

ESS mode 2 and 3

This page explains how to use a Multi/Quattro as a bidirectional inverter operating parallel to the grid, integrated into a customer designed system (PLC or other). In mode 2, Advanced, or more 3, Custom.

Note that it is also possible to run a Victron grid parallel storage system without designing and implementing your own control loop, logic or measurements. See the [ESS manual](#).

1. Overview of ESS operating modes

1.1 Mode 1 - Standard

The system runs automatically, and uses excess energy harvested during the day to fill the gaps when there is not enough PV power available. Typically in the evening and night. Easy configuration in Assistants and on the Color Control GX. For details refer to the [ESS manual](#).

1.2 Mode 2 - Advanced

Same as standard operating mode, but customer adds custom control doing time shifting, load management or other energy management optimization algorithms. The required components in the system, as well as the general software setup, is 100% equal to the default, Mode 1. The available control points are:

- Grid power setpoint
- Enable/Disable charge
- Enable/Disable inverter

There are two ways access those control points:

- Send commands to the CCGX via ModbusTCP, from an external control module, a PLC for example.
- Run self-implemented scripts on the CCGX, same functionality, but then it is not needed to add a PLC to the system.

For more information, see [the Mode 2 details](#).

1.3 Mode 3 - Custom

Customer self implements their control loop and grid measurements, and uses the MultiPlus and/or Quattros as simple, remote controllable, bidirectional inverter/chargers that can be set to either charge or discharge an x amount of Watts. Note that the point of control is the AC-input, not the charger itself.

Power to/from AC-input = Power to/from battery + Power to/from AC-output

Necessary Victron equipment:

- Multi or Quattro inverter/charger
- Color Control GX
- Note that there is no AC sensor necessary, since the inverter/charger will act as a 'dumb' bi-directional inverter/charger. It will act on the external command given, which can for example be 'take 2000W from AC in, or feed back 100W through AC in'.

Available control points:

- Switch (on, charger-only, inverter-only, off)
- Power setpoint in Watts: regulates the power on the ac-input.
- Disable charge flag
- Disable feed-in flag

For more information, see [the Mode 3 details](#).

2. Details of operating mode 2 - Advanced

2.1 Available control points

a) Grid power setpoint - Modbus-TCP register 2700

- Positive: take power from grid.
- Negative: send power to grid.
- Default: 0W.
- This register has range -32768W to 32767W (scale factor=1). Use register 2703 for a larger range (scale factor=0.01).

b) Enable/Disable charge - Modbus-TCP register 2701

- 0: disable charging. This setting may be used for time shifting. For example by disabling charging the battery when feeding back to the grid is profitable, and leaving battery capacity for later.
- 100: unlimited charging. Battery, VEConfigure settings, and BMS permitting. Use value 100 here instead of 1 because this setting was originally designed to be used as a percentage.

Note that this settings has a higher priority than the *Grid power setpoint*.

c) Enable/Disable inverter - Modbus-TCP register 2702

- 0: disable inverter
- 100: enabled inverter. Use value 100 here instead of 1 because this setting was originally designed to be used as a percentage.

Note that this settings has a higher priority than the *Grid power setpoint*.

See the Modbus-TCP excel sheet for scaling and datatypes, available [here](#).

2.2 Accessing the control points

A) Via ModbusTCP

See above mentioned register numbers. Use ModbusTCP unitid 100.

B) Via MQTT

Recently we have added MQTT to the protocols on the CCGX. For more information, see [the developer mailing list](#) as well as the [mqtt github repo](#).

C) Running your own scriptson the CCGX

Start reading [here](#).

The ESS related D-Bus paths are:

- com.victronenergy.settings /Settings/CGwacs/AcPowerSetPoint (Grid power setpoint)
- com.victronenergy.settings /Settings/CGwacs/MaxChargePercentage (Enable/Disable charger)
- com.victronenergy.settings /Settings/CGwacs/MaxDischargePercentage (Enable/Disable inverter)

Note that the paths are represented as percentage, but should be used as on/off switch (0: off, 100: on).

2.3 Background

In standard mode the ESS control system tries to keep the power flowing through the grid meter at 0 Watt (so no power is taken in from the grid, nor is any power fed back to the grid). Mode 2 means you set the target for the grid power. Setting the target to 100 Watt means that the system tries to take 100 Watt from the grid. The power will be used to feed the loads or charge the battery. Similar, a negative value will instruct the system to feed back power to the grid. This will be PV power when possible, otherwise the battery will be discharged. Reset the setpoint back to 0 Watt, and you are back in standard mode again.

In addition you can also control battery charge and discharge. This allows you to control when the battery is charged and discharged.

2.4 Notes

- The above settings are intended for power management, and will be overridden by battery safety mechanisms. For example: if the multi is in sustain mode - because the battery is almost

empty - it will start charging the battery, even if the grid power setpoint is negative or the maximum charge percentage is set to zero.

- Sustain will always remain in operation. Disabling charge will not disable sustain.
- In mode 2 the CCGX will change the Multi's AC-In power setpoint (see Mode 3) continuously, so it does not make sense to change the setpoint in this mode.
- See modbustcp excel sheet for scaling and data types, available [here](#).

3. Details of operating mode 3 - Custom

3.1 Operation

Mode 3 means you take direct control of the Multi itself by setting the power it should take/feed back on its AC input. It allows for easy control of the power flowing to the battery. The power flowing to the batter (or more precise: to DC system attached to the Multi) is equal to the AC-In power minus the AC-Out power. In mode 3 you have to create your own control loop, and update set setpoint frequently.

- When the grid is available, the Multi will be connected to the grid. You can control its operation with the Power setpoint. When positive, energy will flow to the grid. When negative, energy will be taken from the grid. Some examples:
 - When set to +400W, it will feed 400W back through its input. This energy will be taken from the battery. If there is also a 200W AC load connected to AC output the total energy taken from the battery will be 600W. The batteries will always be discharged when the setpoint is positive.
 - When set to -400W, it will take 400W from the AC input. When the load on the output is lower than 400W, it will charge the battery with the difference. When the load on the AC output is higher, it will discharge the battery with the difference. So with a negative setpoint charge/discharge depends also on the connected loads.
 - **Important note:** When using the CCGX to communicate with the ESS assistant (see further on) you should bear in mind that the CCGX inverts the setpoint. So positive becomes negative and vice versa.
- Note that it will always remain within battery and maximum inverter power limits: when the battery is full, or when the maximum charge current as configured in VEConfigure is already met, it will not draw more power. And when instructed to discharge with 10000 watt, while it is a 2500W inverter, it will discharge with 2500W, until the battery is empty.
- To force the Multi to Inverter Mode, set the switch to Inverter-only. Note that when you do that, there will be no grid assist, meaning that on an overload the Inverter will switch off, signalling overload alarm. Instead of switching back to grid.
- When no grid is available, it will automatically switch to inverter mode (seamless), unless the switch is set to charger-only. While in inverter mode, the Power setpoint is in-effective.

3.2 Notes

If no new value is sent to the Multi for longer than 60 seconds, the Multi will automatically fall back to 'bypass' that is: No charge/No discharge. The internal transfer relay is closed when AC input is available. In that case any loads on the AC output are fed by the AC input. If there is no AC input available, the unit will switch to inverter mode. (Unless it is set to 'Charger Only' or receives a 'low cell' signal from the VE.Bus BMS).

- Send a target value to the CCGX via ModbusTCP:
 - unit-id 246 (= CCGX VE.Bus port)
 - register-id 37 (= /Hub4/L1/AcPowerSetpoint)
Value of the setpoint (phase 1 on multi phase systems)
Important: The CCGX inverts the value of the setpoint. So use a positive value to instruct charging and a negative one to tell it to discharge. The unit is Watts.
 - register-id 38 (= /Hub4/DisableCharge)
Value 0: charge enabled, Value 1: charge disabled.
Important: Disabling charge will also disable feedback.
 - register-id 39 (= /Hub4/DisableFeedIn)
Value 0: feed-in enabled, Value 1: feed-in disabled.
If feed-in is disabled, the battery will not discharge. In case of grid failure, this parameter will be ignored and power will be supplied to AC Out.
 - register-id 40 (= /Hub4/L2/Setpoint)
Value of the setpoint on phase 2
 - register-id 41 (= /Hub4/L3/Setpoint)
Value of the setpoint on phase 3
- Note that it can very well be that the Multi does not do what you want it to do, because the battery is either empty, or full for example. Therefore, for your control algorithm, read the actual power back from the Multi, unit-id 246 and register-id 12.
- See modbustcp excel sheet for scaling and data types, available [here](#).
- Note that the mechanism is slow, which to our opinion is not perfect, but also no problem.
- The 'VE.Bus to VE.Can interface' does not yet support reading and writing the ESS/grid-parallel setpoint.
- If your system contains a ESS compatible AC-Sensor which is set up as grid meter, the CCGX will automatically enter mode 1 and start updating the AC power setpoint continuously. You can disable this behavior by setting *Settings→ESS→Mode* to *external control*. This will also disable [BatteryLife](#). To do this via D-Bus or MQTT: set the value of /Settings/CGwacs/Hub4Mode in the com.victronenergy.settings service to 3 (=ESS control disabled).

3.3 Using the MK3 directly instead of CCGX

3.3.1 Introduction

In this setup, it is not necessary to use a CCGX. Instead an MK3 is used. We have both MK2-RS232 and an MK3-USB available, see the pricelist.

The MK3-USB has replaced the MK2-USB. There are no differences in the protocol.

A direct connection to the VE.Bus RS485, without MK3 or CCGX, is not possible.

Note that, as also indicated on the Datacommunication whitepaper, the MK2/3 protocol is not an easy protocol. That is unfortunate, but it is what it is. And we cannot give support on it unless there is a huge commercial value behind the project, read thousands of Multis or Quattros.

And now, after all the warnings, the information:

3.3.2 Working with RAM IDs to address Assistants

Use RAM ID 128 and higher. Every RAM ID is a word (2 bytes)

The assistant RAM will be filled from ID 128 with 'assistant RAM records'. Each record starts with a word that contains the AssistantID and the size of the record, and then a number of AssistantRAM words.

RAM ID	contents
128	ID_Size (1st Assistant)
129	1st AssistantRAM0
130	1st AssistantRAM1
...	...
RAMn	1st AssistantRAMn
RAMn+1	ID_Size (2nd Assistant in this VE.Bus device, if any)
RAMn+2	2nd AssistantRAM0
RAMn+3	2nd AssistantRAM1
etcetera	

The ID_Size word contains 0xZZZY, where:

- ZZZ = the Assistant ID. This is where you can recognize the function of the assistant (ESS ID = 5)
- Y = the number of ramIDs that will follow after the ID_Size. At the moment of writing this is 2 for the ESS Assistant version. This can be increased in future releases if more parameters become available.

So you have to scan the Assistant RAM records by looking at each ID_size record.

3.3.3 ESS Assistant RAM IDs

The RAM ids of the ESS Assistant are:

- AssistantRAM0: AC-in setpoint in Watts (positive for charge, negative for discharge)
- AssistantRAM1-bit 0: 'disable charge'-flag
- AssistantRAM1-bit 1: 'disable feed-in'-flag

Above information is an addendum to the 'Interfacing with VE.Bus products' document. Available from our [whitepapers](#).

3.3.4 EXAMPLE

A communication example (assumed is that the ESS assistant is the 1st assistant in the assistant list using AssistantRAM. So this means that the ID_Size is at RamID 128.)

Reading the Assistant ID and Size in the RAM-ID table:

This uses the CommandReadRAMVar command, 0x30:

→ 0x05, 0xFF, 0x57, 0x30, 0x80, 0x00*, 0xF5
(Length, 0xFF, 'W', 0x30, Lo(ID), Hi(ID), Checksum)

Response:

← 0x07, 0xFF, 0x57, 0x85, 0x32, 0x00, 0x52, 0x5A, 0x40
(Length, 0xFF, 'W', 0x85, Lo(ValueA), Hi(ValueA), Lo(ValueB)*, Hi(ValueB)*, Checksum)

ValueA is the contents of RAMID 128. In this example it is 0x0032 which indicates ESS with 2 extra RAMIDs.

**) Please note that you will get an extra ValueB. This is a feature of newer Multi firmware versions. Because the IDs range from 0..255 the Hi(ID) field would always be 0. Newer Multi firmwares allow you to specify a second ID in this field. So in this case ValueB is the value of RAMID 0 because the 0x00 is interpreted as the second ID. RAMID 0 corresponds with UMains (This can be found in paragraph 7.3.11 of the 'Interfacing with VE.Bus products' document.) So in this example the UMains value is 0x5A52 ⇒ 231.22V NOTE: You will always get a ValueB in the response. You can make handy use of this by reading an extra RAMID or you can ignore it if you don't need it.*

Writing the set point with +200 Watt:

This uses the CommandWriteRAMVar command, 0x32:

We should write RAM ID 129 to +200. Writing requires 2 frames, one frame specifying the ID to write and one frame specifying the data to write.

→ 0x05, 0xFF, 0x57, 0x32, 0x81, 0x00, 0xF2
(0x32=Command Write RAMID, 81 00 = 129, Note that 2nd byte will always be 0 in this command)

→ 0x05, 0xFF, 0x57, 0x34, 0xC8, 0x00, 0xA9
(0x34=Command Write Data, C8 00 = 200)

Note: If a negative set point is needed you should specify this as the 2's complement value so for example -200W must be specified as 0xFF38 (=65536-200) so that would result in: → 0x05, 0xFF, 0x57, 0x34, 0x38, 0xFF, 0x3A

Response:

← 0x05, 0xFF, 0x57, 0x87, 0x00, 0x00, 0x1E Write OK (87 means successful. Just ignore the rest of the frame (00,00 in this case))

Please refer to the 'Interfacing with VE.Bus products' document, available from our [whitepapers](#), for more info on communicating with the MK3 in general, and more specifically the CommandReadRAMVar and CommandWriteRAMVar commands.

4. Combining ESS with Lithium batteries

- Victron Lithium batteries with a VE.Bus BMS: select this in the ESS assistant and all will be done automatically.
- Non-Victron batteries:
 - when you do not want to discharge, set the switch to charger-only. Note that when the switch is set to charger-only, and there is no grid available, there will still be a small power draw on the battery to power the control board.
 - when you do not want to charge, disable charging via the disable-charge flag.

- As an alternative to running the control loop externally, using ModbusTCP, it is also possible to run code on the CCGX itself and update the AcPowerSetpoint via D-Bus. We have one customer that is running a MQTT client on the CCGX, written in Python, that gets the control-loop output as updates from a MQTT broker. And the Python script sends them to the Multi, using D-Bus service `com.victronenergy.vebus.ttyO1`, and path `/Hub4/AcPowerSetpoint`

5. Response times

Depending on which components are used, and from which point the communication is sent to the inverter, there are several factors involved in the response time: the Color Control GX, ModbusTCP, MK3 microprocessor, the Assistant, and the Multi itself.

The (now deprecated) Hub-4 Assistant had no rate limiter.

The ESS Assistant has a rate limiter. In the currently latest version (162) it is at 400W per second

Background: late 2016, we copied the Hub-4 Assistant, and named the copy "ESS Assistant". And then development on the Hub-4 Assistant was stopped. The reason for the rate limiting is that without that there are regulation problems (overloads and such) when the mains is weak (long cables and such resulting in a relatively high impedance). More information on that [here](#), as well as in the main ESS manual.

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