Instructions for building and operating the FreeVario

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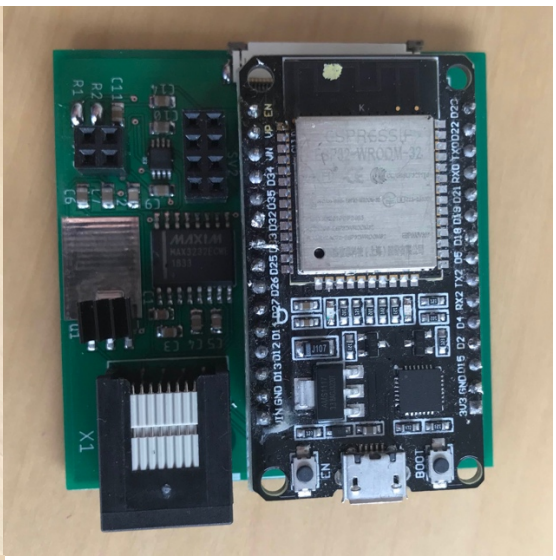
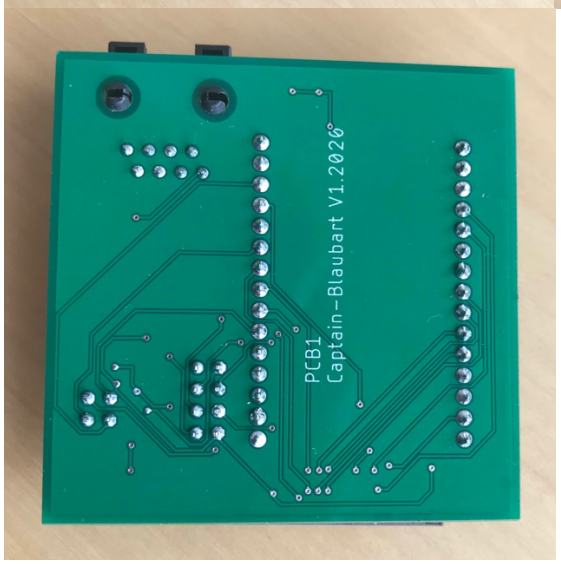
I work on a Mac or Linux system. Little things can differ on a Windows computer!

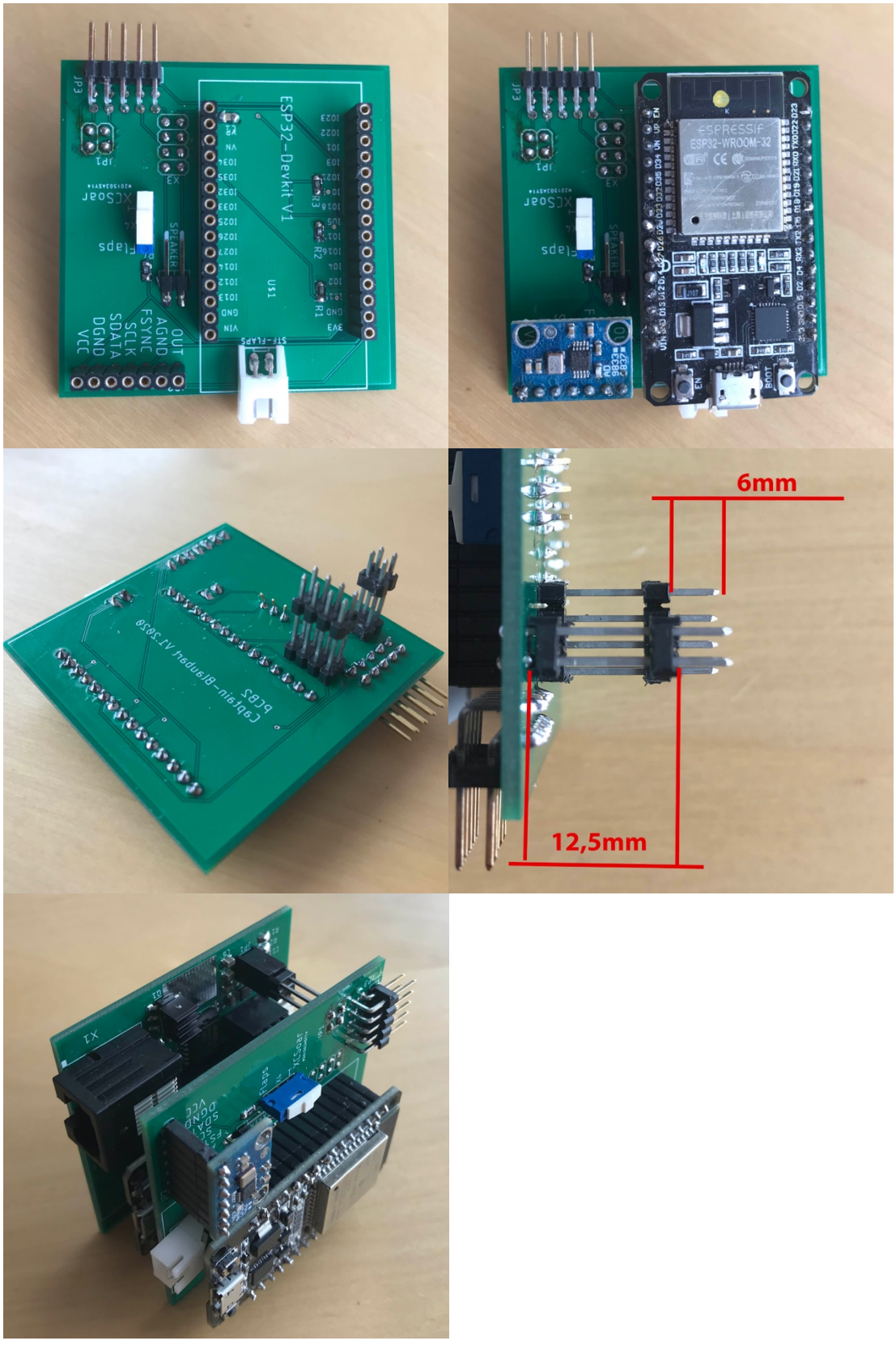
I. Assembling the boards and assembling the vario gauge

1. Solder PCB1 as well as shown in the pictures.





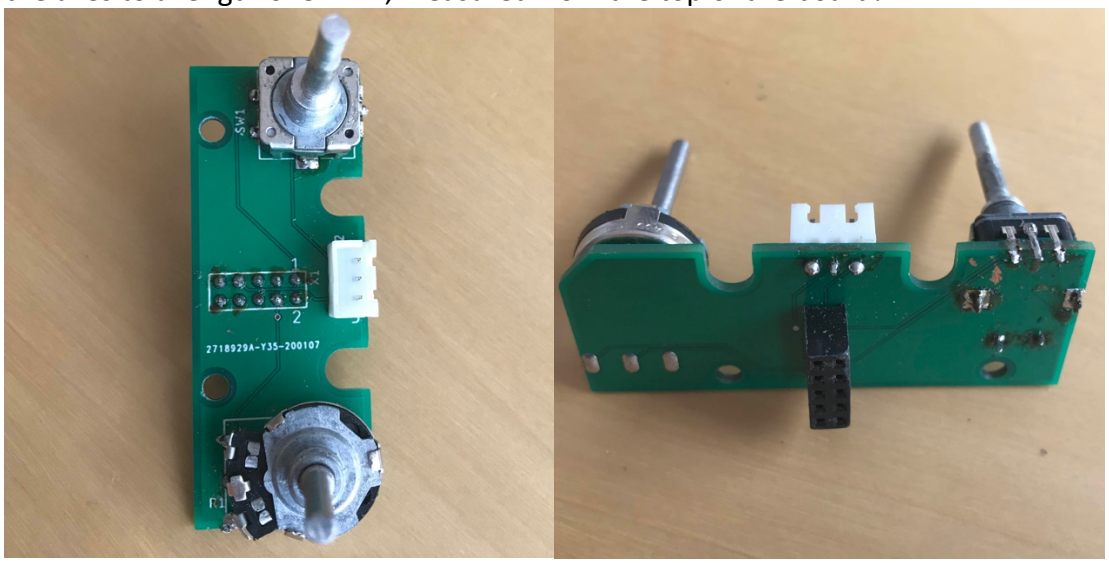
2. Solder PCB2 as well as shown in the pictures. The distance between the two plastic holders on the stacking strip must be set to 8mm. Shorten the long pins with a side cutter to 22 mm (see 3rd picture).
   With the help of the slide switch you can set how the vario will later work in automatic mode. If you put it on XCSoar, XCSoar sends commands to switch between STF and vario. If you set it to flaps, the automatic mode switches between the STF and vario using a switch connected to the white, two-pin connector. This switch can e.g. be attached to the flaps. If the vario is to be set to STF, this switch should be closed.



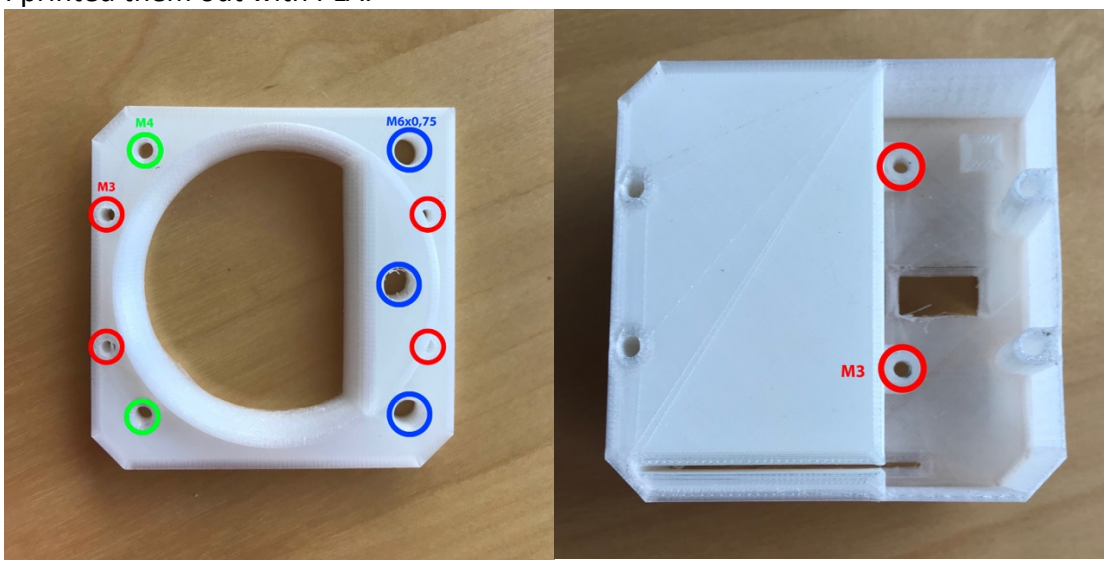
3. Carefully disassemble the rotary encoder by bending the small metal brackets. The axis of the rotary encoder is secured with a locking ring. You have to go carefully with a side cutter into the gap between the axis and the upper part of the housing and press lightly. If the axis is slightly damaged by the side cutter, file away the spot. Clamp the axes in the lathe, turn by 4mm. Then carefully reassemble the rotary encoder and bend

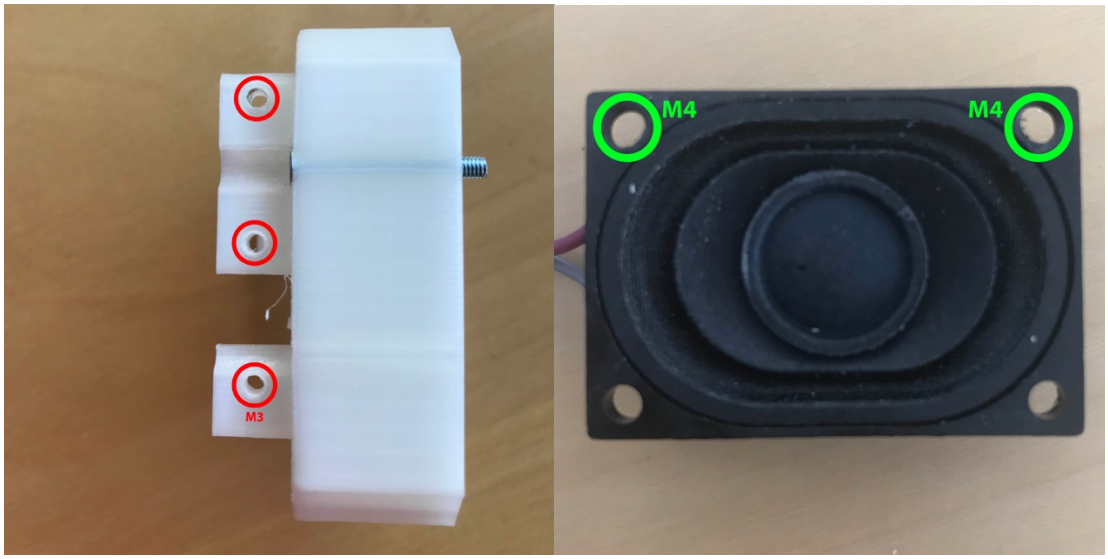
the metal brackets back. Secure the axis of the rotary encoder again with the ring. For safety's sake, buy the encoder twice, the first time it may go wrong. Drills the banjo bolts to 4.3mm.

4. On the PCB3 at the position where the encoder is located, you have to file away the protruding part of the board on the side with the 3 PINs and above, otherwise the board will not fit into the housing without tension. It may well be that you have to file a little more after soldering. Carefully bend the contacts of the potentiometer downwards by 90° and solder them on. Tests whether the axes of the encoder and the potentiometer fit well through the banjo bolts and are easy to operate after installing the front plate. If necessary, loosen again and move something.Solder PCB3 as well as shown in the pictures. Make sure that you solder the white connector so that the PINs are on the right side. Otherwise the board will not fit into the housing later. Shorten the axes to a length of 37mm, measured from the top of the board!



5. Print out the three housing parts and cut the threads into the plastic as marked in the pictures. Red = M3, green = M4, blue = M6x0.75.
I printed them out with PLA.





6. Cut two M4 threads in the speaker and fasten the speaker in the housing with 2 countersunk screws M4x8. Solder about 10cm long cables to connect the speaker beforehand. **The speaker is only required if the FreeVario is to output the vario sound. If you want to continue using the vario sound from OpenVario, you can omit the speaker.**

7. Crimp the connector to an approximately 5cm long, 3-pin cable and solder it to the toggle switch. Solder as space-saving as possible by soldering at an angle. Otherwise there will be a short circuit later between the solder joints and the contacts behind them on the PCB3. Make shrink wise the solder contacts!
   The middle cable comes to the middle solder lug. Depending on how you solder the two outer cables, you will later have STF or Vario on top. If you solder the upper cable of the plug to the upper soldering tab of the toggle switch, and the lower cable of the plug to the lower soldering tab of the toggle switch, STF will be in the lower position of the toggle switch, and Vario in the upper. Automatic is in the middle.

8. Shorten the threads of the two M4 fastening screws to 3mm + instrument panel thickness. Work very precisely here, because if the screws are too long, press the display later and destroy it. It is best to screw the front panel into the cockpit on your own and check that the screws do not protrude into the area of the display.

9. Install the toggle switch and the display in the front panel.

10. Insert PCB3 in the middle part and screw tight with 2 screws M3x6. Tighten screws carefully, the threads are plastic!

11. Screw the front panel and middle section together using 4 countersunk screws M3x25. Connect the toggle switch beforehand and lead the FFC cable back through the slot. Tighten screws carefully, the threads are in plastic!

12. Carefully assemble PCB1 and PCB2, connect display, loudspeaker (do not interchange plus and minus) and connect PBC3.

13. The best thing to do now is to jump to the programming of the two ESP32 and then continue here.

14. Now push the housing pot carefully over the circuit boards. Make sure that the boards are in the rails and carefully guide the Western Digital socket through the rear wall.

15. Screw the housing parts together with 6 countersunk screws M3x6. Tighten screws carefully, the threads are in plastic!

16. Using the two fastening screws and the two banjo screws, install the Vario in the I-board, mount the knobs and connect the Vario. Tighten screws carefully, the threads are in plastic!

17. The connection cable has the same assignment on both sides, i.e. same color on the same PIN, like a normal LAN cable.

II. Programming the two ESP32

1. Put the Binaries folder e.g. to the desktop.

2. Open a terminal or the command prompt. There you can see if you can find the path to Binaries. For example, it is /Users/PC1/Desktop/Binaries/

3. In Arduino IDE click on Arduino -> settings.

4. Add the URL under "Additional Board Administrator URLs". If URLs have already been entered, add further URLs with commas and spaces.
   https://dl.espressif.com/dl/package_esp32_index.json

5. Also click here under "Verbose output during" "Upload".

6. Click Tools -> Board -> Board Administrator and search for ESP32.

7. Select „ESP32 by Espressif Systems“ and install.

8. You may have to install the driver for the serial adapter of the ESP.
   https://www.silabs.com/products/development-tools/software/usb-to-uart-bridge-vcp-drivers

9. Open and save a new sketch. Remember the name. To upload, set the following under Tools:

   - Board: DOIT ESP32 DEVKIT V1
   - Upload Speed: 115200
   - Flash Frequency: 80MHz
   - Core Debug Level: “none”

- Port: Check out which is added after connecting the ESP32 with the USB cable

10. Then upload the empty sketch. There is a very long command in white letters above the error message in the Arduino IDE, which is roughly as follows:
*/Users/*PC1*/Documents/Arduino/hardware/espressif/esp32/tools/esptool/esptool --chip esp32 --port /dev/cu.SLAB_USBtoUART --baud 115200 --before default_reset --after hard_reset write_flash -z --flash_mode dio --flash_freq 80m --flash_size detect 0xe000*
*/Users/*PC1*/Documents/Arduino/hardware/espressif/esp32/tools/partitions/boot_app0.bin 0x1000*
*/Users/*PC1*/Documents/Arduino/hardware/espressif/esp32/tools/sdk/bin/bootloader_dio_80m.bin 0x10000*
/var/folders/6t/qjgfw2413f7ddnjzk_08btxw0000gp/T/arduino_build_661147/sketch_dec30d.ino.bin 0x8000
/var/folders/6t/qjgfw2413f7ddnjzk_08btxw0000gp/T/arduino_build_661147/sketch_dec30d.ino.partitions.bin

11. Copy this command, you need it to load the file onto the ESP32.

12. The first part of the command shows you where Arduino IDE creates its working directory. Remember the place. In this example it would be:
*/Users/*PC1*/Documents/Arduino*

13. Change the command with your location where the Binaries folder is located. Also change the last two file names (see bold). Pay attention to which ESP32 you are currently programming. Use the VarioSound files for the Sound-ESP32 and the FreeVarioGauge files for the Display-ESP32.
/Users/PC1/Documents/Arduino/hardware/espressif/esp32/tools/esptool/esptool --chip esp32 --port /dev/cu.SLAB_USBtoUART --baud 115200 --before default_reset --after hard_reset write_flash -z --flash_mode dio --flash_freq 80m --flash_size detect 0xe000 ***/Users/PC1/Desktop/Binaries****/boot_app0.bin 0x1000*
/Users/PC1/Desktop/Binaries*/bootloader_dio_80m.bin 0x10000*
/Users/PC1/Desktop/Binaries/FreeVarioGauge.ino.bin *0x8000*
/Users/PC1/Desktop/Binaries/FreeVarioGauge.ino.partitions.bin

14. Connect the ESP32 to the PC using the USB cable and open a terminal or the command prompt. Issue the above command there.

15. After the upload is complete, the ESP32 restarts. The Sound-ESP32 is done. If the display is already connected, the display ESP32 ends with a black screen. Files still have to be uploaded to the memory of this ESP32.

16. Install ESP32 Sketch Data Upload. Download ESP32FS-1.0.zip from https://github.com/me-no-dev/arduino-esp32fs-plugin/releases/

17. On Mac, copy the extracted folder ESP32FS to /Programme/Arduino (Show package contents)/Contents/Java/tools.

18. Under Windows, copy the extracted folder ESP32FS to / Programs / Arduino / tools.

19. Go to the Arduino IDE working directory (z.B. */Users/*PC1*/Documents/Arduino*) and there into the folder of the sketch you just created. Copy the data folder into this folder.

20. Restart the Arduino IDE, open your newly created sketch and click on “ESP32 Sketch Data Upload” under Tools.

21. When uploading files, make sure the serial monitor is closed. After the upload is complete, the ESP32 restarts and, if the display is already connected, you can now see the display of the vario gauge.

22. Now go back to point 13 of the assembly part of the instructions.

III. Switch off the vario sound from OpenVario

1. **Skip this section completely if you want to continue using the vario sound from OpenVario. If you wanted the FreeVario to make the sound, you have to work through this section.**

2. Choose "Exit to the shell" from the OpenVario menu and enter the command "systemctl disable variod" to switch off the vario sound from OpenVario.

3. Reboot OpenVario.

4. Changes the port of NMEA port A from 4352 to 4353.

5. If vario sound can still be heard in XCSoar, it will be generated by XCSoar.

6. At System -> Display -> Audio Vario set Audio Vario to Off. Confirm with Close.

IV. Settings in XCSoar

1. Click Config. -> Devices, select a free device from A, B, C or D and select Edit.

2. Select the port, where the electronical vario is connected with (e.g. ttyS1).

3. Baud rate is 115200, Driver is FreeVario, confirm with OK and Close.

V. Install XCSoar incl. FreeVario driver without reinstalling the OV image

1. If you don't want to reinstall the complete image of OV, but only want to replace the version of XCSoar, you can do that as described below. Your settings in XCSoar remain completely intact. I would always create a backup file of the SD card beforehand. Something always can go wrong!

2. Copy the new version of the installation file from XCSoar to a USB stick, select "Exit to the shell" in the OpenVario menu. Find the path of the USB stick with fdisk -l (e.g. /dev/sda1).

3. mkdir /tmp/USB

4. mount /dev/sda1 /tmp/USB

5. cd /tmp/USB

6. opkg remove xcsoar

7. opkg install xcsoar*.ipk

8. Set the language in the OpenVario menu again and reboot.

VI. Install the new OV image including XCSoar with FreeVario driver

1. Back up the .xcsoar folder from the old system
- Boot OpenVario and go to the menu. Select "Exit to the shell" and confirm with Yes. Connect your USB stick to manage the OpenVario and a USB keyboard. Enter the following commands.
- mkdir /tmp/USB
- mount /dev/„USB-Stick“ /tmp/USB (/„USB-Stick“ usually is /dev/sda1)
- cp -r .xcsoar /tmp/USB (takes a bit of time!)
- cd /tmp/USB
- mv .xcsoar xcsoar
- rm -r openvario/upload/xcsoar
- mv xcsoar openvario/upload/

2. Save the value for calibrating the voltage display (if you have calibrated it at all, skip step otherwise):
- Boot OpenVario and go to the menu. Select "Exit to the shell" and confirm with Yes. Connect a USB keyboard and enter the following commands.
- nano /opt/conf/sensord.conf
- write down the value for the "voltage_config" variable. For me it was 1204.

3. Save the WiFi settings:
- Copy the folder /var/lib/connman to the USB stick, which is already mounted.

- cp -r /var/lib/connman /tmp/USB

4. Install the new image:

Variant 1: Use a new SD card (secure method)

- Use a Linux PC to write the new image to another SD card. So you can be sure that on the old map there is still a working system in case something goes wrong.
- unzip the image first:
- gunzip "Path_to_Image"
- e.g .: gunzip /home/USER/Schreibtisch/OpenVario-linux-openvario-image-testing-glibc-ipk-20149-openvario-7-PQ070.rootfs.img.gz
- dd if=“ Path_to_image“ of=/dev/„ new_SD card “
- z.B.: dd if=OpenVario_new.img of=/dev/sda

Variant 2: Overwrite old SD card (insecure method)

- In the main directory of the USB stick "openvario" you put the recovery file "ov-recovery.itb", which you can download on the FTP server (ftp://ftp.openvario.org/recovery).
- IMPORTANT!! If you do not want to perform a recovery, the file "ov-recovery.itb" must be renamed, e.g. in "ov-recovery.xxx".
- Copie the image to be installed as a .gz file to the USB stick in the images subfolder
- Insert the USB stick into the OpenVario and boot.
- The recovery menu is shown in red. Remember that all files in OpenVario will be deleted when you restore!
- Select "Write image to SD Card" and then "Update complete SD Card".

5. Insert the new SD card into the OpenVario and start. Then go back to the OpenVario menu.

- Click "Copy file to and from OpenVario" -> "Upload files from USB to XCSoar". This will restore all of your settings. Wait until “done !!” is shown.
- Click "Update, Settings, ...". If necessary, select "Calibrate Touch" there.
- Then set the desired orientation of the display under "Update, Settings, ..." -> "System Settings" with "Set rotation of the display".
- Finally, set the language under "Update, Settings, ..." -> "System Settings" -> "Set language used for XCSoar".
- Back to the main menu with ESC and select "Restart" and confirm with Yes.

6. Restore the voltage display calibration:

- nano /opt/conf/sensord.conf
- „voltage_config” reset to the noted value

7. Restore backup of old WiFi settings:

- Copy the connman folder saved on the USB stick back into the /var/lib directory
- mkdir /tmp/USB
- mount /dev/„USB-Stick“ /tmp/USB (/„USB-Stick“ usually is /dev/sda1
- cp -r /tmp/USB/connman /var/lib

8. Set up WiFi again if there is no backup of the old settings:

- Boot OpenVario and go to the menu. Select "Exit to the shell" and confirm with Yes. Connect a USB keyboard and enter the following commands.
- connmanctl
- enable wifi
- scan wifi
- services
- agent on
- connect wifi_...
- Enter password

VII. Installation of the new OpenVario menu from Kedder

1. The OpenVario must be connected to the Internet and a keyboard must be connected.

2. Start OpenVario and go to the OV menu. Select "Exit to the shell" and confirm with Yes.

3. Enter the following commands there:
   - echo src/gz kedder_core http://openvario.lebedev.lt/opkg/armv7vet2hf-neon/ >> /etc/opkg/customfeeds.conf
   - echo src/gz kedder_all http://openvario.lebedev.lt/opkg/all/ >> /etc/opkg/customfeeds.conf
   - opkg update
   - opkg install openvario-shell openvario-shell-autostart --force-removal-of-dependent-packages

4. Use ESC to return to the main menu and select "Restart" and confirm with Yes. The new menu is now used.

VIII. Operating the FreeVario

1. Using the toggle switch, the Vario is switched to SpeedToFly (STF) or Vario mode (Vario). Automatic mode is active in the middle position. Depending on the position of the slide switch in the device on the upper board, XCSoar or an externally attached switch determines the automatic mode. The external switch can, for example, be connected to the flaps, so that the Vario and STF are automatically switched depending on the flap position.

2. With the rotary encoder above, the McCready value is set in normal mode and sent to XCSoar.

3. If the push button of the rotary encoder is pressed for more than 0.5s, the menu is activated and the line in which the height is displayed turns red. The line with the speed display or with the McCready value can be selected by turning the encoder. The selected menu item is activated by briefly pressing the push button. In the high menu you can now choose between altitude above sea level (MSL) and altitude above ground (AGL), in the speed menu you can choose between ground speed (GS) and true air

speed (TAS). Another short press on the push button selects the current setting and the desired values are shown in the display.

4. A special feature is the lower display for the McCready. Here you can choose between QNH and Bug by turning the menu. A short press on the push button activates the desired option and turning the encoder sets the value and sends it to XCSoar. Another short press on the push button closes the menu item and the McCready value is shown in the display again.

5. If the menu is not used for at least 10s, the menu is automatically exited and the setting selected at this point is adopted.

IX. Disclaimer

The vario gauge is not EASA or FAA certified. Note that this is exactly the same for all the fancy commercial electronic varios and flight computers you are probably used to.

If would you like to know, if you are allowed to use it legally at your glider, ask this question to your airworthiness inspector. Can you legally install any other big brand (as well, non certified) vario gauges? If yes, you should also be able to legally install this vario gauge. If you are under EASA rules see CS-STAN, standard change CS-SC402a.

This instrument is a craft project and not an aviation-approved instrument. I explicitly point out that the use is made under exclusion of any warranty at your own risk!