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Introduction

This document is a guide for those who are interested in creating an AI Headstamp Sorter machine. This document references resources found in the GitHub Repository at https://github.com/sjseth/AI-Case-Sorter-CS7.1

Also available is the video build series at: [link to youtube playlist] (TBD)

Computer Requirements

Central to this project is the Windows based software which handles the picture classification and builds the machine learning models used for classification. Here is the list of requirements to run the software:

- Windows 10 (x64) or greater
- 64bit processor architecture
- Processor must support AVX instructions (AVX, AVX2, etc). Most processors made after 2015 support it. Most Celeron and Atom processors do not support AVX instructions.
- C++ VS Redistributable
- (2) USB 3.0 or type A ports. (a USB hub can be used if the machine has other USB port types)

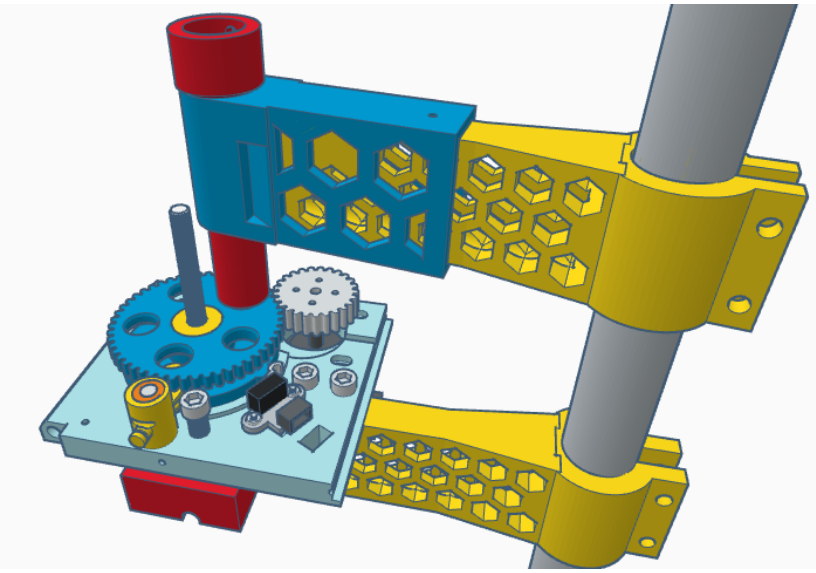
Overview

The AI Headstamp Sorter machine has 3 major components:

- Classifier – The part of the machine which takes a picture of the brass and classifies it. Then it is dropped into the sorter. The camera assembly is included as part of the classifier.
- Sorter – The bottom half of the machine which has a rotary arm with tubes to sort the brass into bins.

- Electronics & Enclosure – The electronics are housed in an enclosure which is powered by an external power supply and connects to the computer using USB.

Building the Classifier



Printing the Classifier Models – General Settings

It is highly recommended that you use Black PLA+ for all components in this project. I have used the JAYO brand of PLA+ with great success. For all models, these are the general print settings that I have used:

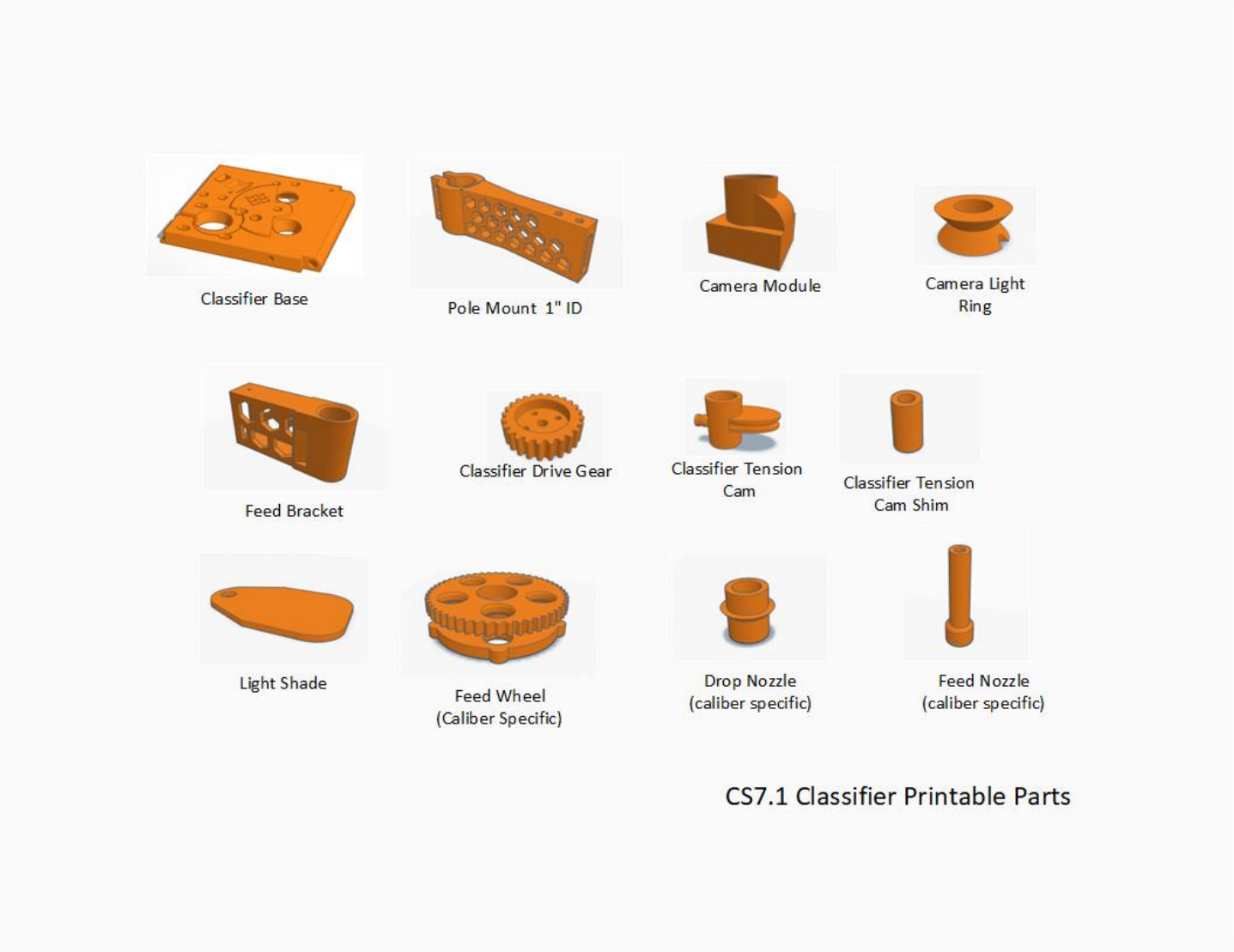
- **Nozzle Temp:** 222C
- **Bed Temp:** 60C
- **Layer Height:** .20mm
- **Support overhang angle:** 88 degrees.
- **Support type**: tree
- **Infill**: 30%
- **Infill Pattern**: Lines or Grid

These should be the assumed print settings for all models unless specific changes/overrides are indicated below.

The models account for shrinkage already and though a calibrated printer will give you better dimensional results, if you print all the parts with the same print settings, everything should fit together with minimal post-print modification.

The classifier models are available in the GitHub repo folder 3dModels/Classifier

Classifier Parts Listing Diagram



Classifier – Base Plate

Recommend using black PLA+ but if you decide to use a different color, you will need to "black-out" the bottom of the camera hole and surrounding side surfaces to keep the picture dark. Flat black paint or a sharpy will usually work as these parts do not have any wear.

Classifier – Camera Module

Layer Height: .16mm (or smaller).

The camera module has some very small screw holes to facilitate the m2.5 screws needed to bolt on the blower fan. The more precision you can get out of your printer, the better. Recommended to use Black PLA or PLA+ as any other color will result in less-than-optimal image processing results.

It may also help to slow down your print speed on the first 10 layers of this print to get better screw hole definition.

Classifier – Camera Light Ring

Color Material: Non-Opaque White PLA.

The purpose of this part is to diffuse the light from the LED light strip. The more translucent the material, the better. Generally cheap white PLA works great here.

Classifier – Feed Wheel (Caliber Specific)

This wheel can be printed in either orientation however, it is recommended to print the wheel with the bottom (non-geared side) down. If you are printing to a smooth glass bed, this may result in a very shiny bottom on the part and you will need to "scuff" it with some light sandpaper (300-400 grit) to avoid reflections from the camera backlight. Using print base with a matte texture is recommended. (Example of magnetic print surface)

Classifier – Drive Gear

This part can be printed in any color you choose. Recommend PLA+ for greater durability but no problems have been reported with just standard PLA.

Classifier – Feed Bracket

This holds the feed nozzle and can be adjusted so that the tip of the nozzle hovers approx. 2-3mm over the feed wheel. The bracket attaches to the 2nd pole mount.

Classifier – Light Shade

The light shade is attached to the M6 feed wheel axel via a nut and should hover over the camera hole just above the feed wheel about 5mm. Should be printed in black or similar dark filament.

Pole Mount

You will need to print 3 pole mounts in total. Two for the classifier and 1 for the sorter. This can be any color but recommended to use PLA+ for increased strength.

Classifier – Feed Nozzle (Caliber Specific)

Any desired color can be used for this part.

Classifier – Tension Cam

- **Layer Height:** .16
- **Infill**: 100%

Classifier – Tension Cam Shim

This part should thread snugly onto an M6 bolt or threaded rod. It should also fit loosely in the tension cam. Print the part as is and if there is a fit issue, scale the part up or down by 1% until you get the desired fit. The cam should move freely and easily when installed over this part.

This part should be printed in Black.

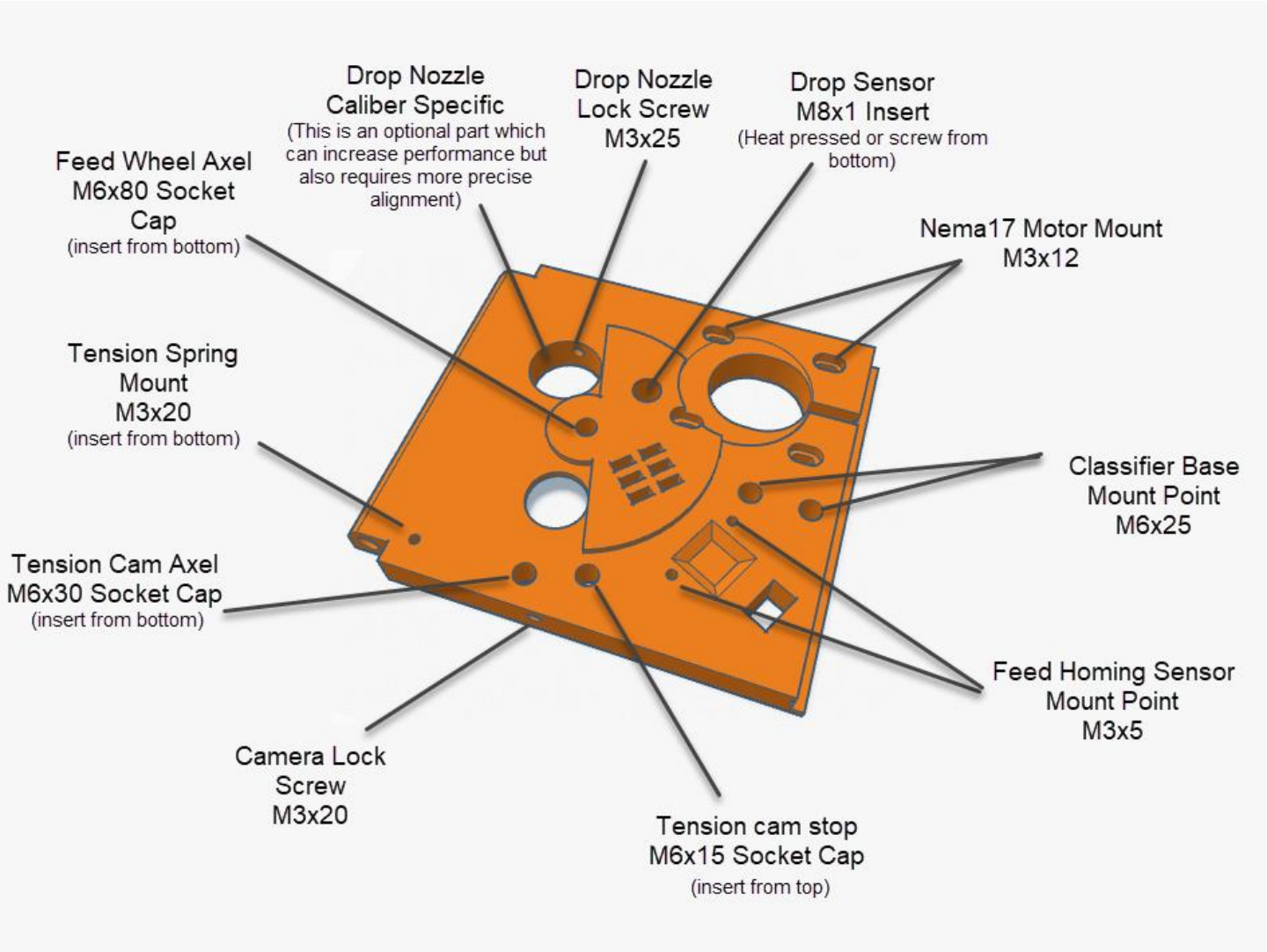
Classifier – Drop Nozzle (Caliber Specific)

The drop nozzle is designed cancel the rotational effect on the falling brass and allow the brass to drop straight down into the sorter tube which as the effect of a smoother/faster sort drop (vs the brass rattling around in the tube and not making it into the desired sorting bucket in time. Standard print settings apply but the part should be a press fit into the drop hole. If it is too tight/loose, use scaling in your slicer to upscale/downscale by 1%.

This part is not required but may improve performance. It can be printed in the color of your choosing.

Classifier Assembly

Assembly Diagram



Assembly Steps

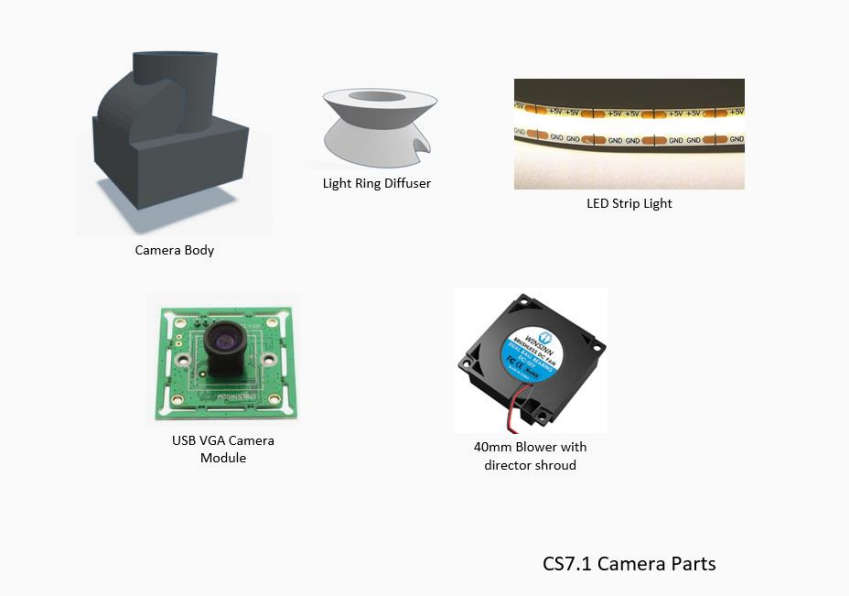
Installing the parts in the correct order can save you time and frustration. Here is the best order I have found for construction:

1. Test fit the camera housing into the base. It should have a snug press fit. If the fitment is loose, you will need to use the Camera Lock Screw (m3x20) to secure the camera in place. You will need to remove any burrs and might need to lightly sand the outside of the camera housing to get a good fit. We will install this part last, but it is easiest to make sure it is going to fit before installing the rest of the hardware.
2. Install the Drop Sensor insert. This is an M8x1.0 threaded insert (see parts list) (don't confuse it with M8x1.25 which is more commonly available). The threaded insert can be threaded into the sensor hole from the bottom if you have an m8x1 bolt handy, otherwise it is recommended to use a hot soldering iron to press fit it into the hole.
   Be careful not to seat the insert all the way in flush to the body and it should hang approx. 1/8in below the base.
3. Install the Proximity Sensor (Drop Sensor) into the threaded insert. You should screw this in until the top of the insert is flush or slightly below the top surface of the classifier base. If sensor is too high, it will catch on the feed wheel.

4. Install the Feed Wheel Axel (m6x80mm socket cap screw). This screw threads from the bottom and should be threaded snug to the base. **DO NOT OVER TIGHTEN.** If you use a different type of screw, it is possible the head of that screw may be too large and interfere with the camera hole. Socket head is recommended.
5. Install the Nema17 Motor. Do not tighten the motor screws all the way down yet. Slide the motor towards the back of the slot. Install the coupler flange on to the motor shaft.
6. Press fit the drop nozzle for your desired caliber (see caliber conversion kits). If the fit is too loose, you will need to use an m3x30 set screw to hold it in place.
7. Install Tension Cam Axel Screw from bottom and seat flush to base (M6x30). Thread the Tension Cam shim onto the tension cam screw until it is snug to the base. You should be able to thread this part by hand. If it is too tight, you might consider printing another which is 1-2% larger.
8. Install the Tension Cam spring mount from the bottom (m3x20)
9. Install the Tension Cam stop screw from the top and thread until the bolt is flush with the bottom of the base.
10. Insert [16x1.5 – 17x2.4] O-ring on the tension cam
11. Slide Tension cam over the tension cam shim/axel.
12. Attach extension spring to cam and spring mount. Thread m3 nut down onto spring mount screw.
    Pro Tip: Rather than use a nut to secure the spring, use the edge of a sharp file or Dremel to cut a notch about 1/4in down on the m3 screw. It only needs to be deep enough to keep the spring from sliding off. This makes removal of the cam much easier.
13. Install Feed wheel with bearing preinstalled. The wheel should easily slide down over the m6 axel screw. Add a lock nut or two standard nuts to the top of the wheel. Do not over tighten as the wheel should move freely.
14. Install the homing sensor. This takes two m3x10 (or shorter) screws.

Camera Assembly

The following diagram illustrates the parts required to complete this part of the build



Here is an overview of the basic assembly steps to complete the camera module

1. Focus the camera
2. Build the Lighting Ring
3. Install the lighting ring and wiring

4. Install the camera
5. Install the Fan
6. Test

Focusing the Camera

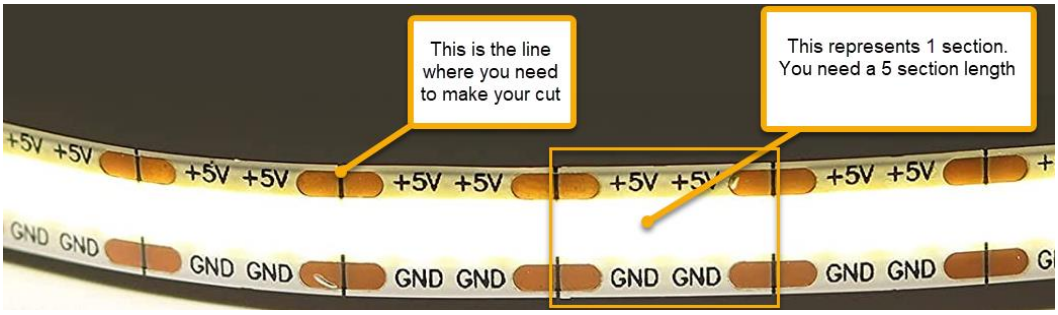
Connect Camera USB cable and connect to a computer and open the default windows camera app. Select the VGA camera.

Set the focus of the camera by using the camera body as a guide. You can rotate the camera lens to focus the camera. Set the camera body on its side and set or hold a piece of brass approx. 5mm from the top edge of the body. Place the camera into the body and check the focus on your computer.

Once you have the camera reasonably focused, you can unplug it and set it to the side.

Build the Light Ring

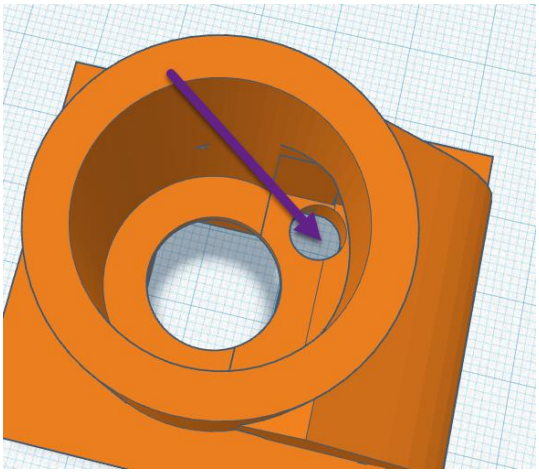
1. Unroll the USB strip light and cut a section length of 5 sections using scissors or a box cutter.



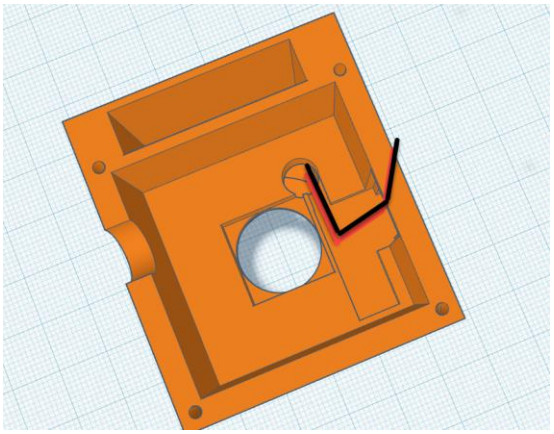
2. Solder a wire pair to the 5v and ground tabs. The wires should be at least 5 inches long. Recommend using yellow and black wire so the wiring is not confused later with the fan wiring but of course any color will work.

3. Wrap the light strip around the light wring with the strip facing into the ring. Make sure to align your wires with the notch in the light ring. Tightly wrap at least 2 lengths of electrical tape around the outside edge of the ring to secure the led strip and wiring in place.

4. Install the light ring into the camera housing through the top. Guide the wire pair through the offset hole (not the big center hole)

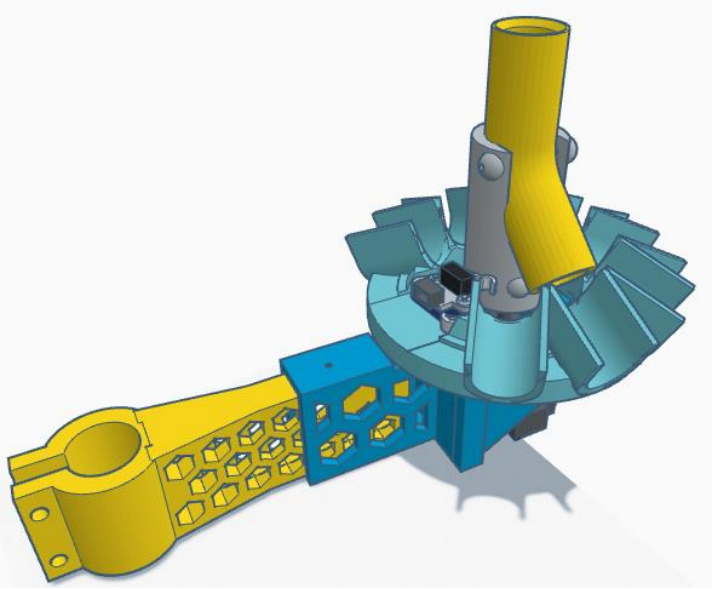


5. Run the wiring in the slots provided



6. Place the camera into the house making sure the connector side is oriented with the recessed slots
7. Place a piece of foam rubber or packing foam on the back of the camera so that it is pressed firmly in the housing when the fan is installed
8. Connect the usb cable to the camera
9. Run both the usb wire and the light ring wire out the half-circle hole
10. Install the fan on top the camera housing using 2mm socket head screws. Make sure the director shroud is oriented correctly.
11. At this point all the wires should close together (fan, lightring and camera). It may be helpful to put a piece of electrical tape around them to keep them together.
12. Install connectors on the fan and light ring wires so they can be easily detached later.

Building the Sorter



Printing the Sorter Models – General Settings

When printing the sorter parts, you can use the filament type and color of your preference.

Recommend PLA+, PETG, PLA with layer height of .2.

The models account for shrinkage already and though a calibrated printer will give you better dimensional results, if you print all the parts with the same print settings, everything should fit together with minimal post-print modification.

Sorter Parts List Diagram

Sorter – Base & Pole Mount

This part can be printed in any color you choose. Recommend PLA+ for greater durability but no problems have been reported with just standard PLA. **The base should be printed with supports with minimal support angle of 88 degrees**. The base slides over the pole mount so it is highly recommended to print these two parts together with the same material. If you print these with different colors/materials, you might have to do some light sanding on the pole mount to achieve the desired fit as difference filaments often have different shrink profiles.

Sorter – Base 8 Slot Ramp

This part slips over the sorter base and is secured by two m6 screws. No specific recommendations for this part.

Sorter – Pipe Bracket

This part is attaches to the sorter motor via a 5mm coupling flange. Supports should be turned off when printing this part and it is recommended to use the minimal infill possible 5-10% max. The lighter this part is, the better as it can affect the amount of torque needed to start/stop the sorter in correct position.

Sorter – Sort Pipe

There is some benefit in printing this part as high-quality as possible. Recommend .16 or finer layer height and using a glossy filament if available. The reason for these recommendations is that the smoothness of the internal surface of the pipe will affect the speed and consistency at which the brass drops through the pipe. It is also highly recommended to use a 10–15 lines brim on this part for better surface adhesion. The part should be printed with the flat end of the tube on the print bed surface and no support should be used.

Sorter – Homing Bracket

Recommended to use a tough filament such as PLA+ or PETG but really any filament should work as long as you don't overtighten the m6 mount screw

Sorter – Sort Bin

These optional sort bins can be used to sort the brass into. They are designed so that they can be oriented at the correct angles to the sorter arm. Recommended to use a layer height between 2 – 3 and print with 0 infill to reduce print time. Typical print time for each bin is roughly 6.5 hours. If you use "vase mode" in Cura, this can be reduced to 2-3 hours per bin, but the bins will be much weaker.

Electronics and Enclosure Assembly

Printing the Enclosure Models – General Settings

The electronics enclosures can be printed in any material and color of your choosing. This is entirely personal preference and I make no recommendations here.

Enclosure – Box

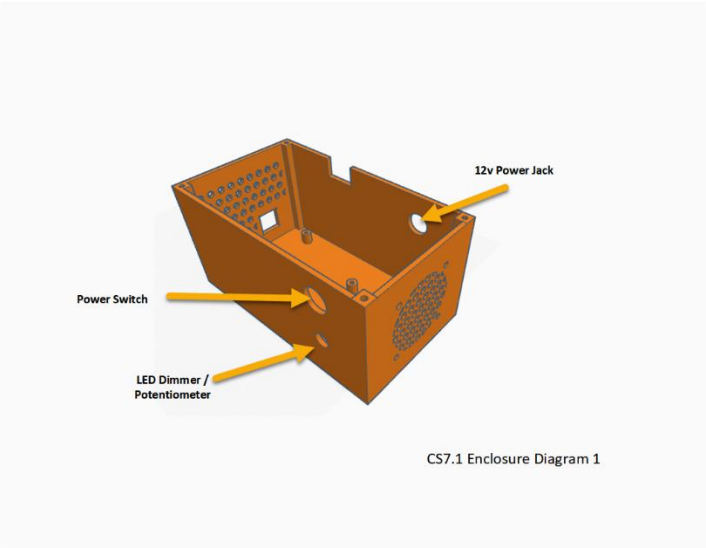
This box houses the electronics. If it is printed to spec, it should match up to existing Arduino uno holes. It is recommended that you should use a support angle of 88 degrees. The only support area needed is the USB hole.

Enclosure – Lid

Recommend printing along with the box with the same material so after accounting for shrinkage, everything works.

Electronics Assembly

Refer to the Parts List section below for the list parts and resources to acquire the needed components to complete this project



CS7.1 Enclosure Diagram 1

QUICK STEPS

1. Install 40mm Fan
2. Install LED Dimmer with 4.7K resistor.
3. Install 12v Jack
4. Install Power switch
5. Install Arduino Uno
6. Install Motor Shield
7. Connect all 12v power lines and ground
    a. Arduino Shield
    b. Dimmer
    c. Fan
    d. Drop Sensor
    e. Wires for Camera Fan with connectors
    f. Wires for Camera Light with connectors
8. Attach motor cables to shield
9. Add Motor controller to shield (TCM2209)
10. Adjust Vref on motors
11. Load Arduino code onto Arduino

Detailed Instructions

Install 40mm Fan

The 40mm fan should be installed on the inside of the enclosure. The back of the fan has hex shaped holes where the 3mm nuts should be placed the front of the fan should face the enclosure wall grill. You will need (4) M3 screws of approximately 15mm length. Do not connect the fan wiring just yet.

Install LED Dimmer

Connect red and black wires to the power side of the dimmer. The wires should be approx. 4-6 inches in length to and they can be cut down to size later. These wires will connect to 12v and ground. On the motor/led side of the dimmer, connect two smaller wires (22-24AWG) of approximately 6-8in. You will need to install the 4.7K resister between the positive output and the connector which will provide a more useable light range. It is recommended to use yellow and black to signify low signal and ground. These wires should have female connectors so they can be quickly detached from the sorting system for maintenance.

Install Power Jack (12v)

If you are not using the power jacks with pre-soldered wires, you will need to solder 6” 16AWG wires to the leads. Red wire on the center pin and black on the outer.

Install Power Switch

Solder 16AWG red wires of approx. 6” length to both leads on the power button. Install into the enclosure and secure with a nut.

Install the Arduino Uno

The Arduino Uno should drop right into the box and us the USB hole for alignment. The Arduino is secured by M3 x 5mm screws. Do not over tighten these or you will break the screw risers. If you can get all 4 screws in, don’t fight it. It will be plenty secure with just two screws. Magnetic screwdriver helps here.

Install the CNC Motor Shield

Before seating the motor shield, you should attach the two 16AWG wires (red & black) of approx. 6” length to the power connector on the shield. This can be difficult to do after it has been seated.

Align the pins and carefully press down on to the Arduino. If you have it lined up, it should only take mild pressure to seat it.

Connect up power wires and ground

The red wire from the power jack should connect directly to one of the red wires on the power switch (it doesn’t matter which). The rest of your red wires should be bonded together to form a power rail. Your black ground wires should also be bound together to form a ground rail. You can use any method you like to wire these together, but I prefer to use connectors such as these:

https://www.amazon.com/gp/product/B0BKTNDP9K

Parts List

Electronics and Enclosure Parts	
12v Jack	• https://www.amazon.com/gp/product/B091PS6XQ4 • https://www.amazon.com/gp/product/B07Y8KKSR1/
12mm Push button switch	• https://www.amazon.com/gp/product/B06XF6PT9L • https://www.amazon.com/Cylewet-Self-Locking-Latching-Button-CYT1091/dp/B075VBV4QH
12v motor dimmer PWM (led dimmer)	• https://www.amazon.com/gp/product/B07GP72BWV
Arduino Uno R3 (Genuine Arduino recommended)	• https://www.amazon.com/ELEGOO-Board-ATmega328P-ATMEGA16U2-Compliant/dp/B01EWOE0UU • https://www.amazon.com/Arduino-A000066-ARDUINO-UNO-R3/dp/B008GRTSV6 • https://www.amazon.com/SunFounder-Board-Arduino-ATMEGA328P-ATMEGA16U2/dp/B08353DL5P •
CNC Expansion Shield	• https://www.amazon.com/WWZMDiB-CNC-Shield-V3-Engraving/dp/B0BQDW1H8Z • https://www.amazon.com/Ximimark-Engraver-Printer-Expansion-Arduino/dp/B07L74X18N • https://www.amazon.com/Printer-A4988-Expansion-Arduino-Engraver/dp/B09YR2HZP6
(7) 2-pin jumpers	• https://www.amazon.com/gp/product/B077957RN7
40mm 12v Fan	• https://www.amazon.com/gp/product/B07CH6YC32
12v 5amp Power supply	• https://www.amazon.com/gp/product/B01GEA8PQA • https://www.amazon.com/gp/product/B0711Q5B49
4.7K Ohm Resistor	• https://www.amazon.com/California-JOS-4-7K-Tolerance-Resistance/dp/B0B4FXTWWY
Classifier and Sorter Parts	
(2) NEMA 17 Motors (1.5a)	• https://www.amazon.com/STEPPERONLINE-Stepper-Bipolar-42x42x38mm-Connector/dp/B0B38GX54H • https://www.amazon.com/gp/product/B07TGJT5M2
Nema17 motor cables	• https://www.amazon.com/Iverntech-XH2-54-Terminal-Stepper-Printer/dp/B08SQ35LRQ
(2) 5mm ID Flange Shaft Coupling	• https://www.amazon.com/gp/product/B07L1FMBBC • https://www.amazon.com/Befenybay-Hardness-Flange-Coupling-Screws/dp/B07V5YZHTC
6.35mm (.25in) x 22mm (.88in) extension spring	• https://www.amazon.com/gp/product/B076XKY3JM

	You can order the spring by itself, but cheaper to buy the spring kit and have extra springs when you need them.
6mm ID, 19mm OD Bearings	• https://www.amazon.com/dp/B07FMV2ZHR Recommended have 2 for each caliber you plan on sorting.
(2) Homing Sensors	• https://www.amazon.com/gp/product/B07PCN6T6F • https://www.amazon.com/OCTSEPCY-Mechanical-Horizontal-Switches-Printers/dp/B0B6FJ5YPG
Inductive Proximity Sensor (8mm, 3wire NO) Part Number: PR08-2DN	• https://www.amazon.com/gp/product/B081254GB2 • https://www.amazon.com/Baomain-Proximity-PR08-2DN-3-wires-Inductive/dp/B01KUIR2QQ/ • https://www.amazon.com/uxcell-Inductive-Proximity-Detector-PR08-2DN/dp/B07CWQHQZ1
M10x1 Male to M8x1mm Female Thread Adaptor (for proximity to screw into) Also called thread reducing nut	• https://www.amazon.com/FZJDSD-Thread-Adapters-Reducing-Conversion/dp/B09MVQS52Y • https://www.harfington.com/products/p-1334884 • https://www.amazon.com/Reducer-Metric-M10X1-0-Headless-Adapter/dp/B079159HNG • https://www.fittings.space/gsm26-m8x10-m10x10m • https://www.ebay.com/itm/201781023109 • https://www.ebay.com/itm/115667535076 • https://www.ebay.com/itm/234705490225 •
M6 x 80mm Socket Head Cap Screw	• https://www.amazon.com/dp/B01N91YP3N
M6 Nuts . Locknuts are great	• https://www.amazon.com/M6-1-0-Stainless-Thread-Bright-Finish/dp/B08Y8PV88V • https://www.amazon.com/M6-Lock-Nuts-Locknuts-Stainless/dp/B0BFWRKJGZ
Threaded Inserts (m3, m4)	• https://www.amazon.com/gp/product/B08Z86Z85R • https://www.amazon.com/ShineNow-Inserts-Plastic-Printing-Threaded/dp/B09MK4X1KQ • https://www.amazon.com/QLOUNI-Threaded-Embedment-Assortment-Projects/dp/B07YFQ1H5J
M6 Cap Screws • (10) M6x25 (Mounts) • (1) M6x16 (TC Stop) • (1) M6x30 (TC Axle)	• https://www.amazon.com/120Pcs-Stainless-Socket-Washers-Assortment/dp/B01N0ZU46G
M3, M4 Screw assortment • (8) M3x12 (motor mounting) • (1) M3x15 (Feed Tube Set Screw) • (2) M3x15 (Sorter Body Set Screws)	• https://www.amazon.com/Assortment-GTERNITY-Assorted-Stainless-Phillips/dp/B08T69WNQ1

• (1) M3 x 20 (Tension spring mount) • (8) M3 x 10 (motor shaft flange coupling) • (1) M3x 15 Camera Set Screw • (1) M3x 25 Drop Nozzle Set Screw • (2) M4x 15 (Classifier Lid hinge)	
M2 Screws (3) 8mm screws (1) 12mm screw	• https://www.amazon.com/gp/product/B07W5J19Y5