Solar home storage sytem

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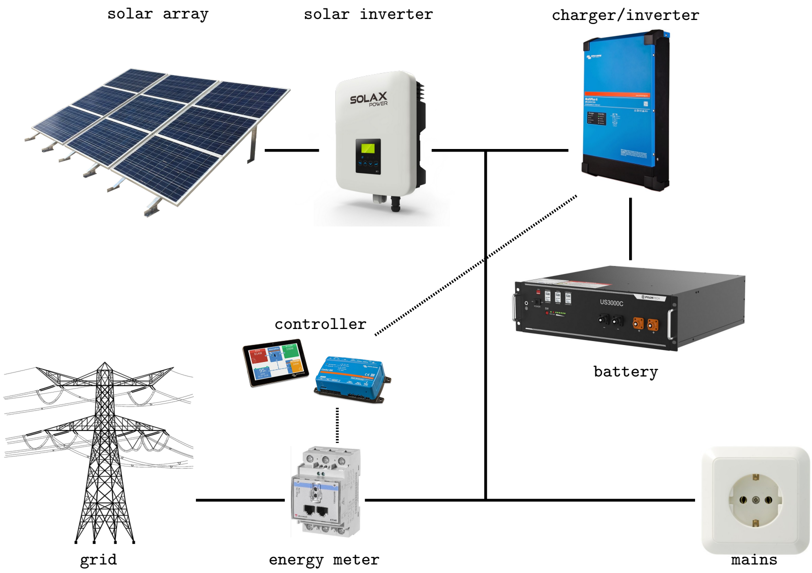


Abstract

My house is equiped with solar panels. These are grid tied. During the day time, I can use part of the energy from the solar systems myself. And surplus energy is being fed back into the grid. During night time I use energy from the grid. The Dutch government subsidize these type of systems by allowing netting of the energy, meaning that I only have to pay for the difference between used energy from the grid and the energy fed back into the grid. This subsidy is about to end.

To become more self sufficient in energy and save some money in the process, I added a battery storage system to my existing grid tied solar system. The idea is that a days worth of sunshine is enough to power my house for the whole 24 hours, also in late autumn and early spring. Surplus energy is still being fed back into the grid.

In this build document I describe the specifications, component selection and build of this storage system.

Contents

1 The specifications

1.1 Energy storage

First, I have to figure out the specifications for the system. To start, it is important to know how much energy is needed every day. According to the electricity bill, I consume $1500kWh$ per year. That's $1500kWh/365days = 4kWh/day$. But that's only the average as the actual power consumption will vary day by day. For example, I do not use the washing machine every day but when I do, the power consumption of that day can easily be $1kWh$ higher.

So, just to be on the safe side I use a factor of 1.5 to calculate the needed energy storage capacity: $4kWh \cdot 1.5 = 6kWh/day$.

1.2 Energy harvesting

The energy harvested by the solar panels must be at least the same as the energy that is consumed every day. Otherwise, there will be no energy left in the battery the next day. The solar panels must therefore be able to generate $6kWh$ of energy every day, preferable during the whole year.

And therein lies the challenge: table 1 shows the hours of daylight per day for each month. January has only half the hours per day as July. And on top of that, the angle of the sun is lower in the winter. The amount of energy per m^2 is significantly lower in winter compared to summer. And not every day is sunny, which makes the problem even more difficult.

Month	Hours of daylight
January	8
February	10
March	12
April	14
May	16
June	17
July	16.5
August	14.5
September	12.5
October	10.5
November	8.5
December	7.5

Table 1: hours of daylight at 53 degrees latitude.

A compromise has to be made. Lets design a system that can generate enough energy to charge the battery on a sunny day from March to October. First, we need to know the amount of energy we can expect from the sun per m^2 in every month. Than we take the month with the least amount of energy per m^2 as base for further calculations.

Luckily, there is a good data source on the internet[1] which has data collected over a 22 year period. Table 2 shows the numbers for the north of the Netherlands for a panel facing south with various panel angles. October seems to be

[1] http://www.solarelectricityhandbook.com/solar-irradiance.html

the month with the lowest energy per m^2 per day. The optimal summer angle of 52° is, with $2.18kWh/m^2/day$, which is also the worst performing angle for October from the three different angles.

Month	22° angle **optimal winter** $kWh/m^2/day$	37° angle **optimal year round** $kWh/m^2/day$	52° angle **optimal summer** $kWh/m^2/day$
January	1.18	1.16	1.08
February	2.08	2.09	2.00
March	2.92	3.07	3.07
April	3.87	4.24	4.43
May	4.28	4.83	5.25
June	3.98	4.54	5.03
July	4.02	4.55	5.01
August	3.94	4.41	4.67
September	3.08	3.28	3.33
October	2.21	2.25	2.18
November	1.38	1.37	1.28
December	0.97	0.94	0.87

Table 2: averge solar insolation figures

A typical solar panel has an efficiency of about 20%. So it can harvest $2.18kWh/m^2/day \cdot 20\% = 436Wh/m^2/day$. For the total amount energy of $6kWh/day$ we need a panel of $\frac{6kWh/day}{436Wh/m^2/day} = 13m^2$.

Solar panels are typically specified in Watts, measured at an irradiance of $1000W/m^2$. That means that a solar panel with an efficiency of 20% and an area of $13m^2$ has a defined specified output power of $1000W/m^2 \cdot 20\% \cdot 13m^2 = 2600W$. So, for the project I need a solar panel array with a specified output power of at least $2600W$.

1.3 Grid tied

In the Netherlands, it can be cloudy for days. In summer, this is not a big deal. As the system is designed to work during the darker October days, there should still be enough light to charge the battery. But later in the season, it can become a problem. That's why the system should be grid tied: when the solar panels do not produce enough power **and** the battery is empty I don't want the lights to go off.

1.4 Mains

The system should be retrofitted to the existing mains power, so I do not have to rewire the whole house. Energy I use should comes from the solar panels and the battery first. Only when these cannot produce enough power, energy from the grid is used. Surplus energy from the solar panels is fed back into the grid.

My home is powered from a $16A$ connection. The inverter should ideally be able to produce equally as much power. As the mains voltage is $230V$, that's $P = U \cdot I = 230V \cdot 16A = 3680W$.

1.5 Backup

The system should be able to act as an **U**ninterruptible **P**ower **S**upply or UPS and power at least part of the house during a mains power outage. In the Netherlands, these outages are very rare. But when it happens it is frustrating that the light go out even when I have a full battery in the attic.

1.6 Summary

We now know the specifications for the system. The next step is to design the system using the appropriate components.

- $2600W$ solar panel array
- $6kWh$ battery
- $3680W$ inverter for mains output
- Grid tied
- Prioritize solar and stored energy
- Feed back surplus energy into the grid
- UPS capabilities

2 The design

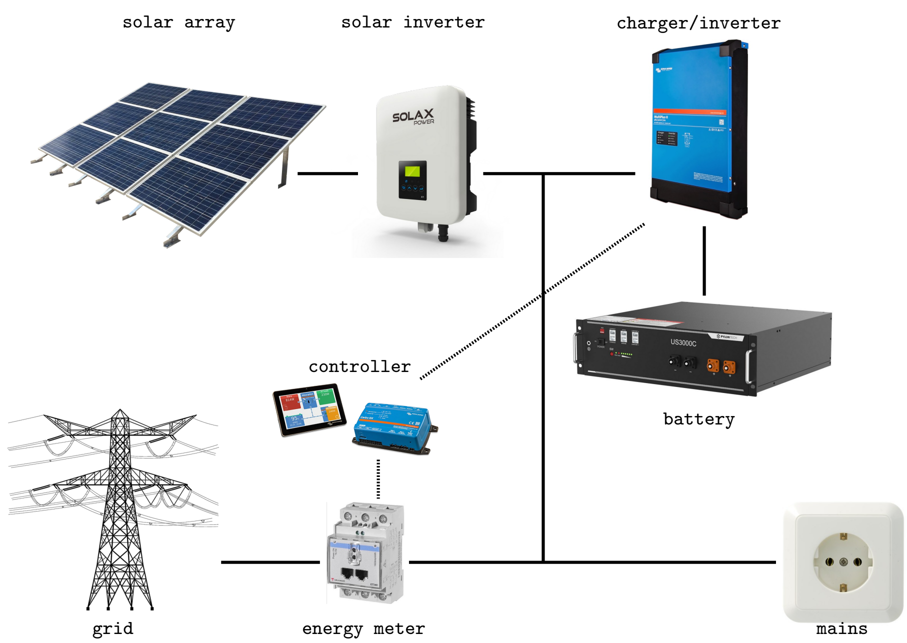


Figure 1: block diagram

2.1 Battery

There are three types of battery technology suitable for a home storage system: lead acid, lithium and salt water. Every technology has its own pros and cons:

Lead acid	
pros	**cons**
cheap charge/discharge at high current easy to charge	500-1200 cycles heavy only 50% usable capacity must stay below 40° C

Lithium	
pros	**cons**
5000-7000 cycles charge/discharge at high current 90% usable capacity not damaged by high temperatures	expensive fire hazard dificult to charge doesn't work below 0° C

Salt water	
pros	**cons**
5000-7000 cycles Safe 80% usable capacity large temperature range	very expensive can't charge/discharge at high current bulky not supported by major inverter brands

Table 3: Pros and cons of different battery technologies

Lead acid is cheap, but doesn't last nearly as long as lithium or salt water batteries, which makes it more expensive in the long run. Salt water batteries cannot charge and discharge at high power levels. When enough batteries are connected in parallel, larger power levels can be achieved, but that makes this already expensive technology even more expensive. Lithium is difficult to charge, but modern chargers are more than capable in this regard. Lithium batteries are also expensive, but last for 15 years ore more, which makes them cheap in the long run.

Than there is the elephant in the room: the fire hazard. Well, let me try to put that into perspective. We daily drive our cars full of highly flammable liquid fuel. We cook and heat our homes with natural gas burners. All very dangerous if you think about it, but we made it safe enough to not having to worry about that. The same it true for lithium batteries: they can explode and burn down your house, for sure. But when choosing the right battery technology and sticking with trusted brands the risks are low enough to not having to worry about that. For home storage systems, lithium iron phosphate batteries are the best choice. $LiFePO_4$ is an intrinsically safer cathode material than $LiCoO_2$ and manganese dioxide spinels used in other lithium-ion technologies. This makes it thermal and chemical more stable, which improves battery safety. This means that $LiFePO_4$ batteries will not catch fire that easily when abused[2].

[2]https://en.wikipedia.org/wiki/Lithium_iron_phosphate_battery#Safety

For home storage systems, 12 Volt, 24 Volt, 48 Volt and high voltage batteries can be used. 12 Volt batteries are plenty-full and at first sight the obvious choice. But when the system has to deliver $3680W$ of power, the current at 12 Volt is $I = \frac{P}{U} = \frac{3680}{12} = 307A$, which is substantial. When using sufficiently thick wiring, it is possible. But power losses can be high. A higher voltage results in a lower current at the same power level. A high voltage battery seems the better choice. But these batteries come as expensive proprietary systems not suited for DIY. But what about the 48 Volt batteries? I am clad you asked! These batteries are used in large scale battery storage systems at wind and solar farms and by design suited for scalable custom builds. Perfect for DIY. And with four times the voltage of a 12 Volt system, the maximum current will be four times lower: $\frac{307A}{4} = 77A$.

The Pylontech batteries are compatible with most available inverters and therefore a good choice. Two Pylontech US3000C $3.5kWh$ batteries (a total of $7kWh$) or three Pylontech US2000C $2.4kWh$ batteries (a total of $7.2kWh$) in parallel should be sufficient.

The batteries can safely be discharged to 10% of the specified capacity, so from a $7kWh$ battery I can use up to $7kWh \cdot 0.9 = 6.3kWh$ of energy, which is slightly more than the $6kWh$ I need.

The **absolute maximum** charge and discharge current for one $3.5kWh$ battery is $74A$. Two batteries together can therefore deliver $2 \cdot 74A = 148A$. The **recommended maximum** charge and discharge current is $37A$ per battery, which is $2 \cdot 37A = 74A$ in total. The **absolute maximum** charge and discharge current for one $2.4kWh$ battery is $50A$. Three batteries together can therefore deliver $3 \cdot 50A = 150A$. The **recommended maximum** charge and discharge current is $25A$ per battery, which is $3 \cdot 25A = 75A$ in total. In both cases, the recommended charge and discharge current is slightly below the maximum needed current of $77A$. But this high a current is almost never needed. But when it is, the battery can handle it.

For the battery I choose the Pylontech US2000C ($2.4kWh$) or Pylontech US3000C ($3.5kWh$) LiFePO4 battery.

2.2 Inverter

The inverter has to deliver a maximum of $3680W$ of power to my house when I need it, but only when there is not enough solar power available **and** the battery has enough energy stored. When solar energy is available **and** the battery is not fully charged it has to charge the battery. When the battery is fully charged, the surplus solar energy has to flow back into the grid. And when there isn't enough solar power available **and** there isn't enough energy stored in the battery, the grid should deliver the needed energy for my house. But in that situation it should not charge the battery. And it also has to handle every situation in between. Finally, it must have a UPS function for those rare power outages. There is really only one contender for DIY projects and that's Victron Energy. This company used to make energy storage systems for boats, but shifted towards off-grid systems and now also makes grid tied systems. They provides excellent documentation and have a great community.

The only drawback is the noisy fan in there units. On a boat, that's probably not an issue, but in a domestic house, it can be. I can install the unit in a sound proof room, but it is something to be aware of.

For the inverter I choose the Victron Energy MultiPlus-II 5000VA.

2.3 Solar chargers

The Victron Energy inverter can charge the battery with existing grid tied solar inverters. This means I can use my already installed solar grid inverters.

For the solar charger I can use the existing solar inverters.

2.4 Solar panels

My existing solar system has an output of $1800Wp$. I need $2600Wp$ in total for the new home storage system, so I have to install at least another $800Wp$ worth of solar panels. The roof can accommodate four extra panels of $345Wp$ each. This will give me an extra output power of $4 \cdot 345Wp = 1380Wp$. Together with the existing $1800Wp$, the total output power will be $1800Wp + 1380Wp = 3180Wp$ That's lower than the maximum allowed power of $3680W$ for a $16A$ connection, so I can install the extra solar panels on the existing connection.

For the solar panels I choose the JA Solar JAM60S10/345.

2.5 Controller

The Victron Energy MultiPlus-II cannot do its job as a stand alone unit. It needs a special controller, which can keep track of all the generated, stored and needed energy in the house. This is important as it has to be able to prioritize the energy generated and stored by the system. Only when no energy is available, the grid is used as a backup. And only when there's more energy generated than the system can store and use in the house itself, the system will feed this surplus energy back into the grid.

The controller also needs an energy meter, which should be installed at the point where the grid enters the house.

For the controller I choose the Victron Energy Cerbo GX and an EM24 energy meter.

3 The build

3.1 Solar panels

This is straight forward: climb on the roof and bolt them down. The inverter is connected to the grid just like any other ordinary solar installation.

3.2 Controller

The Victron Energy Cerbo GX is basically a Linux computer with a lot of special I/O ports. Via these ports the controller communicates with the various part of the ESS system. It can be programmed via a smartphone, a web interface or a dedicated touch screen. A smartphone app sounds like a good idea until you think about it: smartphones have a service life of about three years (if you're lucky). The ESS has an expected service life of more than fifteen years. I cannot guarantee that in fifteen years time I still own a smartphone which is capable of configuring the Cerbo GX. A web interface is probably a better choice. Except

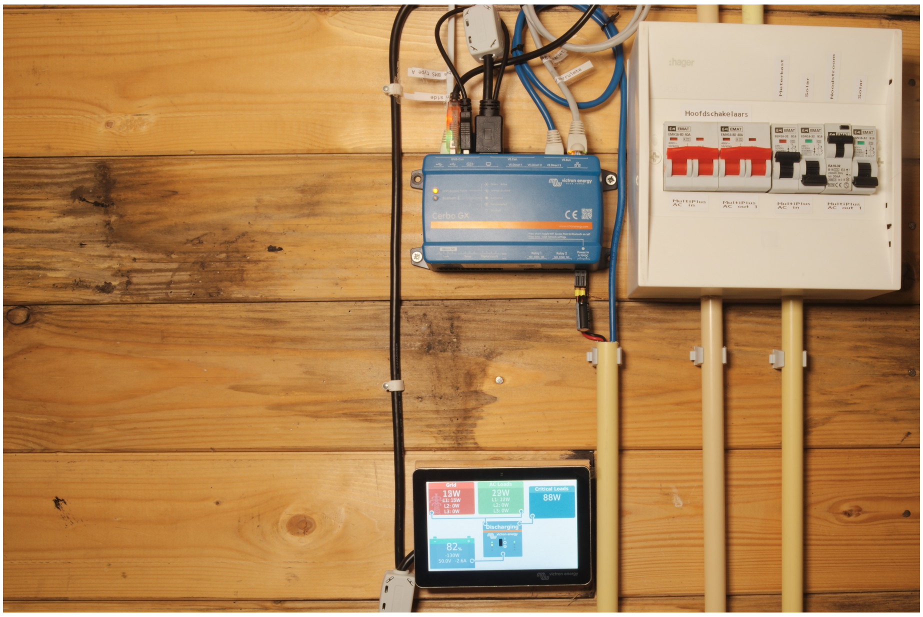


Figure 2: Victron Energy Cerbo GX

that the web interface can only be activated by first connecting a smartphone to the Cerbo GX. Oops!

A dedicated touch screen makes the Cerbo GX work as a stand alone unit, which is a future proof solution. With the touchscreen you can also activate the web interface, making the device configurable via the local network.

The unit will be installed close to the inverter and the battery. It will get its power from the 48V lithium battery bank.

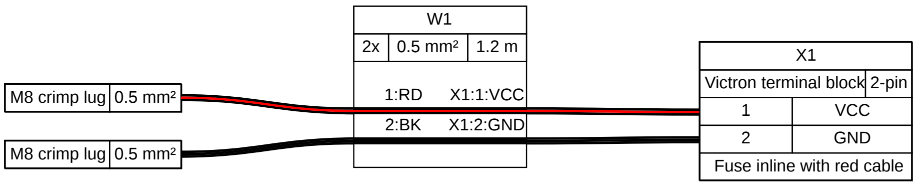


Figure 3: Power cable between battery bank and Cerbo GX

Victron Energy made a mistake: early Cerbo GX units cannot tolerate a fast rising voltage of 48V on the power input. They sometimes simply destroy themselves at power up. The precise cause is not know by me, but Victron Energy supplied the Cerbo GX with an electrolytic capacitor and a modification leaflet. Simply put, I had to install the capacitor between the plus and minus leads of the power cord as close as possible to the Cerbo GX itself.

3.3 Energy meter

The Victron Energy EM24 energy meter (which is a Carlo Gavazzi EM24) is needed to measure the power consumption of the house. The Cerbo GX can

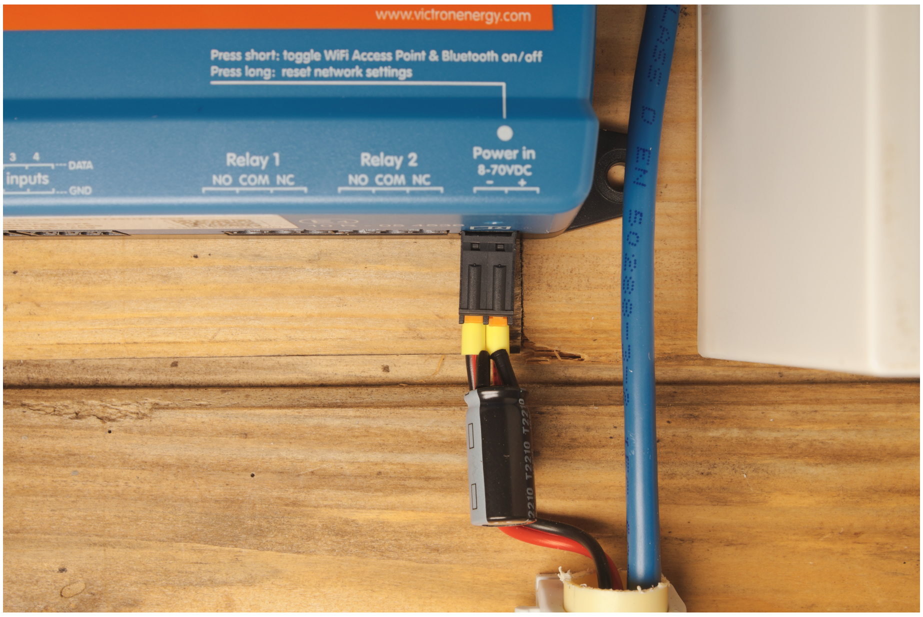


Figure 4: Power cable modification Cerbo GX

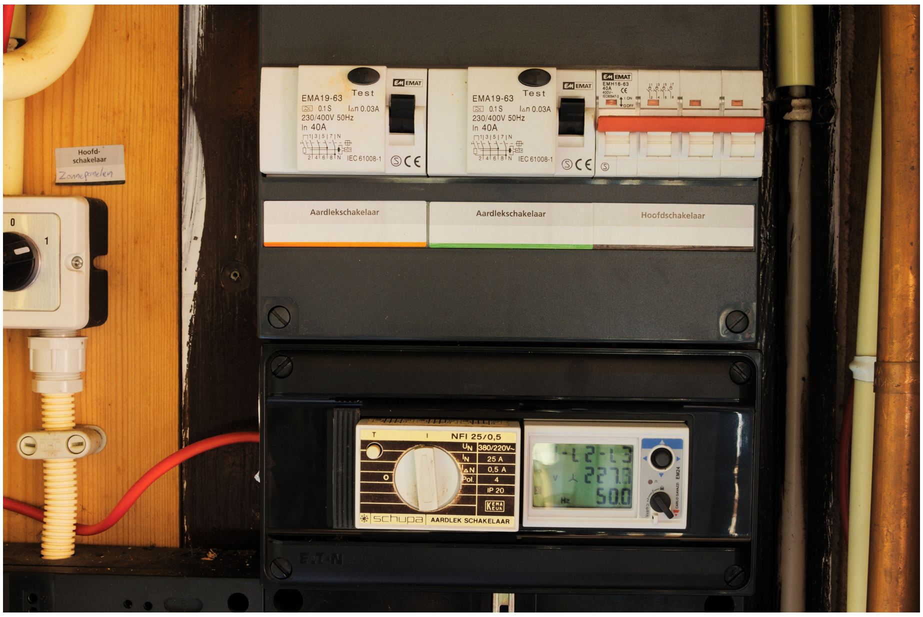


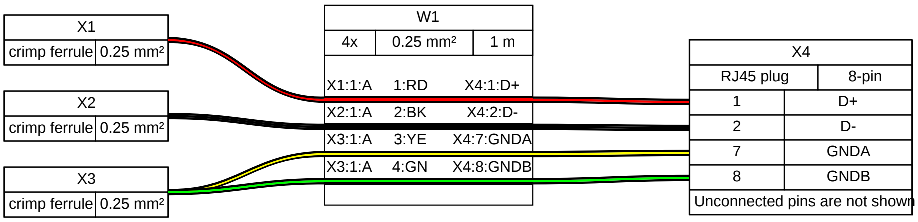
Figure 5: Victron Energy EM24

than decide whether this power is sourced from the solar panels, the battery or the grid. Basically, the Cerbo GX tries to keep the power drawn from the grid close to zero unless the battery is depleted and no solar energy is available.

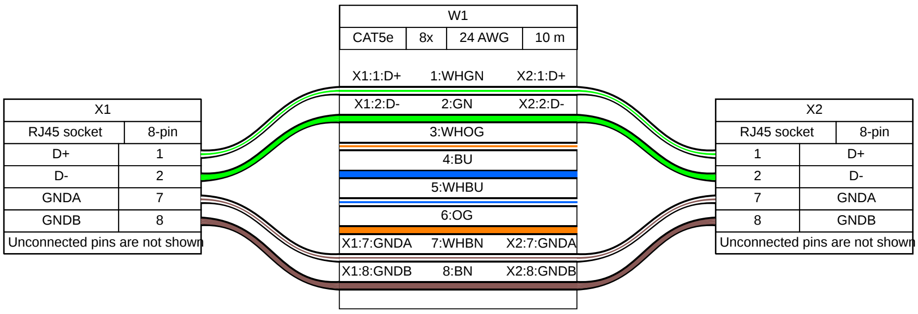
The energy meter communicates with the Cerbo GX via an RS-485 connection. Normally, this connection should be terminated with 120Ω on both sides, but I found that this did not work. Without the termination, the communication was flawless.

The unit must be installed in the main distribution cabinet directly behind the main switch. The small switch on the front of the meter has to be in the 1 or 2 position. Otherwise, the Cerbo GX cannot communicate with it.

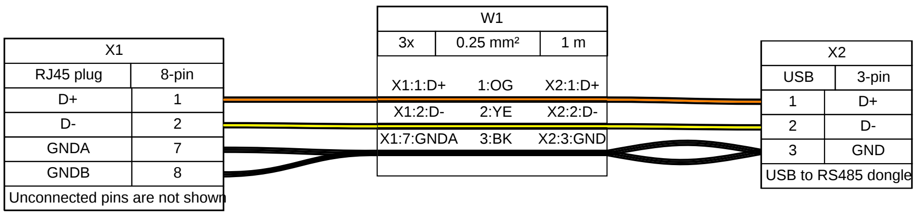
Victron Energy also list the ET340 as a possible energy meter. But this meter uses another means of calculating the energy consumption. Energy on the individual phases is measured separately, whereas the EM24 only registers the net energy of all the phases combined. Different countries use different methods. In the Netherlands energy is measured according to the EM24's method.



(a) RS-485 cable between EM24 and wall socket



(b) RS-485 cable between both wall sockets



(c) RS-485 cable between wall socket and Cerbo GX

Figure 6: RS-485 cable run

3.4 Inverter and charger

Figure 7: Inverter and charger

The Victron Energy MultiPlus-II 5000VA inverter/charger can charge and discharge the battery with up to 5000VA or 4000W of power. It is controlled by the Cerbo GX via a proprietary connection called the VE.bus.

The inverter is heavy and noisy. When handling large amounts of power, a fan starts running. But even more problematic, the large toroidal transformer is always humming. Therefore, I installed the inverter in a sound proof area.

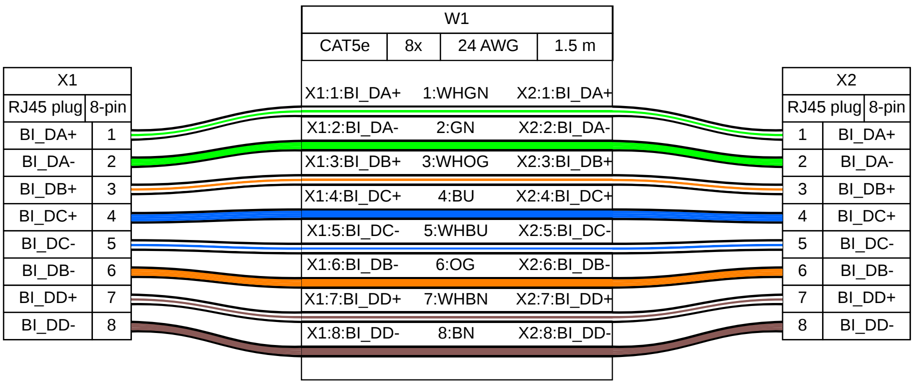


Figure 8: VE.bus cable between Cerbo GX and inverter

Before use, the inverter has to be programmed via a special programmer from Victron. The software only runs on Windows, so it is important to keep an old Windows 7 computer around. This is almost as bad as having to program the Cerbo GX via a smartphone. But this we could overcome by using a dedicated touch screen. For future troubleshooting I have to make sure I always keep this old Windows computer at hand.

3.5 Breaker box

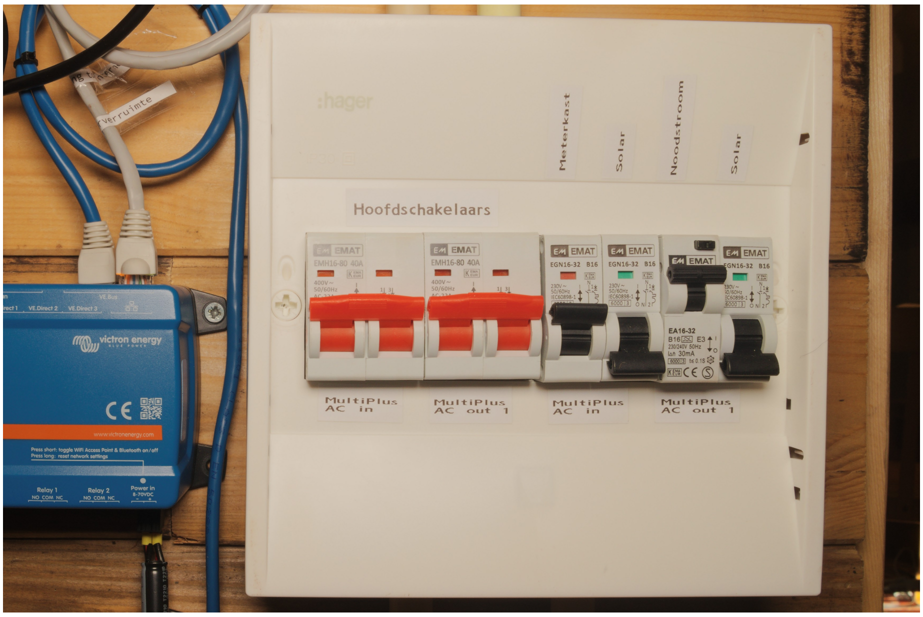


Figure 9: Breaker box

It should be possible to disconnect the inverter from the grid at any time. Therefore, I installed a small breaker box next to the inverter. This box also holds four automatic fuses, two for the input and two for the output of the inverter. This way, it is possible to connect both solar panels (producers) and consumers directly to the inverter, without having to route them through the main distribution cabinet.

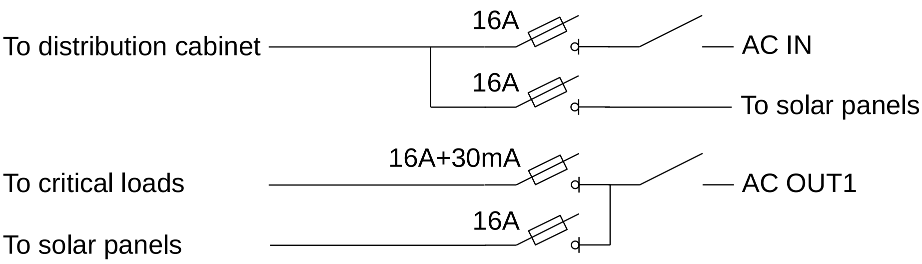


Figure 10: Wiring diagram of breaker box

3.6 Battery

Figure 11: Pylontech US5000 batteries

The Pylontech batteries can be coupled together: up to eight per bank without special equipment. You just connect them together with the supplied communication cables. The first battery is the master and is connected to the Cerbo GX via a CAN cable. The DIP switches should all be set in the OFF position.

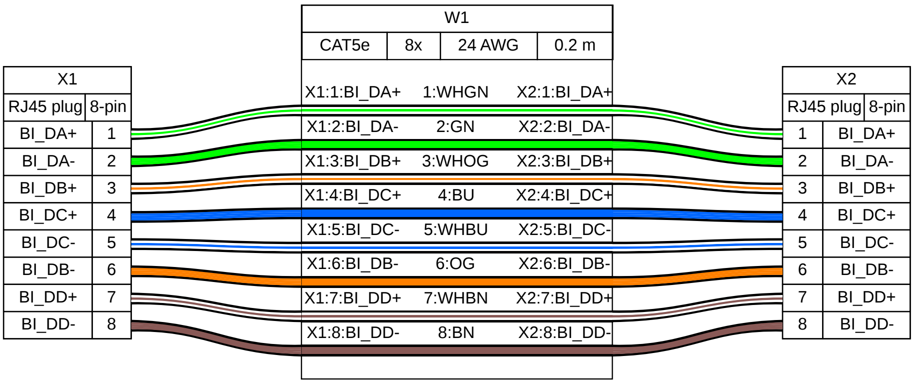


Figure 12: Interconnect between both batteries

Initially, I wanted to install about 7kWh of battery capacitance. But I was offered a good deal on two 4.8kWh batteries. Now I could install almost 10kWh of capacity for the same price as a 7kWh battery bank. Same brand, same quality, same service but lower price. These batteries also come with a build in circuit breaker eliminating the need for an external one. How about that?

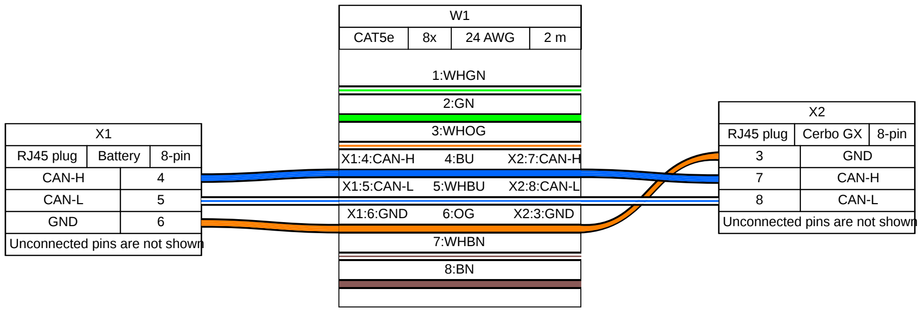


Figure 13: CAN cable between battery bank and Cerbo GX

4 Programming

4.1 Multiplus II

As mentioned in the previous chapter, the Victron Energy MultiPlus II must first be programmed. As the name suggest, it is a multifunctional unit. Without proper programmer it simply does not know what to do.

Figure 14: Victron interface MK3-USB

To program the Multiplus, a special programmer (Victron interface MK3-USB) as well as a Windows computer is needed. Unfortunately, the software doesn't run on a Linux computer, but fortunately the software will run on any 32 or 64 bit Windows computer. So even a ten year old laptop will do. Once programmed, the Windows machine is no longer needed, but you never know. So keep this laptop with the ESS system for future reprogramming.

Connect the Multipuls to the mains and to the Victron interface MK3-USB. The switch on the bottom of the Multiplus should be in the I position.

Install and start the *VE Configuration tools for VE.Bus Products* software[3].

[3] https://www.victronenergy.com/support-and-downloads/software

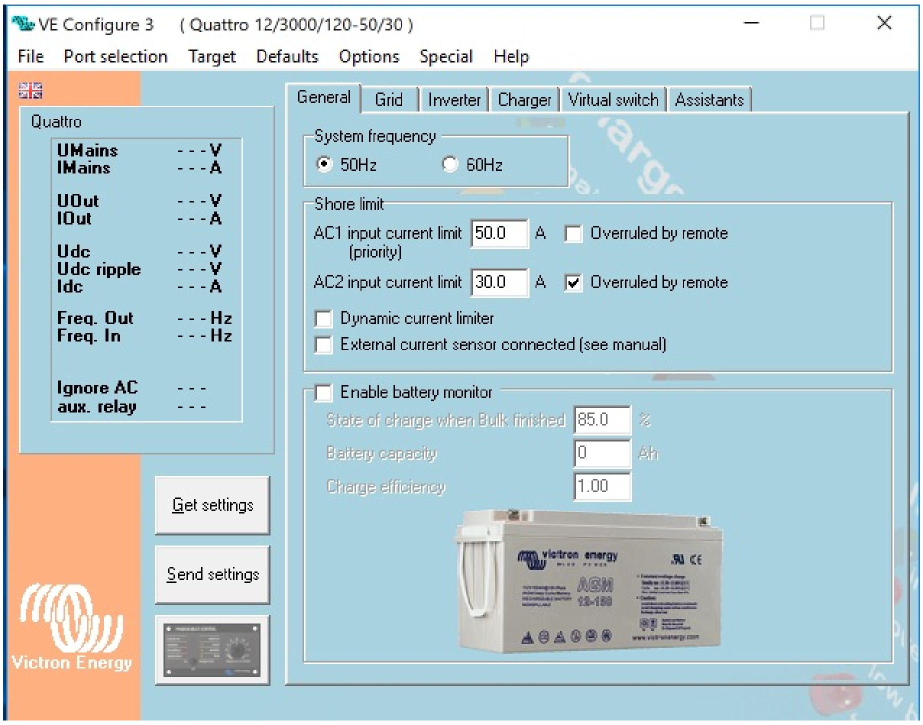


Figure 15: VE Configure

4.1.1 Grid code settings

First, the *country/grid code standard* has to be set. I selected *Europe*, but *Germany* should also work. The very first time this option can be set without the nees of a password. If in the future for some reason the code has to be changed, a password is needed. This password can be obtained from the manufacturer or distributor[4].

4.1.2 General settings

In the *General* tab, check the *Enable battery monitor* function. Than set the battery capacity to the total capacity of the battery bank. In this case 2x 100Ah or 200Ah.

4.1.3 Charger settings

Set the settings in the *Charger* tab according to table 4.

4.2 Inverter

Set the settings in the *Inverter* tab according to table 5.

Parameter	Setting
Battery type	Lithium
Charge curve	Fixed
Absorption voltage	52.0 V
Float voltage	51.0 V
Absorption time	1 Hr

Table 4: Charger settings

Parameter	Setting
DC input low shut-down	44V
DC input low restart	48V
DC input low pre-alarm	48V

Table 5: Inverter settings

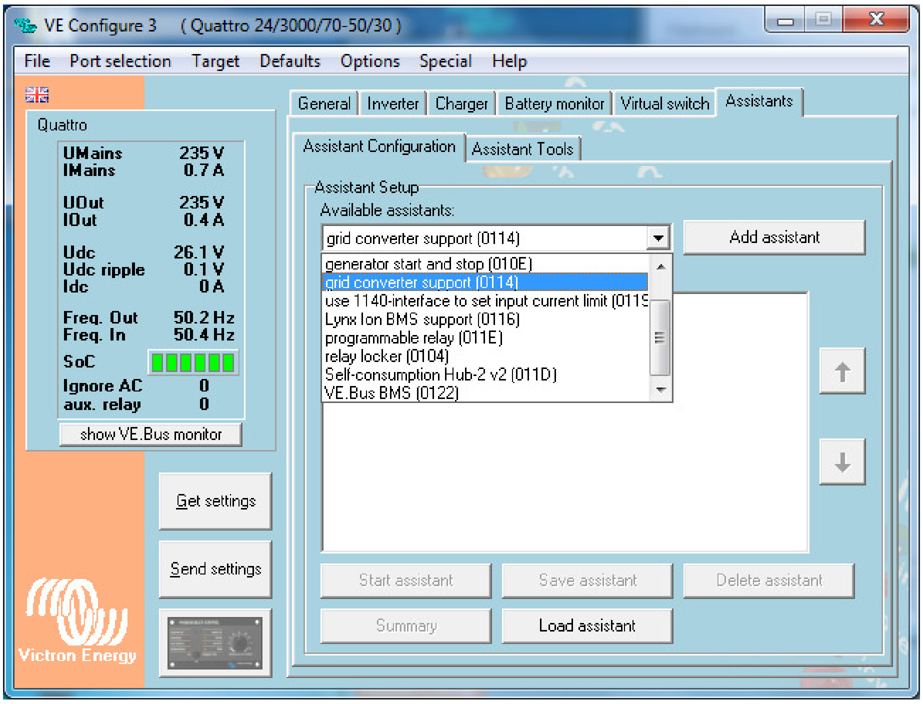


Figure 16: VE Configure: add ESS assistant

4.2.1 ESS assistant

Go to the Assistants tab and install the *ESS assistant* by selecting it in the drop down menu (see figure 16). Next, click the *Add assistant* button. The assistant is now added, but not configured yet. Click the *Start assistant* button. Choose *LiFePo4 with other type BMS* and enter the values as given in table 6.

The ESS Assistant will have enabled the built-battery monitor in the *General*

[4]Grid code password: TPWMBU2A4GCC

Parameter	Setting
Sustain voltage	48V
Dynamic cut-off values	set all values to 46V
Restart offset	1.2V (Default)

Table 6: ESS assistant settings

tab. Leave that enabled.

In the *Charger tab*, the ESS Assistant will have selected the proper battery type, as well as disabled the Storage mode. Verify and where necessary change the rest of the settings: charge voltages and maximum charge current. Note that, for systems with the ESS Assistant installed, the MPPT Solar Chargers will follow the charge curve as set in VEConfigure. The charge parameters configured in the MPPT Solar Chargers are ignored in an ESS setup.

4.3 Cerbo GX

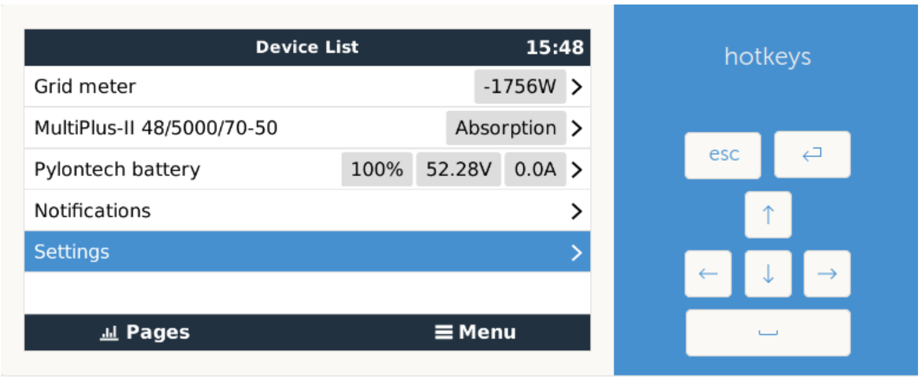


Figure 17: Cerbo GX settings

All settings can be changed via the touch screen or via the web interface on port 80.

4.3.1 ESS settings

Make sure the energy meter is detected and used by the system. Than, make the following changes:

- DVCC: ON (SCS -Shared current sense ON; others OFF)
- System setup/AC input 1: GRID
- ESS/Grid metering: EXTERNAL
- ESS/Inverter AC output in use: ON
- ESS/Multiphase regulation: TOTAL OFF ALL PHASES
- ESS/Grid setpoint: 0W
- ESS/Grid feed-in/AC-coupled PV - feed in excess: ON

4.3.2 Non essential setting

4.3.2.1 Ethernet The Cerbo GX has two network connections: wifi an ethernet. The use of these connection is optional and the ESS will happily work without a network connection.

When connected to a network with access to the internet, the Cerbo GX will try to call the mother ship. If you want to use the Victron Energy dashboard this is necessary. But I don't like the idea of manufacturers keeping track of my personal data.

The Cerbo GX can be configured via a web interface. This is handy and I want to be able to use it. Furthermore, I want to log the data for personal use. Therefore I connected the device to my isolated LAN without internet access. This way I can connect to the Cerbo GX, but the Cerbo GX cannot connect to the Victron Energy servers.

To enable the web interface on the LAN, go to **Remote console** and enable **Enable on LAN**.

4.3.2.2 Superuser Victron Energy allows you to be truly the owner of your own device: you can get full access to the Cerbo GX by becoming the *superuser*.

- Go to Settings, General
- Set the Access Level to User and installer, the password is ZZZ
- Highlight Access Level (don't open the select page, ie. make sure you are in the General Page, not the Access Level page)
- Press and hold the right button of the center pad until you see the Access Level change to Superuser. Note: when working from the Remote Console, you need to use the right key on your keyboard. Pressing and holding the right button with your mouse won't work.

Now you have access to the superuser features. Note that on a touchscreen, such as a Cerbo GX + GX Touch, there is no *right* button.

4.3.2.3 SSH access The Cerbo GX is basically a small Linux computer. And therefore it is possible to access it via *ssh*. Even better, you have root permissions, so you are really in control!

The first step is to set a root password. This can be done by going to **Settings/General/Set root password**.

Note that, for firmware version v2.00 and later, the root password will be reset by a firmware update. The reason is that the passwd file is on the rootfs, which is fully replaced by an update. More info here.

It is advisable to create a root password. But use it to login only the first time, and then install a public ssh key. Thereafter login with the keys. So lets do that right now.

To login via ssh, enable SSH on LAN (**Settings/General**). Than try to login by entering the ip address of the Cerbo GX device in a ssh client. On Linux you will simply do this from the command line:

```
$ ssh root@192.168.86.98
```

```
root@victron_cerbo_gx:~# cat /proc/cpuinfo
processor       : 0
model name      : ARMv7 Processor rev 4 (v7l)
BogoMIPS        : 50.52
Features        : half thumb fastmult vfp edsp neon vfpv3 tls vfpv4 idiva idivt
vfpd32 lpae evtstrm
CPU implementer : 0x41
CPU architecture: 7
CPU variant     : 0x0
CPU part        : 0xc07
CPU revision    : 4

processor       : 1
model name      : ARMv7 Processor rev 4 (v7l)
BogoMIPS        : 50.52
Features        : half thumb fastmult vfp edsp neon vfpv3 tls vfpv4 idiva idivt
vfpd32 lpae evtstrm
CPU implementer : 0x41
CPU architecture: 7
CPU variant     : 0x0
CPU part        : 0xc07
CPU revision    : 4

Hardware        : Allwinner sun7i (A20) Family
Revision        : 0000
Serial          : 1651665707409105
root@victron_cerbo_gx:~# _
```

Figure 18: the Cerbo GX lets you login via ssh

Using a ssh key for authentication, instead of a root password, has the advantage that it isn't lost during a firmware update. The keys are stored on the /data partition.

First login with the root password and then copy a public ssh key to the */home/root/.ssh/authorized_keys* file.

The Cerbo GX uses *einstein* at its hostname. It can be changed by editing */etc/hostname*. The *nano* editor is available on the Cerbo GX. The new hostname will be lost after a firmware update.

4.3.2.4 MQTT The Cerbo GX runs a *Mosquitto MQTT broker* instance. It can be enabled via **Services/MQTT on LAN**. It times out after a minute or so. To keep it alive, publish something on *R/+/system/0/Serial* every 30 seconds.

4.3.2.5 Telemetry An old computer or a Raspberry Pi is all that is needed to run some prety powerfull analitic tools, like Grafana and Home Assistant. To access the data from the MQTT broker on the Cerbo GX, I wrote several scripts and programs. It is beyond the scope of this document to fully describe it all. This paragraph is just to give an impression of what's possible.

Grafana power dashboard The first system shows the power being generated and consumed by the house. An MQTT scraper reads the data from the Cerbo GX and forwards it to Prometheus. Grafana processes this data and shows it on a dashboard.

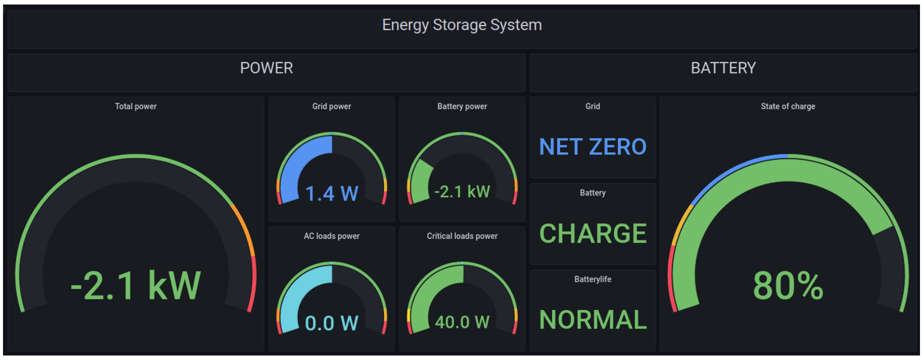


Figure 19: Grafana power dashboard

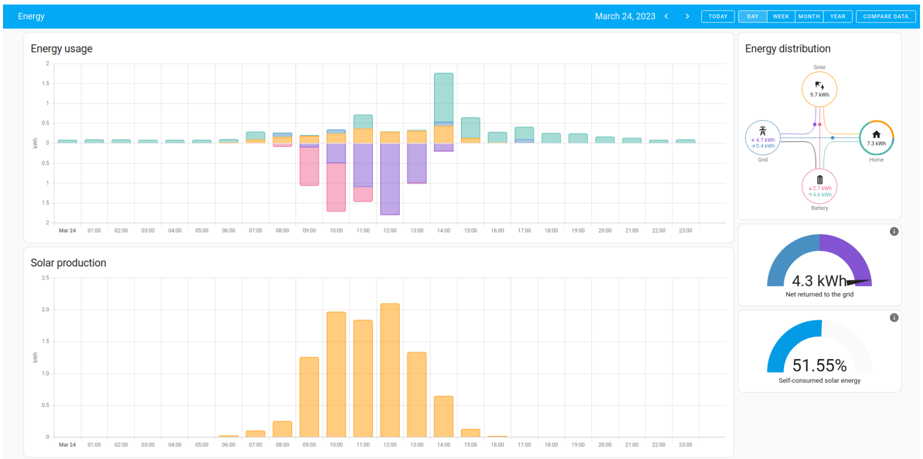


Figure 20: Home Assistant energy dashboard

Home Assistant energy dashboard The second system shows the energy produced and used by the house. Home Assistant reads the data from the Cerbo GX via MQTT and generates hourly statistics. It is possible to generate energy graphs from the last days, weeks, months and years.

A Installation diagram

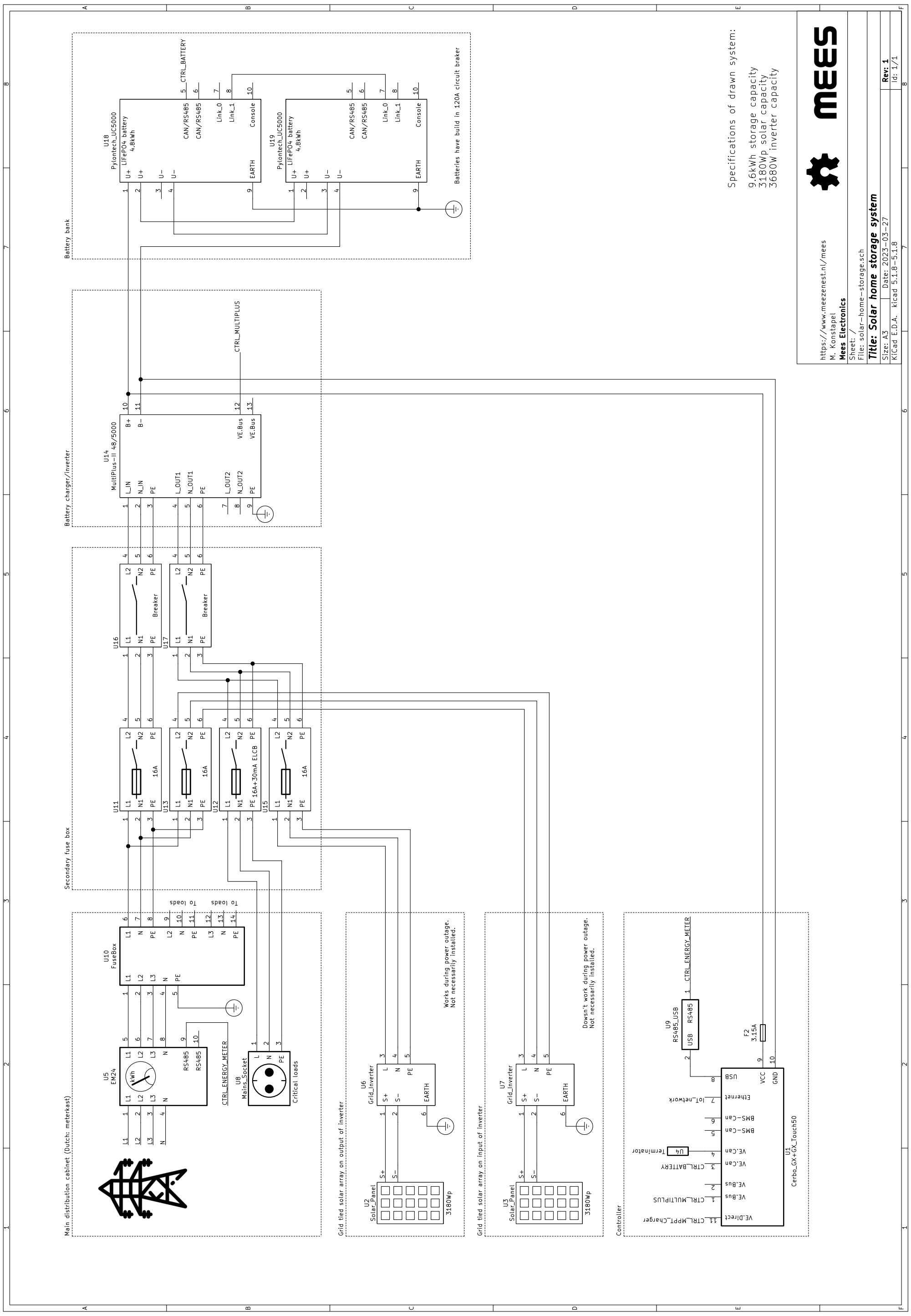


Figure 21: full diagram of the ESS installation

B Bill of materials

The bill of material only lists the main components of the system as seen in the *installation diagram*. This excludes all the wire harnesses.

Quantity	Reference	Value	Manufacturer	Distributor
1	F2	3.15A	Victron Energy	-
1	U1	Cerbo_GX+GX_Touch50	Victron Energy	Smartenergyshop.be
1	U10	FuseBox	Various	-
3	U11 U13 U15	16A	EMAT	elektramat.nl
1	U12	16A+30mA ELCB	EMAT	elektramat.nl
1	U14	MultiPlus-II 48/5000	Victron Energy	kleinezonnepanelen.nl
2	U16 U17	Breaker 2 pole 40A	EMAT	elektramat.nl
2	U18 U19	Pylontech_UC5000	Pylontech	Smartenergyshop.be
2	U2 U3	Solar_Panel	Various	-
1	U4	Terminator	Victron Energy	-
1	U5	EM24	Victron Energy	acculaders.nl
2	U6 U7	Grid_Inverter	Various	-
1	U8	Mains_Socket	QPL	-
1	U9	RS485_USB	Victron Energy	acculaders.nl

Figure 22: bill of material main components

C Cerbo GX modification

Cerbo GX power supply issue in 48V systems

Technote August 2022 – v5

www.victronenergy.com

Summary

On the recent batches of the Cerbo GX, there is an error in the design of the power supply causing it to fail – on some – 48V systems. In such system, a replacement Cerbo with the same internals is likely to fail again, unless installed according to this document.

In most cases, the failure happens immediately when power is applied to the unit. I.e. when wiring it, installing the fuse and/or switching the system on.

This document provides a solution by adding a capacitor on the power input. This also applies to already installed systems, to prevent those from failing later on.

The failure typically occurs when first connecting the system; but can also happen once installed.

Systems with a 12 or 24V battery are not affected.

Note that the solution proposed in this document does not fix an already broken Cerbo. A broken Cerbo needs to be replaced, which is covered under warranty. When installing the replacement, check its serial number against the range in this document. When it matches, make sure to add the capacitor, to prevent the replacement from failing as well.

Background

At power-up of the Cerbo GX the inrush current causes a voltage peak. The maximum voltage of the peak depends on the length of the supply cable, size of the current and other parameters that will differ from one system to another. In some 48V systems this transient exceeds the limits of the power supply circuit causing it to break.

Affected model/serial numbers

Model: Cerbo GX, part number BPP900450100
Serial numbers: HQ2201xxxxx up and including HQ2220xxxx

The serial number can be found on the carton, on the unit, in the E-Order environment and in the VictronConnect App as well as on the VRM Portal.

Situation in stock

All current stock is affected by this issue. The plan as well as time needed for reworking that is not yet clear. This instruction was selected and is distributed for sake of speed, to prevent more systems from failing. An update will be provided once more information is available.

Also, once we have stock of good units, we are happy to replace it with a Cerbo GX that does not require an external capacitor for systems where the external capacitor is not accepted.

Victron Energy B.V. | De Paal 35 | 1351 JG Almere | The Netherlands
E-mail: sales@victronenergy.com | www.victronenergy.com

Figure 23: Official Victron Energy Cerbo GX modification technote (1 of 2)

Solution & required parts

Solution

Add a capacitor on the input, in parallel to the power wiring, as shown in picture on the right.

The capacitor needs to stay there permanently, to avoid issues in the future on powerup.

We recommend to isolate the pins with a small piece of heat shrink, as shown in the second photo.

Carefully check proper connection of both the capacitor and the Cerbo power wires. The factory power cables are bootlace ferrule terminated and the smaller capacitor leads will be loose if not carefully aligned. We recommend to cut the factory bootlace ferrules off and re-crimp the wire and the leads of the capacitor into new bootlaces.

Its not necessary to install the capacitor on 12 or 24V systems. Its also not a problem to install the capacitor on such systems.

Important! Polarity of the capacitor

The capacitor has a minus (**–**) polarity marker. It is the white band with the minus in it, as shown on the picture here on the right. The pin on that side is the minus pin, and must be inserted into the minus terminal on the Cerbo GX.

Type and how to obtain the capacitor

Below types have been selected on availability from stock as well as tested to solve the issue. For now, the best and fastest way to obtain them is purchasing them locally from a electronics distributor; such as Farnell, Digikey or Mouser.

We will also be stocking these capacitors in Almere, but due to distance as well as volume of Cerbo GX-es sold monthly, it will for many situations be quicker to order locally through one of the mentioned electronics distributors.

Manuf.	**Description**	**Mfg part number**	**Farnell #**	**Digikey #**	**Mouser #**
Rubycon	100 µF, 100 V Elco	100ZLH100MEFC10X20	1547012	1189-1887-ND	232-100ZLH100MEFC10X
Panasonic	100 µF, 100 V Elco	ECA2AHG101	9694625	P5597-ND	667-ECA-2AHG101

Electrolytic capacitors of a similar rating can be used as well. When selecting another capacitor, do make sure to not select special low ESR capacitors. A lower ESR will reduce the required effect.

Victron Energy B.V. | De Paal 35 | 1351 JG Almere | The Netherlands

E-mail: sales@victronenergy.com | **www.victronenergy.com**

Figure 24: Official Victron Energy Cerbo GX modification technote (2 of 2)

D Links and addresses

Victron Energy publishes a lot of very good documentation about there products. I was able to completely design the system exclusively on their documentation alone. And when something wasn't clear the first time, I could consult their great community.

https://www.victronenergy.com/

https://www.victronenergy.com/media/pg/Energy_Storage_System/en/index-en.html

https://community.victronenergy.com/index.html

https://www.youtube.com/@VictronEnergyBV

Software for the various dashboards is all open source and comes with great community support.

https://www.home-assistant.io/

https://grafana.com/

https://prometheus.io/

An MQTT exporter for Prometheus specially made for the Cerbo GX.

https://git.meezenest.nl/marcel/victron_mqtt_exporter

E Open source hardware and software

All the design files are published under free licences and are available via my website: https://www.meezenest.nl/mees or can be found in my git repository: https://git.meezenest.nl/

If you cannot find specific files, please contact me. I am more than happy to help you out.