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Otii Battery Toolbox

User manual

Profile, emulate, and validate batteries for low-power IoT and embedded electronics. Replace guesswork and multi-week runtime tests with repeatable measurements and battery life estimation done in seconds.

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Otii Toolboxes

Elevate Otii instruments with additional software toolboxes for scripting capabilities and battery profiling, emulation, testing and validation.

Otii Toolboxes are additional software licenses that can be purchased perpetual or as monthly and yearly subscription. The two avaliable Otii Toolboxes are:

Otii Automation Toolbox

This license elevates the Otii software with scripting capabilities and opens for endless automated use cases.

Otii Battery Toolbox

This license enables capabilities for battery profiling, emulation, and cycling - everything needed to pick the right battery for your project.

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Otii Battery Toolbox

The ultimate solution to find and validate the right, first and second source battery through out the IoT and embedded product lifecycle.

Battery profiling

- Simple set-up: one battery connected at main connectors of one Otii instrument
- Connect as many Otii instruments as the computer allows for multi channel usage
- All connected batteries will be discharged with the same chosen profile
- Otii Arc resp. Ace can sink currents up to 2.5A resp. 5A and source currents up to 5A.
- Create discharge profiles with two levels of discharge: low for sleep mode and high for active mode.
- Discharge the battery with a constant current. The current will not change as the battery voltage drops. This is similar to as if there were a linear regulator as load.
- Discharge the battery with constant power. Voltage is measured and discharge current is calculated to get set power. The discharge current will increase as the battery voltage drops while profiling.
- Discharge the battery by simulating a resistance connected to the battery. The discharge current will decrease as the battery voltage drops during the profiling.

Battery emulation

- ‘Fixed’ emulation to emulate the battery with a constant “Used capacity”. Pick a spot on the discharge curve and emulate in this position (position = how much used capacity is drawn from the battery).
- ‘Follow’ emulation will emulate a discharge over the time of the recording. Position in the discharge curve will then move as per how your device consumes energy.
- Emulate set-ups with battery cells in parallel and/or series – up to 4 batteries for parallel set-up and flexible number for series set-up depending on the Open Circuit Voltage (OCV).
- Automate battery emulation with Otii Automation Toolbox - switch profiles for different state of charge, battery types and temperatures.

Battery life estimation

- Combine a real measurement of your device with a battery discharge profile and get a defensible runtime number, in seconds.
- Create an activity profile from your device measured behaviour and the repeatability of the behaviour.
- Configure a battery from an existing profile, measured or imported. Create a pack in series or parallel.
- Run the estimator. Get the runtime, discharge curve and used capacity. Test “what if” scenarios with ease.
- Use your created discharge profiles with Otii or import collegues’ or manufacturers’.

Battery Validation (Otii Ace Pro only)

- Highly customizable test sequence – option to customize discharge, idle mode and charging, pulse width control, repeated cycles, cut-off voltages
- No limitations on number of cycles
- No limitations on number of batteries to be tested at the same time. Connect as many Otii Ace Pro as the computer allows.

Shareable license

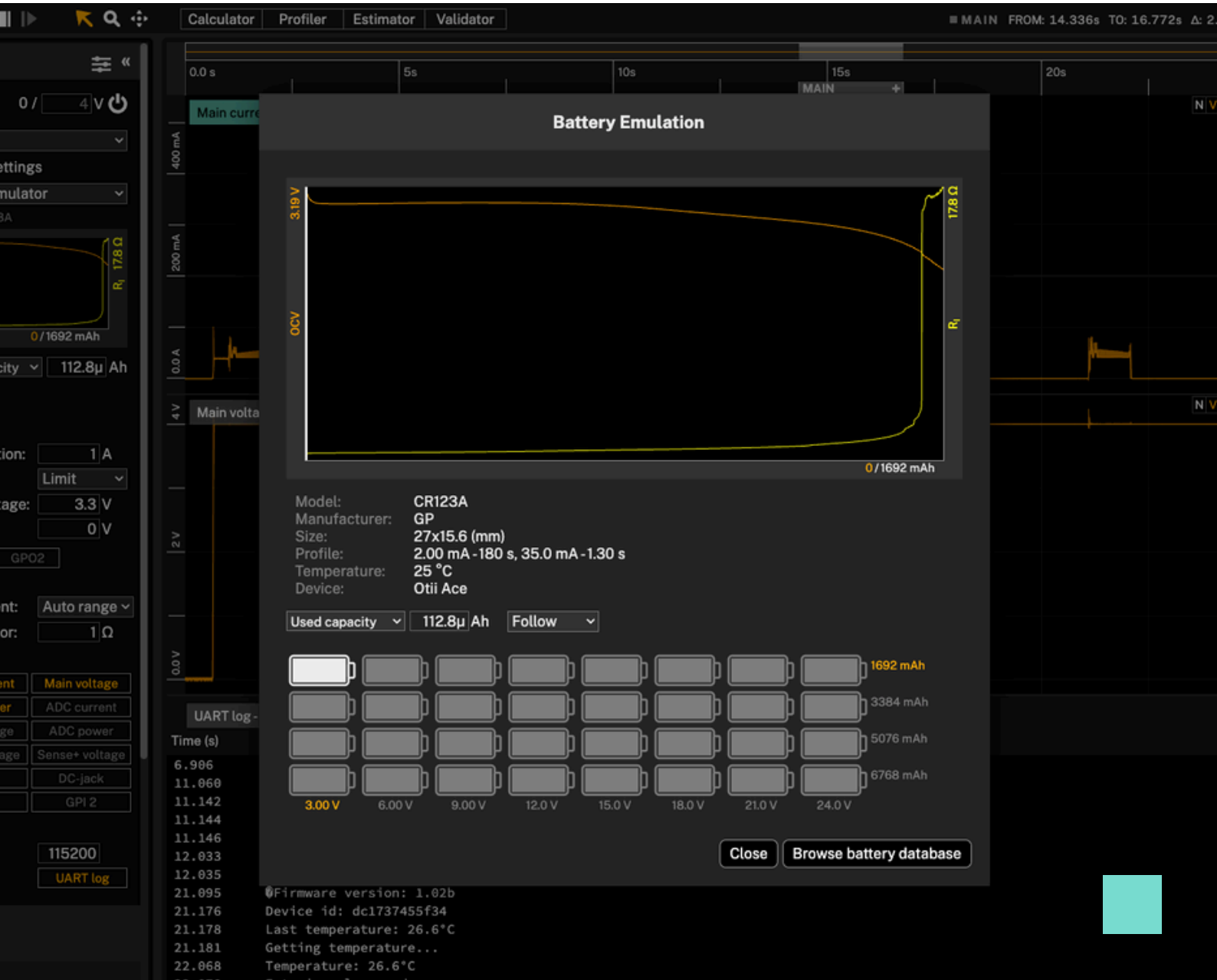
- Otii Battery Toolbox is shareable. The license can be assigned only at one user at the time. The license management is done in Otii User Management.
- The license can also be used in offline mode.

Otii Battery Toolbox

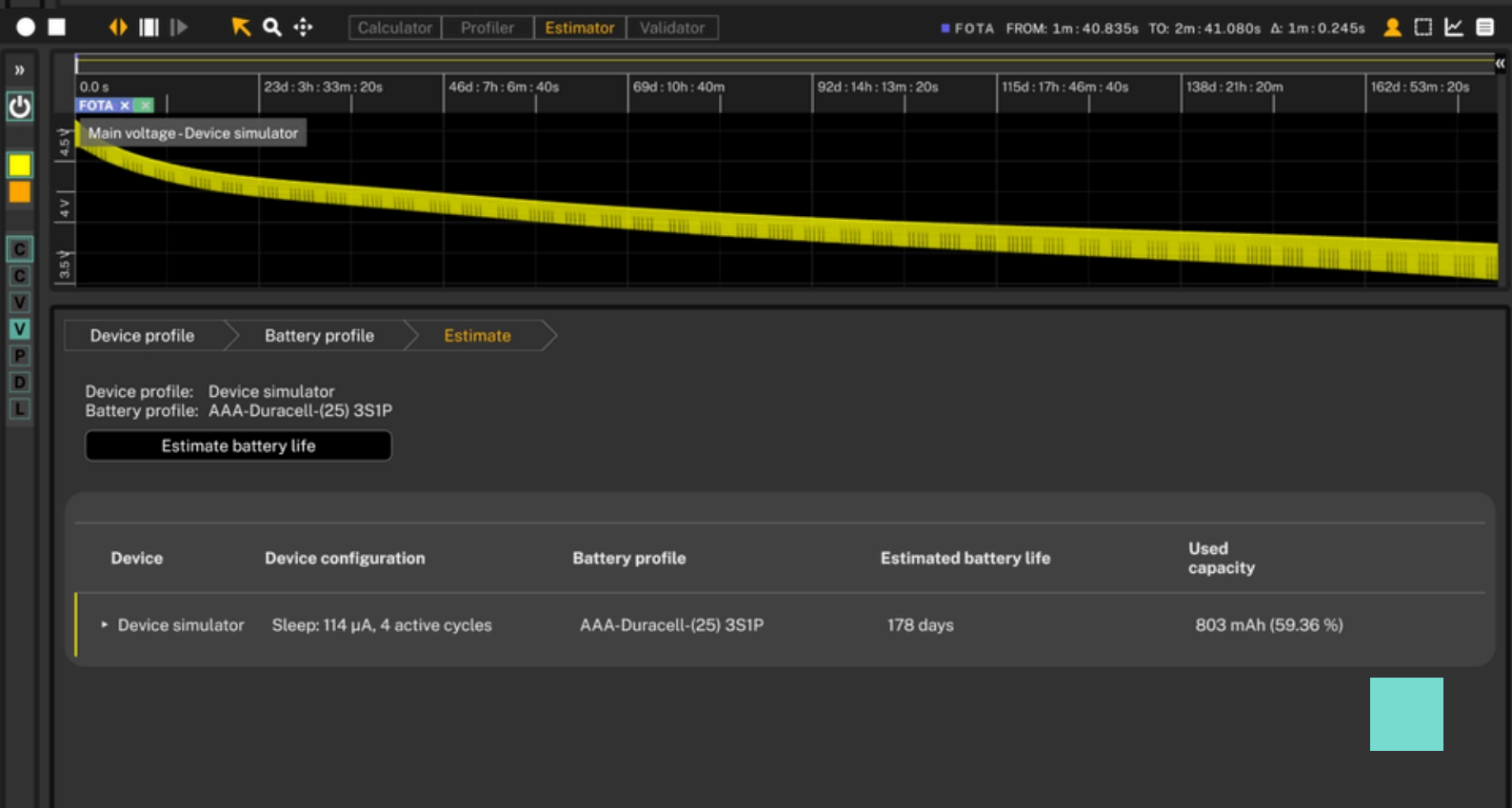
Battery model parameters

	Otii Ace Pro	Otii Arc Pro
Points in Emulation	as many as no of iterations	as many as no of iterations
ESR Range[1]	up to 5 kohm	up to 5 kohm
ESR Resolution	down to 1 mohm	down to 1 mohm
Voc Range	0V to 25V	0.5V to 5V
Voc Resolution	1 mV	1 mV
Capacity Range	no limit	no limit
Capacity Resolution	1 µAh	1 µAh

[1] Otii Battery Toolbox emulates the total ESR.




Calculator
Profiler
Estimator
Validator
FOTA FROM: 1m:40.835s TO: 2m:41.080s Δ: 1m:0.245s
0.0 s
20s
40s
1m
1m:20s
1m:40s
2m
2m:20s
2m:40s
Sleep
Active_1
Active_2
Active_3
FOTA
Main current - Ace
400
200 mA
0.0 A
Device profile
Battery profile
Estimate
Device name: Device simulator
Voltage range: 3 - 5 V
Sleep current: 114µ A
Sleep from selection
Measurement: Main current - Ace
Recording: ESP32
Delay 0 seconds
Every 1 hours
Delay 2 hours
Every 6 hours
Delay 4 hours
Every 4 hours
Delay 6 months
Every 6 months
Add activity from selection
Device profile
Battery profile
Estimate
Select battery profile
AAA-Duracell-(25)
1.61 V
0 mAh
1.61 V
498 mΩ
OCV
2.07 Ω
Ri
1352 mAh
1352 mAh
2705 mAh
4057 mAh
5410 mAh
1.50 V
3.00 V
4.50 V
Self discharge: 0 % every 1 years
Model: AAA
Manufacturer: Duracell
Size: 10.5x44.5 (mm)
Profile: 10.0 µA -1.30 s, 35.0 mA -1.30 s
Temperature: 25 °C
Device: Otii Ace


Calculator
Profiler
Estimator
Validator
FOTA FROM: 1m:40.835s TO: 2m:41.080s Δ: 1m:0.245s
0.0 s
23d:3h:33m:20s
46d:7h:6m:40s
69d:10h:40m
92d:14h:13m:20s
115d:17h:46m:40s
138d:21h:20m
162d:53m:20s
FOTA
Main voltage - Device simulator
4.5 V
4 V
3.5 V
Device profile
Battery profile
Estimate
Device profile: Device simulator
Battery profile: AAA-Duracell-(25) 3S1P
Estimate battery life
Device
Device configuration
Battery profile
Estimated battery life
Used capacity
Device simulator
Sleep: 114 µA, 4 active cycles
AAA-Duracell-(25) 3S1P
178 days
803 mAh (59.36 %)

Overview

ⓘ All these features require a Battery Toolbox License.

The Otii Battery Toolbox is a software license that extends the capabilities of the **Otii Product Suite** to enable battery profiling, battery life estimation, battery simulation, battery testing and validation for low-power IoT devices and electronics.

The Otii Battery Toolbox license is:

- Associated with a user, not a specific piece of hardware.
- Sharable; a user can share it with another user, but it can only be used by one user at a time.

Using Otii Automation Toolbox, you can also configure a license pool that automatically shares the licenses among your battery evaluations setups. When using a shared pool, your test scripts can be configured to wait for a license to become available before execution.

Read more about each Battery Toolbox feature here:

- Battery emulator
- Battery profiler
- Battery life estimator
- Battery validator

Battery model parameters

Battery model parameter	Otii Arc Pro	Otii Ace Pro
Points in Emulation	as many as no of iterations	as many as no of iterations
ESR Range[15]	up to 5 kohm	up to 5 kohm
ESR Resolution	down to 1 mohm	down to 1 mohm
Voc Range	0.5 V to 5 V	0 V to 25 V
Voc Resolution	1 mV	1 mV
Capacity Range	no limit	no limit
Capacity Resolution	1 µAh	1 µAh

15: Otii Battery Toolbox emulates the total ESR.

Battery profile manager

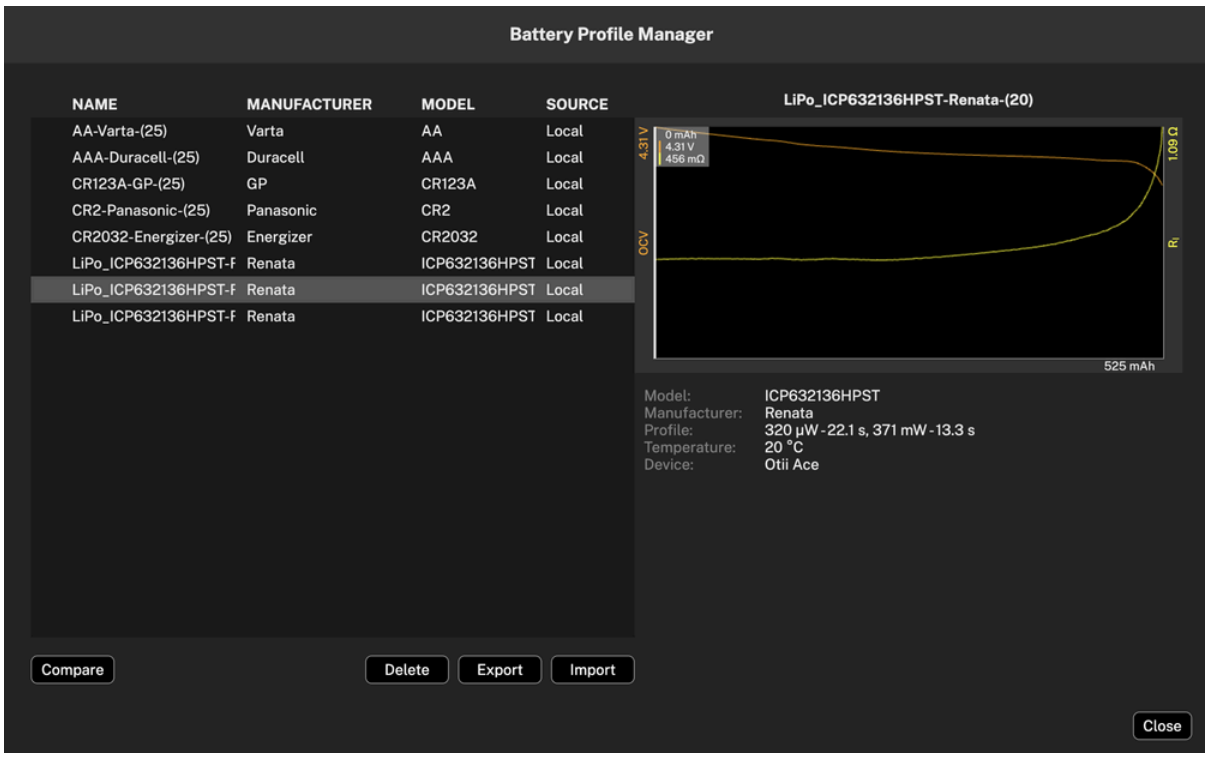
ⓘ This feature requires a Battery Toolbox License.

The battery profile manager let you browse your database of battery profiles, to compare two or more profiles, and to import and export profiles.

You find the battery profile manager in *File > Battery Profile Manager*.

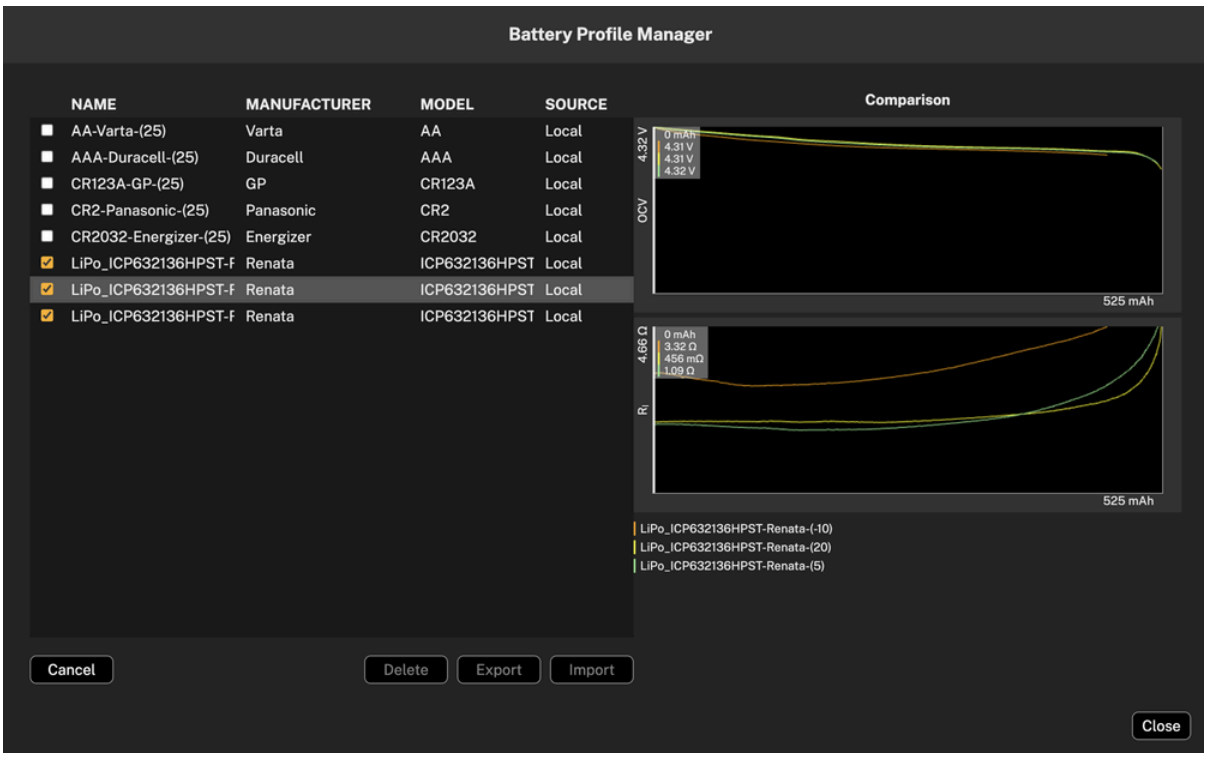
Profile manager dialog

In the profile manager you can see the discharge curves for the battery by selecting a profile.



Compare

If you want to compare several profiles, you click on “Compare” and the select the profiles you want to compare:



Delete

By selecting a profile you can remove it by clicking

⚠ This operation cannot be undone

Export

You can export the selected profile by clicking Export and the selecting a name and a destination.

The profile will be exported in a JSON format, and can be imported into another instance of Otii.

Import

By clicking Import you can import one or more battery profiles previously exported from Otii. If you want to import a profile created in another tool, use the format shown below.

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Battery profile format

Required fields


```
{
    "id": "273c2632-c7ce-4c90-accc-ea095c2f0d5e",
    "dischargetables": [{
        "id": "4a8a56cc-309a-47d9-9997-adccd0a13cb7",
        "table": [
            {
                "voltage":          3.2014355659484863,
                "resistance":       10.413976669311523,
                "capacity": 0.0041708676144480705
            },
            {
                "voltage": 3.1991329193115234,
                "resistance": 10.606740951538086,
                "capacity": 0.008341789556046328
            },
            {
                "voltage": 3.1971662044525146,
                "resistance": 10.62671947479248,
                "capacity": 0.01251272236307462
            },
        ]
    }]
}
```


All fields


```
{
    "id": "273c2632-c7ce-4c90-accc-ea095c2f0d5e",
    "battery": {
        "capacity": 240.99087185329861,
        "capacityunit": "mAh",
        "voltage": 3,
        "voltageunit": "V",
        "model": "CR2032",
        "manufacturer": "Duracell_Ace_I",
        "size": "20x3.2",
        "sizeunit": "mm"
    },
    "dischargetables": [{
        "id": "4a8a56cc-309a-47d9-9997-adccd0a13cb7",
        "temperature": 25,
        "temperatureunit": "°C",
        "table": [
            {
```

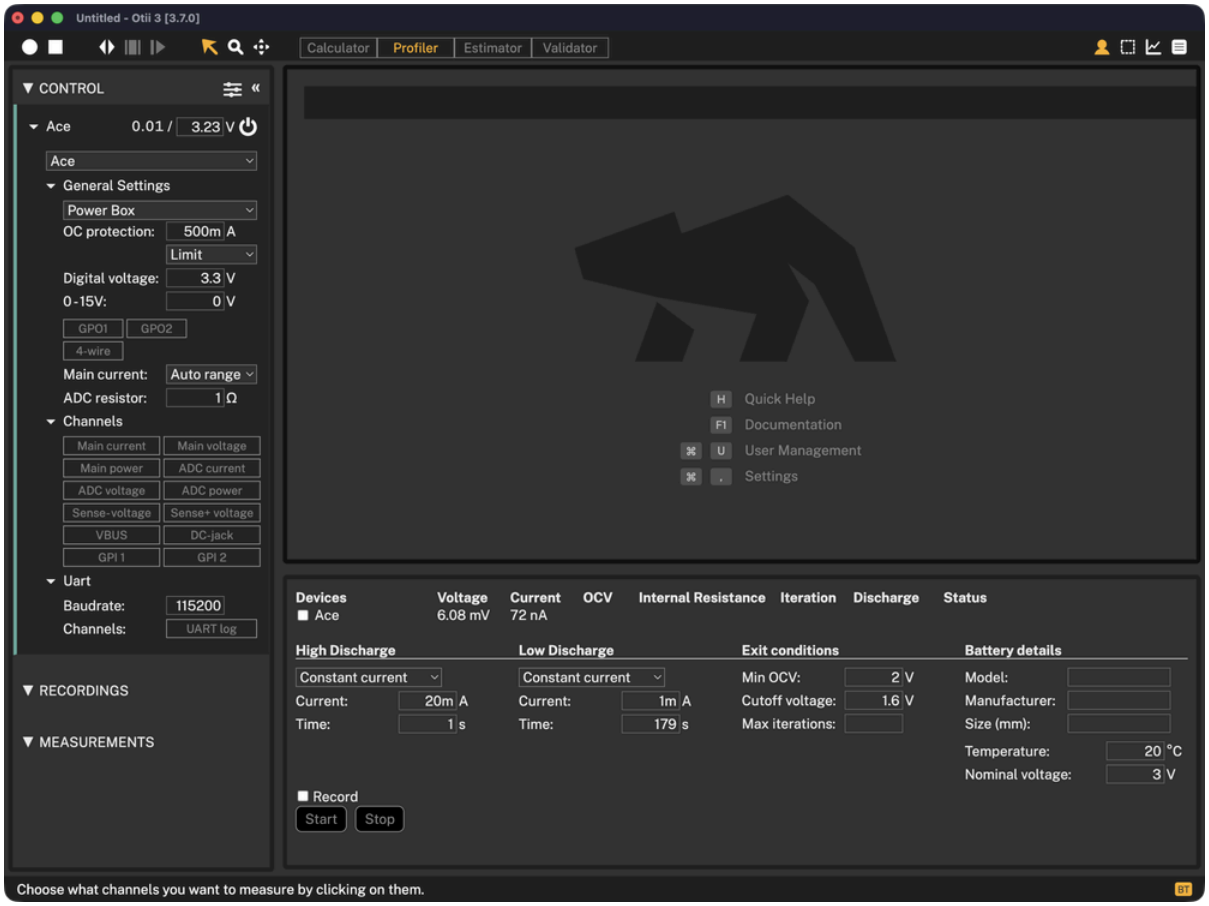
```
                "voltage":          3.2014355659484863,
                "resistance":       10.413976669311523,
                "capacity": 0.00417086761444807O5
            },
            {
                "voltage": 3.1991329193115234,
                "resistance": 10.606740951538086,
                "capacity": 0.008341789556046328
            },
            {
                "voltage": 3.1971662044525146,
                "resistance": 10.62671947479248,
                "capacity": 0.01251272236307462
            },
        ]
    }]
}
```

Battery profiler

ⓘ This feature requires a Battery Toolbox License.

In addition to source current, the Otii instruments can be set to sink current. E.g. by connecting a battery to the main connectors, you can test how the battery performs with different kind of loads.

To get started with battery profiling, choosing Battery Profiler from the toolbar will open the following panel:



Configuration

Devices

Here you choose which of your connected devices you want to use for battery profiling. When the profiling is running you will see some information of the current status of the profiling for each device.

Profiling Settings

Here you configure the profiling parameters, see more below on some best practices in choosing them.

You can also choose to automatically start a recording of the profiling. Recording the profiling session is optional, and for longer profiling sessions will require a lot of free space on your computer.

Battery Details

Here you enter the model, manufacturer and size of the tested battery.

Output

Scroll down the dialog to see a more detailed output from the profiling.

Start

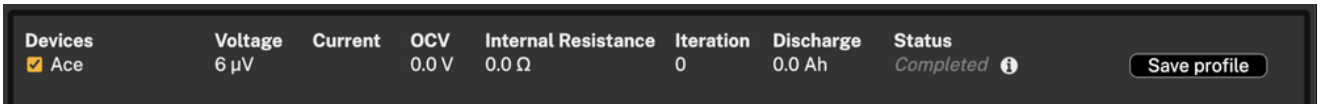
Start is used to start a new profiling.

Stop

Stop is used to stop an ongoing profiling.

Save profile

When any of the exit conditions has been fulfilled, or the stop button has been pressed, a save button will appear after each device allowing you to save the discharge profile for use in the battery emulator. Once the battery discharge profile is saved, it will automatically end up in the Battery Profile Manager, to be used for emulation, analysis, comparison and sharing.



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Getting started with battery profiling

1. Connect the battery positive pole to the red banana connector (+) and the negative pole to the black banana connector (-)
2. Start **Otii 3 Desktop App**, log in and reserve a **Battery Toolbox license**
3. Open Battery Profiler tab
4. Select the **Otii Arc/Ace(s)** that is going to profile the battery/batteries. It is possible to have several Otii Arc/Aces connected to the same computer to be able to profile several batteries at the same time
5. Select if the discharge should be constant current/power or resistance for both the High Discharge and Low Discharge. This represent how your device draws energy from the battery. Typically, a LDO draws energy in constant current mode, a DC/DC in constant power mode and a resistive leakage in constant resistance mode.
6. Input data for the High discharge and the Low Discharge period. This could be the active period and the sleep period of your device, how if draws the energy from the battery. There must be a difference in the High discharge and Low Discharge and High Discharge must be higher than Low discharge. This to be able to calculate the internal resistance of the battery.
7. Input data for when the battery profiling is to be stopped, there are three possible exit condition and if one of them are met, then the profiling stops.
    a. Min OCV is the calculated Open Circuit Voltage (OCV) of the battery. It is not necessary to have a 0 load to be able to react on OCV as this is a calculated value based on the measured battery data.
    b. Cutoff voltage is the measured battery pole voltage
    c. Max iterations is if you would like to limit the number of iterations. If you do not want to limit the number of iterations, just leave this field empty
8. Input the Battery details data like the module, manufacturer and size of the battery. This is just for your information, to remember what battery that was profiled.
9. Input what temperature the battery was profiled in. It is good to have the battery profiled in the different temperatures that it will be subjected to in the real use case. Make sure to only put the battery inside the temperature chamber, not the Arc/Ace.
10. Input the battery datasheet nominal voltage of the battery.
11. Select if you want to have a recording ongoing during the battery profiling. This is not needed, the battery data is being measured anyways.
12. Enable Main current and Main voltage channels and set wanted sample rate if a recording is wanted during profiling. Typically, the sample rate is set to 1000 samples per second as batteries has slow response.
13. Click Start button to start the battery profiling and then wait for it to finish.
14. When battery profiling has met an exit condition, the relay opens and a button “Save profile” appears. Click this to save the generated battery profile. The measured battery profiling data is also stored in the active project.

Why do I get internal resistance warning when profiling a battery

The internal resistance warning is a warning, so the profiling continues regardless.

The warning is that the internal resistance calculation ended up with a negative resistance. To understand this, the theory behind the internal resistance calculation needs to be understood.

Battery profiler discharges the battery with a high discharge pulse and a low discharge pulse. When the switch from high to low happens, the voltage (VH) and current (IH) is measured . Then when the switch back from low to high happens, the voltage (VL) and current (IL) is measured. The internal resistance is then calculated by Ohms law Rint = (VL-VH)/(IL-IH) The currents are negative. If the battery has a lower voltage in the end of the low discharge, than the voltage at the end of the high discharge, Rin will be negative.

To avoid this do the following:

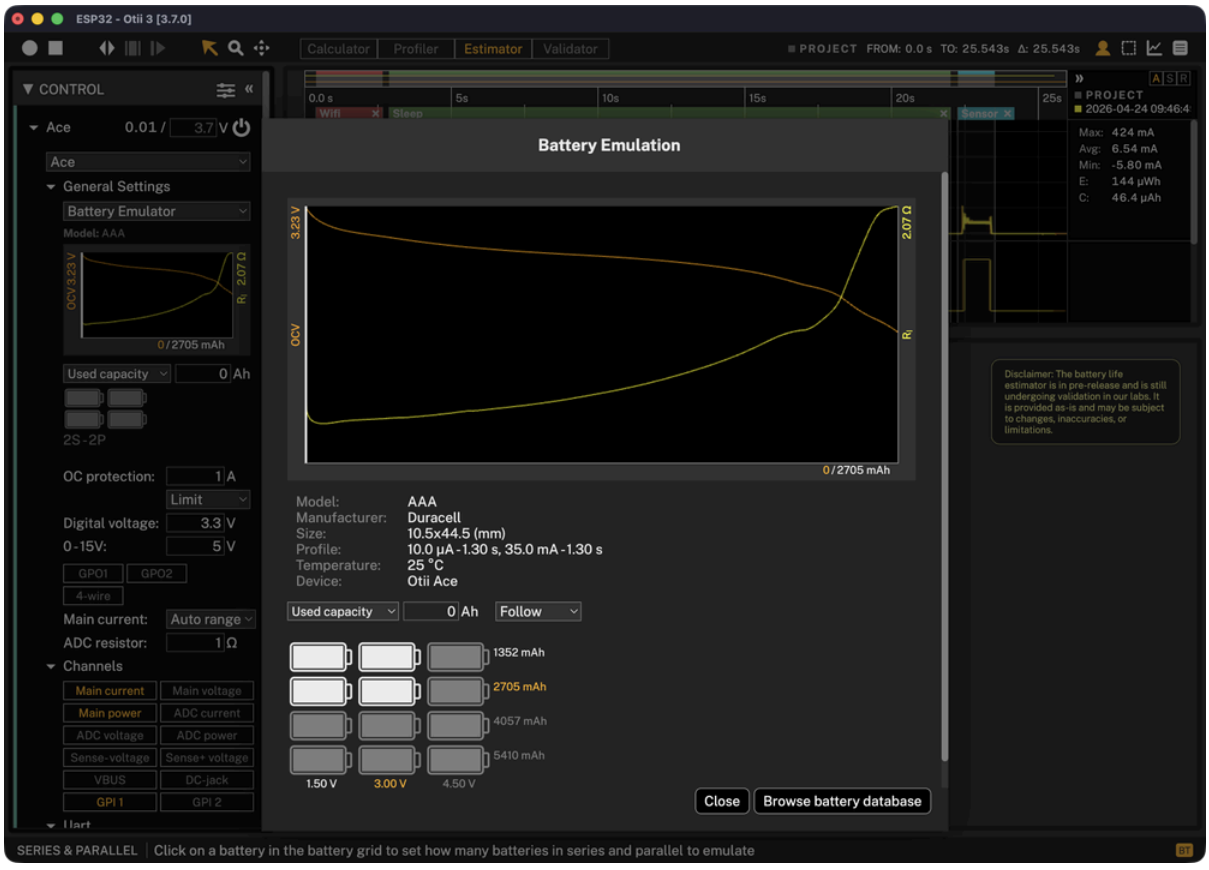
- Have a shorter cycle time
- Have a higher difference between high and low current

Battery emulator

ⓘ These features require a Battery Toolbox License.

Otii can act as a battery, following a discharge curve. If you have reserved a **Battery Toolbox** license, a Supply section will appear in the Arc/Ace control settings. Press the Emulate battery button to open the battery emulation dialog. Choose the battery profile you want in the drop down list. A discharge curve will be shown for the chosen battery.

There are two curves, one shows the unloaded battery voltage over the used capacity and the other curve shows the internal resistance. Otii will adjust the output voltage depending on the load, just like a real battery with internal resistance.



Settings

Used Capacity

Enter how many Ahs of the emulated battery's capacity that has been used if you selected Used capacity or how many percent if you selected SOC(%). To emulate a fresh battery, enter 0 for Used capacity and 100% for SOC(%).

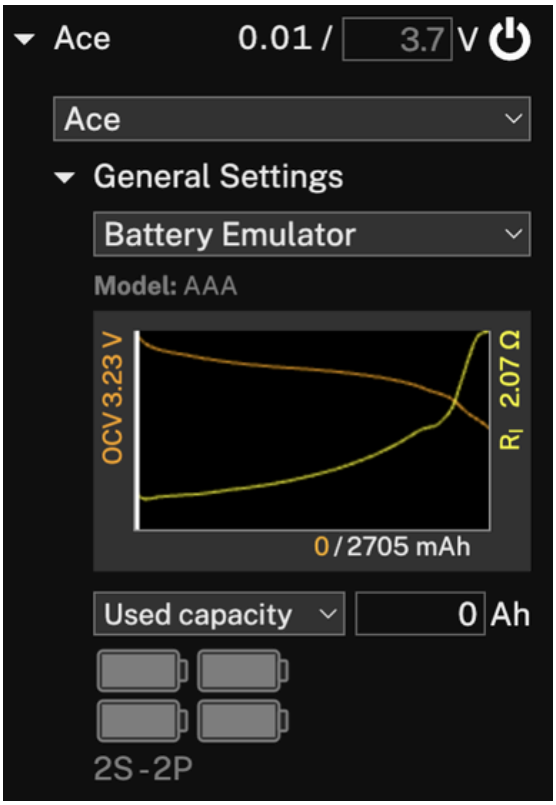
Select Fixed to emulate the battery with a constant Used capacity as entered above. Follow will emulate a discharge over the time you are recording.
The rest of the settings are the same as when using the Arc as a constant power supply.

Series and Parallel

Click on a battery in the battery grid to set how many batteries in series and parallel to emulate.

Hide

Press to hide the battery emulation dialog. Your current settings will still be visible in your Arc/Ace control settings, as displayed below. Here you can edit the used capacity or state of charge. To update other settings, press the curve to re-open the dialog.



Battery life estimator

ⓘ This feature requires a Battery Toolbox License.

⚠ Disclaimer: The battery life estimator is in pre-release and is still undergoing validation in our labs. It is provided as-is and may be subject to changes, inaccuracies, or limitations.

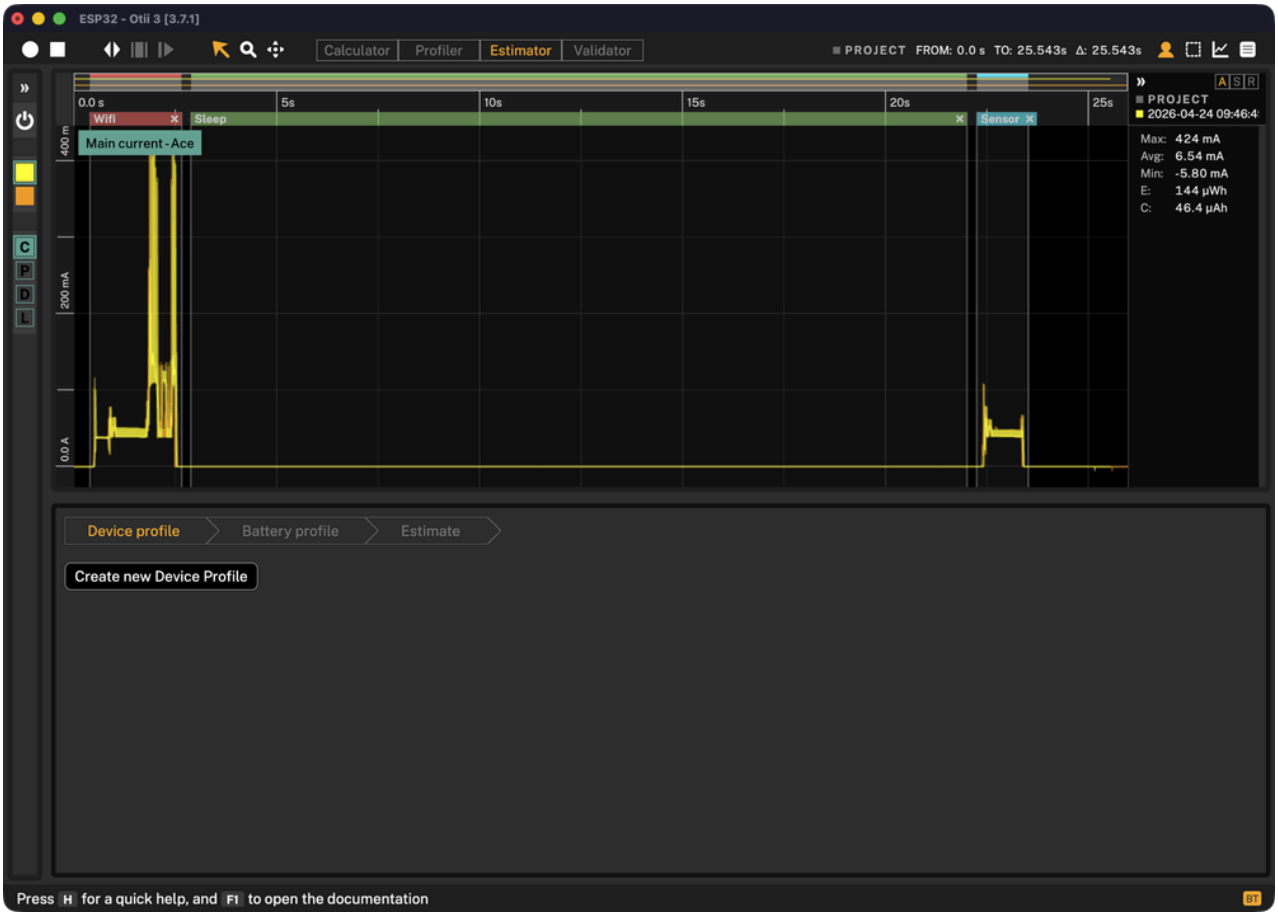
The battery life estimator is a tool that let you estimate the battery life for your device based on different device profiles based on actual power measurements of your device, and using battery profiles created with the battery profiler or provided to you.

Battery life estimation is done in four steps:

1. Measure the current profile of your device
2. Create a device profile from the measurement
3. Configure a battery from an existing battery profile
4. Run the estimator

Measure a device

Make a measurement that contains all different activity periods, e.g. getting sensor data and sending data to the cloud. Make saved selections to identify those activities:



Create a device profile

Open the Estimator by selecting it in the toolbar.
Click on Create device profile in the estimator and then setup the profile:

Device name

Choose any name for your device.

Voltage range

This is the operating range for your device. The voltage range will limit the available battery profiles, and will determine at what battery voltage the estimator should stop estimating.

Sleep current

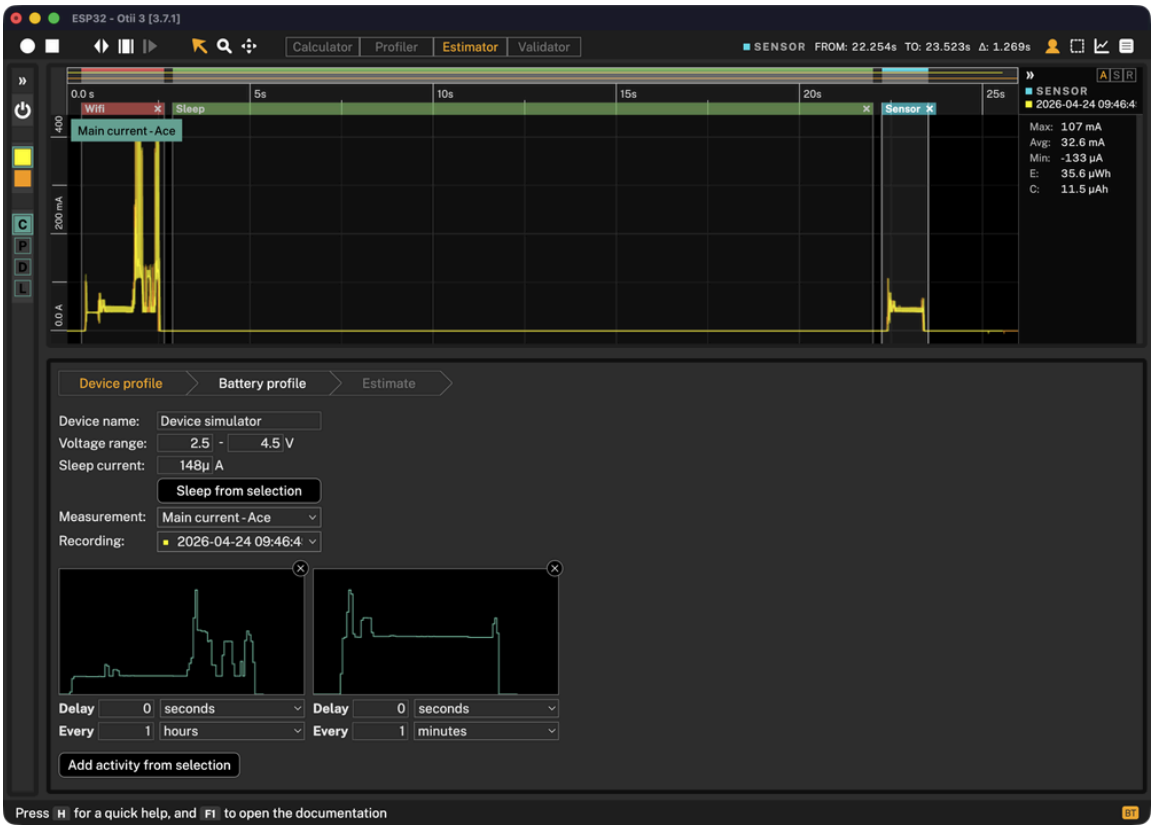
This is the average sleep current of your device. Make a selection, or click on a saved selection, and then click on Sleep from selection to copy the average current.

Add activity

Make a selection, or click on a saved selection, and the click on Add activity from selection to create a new activity.

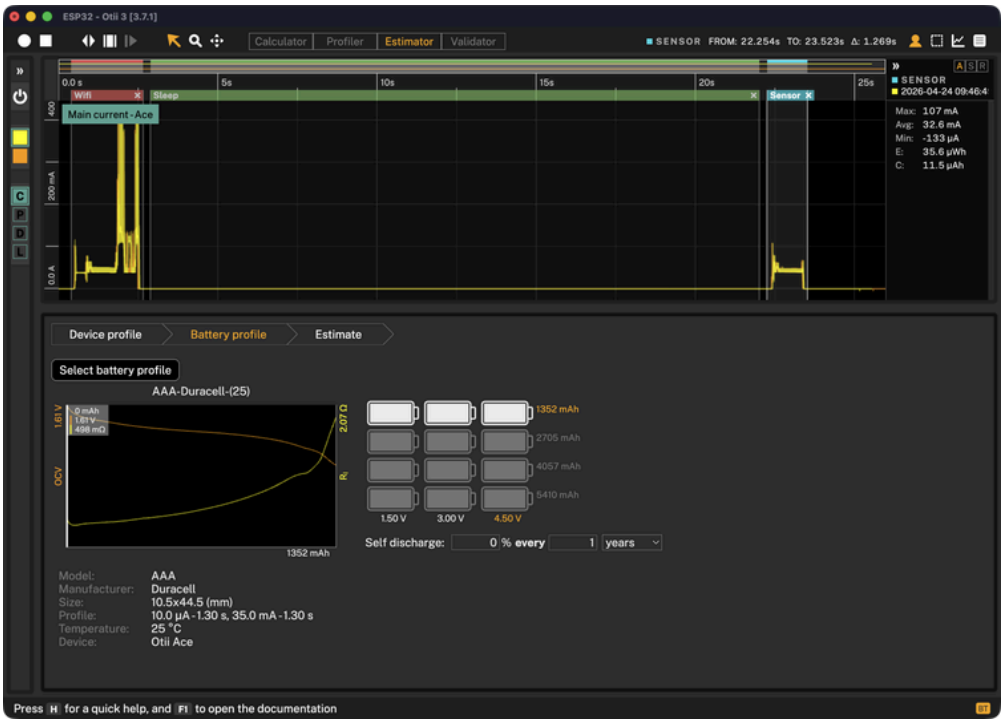
You can now set the delay before the first time this activity is going to happen, and then you can set the frequency that it will occur at.
You can create more than one activity.

Here is an example of a device profile where it reads the sensor every minute and sends data to the cloud every hour:



Setup a battery profile

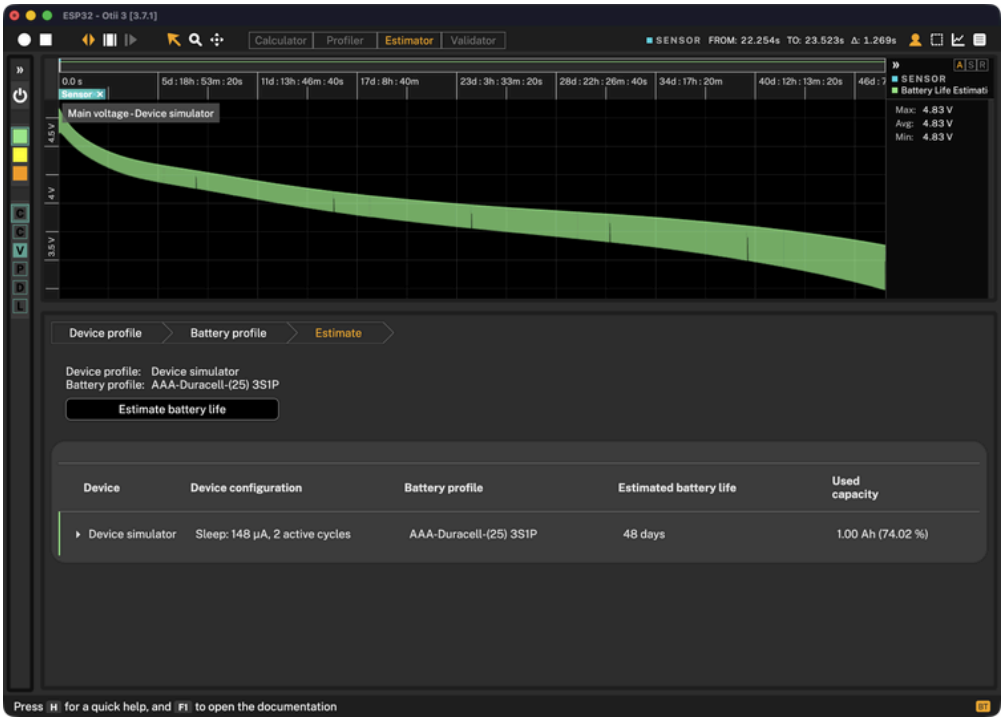
Select a battery profile from your library of profiles, choose the configuration of your battery pack, and optionally set the self-discharge of the battery.



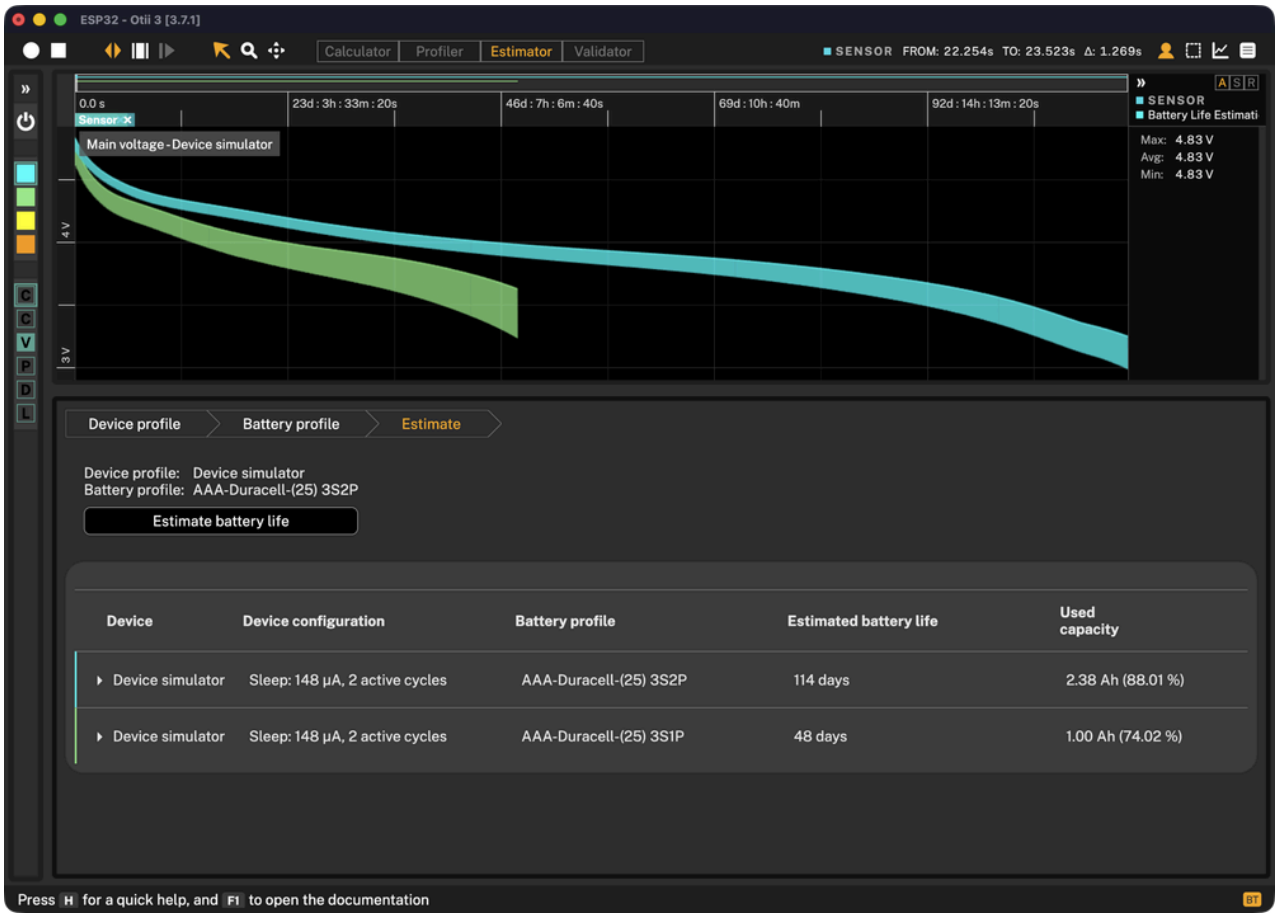
Estimate

To run an estimate, press Estimate battery life. Depending on your configuration this could take some time.

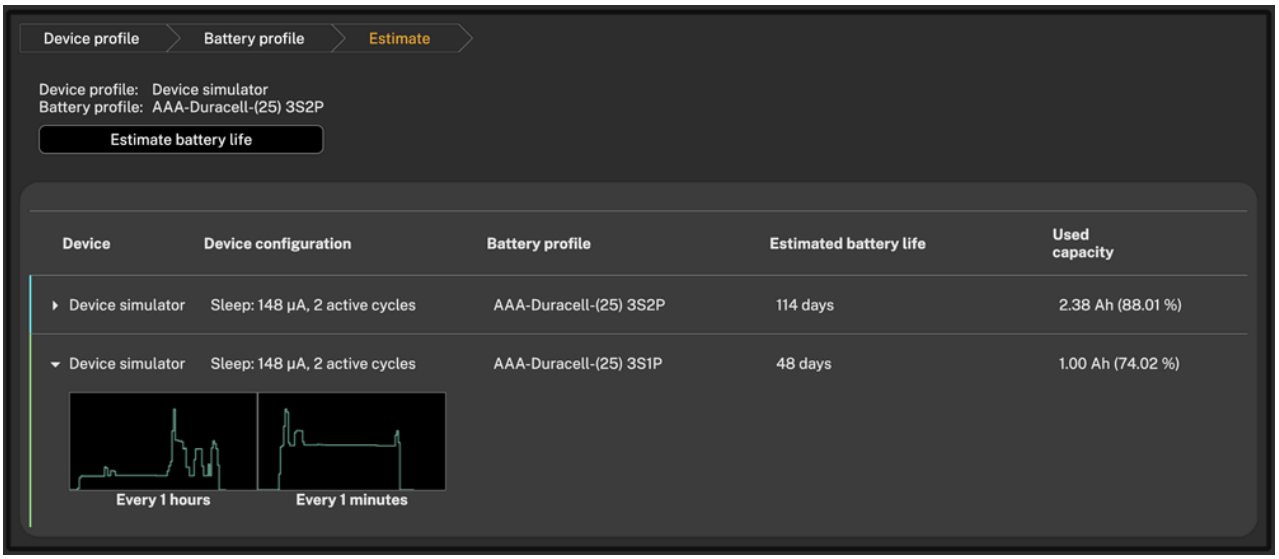
When the estimation is done, an estimated life tile will be presented:



You can now do changes to the device profile or the battery profile and run the estimator again to compare different scenarios:



If you click on the arrow left of the estimate, you can see the configuration that was used for this specific estimation:



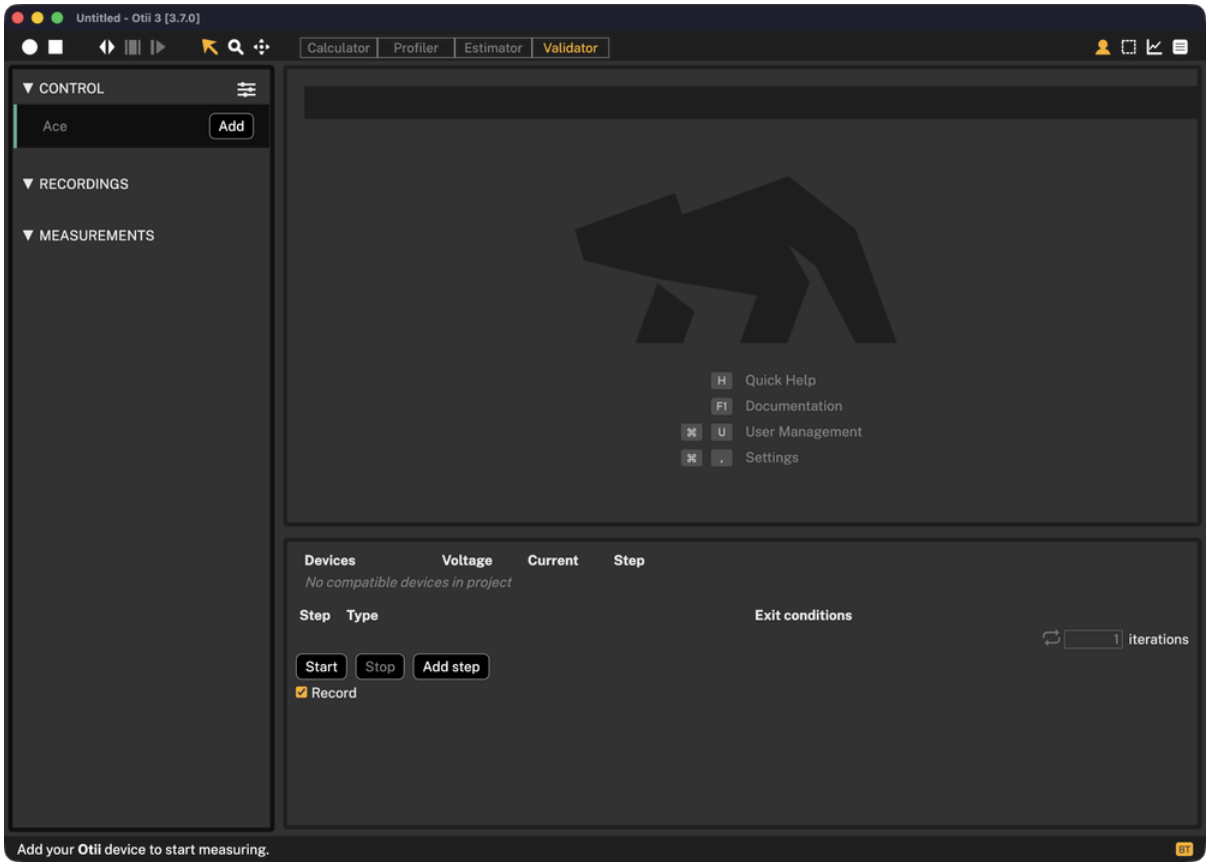
Battery validator

ⓘ This feature requires a Battery Toolbox License.

ⓘ Battery Validation requires an Otii Ace Pro.

Battery Validation provides a comprehensive view of your battery by monitoring its performance in various scenarios. You can charge and discharge the battery in one or multiple steps, repeat discharge cycles, and create custom scenarios.

To start using Battery Validation, select Battery Validation in the toolbar or press Ctrl-T / Cmd-T combination. A panel will then appear where you can view and modify the validation configuration.



Configuration

Devices

Here you will see a list of connected devices where you can pick which of them you want to use for battery validation.

Start

To start battery validation, press *Start*.

Stop

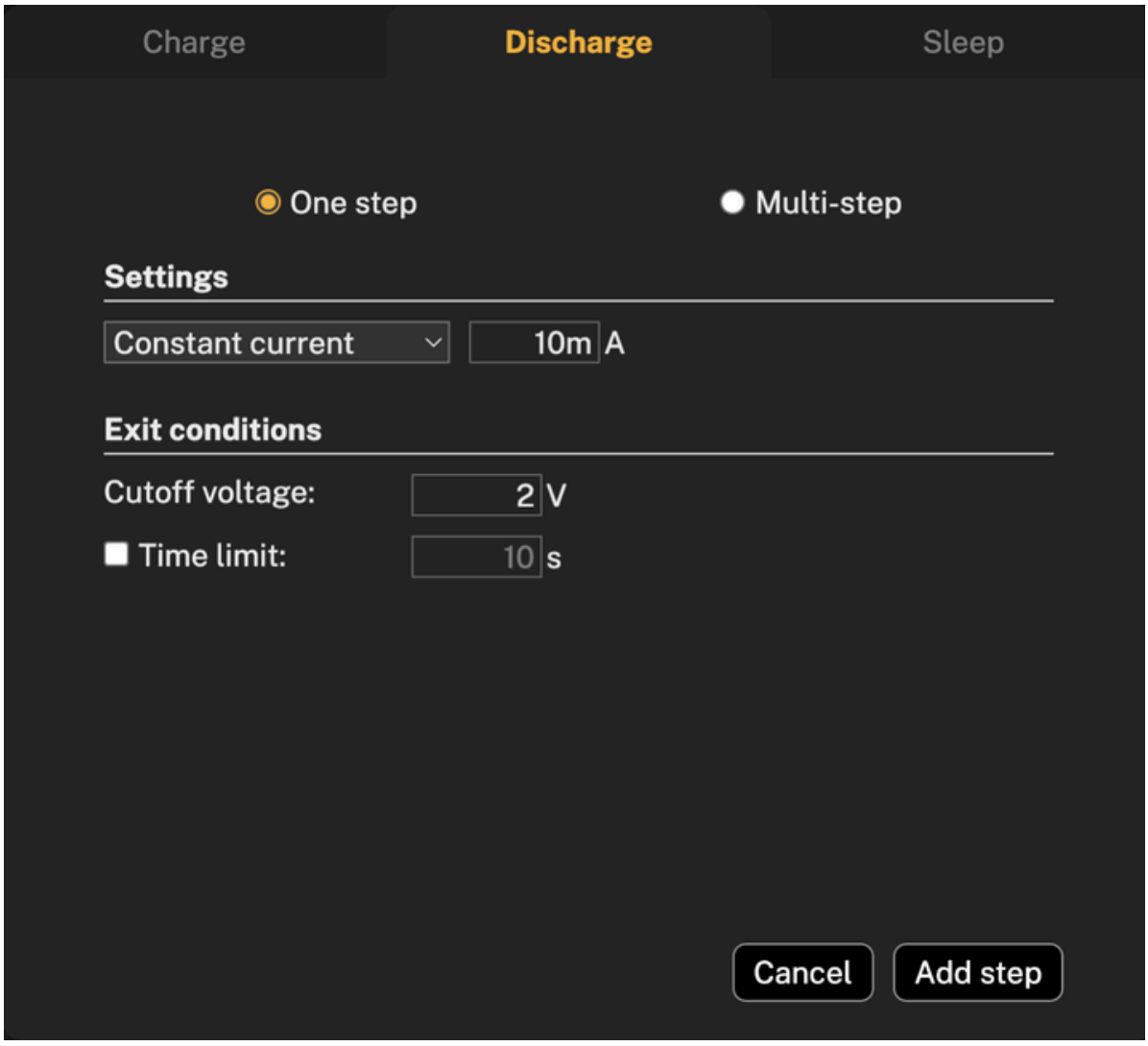
To stop battery validation, press *Stop*.

Record

You can optionally record the ongoing battery validation session by selecting Record.

Add step

Press Add step to open the battery validation dialog.



Discharge step

The discharge step function is splitted by One step and Multi-step.

One step

One step allows you to have a discharge step without specifying max time.

Settings

In the settings you can pick between Constant current, Constant power or Constant resistance and insert your value, according to the battery under the test.

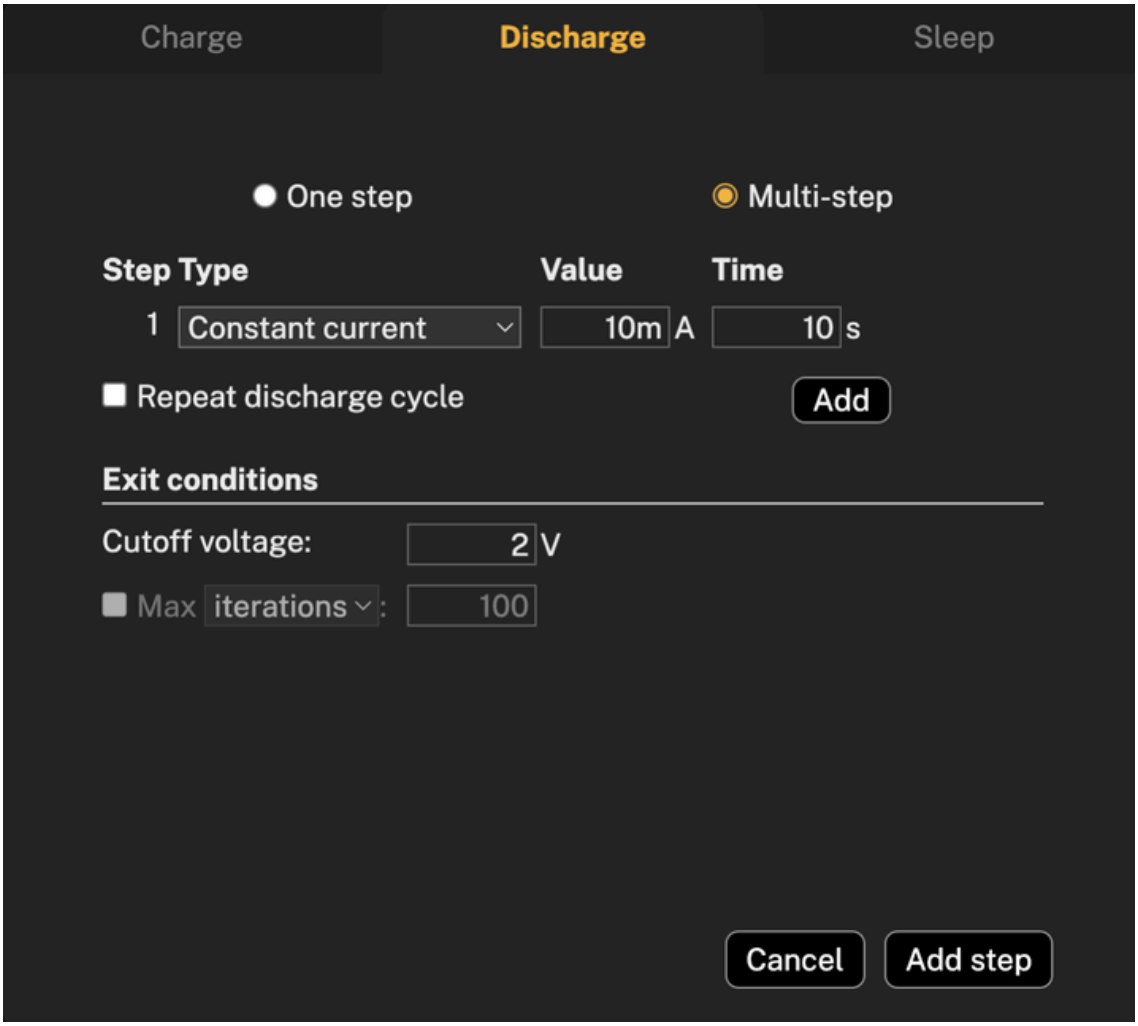
Exit conditions

The exit conditions for discharging a battery are the conditions under which the battery should be stopped from discharging to prevent damage to the battery. Cutoff voltage means setting a minimum voltage below which the batterry is not allowed to discharge. Check battery datasheet for this information. Time limit is optional in case of One step discharge, but recommends to prevent overdischarging or other unexpected behaviours.

To add step, press Add step button and the configured step will appear in the dialog.

Multi-step

A multi-step battery discharge involves discharging the battery in several steps, each with a different constant current, power, or resistance profile, depending on the desired outcome and battery type.



Step type

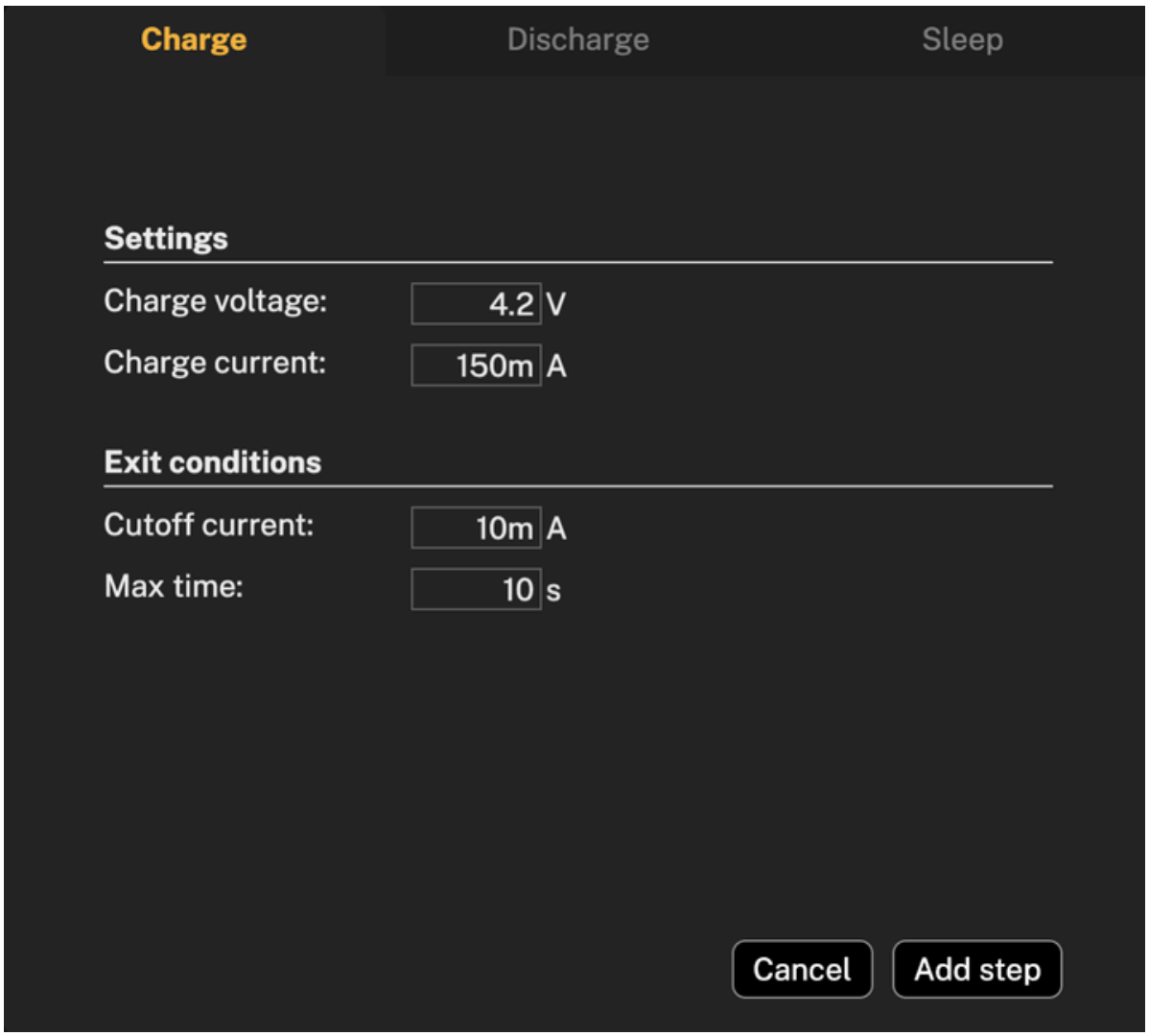
To create a profile with several step types for battery discharge, select the desired step types and configure the parameters for each step, including time, and press Add to add more steps. It is also possible to repeat discharge cycle by selecting Repeat discharge cycle.

The exit conditions in the multi-step discharge, besides cutoff voltage that works same principle as in one step discharge, contains a checkbox where in case if you decide to have repeated discharge cycle, you can choose between Max iterations or Max time.

To add multi-steps, press on Add step button and configured multi-steps will appear in the dialog.

Charge

A battery charging test is often used to evaluate a battery design to see if it meets its performance and safety specifications. Charging is Constant Current / Constant Voltage, this means that the battery is first charged with Constant Current according to the Charge current setting. When the voltage meets the Charge voltage setting, it changes to Constant Voltage, lowering the current until the current drops below the Cutoff current. Then the charging stops.

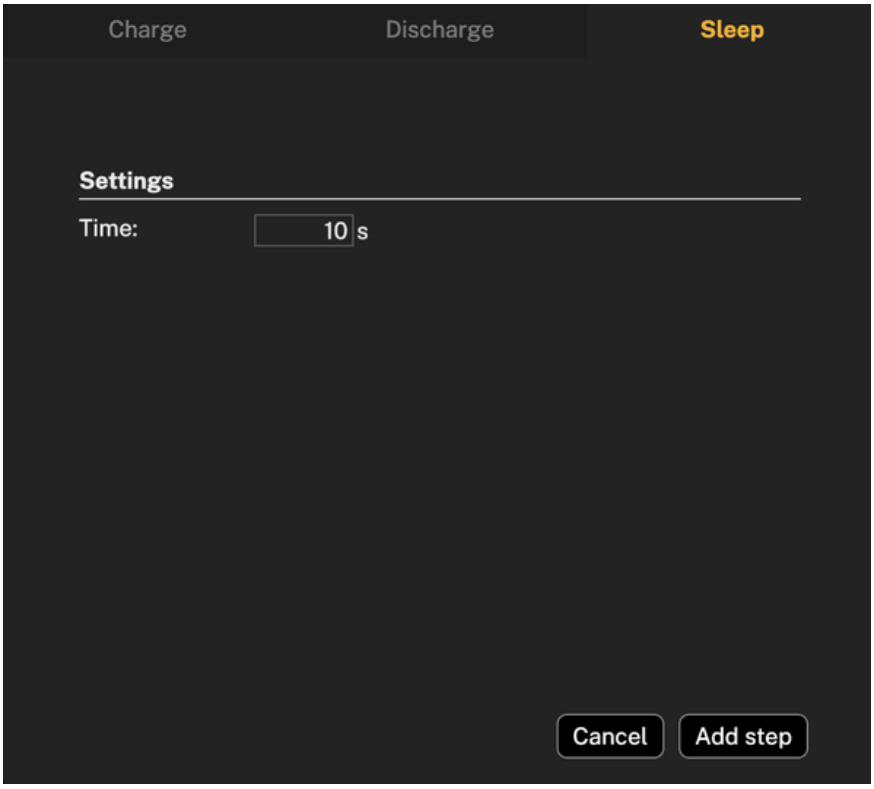


Settings

Before charging the battery, make sure to set up the settings according to the documentation of the tested battery.
Charge voltage is the voltage applied to the battery in the Constant Voltage phase. This must never be above the maximum voltage for the battery, make sure that you read the datasheet for the battery before setting this value.
Charge current is the maximum current that flows into the battery while its being charged in the Constant Current phase, make sure that you read the datasheet for the battery before setting this value.
The exit conditions of battery charging are the Cutoff current and Max time of charging the battery.
Cutoff current is the current at which a battery will stop charging; this prevents battery's overcharging.
Max time is the longest amount of time that a battery will be charging. This ensures that the battery is not being overcharged.
Battery types will have a different cutoff current and maximum charging time, so make sure to read the documentation first.

Sleep

Due to different battery types and their chemistry, battery temperature and protection security it is important to have a time sleep between charging/discharging steps. To set up sleep time between selected steps, swich to the Sleep tab and set up desired sleep time. Press Add step. During sleep period, the battery is neither charged nor discharged but the voltage is measured. This mode can also be used to measure the voltage of a battery, before charging or discharging it.



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Battery validation in numbers

Technical specification	Otii Ace Pro
Current max	5A
Voltage max	25V
Power max.	Source: 50 W peak, 30 W continuous, Sink: 125 W peak, 15 W continuous
Accuracy	Readback accuracy according to the datasheet: Voltage: ±(0.05 % + 25 nA) Current: ±(0.01 % + 1 mV)
Number of cycles	unlimited
Number of batteries per project	unlimited

Resources

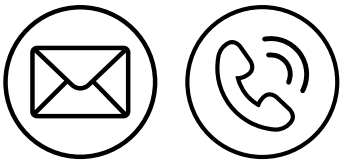
Otii Ace Pro datasheet

Otii Arc Pro datasheet

Otii Battery Toolbox documentation

Otii Automation Toolbox documentation

Otii Product Suite documentation



Contact us

To discuss how Otii Product Suite can best suit your team/s and how to tailor it for optimal utilization and cost efficiency, please contact our sales team at

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For technical questions and support, please contact us at

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We’re here to help!

The Qoitech Team

QOITECH

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Qoitech creates the most effective solutions for energy consumption analysis and optimization, battery life analytics and prediction, and testing of batteries and energy harvesters, applicable across all industries. Founded as subsidiary of Sony, Qoitech is a Swedish company with global reach.