# EE 466

# Laboratory 1

Prof. Dr. Fabrizio Sossan (HES-SO Valais-Wallis)

fabrizio.sossan@hevs.ch

Slides compiled on: December 4, 2025

# Laboratory 1 and today's laboratory session

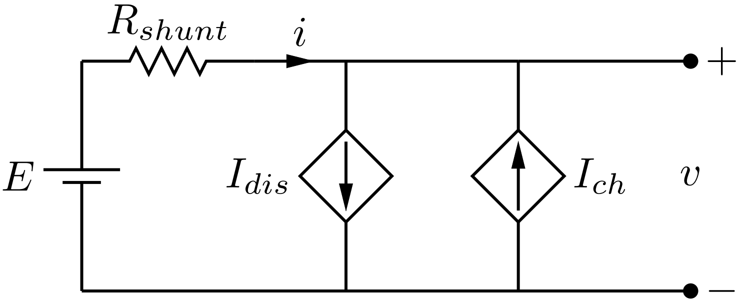
The objective of Laboratory 1 is to gain an understanding of the relation between battery internal voltage and battery SOC.

To achieve this, you will need two steps:

1. Today's laboratory session: perform measurements that will be instrumental to accomplish the assignments.

2. Extra work beyond today's laboratory session (approx. 2 hours): postprocess the measurements and complete the assignments.

# Experimental setup




$I_{dis}$ corresponds to the load, $I_{ch}$ corresponds to the power supply.

# Starting the computer

- Switch on the computer, select the `Labview` partition.
- Login with the credentials: { .\energystorage, eld040ee466 }

# Download LabView repository

Download zip file from:

https://shorturl.at/0Leia

How to use it (please follow this **verbatim** - doing anything else will result in software failures):

- **Unzip** the file somewhere (e.g., desktop).
- After extraction, open the folder `labview_student_dist`.
- Open the file `ee466` (file format: labview project).
- Once Labview is open, open the file `main.vi` in the Labview's Project Explorer.

# Starting the setup

- Make sure that both the Power supply and the Electronic load are connected to the NI C-RIO with a cable.
- Execute the .vi by clicking on the play button (▶).
- In the vi, ensure that both the supply and load are off, and that charging and discharging current are set to 0.
- Switch on the power supply (switch is on the back) and the electronic load (switch is in the front).
- You can now stop the vi by using the stop button on the mask and close the vi. You will start this later again once you will start with the experiments.

Now come to me and pick up a battery cell. You need to tell me your group number.

# Estimated timeline of today's laboratory session

**Today, time is of the essence.**

Approximate schedule:

1. 13:15 - 13:30 Introduction
2. 13:30 - 13:50 Getting familiar with this presentation and the experimental setup.
3. 13:50 - 14:10 Understand the assignments and design the experiments.
4. 14:10 - 16:10 Perform experiments and make sure everything is going well.
5. 16:10 - 17:00 Extra time (you might need it).

Example of where time will go during the experiments:

- Discharging the battery by 80% at 3 A = 0.8 * 5 Ah / 3 = 1 hour and 20 minutes.
- 10 minutes of resting phase or charging at very low current, 4 times = 40 minutes.
- Total time: 2 hours.

# Equipment

Hardware:

- controllable power supply $\rightarrow$ what charges the battery
- controllable load $\rightarrow$ what discharges the battery
- battery cell
- resistive shunt to measure the battery current
- data acquisition system (National Instruments Compact RIO)

Battery, load, and power supply are connected in parallel, on a “DC bus”.

Software:

- `main.vi`

# main.vi

It implements the following functionalities:

- it enables/disables the load and the supply. Load and supply activation is mutually exclusive. Mutual activation will prevent any charge or discharge.
- it sets a discharging/charging current for the cell.

Overvoltage and undervoltage protections:

- When discharging, if the cell terminal voltage falls below the configurable `Minimum Voltage` value, the discharging will stop. Resuming the discharging requires resetting the undervoltage error. However, if you won't remove the cause of the undervoltage, the system will interrupt the discharge again.
- When charging, if the cell terminal voltage raises above the configurable `Maximum Voltage` value, the charging will stop. Resuming the charging requires resetting the overvoltage error. However, if you won't remove the cause of the overvoltage, the system will interrupt the discharge again.

# `main.vi` (continued)

Additional functionalities:

- it shows the measured values of battery terminal voltage and current. Monitoring these values will be critical to perform experiments.
- It plots time series of the battery terminal voltage, current, power, energy and charge. Plots are resettable. (although useful for preliminary data visualization, these plots are not critical for your assignment).
- **IMPORTANT for your assignment** → It allows you to save data on a CSV file (that you can find in the same folder as the project reside). **DOUBLE IMPORTANT** To enable recording, make sure that the `Start saving data is enabled` button on the lower left corner of the mask is enabled!

# CSV file

- Default sampling time of the measurements is 500 ms.
- It is saved in the same folder as the project reside.
- Columns of the CSV are: time (in seconds), current (in amperes) and cell terminal voltage (in volts). For the other columns (you don't really need them though...), check the .vi file.
- **Saving won't start unless the** `Start saving data` **switch is enabled**
- Don't play too much with the switch as you might override the file. My suggestion is to leave the switch on at all times once you start the experiments. Test runs or data which are not relevant can be removed easily by postprocessing the CSV file.

# Suggested work methodology for today's laboratory session

- Take some time to understand the experimental setup and assignments.
- Design the experiments (you will probably need to discharge the battery, and at some predefined points, stop the discharge and allow for some time to the battery terminal voltage to stabilize so that you can estimate the battery internal voltage).
- Perform the experiments and save the data!
- **Don't open the CSV file while the vi is writing measurements!** The OS won't be happy. If you want to take a look to measurements (for example, to validate that measurements are being saved and cross-validate measurements are as expected), copy the CSV file in another location and open it.
- After the lab, process the measurements to perform the assignments.
- Because you are in a group, you have the opportunity the opportunity to cross-validate data.

# Getting familiar with the experimental setup

Acquaint yourself with the hardware setup:

- Identify all the hardware components; and
- Discuss your understanding within the group

Acquaint yourself with the software setup:

- Open `main.vi`.
- Discuss your understanding of the code within the group.
- Try to apply mild charging and discharging current setpoints ($|i| < 2$ A) and discuss what happens.

Look at the cell datasheet in today's material.

# Laboratory 1 - step 0

The current sensor has an offset.

# Laboratory 1's assignment

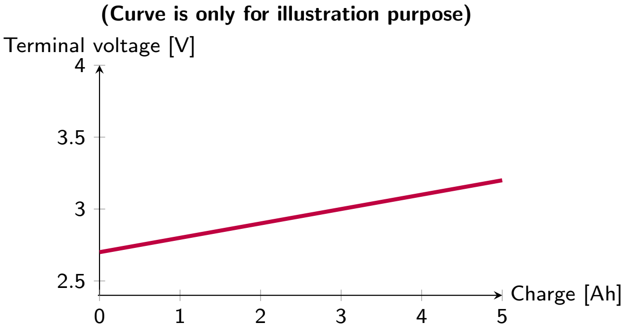
1. Identify the *Battery internal voltage vs. Battery charge curve* in the voltage range $[2.85, 3.75]$ V. See next slide for an example.

2. By using the same measurements used to perform the assignment above, estimate the value of the battery internal resistance.

3. Put in place a methodology to estimate the current capacity of the cell.

# Example of Battery internal voltage [V] vs. Battery charge [Ah] curve

You are expected to produce the following curve (the red one) starting from processed experimental measurements:



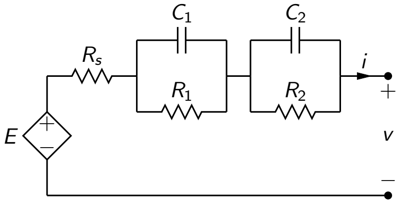

- The y-axis shows the Battery internal voltage. Do you remember how to estimate it? See next slide.
- The x-axis shows the Battery charge, namely the integral over time of the battery current. When drawing the plot, assume that the Battery charge is 0 Ah when the cell voltage is 2.85 V.

You won't need all the points. Just some points (e.g., 4) that one can interpolate linearly afterwards to obtain a more dense curve.

# More on the Battery internal voltage [V] and Battery charge [Ah]

## Battery internal voltage

Remember that the battery internal voltage is not directly measurable. However, you can estimate it by using measurements of the battery terminal voltage under two conditions: the charging/discharging current is zero, and the voltages of capacitors of the TTC model are zero. For the second condition to be verified, you need to wait some time with zero or low current ($\leq 0.5$ A) so that voltage stabilizes.



# More on the Battery charge [Ah]

## Battery charge [Ah]

How do you compute it? In postprocessing, you take the current measurements and you integrate them over time. Integral over time means a cumulative sum times the sampling time (default sampling time of the CSV is 500 ms).