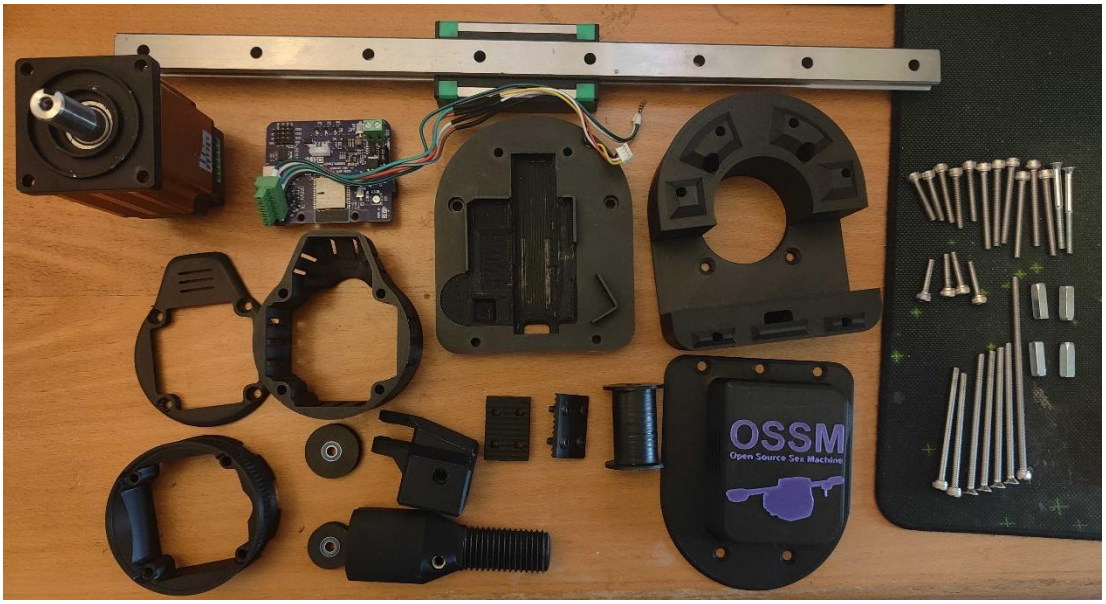
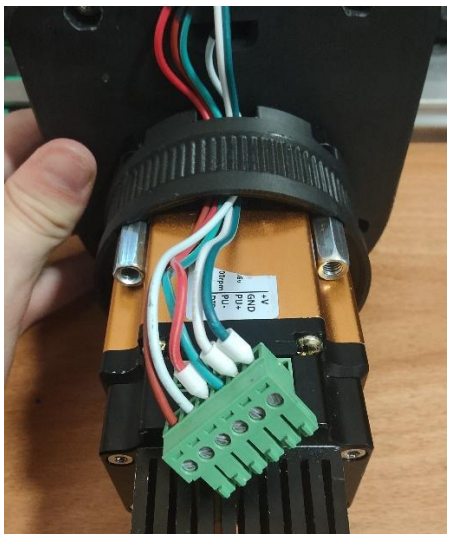
1. Bushing Pulley/Spindle/Drum/Capstan:
    1. With the Bushing Pulley files printed, make sure the Bushing/Bearing Shell fits on top of the drum. Shouldn't be too loose or too tight. Top Part needs to fit on top as well with a somewhat secure fit. Also assure the pulley fits onto the motor shaft. Shouldn’t be too tight or loose. If things don't fit, adjust with the included .f3d file or pm me.
    2. Take the bushing and slide the 24 mm shrink tubing on top. Cut it off so it fits well.
    3. Heat the shrink tubing with a lighter or a heat gun. You can hold the bushing with some tongs or pliers, so you don’t burn yourself. Make sure to heat everywhere so it sticks to the bushing properly.
    4. Spread some epoxy 2 part glue on the Bottom printed file.
    5. Slide the Bushing/Bearing Shell on top. Put on the top part as well.
    6. Put some weight on the Pulley and let it dry for 24h under pressure
    7. Make sure the bushing holds well. It should be very rigid.

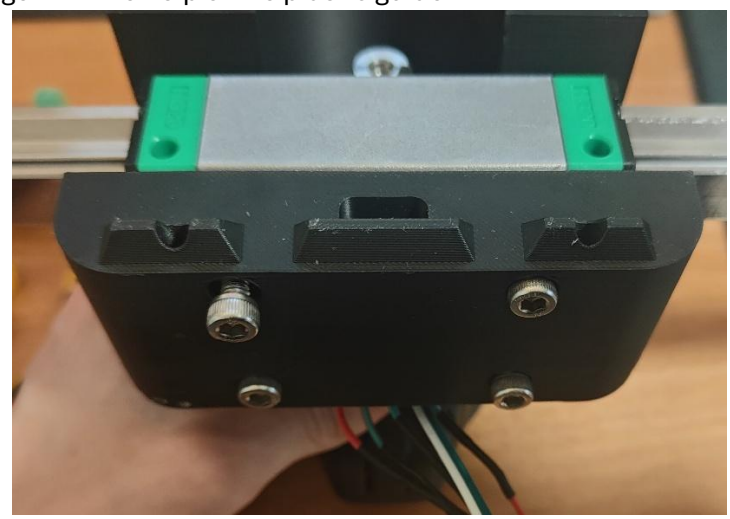
2. Clean the HGR20 Rail and HGH20HA Carriage (e.g. soaking in 99% isopropyl alcohol). Lube the carriage up well before mounting with some silicone grease



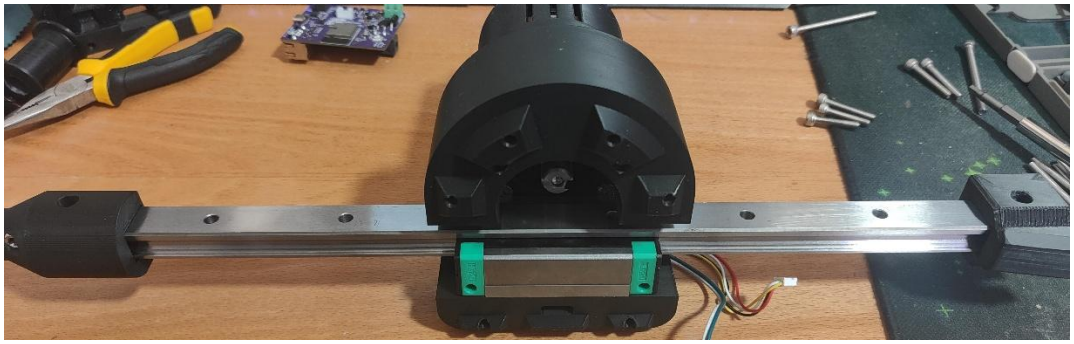
3. Mount the Motor Head Back to the Motor with Armpit’s 60AIM40F Ring behind (optional, if you want PitClamp Mounting) with 2 Hex Cap M5x65, 2 Countersunk M5x45 Screws and 4 M5 Nuts on the back. If you want to use the Motor Cover replace the Nuts with M5x20 Coupling Nuts (as pictured). Make sure the Motor Terminal and the Notch in the Motor Ring are aligned to each other and the cable hole in the Motor Head Back right below the motor shaft. Ignore the cable in the second picture.

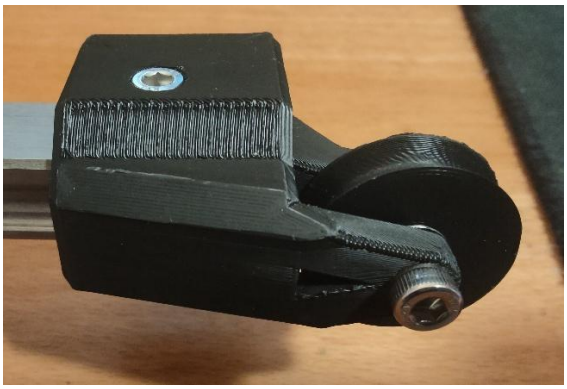
1. Screw the HGH20HA Rail Carriage to the Motor Head Back with 4 Hex Cap M5x20 screws. Slide the rail onto the carriage with the help of the plastic guide.



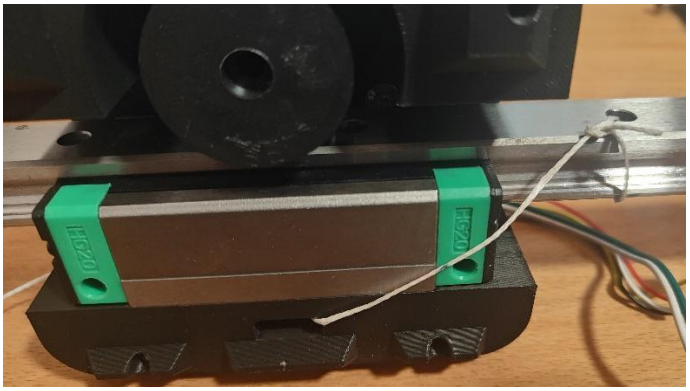
2. Slide the Rail End and End Effector onto the ends of the rail in the exact orientation shown below.



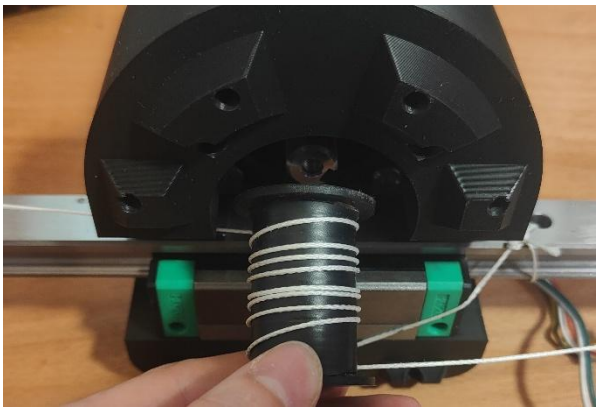
3. Fasten End Effector and Rail End each with a M5x30 Hex Cap Screw and a M5 Nut on the other side.
4. Insert 2 MR115 bearings each into big and small end pulleys. Mount the bigger pulley onto the Rail end with a M5x25 Hex Cap and the smaller one onto the End Effector with a M5x30 Hex Cap, as shown below. Use one M5 Nut each.



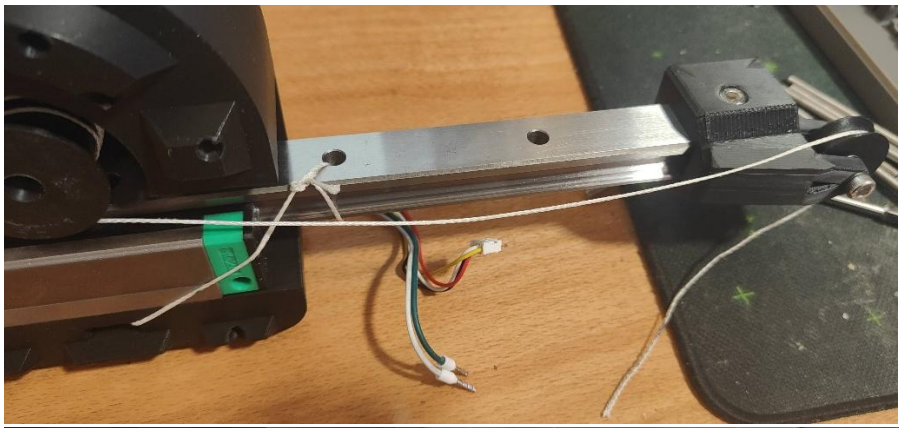

5. Slide the Capstan Drum onto the motor head.
6. Slide the motor head on the rail so it is roughly centered on the usable rail.
7. Take the rope and guide it through the circular hole on the side of the motor head through the "main channel" and out in the front (see pictures). Tie one end to a hole on the rail of your choosing. This makes the wrapping of the rope easier. Leave a generous length of rope on this end. Do not cut the rope.
8. Guide the rope around the End Effector's Pulley from bottom to top.

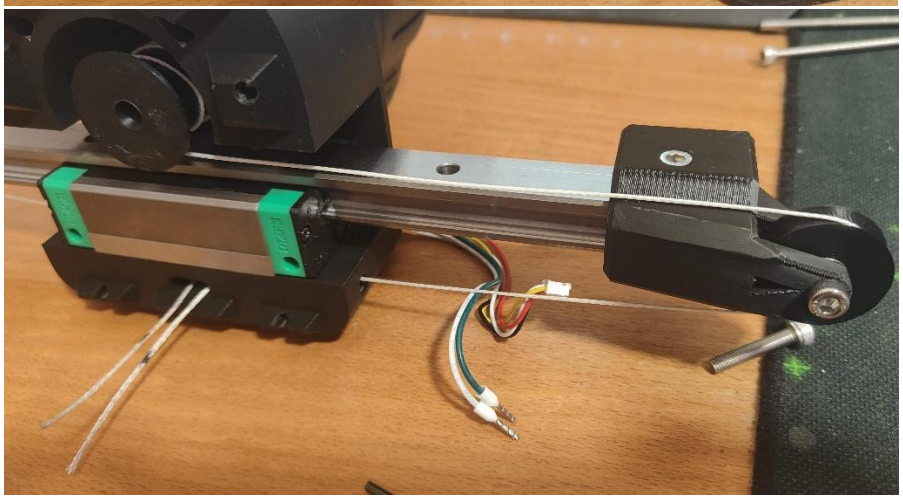



9. Wrap the rope rather tightly around the capstan pulley. The amount of wraps I used was 8, which works well with the Shrink Tubing I use. Your mileage may vary depending on how you increase the friction of the bushing. This is something you may need to play around with. More wraps have only the disadvantage of taking up more space, which makes it not possible to accommodate higher rail lengths. 8 wraps works well with 450mm rail length. Not enough wraps will result in slipping of the rope. The more wraps, the harder it is for the rope to slip. When you are done, roughly center the wraps on the drum by sliding them around.

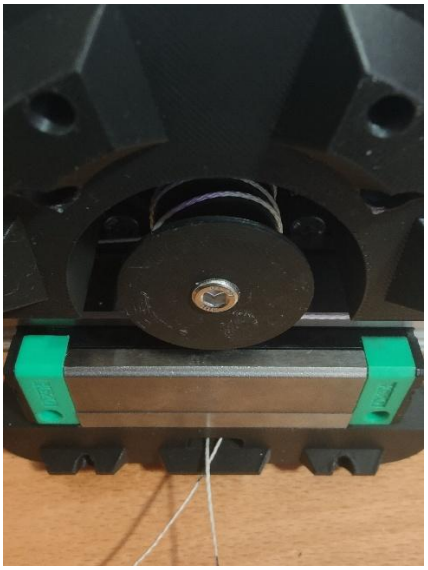


10. Guide the rope as pictured below and slide the end through the circular hole on the left side of the motor head, again through the "main channel" and out through the front (see pictures).



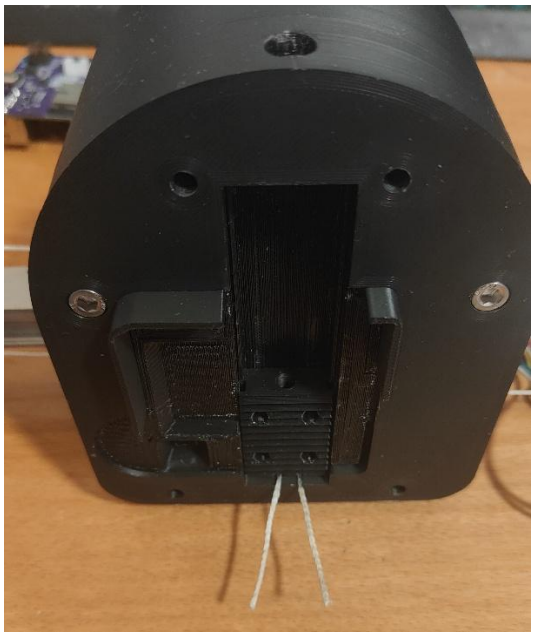
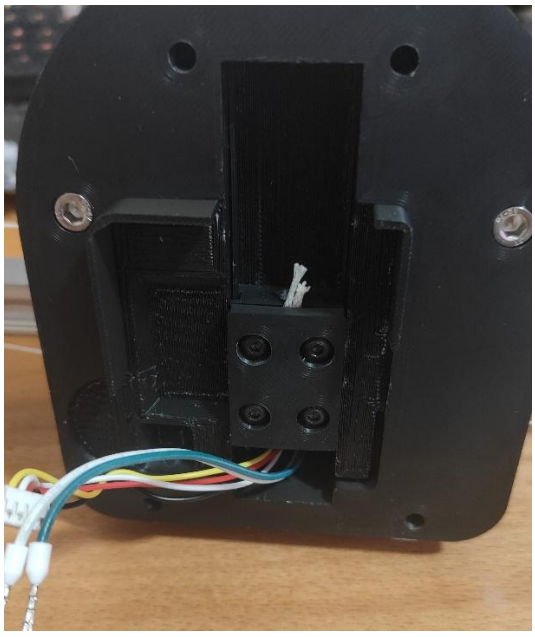


11. You can let go of the rope. This will relieve some tension from the wraps, but that is no problem, we can tension it as much as we like later.
12. Push the pulley onto the motor shaft completely. Screw it onto the shaft using a M5x25 Hex Cap screw. You don't need to screw it very tight.

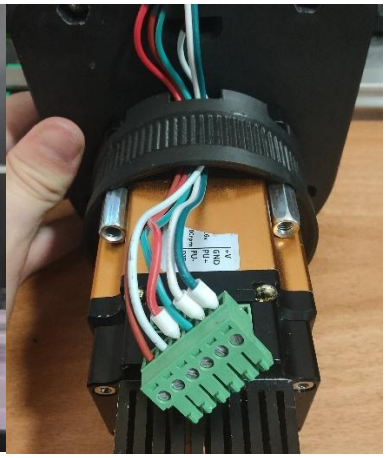


13. Take the Motor Head Front part. Push in the standoffs in the fitting slots. Use violence if needed. Make sure it fits properly and take out the bottom one as that obstructs the next steps.
14. Push 4 M4 and 1 M5 Nuts into the lower part of the tensioner.
15. Insert the lower part of the tensioner into the Motor Head front part as pictured below.
16. Push the Tensioner around a bit to make sure it moves around.
17. Put the Motor Head Front onto the Motor Head Back with 2 M5x65 Hex Cap Screws and slide the rope through the appropriate passthrough hole.

18. Flip the rope ends up, onto the Tensioner and tension them by pulling them. Now put the top part of the Tensioner on top and screw it tight with 4x M4x12 ISO7380 screws. Ignore the cables in the picture.

19. Take the 300mm JST Header cable as well as some awg 18 or thicker (not too thick) 2 pin cable (power cable). Don't cut anything off
20. Crimp one end of the power cable.
21. Route the power and JST cable through the main channel and Motor ring to the Motor. Screw the crimped end of the power cable and the cable end of the JST cable into the motor terminal. Check the labels on motor and control board pcb. They need to match.

22. Check Cable lengths. Look at a picture further down how the PCB is mounted. There needs to be enough cable to mount it without tension. Avoid having too high lengths of cable though. Cut it shorter if needed.
23. Crimp the other ends of the cable.
24. Connect JST Header and Power cable to the control board.
25. Screw an M5x110 Hex Cap screw from the top of the Motor Head Front through the Tensioner. Turning this screw will slide the Tensioner up and therefore tighten the rope. Tighten it a bit for now.
26. Clip on the lowest standoff back onto the Motor Head Front.

27. Now turn the M5x110 screw to tension the rope. Tension it guitar string tight. Move around the rail a bit and see if anything is wrong. The motion should be very fluent. Make sure the rope wraps are roughly centered on the capstan pulley. If they are not, it may be that it gets hard to push the rail to the end because the rope wraps over itself (thus increasing diameter of the capstan pulley -> longer rope needed). If you have issues with this and can't get it to work, feel free to pm on discord.
28. The rope will stretch a tiny bit over the first few hours of use. Retension accordingly to keep it guitar string tight or even tighter. The tighter the rope is tensioned, the less shifting on the rope on the drum you will have (in extreme conditions). I haven't played around with limits on how tight is too tight, but at some point the tensioner will probably fail. Before use, always make sure the rope is properly tensioned.
29. Cut the rope now but leave some redundancy in length.
30. Finally, screw down the front cover with 4x M5x75 countersunk screws and 4x M5 Nuts on the back.

31. Have fun!