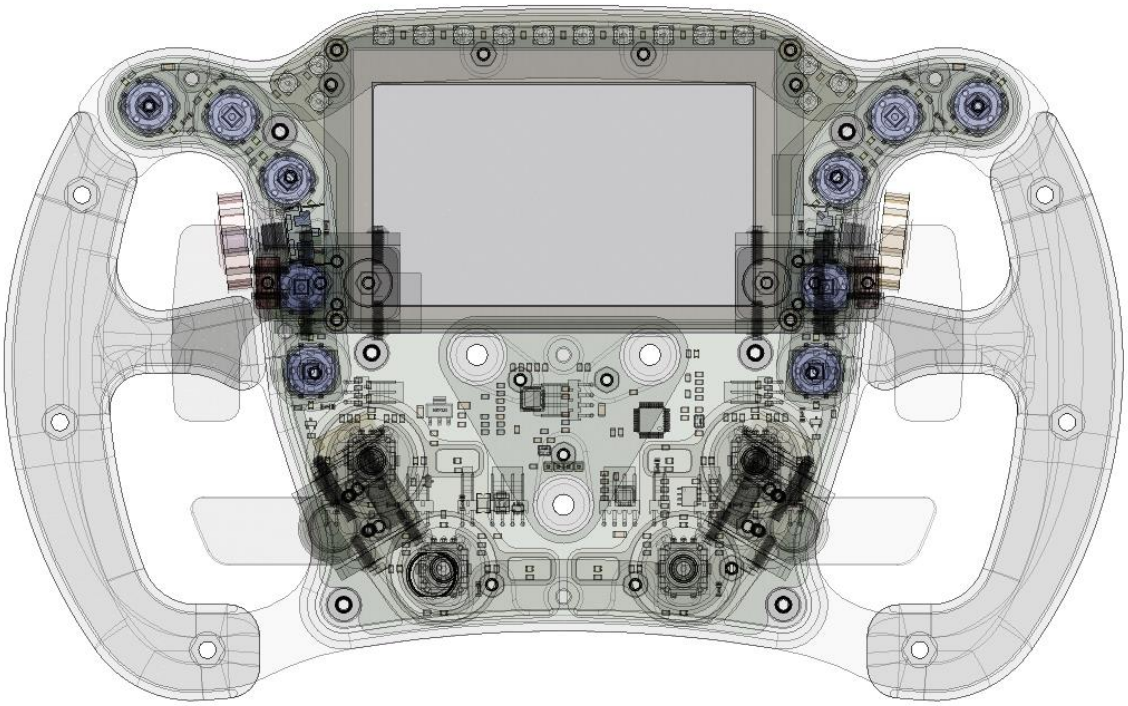
LMP-Pro

Assembly Guide



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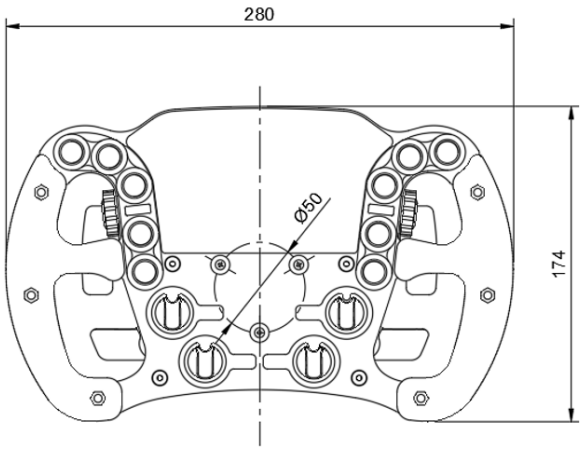
Specification

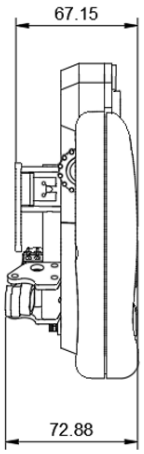
Features

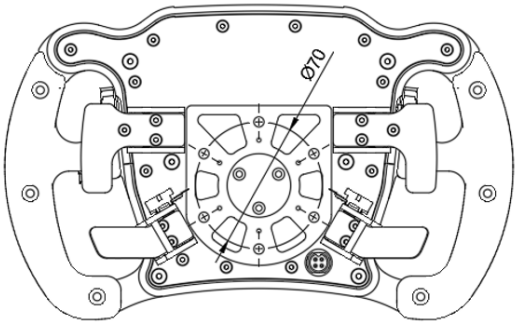
- Full carbon fiber composite/metal structure
- Suede leather grips
- Magnetic paddle shifters
- Total 25 inputs
    - 9 buttons (+1 for adjust function)
    - 2 shifters
    - 6 rotary encoders (6x 2 inputs)
    - +2 if clutches are used as switch
- Dual clutch paddle system with 3 different mode (dual-clutch, analog, switch)
- Adjustable button and rotary backlight
- 16 RGB LEDs
- 4.3” LCD display
- 50mm and 70mm PCD quick-release compatibility

Technical details

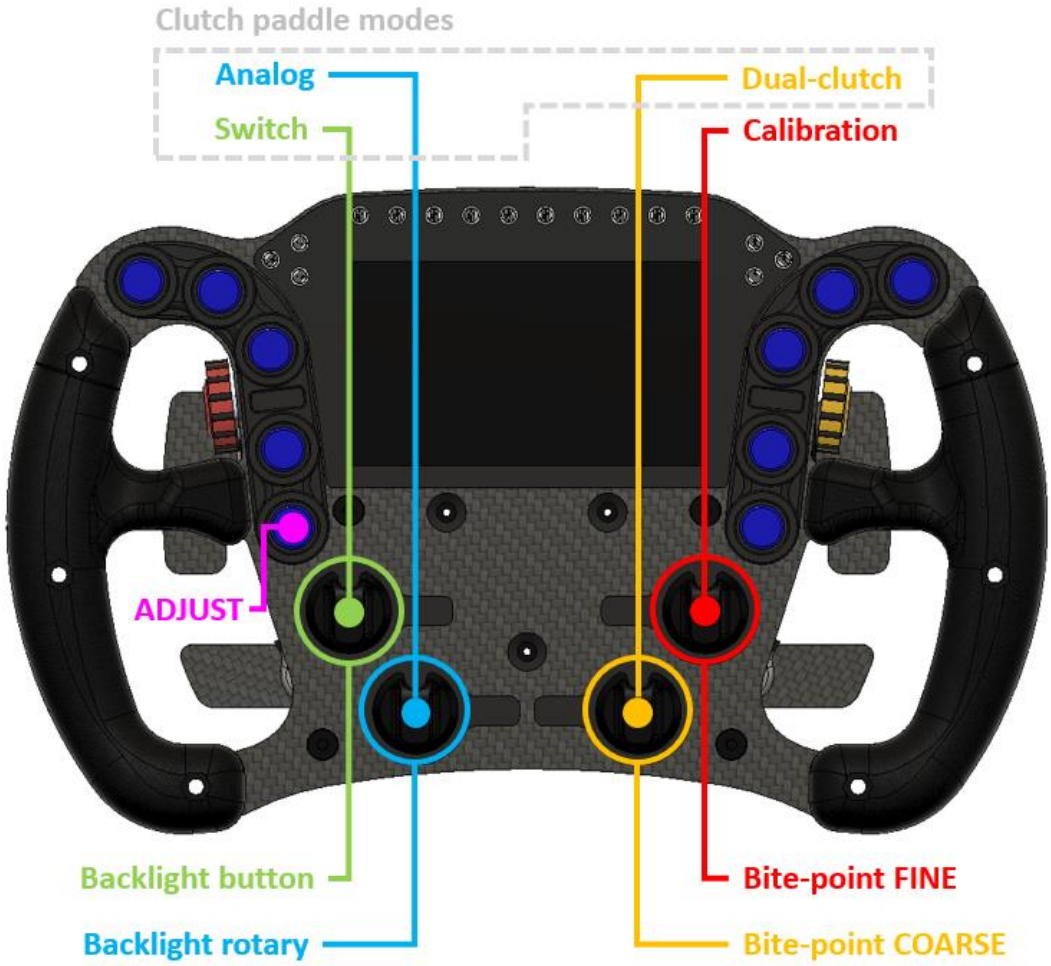
Wheel diameter	280 mm
Wheel weight	1200 g (from carbon fiber)
Input voltage	Typ. 5.0 V (4.5 - 5.5 V)
Current consumption	Max. 1.5 A (always use with min. 1.5 A USB port)
Display resolution	480x272 (Nextion)
Display brightness	230 nit (Nextion)



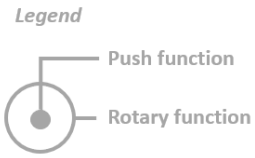




Manual



Clutch paddle calibration



To switch into calibration mode, hold the **ADJUST** button (left-bottom button) and hold the right-top rotary encoder for 5 sec. After 5 sec the backlight starts flashing, that indicates, that you are in calibration mode. You can release all the buttons. Now move the clutch paddles from end to end. So, the wheel can capture the min/max values. If you moved both clutches, press the adjust button once again and the wheel will exit from calibration mode.

The calibration values are saved when exiting calibration mode.

Clutch paddle modes

The clutch paddles have 3 different mode:

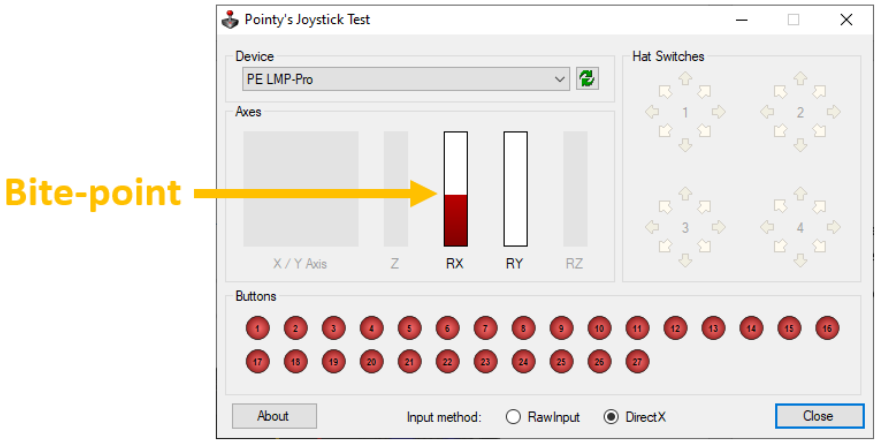
- Dual-clutch: The 2 clutch paddles are working as 1 analog input. Right side clutch is the master. Bite-point adjustment available only in this mode.
- Analog: The 2 clutch paddles are working as 2 separate analog inputs.
- Switch: The 2 clutch paddles are working as a switch.

You can switch between the modes by holding **ADJUST** button and pressing the appropriate (shown on the picture above) rotary encoder.

Bite-point adjustment

Bite-point adjustment is available only in the dual-clutch mode. If you are not in this mode, please see the previous chapter (*Switching clutch paddle mode*).

Open Windows game controller properties panel or this test application. So, you can see what you are doing.



Pull the left-side clutch paddle fully in. (Hold like this while bite-point adjustment.) Now you can see that the input is increased to the bite-point. Now, while holding **ADJUST** button you can adjust the bite-point with the right-side rotary encoders:

- Right-top rotary: FINE (~0.5% steps)
- Right-bottom rotary: COARSE (~5% steps)

You can see the rotary encoder functions on the picture above.

Backlight brightness

The button and rotary encoder backlight brightness can be adjusted separately. By holding the **ADJUST** button and rotating the left-top rotary encoder, the buttons backlight can be adjusted, with the left-bottom encoder the rotary backlight can be adjusted.

You can see the rotary encoder functions on the picture above.

Manufacturing parts

Plates

The plates can be made from aluminum (recommended AL 6061 or 5082) or carbon fiber composite.

If made from aluminum, it can be cut with water jet, CNC mill or laser. Carbon fiber composite can only be cut with CNC mill.

Recommended carbon fiber composite service: http://www.szgdctech.com/

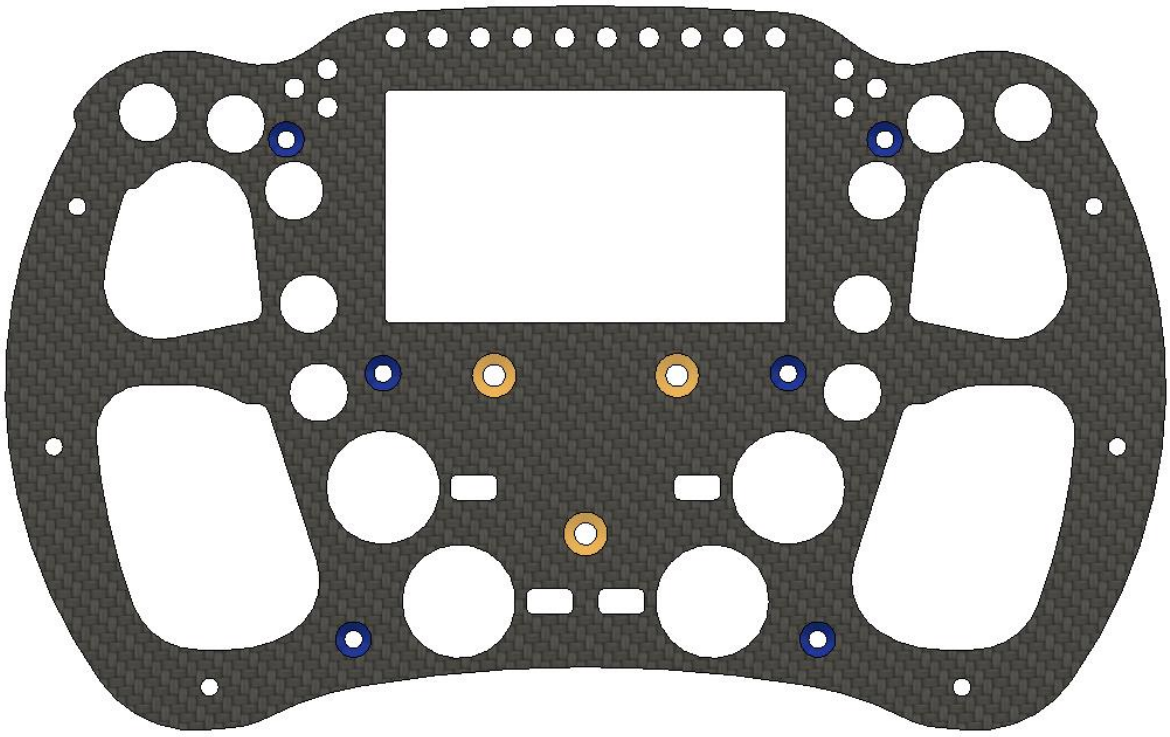
If the service you want to use can make the countersinks, you can use the files from the ***PLATES/Step*** folder. If not, you can use the DXF files from ***PLATES/DXF***.

You can find the required quantities and the other spec (thickness, etc.) in the BOM.

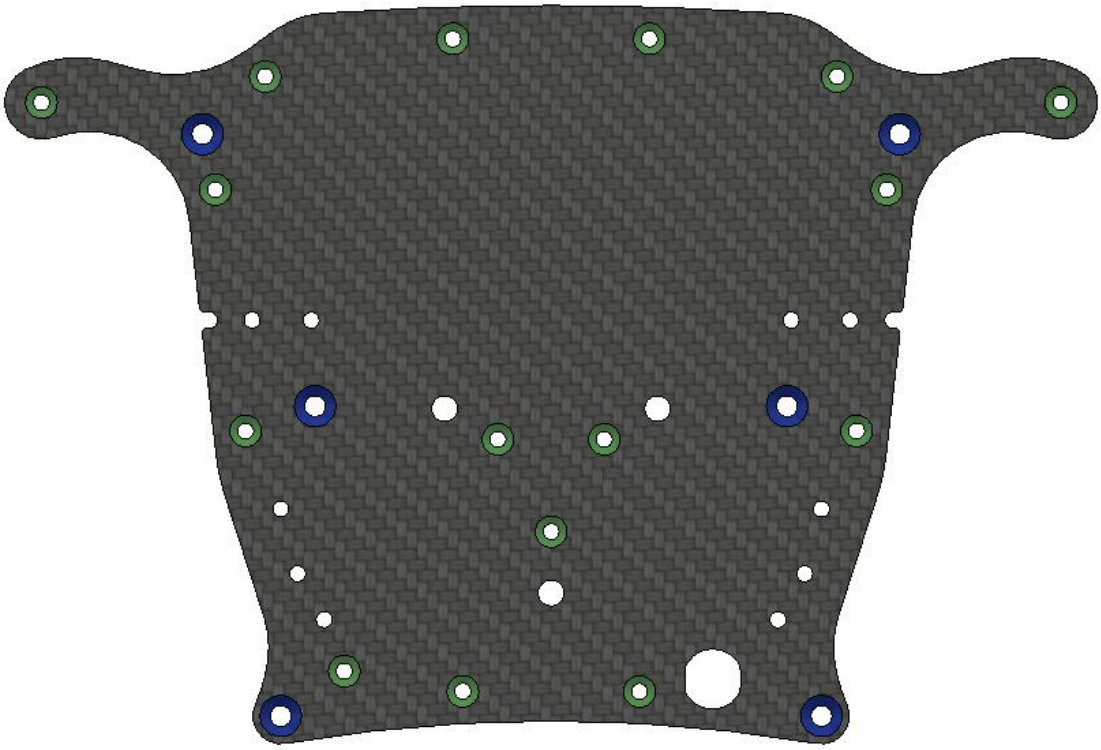
If you do the countersinks for yourself, countersink all the colored holes marked on the following pictures.

Yellow mark – Countersink for M5 screw
Blue mark – Countersink for M4 screw
Green mark – Countersink for M3 screw

Front plate countersinks

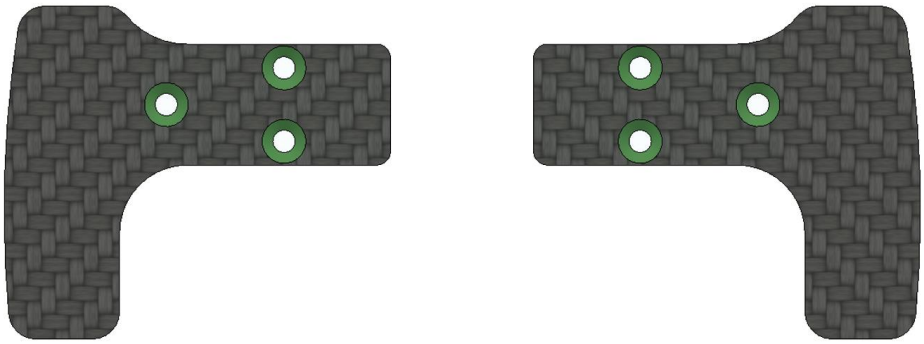


Back plate countersinks



Clutch paddles countersinks

Shifter paddles countersinks



3D Printed parts

You find the models needed to 3D print in the ***3DPRINT*** folder. The files under the SLA folder can be also printed with FDM printer, but those parts are harder to sand, so it's recommended to print with SLA technology. The required quantities from each model is described in the BOM.

Recommended material	PLA (PETG)
Layer height	0.2 mm
Infill density	60% (100% for *QRSpacer*)
Wall line count	4 (1.6 mm)
Top/bottom layers	4 (0.8 mm)
Support	Recommended to turn ON (OFF in small holes)

You can change any printer settings based on you printer, experience.

Plastic post-production/painting

Sand all the parts with grit 120 then apply 2 coats with acrylic filler spray.

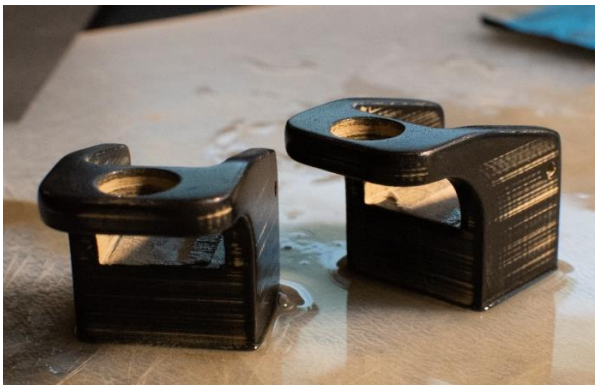
Before applying the second layer wait minimum 120 min. After the second layer wait at least 24h before start sanding. About 90% of the filler coats should be removed with the sanding. The filler supposed to fill only the thin gaps between the layers.


The photos are for reference only (the sanding steps are shown on different 3D models; those models are not part of this wheel)!

Sanding grit steps:

120 → 180 → 240 → 320 → 400 → 600

Always sand wet, because the PLA can melt from the heat of sanding. After sanding you should have similar result:




The photos are for reference only (the sanding steps are shown on different 3D models; those models are not part of this wheel)!

After sanding, clean the surface and apply 3 layers of acrylic matte spray. Always wait 1-2h between the layers and 24h after the last layer. You should have similar result as on the right-side photo above.

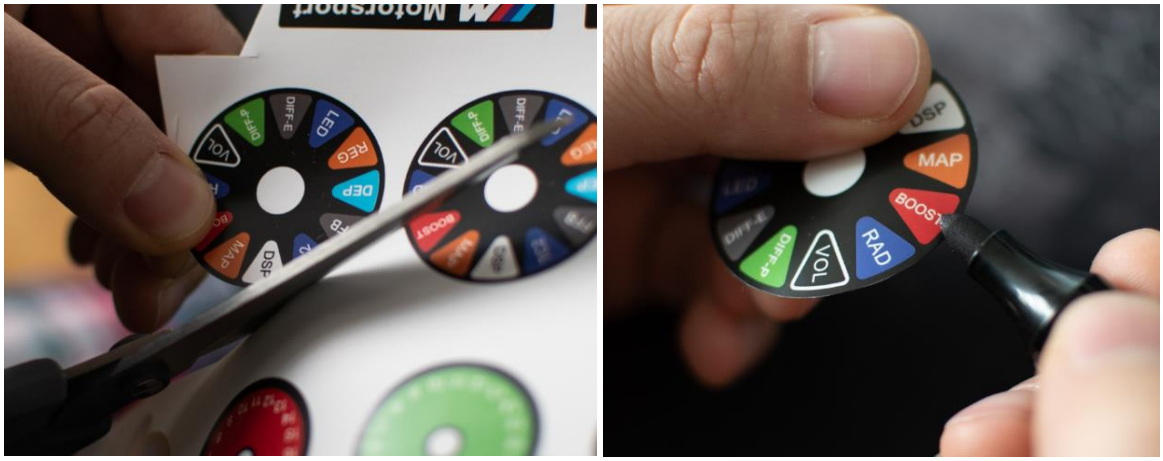
For the SLA printed parts, you can skip the sanding. That technology gives already smooth surface already, so you can paint it with matte acrylic spray right after printing.

Decals

Decals can be printed on **matte white polyester adhesive** in a simple copy-store. The button stickers can be printed on transparent polyester.

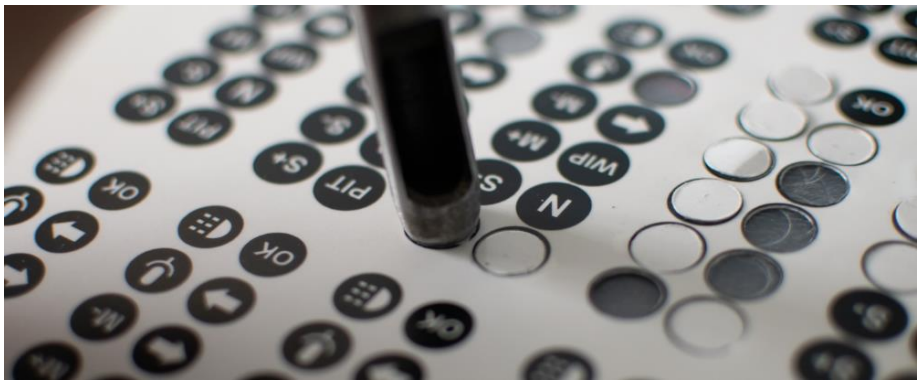
The files can be found in the *DECALS* folder.

There are no difficult forms, so I recommend to cut with scissor and "paint" the edges with black permanent marker.



The photos are for reference only (the stickers on the photos are for different wheel design)!

The button decals can be cut with 9mm round punch tool.

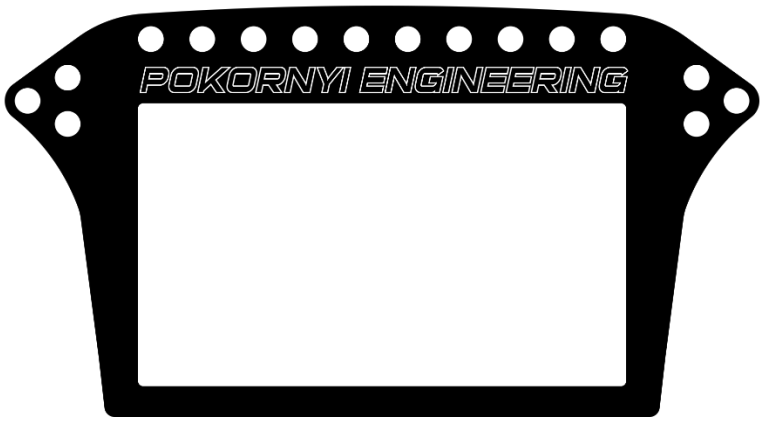


If the rotary stickers don't have enough strong color when the light is turned on, you can put an additional „color" layer (*DECAL_RotaryColor.pdf*) under the sticker printed on transparent polyester.

Plexiglass

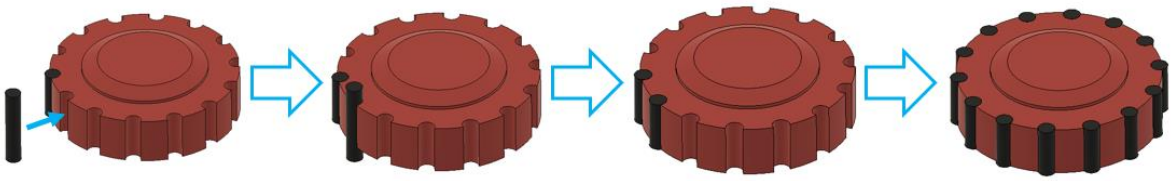
The plexiglass is designed for direct (UV) printing technology. All the files required for this can be found in the *GLASS* folder.

If you can't find company for direct printing, you can use sticker on the back side of the plexiglass: *DECALS/DECAL_Plexiglass.pdf*.



Side rotary knobs

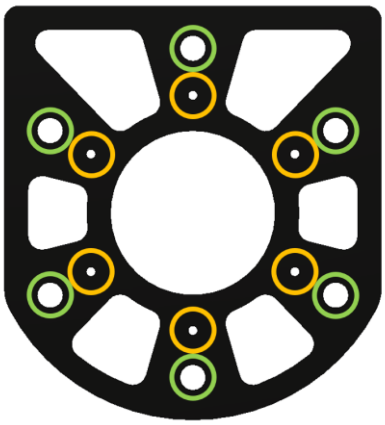
The main parts of the side rotary knobs should be 3D printed (recommended from PLA). Cut ~10 mm straight pieces from 1.75 mm black filament. Glue those pieces into the slots of the knob. After the glue is dry, you can cut the overhangs.



QR Adapter

The *QRAdapter* should be cut from 10mm aluminum (min. AL 5754, recommended AL 6061). Drill the yellow marked holes to 4.2mm. Cut M5 threads into those holes.

Countersink the green marked holes for M5 screw. Pay attention the countersunk depth, the head of the screw should not stand out.



PCB

The wheel needs a custom PCB, which can be manufactured with the attached files (GERBER, BOM, CPL).

The cheapest way to make the PCB is to order bare board and solder all the components for yourself. I recommend this way only for those who have good electronics knowledge/experience. Because if some solder error happens or you make something wrong it will be hard to debug without any electronics knowledge.

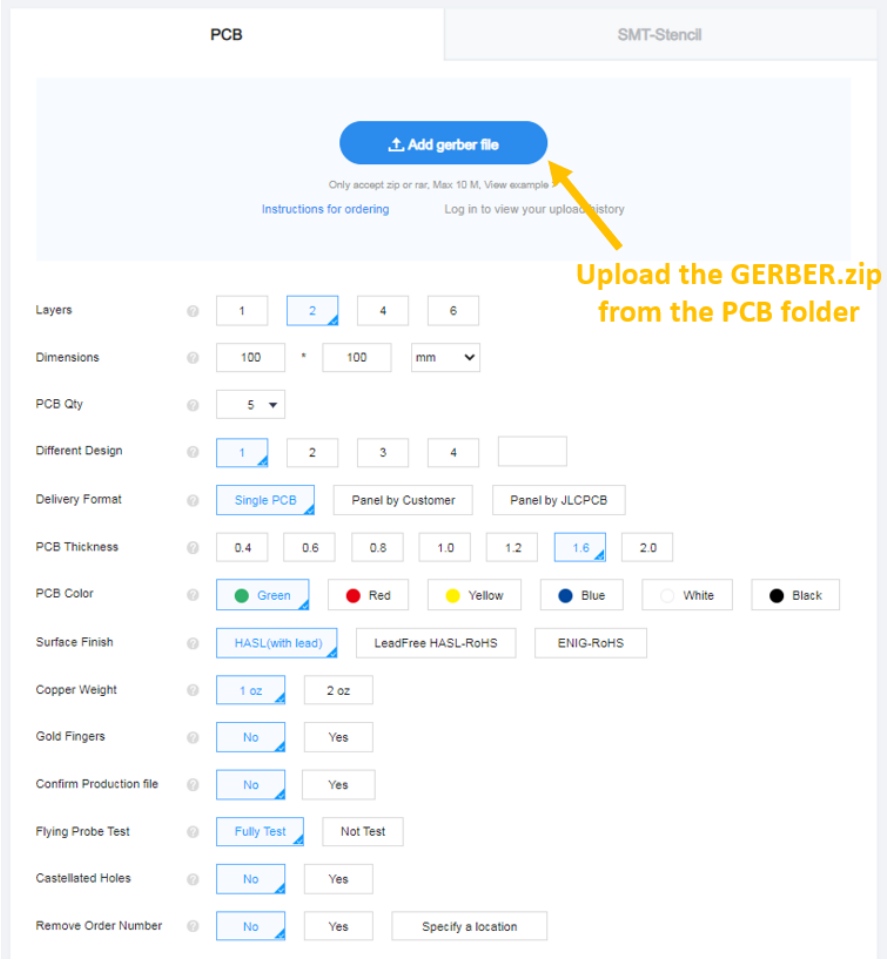
PCB can also be ordered from PCBway.com. They are more expensive than JLCPCB, but they can do also THT component soldering, etc.

Ordering the PCB from JLCPCB

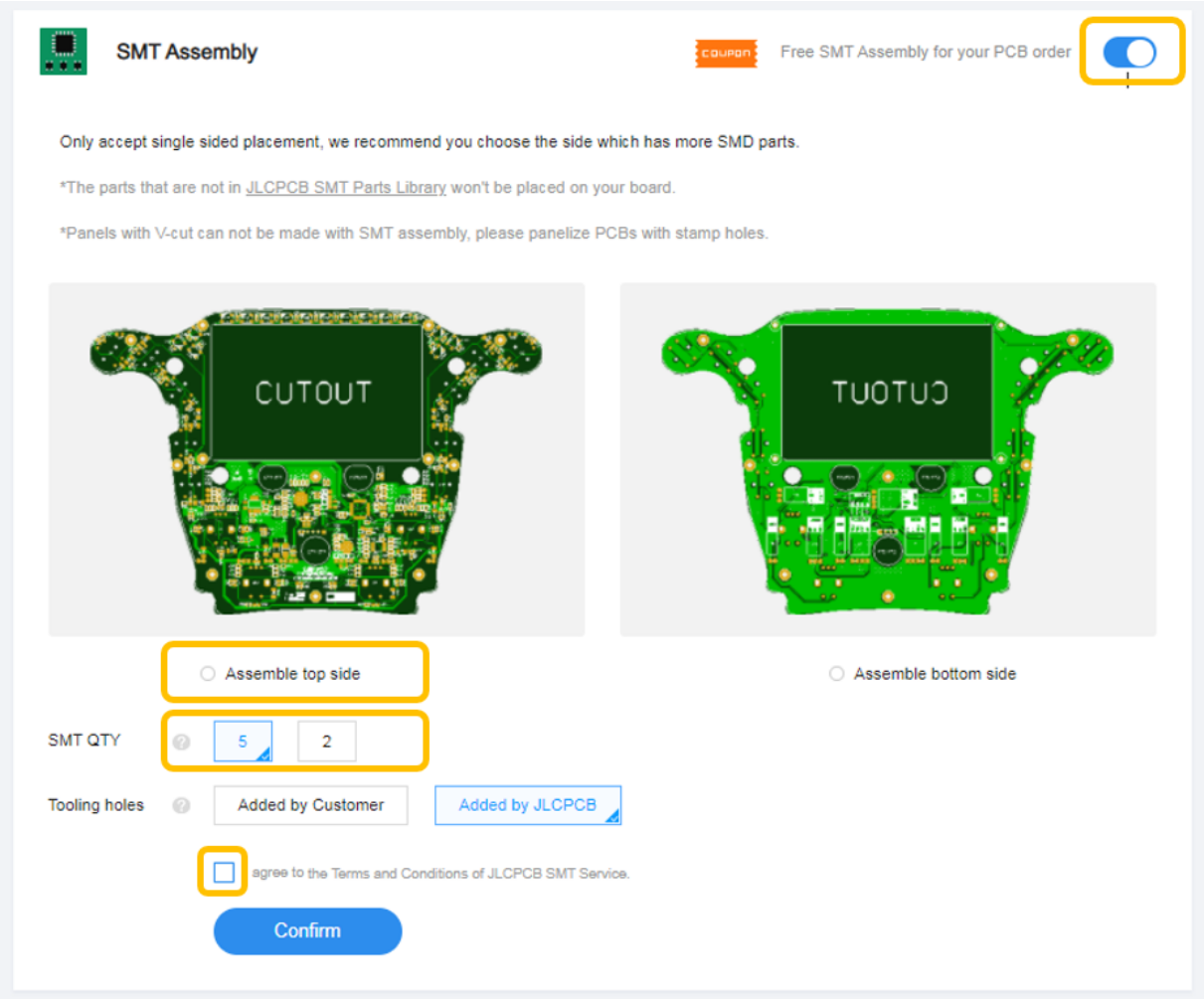
You can order the PCB with most of the components mounted (surface mounted components) from JLCPCB.COM. The other components (connectors, buttons, rotaries and the component JLCPCB don't have on stock) need to be soldered by you.

Upload the GERBER file. The default settings will be fine (the dimensions will be updated according the uploaded files, you don't need to change it). If you want, you can select different PCB color, but it might take longer time or might more expensive.

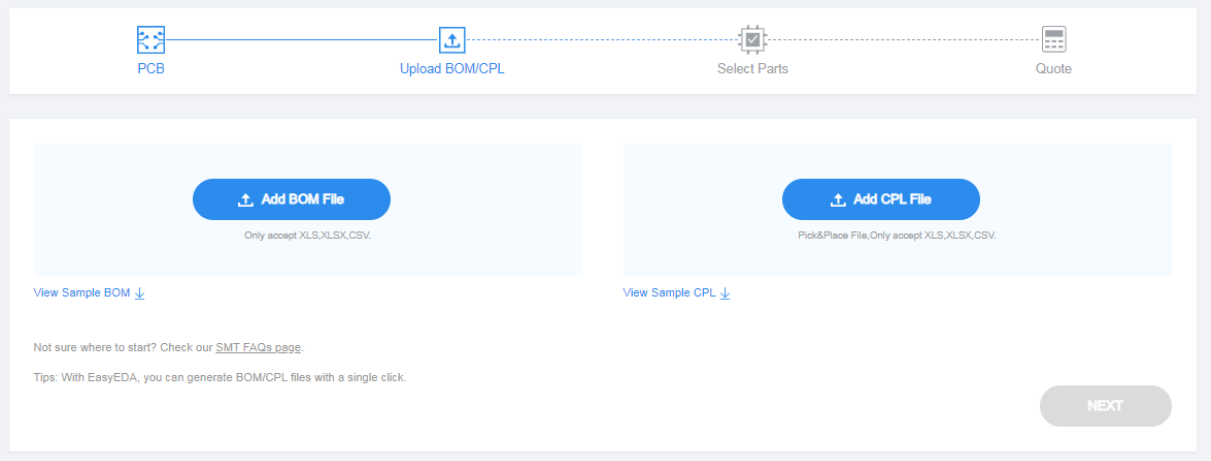
If you want to order bare PCB (without components) you don't need to upload any other file. In this case you can put into the cart and pay.



For SMT (surface mounted) assembly turn on the SMD service.
Select the top side.
If you don't need all PCBs assembled (cheaper), you can select "2" for SMT QTY.
Mark the checkbox and click confirm.



Upload the BOM (JLCPCB version) and CPL file from the PCB folder on the next page and click NEXT.



On the next page you will see the parts which can be mounted by JLCPCB. You can click NEXT and SAVE TO CART on the next page.

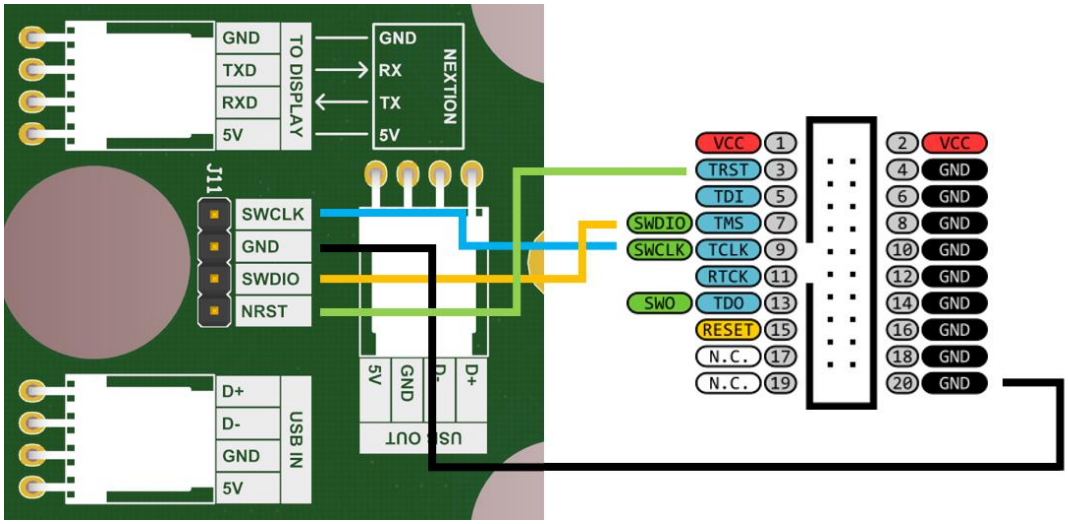
Programming the PCB

To upload the firmware to the STM32 microcontroller, you will need an ST-Link/V2 programmer.

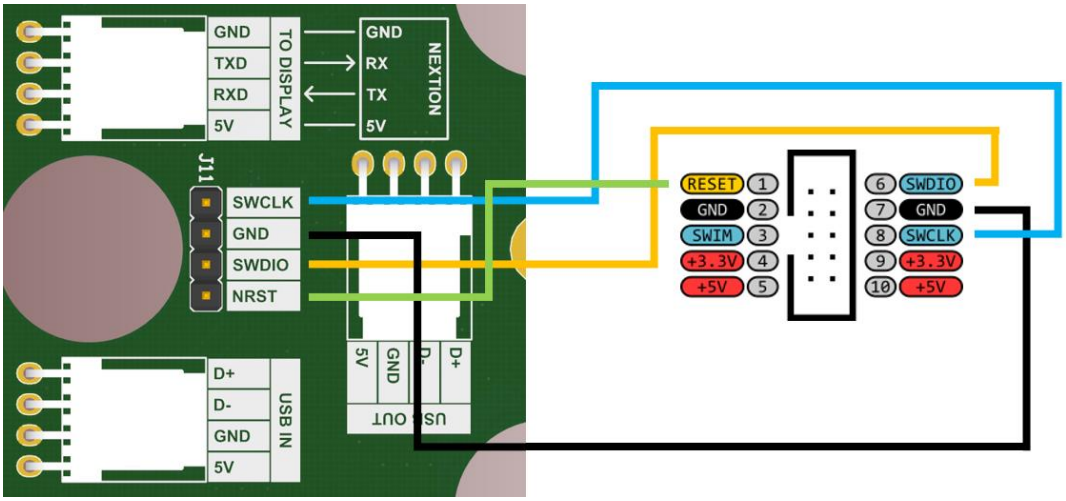
You can buy cheap ST-Link V2 clone from eBay (left side picture) or original ST (right side picture). The cheap version from eBay usually works fine, but you can run sometimes in faulty one.

Connect the programmer according the diagrams below.

Original ST-Link V2:

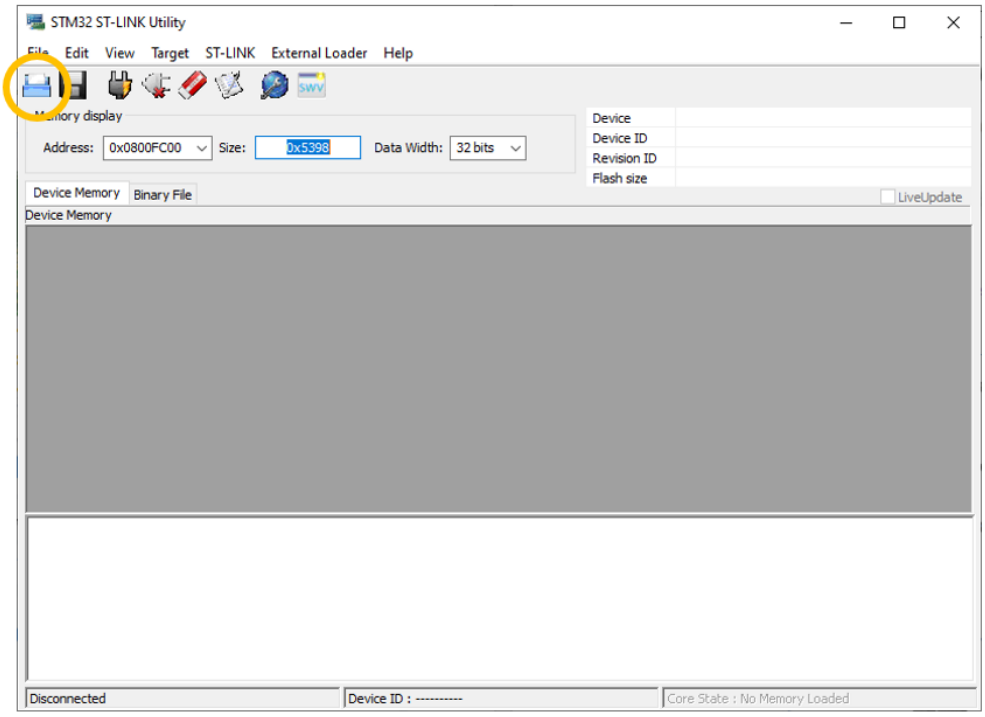


eBay ST-Link V2 clone:

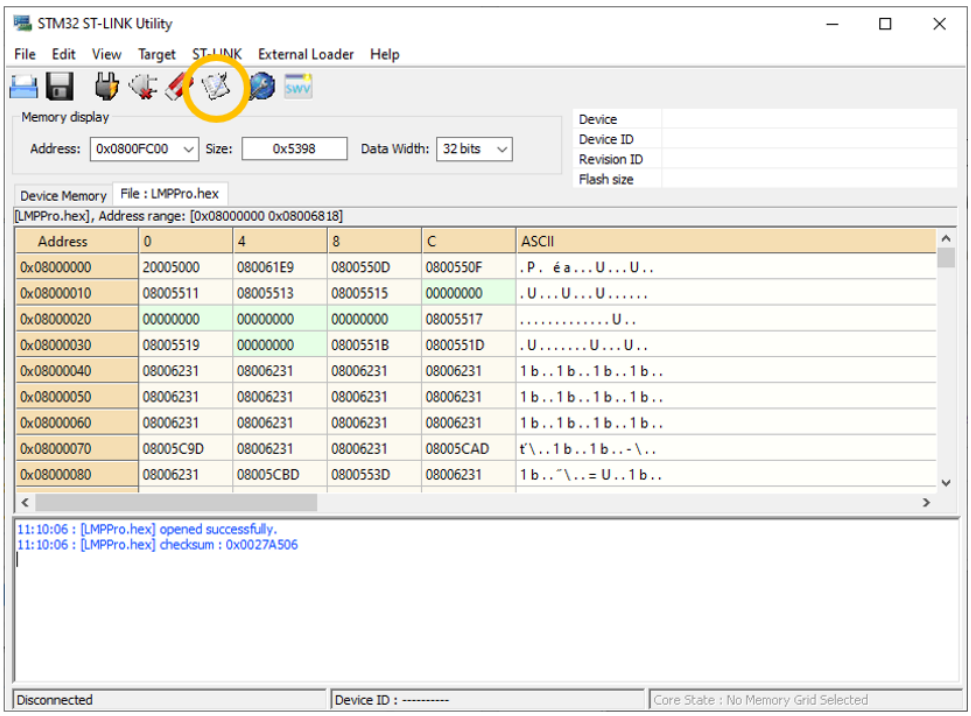


Connect the PCB to PC via USB cable (*USB IN* connector)! The board should be powered under programming, the programmer is not powering up the PCB.

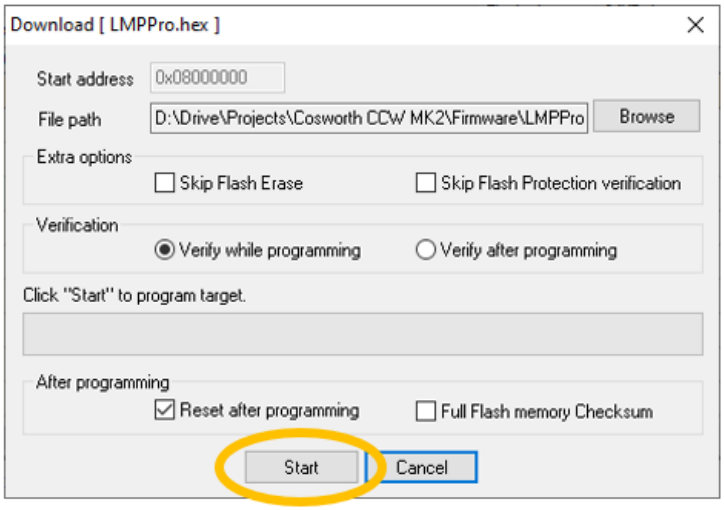
You need to install ST-LINK Utility, which can be downloaded from here.
Start ST-Link Utility software and click on the folder icon to open the firmware from the FW folder file:
LMPPro_Vx.xx.hex



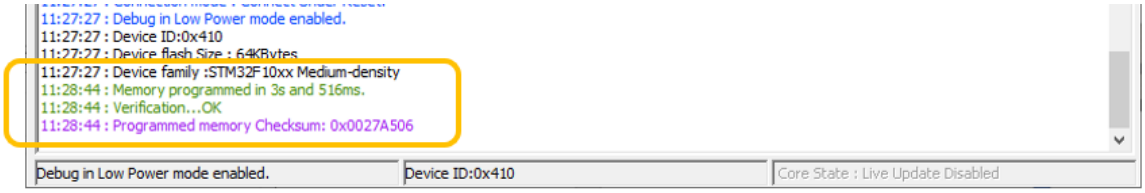
Click on the marked **ICON** (on the picture below) to program and verify the STM32 microcontroller.



Click **START** in the pop-up window.



If the microcontroller is successfully programmed, you should see the following messages in the log window.



Backlight buttons

The LEDs for the buttons are on the PCB. The switches are from itself not illuminated. The LEDs on the PCB are strong enough to light through the button caps.

Good working caps:

- White
- Red
- Yellow
- Green

The blue (and black) cap is not working fine (too dark).

Through hole components

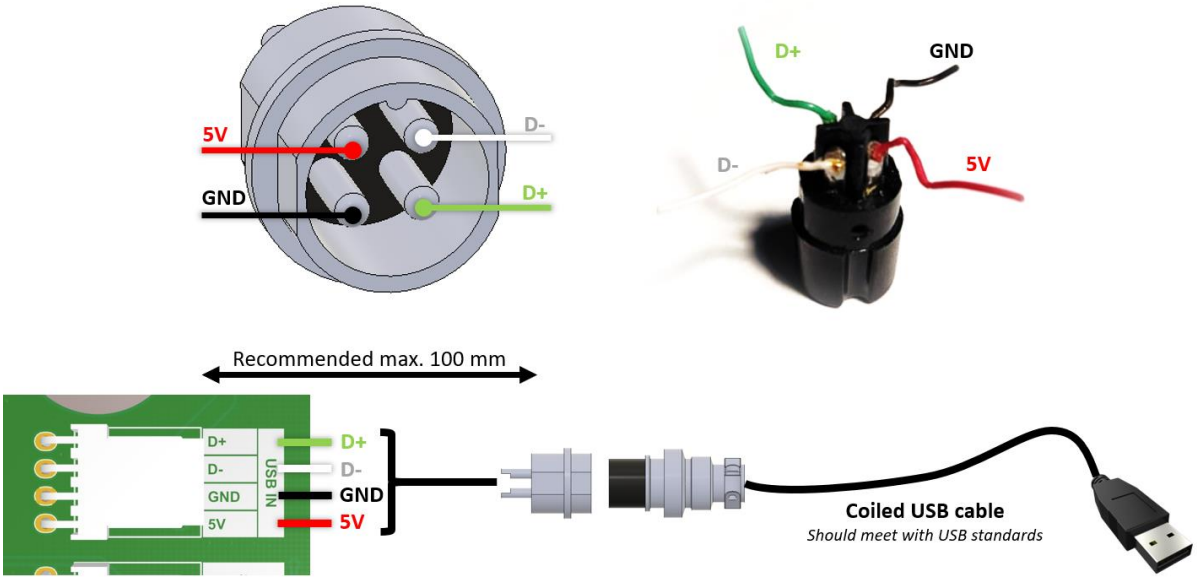
JLCPCB can solder SMD (Surface Mount Device) components. So, the through hole components (buttons, encoders and connectors) you will need to add by yourself. These parts are part of the FULL BOM of the PCB.

GX12 USB connection

The GX12 socket should connected to the "**USB IN**" connector on the PCB. The GX12 pinout is not fixed, but you need to take care that the USB signals is connected in right order to the PCB.

For PC connection you need to make an USB to a GX12 plug cable.

A recommended pinout:



Recommended USB cable: **Leo Bodnar USB coiled USB cable**

Don't use bad quality USB cable which don't meets with USB standards (without twisted pair, shielding, etc.). Too long USB cable will cause too high voltage drop on the cable due to the high

Solder joints always cover with shrinking tube, otherwise short circuit may damage the PCB.

Molex – GX12 cable shouldn't be much longer than 100mm. Green and white wires (D+ and D-) should be twisted.

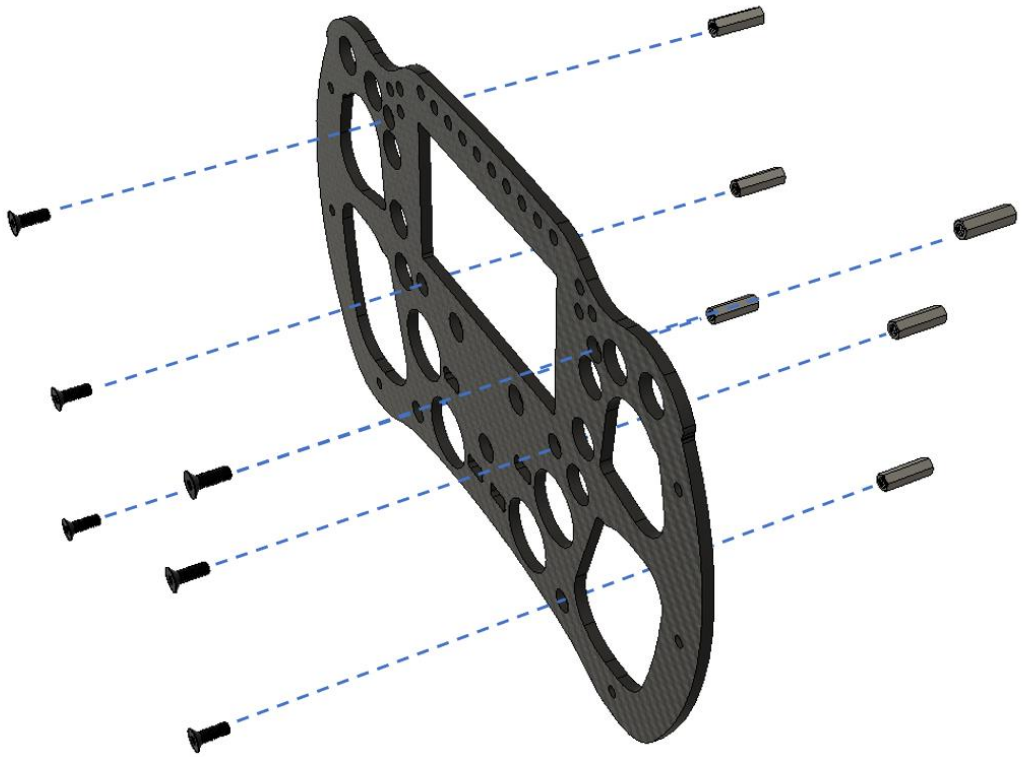
Molex connector pinout depending on the PCB!
Don't use the picture below as reference for the pinout. Use the picture above.

Assembly

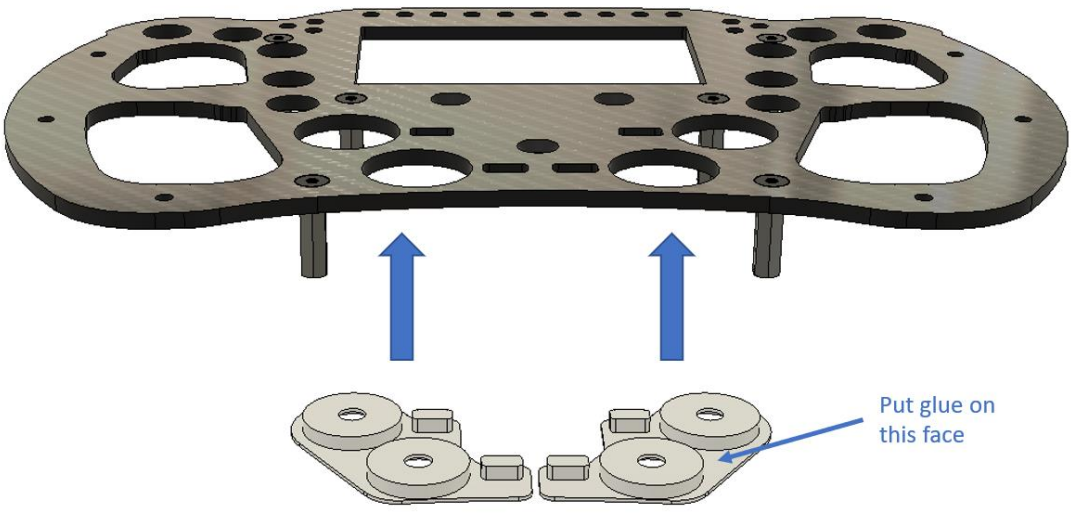
If all of the parts manufactured, then you can start to assemble the wheel.

Front plate

Mount the 6x **M4x20mm Hex Standoffs** to the front plate with 6x **M4x10mm Hex Socket Countersunk Black** screw.



Put superglue on the marked face of the 3D printed *RotaryPlate* and glue in in place.

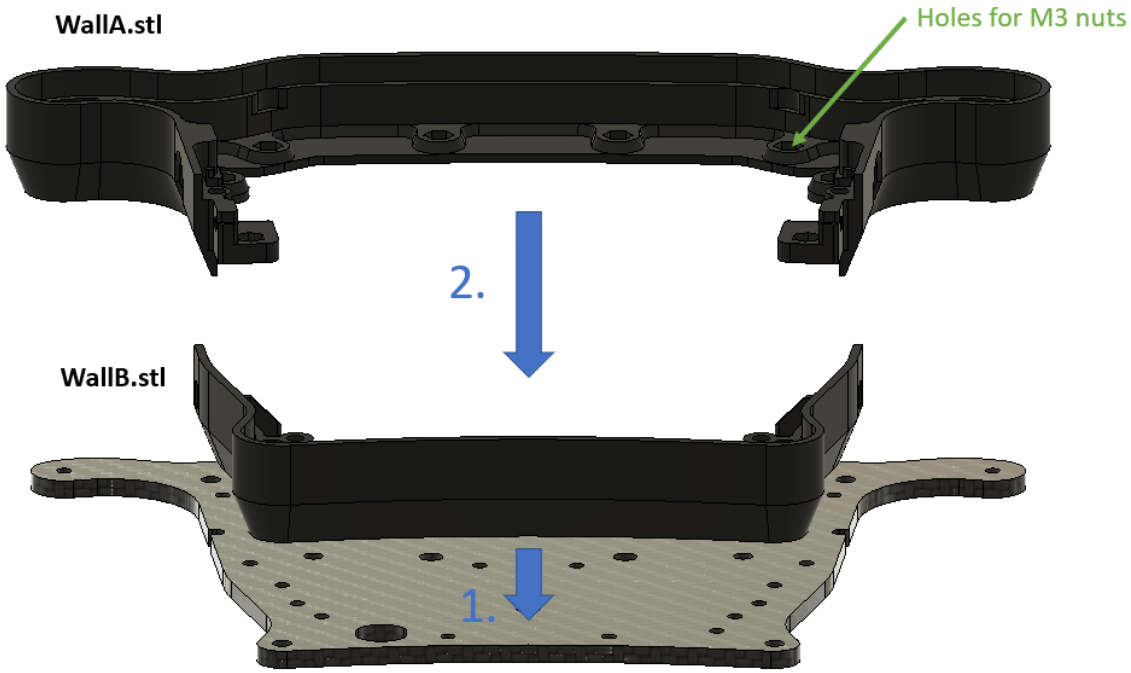


Mount the left and right-side grips from the back with 6x **M4x20mm Hex Socket** screw.

The grips should be already wrapped with suede leather and the M4 nuts placed inside the front part before this step!

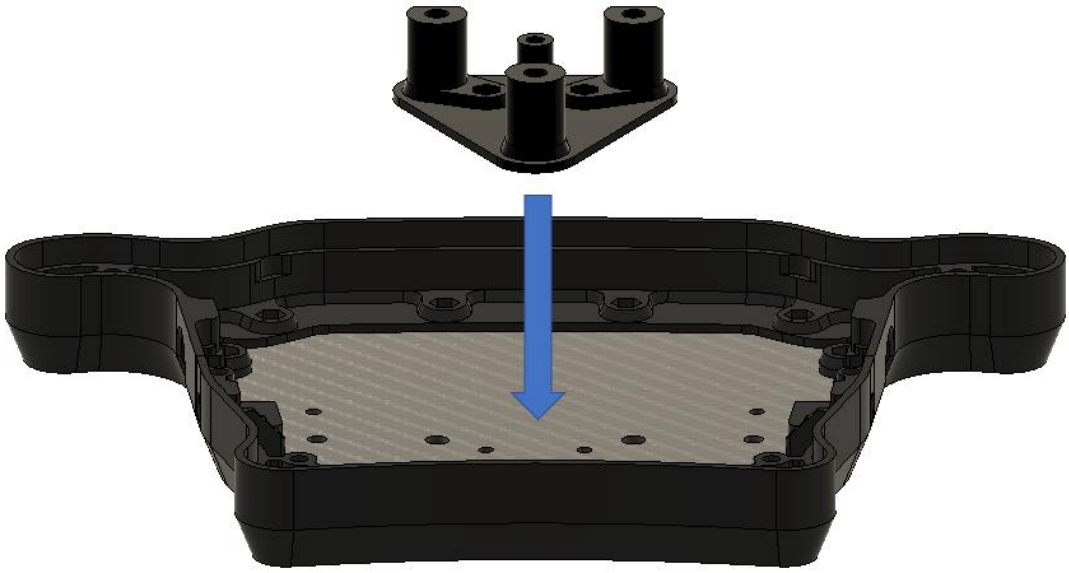
Backplate

Put 13x **M3 Nut** into the holes of the side walls (WallA and WallB). Mount the WallB first with 3x **M3 Hex Socket Countersunk Black** screw, then mount the WallA.stl with 10x **M3 Hex Socket Countersunk Black** screw.



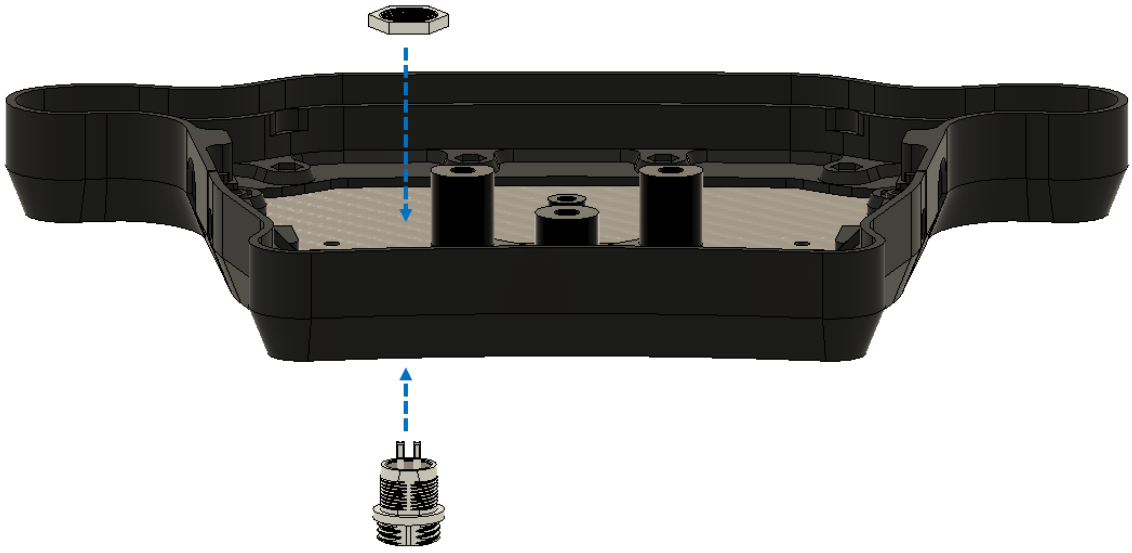
Put 2x **M3 Nut** (left and right) into the side holes of the *WallA*. Fix the *WallA* to *WallB* with 2x **M3 Hex Socket Countersunk Black** screw.

Put 3x **M3 Nut** into the holes of *QRSpacer* and mount it to the backplate with 3x **M3 Hex Socket Countersunk Black** screws.



Insert 8x **M3x6mm Brass Threaded Inserts** in the side walls and *QRSpacer* with soldering iron set to 240°C.

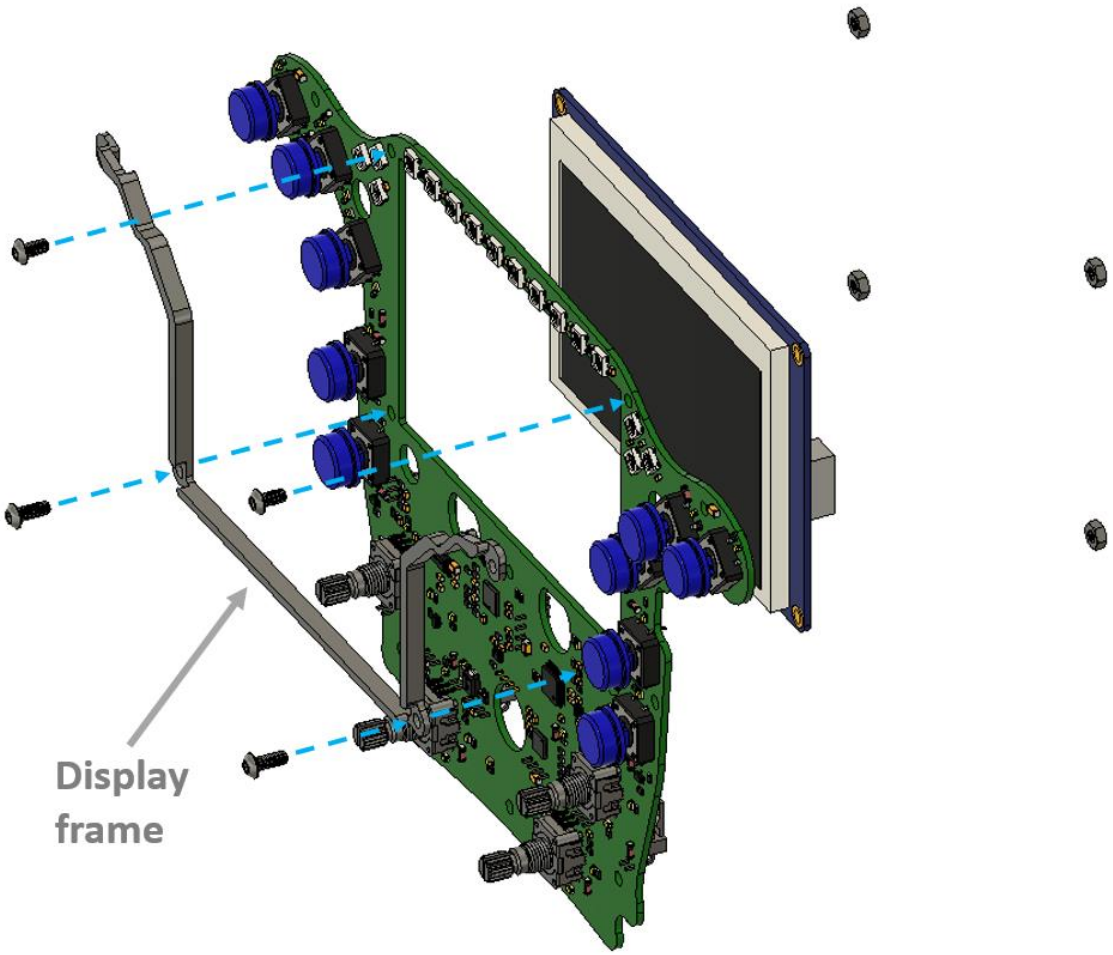
Mount the **GX12 4Pin Socket Connector** to the backplate.



PCB and Display

Mount the **NX4827T043** Nextion display and *DisplayFrame* to the PCB with 2x **M3x6mm Hex Button Head Screw** (top), 2x **M3x8mm Hex Button Head Screw** (bottom) and 4x **M3 Nut**.

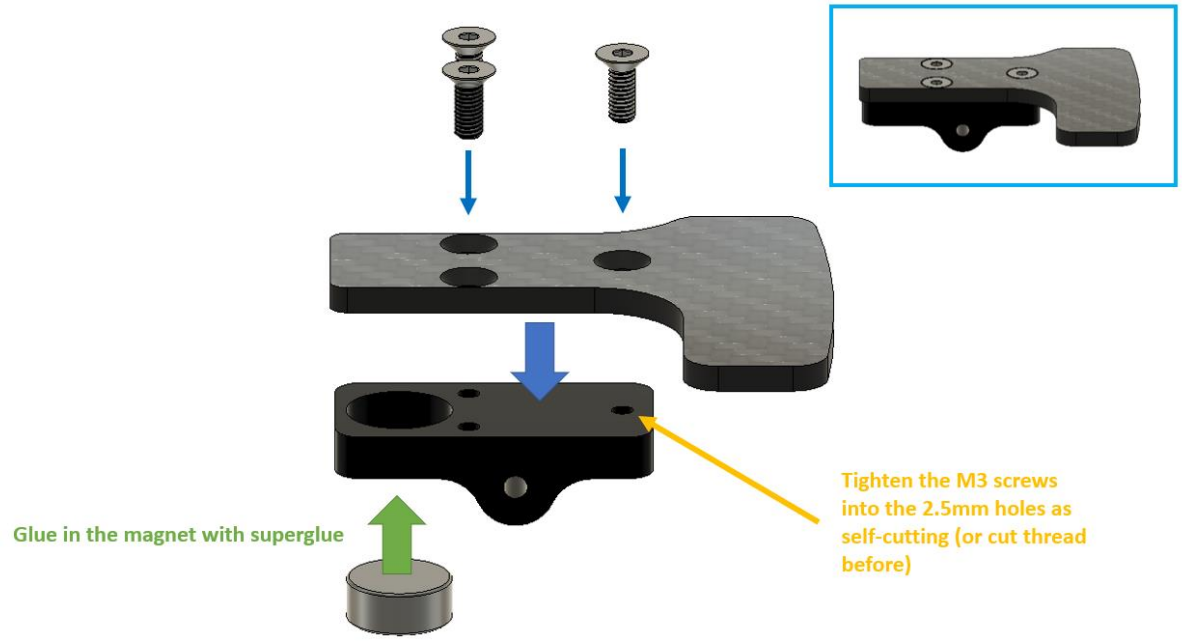
The *DisplayFrame* is mounted only with the 2x bottom screw. The top part of the frame will be fixed when putting PCB in the place.



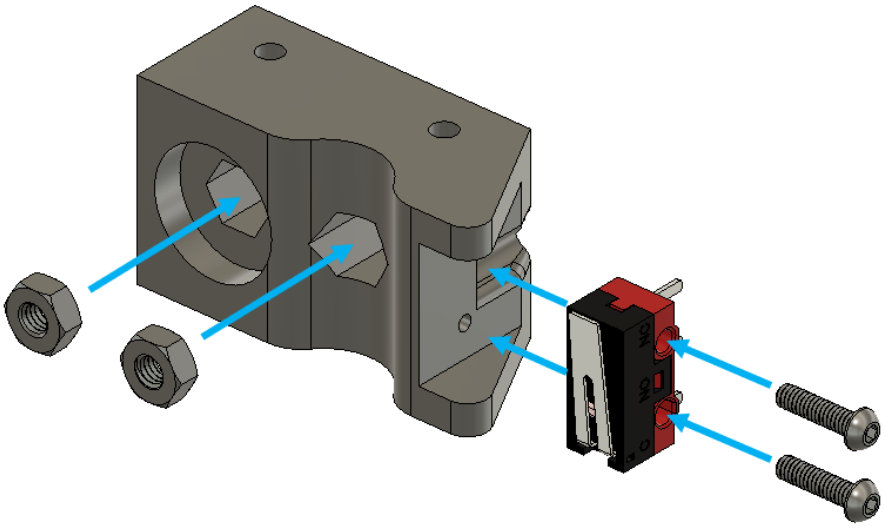
Shifter

Only the left side shifter is shown in this chapter, the right side is the same but mirrored.

Mount the *ShifterPaddle* to the *ShifterLever* with 3x **M3x8mm Hex Countersunk Screw.** The screws should be used as self-cutting screws tighten directly into the 3D printed part. If the holes are too small you can drill with 2.5mm drill bit or cut thread with M3 cutter. After fixing the *ShifterLever* to the paddle, glue the **Ø12x5mm Magnet** in place with superglue.

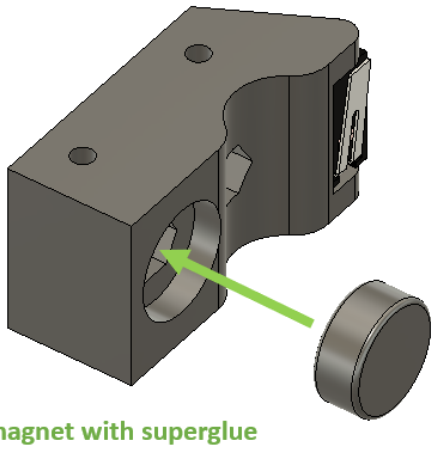


Put 2x **M3 Nut** into the holes of *ShifterBody*. Fix the micro lever switch to the *ShifterBody* with 2x **M2x8mm Hex Button Head Screw.**



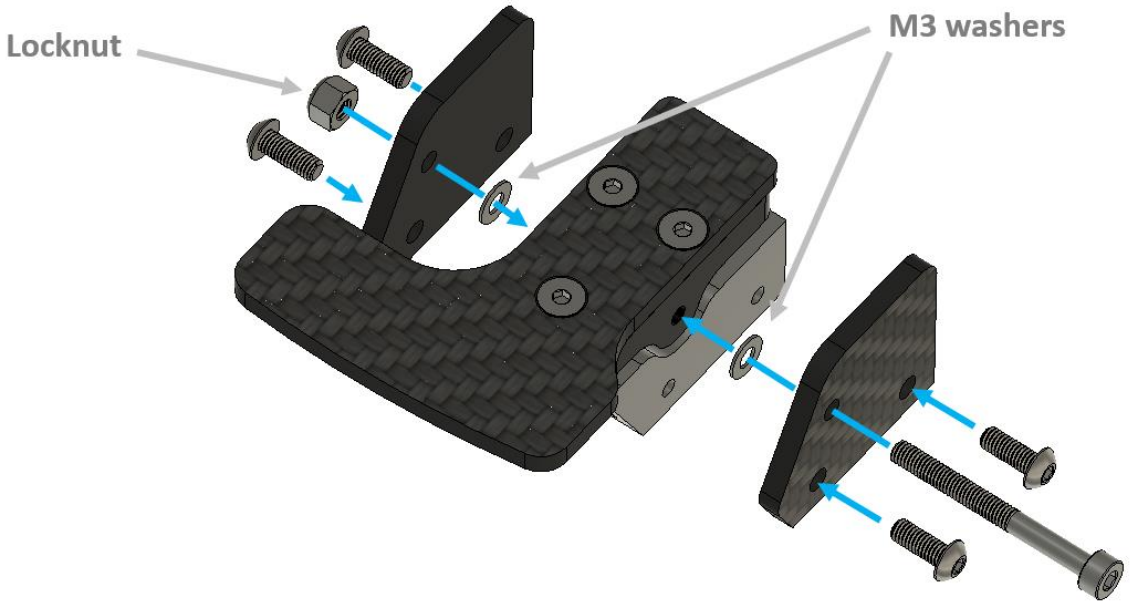
Glue the **Ø12x5mm Magnet** in the *ShifterBody* with superglue.

Pay attention to magnet polarity. It should attract the shifter lever.



Glue in the magnet with superglue

Mount the side walls (*ShifterSide*) to the *ShifterBody* with 4x **M3x8mm Hex Button Head Screw.** Same as before: the screws should be used as self-cutting screws tighten directly into the 3D printed part. Mount the shifter paddle with 1x **M3x30mm Hex Socket Screw** and 1x **M3 Locknut**. Don't forget to put **2x M3 Washer** between the lever and the walls to avoid their contact.

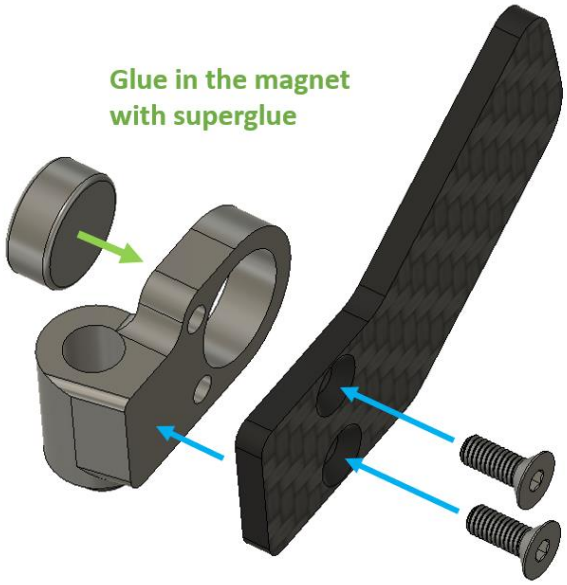


You can put a little bit grease on the 30mm screw to have better lever rotation.

Clutch

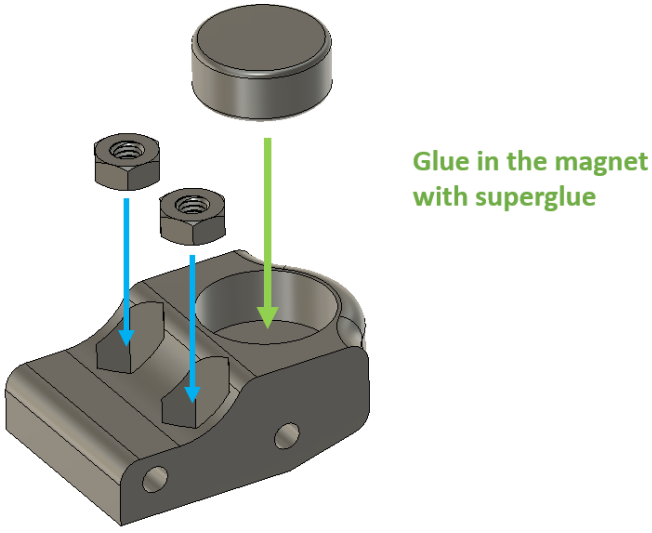
Only the left side clutch is shown in this chapter, the right side is the same but mirrored.

Mount the *ClutchPaddle* to the *ClutchLever* with 2x **M3x8mm Hex Countersunk Screw.** The screws should be used as self-cutting screws tighten directly into the 3D printed part. If the holes are too small you can drill with 2.5mm drill bit or cut thread with M3 cutter. After fixing the *ShifterLever* to the paddle, glue the **Ø12x5mm Magnet** in place with superglue.

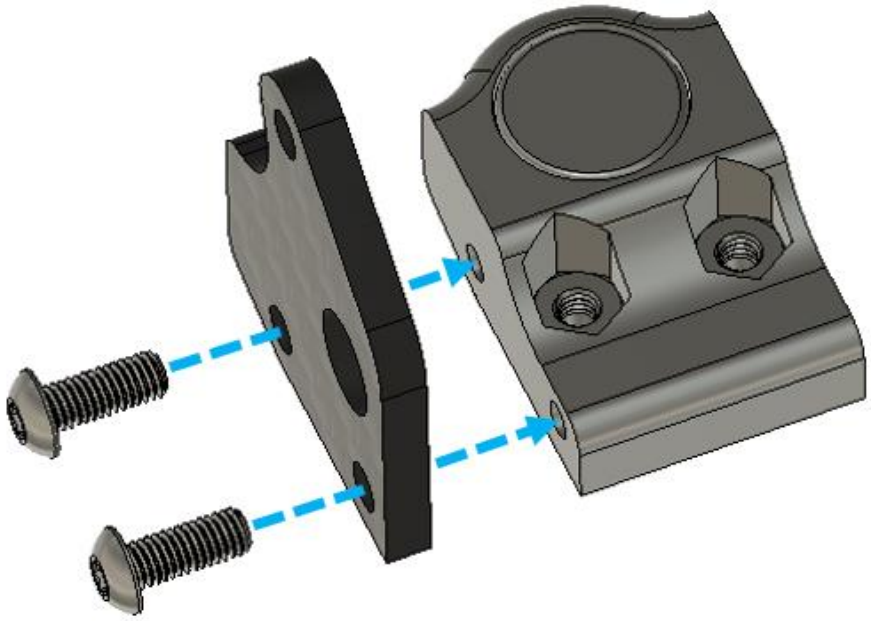


Put 2x **M3 Nut** into the holes of *ClutchBody* and glue the **Ø12x5mm Magnet** in with superglue.

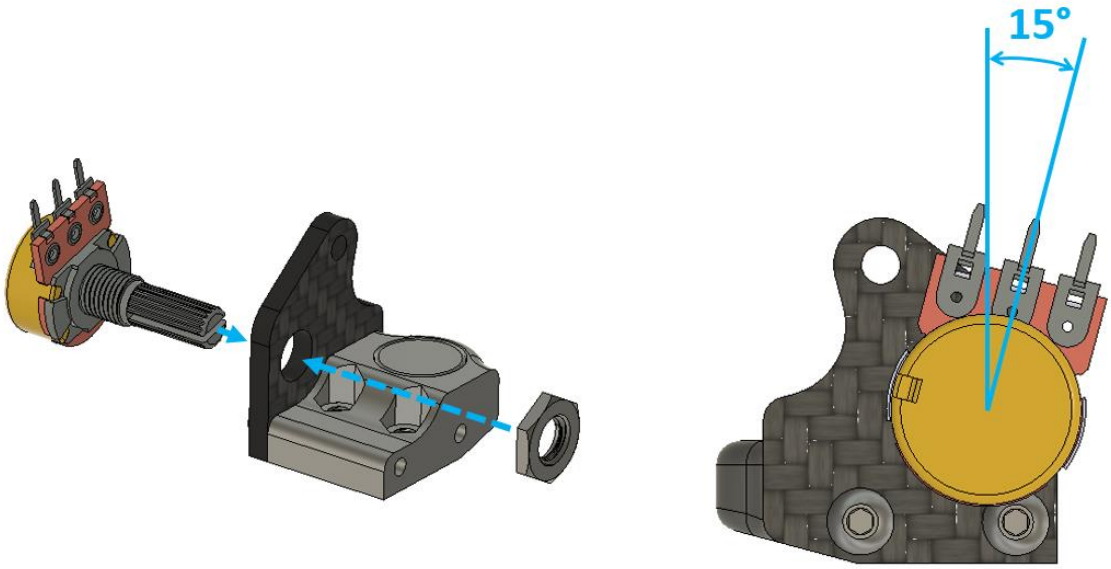
Pay attention to magnet polarity. It should repel the clutch lever.



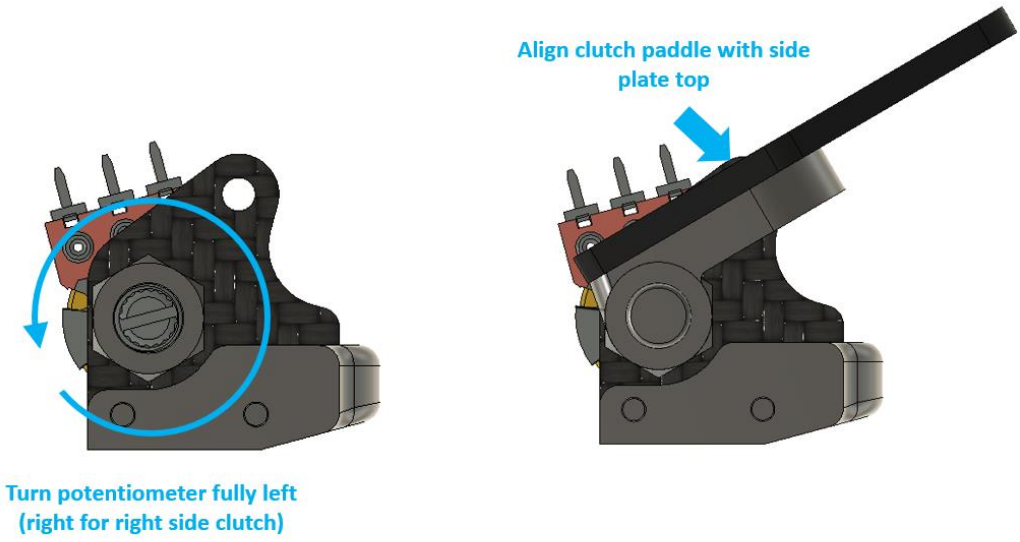
Mount one side wall (*ClutchSide*) to the *ClutchBody* with 2x **M3x8mm Hex Button Head Screw.**



Mount the potentiometer to the already mounted side wall like the picture shows below. The potentiometer should be rotated 15° from the vertical position, to have place for the screw which goes into the upper hole. If the positioner pin of the potentiometer stands it off from the clutch side, it should be cut. You can use screw fastener under the potentiometer to avoid the rotation of it later.

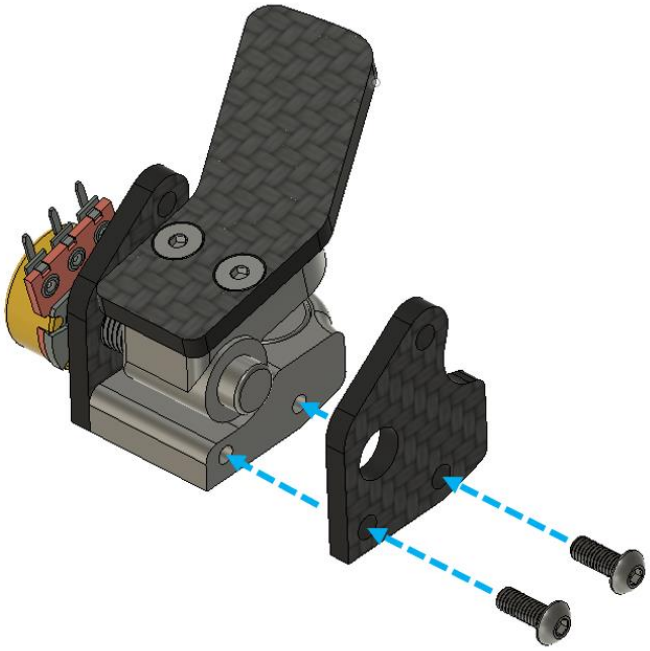


Turn the shaft of the potentiometer fully left (like shown on the left-side picture below). (For the right-side clutch reverse.) The clutch lever should be pushed onto the shaft as shown on the right-side picture below. So, the potentiometer shaft should be moved almost from the starting position, but leaving 10-15° range.

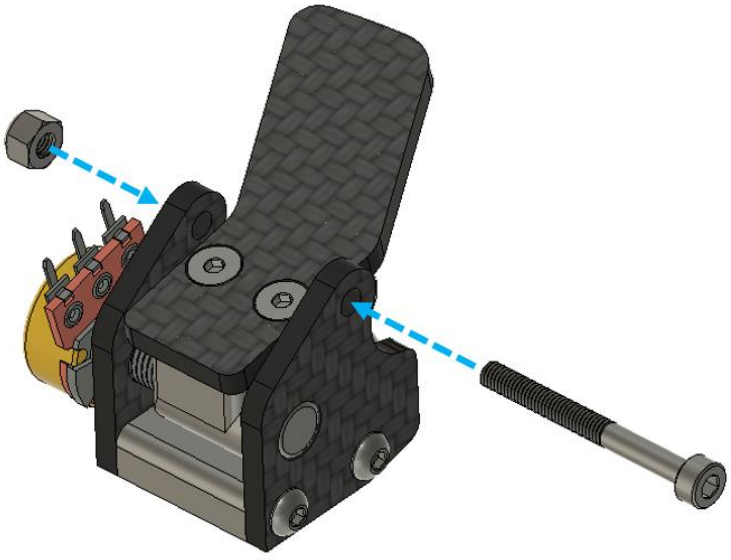


Then push the clutch lever onto the potentiometer shaft like shown above.

Mount the other side wall (*ClutchSide*) to the *ClutchBody* with 2x **M3x8mm Hex Button Head Screw.**



Mount the **M3x30mm Hex Socket Screw** with **M3 Locknut** which is responsible for the end position.

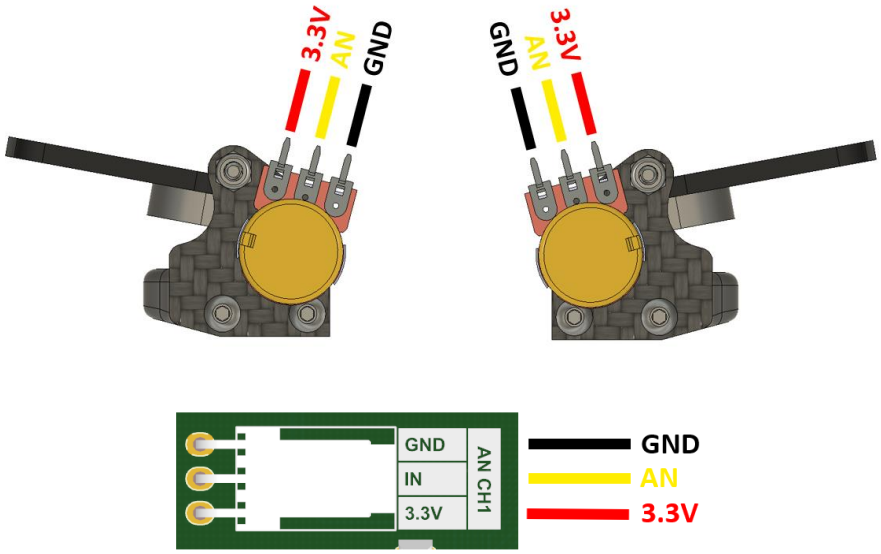


You can put a little bit grease on pin of the plastic lever part to have better lever rotation.

Wiring

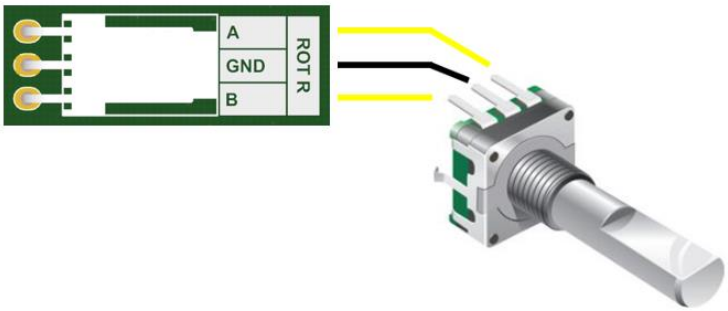
Clutch wiring

Connect the clutch to the PCB according the pictures below. (The clutch should be mounted first to the backplate.)



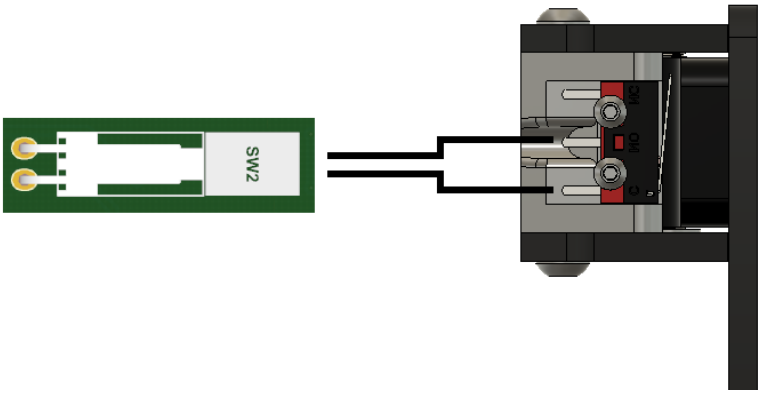
Rotary encoders

Connect the encoders to the PCB according the pictures below. Side pins can be swapped.



Shifters

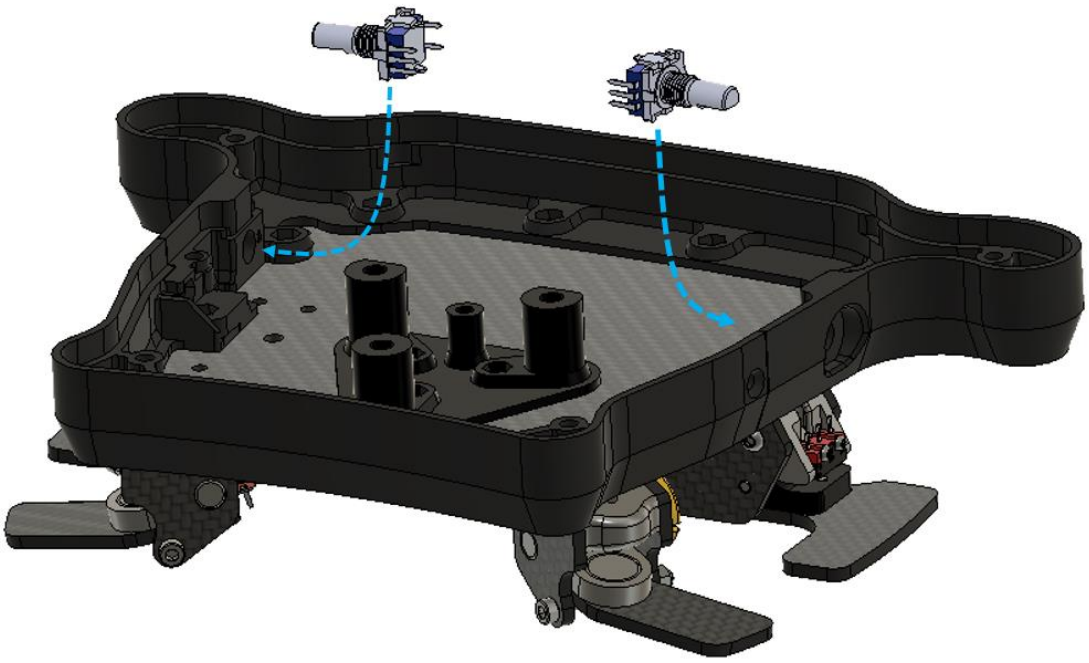
The shifters should be connected to any of the SW inputs (SW1, SW2, SW3, SW4). 2 of those inputs are designed for the shifters and the other 2 is optional/extra switch input.



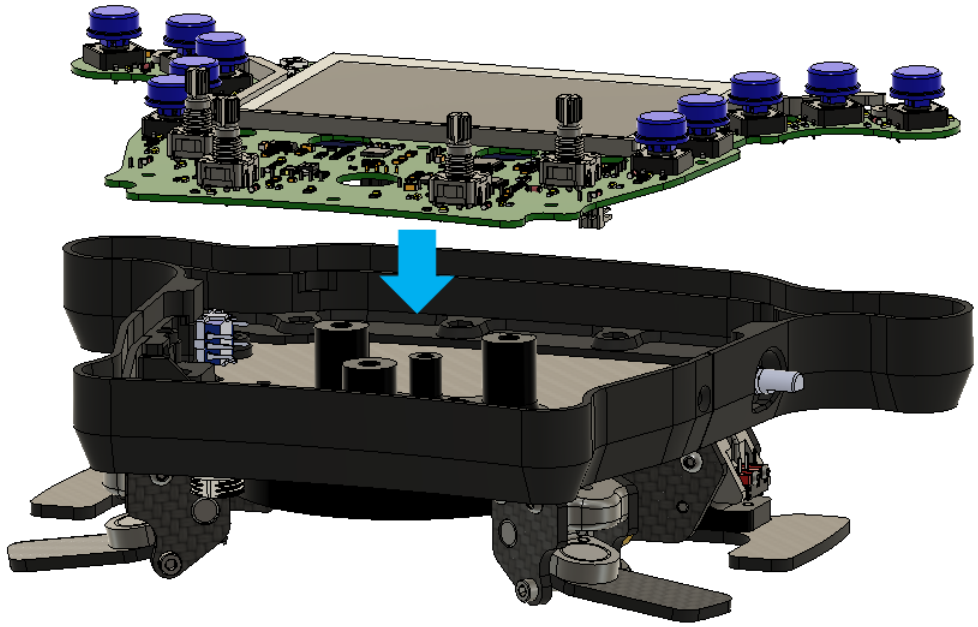
Main parts

Mount the shifters to the backplate with 4x **M3x12mm Hex Button Head Screw** and the clutches with 4x **M3x10mm Hex Button Head Screw**.

Mount the side encoders.

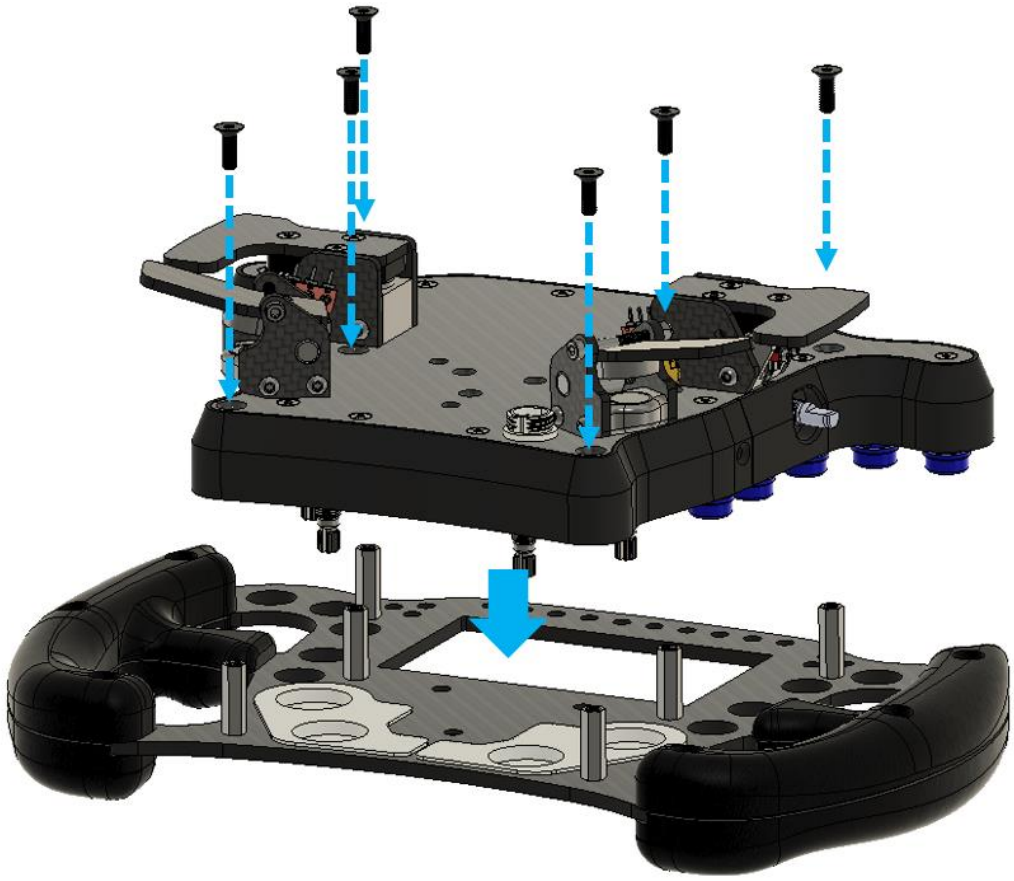


Mount the PCB with 8x **M3x6mm Hex Button Head Screw**.

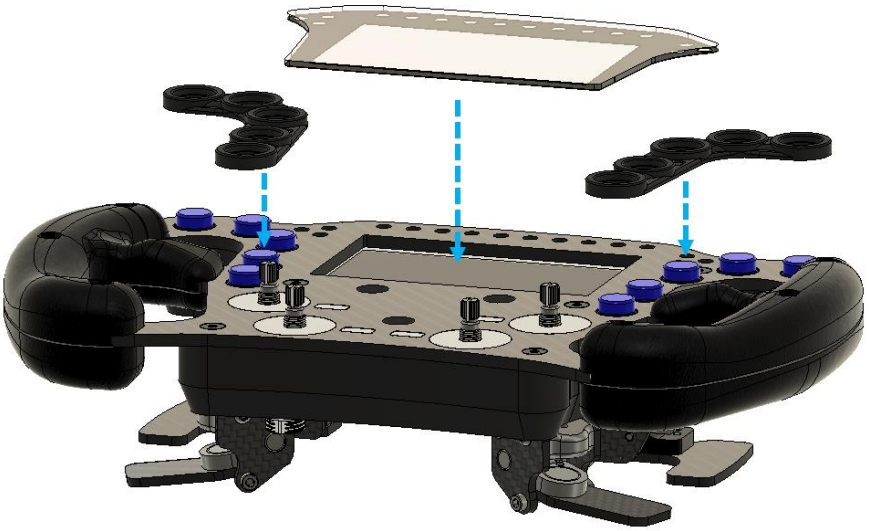


Mount the front plate to the rear part with 6x **M4x10mm Hex Socket Countersunk Black Screw**.

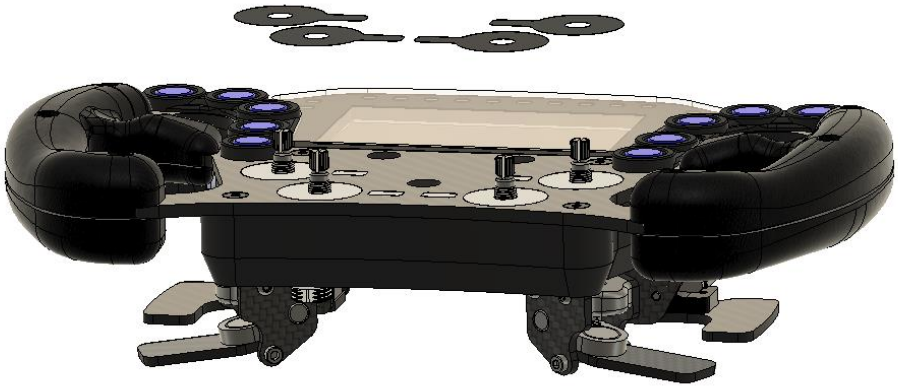
Pay attention on the wires. Check the holes for cables before mounting the front plate.



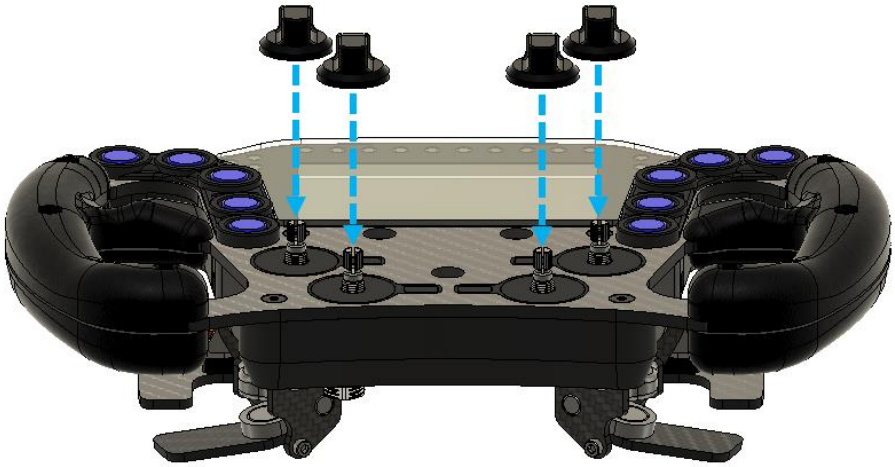
Mount the plexiglass and the button plates with double sided tape.



Put all the decals on.



Put front rotary knobs on.



Put side rotary encoder knobs on:

Software configuration

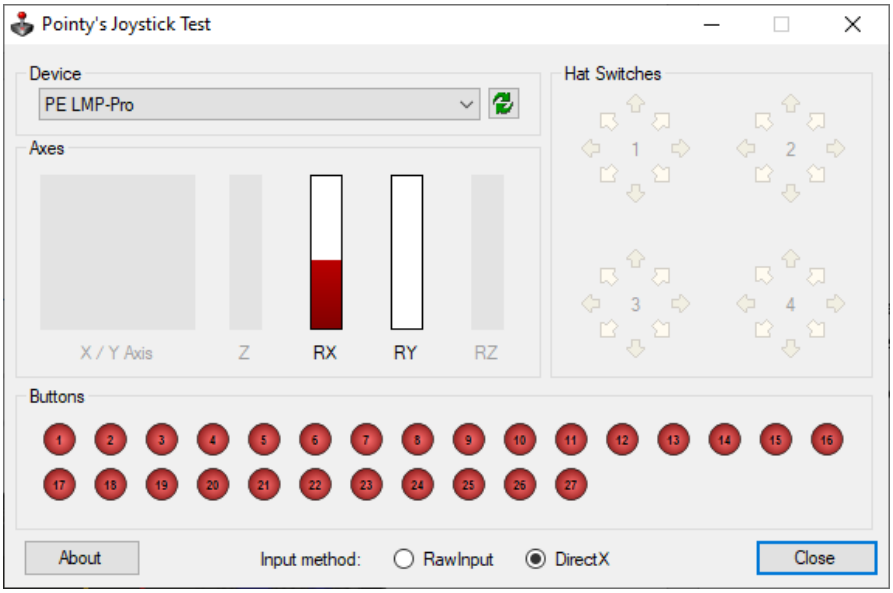
To control the LEDs and the display, you will need SimHub software, which can be downloaded from here.

If you don't have license for SimHub, the FPS will be limited to 20 FPS.

USB Game Controller

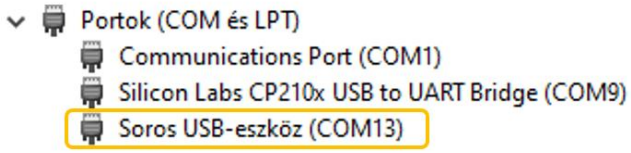
The inputs (buttons, encoders, analog) will appear on PC as USB Generic Game Controller HID device. No extra driver required.

I recommend to use this Joystick test application:
http://www.planetpointy.co.uk/joystick-test-application/



RGB LEDS

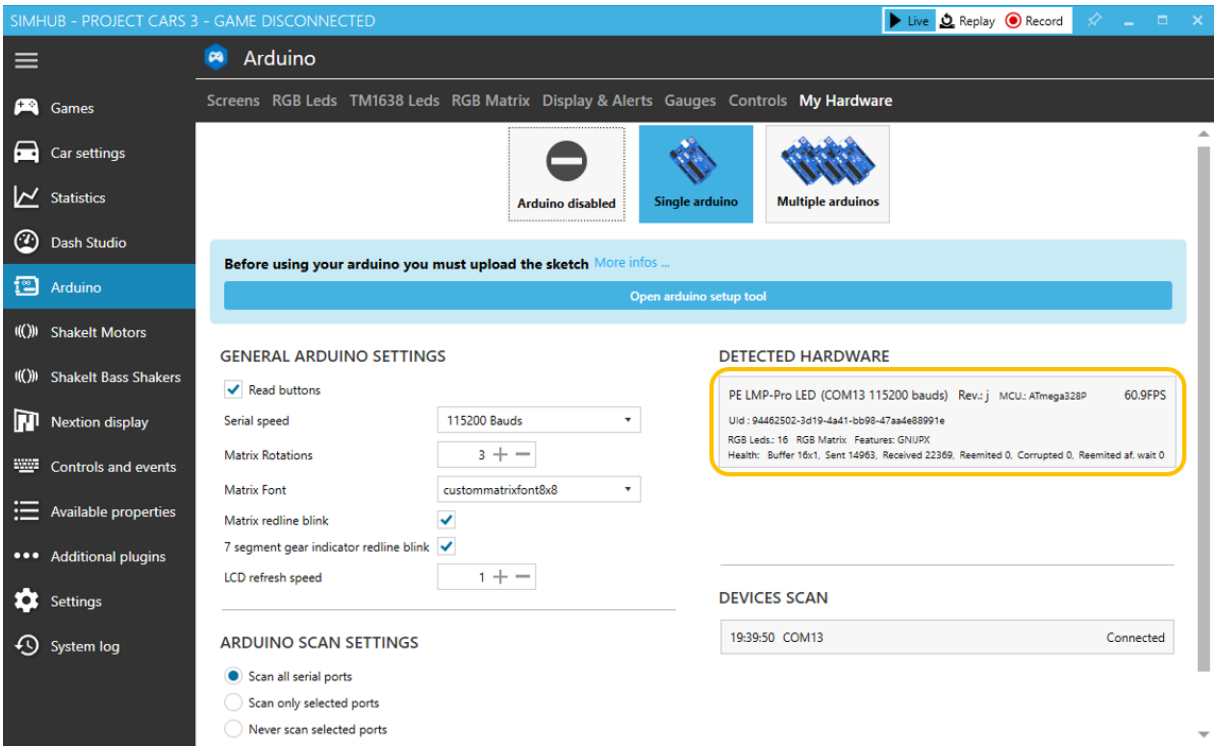
If the wheel is connected, you should see 2 new serial ports in Windows Device manager.



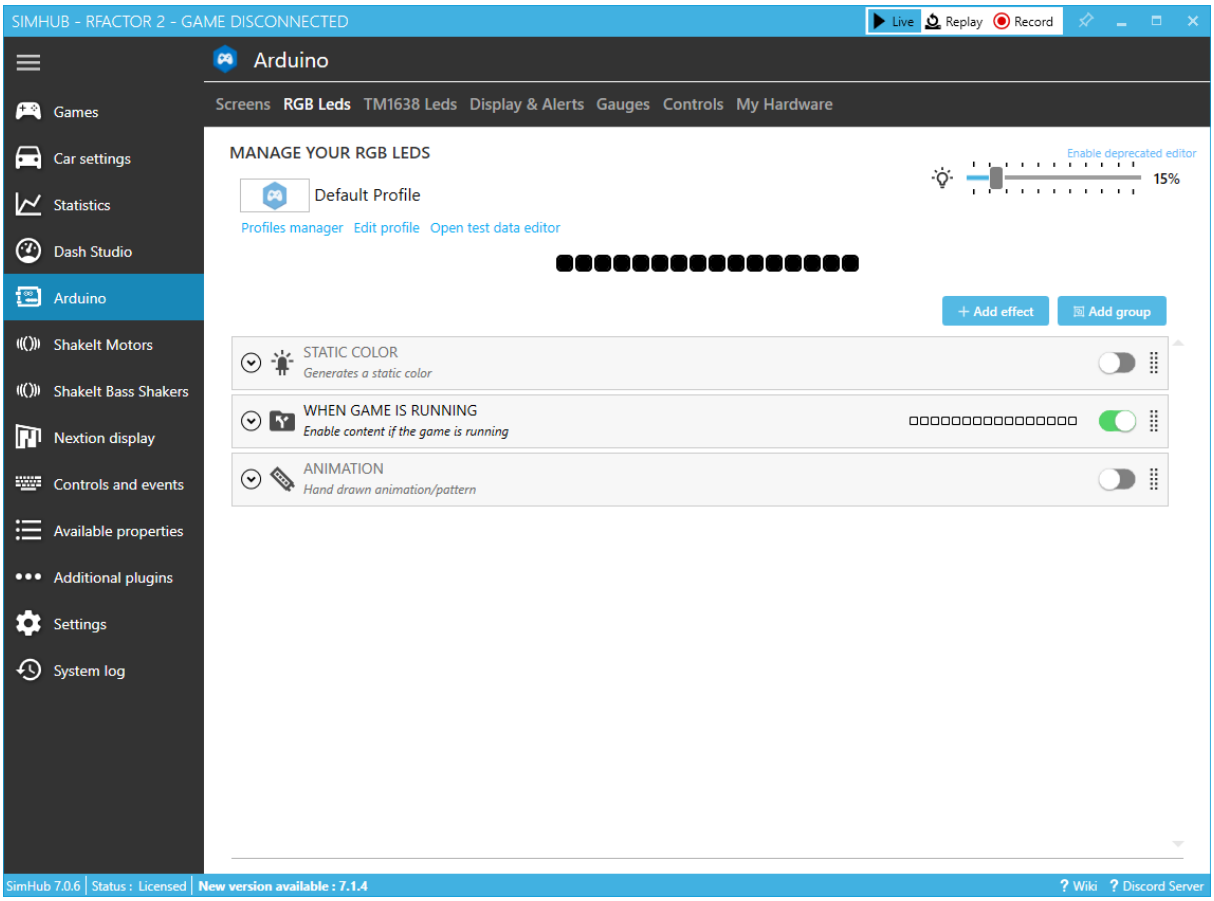
The "Serial USB-device" port will be the port of the RGB LEDs. The STM32 microcontroller is emulating an Atmega328P MCU with 16x WS2812B LEDs.

On "Arduino" page under "My Hardware" tab select "Scan all serial ports".

The right COM port will be automatically opened. (The other COM port of the PCB will be the port for the display).



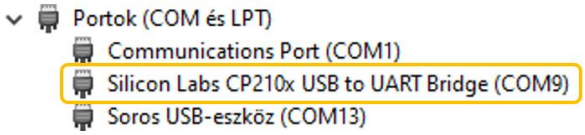
If the device is connected successfully, you can customize the LED profile on the “RGB Leds” tab as you want.



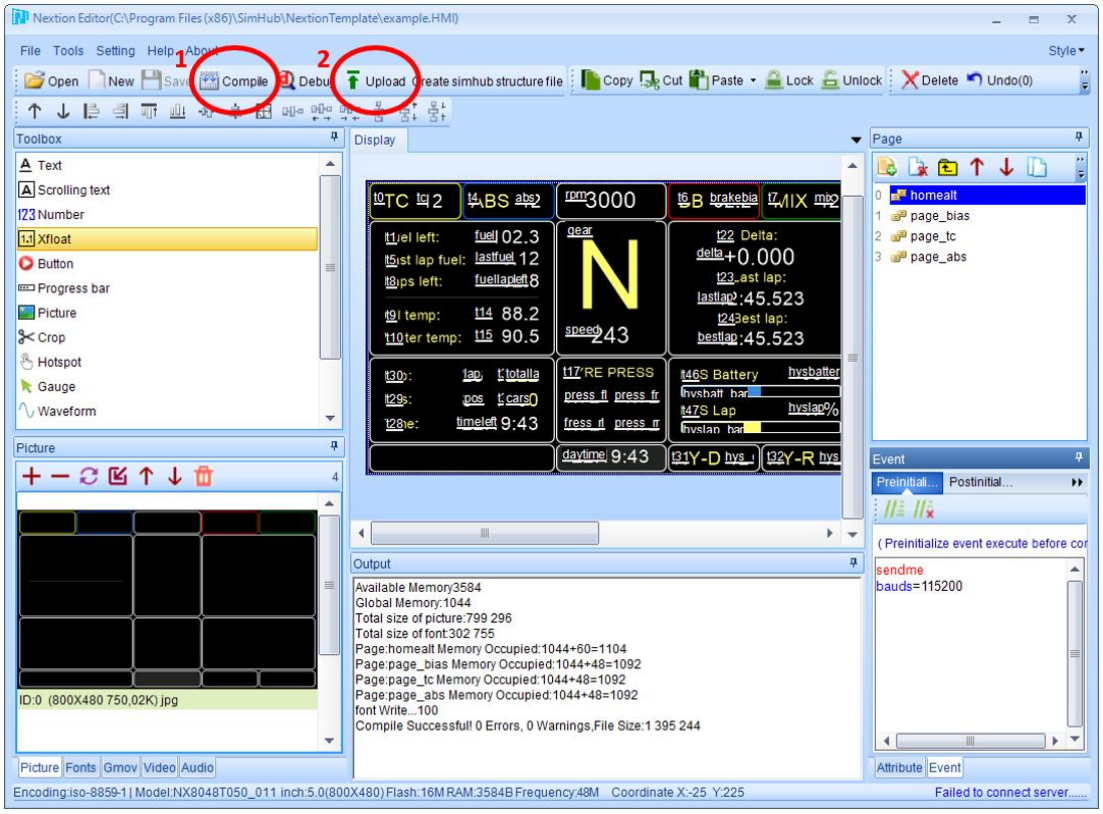
Nextion display

Copy the template files (e.g. *example.HMI, example.hmijmap, example.hmistruct*) to the SimHub templates folder: *Program Files (x86)\SimHub\NextionTemplate*.

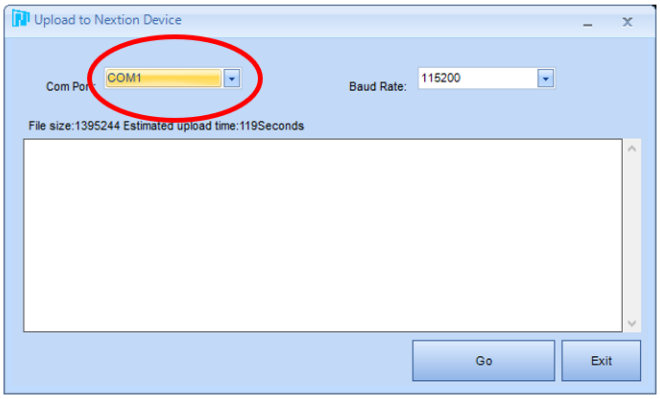
If the wheel is connected, you should see 2 new serial ports in Windows Device manager.



Start “SimHub nextion editor” and open the template file you want to use. Click on “Compile”, if finished, click on “Upload”.
If you modify something in the template, click on “Create simhub structure file”.

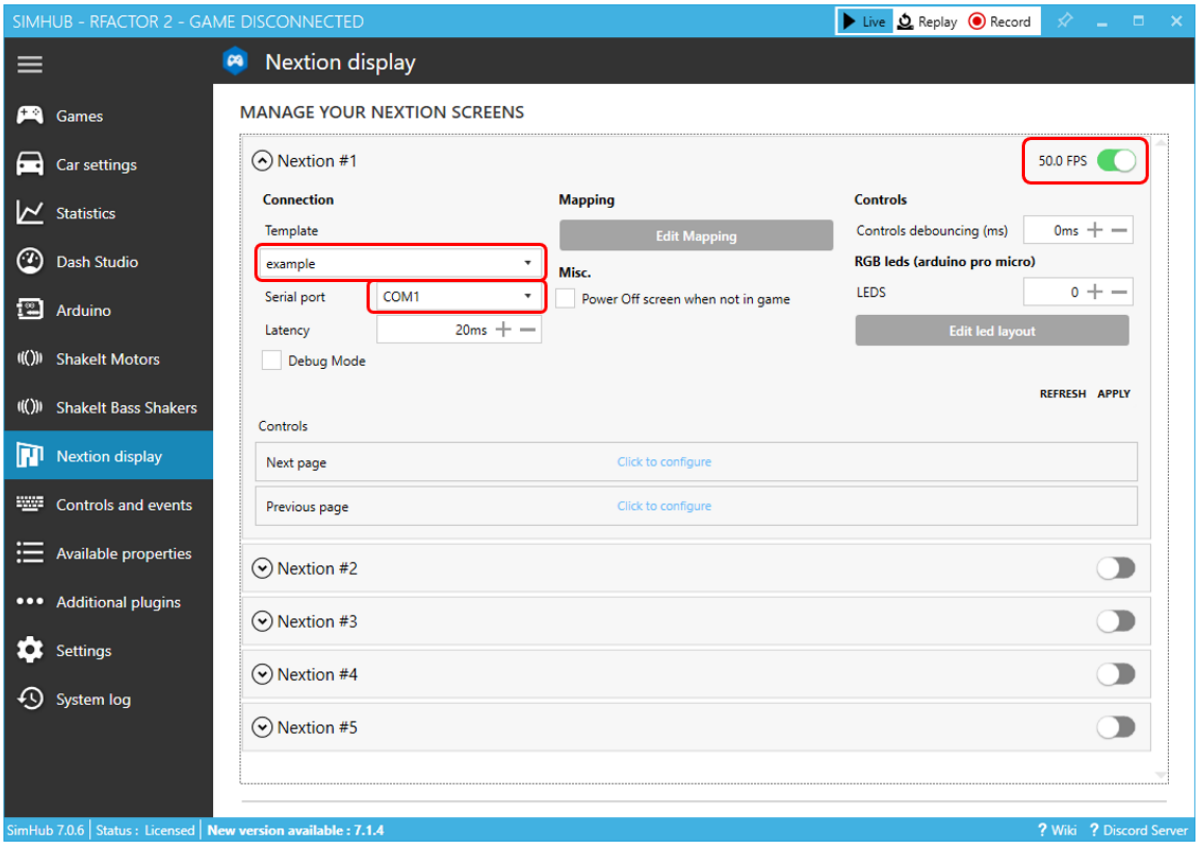


Select the COM port of the display. If you don’t know, you can try the available COM ports. Then click “Go”.



If the template is successfully uploaded, start SimHub.

Select the uploaded template on the “Nextion display” page.
Select the serial port of the display.
Turn on the display in the upper right corner.



Alternatives

VoCore display

VoCore display is also supported by the design: https://vocore.io/screen.html

If you want to use this display, you will need to print the *VoCoreAdapter.stl.*

The display can be connected to the “USB OUT” connector on the PCB, which is a downstream port of the USB HUB.

Multiple front knob files

You may notice that there are multiple FrontKnob_... files.

Hole:

- 6.0 mm → Default hole size (this should be the final size)
- 6.2 mm → On some printers the end size of the hole will be smaller, so you can use this file if your hole is smaller after printing than on the model

Tooth:

- 12 → For 12 position rotary encoder
- 20 → For 20 position rotary encoder

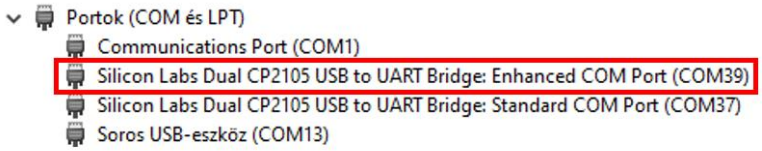
Alternative PCBs

Normally, you always should use v1.1 PCB if everything is available for that PCB. Unfortunately, there is currently shortage of many components (USB2514B, CP2102, …). If any of the components is not available at JLCPCB you can use the following alternatives:

- CP2102 not available → Use PCB v1.2 with CP2105 (see below)
- USBLC6-2SC6 not available → Select TPUSBLC6-2SC6 as alternative
- USB2514B is not available → Select USB2514BI (Industrial version) if available
- USB2512BI is not available either → Use PCB without HUB (see below)

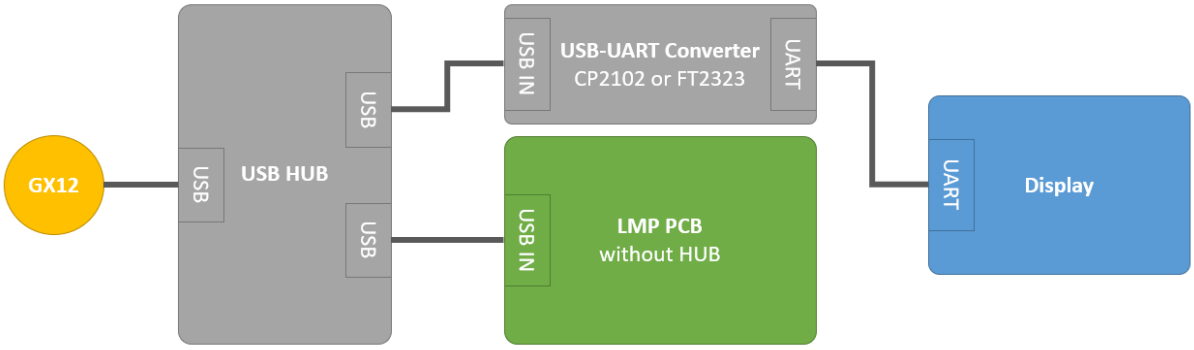
PCB v1.2

This PCB can be used if CP2102 is not available for the v1.1 PCB version. There is no other difference compare to v1.1. On this PCB CP2105 is used instead of CP2102. CP2105 has 2 serial port, but only one is used. So, for the Nextion display you need to select the “Enhanced COM Port”:



Without USB HUB

If USB2514B and USB2514BI is not available either, you can use this PCB version without USB HUB. In this case you will need to add an external HUB PCB (e.g. NANOHUB) and USB-UART converter for the display (e.g. CP2102). So, in this case you need to use the following architecture:



Closing remarks

I hope you enjoyed the build as much as I did. If you need any kind of help, please drop me a mail. Any photos about your finished wheel, comments, recommendations are well received.

info@pokornyiengineering.com

Enjoy your wheel!

Pokornyi Engineering