Venus OS: Root Access

1. Introduction

This document explains how to access a GX device via SSH, or straight on the Serial Console, with the root user. It also covers customizing and hardening a GX device against nonauthorised access.

This document is part of the Venus OS developer documentation. The main document is the Venus OS wiki on github.

Do note that, while we try to maintain to provide all mentioned functionality in this document, the used commands and functionality may change with future updates.

2. Warning about modifying the rootfs

1. Your changes can be lost during a firmware update

Changes made to the rootfs will be lost in case of a firmware update. The complete rootfs is overwritten during an update.

Of course it is always possible to disable automatic firmware updates. Also there is a data partition (/data), which will be left alone in the image updates, and as such can be used to, upon boot, (re-)install certain changes onto the active rootfs. More details on that below.

2. It is possible to brick your GX device

For those unfamiliar with the term: Bricking means rendering it useless and unrecoverable. Chances of this are small (depending on what you do), but its certainly possible. And if not fully bricked, then at least in a state from which there is no documentation nor support on how to recover.

Note that a solution to this is to do Venus OS experiments on a RaspberryPi rather than a real GX device. The advantage of a raspberrypi is that you can always start from scratch, by re-imaging the sdcard. And the other is that it (the pi) is a low cost device. more information on that.

The factory reset procedure, as documented in the normal user manuals of the GX devices, removes everything from the data partition, except for the factory installed files. This will recover from issues caused by problems on the data partition, such as it being full or invalid settings or custom scripts.

But it will not recover from all possible mistakes that can be made. Some examples:

1. if you accidentally remove files crucial for the boot process, either on the boot partition or the rootfs, then the device won't boot anymore. The above mentioned factory reset feature depends on at least certain parts of the system booting up properly. More specifically, it depends on the linux init process.
2. if you remove the files in /data/venus, then -depending on the production date- you might have to restore those manually which might require serial console access. See below. Why does this depend on the production date? Thats because somewhere in 2021 we started writing all

factory data to a different place (an eeprom) to make it more robust.

3. Root access

3.1 Set access level to Superuser

To set the root password, first set the access level to Superuser:

1. Go to Settings, General
2. Set the Access Level to User and installer, the password is ZZZ
3. Highlight Access Level (don't open the select page, ie. make sure you are in the General Page, not the Access Level page)
4. 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 super user features.

Note that on a touchscreen, such as a Cerbo GX + GX Touch, there is no “right button”. Instead, drag the menu down and hold it down for five seconds. Or, use Remote Console.

3.2 Create a temporary root password

Go to *Settings* → *General* → *Set root password*. And create a temporary 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.

Our advice is to create a complex root password. But use it to login only the first time, and then install a public ssh key(s). Thereafter login with the keys. If key authentication works, you can also safely delete the root password afterwards (`passwd –delete root`).

3.3 Enable sshd and log in

To login via ssh, enable SSH on LAN (*Settings* → *General*). On Venus versions before v2.40, you need to enable Remote Support, which also enables sshd. More info on Remote Support here.

To the login, enter the ip address of the GX device in a ssh client. Most Linux and Mac users will simply do this from the command line:

```
ssh root@192.168.1.23
```

And a very commonly used client for Windows is Putty. For more info, look around on the Internet, there is plenty information available.

3.4 Installing ssh keys

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 set the root password (once), use that to login, and then copy a public ssh key to `~/.ssh/authorized_keys`.

sshd works with three authorized keys files:

- `~/.ssh/authorized_keys` ← you can use this freely
- `~/.ssh/authorized_keys2`
- `/usr/share/support-keys/authorized_keys`

The third file contains the keys we use for Remote Support login.

3.5 Play time! Start executing commands

https://www.victronenergy.com/live/open_source:ccgx:commandline

4. Customizing a GX device

4.1 Hooks to install/run own code at boot

Everything, except for information on `/data`, will be wiped after an update.

Therefore, the trick to make changes & modifications survive an update, is to put your (patch)files on `/data`, make them be (re-)installed automatically on startup.

If the files `/data/rcS.local` or `/data/rc.local` exists, they will be called early (rcS) and late (rc) during startup. These scripts will survive upgrades and can be used by customers to start their own custom software. Implementation details in this commit.

Also if `venus-data.{tar.gz,tgz,zip}` is found on removable storage (usb stick, sd-card) when booting, it will be unpacked into /data. Implementation details in this commit. Added per Venus v2.30~28. Use this to for example make a USB stick that installs the modifications.

That venus-data file has one extra feature: if the archive contains `rc/*` files, it will extract those first. And if there is a file called `rc/pre-hook.sh` it will run this before unpacking the rest of the archive. Similarly, if there is a file called `rc/post-hook.sh`, then that file will run this after the unpacking of the archive. For details, read the code in the `/etc/rc5.d/S30update-data.sh` file.

You can test the 'update' with `/opt/victronenergy/swupdate-scripts/check-updates.sh -update -force` which will install the same version again, but in the other rootfs.

For details of the used update mechanism, see here:
https://github.com/victronenergy/venus/wiki/swupdate-project

4.2 Partitions, read-only rootfs and available disk space

On a GX Device, there are three partitions that matter:

- rootfs partition one
- rootfs partition two
- the data partition

4.2.1 One active rootfs at a time

Only one of the two rootfs partitions will be in use at time. During a firmware update, the new firmware is installed on the other one; and once finished the subsequent reboot will reboot the device onto that other partition.

The data partition is not touched during a firmware update, except maybe some migration scripts that run at boot.

4.2.2 Read-only rootfs

By default, the rootfs is mounted read only. Also, by default, it only has 5% of free space.

The solution is to run `/opt/victronenergy/swupdate-scripts/resize2fs.sh`.

Further details in the next section.

4.2.3 Always prevent running out of diskspace

When doing modifications, make sure both the data partition and the rootfs do not run out of space. We don't design or test for that situation.

With regards to the size of the data partition, thats easy to check using the `df` utility. But not so for the rootfs:

After logging into a GX device, and checking the free disk space on the rootfs (! that is not the data partition), you might get a bit disappointed at first. Don't worry about that, there will always be only 5% of free space, but thats not the actual free space:

The reason for this is that a firmware update replaces the full filesystem on the rootfs, as an image. And its then **not** by default expanded to the full available space of the partition.

To expand it, run `/opt/victronenergy/swupdate-scripts/resize2fs.sh`. It will expand the filesystem to use all of the available space.

Also this remounts that rootfs as read-write.

For actual available diskspace on our GX Devices, see https://github.com/victronenergy/venus/wiki/machines.

To see what `resize2fs.sh` is doing, without having to log into your Venus OS, see it also here.

Note that a firmware update will replace all of the rootfs, as also explained above. Which implies that you'll need to run `resize2fs.sh` again after doing a firmware update.

4.3 Creating a patch file

As mentioned before, the recommended way of customising Venus OS is by applying patch files. This section describes how to make and apply a patch.

You start by making a copy of the original file and modifying it to accommodate your changes. In order to create a patch file containing the changes you've made, run the following command:

```
diff -u OriginalFile UpdatedFile > PatchFile
```

In order to patch the original file with your changes, you can use the below command:

```
patch OriginalFile < PatchFile
```

For more advanced features please check the manual page of diff and patch.

4.4 Adding or modifying services

Changes made to `/service` will not survive a reboot. The reason is the `/etc/rcS.d/S10overlays.sh` script, which copies over the files from `/opt/victronenergy/service/*` to `/run/overlay/service` and bind mounts that under `/service`. So in order to have changes survive a reboot, you need to change the service under `/opt/victronenergy/service/*` instead of under `/service`.

By default the root filesystem of Venus is read-only. There are three ways to change that:

- *temporally*: issue the command `mount -o remount,rw /` (which holds until the next reboot or issueing `mount -o remount,ro /`)
- *semi-permanent*: issue the command `/opt/victronenergy/swupdate-scripts/remount-rw.sh` (which holds until the next firmware update)
- *permanent*: adding one of the above commands to `/data/rc.local` (which holds permanently)

5. Hardening a GX device

5.1 Limit physical access to the device

The first thing to keep in mind is that we as Victron Energy always want an end-user with physical access to the device to be able to gain access to the device again after he has himself accidentally locked out.

So the best solution to keep people from tampering with a Venus device is to block physical access to

the device. We do not give specific recommendations regarding that, but a compact server rack with key protection seems to be safe enough in most cases. You can also add an alarm on the digital input of the Cerbo that will ring as soon as the door of the rack opens.

People with enough time, knowledge and for example an angle grinder on their hands will always be able to get in. But you will probably be able to tell if people did get access to the device. Also keep in mind that extra physical security will also give extra hassle for the people that are allowed to get the physical access to the device.

5.2 Disable touch on the attached screen

Per Venus OS version v3.00, we are introducing a feature that allows disabling the touch feature on the GX Touch display.

This allows mounting the GX Touch where it is visible by the operators of the system; and at the same time prevent them from using that to elevate their access.

Details per GX device:

- Ekrano GX: a digital input can be configured to be used for this. Wire it to a momentary-push button, that shorts the input (grounds it).
- Cerbo GX + GX touch: a digital input can be configured to be used for this. Wire it to a momentary-push button, that shorts the input (grounds it).
- Venus GX: has no screen, not relevant.
- Color Control GX: will not get this feature.

Inside Venus OS, this is handled by the setting `/Settings/Gui/TouchEnabled` under `com.victronenergy.settings`. Which can be scripted with the `dbus -y` command. See Limiting digital access for an example on how to do that.

Note that this setting only disables touch/mouse control. On the remote console you are still able to control the device with keyboard input. That is also true if you plugin an external USB keyboard. With the keyboard it is also possible to toggle the `/Settings/Gui/TouchEnabled` setting by pressing the Pause/Break key key. So if you need this feature to be switched on, make sure that the USB ports are not accessible.

5.3 Limiting digital access

When securing the device, it is also advised to disable the Wi-Fi access point, bluetooth and other non-essential services on the device. The below list should be treated as a starting point and can be extended up on:

- Disable remote touch control
- Disable bluetooth
- Disable Wi-Fi Access point
- Set Access level to User
- Disable LAN SSH
- Disable LAN remote console (VNC)
- Disable Modbus TCP

- Disable MQTT (via SSL, plaintext and VRM)

If you have multiple devices to harden, here is an example of how to automate the process in a scriptable way. Note that we might change those commands, or names and locations of those settings. Therefore, make sure to be careful to check for example the exit code of such script, as well as visually confirm that all works as expected:

```
  #!/bin/bash
  items="
  Disable remote touch
control;com.victronenergy.settings;/Settings/Gui/TouchEnabled;0
  Disable
bluetooth;com.victronenergy.settings;/Settings/Services/Bluetooth;0
  Disable Wi-Fi
AP;com.victronenergy.settings;/Settings/Services/AccessPoint;0
  Set access level to
User;com.victronenergy.settings;/Settings/System/AccessLevel;0
  Disable LAN ssh;com.victronenergy.settings;/Settings/System/SSHLocal;0
  Disable LAN Remote console
(VNC);com.victronenergy.settings;/Settings/System/VncLocal;0
  Disable Modbus TCP;Settings/Services/Modbus;0
  Disable Modbus TCP (Plaintext);Settings/Services/MqttLocalInsecure;0
  Disable MQTT on LAN (SSL);Settings/Services/MqttLocal;0
  Disable MQTT on LAN (Plaintext);Settings/Services/MqttLocalInsecure;0
  Disable MQTT via VRM;Settings/Services/MqttVrm;0
  "
  IFS='
  '
  for item in ${items}
  do
    IFS=';' read -r description service path value  <<< ${item}
    echo "# ${description}"
    dbus -y ${service} ${path} SetValue ${value}
  done
```

There are *a lot* more settings that can be adjusted this way. Easiest is using `dbus-spy` to check which ones you find interesting. Instead of disabling services, you might want to enable some things too. Just replace the `0` with a `1` to do that.

5.4 Installing a tamper alarm

By using the digital input(s) of the GX device, you can set the digital inputs as "*Burglar alarm*", which can be used to be alerted on tampering events.

Depending on the need, you might want to switch to a silent alarm under *General → Audible alarm* (service: `com.victronenergy.settings`, path: `/Settings/Alarm/Audible`).

You can decide whether the input should be treated as an alarm condition, whether the labels should be inverted, and whether the logical levels should be inverted.

- To swap the labels attached to the alarm, set *Inverted* to on.
- If a logical low input (0V) should be considered a positive condition, set *Inverted alarm logic* to on.

5.5 Hardening multiple devices

If you have a lot of Venus devices to modify, probably the easiest way is to start with using a per-device specific password for the remote console, which only you can can generate. Combining that with a substring from something like `/opt/victronenergy/venus-eeprom/eeprom –show serial-number | sha256sum` is a fairly secure start.

Later replace that by something more strong and store it in your vault. Use the USB stick to put your public ssh keys on the GX device so you can gain remote access.

6. Connecting on the serial console

The serial console offers a straight connection from your computer. Not relying on TCP or anything else.

Its an alternative to connecting to the commandline over ssh.

Connecting to the serial console requires a USB interface, ie a USB to serial cable with proper pin-out. For example this one: https://www.adafruit.com/product/954.

The serial consoles on all GX devices are configured to 115200 baud.

6.1 Color Control GX

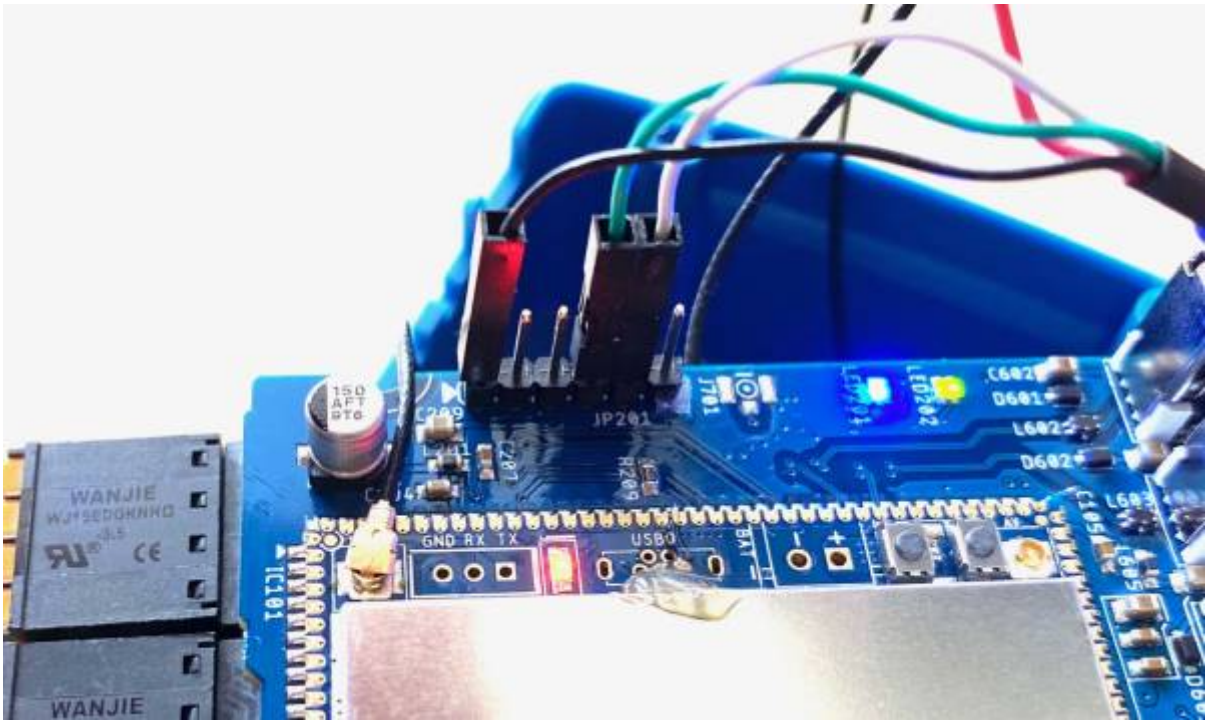
All GX Devices have a dedicated serial console, except for the CCGX. Therefor its documented on a separate page:

CCGX Serial Console.

6.2 Cerbo GX

The serial console is located on the CPU board, header JP201. GND is pin 1, RX and TX are pins 4 and 5. Here is a picture showing a ADA Fruit Serial Console cable connected to it.

Make sure not to connect the red wire.



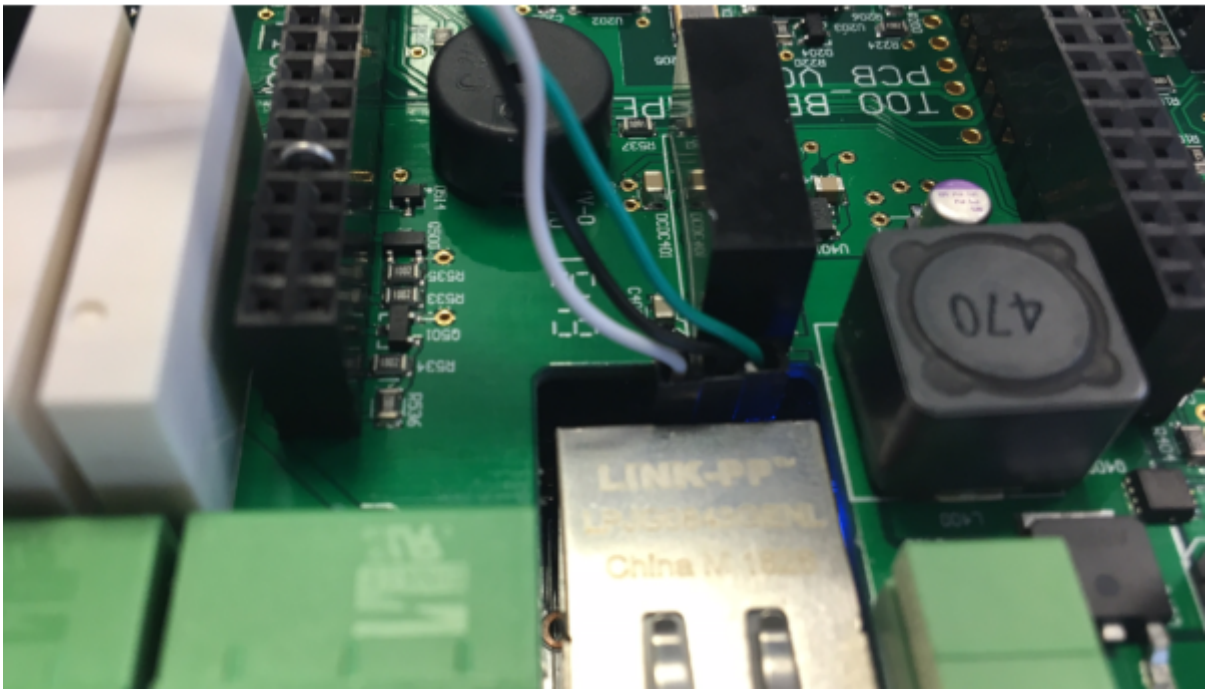
6.3 Venus GX

The serial console is located on the base-board, and can be accessed through the slot between that board and the Ethernet connector on the beaglebone-board.

White: TX of the Beaglebone - connect to RX on your cable Black: ground Green: RX of the Beaglebone - connect to TX on your cable

Make sure not to connect the red wire.

Here is a picture showing how, also using the adafruit serial console cable as referenced above:

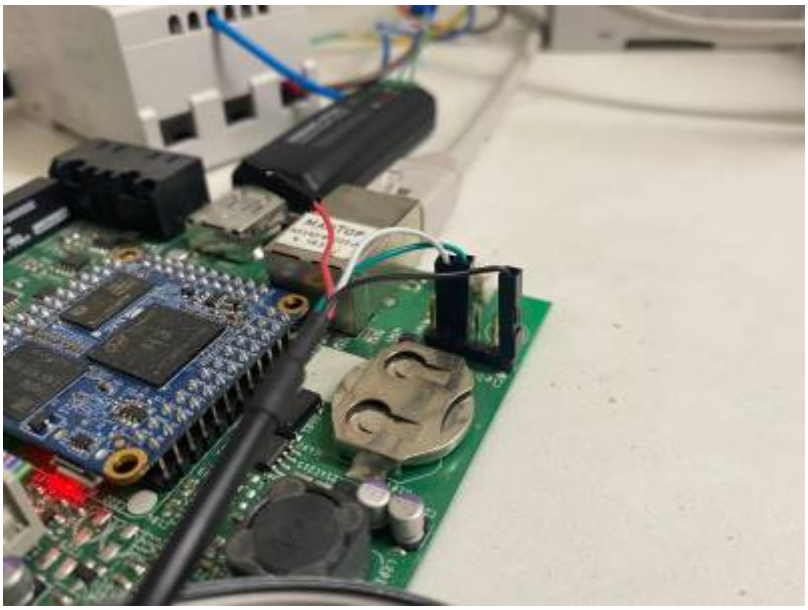


6.4 GX Card / Nanopi

The GX Card is the PCBA inside the MultiPlus-II GX and EasySolar-II GX product ranges. This photo shows the card, when unmounted from these inverter/chargers.

Maybe the pins are also accessible without dismantling it, maybe not. Note that all this is at your own risk, as everything on these pages is.

The serial console is the pinheader on the right of the photo. In the photo, there is an Adafruit serial console cable connected.

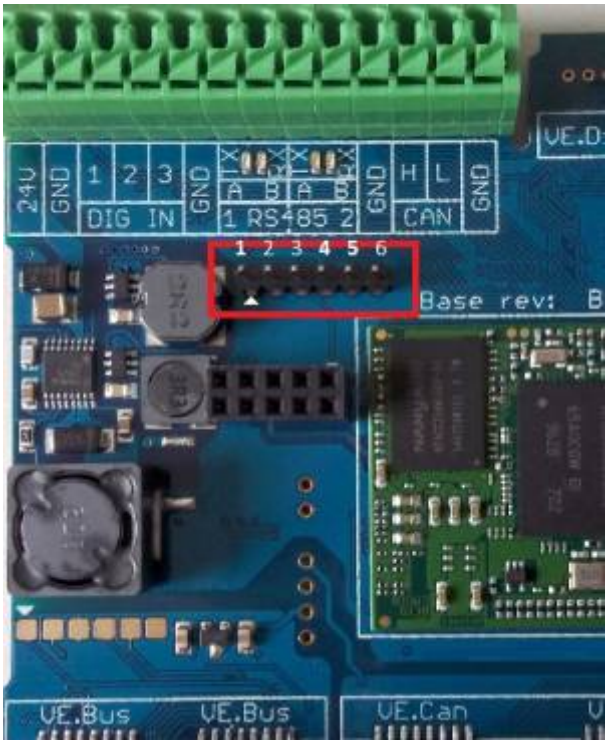


6.5 Octo GX

The serial console is located on the base-board, and can be accessed with the top-board unmounted. With the serial console cable connected the top-board can be put back on again.

1. Black: ground
2. NC
3. NC
4. Green: RX of the Beaglecore - connect to TX on your cable
5. White: TX of the Beaglecore - connect to RX on your cable
6. NC

Make sure not to connect the red wire.



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