

Tangible and Modular Input Device for Character Articulation

Additional Material

Online Submission ID: 0052

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Development tools

IDE (Firmware)

CooCox ARM Cortex MCU Development Tools are used to develop the firmware and load onto the microcontroller.

The Eclipse base CooCox IDE and other useful tools can be found on coocox.org and is free.

The corresponding project can be found in the Firmware folder

CAD

To design the mechanical parts Siemens NX 7.5 was used. In this package we provide STL files of all components in the STLs folder.

PCB Design

For the PCB design the TARGET 3001! (Beta-Layout version) was used. This software is free and can directly be used to order (assembled) PCBs from pcb-pool.com.

Schematics, PCB plans, part lists and the according Gerber files can be found in the PCBs folder.

Folder	Board abbreviation	Description
cBoard	CPS	Connector board with plug and sensor
	CSS	Connector board with socket and sensor
	CP	Connector board with plug
	CS	Connector board with socket
pBoard	P	Power board
sBoard	S2	Splitter board with two sockets
	S6	Splitter board with six sockets (splits I2C, GND, POWER)
	S8	Splitter board with eight sockets (distributes topology lines to plugs)
uBoard	US	Microcontroller board with sensor (only used in joints)
	U	Microcontroller board without sensor

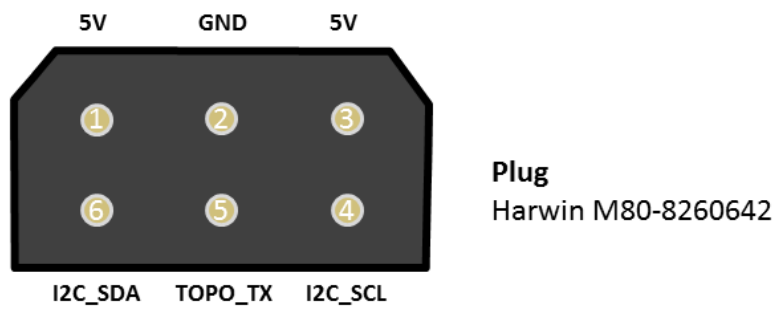
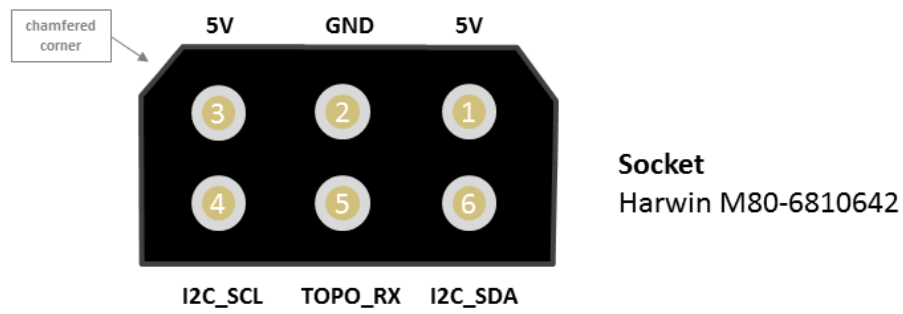
Table of components and their needs

STL File	Component	PCBs needed (see table above)										Cables needed	
		US	U	CSS	CPS	CS	CP	P	S6	S8	S2	30 mm	50 mm
pro_PS_20121116	Power box	0	1	0	0	1	0	1	0	0	0	2	2
pro_TI_12_20121022	12 terminators	0	0	0	0	0	0	0	0	0	0	0	0
pro_AS_20121022	A-splitter = 1 in / 5 out	0	1	0	0	5	1	0	1	1	0	10	1
pro_YS_20121022	Y-splitter = 1 in / 2 out	0	1	0	0	2	1	0	1	1	0	4	1
pro_HS_20121022	H-splitter = 1 in / 3 out	0	1	0	0	3	1	0	1	1	0	6	1
pro_XS_20121022	X-splitter = 1 in / 3 out	0	1	0	0	3	1	0	1	1	0	6	1
pro_b_short_20121022	Bone	0	0	0	0	1	1	0	0	0	1	2	0
pro_TBT_20121022	TBT joint	1	0	1	1	0	0	0	0	0	0	2	2

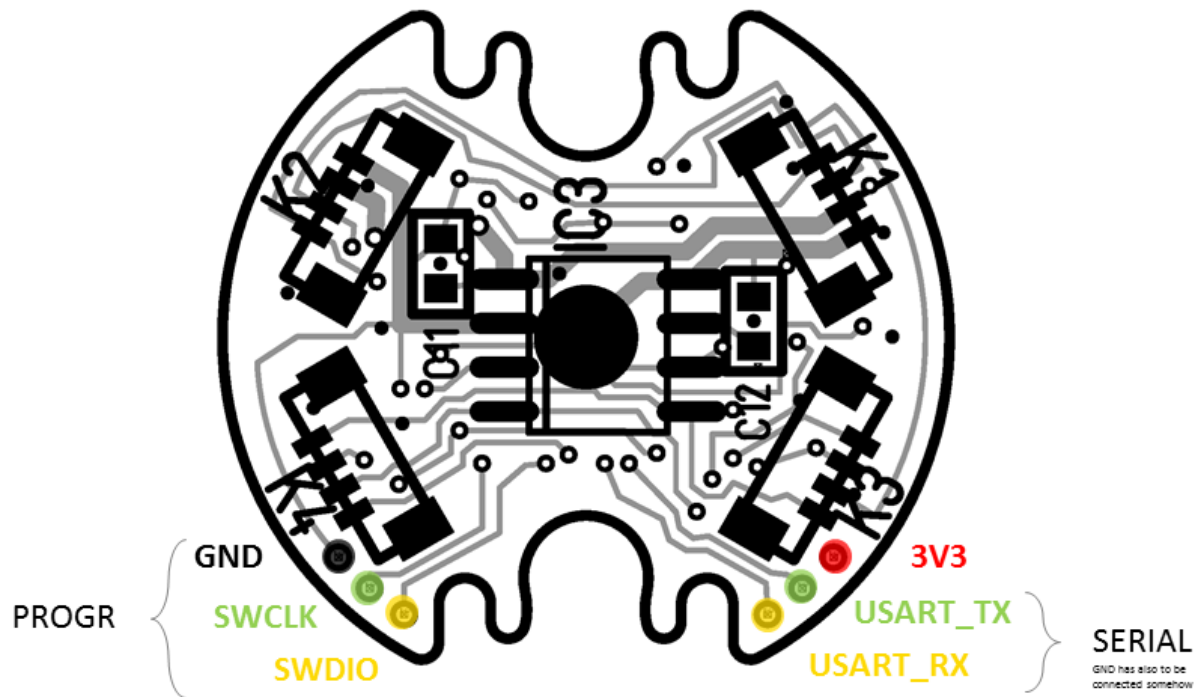
More details about how to assemble and where to order can be found in this manual.

Connector assignments

Plug and socket (main bus)

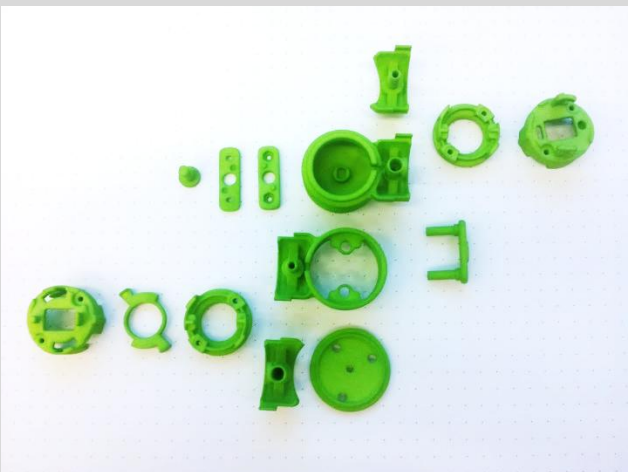
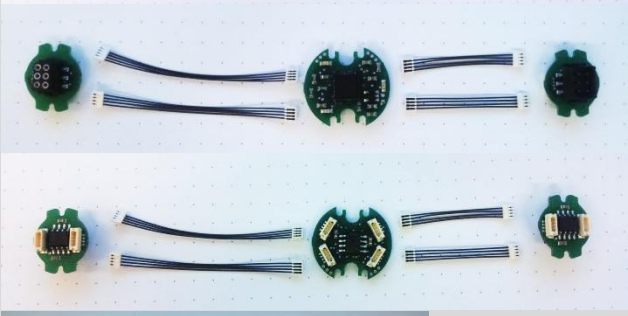
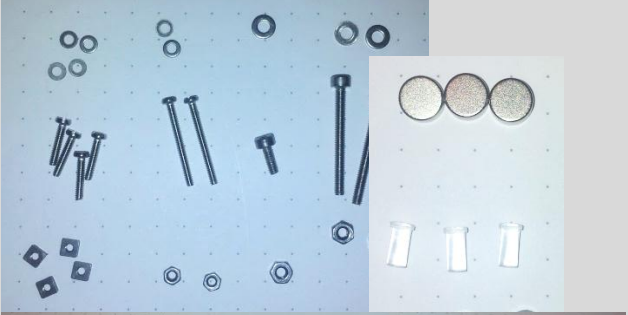



uBoard (programming and serial)

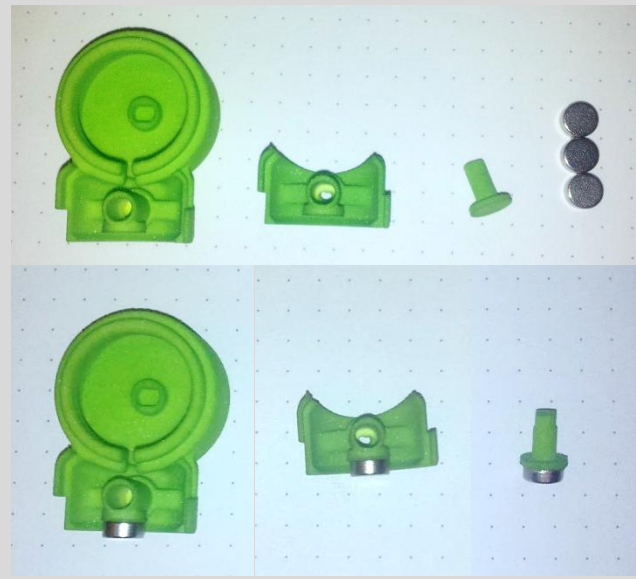


Assembly plans

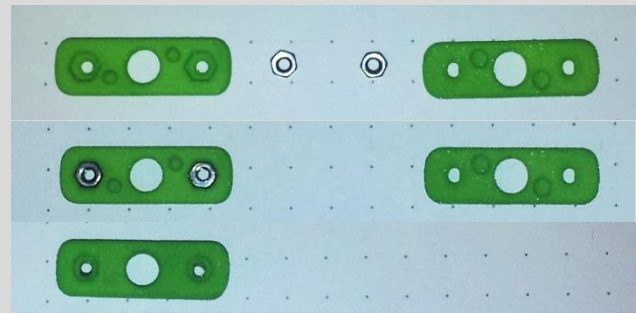
TBT JOINT

#	Explanation	Pictures
0	<p>What parts are needed?</p> <ul style="list-style-type: none"> — 14 laser sintered parts (any color) — 2 short (30 mm) internal cables (4 wires) — 2 long (50 mm) internal cables (4 wires) — 1 uBoard with sensor — 1 cBoard with socket and sensor — 1 cBoard with plug and sensor — 4 M1.6 squared nuts (DIN 562) — 2 M1.6 hex-nuts — 3 M2 hex-nuts — 6 M1.6 washers — 3 M2 washers — 4 M1.6x8 screws (slotted) — 2 M1.6x16 screws (slotted) — 2 M2x20 screws (internal hex) — 1 M2x5 screw (internal hex) — 3 light pipes — 3 light pipe mounting rings — 3 Magnets (S-06-2.5-DHN) — Some glue <p>What tools are needed?</p> <ul style="list-style-type: none"> — Tweezers — Small hex wrench — Small slotted screwdriver — Steady hands 	   

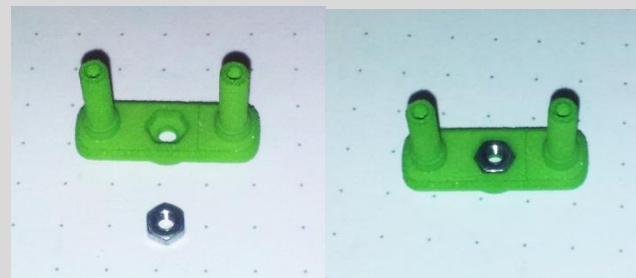
- 1** Glue the three magnets on the corresponding plates on the *base*, on the *tofollower* and on the *magnetholder*



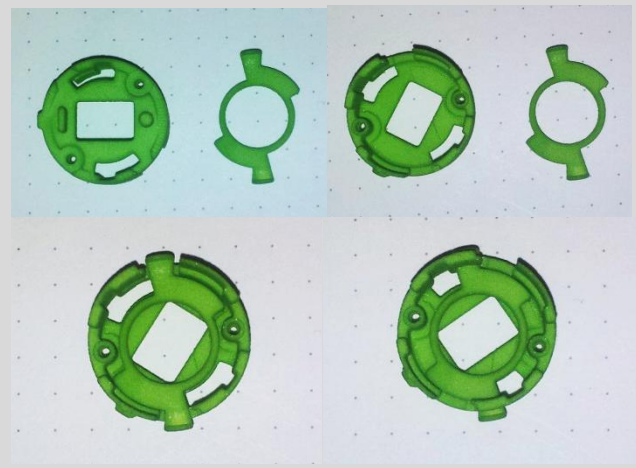
- 2** Put the two **M1.6 hex-nuts** into the hexagonal pockets of the lower part of the *bar* and then glue the upper *bar* part onto the lower part.



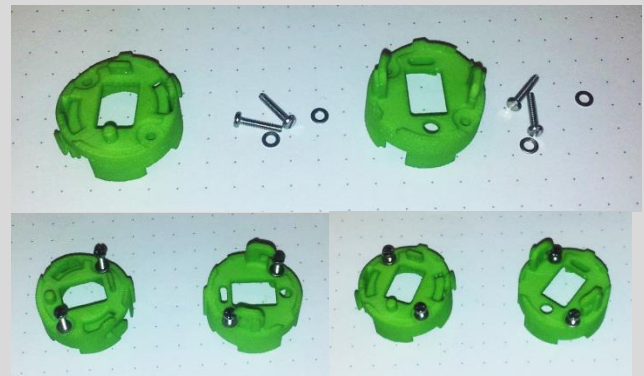
- 3** Then glue one of the **M2 hex-nuts** into the hexagonal pocket of the *tobar*.



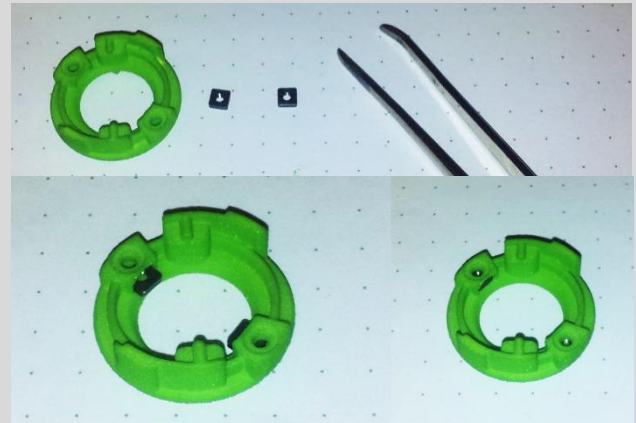
- 4** Insert the *holder* into the *connector socket* and rotate the *holder* by holding it on both ends carefully.



- 5 Screw the four **M1.6x8 screws with the washers** into the holes on the *connector socket* and the *connector plug*, just that the tip of the screw is visible at the end of the hole (not fully).

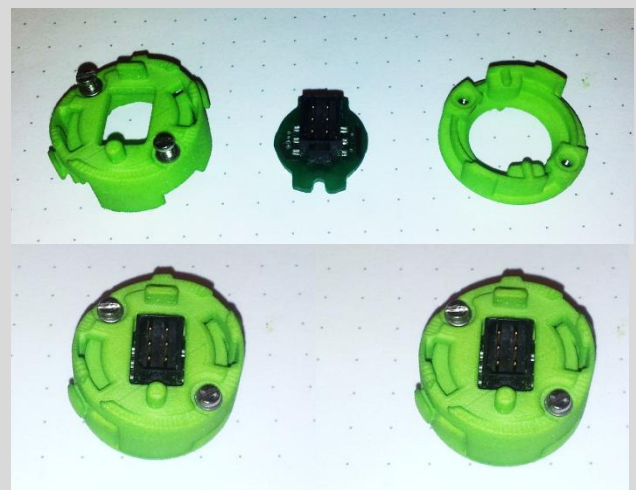


- 6 Insert the **squared nuts** in the corresponding pockets of one of the *toconnector* parts using the tweezers.



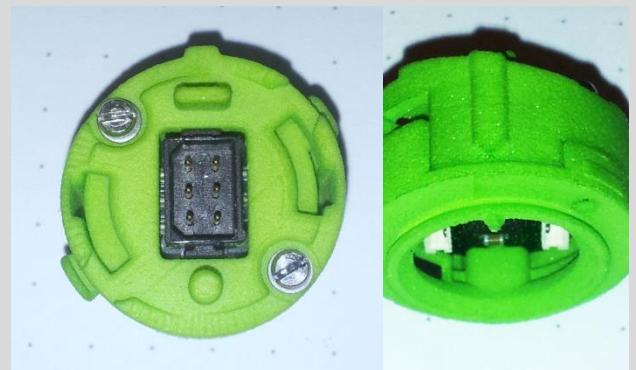
- 7 Carefully rotate the *toconnector* so that the little knob on its back side is away from you. Then place the *socket cBoard* with the chamfered corners pointing to the left on the *toconnector* part. Finally add the *connector socket* with the ridge on its outside pointing away from you.

Now screw the parts together.



- 8 Compare the resulting piece with the pictures on the right to check if everything is aligned as it should.

Then repeat **step 6** for the second *toconnector* and place it with the little knob on the backside away from you.



- 9 This time the *plug cBoard* has to be placed on the *toconnector* with the chamfered corners pointing to the right. And again the ridge on the outside of the *connector plug* has to point away from you.

Now screw the parts together.

In top view the resulting assembly should look like the image on the right. Make also sure that the ridge and the knob are aligned.

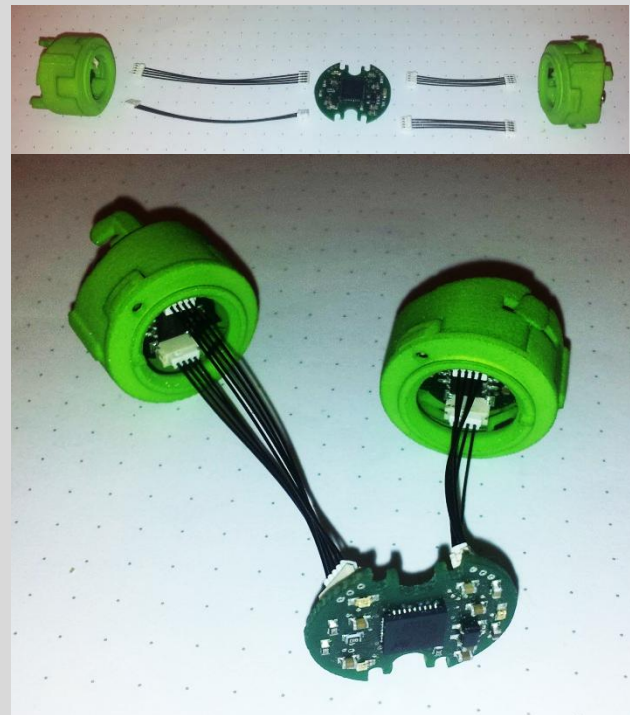


- 10 In a next step the *uBoard* and the two *connector* parts will be connected with the **cables**.

To achieve the correct connections lay out the parts as shown in the upper image.

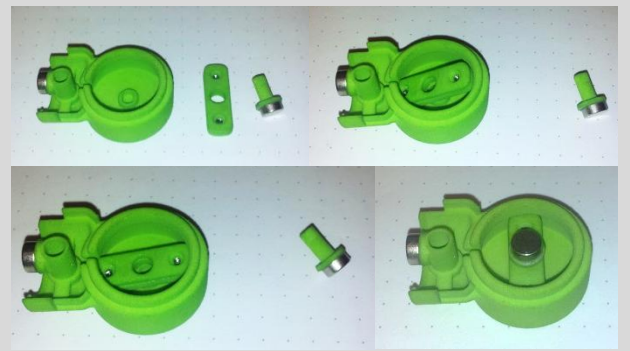
On the *uBoard* the side with the two times three holes is pointing away from you. The *connector* parts are placed with the outside ridges pointing up.

Then connect the **cables** as shown in the lower image. Start with the *connector* parts.



- 11 Insert the *bar* carefully into the *base*. Make sure the cylindrical pockets are pointing up.

Then insert the *magnetholder* through the *bar* into the *base*.



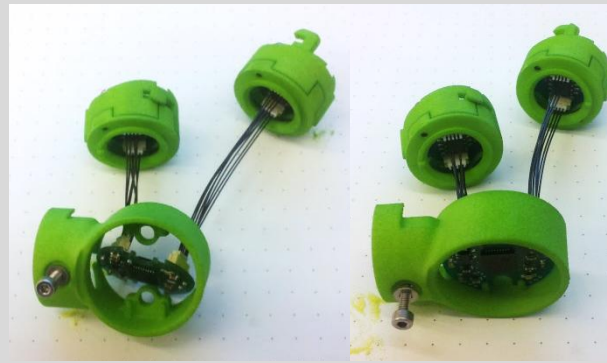
- 12** Insert the **M1.6x16 screws** and **washers** into the **tobar**. The tips of the screws should just be visible at the end of the holes.



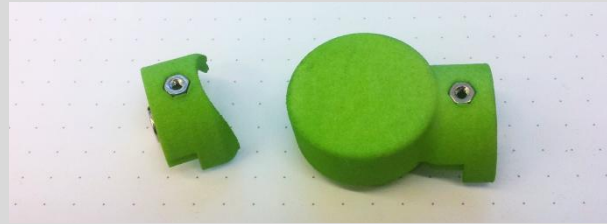
- 13** Insert the **two M2x20 screws** and **washers** into the *follower* and the *tobase*.



- 14** Insert the *uBoard* into the *follower* (as shown in the images).

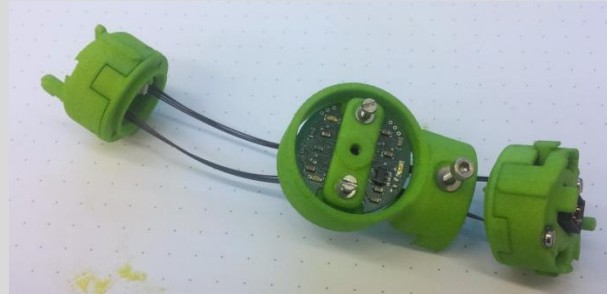
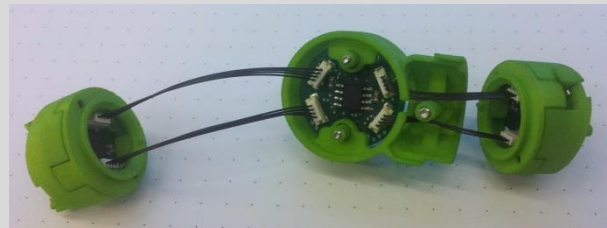


- 15** Insert the **M2 hex-nuts** into the hexagonal pockets of the *base* and the *tofollower*.



- 16** Gently push the two (times four) **short cables** through the opening (e.g. using a screwdriver). So that they end up in the position shown in the image.

Then insert the *tobar* into the *follower*.



-
- 17** Now the *follower* and the *base* are to be married.

Make sure that the *bar* is in the position shown in the image (e.g. with a screwdriver).

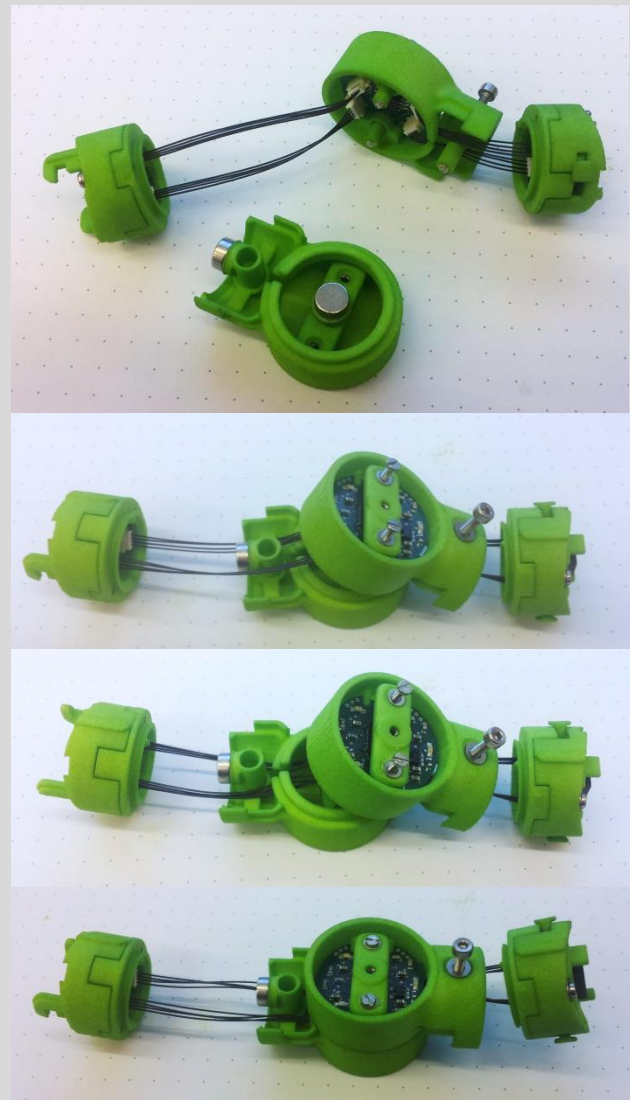
Then place the *follower* on the *base* and route the **long cables** through the opening.

Now carefully impose the *follower* on the *base* totally.

Then screw the *tobar* to the *bar* (not visible anymore). If not nicely aligned this step might take a few tries.

At some point the screwing might need quite some force.

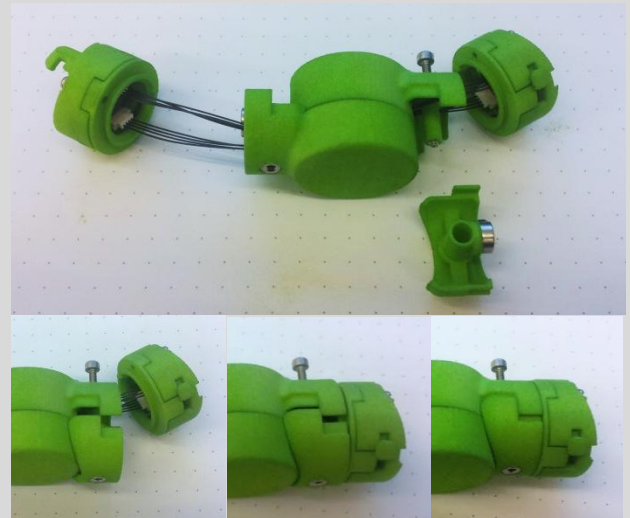
After the screwing the *base* and the *follower* should still be able to rotate against each other without effort.

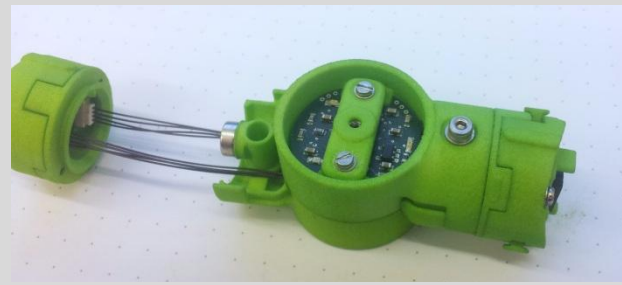


-
- 18** To attach the *connector socket*, first insert the *tofollower* (as shown in the first image in the middle row).

Secondly insert the assembled *connector socket*.

Finally tight the screw.





- 19** Before attaching the *connector plug*, bend the joint. Then repeat the tasks of step 19.

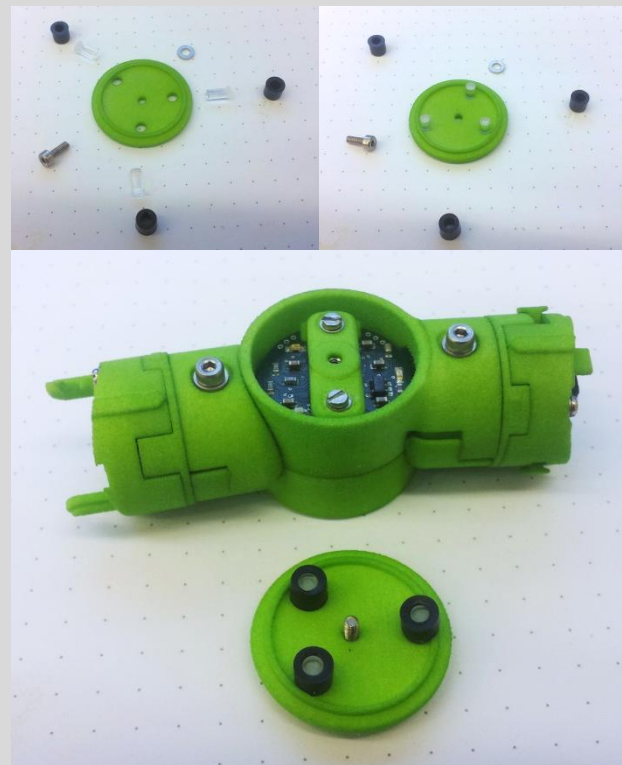


- 20** Now the *top* can be prepared.

Insert the **lightpipes** and fix them on the backside with the black **mounting rings**.

Then the top can be screwed (don't forget the washer) onto the follower – into the *tobar*.

And then we're done!



21 Programm, Calibrate, Test



SPLITTER

Y as example

#	Explanation	Pictures
0	What parts are needed? <ul style="list-style-type: none"> 7 laser sintered parts (any color) 8 short (30 mm) internal cables (4 wires) 1 long (50 mm) internal cables (4 wires) 1 uBoard without sensor 2 cBoard with socket and without sensor 1 cBoard with plug and without sensor 1 distributor Board 1 multiplier Board 8 M1.6 hex-nuts 8 M1.6 washers 8 M1.6x8 screws (slotted) What tools are needed? <ul style="list-style-type: none"> Tweezers Small slotted screwdriver 	<p>The pictures show the components for the splitter assembly. The top row displays seven laser sintered parts: three small circular rings, one larger central ring, and three small rectangular pieces. The middle row shows eight short (30 mm) internal cables (4 wires) and one long (50 mm) internal cable (4 wires). Below the cables are four electronic boards: one uBoard without sensor, two cBoards with socket and without sensor, and one cBoard with plug and without sensor. The bottom row shows two distributor boards and one multiplier board. The bottom-most row displays eight M1.6 hex-nuts, eight M1.6 washers, and eight M1.6x8 screws (slotted).</p>

- 1 Insert the eight squared nuts (simplest done by using tweezers) into the corresponding pockets.

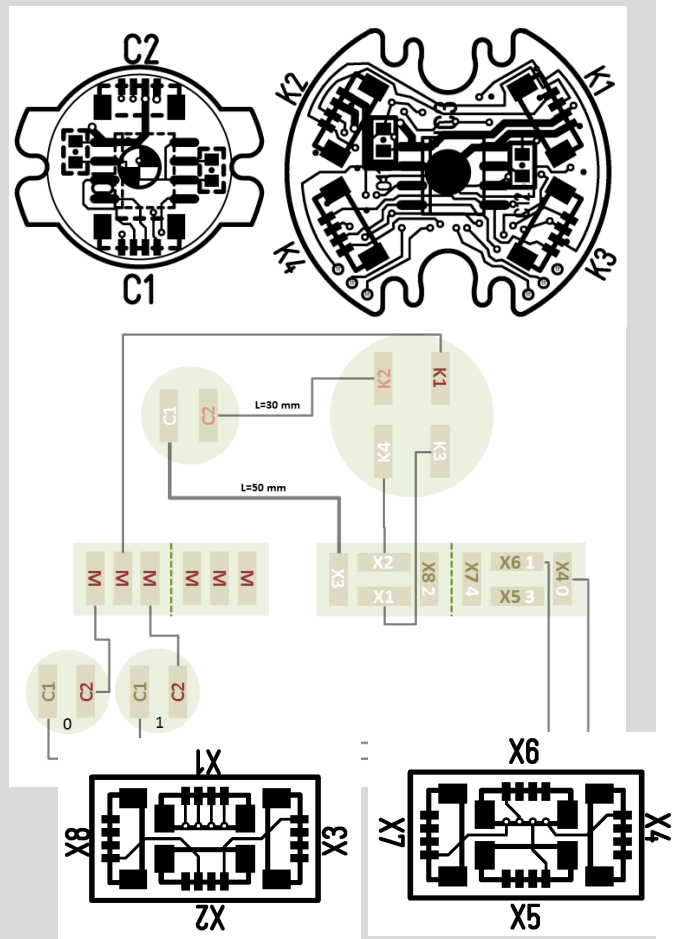
Six in the base part and two in the cover part.



- 2 In a next step the Boards have to be connected following the plans on the right.

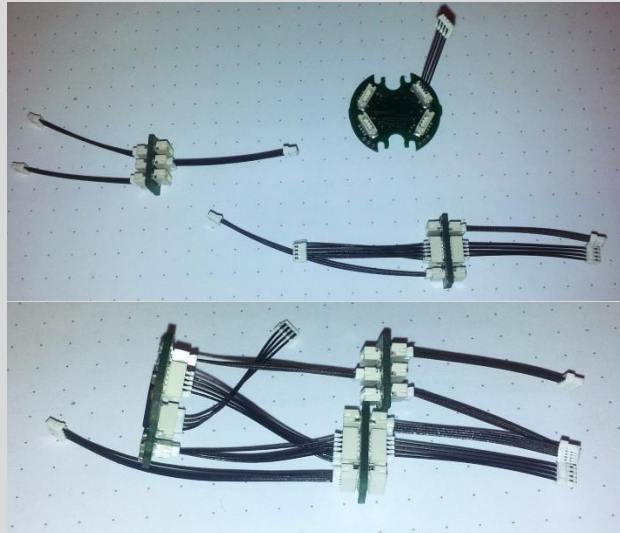
Because the Y splitter has only two outputs only wires for two outgoing boards have to be connected.

Do not yet connect the cBoards!

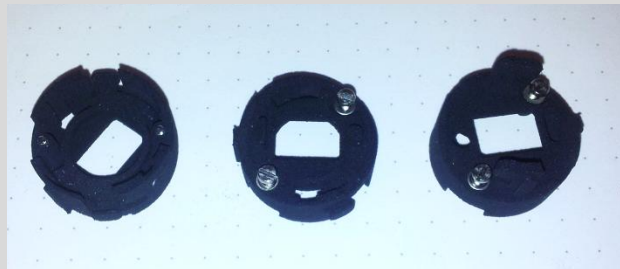


- 3** First connect the wires as shown in the picture and then continue as shown in the lower picture.

When there are more than two outputs, just connect them as shown in the complete connectivity map at the end of this section. Make sure to follow the numbers.



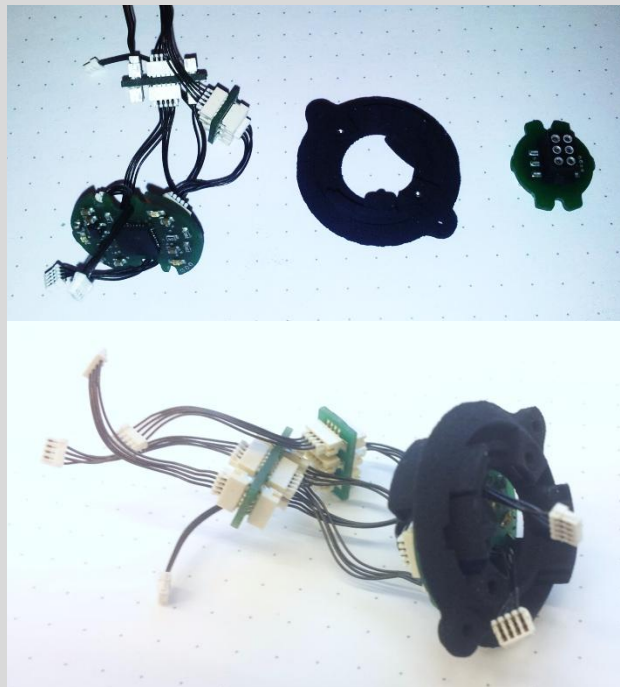
- 4** Put the screws (with washers) into the corresponding holes in the three connector parts.



- 5** Now put the two wires to be connected to the connector board through the large openings of the uBoard and insert it into the holder on the lower side of the splitter cover. Guide the two wires through the hole in the middle of the cover.

Then connect the wires to the connector board corresponding to the connectivity map.

Then screw the connector plug onto the cover. Make sure the chamfered corners point to the right when the ridge on the outside of the connector points away from you.



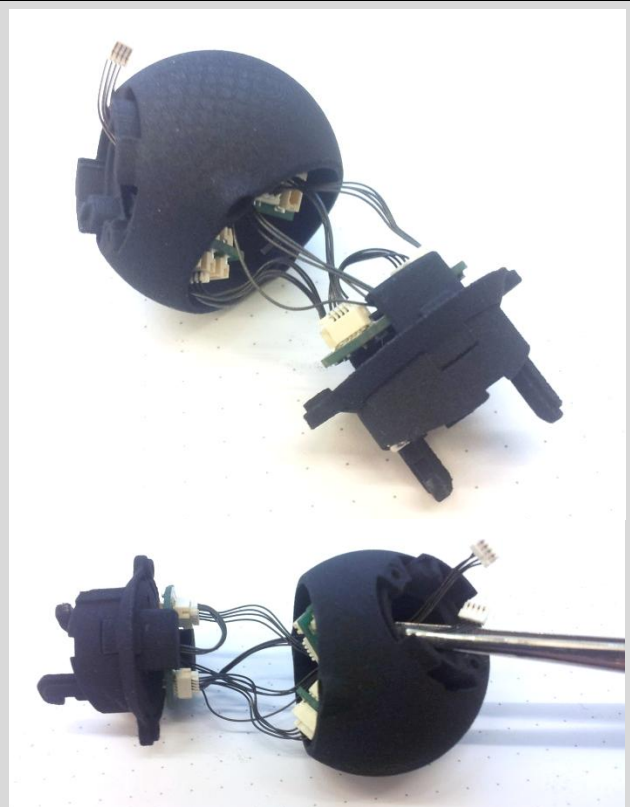


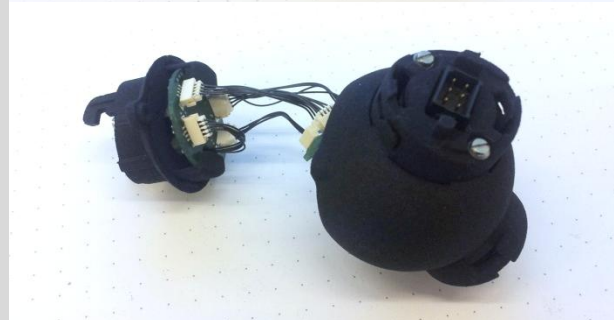
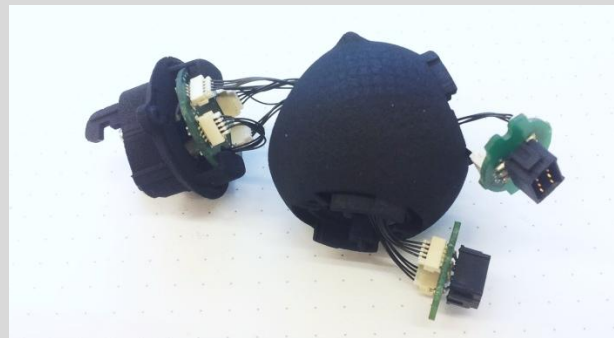
- 6** Then carefully stuff the things into the splitter base.

Using tweezers gently pull out two connectors per opening. Make sure there's always one connector from each board.

Whenever you have pulled out two connectors at a hole, connect a socket cBoard (see connectivity map).

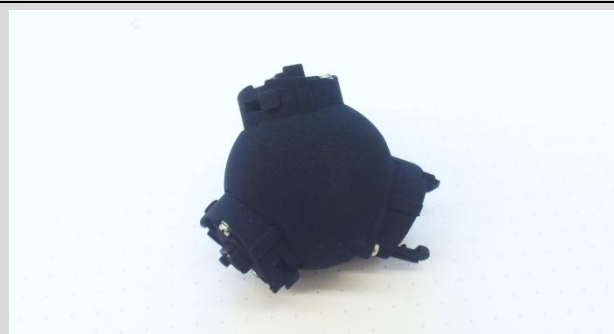
After having connected all cBoards, the connector sockets are screwed onto the splitter base. Make sure the chamfered corners are pointing to the left when the ridge on the outside is pointing away from you.





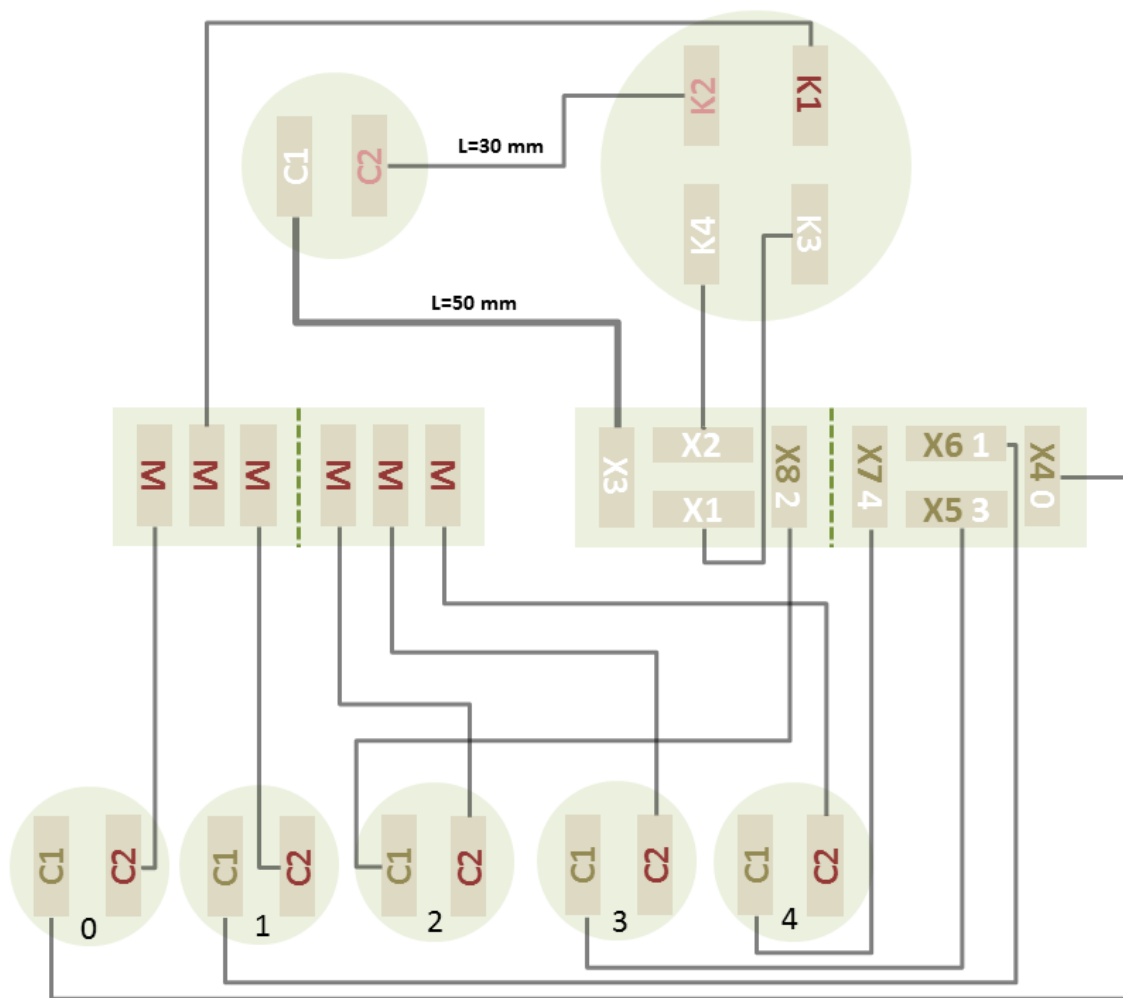
In a final step screw the cover onto the base. This should be done in a way that all outside ridges are on the same side.

Then we're done. Now the splitter should be calibrated!



For other geometries it just works the same way. Compare "connectivity map" on next page.

Connectivity map for an five-out splitter (A)



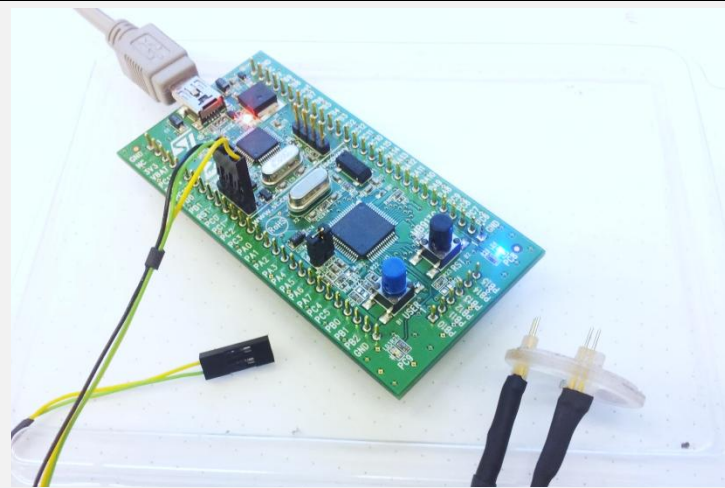
Programming

This section shows how the parts can be reprogrammed = a new program can be stored into flash.



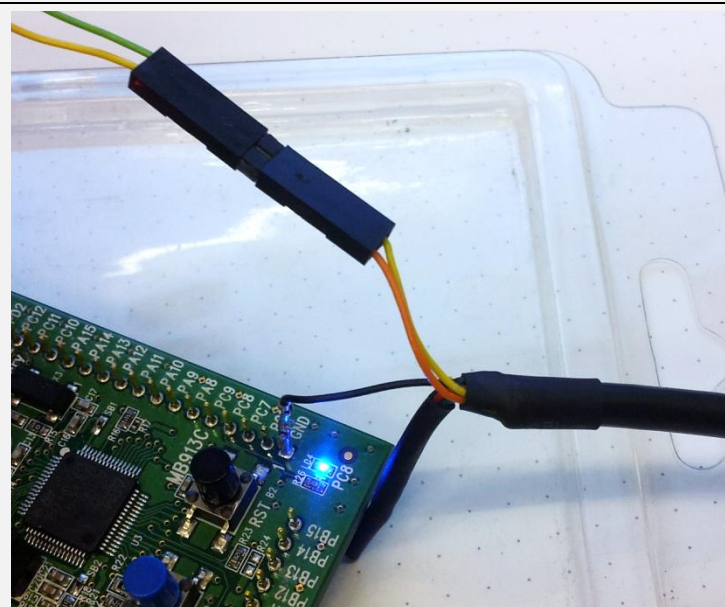
The power box has to be plugged in. Also plug in an elongation wire. To start the power box should be off (green led off).

The USB cord is not needed to be plugged in.



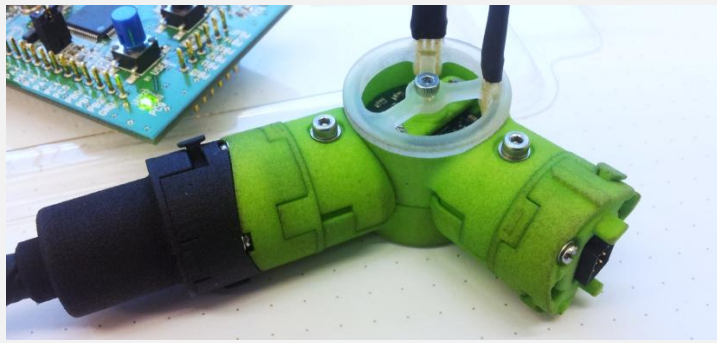
As a programmer a **STM32VLDISCOVERY** evaluation board is used.

To do so connect the triple connector of the programmer top to the board as shown in the picture.



Connect the double connector to an FTDI Serial-USB cord as shown in the picture (yellow-orange and green-yellow).

Connect the GND (black) of the FTDI cord to one of the GNDs on the evaluation board.



Now remove the top from the TBT joint to be programmed and connect it to the elongation wire.

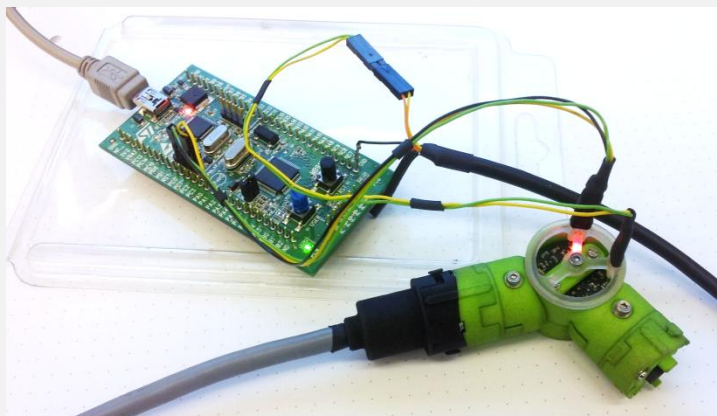
Carefully put the programming top on the TBT joint.



Make sure the five spring contacts meet the provided holes (vias) on the PCB.

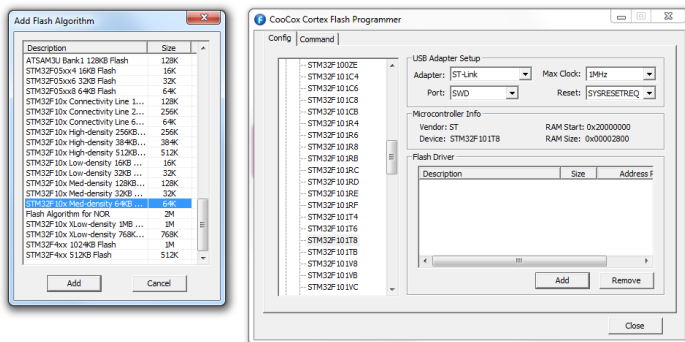
Then tight the screw – just a bit.

The power box can now be switched on and the two USB cords (FTDI Serial-USB and from the evaluation board) plugged in.



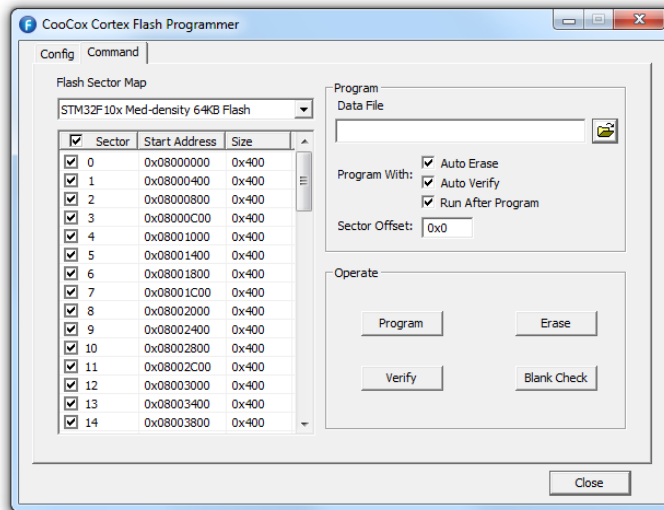
The final setup should resemble the picture on the left.

The power box is not shown.



To download the program into the flash of the microcontroller as an example the “CooCox Cortex Flash Programmer” can be used.

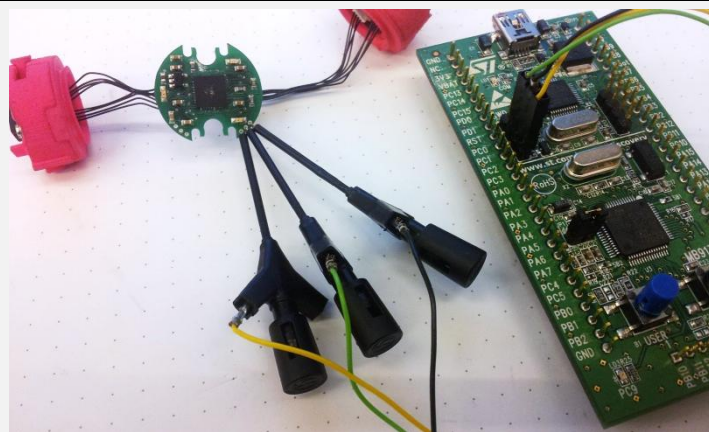
In our case it is a STM32F101T8U6 microcontroller and for programming we’re using a ST-LINK with a SWD port. All these options have to be chosen.



Then you can switch to the command tab, load the data file (.bin), click program and we're done.

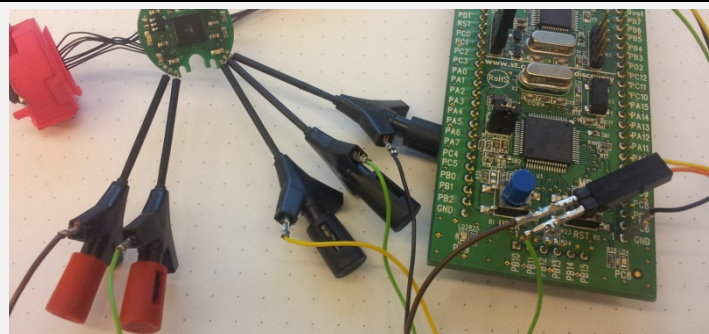
It might happen that in the first try a timeout occurs, just click again on program and it should work.

There's a variety of programs for each OS to download binary files to microcontroller's flash.



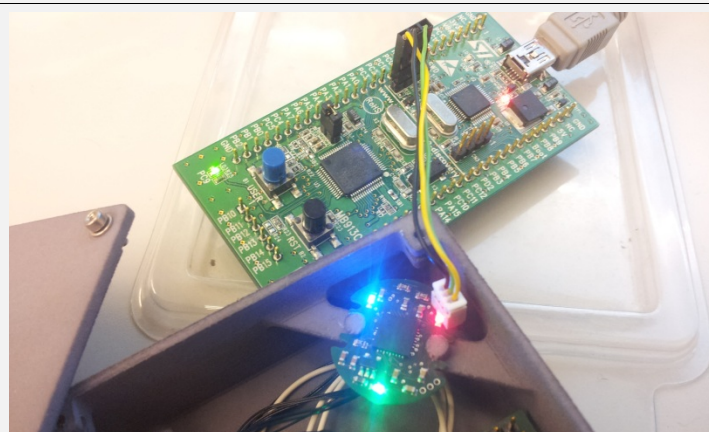
If the uBoard isn't built into a joint, as an alternative for reprogramming these mini clamps can be used.

The picture shows the needed programming connection. Naturally additionally a power source (like e.g. the power box) is needed.



Also a serial connection can be established using the clamps. The picture shows how to connect to a FTDI serial-USB cable.

Green and brown are arbitrary colors here whilst orange and yellow of the FTDI cable are always the same.



A third way to connect (at least with the newest board version, only for splitter and collector boards) is the use of picoBlade connectors.

For example for the collector and the splitter this is the best method. Just make sure the colors match the connection shown in the picture.

Serial Commands

Baudrate = 115200

Direct connection to part	Through collector	Description	Paramters										
t,type		Define the type of part	<table><tr><td>Type:</td><td></td></tr><tr><td>TBT joint</td><td>f4</td></tr><tr><td>n splitter</td><td>n8</td></tr><tr><td>collector</td><td>00</td></tr><tr><td>undefined</td><td>ff</td></tr></table>	Type:		TBT joint	f4	n splitter	n8	collector	00	undefined	ff
Type:													
TBT joint	f4												
n splitter	n8												
collector	00												
undefined	ff												
b		Stop the serial output											
l,id,rate_r,rate_g,rate_b	l,id,rate_r,rate_g,rate_b	Set the leds to a certain rate	Id: dynamic id of the target part, 0 when for every part Rate_r, rate_g, rate_b: blinking rate for the leds, in ms										
c,r,g,b		Define the color of the part	R,g,b: [0,255]										
g,output,yaw,pitch,roll	g,id,output,yaw,pitch,roll	Define the splitter geometry	Output: splitter output # or x (for output with calibration connector plugged in) Yaw, pitch, roll: Rotation definition										
s		Get the status											
h		Display help menu											
d		Display debug information											
i		Reinitialize											
o	o[,id]	Defines the current angles (=180) of the joint	Id: dynamic id of the target										
	k	Reset the slaves											

Serial output from collector

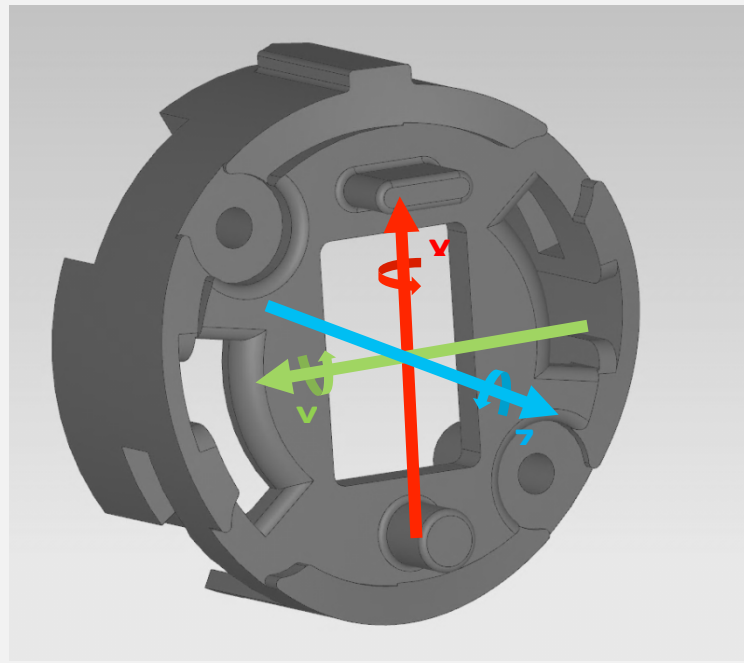
Message	Description	Parameters
A	Start loop	
i,id,type,unique_mc_id,r,g,b	Initialization message from parts present on the bus.	Id: dynamic id distributed Type: see command table Unique_mc_id: unique id of the microcontroller r,g,b: color of the part [0,255]
s,id,branch_nr,yaw,pitch,roll	Before probing a branch the splitter puts out this message.	Id: id of the splitter Branch_nr: Nr of the branch the splitter is going to probe next Yaw,pitch,roll: Rotation from

		the input of the splitter to the 'current' output branch
s,id,ff	Splitter message when all branches were probed.	Id: id of the splitter
m,id,twist_angle,bend_angle,twist_angle	In operation these messages are constantly sent	Id: id of the joint Twist_angle: first angle (16 bit) in hex Bend_angle: Second angle (16 bit) in hex Twist_angle: Third angle (16 bit) in hex
Z	Finished loop	

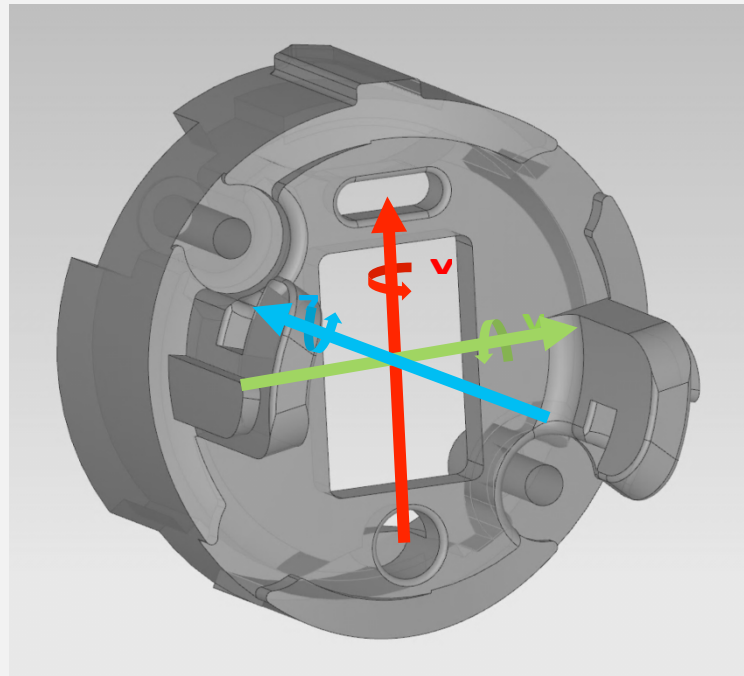
Connector COS

Transformation from input (plug) to output (socket) is defined through a series of three rotations

- Yaw (around Z-axis), Pitch (around Y'-axis), Roll (around X''-axis)
- For each output this transformation (Roll, Pitch, Yaw) is stored in flash and sent to the computer while intializing



- When plugged into each other transformation should be (0, 0, 0)
- Origin on the connector plane on the cylinder axis
- X-axis from circle to bar
- Z-axis out of the socket
- Y-axis to form a right handed COS



- Origin on the connector plane on the cylinder axis
- X-axis from circle to bar
- Z-axis into the plug
- Y-axis to form a right handed COS

Splitter calibration

To get a proper virtual representation of the real skeleton, the splitters have to be calibrated. This means for each output the transformation (rotation defined by three angles: yaw, pitch, roll) from the input to the output has to be stored in the splitter's flash. This can be done with the following steps.

	<p>The power box has to be plugged in. Also plug in an elongation wire. To start the power box should be off (green led off).</p> <p>The USB cord has to be plugged in.</p>
	<p>Connect the splitter which should be calibrated to the elongation wire.</p> <p>Now plug in the blue-green calibration connector part into one of the splitter outputs.</p> <p>Only now switch on the power box. It's very important not to switch on before having plugged in the calibration connector!</p>
	<p>By using a serial terminal (e.g. Putty) one output by the other can be calibrated. To stop the "AZ" output type in <code>b</code>.</p> <p>Then type in <code>g,3,x,yaw,pitch,roll</code> (and confirm with ENTER/line ending) where <i>yaw</i>, <i>pitch</i> and <i>roll</i> are the angles defining the rotation from input to output (compare Chapter "Connector COS"). X stands for the output where the calibration connector is plugged in. When you know which output is which you can also use the output # directly.</p> <p>One output by the other can be calibrated by plugging in the calibration connector.</p>
	<p>When changing the calibration</p>

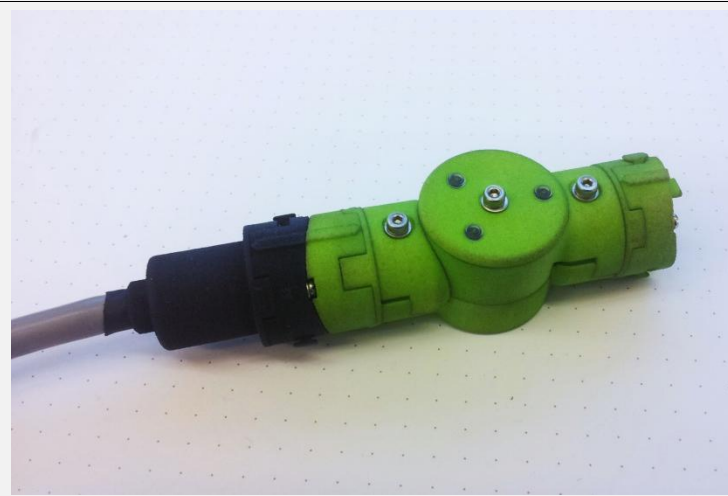
	<p>connector from one output to the next the power box does not have to be restarted.</p> <p>To check if all values have been correctly stored to flash type in b and then i. From the initialization sequence the calibration values can be read.</p>
	<p>After everything is calibrated, make sure to restart (without calibration connector plugged in) before animating anything.</p>

Joint calibration



The power box has to be plugged in. Also plug in an elongation wire. To start the power box should be off (green led off).

The USB cord has to be plugged in.



Connect the joint which should be calibrated to the elongation wire.

Outstretch the joint as shown in the picture. Make sure the arrows are aligned with the screw tops. The three screws should form a straight line.

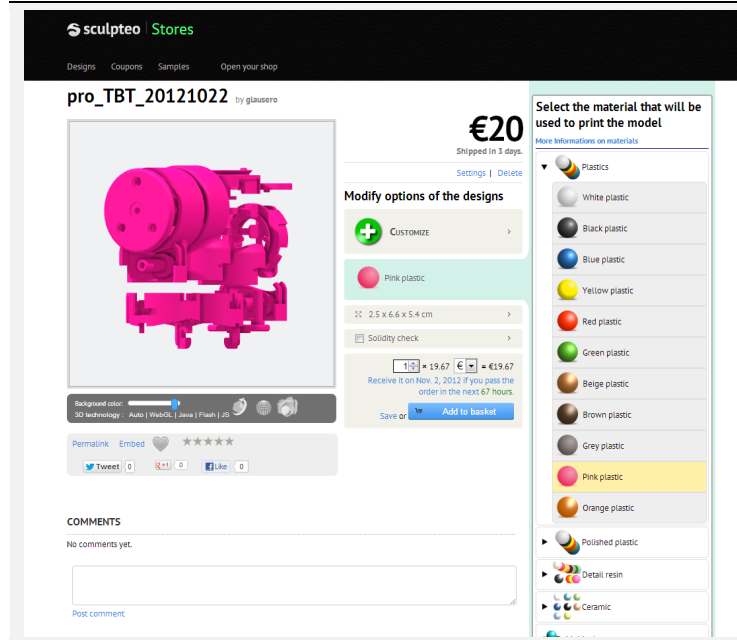
Now switch on the power box. Then type in 0. This way the current angle is defined to be 180°.

To check if everything worked out, have a look at the data stream which should look something like **m,03,7fff,7fff,7fff**. Through to noise values might be a few values off.

Ordering

From Sculpteo

3D laser sintered parts!



Order from sculpteo is quick and easy.

As material use one of the “plastics” – any color.

Don’t use the “polished plastics”!

From Compona

From compona the assembled wires have to be ordered.

Below you can find the order confirmation of the last (first) order with all the details needed:

Pos.	Nummer	Beschreibung	Termin	Menge	Einheit	Preis CHF	Betrag CHF
1	76 402-0	Konf. SUR 4p 30mm 04SUR-30MM ROHS: Ja / Ursprung: CZ	26.09.12	200	Stk	2.00	400.00
2	76 402-1	Konf. SUR 4p 50mm 04SUR-50MM ROHS: Ja / Ursprung: CZ	26.09.12	120	Stk	2.05	246.00
3	76 402-2	Konf. SUR 4p 110mm 04SUR-110MM ROHS: Ja / Ursprung: CZ	26.09.12	50	Stk	2.45	122.50
Total exkl. MWST							CHF 768.50
Mehrwertsteuer							8.00% 768.50 CHF 61.50
Total							CHF 830.00

Preisstellung: Ab Werk Fehraltorf, unverpackt, exkl. MWST

Lieferart: Priority

Zahlung: 30 Tage netto

Es gelten die swissT.net-Lieferbedingungen.

From mouser

From mouser lightpipes and corresponding fasteners have to be ordered:

<http://ch.mouser.com/Search/ProductDetail.aspx?R=RTN100virtualkey59300000virtualkey593-RTN100>

<http://ch.mouser.com/Search/ProductDetail.aspx?R=LMC020CTPvirtualkey59300000virtualkey593-LMC020CTP>

Three of each is needed per TBT joint and per collector. This sums up to **75** (69 + reserve) for the existing TARGET project.