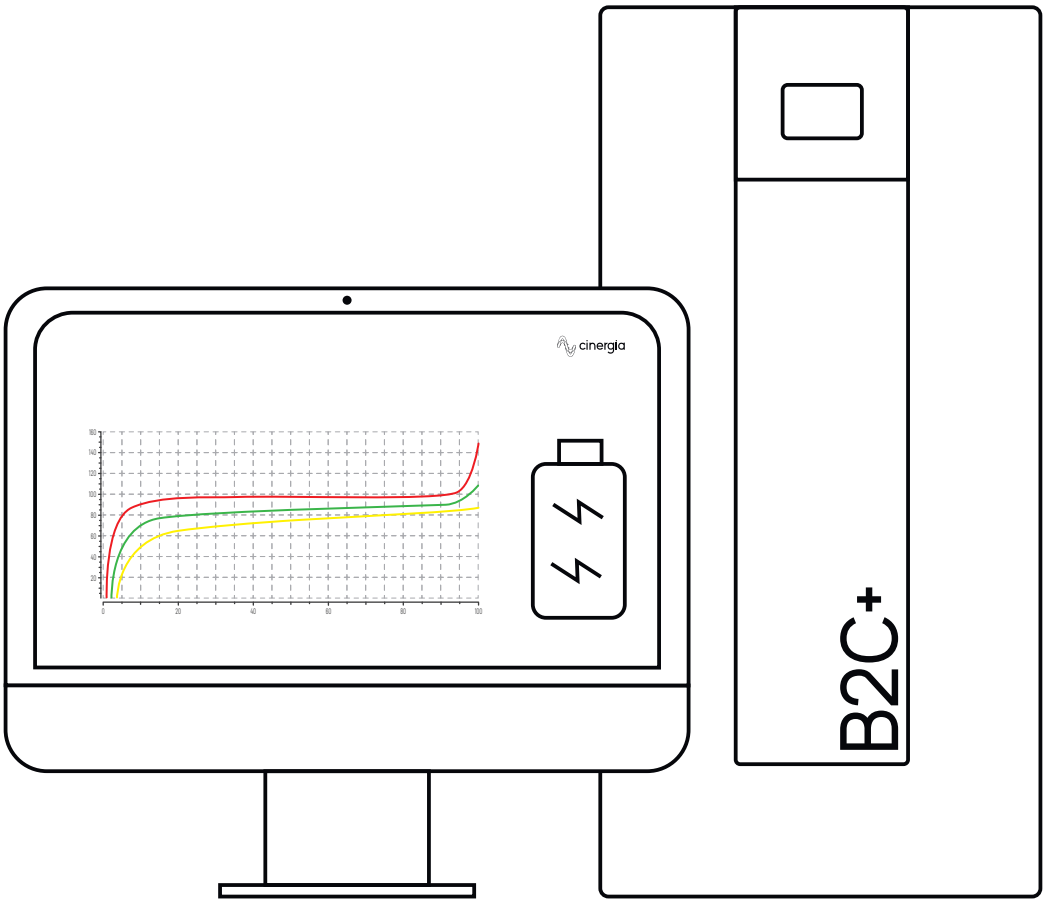
Battery Emulator



Advanced DC Software Application

CINERGIA's DC Programmable Power Supplies are designed to generate a controlled DC source or load, but they can also behave as a battery charger, battery emulator or as a photovoltaic panel emulator. This document provides the necessary information to control the DC converter behaving as a Battery Emulator.

Battery Emulator combined with a regenerative AC to DC converter designed to behave like real batteries. It is a software option of the B2C+ with a DC output, for a single unit, from 20 to 750V (800V with the HV option). It is also possible to serialize units to reach up to 1500V or to parallelize units to increase the power and current. Thanks to the Separated Channel Operation (included up to 54kW) each unit can be used as 3 completely different DC Regenerative Power Supplies in a single cabinet.

It is a versatile and flexible product line perfectly suitable for Battery Testing and Characterization procedures.

The most notable

CINERGIA offers a solution that is characterized by a clear and intuitive design. Its easy handling saves us time in the test setup.

Clear and Intuitive

Control Buttons

Save as CSV

Save all parameters of the configuration in a CSV file, to use anytime.

Load as CSV

Load parameters of configuration from the CSV file.

Send Battery Parameters

It is always necessary to send the parameters. If the user uploads a csv file and does not click on this send button, the parameters will not be introduced to the converter. To find out if the parameters are correctly entered, compare in A if the setpoint values and the actual values are the same.

Send Battery Parameters

Battery Parameters

	Voltage Constant Set Point	Voltage Constant Actual Value		K Polarisation Set Point	K Polarisation Actual Value		Q Capacity Set Point	Q Capacity Actual Value	
Output U	0,00	0.00	[V]	0,00	0.00	[V/Ah]	0,00	0.00	[Ah]
Output V	0,00	0.00	[V]	0,00	0.00	[V/Ah]	0,00	0.00	[Ah]
Output W	0,00	0.00	[V]	0,00	0.00	[V/Ah]	0,00	0.00	[Ah]
Global	0,00	0.00	[V]	0,00	0.00	[V/Ah]	0,00	0.00	[Ah]

	A Exp Amp Set Point	A Exp Amp Actual Value		B Exp Time Set Point	B Exp Time Actual Value		Virtual Resistor POS	Virtual Resistor NEG	
Output U	0,00	0.00	[V]	0,00	0.00	[1/Ah]	0,000	0,000	[Ohm]
Output V	0,00	0.00	[V]	0,00	0.00	[1/Ah]	0,000	0,000	[Ohm]
Output W	0,00	0.00	[V]	0,00	0.00	[1/Ah]	0,000	0,000	[Ohm]
Global	0,00	0.00	[V]	0,00	0.00	[1/Ah]	0,000	0,000	[Ohm]

Voltage Constant
This voltage is usually indicated by the battery manufacturer. It is where the two exponentials meet on the graph, so it is approximately the voltage at the center of the graph.

A Exp Amp
It is the voltage that will be increased from the Voltage Constant depending on the battery technology. If the Ah (explained later in the Output Parameters part) is 0, which means that the battery is fully charged, the maximum voltage will be Voltage Constant + A Exp Amp. This parameter describes the slope on the right side of the graph (the one that makes the voltage go to the maximum).

K Polarisation
This parameter describes the left slope (the one that makes the voltage go to 0).

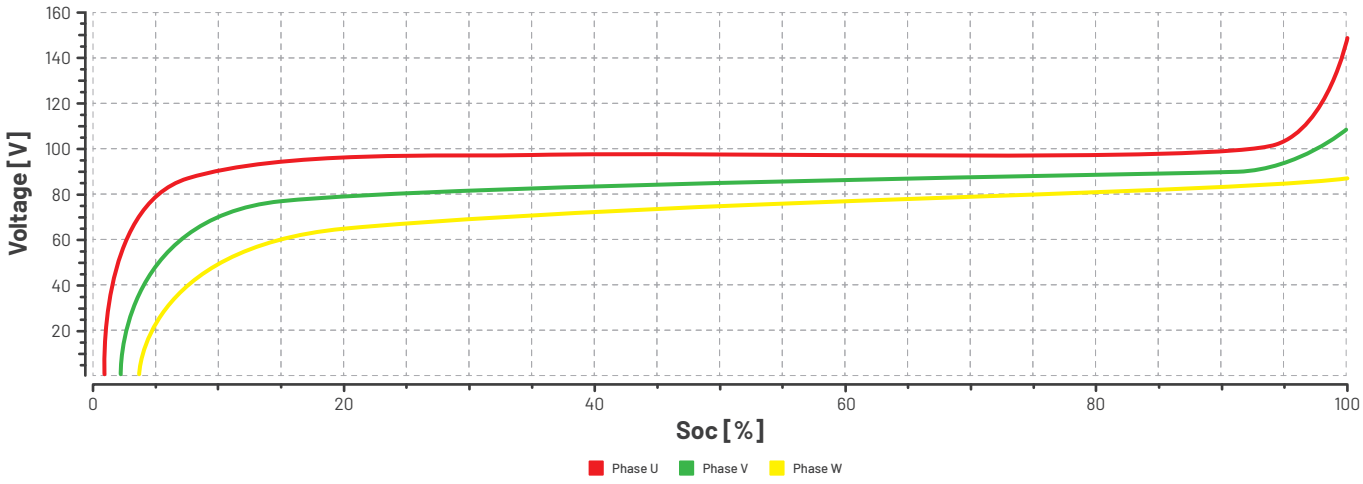
B Exp Time
Describes the duration of the horizontal part of the line on the graph.

Q Capacity
Capacity of the battery in Ah.

Virtual Resistance
This resistance is also delivered by the battery manufacturer, and is the parameter that sets the voltage drop depending on the current flowing through each channel. So, for example, if the voltage is 100V, the resistance is 1Ω and the current is 10A, the voltage drop will be of 10V, so the voltage at the output will be 90V instead of 100V. When the current is positive, the virtual resistance that will affect is the positive one, while if the current is negative, the virtual resistance will be the negative one.

Graph Voltage-SOC

The graph Voltage-SOC represents in real time the state of the battery for each channel. There is a point represented in each line that shows the exact point of the charge.



Mathematical Model

The channel/s configured in battery emulator mode will work as a Constant Voltage source where the voltage is a function of a battery model, as described by the equation below:

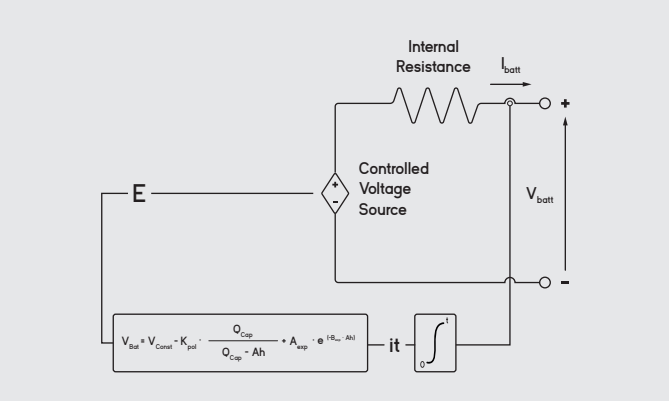


Fig 1. Non-Linear battery model

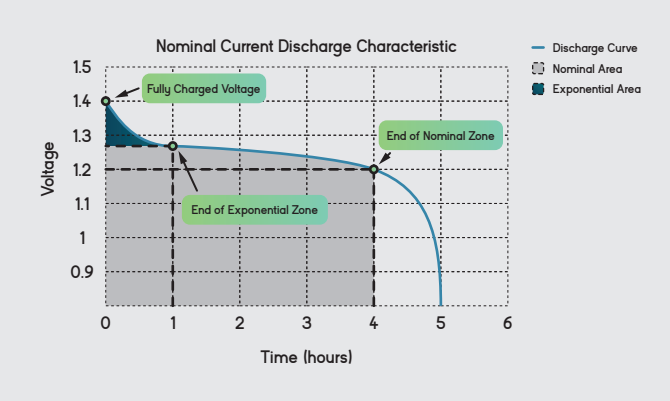


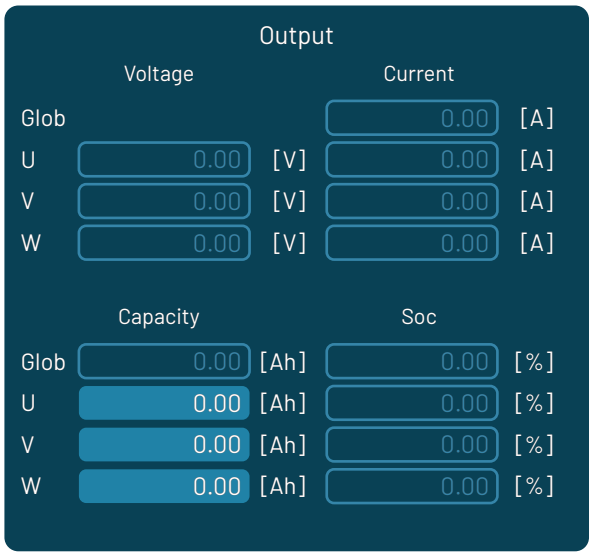
Fig 2. Typical discharge curve

Model are from: O. Tremblay, L.-A. Dessaint, A.-I. Dekkiche, "A Generic Battery Model for the Dynamic Simulation of Hybrid Electric Vehicles", 2007 IEEE® Vehicle Power and Propulsion Conference, September 9-13, 2007, Arlington/Texas, USA

The mathematical model is saved and executed in the DSP firmware, so it warrants precise and deterministic behaviour, but the model cannot be changed. The user can emulate different batteries by adjusting the model parameters and the battery parameters (cells in series/parallel, capacity of the cell, etc.).

$$V_{Bat} = V_{Const} - K_{pol} \cdot \frac{Q_{Cap}}{Q_{Cap} - Ah} + A_{exp} \cdot e^{(-B_{exp} \cdot Ah)}$$

Output Parameters



The output parameters show the values in the output of the converter such as voltage and current. The SOC [%] represents the real time state of charge.

In this part there is also the Capacity [Ah] which can be modified online while the converter is in Run state. It will be useful to make a battery go to any part of the line and do not have to wait until it reaches the desired part. So, for example, if the capacity (Q Capacity) of the battery (introduced in part A5) is 10Ah and the user sets a Capacity of 5Ah in the E part, the SOC of the battery will go to 50%.

Cinergia products that integrate Battery Emulator

		All Terrain GE&EL+ vAC/DC Grid Simulator + Electronic Load An aggregation of Grid Simulators, Electronic Loads and Bidirectional DC Converters in one product.	GE+ vAC/DC Full Grid Simulator Power electronic devices that emulate AC and DC electrical grids in both normal and disturbed conditions.	EL+ vAC/DC Full Electronic Load Power electronics devices designed to emulate AC and DC electrical loads.	B2C+ Bidirectional DC Converter CINERGIA's DC Programmable Power are designed to generate a controlled DC source load.
	AC Power	7.5 kW - 160 kW	7.5 kW - 160 kW	7.5 kW - 160 kW	-
	DC Power	7.5 kW - 160 kW	7.5 kW - 160 kW	7.5 kW - 160 kW	7.5 kW - 160 kW
	AC Current	11 A - 232 A	11 A - 232 A	11 A - 232 A	-
	DC Current	±10 A / ±30 A - ±185 A / ±555 A	±10 A / ±30 A - ±185 A / ±555 A	±10 A / ±30 A - ±185 A / ±555 A	±10 A / ±30 A - ±185 A / ±555 A
Operations Mode	AC	Programmable Voltage	●	●	-	-
		Programmable Current	●	-	●	-
		Programmable Power	●	-	●	-
		Programmable Impedance	●	-	●	-
		Power Amplifier (PHIL)	●	●	●	-
		Steps AC	●	●	●	-
		IEC Testing Optional	● Optional	● Optional	-	-
	DC	Programmable Voltage	●	●	●	●
		Programmable Current	●	●	●	●
		Programmable Power	●	●	●	●
		Programmable Resistence	●	●	●	●
		Power Amplifier (PHIL)	●	●	●	●
		Steps DC	●	●	●	●
		Battery Testing Optional	● Optional	● Optional	● Optional	● Optional
		Battery Emulation Optional	● Optional	● Optional	● Optional	● Optional
		PV Panel Emulation Optional	● Optional	● Optional	● Optional	● Optional

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