

# Advanced Battery Test and Emulation



Power Electronics & Energy Storage event  
14 juni 2022 | 1931 Congrescentrum 's-Hertogenbosch

ENERGY STORAGE  
EVENT 2022

# Agenda



Challenges when designing products with Batteries



Typical Applications



Key Attributes of a Battery-Test Solution



# Challenges of Designing-in Batteries

- Testing can be complex, costly and unrepeatable
- Battery run-time estimates are crucial but may be incorrect
- Generic battery models may not be a good fit for what will be used and engineers may not know how they were created
- Repeatability is often difficult to achieve with real cells
- Getting a battery to a known, controlled state of charge (SOC) can be a tedious process



# Typical Applications

- IoT devices
- Medical (wearable) devices
- Mobiles
- Portables
- E-mobility
- Agriculture
- Spacecraft



e-bike



e-wheelchair



electric golf cart



e-scooter



automated guided vehicles



electric boats



electric forklift



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## Desirable attributes of a battery test solution:

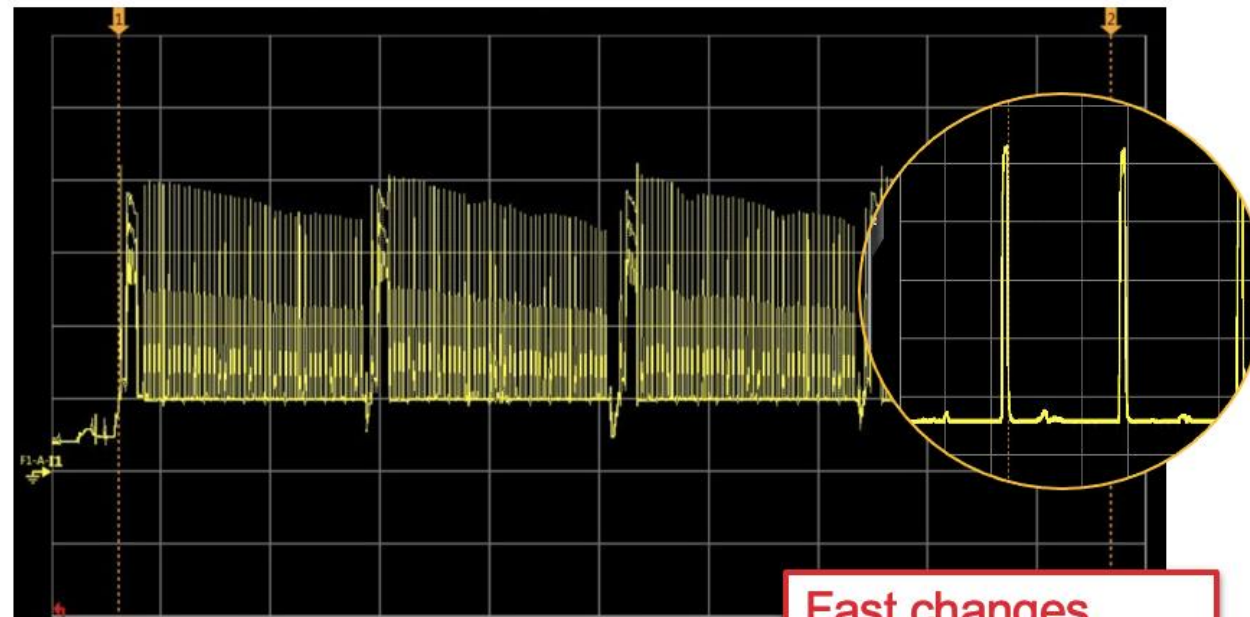
- Multi-channel operation to dramatically reduce test-times
- Test range from a few Watts to 200kW and up to 2kV
- Control of cut-off conditions, capacity rating, SOC, constant of dynamic level selection, pulse-width control, protection setting
- Accurately capture Voltage, Current and Capacity from seconds to days
- Simultaneous digitization of Voltage and Current with measurements
- Easily create complex loading characteristics when using a profiler to generate a battery model from built-in sequences or importing a CSV file



# Optimizing Battery Life is Difficult

- Complex Current Waveforms
- Fast sleep to active Transitions
- Large Dynamic Range

Current waveform of wireless blood pressure monitor transmitting data



Fast changes,  
high crest factor

# Profile:

**Battery Emulator** | Battery Viewer

Settings

New Profile | Load Profile

Profile Settings

File Name: LiFePO4 20Ah 40A

Folder Location: ... \Battery

No. of steps: 200

Discharge Settings

Discharging Mode: CC

Discharge Current: Constant 40 A

Dynamic CD ARB Waveform

No Waveform Configured!

Sequence Count: ∞ Continuous

Capacity Rating: 20 Ah

Battery Voltage: ---V Measure

Current Pulse Width: 20 ms

Rest Time: 200 ms

Run Status: A- N7951A Stopped | B- No Instrument | C- No Instrument | D- No Instrument

**Battery Status**

00.00:30:33:987

Voc: 2.3553 V

Vt: 2.2923 V

Remaining Capacity: 598.908 mAh

Ri: 2.0272 mΩ

I: -39.9983 A

Depleted Capacity: 19.4011 Ah

0.0 %

**Voltage and Current**

I (A) vs Time (s)

Vt (V) vs Time (s)

Current Unit: AMP | C-Rate | Current Graph | Voltage Graph

**State Of Charge**

Voc (V) vs State Of Charge (%)

Ri (Ω) vs State Of Charge (%)

Vcutoff: 2.36 V

X: SOC | Capacity

Flip



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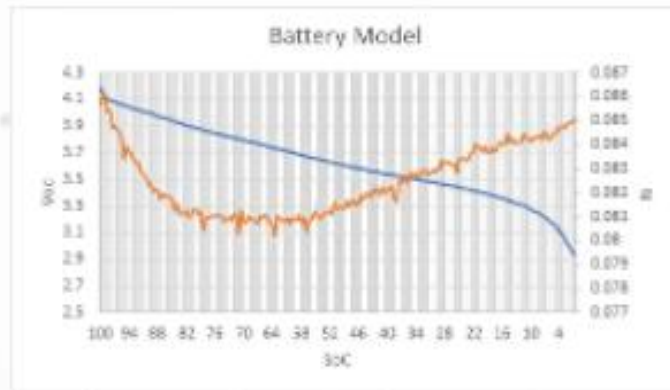
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# Key Benefits

Profiler

Generate battery model based on actual DUT static current or dynamic current consumption. Model generated consists of state of charge, open circuit voltage and series resistance



Battery model





# Battery Profiles

The software provides an easy way to import battery models created outside the test environment. Import CSV files consisting of the battery parameters:

State of Charge(%)	Open Circuit Voltage(V)	Internal Resistance(ohm)	Status
100.00	9.609423	7.544065	
99.50	8.828673	3.889564	
99.00	8.645126	3.791465	
98.50	8.516480	3.767940	
98.00	8.411436	3.780916	
97.50	8.320710	3.804418	
97.00	8.240466	3.840828	
96.50	8.167970	3.886445	
96.00	8.102751	3.927822	
95.50	8.043658	3.971063	
95.00	7.990255	4.014665	
94.50	7.942882	4.057762	
94.00	7.899871	4.098643	



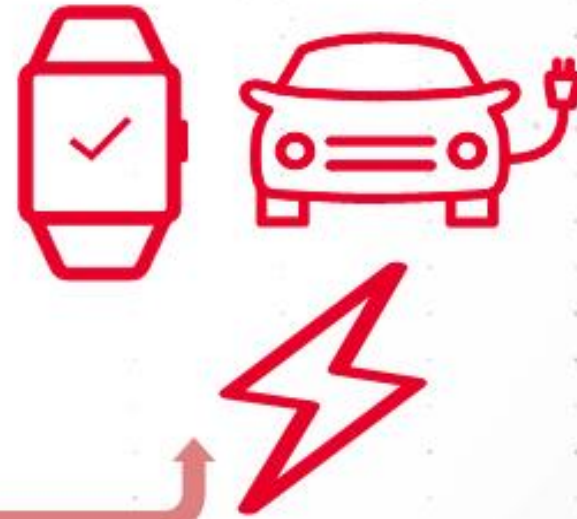
# Emulation:



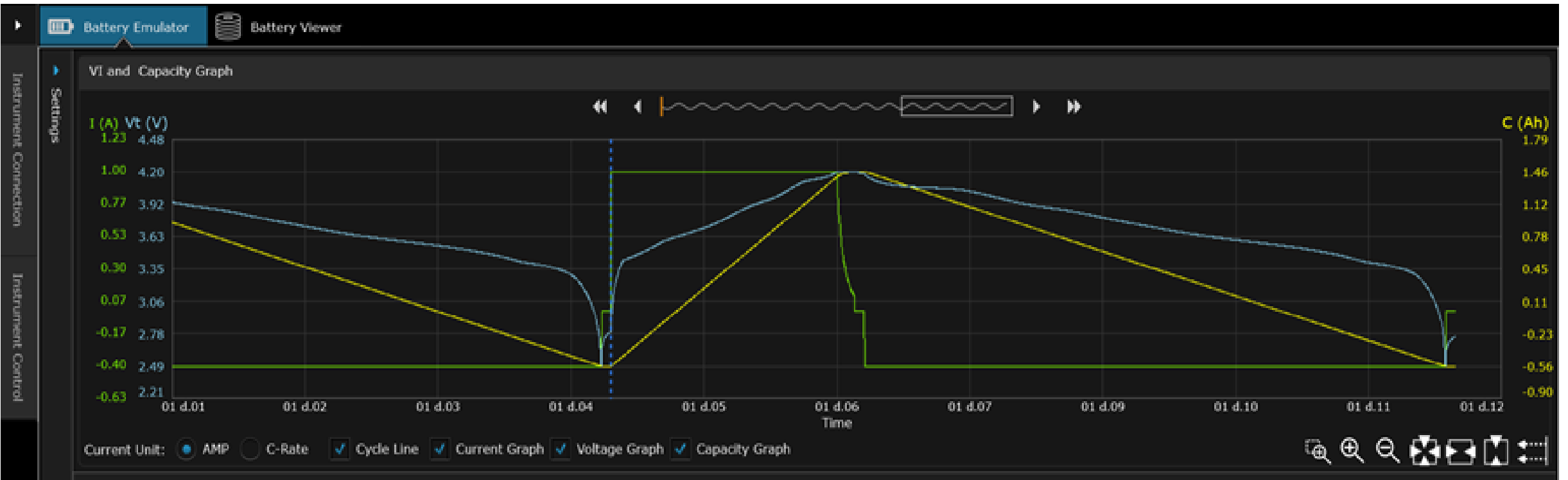
# Key Benefits:

Emulator

Emulate battery model at any state of charge and cut off condition desired.  
Continuous measurement of voltage and current of DUT's consumption and continuous monitor of consumed battery capacity



# Cycling:



# Key Benefits

Cycler

Cycling for a rechargeable battery indicates how many times it can undergo the process of complete charging and discharging until failure or it starting to lose capacity



# Keysight High Power Solution

## Challenge

- Create a realistic battery model (open circuit voltage **Voc**, Internal resistance **Ri** vs State of charge **Soc**)
- 
- Evaluate capacity under different loading conditions
- 
- Understand battery capability to deliver charge at different temperatures
  - Measure battery dynamic power response
- 
- Discharge and test the battery with a realistic current profiles similar to the device that will be connected to it
- 



# Keysight High Power Solution

## Solution



- Keysight's integrated load combined with the arbitrary loading profile allows to measure battery open circuit voltage **Voc** and internal resistance **Ri** and create a battery profile **Voc & Ri** vs state of charge **SoC**



- Power supply with sink capability allowing for battery discharge and capacity measurements with different loading



- Power supply with sink capability allowing for battery discharge and capacity measurements at different temperatures
- Power supply with fast transient loading to test battery response at higher frequencies



- Power supply with sinking capability and arbitrary dynamic loading, able to register any device current consumption and load it back on the battery



# Keysight High Power Solution

## RP7900A Regenerative Power System

5kW  
10kW



3U

## BV9210B/11B Advanced Battery Test and Emulation

+



acal<sup>bfi</sup>  
KEYSIGHT

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Thank You...

Questions?



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