



Training - Advanced programming

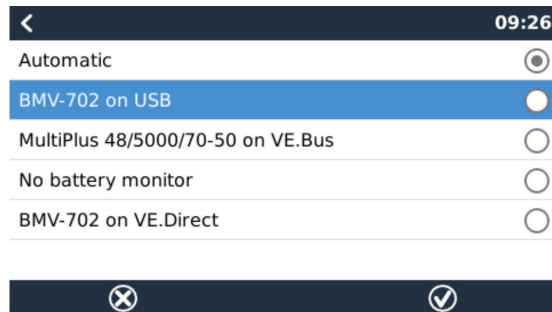
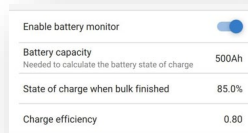
# Battery monitoring and GX device

# GX device allows for one SoC for the whole system

- The CCGX or Venus itself does not calculate State of Charge (SoC)
- It retrieves the SoC value from a connected device like a Multi, BMV, Lynx shunt or a “smart” battery:

- BMV 7xx series
- Lynx shunt
- VE.Bus
- Smart battery with a built-in battery monitors like BYD, Redflow and others. For full list and more info see:

[https://www.victronenergy.com/live/battery\\_compatibility:start](https://www.victronenergy.com/live/battery_compatibility:start)

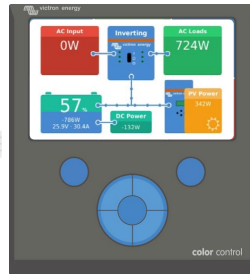


# BMV-7xx series

# Lynx shunt



VE.Direct cable



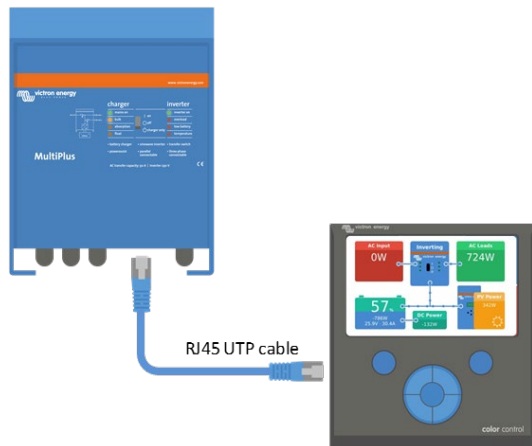
VE.Can RJ45 terminator

RJ45 UTP cable

VE.Can RJ45 terminator



# VE.Bus



# Smart battery

## Type A for:

- BYD

Type A

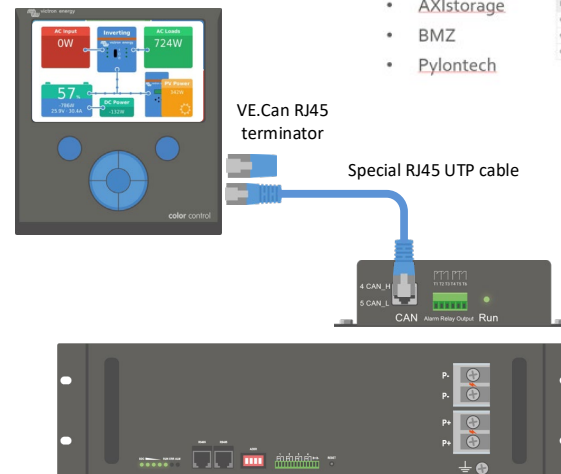
Function	Victron VE.Can side	Battery side
GND	Pin 3	Pin 6
CAN-L	Pin 8	Pin 5
CAN-H	Pin 7	Pin 4

## Type B for:

- LG Chem Resu
- AXIstorage
- BMZ
- Pylontech

Type B

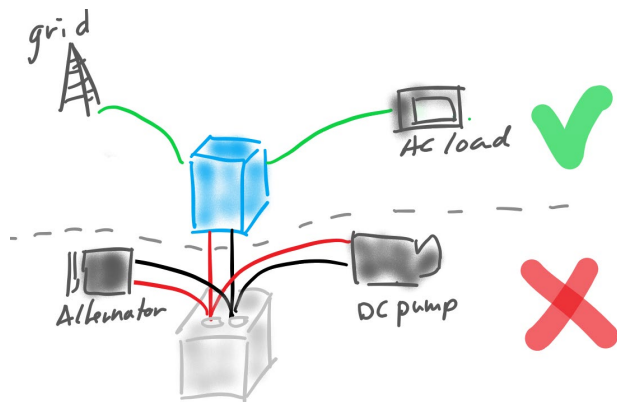
Function	Victron VE.Can side	Battery side
GND	Pin 3	Pin 2
CAN-L	Pin 8	Pin 5
CAN-H	Pin 7	Pin 4



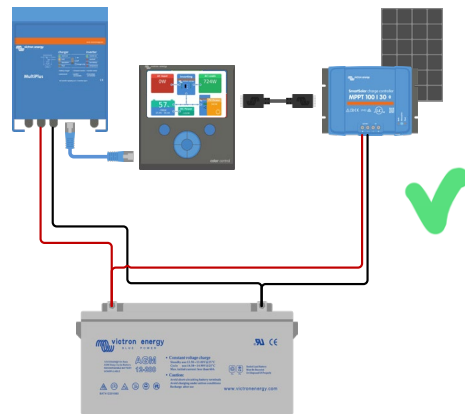
# Note on VE.Bus SoC

- The Multi measures how much current goes in and out of the battery,
- But ... it will miss the current from external DC sources or loads

Don't use the VE.Bus SoC when there are DC loads or charge sources in a system

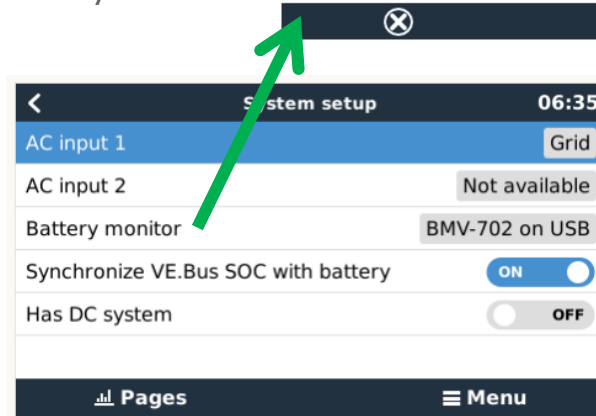
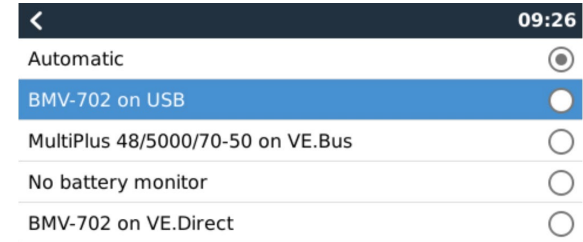


Do use VE.Bus SoC if there are only Victron products in the system and they are all connected to a GX device



# GX device allows for one SoC for the whole system

- The CCGX or Venus itself does not calculate State of Charge (SoC)
- It retrieves the SoC value from a connected device like a Multi, BMV, Lynx shunt or a “smart” battery

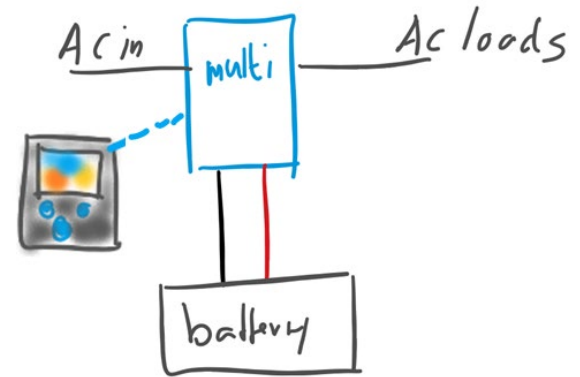


# Battery and Multi or Quattro with CCGX

If the Multi is the only product connected to the battery. No external battery monitor is required. The Multi can calculate SoC.



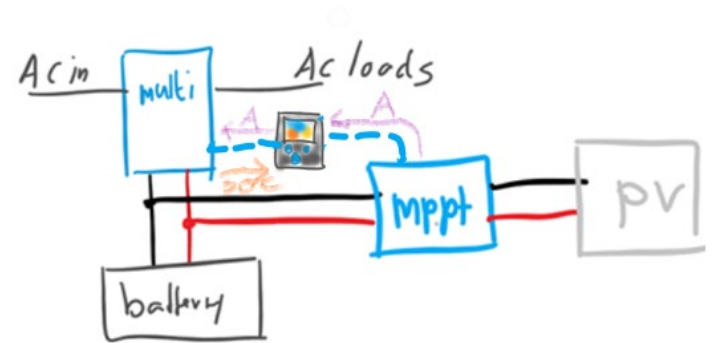
- In VEConfigure enable and configure the Battery Monitor
- In the CCGX select VE.Bus SoC



# Battery with Multi and MPPT and CCGX

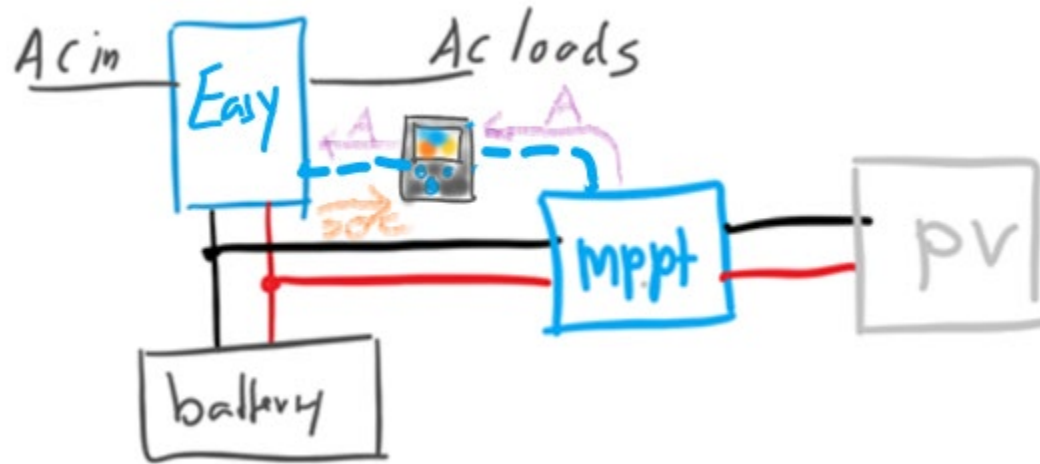
If a Multi and a Victron MPPT are connected to the battery the Multi calculates the SoC. The CCGX will send the current reading from the MPPT to the Multi. The Multi will combine this with its own current reading and will calculate the SoC.

- In VEConfigure: enable and configure the Battery Monitor
- In the CCGX: select VE.Bus SoC
- Verify in the CCGX if "Use solar charger current to improve VE.Bus SoC" is enabled.
- This feature requires CCGX firmware 2.x and above



# An EasySolar with CCGX

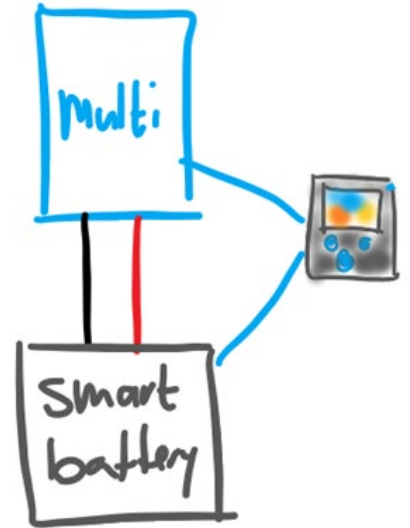
Same as before



# Batteries with a built-in battery monitor and CCGX

A Multi is connected to a “smart” battery. The BMS in a compatible “smart” battery will send its SoC value to the CCGX.

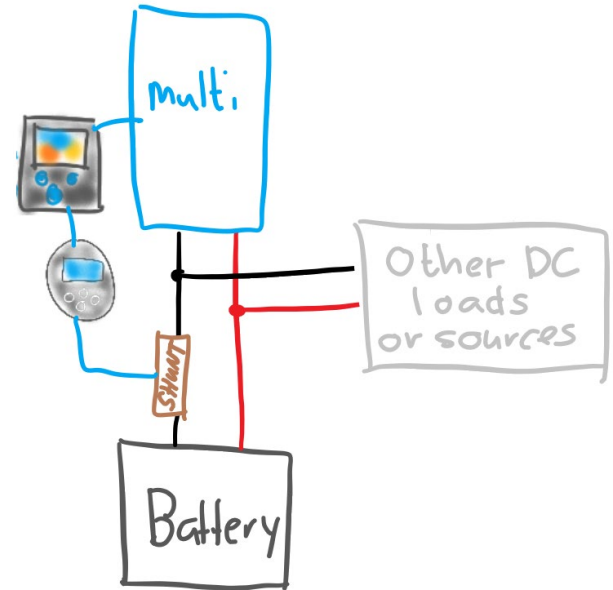
- Connect the battery communications cable to the CCGX according to the instructions.
- In the CCGX verify that the selected Battery Monitor is set the “smart” battery.
- The VEConfigure battery settings are irrelevant



# Other system types

Use a BMV or Lynx shunt when there are more chargers or loads connected to the battery

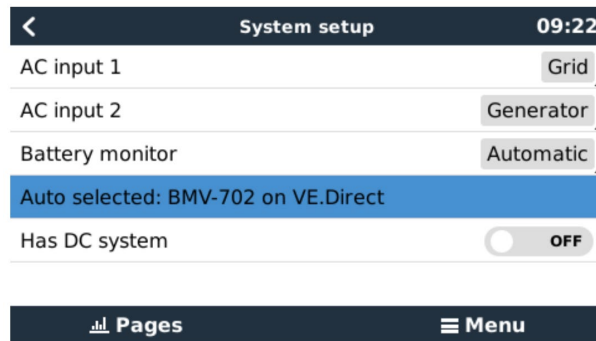
- Configure the battery monitor
- In the CCGX verify that the Battery Monitor is shown



# The Automatic function

The 'Automatic' function uses the following logic:

- When available, it will use a dedicated Battery Monitor, such as the BMV or a Lynx Shunt, or a battery with built-in battery monitor.
- When there is more than one of those connected, it will use a random one: in that case select one manually.
- When there is no dedicated Battery Monitor, it will use the VE.Bus SoC.

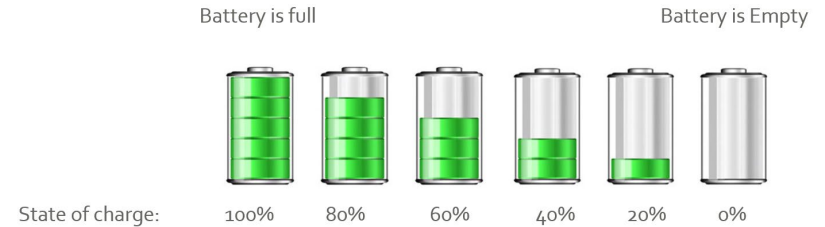


# Battery parameters

# State of charge versus Depth of discharge

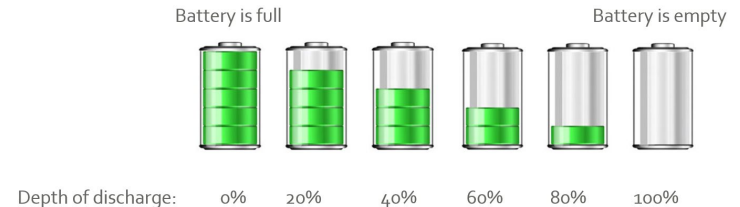
## SoC

- State of charge is an indicator of how full a battery is
- We use SoC in our documentation



## DoD

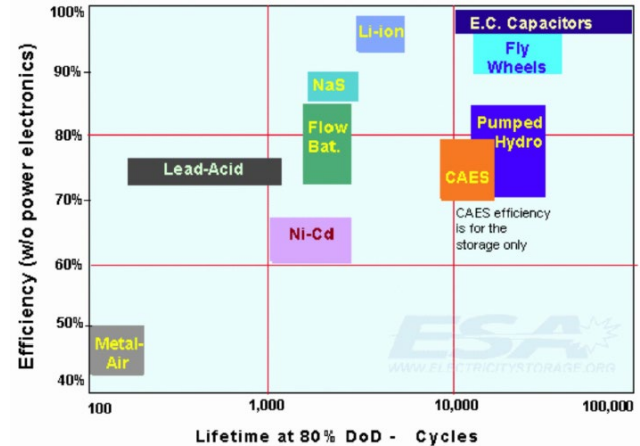
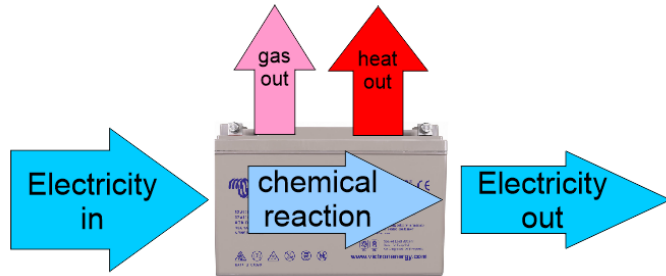
- Depth of discharge is an indicator how empty a battery is



# Charge efficiency

There are losses in batteries when you discharge or charge them.

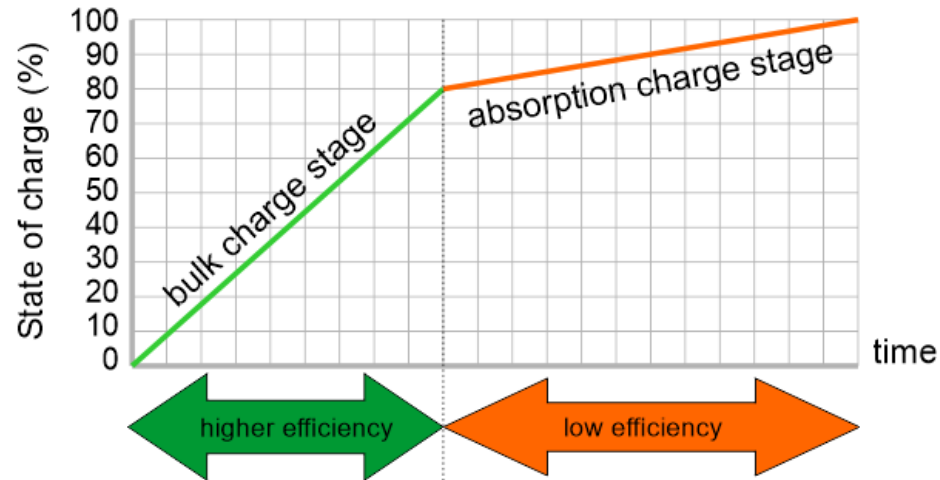
- The round trip energy efficiency a lead-acid battery is 75 to 85%
- For lithium batteries this is around 95 to 99%



# Battery charge efficiency lead acid

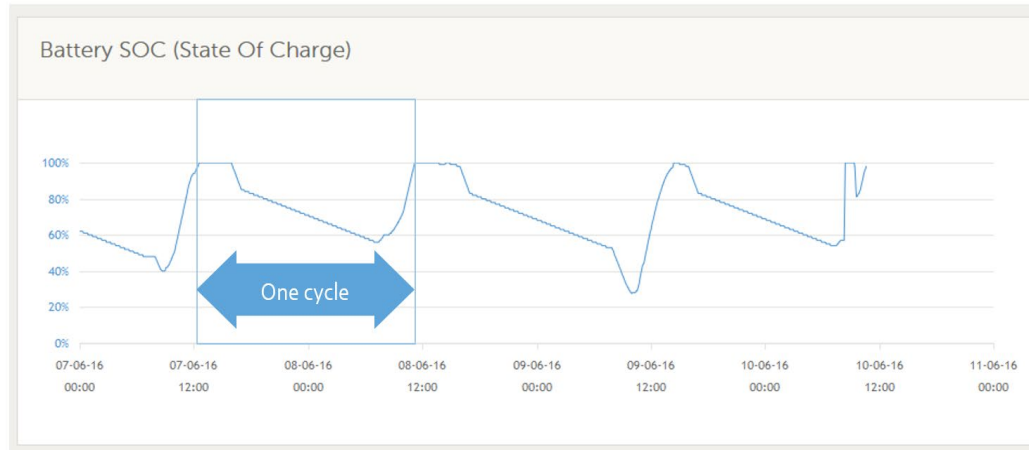
The charge process of lead-acid batteries becomes particularly inefficient once a 80% state of charge has been reached.

Between 80% and 100% the charge efficiency is often less than 50%.



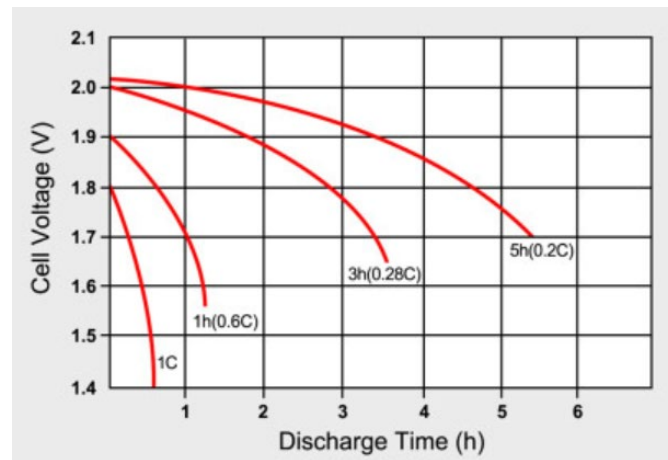
# Battery cycle

- A cycle is one charge and one discharge event
- Typically, you will go through one cycle per 24 hours



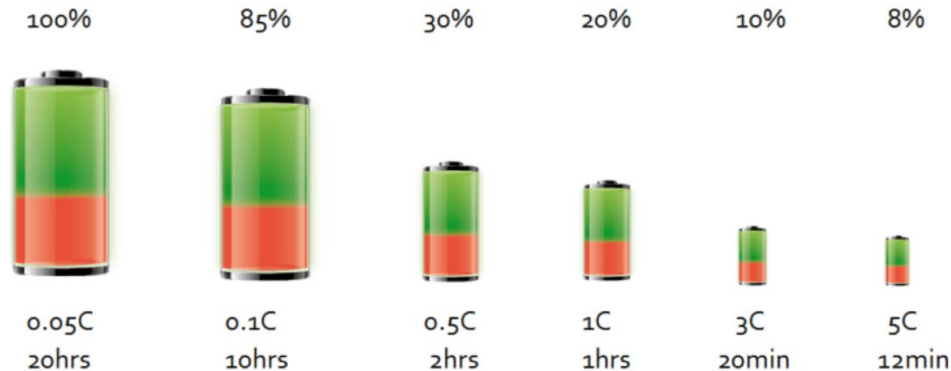
# C-rating

- The C-rate is a measure of the rate at which a battery is discharged relative to its maximum capacity.
- A 20C rate means that the discharge current will discharge the entire battery in 20 Hours
- A 1C rate means that the discharge current will discharge the entire battery in 1 hour.
- For a battery with a capacity of 100 Amp-hrs, this equates to a discharge current of 100 Amps.



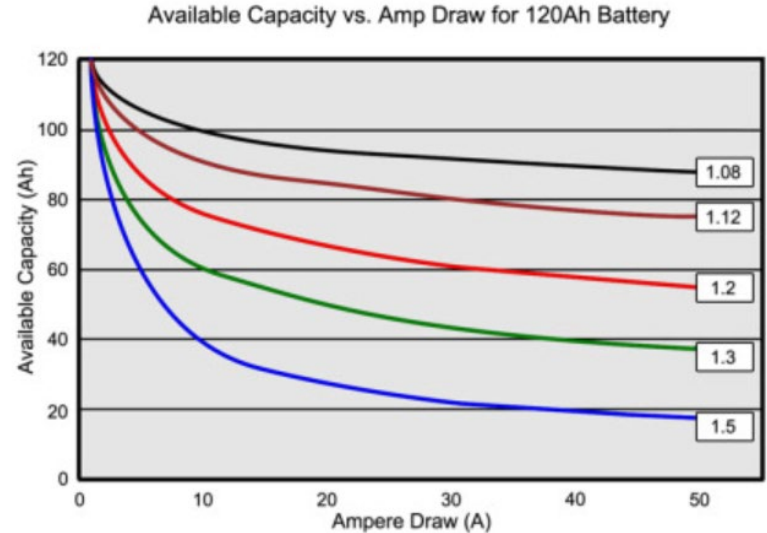
# Fast discharge versus slow discharge

- The faster a battery is discharged the smaller the capacity is
- For the same battery the battery capacity varies per C-rate
- This will vary per battery type, but also per battery chemistry



# Peukert exponent

- The faster a battery is discharged, the smaller the battery capacity will be
- The Peukert exponent is the relation between battery capacity at different discharge rates.
- The Peukert exponent can be calculated if two different C rates are known



# Peukert equation

- To calculate the Peukert exponent you need two rated battery capacities
- For example use the 20h discharge rate and the 5h discharge rate
- A Peukert calculator is available at:  
<http://www.victronenergy.com/support-and-downloads/software/>

$$C_p = I^n \cdot t \quad \text{where Peukert's exponent } n = \frac{\log t_2 - \log t_1}{\log I_1 - \log I_2}$$

$$C_{5h} = 75Ah$$

$$t_1 = 5h$$

$$I_1 = \frac{75Ah}{5h} = 15A$$

$$C_{20h} = 100Ah \text{ (rated capacity)}$$

$$t_2 = 20h$$

$$I_2 = \frac{100Ah}{20h} = 5A$$

$$\text{Peukert exponent, } n = \frac{\log 20 - \log 5}{\log 15 - \log 5} = \underline{\underline{1.26}}$$

# Peukert exponent

- The Peukert exponent is a rough approximation of reality
- Use the C rating that best matches the systems discharge range
- Batteries which supply very high currents have often even less capacity than predicted from a fixed exponent
- The higher the Peukert exponent, the smaller the effective capacity at increasing discharge rates
- Peukert exponent:
  - An ideal battery is 1
  - Lead acid batteries are around 1.25
  - Lithium batteries are around 1.05

# Battery monitor settings

# A battery monitor is like a calculator

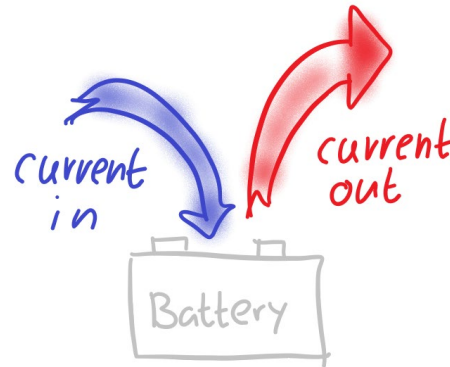
- It keeps a running tally how much current over what time (=energy) is taken out of the battery or put into the battery.
- It constantly adds or subtracts this from the battery capacity

## Example:

- Battery capacity is: 100 Ah (100%)
- 20Ah was taken out
- Now the battery capacity is:  $100 - 20 = 80$  Ah (80%)
- 12 Ah is put back in
- Now the battery capacity is:  $80 + 12 = 92$  Ah (92%)..... and so on

# How is SoC calculated

- By measuring current into the battery and measuring current out of the battery while taking certain factors into consideration.
  - Current in or out
  - Time
  - Battery capacity
  - Charge efficiency
  - Peukert exponent
  - Synchronisation

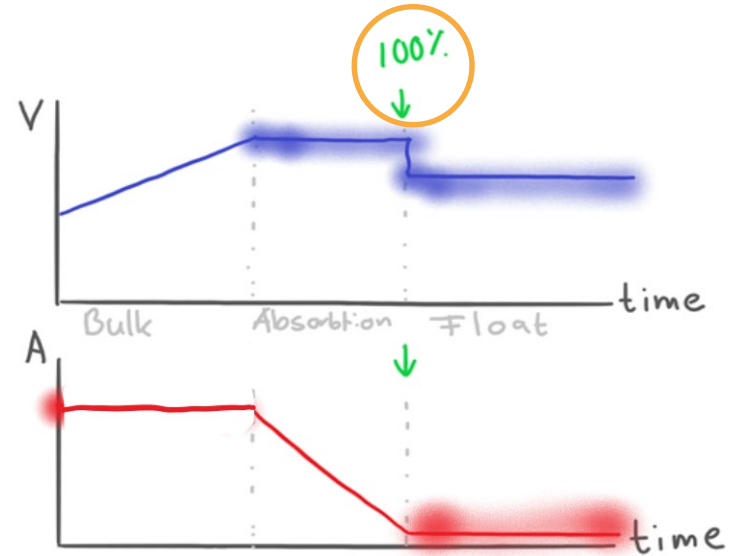


# Synchronisation

- The state of charge calculation is not always perfect
- The real state of charge versus the actual state of charge can slowly deviate over time
- This is why the state of charge occasionally will need to be set to a set value (synchronised) every now and then
  
- Causes of SoC deviation
  - Component tolerances or electrical interference
  - Battery aging or damage
  - Small batteries with high discharge currents

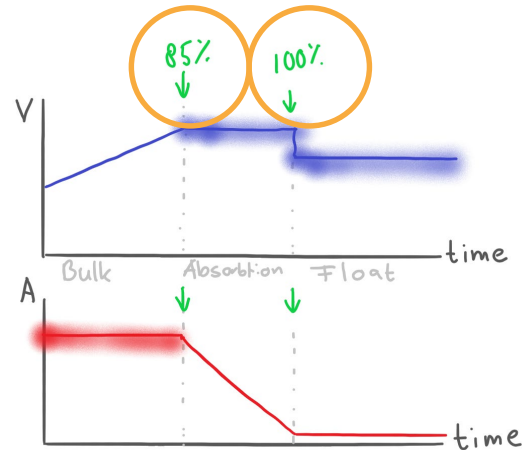
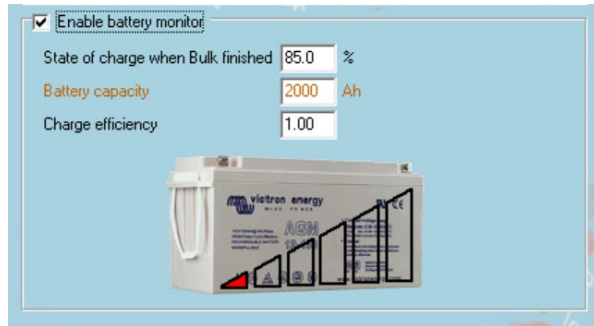
# BMV and Lynx synchronisation

- These battery monitors synchronises when the battery is fully charged
- This happens when the current is below and voltage is above a certain level
- The battery needs to be charged on a regular basis to prevent drift.



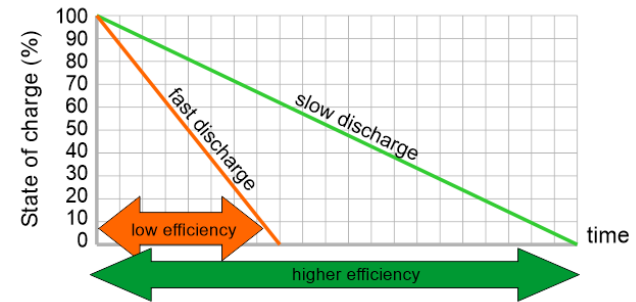
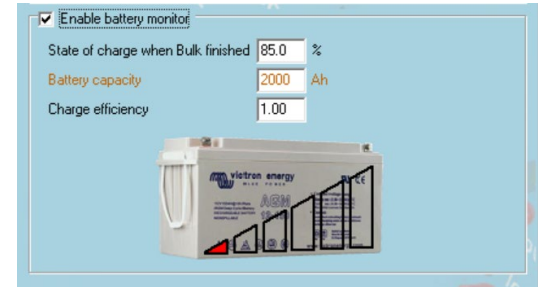
# VE.Bus synchronisation

- When the bulk charge stage is finished the Multi sets the SoC to the percentage you have entered into the settings.
- The Multi will also set the SoC to 100% when the absorption charge stage is finished



# VE.Bus charge efficiency

- Charge efficiency recommendations:
  - Lead acid = 0.85 - 0.75
  - Lithium = 0.99 - 0.95
- The Multi does not take the Peukert exponent into consideration. This means that it will not differentiate between fast or slow discharge.
- If the Peukert exponent of the battery is much higher than 1, it might be beneficial to use a BMV for SoC calculation.



# SoC is stuck at 85%

## The problem:

- In an off-grid system (non ESS) when charging from an MPPT and you are using VE.Bus SoC, the Soc will not get above 85%
- But ... when charging from a generator via the Multi, the SoC will eventually go to 100%

## The reason this happens:

- The Multi won't increase its SoC over 85% as long as it has not detected that the battery voltage has reached its “set” absorption voltage.

## The fix:

- Set the Absorption voltage of the MPPT is slightly above that of the Multi.



Absorption voltage 57.60 V

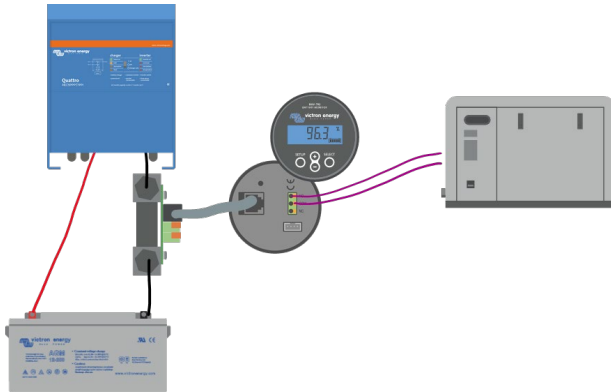
Settings

Battery voltage	
Max charge current	70A
Charger enabled	<input checked="" type="checkbox"/>
Charger settings	
Battery preset	Rotary switch
Position 0 Gel Victron long life (OPzV), Gel oxide A600 (OPzV), Gel MK	
Absorption voltage	57.60V
Maximum absorption time	6h 0m
Float voltage	55.20V

# Generator start/stop

# Generator start from BMV

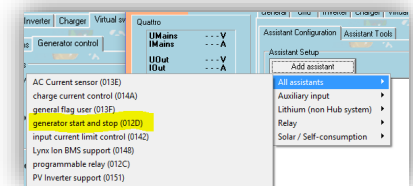
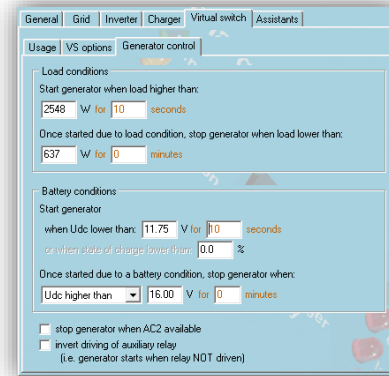
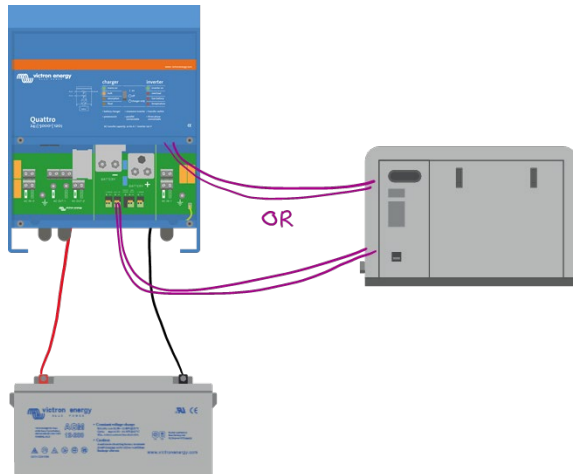
- Using the potential free relay in a BMV-700.
- Start the generator on low battery voltage and/or low battery state of charge.
- See the BMV-700 manual for configuration.



← Relay	
Relay mode	Remote ▾
Invert relay	<input type="checkbox"/>
Minimum closed time	0m
Relay-off delay	0m
Low SOC relay	<input checked="" type="checkbox"/> 50% <input checked="" type="checkbox"/> 90%
Low voltage relay	<input type="checkbox"/> Disabled
High voltage relay	<input type="checkbox"/> Disabled

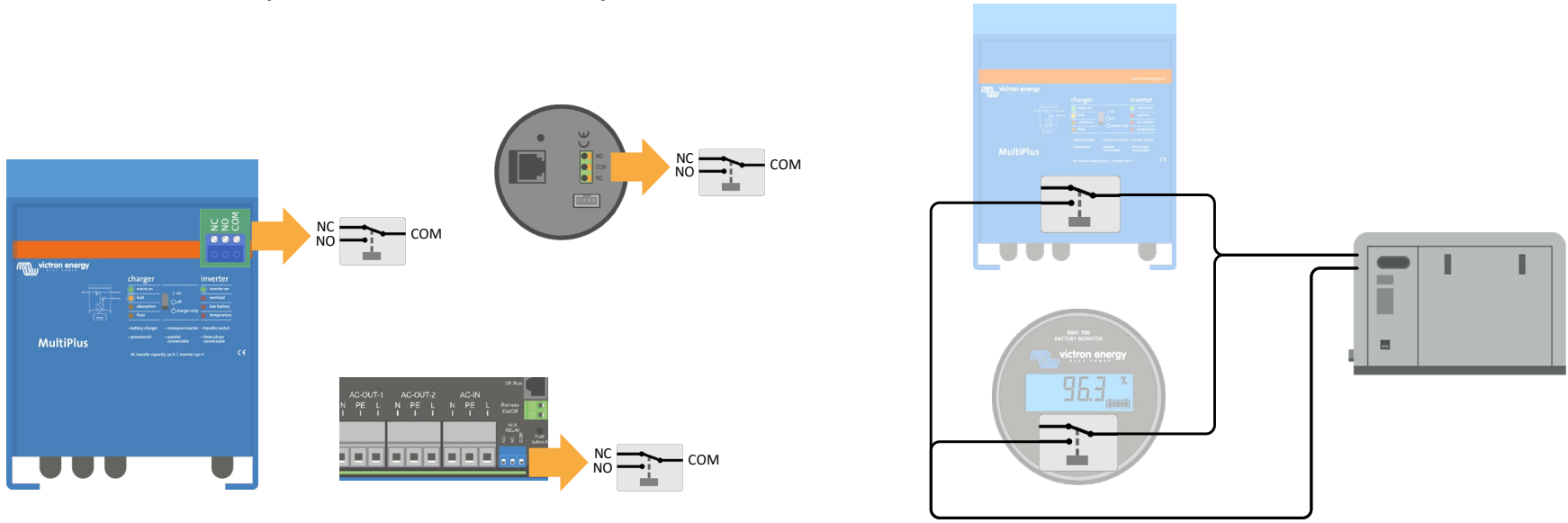
# Generator start from Multi or Quattro

- Potential free relay using the Virtual switch
- Potential free relay(s) or AUX port using the generator start/stop Assistant



# Generator start stop using both BMV and Multi

- The inverter/charger and BMV relays can be used together to start/stop a generator
- Wire the open contacts (NO) in parallel to each other



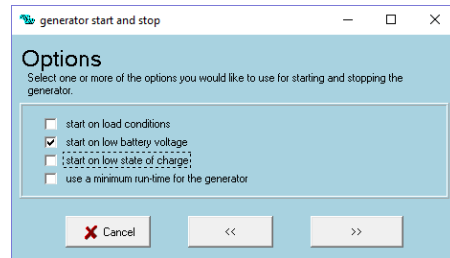
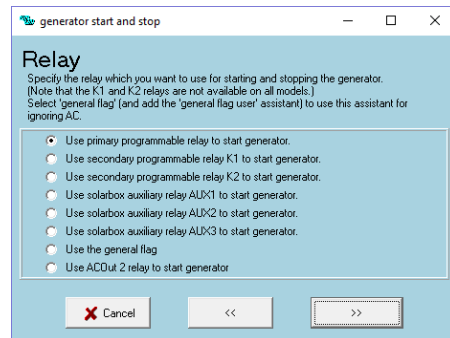
# Generator start and stop Assistant

This assistant is used for starting a generator in off grid systems.

Consider using the CCGX generator start instead

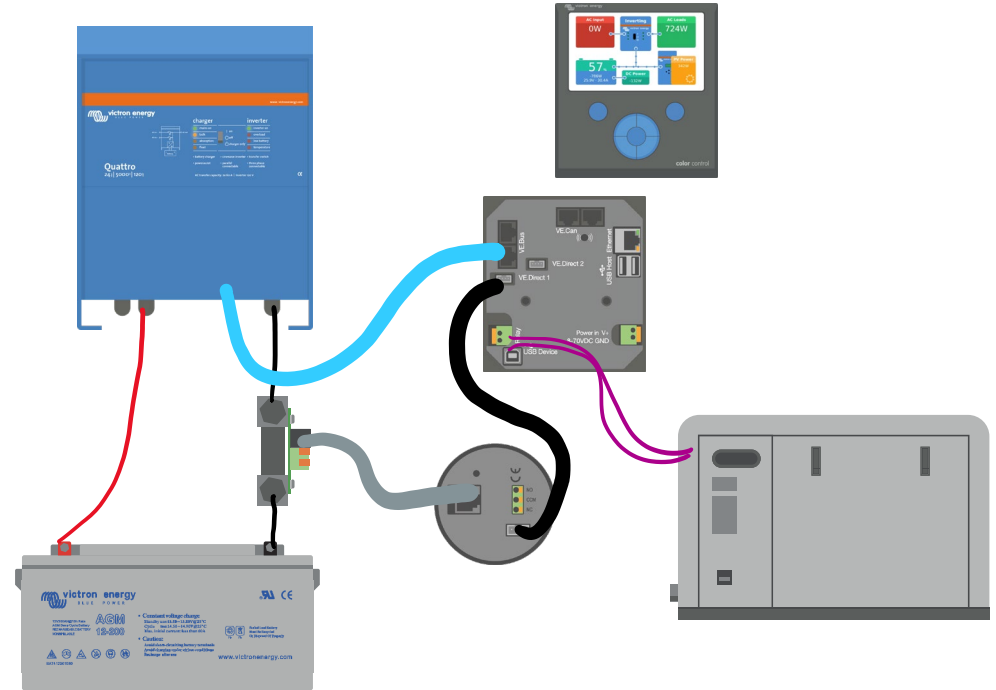
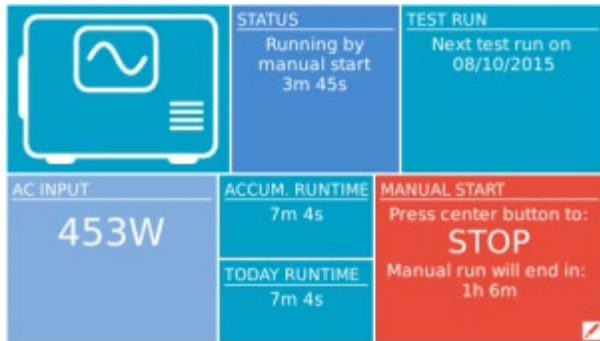
But it can also be used for:

- Selectively letting grid in.
- To turn on a dump load once the batteries are full
- To turn of a grid feed inverter connected to output 2 of a Quattro
- To drive a contactor to turn a grid feed inverter off



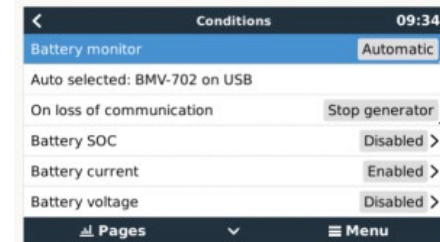
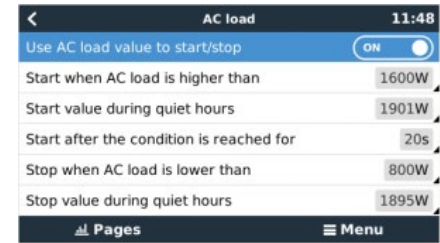
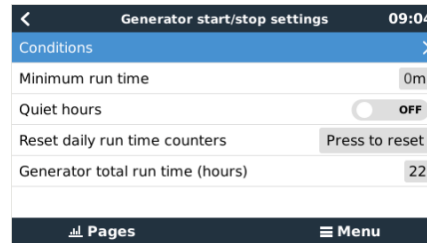
# Generator start from a GX device

Using its programmable relay  
This is the preferred option !



# CCGX generator start/stop settings

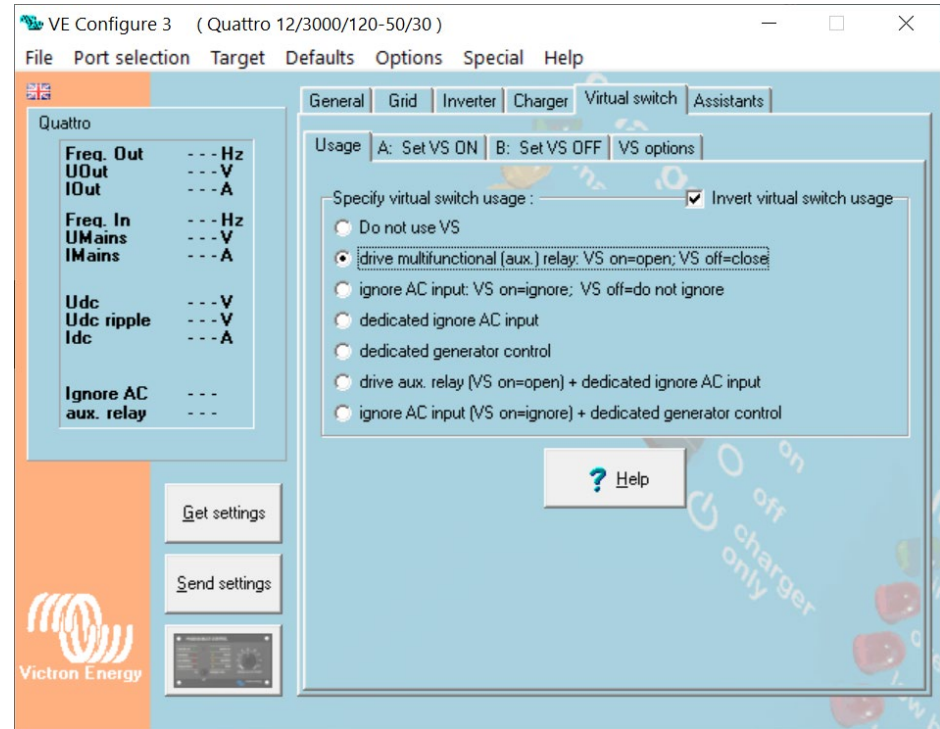
See: [https://www.victronenergy.com/live/ccgx:generator\\_start\\_stop](https://www.victronenergy.com/live/ccgx:generator_start_stop)



# Virtual switch

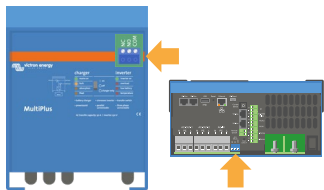
# Virtual switch

- The Virtual switch is an imaginary on/off switch driven by software
- The switching conditions are configurable



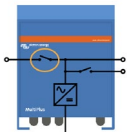
# What can the virtual switch do?

## Programmable relay:



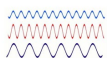
- Generate an alarm signal
- drive an extraction fan
- Generator start/stop signal

## AC input relay



- Specify when grid is allowed in, use the grid as a backup generator

## Frequency shift



- Communication with grid feed inverter

when load higher than  W for  seconds

when Udc lower than  V for  seconds

when Udc higher than  V for  seconds

when not charging for  seconds

when fan on for  seconds

set VS on when bulk protection is activated (charger stopped after 10hr bulk)

set VS on when general system failure occurs

when the following LED alarms are active:

Temperature pre-alarm	for	<input type="text" value="1"/> seconds
Low-battery pre-alarm	for	<input type="text" value="1"/> seconds
Overload pre-alarm	for	<input type="text" value="1"/> seconds
Udc ripple pre-alarm	for	<input type="text" value="1"/> seconds

Load conditions

Do not ignore AC input when load higher than:

W for  seconds

When accepting AC due to load, ignore AC when load lower than:

W for  minutes

Battery conditions

Do not ignore AC input

when Udc lower than:  V for  seconds

or when state of charge lower than:  %

When accepting AC due to a battery condition, ignore AC when:

Udc higher than  V for  minutes

(For virtual switch inversion see Usage page!)

Do not switch off within  minutes from switch on.

Important Note: VS conditions on page B with a delay of 0 ignore this setting!

Change inverter period time when virtual switch is on

Change inverter period time on Udc

Make period time  ms (=  Hz)

when Udc higher than  V for  seconds

Make period time 20.000 ms (=50Hz) again

when Udc lower than  V for  seconds

Note: Udc is temperature compensated in these conditions!

# Assistants

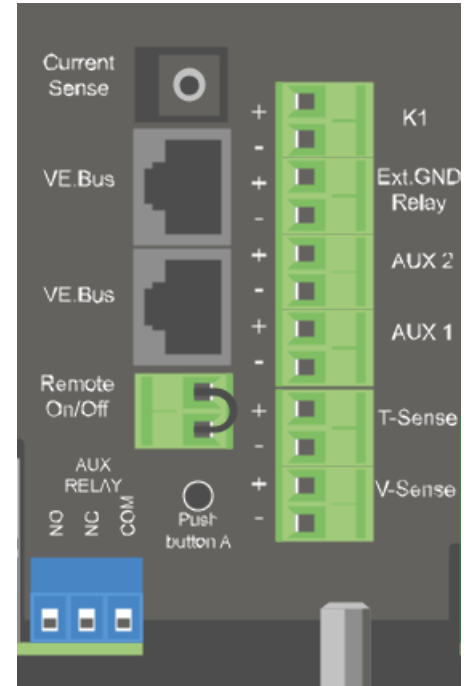
# Assistants

Assistants are programming segments that enable special applications within a Multi or Quattro like:

- Internal processes
- Drive the AC input and output relays
- Drive virtual switch and K relays
- Drive AUX port
- Process incoming AUX port signals

Multiple Assistants can be combined

- <https://www.victronenergy.com/live/assistants:start>



# Available assistants

The screenshot displays the 'VE Configure 3' software window for a 'Quattro 12/3000/120-50/30' device. The 'Assistants' tab is active, showing a list of available assistants. The 'Add assistant' button is highlighted, and a dropdown menu is open, listing various assistants with their IDs.

**Assistant Setup**

Add assistant

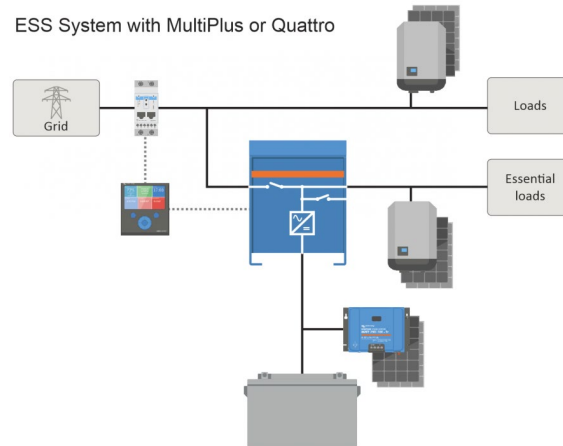
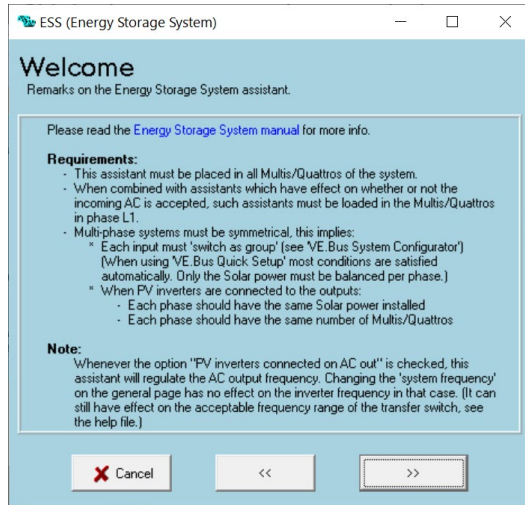
- All assistants
- Auxiliary input
- Lithium (non Hub system)
- Relay
- Solar / Self-consumption

**Used assistants:**

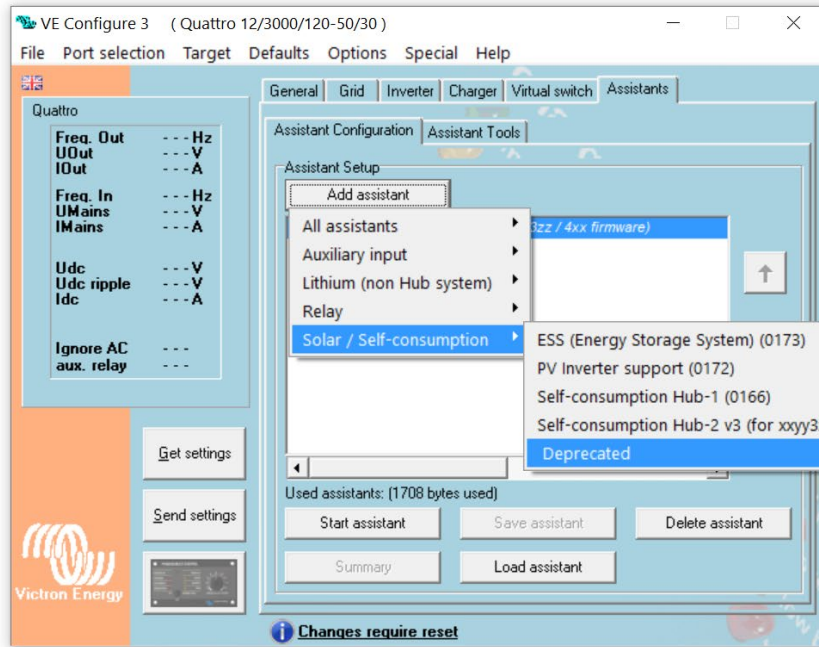
- AC Current sensor (013E)
- charge current control (014A)
- ESS (Energy Storage System) (0173)
- general flag user (013F)
- generator start and stop (015E)
- input current limit control (0142)
- programmable relay (012C)
- PV Inverter support (0172)
- relay locker (0104)
- safety switch (0121)
- Self-consumption Hub-1 (0166)
- Self-consumption Hub-2 v3 (for xxyy3zz / 4xx firmware) (0168)
- Silence fan (0126)
- Two-signal BMS support (016A)
- VE.Bus BMS (015A)
- Self-consumption Hub-2 v2 (deprecated, for xxyy2zz firmware) (0169)
- Self-consumption Hub-4 (deprecated) (0163)

# ESS (Energy Storage System) assistant

Assistant and GX device programming needed and grid feed needs to be enabled  
See [ESS quick start guide](#) on our website. If you can't find the link just "google" it.



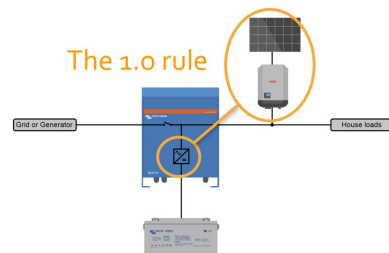
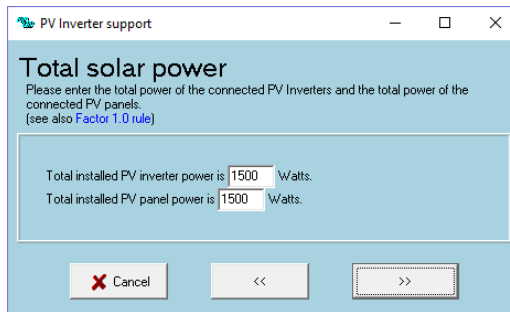
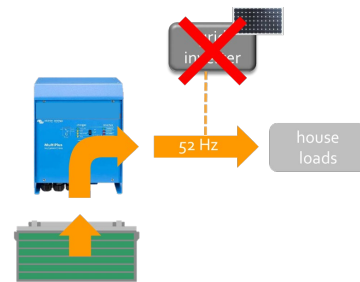
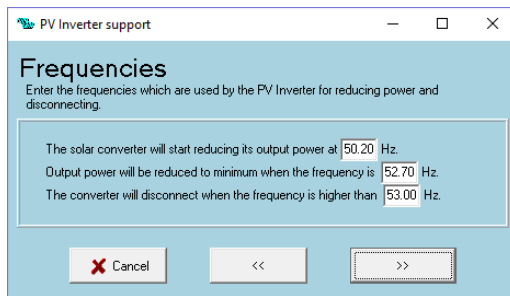
# Self consumption Hub assistants



- Only for old systems
- **Some are deprecated**
- Consider using ESS or ignore AC

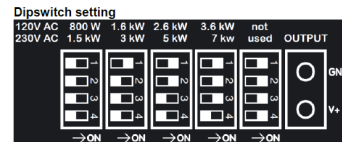
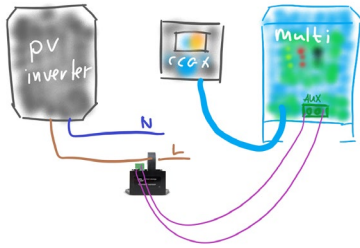
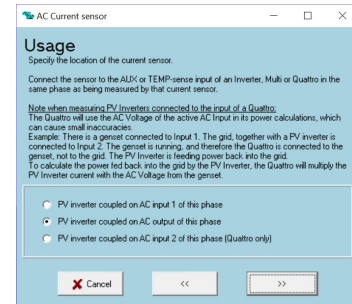
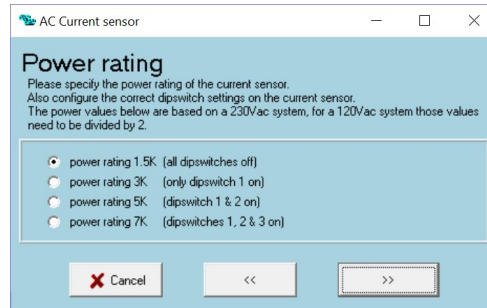
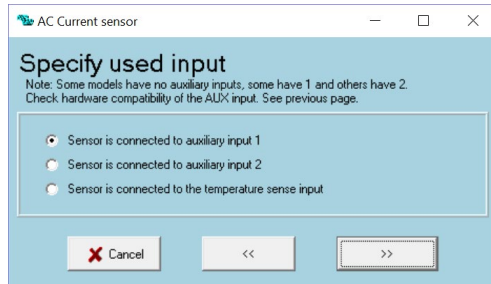
# PV inverter Assistant

- Turning the PV inverter off and on via a frequency shift depending on battery voltage
- Always check if the PV inverter can switch on or off based on a frequency shift
- Battery overcharge will occur if this system is set up incorrectly
- The Factor 1:0 rule: Do not install more KW solar than the KW rating of the Multi or Quattro



# AC Current sensor Assistant

- Use to display the current from a non-Fronius inverter on the CCGX or Venus GX



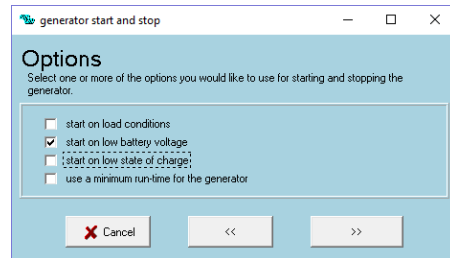
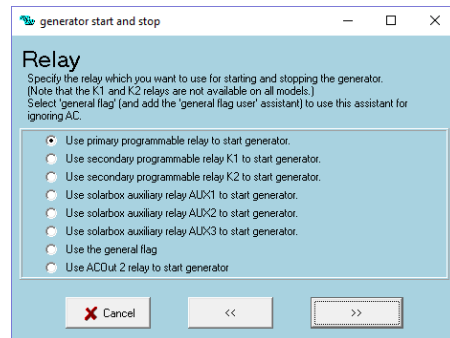
# Generator start and stop Assistant

This assistant is used for starting a generator in off grid systems.

Consider using the CCGX generator start instead

But it can also be used for:

- Selectively letting grid in.
- To turn on a dump load once the batteries are full
- To turn of a grid feed inverter connected to output 2 of a Quattro
- To drive a contactor to turn a grid feed inverter off



# Two wire BMS support

- The AUX or temp sense inputs are used to communicate with the BMS

Two-signal BMS support

### BMS options

Select the option corresponding to the BMS used.

- The BMS has separate contacts for high-cell/battery full and low-cell conditions
- The BMS has one contact which switches only on a high-cell condition
- The BMS has one contact which switches only on a low-cell condition
- The BMS has one contact which switches on low- and high-cell conditions

Cancel << >>

Two-signal BMS support

### Action

Specify the action to perform depending on high-cell/battery full.

Force to float and set SOC to 100% when battery full and switch to charger only when battery empty.

Cancel << >>

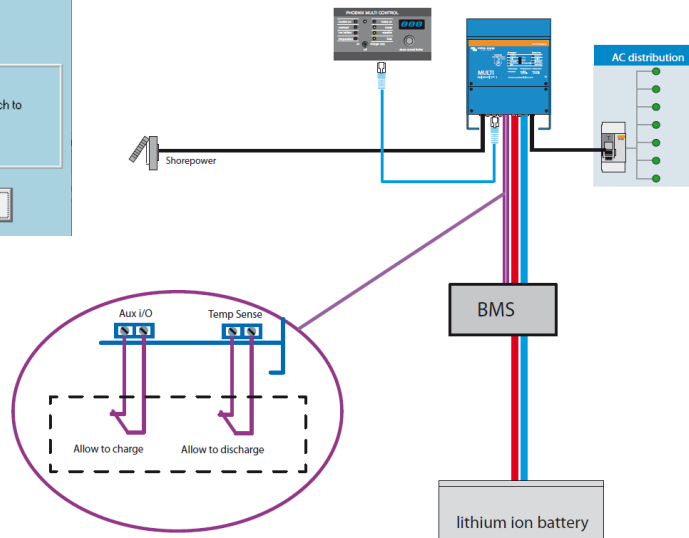
Two-signal BMS support

### Battery state inputs

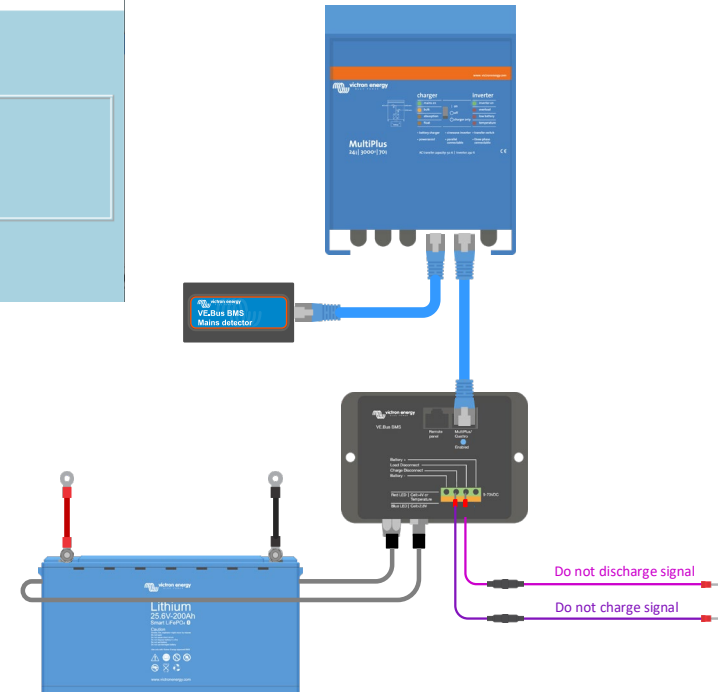
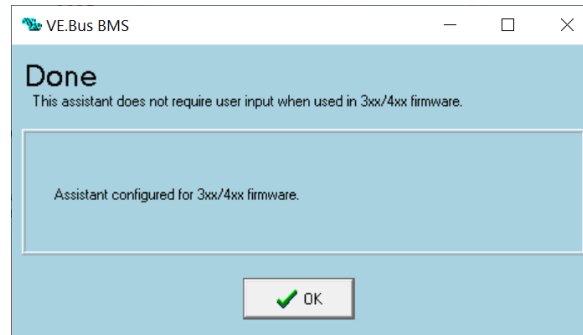
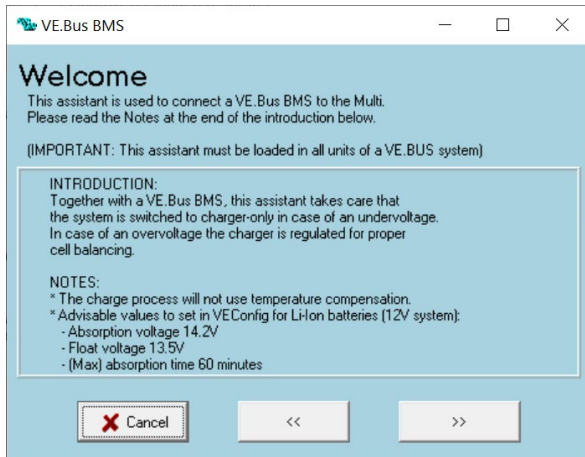
Specify the conditions which indicate high-cell/battery full and empty.  
(Note: Some models have no auxiliary inputs, some have 1 and others have 2)

The battery is full when Auxiliary input 1 is open and the battery is empty when Temperature sense input is open

Cancel << >>



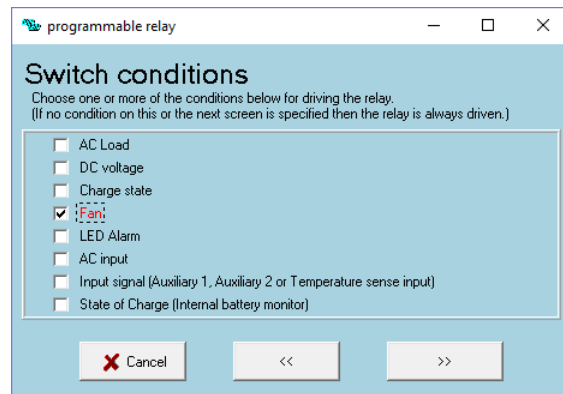
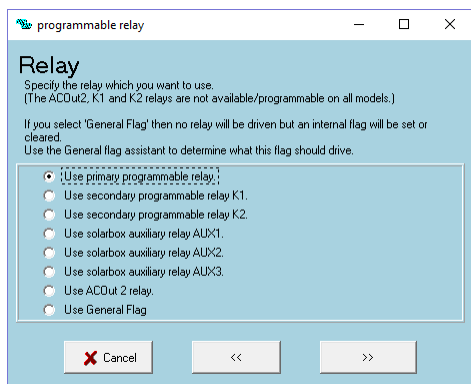
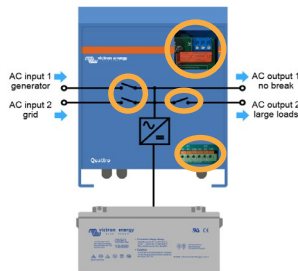
# VE.Bus BMS Assistant



# Programmable relay Assistant

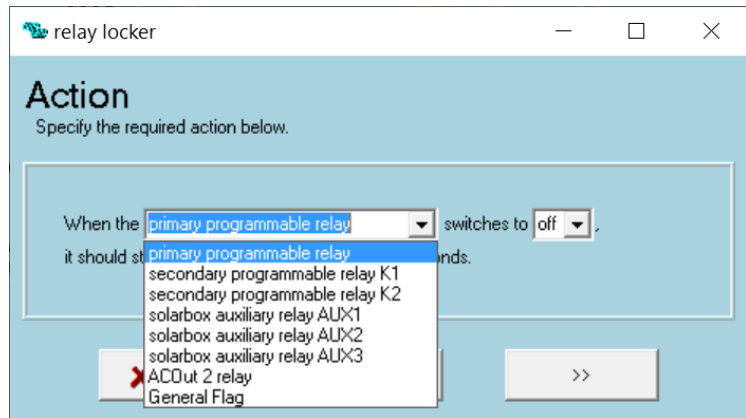
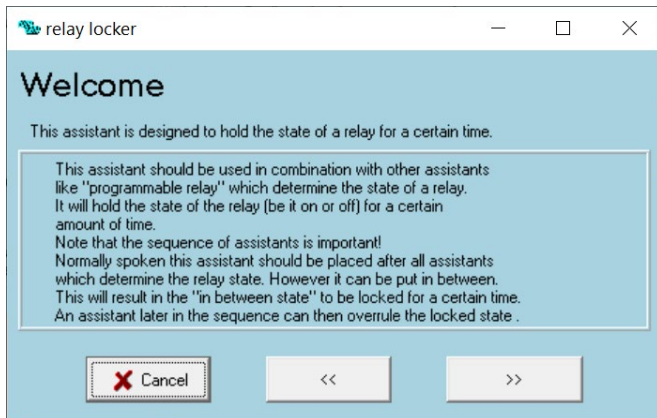
To drive one of these relays:

- Programmable relay
- K relays
- AC output 2
  
- Via the general flag:
  - AC input 1
  - AC input 2
  - AES mode



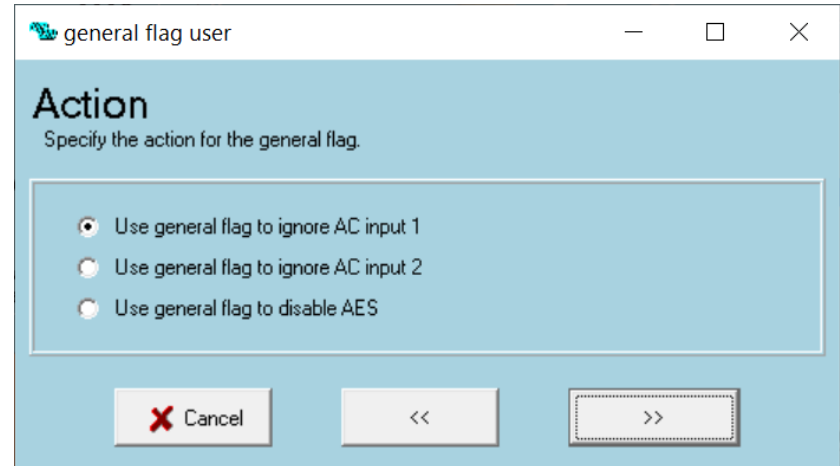
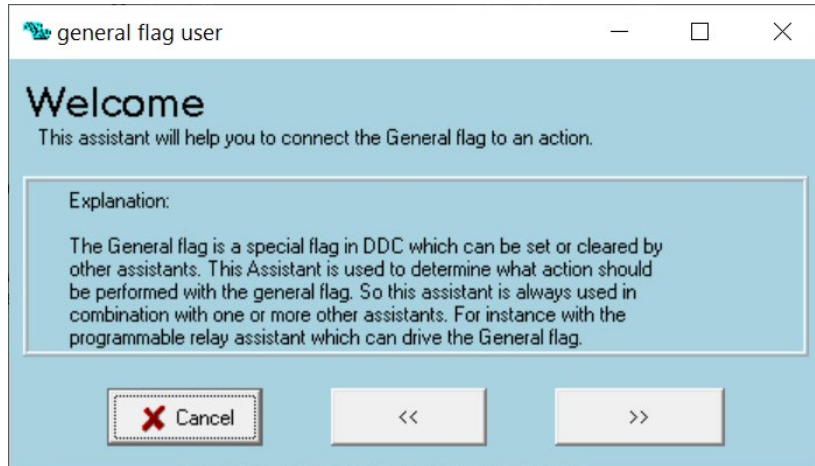
# Relay locker Assistant

Will hold the state of a relay for a certain time



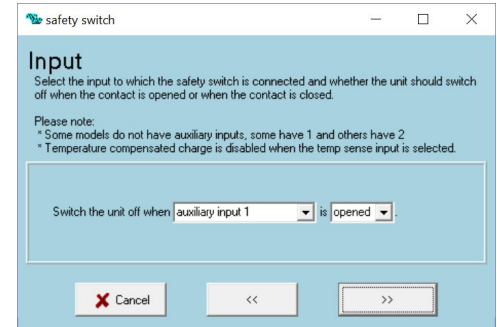
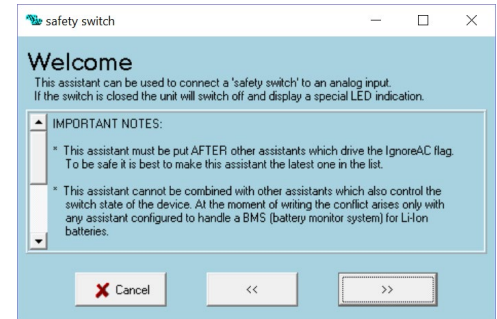
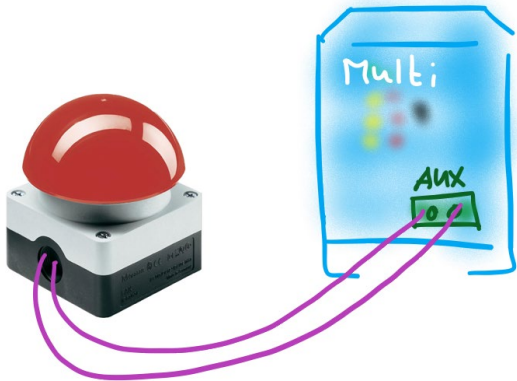
# General flag user

Is needed to connect one or more assistant(s) to a flagged action



# Safety switch Assistant

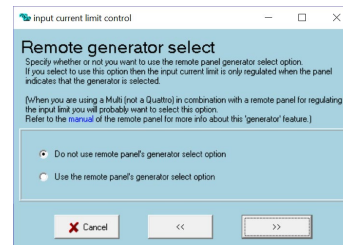
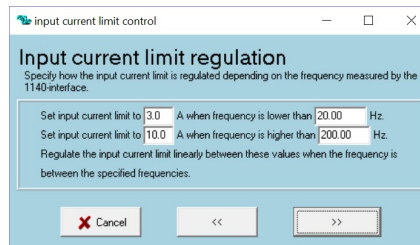
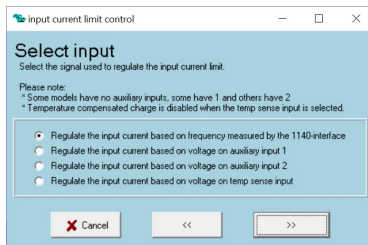
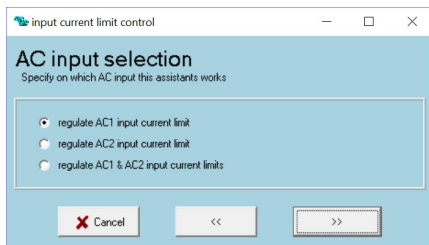
- Use to switch off the AC output when an external switch is pressed
- This assistant might conflict with lithium assistants



# Input current limit control Assistant

AC input current limit can be changed depending on:

- The 1140 interface
- Or status of AUX port



# Charge current control Assistant

Charge current can be changed depending on:

- Which AC input is used
- Or status of AUX port

charge current control

When to change the DC charge current?

Change the DC charge current: always

Cancel << >>

charge current control

Select

Select how the charge current should be changed.

Please note:  
\* Some models have no auxiliary inputs, some have 1 and others have 2  
\* Temperature compensated charge is disabled when the temp sense input is selected.

- Change the charge current based on voltage on auxiliary input 1  
The signal should be connected to THIS Multi/Quattro.
- Change the charge current based on voltage on auxiliary input 2  
The signal should be connected to THIS Multi/Quattro.
- Change the charge current based on voltage on temp sense input  
The signal should be connected to THIS Multi/Quattro.
- Specify a fixed charge current value

Cancel << >>

charge current control

DC charge current regulation

Specify how the DC charge current is regulated depending on the (approximate) voltage measured on the selected input on this device.

[Note: The analog inputs do have an internal pull-up. So if one needs to switch between 2 charge currents one can simply connect a relay and specify the voltage levels below at approx 2V.]

Set DC charge current to 1 A when voltage is lower than 1.00 V.  
Set DC charge current to 52 A when voltage is higher than 4.00 V.

Regulate the DC charge current linearly between these values when the voltage is between the specified voltages.

Cancel << >>

charge current control

Disable charger

Would you like to disable the charger if the DC charge current should be zero?

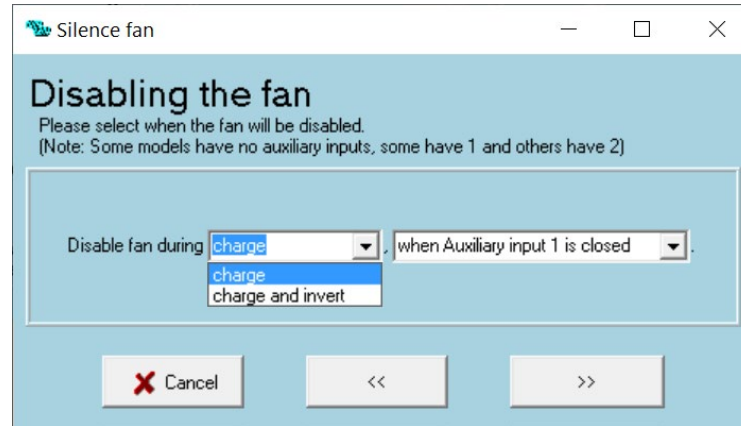
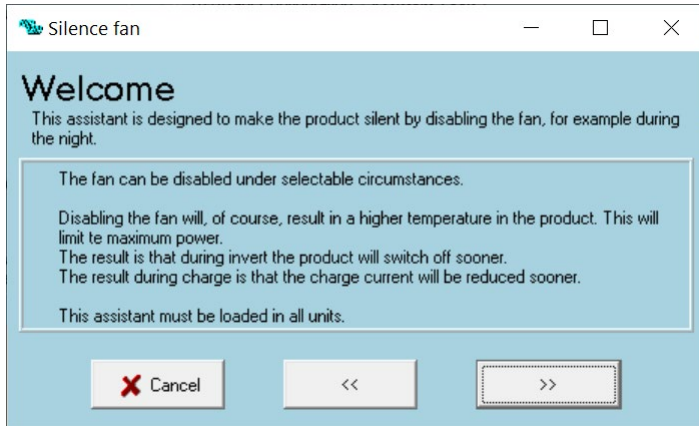
Explanation:  
Normally, a small DC current will remain when charger stays enabled. Disabling the charger will make the charge current really zero.

Disable the charger when charge current should be zero.

Cancel << >>

# Silence Fan

To silence the fan under selectable circumstances





Energy. Anytime. Anywhere.