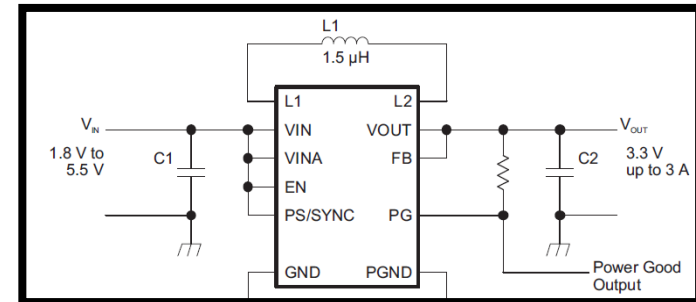
# Battery System Electronics: What You Need to Know

## DC System

- ▶ Voltage Regulators & DC:DC converters:
  - ▶ Also consider efficiency at desired system operating voltage

Example 3.3V DC:DC Buck-Boost  
Lower efficiency at end-of-discharge  
(when battery voltage is lower)  
Discharge current will increase

- ▶ Efficiency varies with output  
Current also (not shown in graph)



*Example component & circuit shown for illustration only.  
Image & graph courtesy of Texas Instruments.*

# Battery System Electronics: What You Need to Know



## Charging

- ▶ On-board (in device):
  - ▶ Requires components & space; Adds heat
  - ▶ Less costly (already have housing)
  - ▶ Battery can be embedded (non-removable)
  
- ▶ Off-board (external):
  - ▶ Additional cost for housing
  - ▶ Removable battery may have higher cost
  - ▶ Higher usage efficiency: Can charge multiple batteries

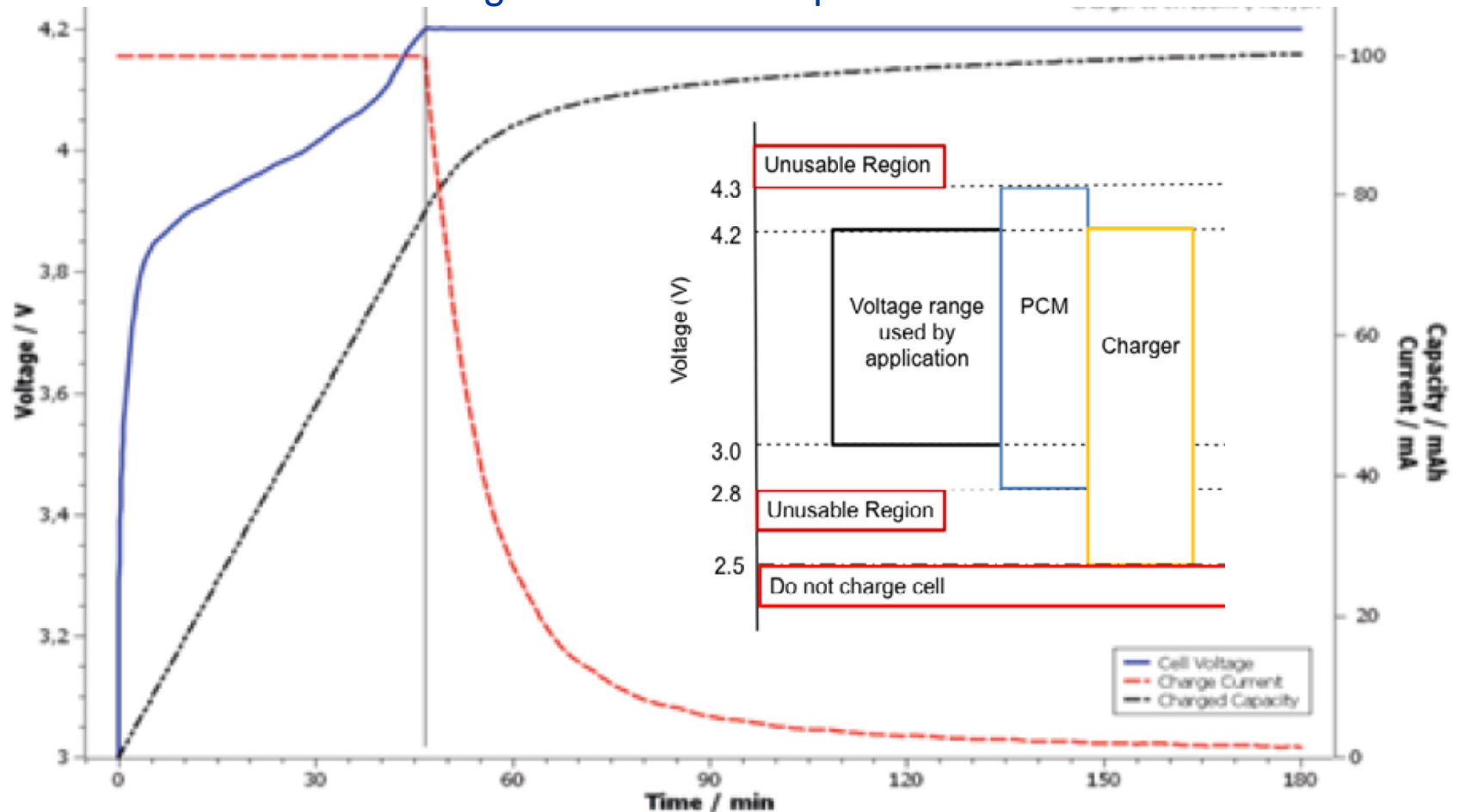


# Battery System Electronics: What You Need to Know



## Charging

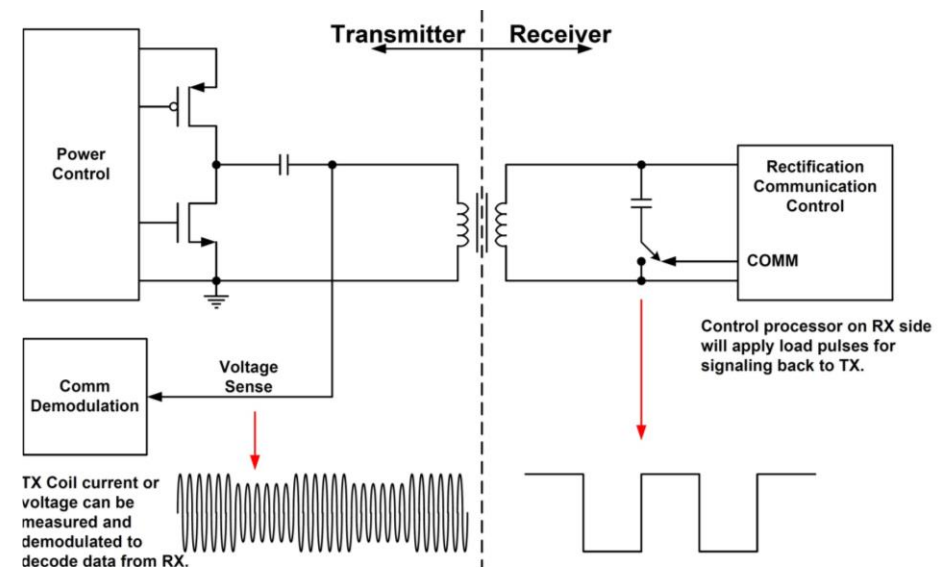
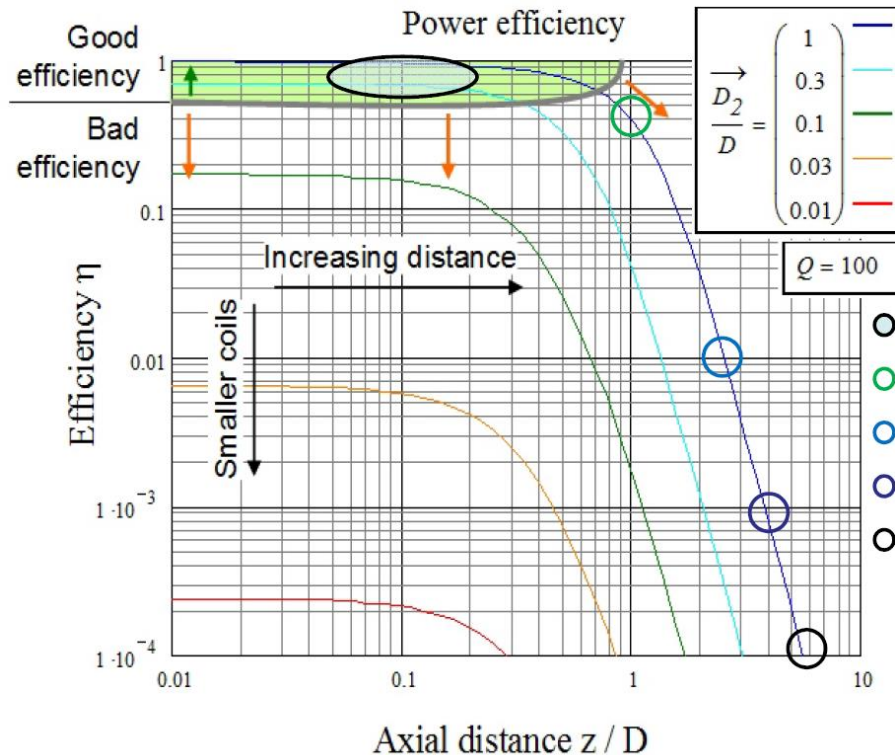
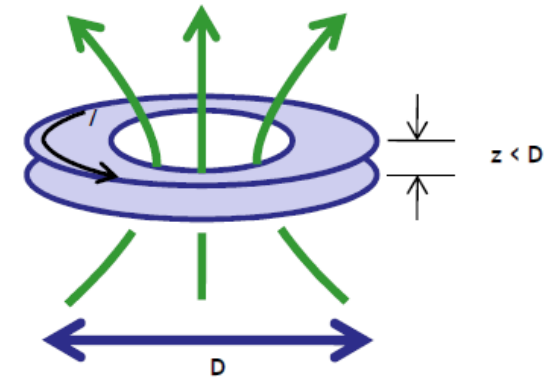
- ▶ Additional electronics for over-voltage & over-current protection



# Battery System Electronics: What You Need to Know

## Charging

- ▶ Wireless Charging
  - ▶ Requires extra electronics on both Charger & Battery
  - ▶ Convenience benefits vs. efficiency losses





# Battery System Electronics: What You Need to Know



## Summary

- ▶ What you need to do in your device to get the most from your Battery system:
  - ▶ Interface
  - ▶ Non-Linear Voltage
  - ▶ DC System
  - ▶ Charging

## VARTA AG

### MICROBATTERIES & SOLUTIONS

### HOUSEHOLD BATTERIES



**Largest Manufacturer of  
Hearing Aid Cells (1B/yr)**  
[www.VARTA-Microbattery.com](http://www.VARTA-Microbattery.com)

**Standard & Custom Battery  
Packs and Energy Storage**  
[www.VARTA-Storage.com](http://www.VARTA-Storage.com)

**Consumer Coin & Cylindrical Cells;  
Home Energy Storage**  
[www.VARTA-Consumer.com](http://www.VARTA-Consumer.com)

# VARTA Products



## VARTA's Family Cells & Batteries:

- ▶ Voltages 1.5V to 48V
- ▶ Capacities 10mAh to >1500Ah
- ▶ Multiple Chemistry Options
- ▶ Coin & Cylindrical Sizes
- ▶ Pouch & Prismatic Sizes
- ▶ Embedded Battery Packs
- ▶ Consumer Removable Packs
- ▶ Industrial, Mobile Robotics Batteries
- ▶ Custom Designed Batteries
- ▶ Application Specific Standard Batteries

### Cells



### Easy Block & Blade



### CellPac LITE



### EasyPack



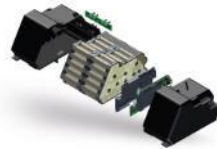
# More than 130 years of innovation



VARTA  
Primary Lithium  
Cell assembly  
+  
Wire connector



VARTA  
PowerPack  
Solutions  
+  
Mechanical and  
Electrical Design



VARTA Storage  
Residential Energy  
Solutions  
+  
Cell and charge balancing,  
Power interface



VARTA Storage  
Commercial Storage  
Solution  
+  
Addressing multiple  
energy management  
functionalites



Production  
+  
Massive Investments in  
production in lithium ion  
cells in Ellwangen and  
Noerdlingen

1990

1995

2000

2010

2011

2012

2014

2016

2018

2019

VARTA has a long history in research, development, and mass production of a variety of electro-chemistry and battery systems.



VARTA  
Lithium Cells



VARTA  
Customized Lithium-  
Polymer Pouch  
+  
Safety Electronic



VW VARTA  
Joint Venture  
+  
New material  
technologies



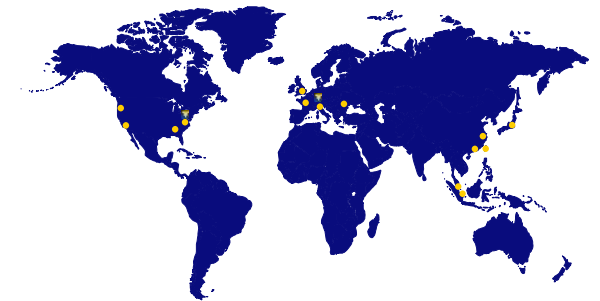
VARTA  
CoinPower Series  
+  
Innovative  
Cell-Design for highest  
Performance & Safety



New VARTA  
CoinPower types  
+  
form factors

## The Right Battery Partner:

- ▶ Technology Leader
- ▶ Well known in the Industry
- ▶ Standard line of products in a variety of sizes
- ▶ Previous Custom designs with well known customers
- ▶ History and Industry Experience in Battery systems
- ▶ High-volume Manufacturing Expertise (not just a Design House)
- ▶ Worldwide Reach & Support
- ▶ Multiple Manufacturing & Design locations
- ▶ Reputable firm – ideally a public company
- ▶ Financially Stable & Reliable





Thanks for  
joining us!

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