Prerequisites

Complete the assembly of the printed circuit boards (PCB) and electric motor wire soldering.

Tools

3D printer

Wire Stripper for 28 AWG stranded wire

Small Philips head screwdriver

Dupont connector tool

Soldering station with solder/flux

Needle nose pliers

Tweezers

Clamping tweezers

Zinc strip or thin metal strip (for melting plastic)

Wire snipper

Multimeter

Breadboard and jumpers for testing electronics

Label maker (optional)

Computer with USB connector

Software

VS Code

Micropython

Bill of materials

Item	Quantity
Digit 0,2,3 PCB	3
Digit 1 PCB	1
Powerbank PCB	1
A4 Size Felt Sheets with Adhesive Backing, Peel and Stick Felt Sheets Adhesive Backed, Felt Adhesive Sheet	3
2 Inch Jumbo Paper Clips (Smooth Big Paperclips)	20
M2 x 6mm Stainless Steel Phillips Round Head Self Tapping Screws	
M2 x 8mm Stainless Steel Phillips Round Head Self Tapping Screws	
M2 X 15mm Stainless Steel Phillips Round Head Self Tapping Screws	
Micro 130 DC Motor Strong Magnetic Brushed Electric DC 3V -12V 25000 RPM Cars Toys Electric Motor, High Speed Torque DIY Remote Control Toy Car Hobby Motor, Metal Car Engine Motor Kit for Toys	30
28 AWG Gauge Flexible Silicone Rubber Electric Wire 6 Colors 32.8 feet each	1
Dupont Jumper Wire Cable Female Pin Connector 2.54mm	100
2.54mm 1x2p Dupont Connector Housing Female for Dupont Cable and Jumper Wire	100
Digital Temperature and Humidity Sensor DHT11 LED Module, 3 pin	1
5mm 0.5 Ω ohm Photoresistor LDR Resistor 5516 GL5516 Light-Dependent Photoconductor (Photo Light Sensitive)	1
5mm Flat Top LED Diode Lights (Clear Transparent Lens) Bright Lighting Bulb Lamps Electronics Components Indicator Light Emitting Diodes	112
3mm Flat Top LED Diode Lights (Clear Transparent Lens) Bright Lighting Bulb Lamps Electronics Components Indicator Light Emitting Diodes	2
Vertical Slide Switches Micro High Knob 3 Pin 2 Position 1P2T SPDT Panel Mount AC 125V 2A	1
2.54mm 0.1" Pitch PCB Mount Screw Terminal Block Connector, 2P 3P 4P Terminals 150V 6A for 26-18AWG Cable	1
LM2596 DC-DC Step Down Variable Volt Regulator Input 3.2V-40V Output 1.25V-35V Adjustable Buck Converter Electronic Voltage Stabilizer Power Supply Module	5

2.1mm Barrel Jack 5.5x2.1mm Female DC Power Jack 2.1 X 5.5mm DC Jack Connector 6V 9V 12V DC Jack Panel Mount	1
12V 5A Power Supply, Waysse Power Supply Adapter, AC DC Converter 100-220V to 12 Volt 5 Amp Transformer 5.5x2.1mm Plug	1
S8050D S8050 NPN Transistor TO-92 20V 700MA 1W	1
1N4001 Diode, standard, 1A, 50V, DO-41	1
(optional) 20pin x 10pcs Female Headers Pins Straight Single Row Gold Plated Pitch 2.54mm 0.1 inch for PCB Connector Machine Breadboard Electronic Circuit Board	10
SONGLE SRS-05VDC-SL 05VDC-SL 4100 Blue 5V 6PIN Power Relay Original	1
L293D 16-pin IC Stepper Motor Drivers Controller	17
0.1uF Ceramic Disc Capacitor - 50 Volts	5
1uF Electrolytic Capacitor 1UF-50V-5X11	5
SS8550 TO-92 PNP Transistor	1
2N2222 TO-92 - NPN Transistor	1
10K ohm Resistor 1/2w (0.5Watt) ±1% Tolerance Metal Film Fixed Resistor	2
Vertical Slide Switch Micro High Knob 3 Pin 2 Position 1P2T SPDT Panel Mount AC 125V 2A	1
Raspberry pi 2040 pico	4
Raspberry pi 2040 pico-W	1
Superglue (small tube)	1

Test and solder components onto the PCBs

Face assembly

Print the display faces following the table of FDM settings below and press together.

Table 1. Display Face FDM settings

File Name	face-digit0-1.stl	face-digits2-3.stl
Description	Right side of display face (when viewed from front)	Left side of display face (when viewed from front)
Material	PLA	PLA
Color	White	White
Size	1.75mm	1.75mm
Temp (C)	190-210	190-210
Quantity	1	1
Per unit (g)	340	315
Plate	Smooth	Smooth
Layer Height	0.2 mm	0.2 mm
Infill	50%	50%
Infill Pattern	Grid	Grid
Enable Support	Yes	Yes
Ironing	Top Surfaces	Top Surfaces

Below are few guidelines to keep in mind when printing and assembling the display face:

- The display face uses over 2/3rds of the 1 KG roll of filament. Therefore, be sure to use the same roll of filament when printing both halves of the display face. Also, have two 1 KG rolls of white filament from the same batch to avoid inconsistencies in your print color.
- The infill should be 50% or greater to avoid light leaching from the segment LEDs or from the backside of the display face. I suggest you use a grid infill pattern only for speed and efficiency. The type of infill pattern is at your discretion.
- Don't use any glue as it isn't necessary and may make a mess.
- Don't worry if your 3D printer and slicer can't iron the top surfaces. Ironing the top surfaces is for fit and finish and won't affect the functionality of the display.
- Make sure you apply an adhesive to the printer plate bed otherwise the edges and corners of the display face may warp. I used all weather Aqua Net, super hold hair spray for my display faces which provided an even coating of adhesive across the entire surface of the bed plate and resulted in nearly perfect corners and edges.

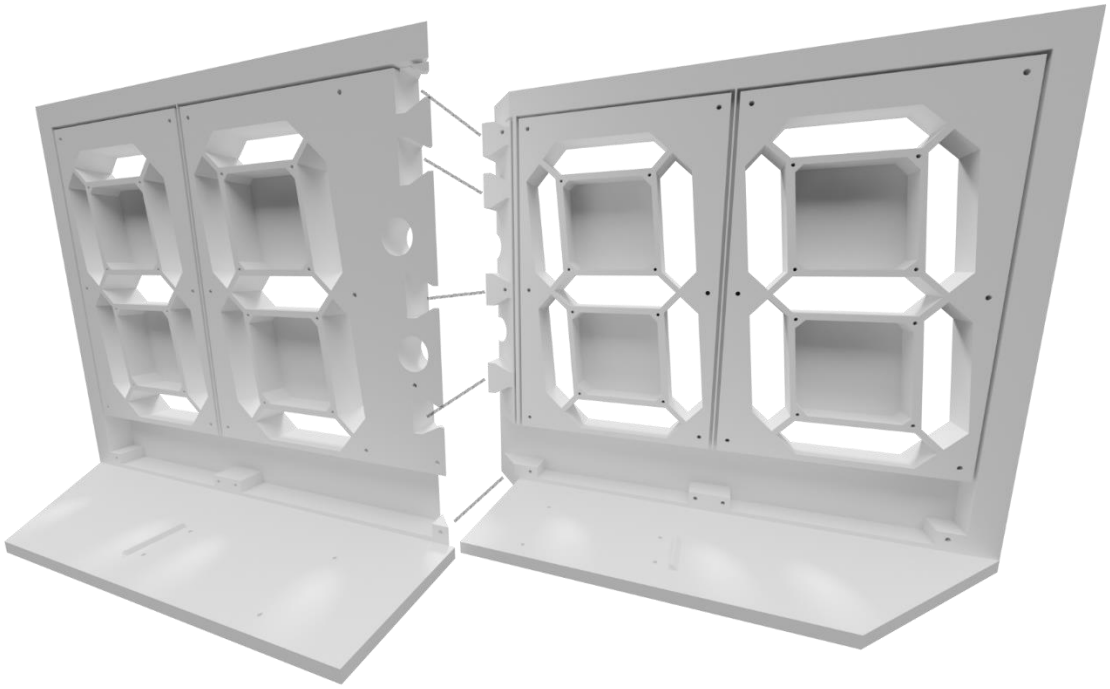


Figure 1. Back view of the display face

- From the back view of the display face, the left face piece (from left to right) are digits 0, 1 followed by the colons. The right face piece (from left to right) are digits 2 and 3. When viewing the assembled display face from the back, digit 0 is the left-most digit whereas digit 3 is the right-most digit. Consider adding a label above each digit.
- To prevent unwanted warping of the face, allow the display face to thoroughly cool (about 30 minutes after completion) before removing it from the printer.

Gasket and Digit PCBs Assembly

Print the gaskets and assemble with the PCBs using M1.7x8mm self-tapping screws. Each digit PCB will have two, 28 AWG stranded wires that need to be long enough to reach its corresponding buck converter.

Table 2. Digit gaskets FDM settings

File Name	digit-colon-gasket.stl	digit-gasket.stl
Description	Colon/Digit PCB gasket	Digit PCB gasket
Material	TPU	TPU
Color	Black	Black
Size	1.75mm	1.75mm
Temp (C)	190-210	190-210
Quantity	1	3
Per unit (g)	39	20
Total (g)	39	60
Brand	Colorful (Flexible)	Colorful (Flexible)
Plate	Smooth	Smooth
Layer Height	0.2 mm	0.2 mm
Infill	50%	50%
Infill Pattern	Grid	Grid
Enable Support	No	No
Ironing	None	None

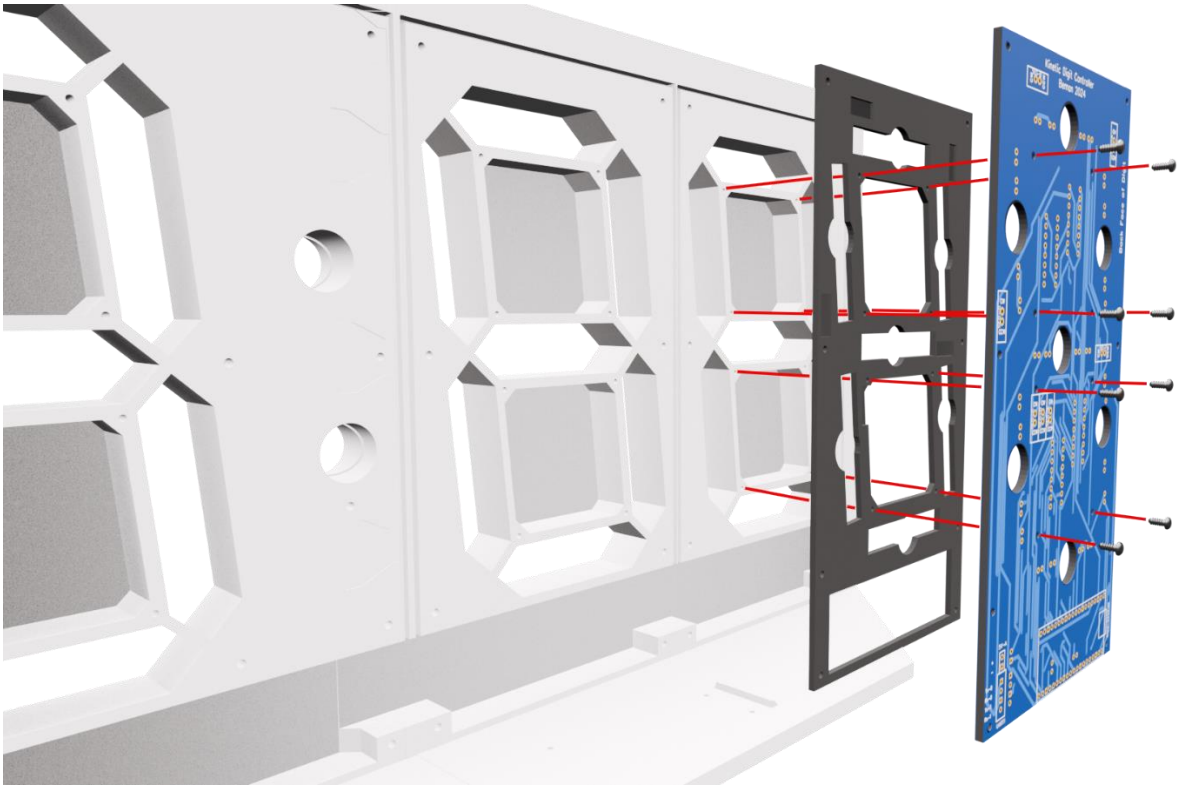


Figure 2. Add digit 0, 2, and 3 gaskets and the digit PCBs to the back of display the face*

*Note this diagram doesn't display the PCB completed with the components soldered onto the board. At this stage you should have completed the soldering and testing of all components onto the PCBs.

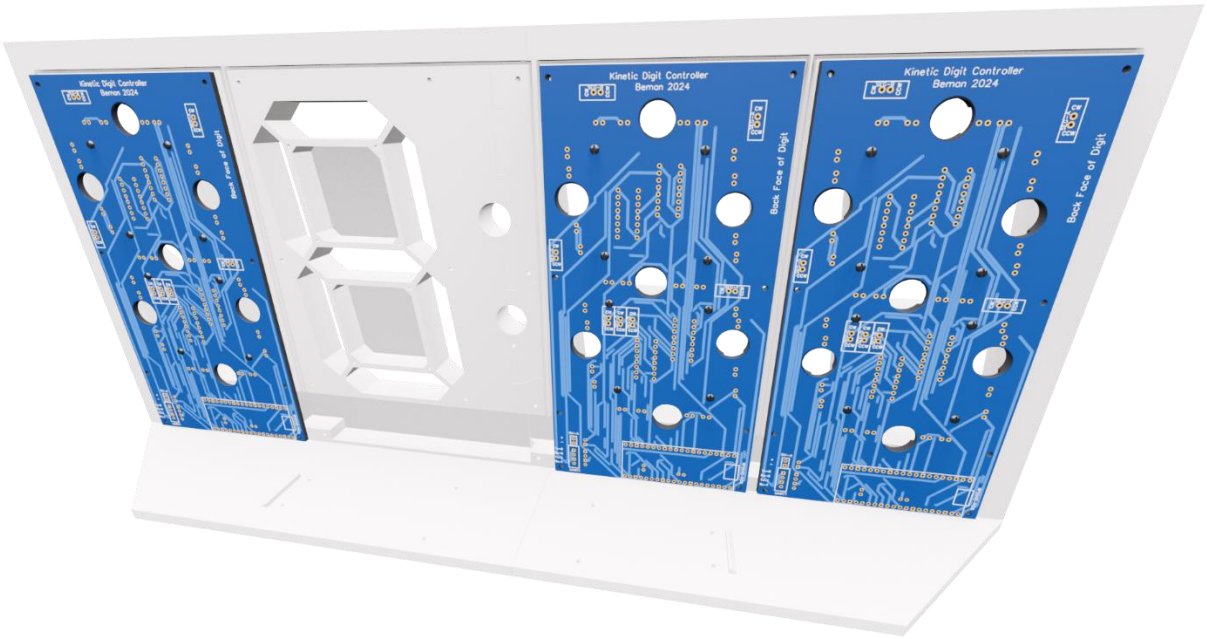


Figure 3. Back of the display showing assembled digits 0, 2, and 3 with gaskets

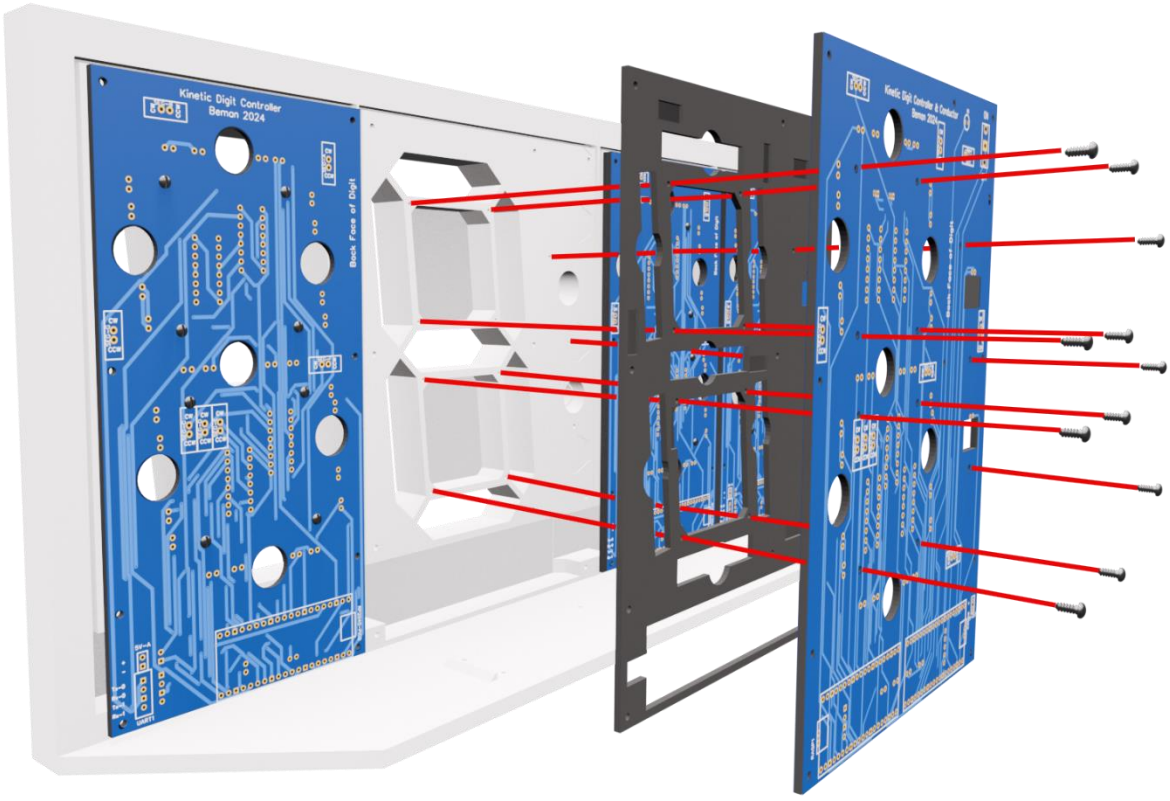
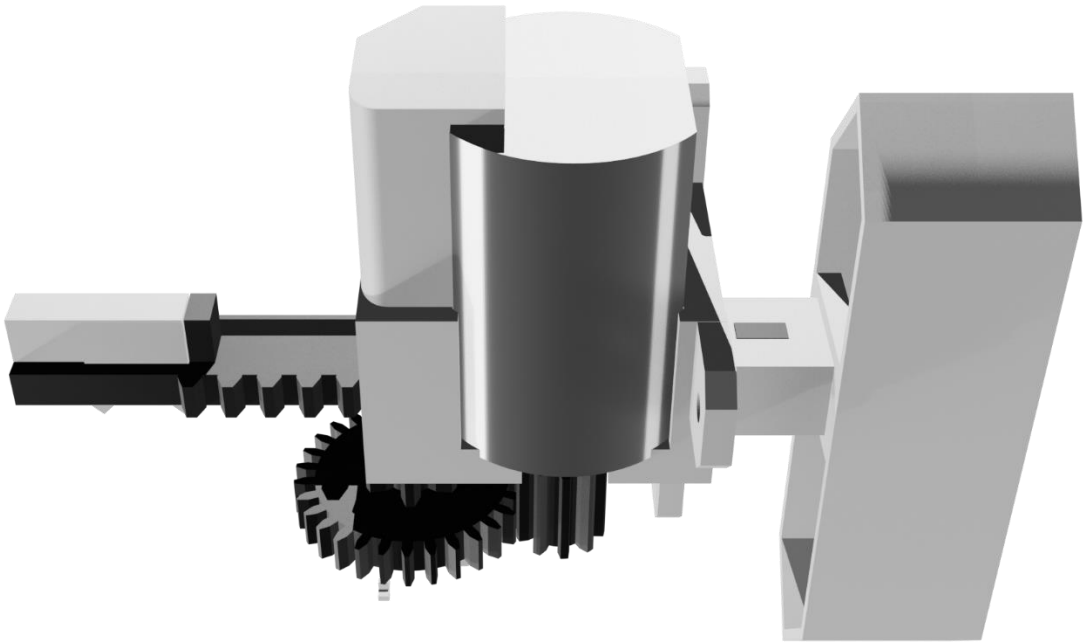
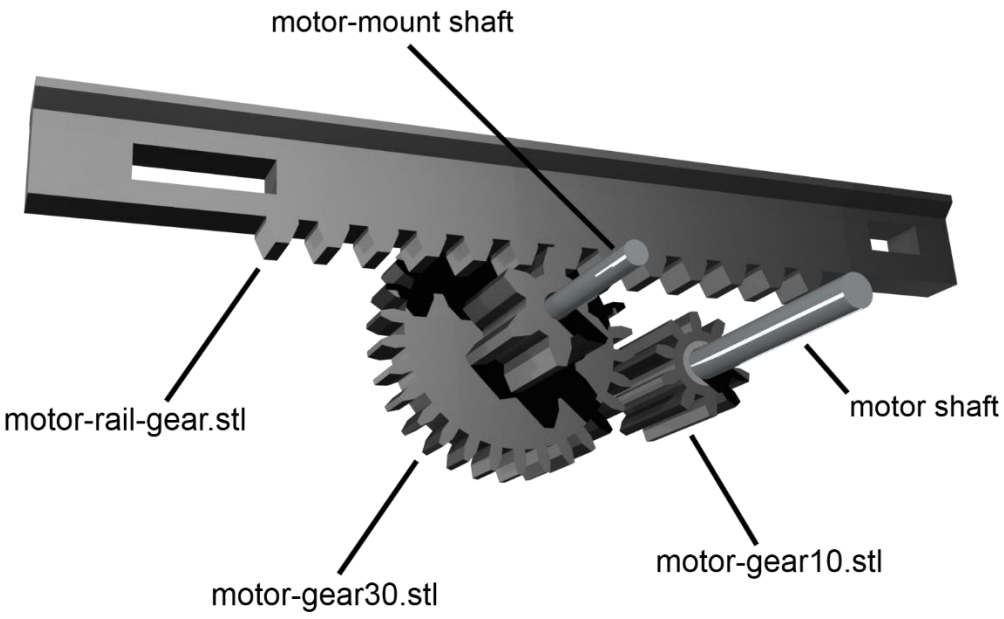


Figure 4. Back of the display showing the assembly of digit 1 and colons with gasket

Actuator assembly

There are 30 actuators in the display, 7 per digit and 2 for the colons (4 digits x 7 segments + 2 colons = 30 total actuators). The diagrams below identify the various parts of each actuator. Take careful note that various parts of the actuator require differing types of filament.





Assembling the motor mount

Print 30 motor mounts and 30-toothed gears using the settings in the table below. Be sure to thoroughly dry the Nylon (PA) for 48 to 72 hours at 45° C before printing, otherwise your print will have fine webs of filament showing the print head travel occurred.

File Name	motor-gear30.stl	motor-mount.stl
Description	3:1 reduction gear	Micro 130 DC 3V -12V motor mount
Material	Nylon (PA)	PLA
Color	Black	White
Size	1.75mm	1.75mm
Temp (C)	245-260	190-210
Quantity	30	30
Per unit (g)	1.4	9.7
Total (g)	42	291
Brand	Overture (Easy Nylon)	Comgrow
Plate	Smooth or glass	Smooth or glass
Layer Height	0.2 mm	0.2 mm
Infill	100%	50%
Infill Pattern	Rectilinear	Grid
Enable Support	No	No
Ironing	None	Top Surfaces

Cut 30, 20mm shafts from the straight sections of large paper clips.

Following the diagram below, discard the motor mount section in red. Insert the 30-tooth gear with the large, flat edge facing the outer collar on the motor mount. Slide the shaft into the outer collar, through the 30-tooth gear, and into the collar on the inside of the motor mount. Using a soldering iron set to 250ºC, melt the outer collar over the end of the shaft to prevent it from working out of the motor mount. The 30-tooth gear should move freely back and forth by pushing it with your finger but should not move side to side nor freely spin.

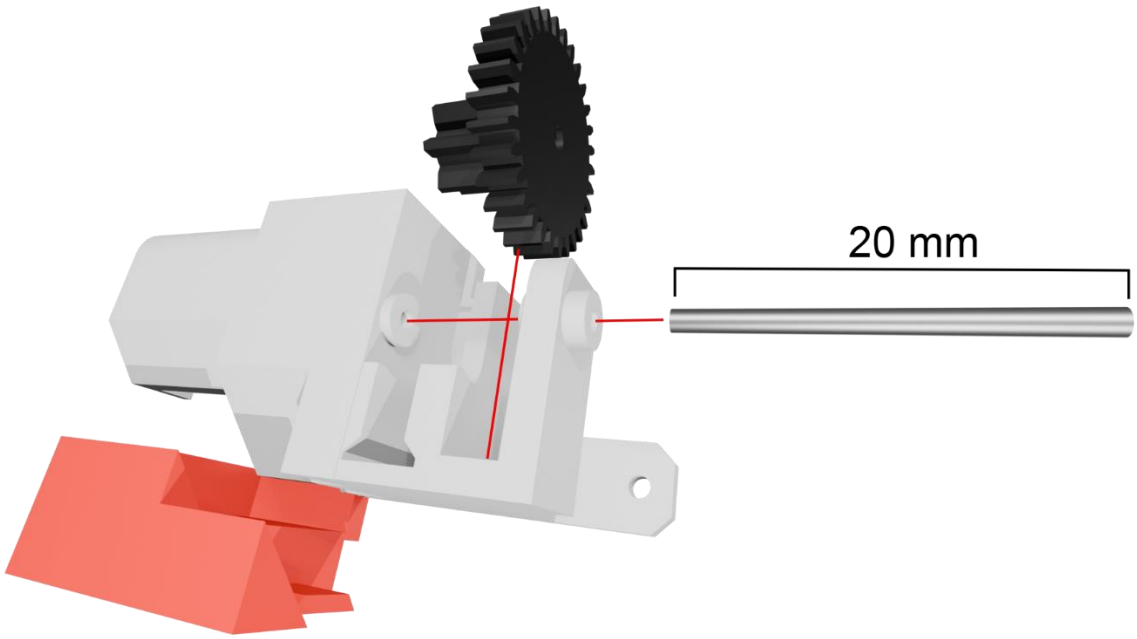
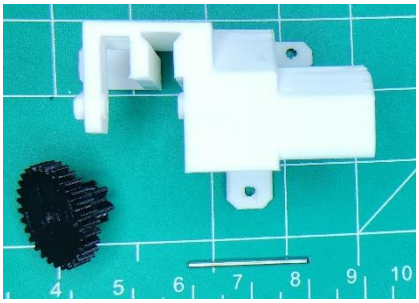


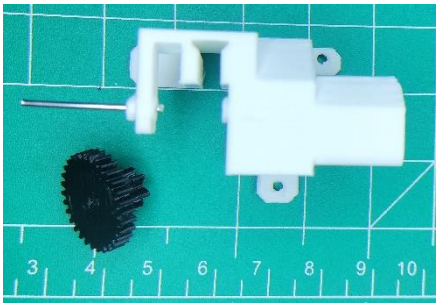
Figure 5. Motor mount assembly with 20mm shaft, the red support section is discarded

Motor mount step-by-step assembly

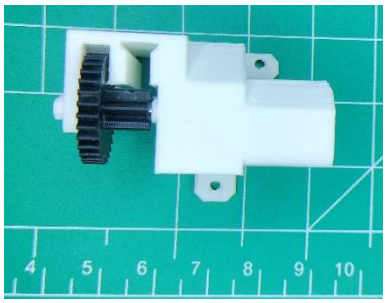
1. Print the motor mount, 30 tooth gear, and cut a 20mm length of shaft from a large paper clip.



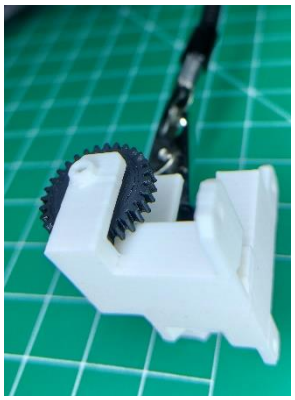
2. Feed the shaft into the outer collar of the motor mount. Have about 1mm protruding through the outer collar.



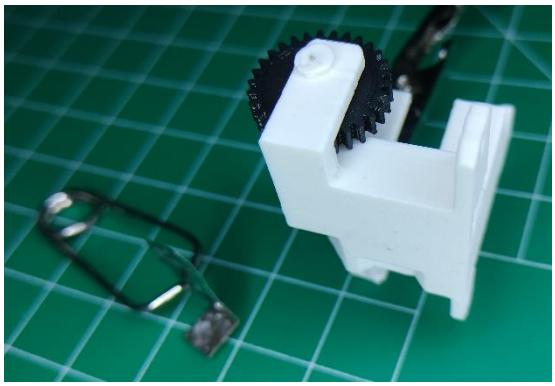
3. Align the 30-tooth gear with the large gear facing out and the small gear on the inside. Slide the shaft all the way in so that it countersinks into the outer collar.

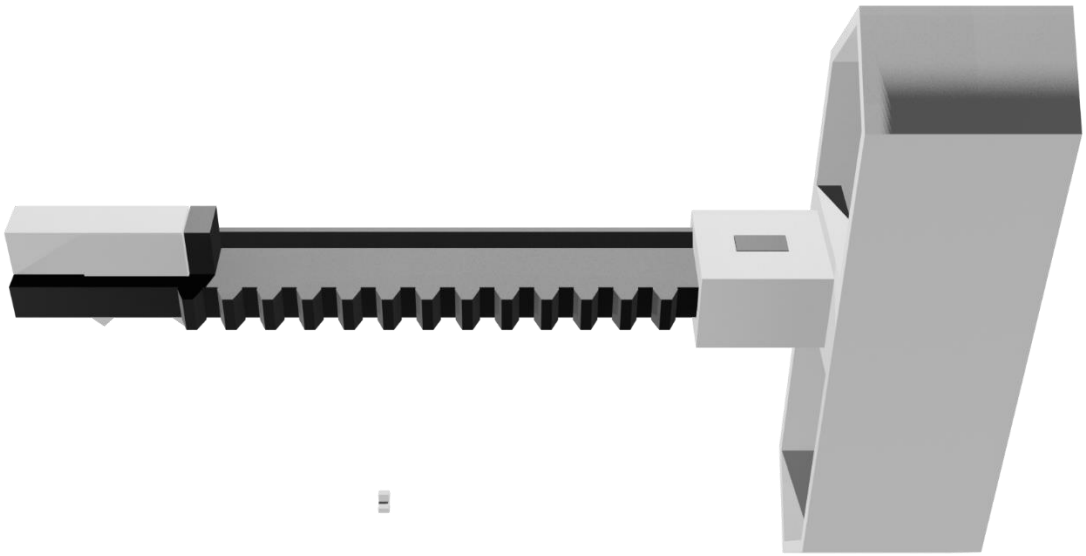


4. Heat up your soldering iron to 250°C and melt the outer collar over the end of the shaft to prevent it from working out of the motor mount.



5. The half-melted collar forms a permanent hold for the motor mount shaft and 30-tooth gear. I melted the outer collar using a small zinc strip held by clamping tweezers. Once complete, the 30-tooth gear should move freely back and forth by pushing it with your finger but should not move side to side nor freely spin.





Prepare the Motors

Schematics for Digits 0, 2 & 3

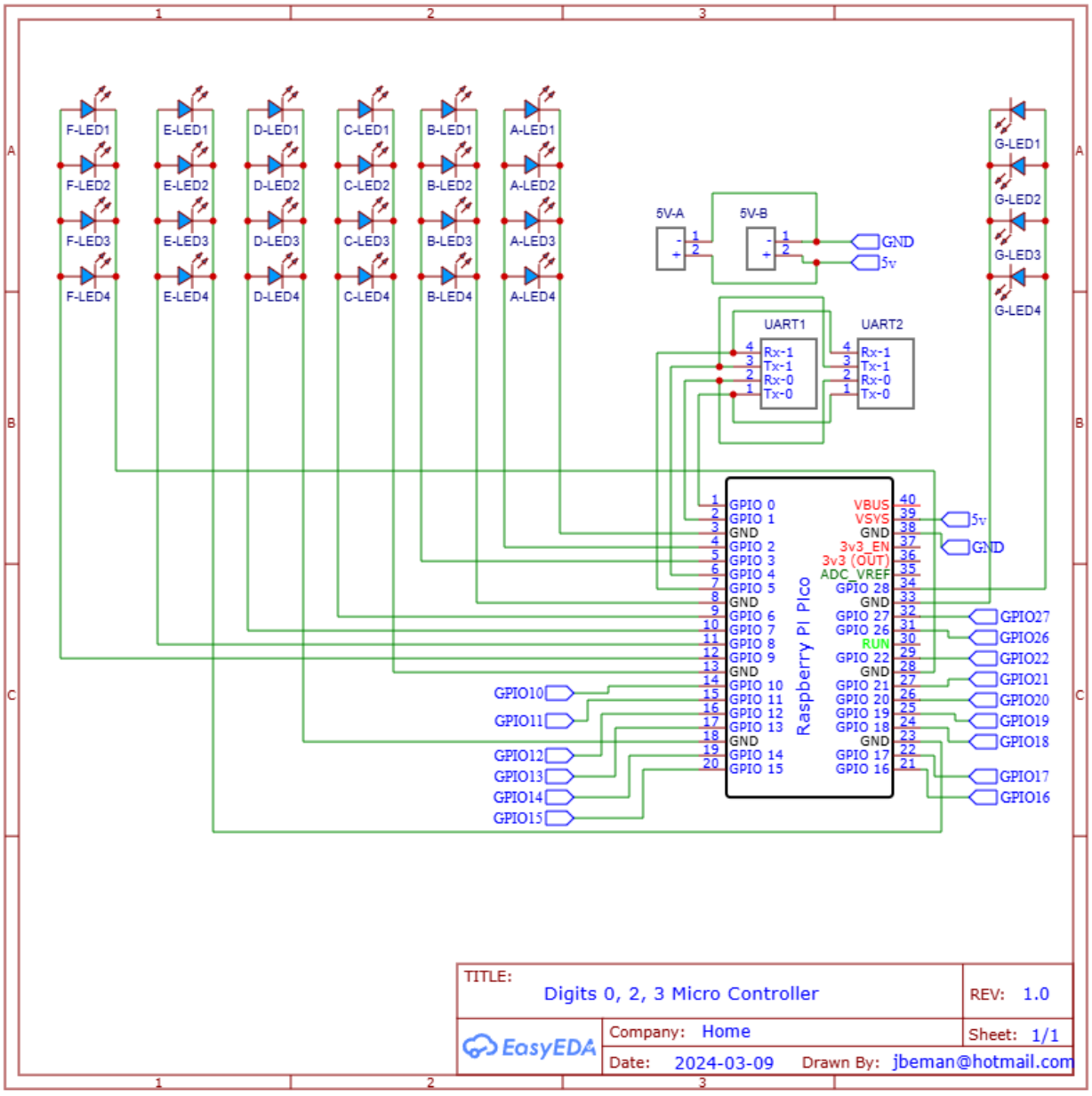
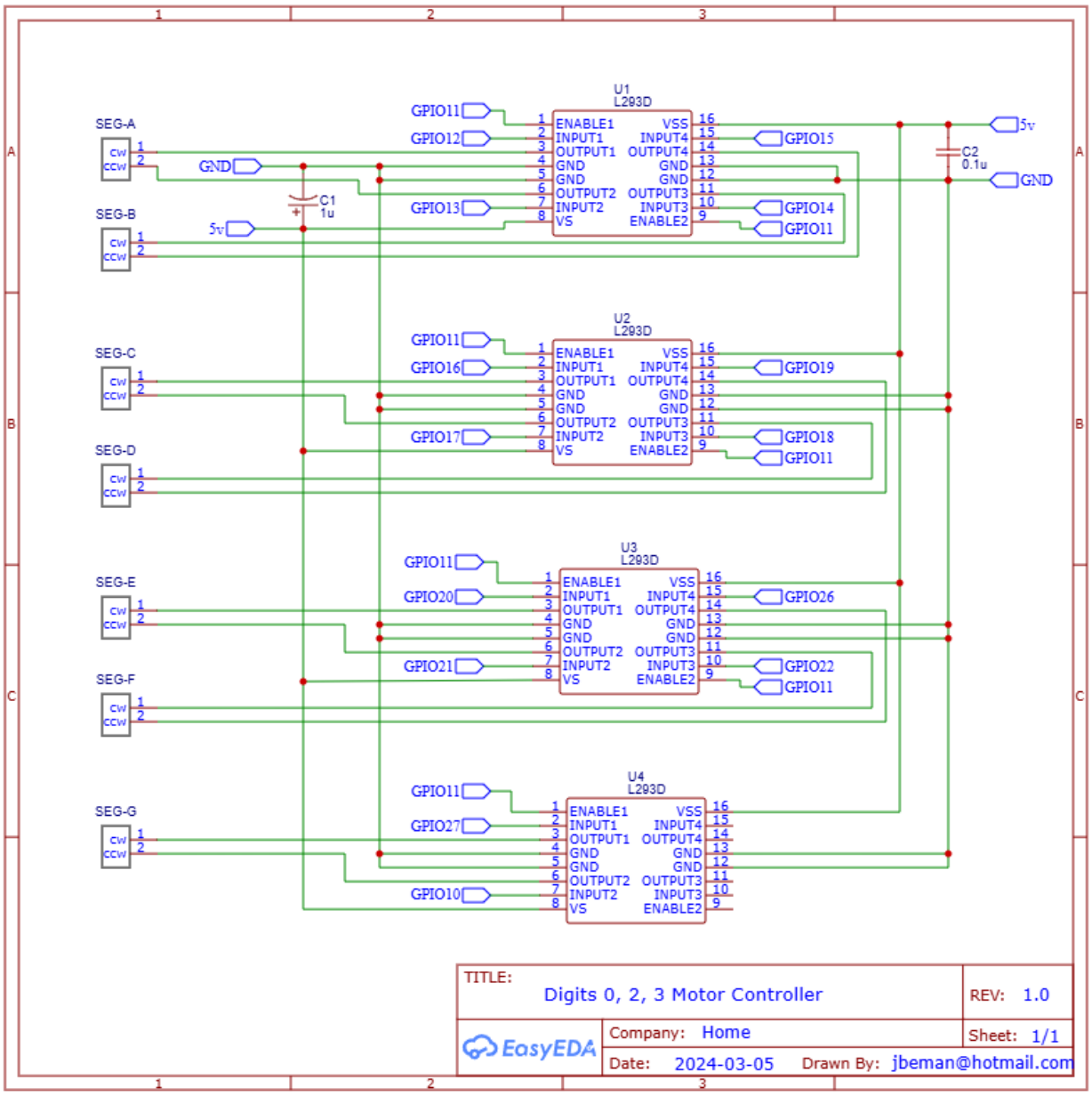


Figure 6. Schematic for Digits 0, 2, 3 Microcontrollers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U2
L293D
U3
L293D
U4
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OUTPUT1
GND
GND
OUTPUT2
INPUT2
VS
VSS
INPUT4
OUTPUT4
GND
GND
OUTPUT3
INPUT3
ENABLE2
GPIO11
GPIO12
GPIO13
GPIO15
GPIO14
GPIO11
GPIO16
GPIO17
GPIO19
GPIO18
GPIO11
GPIO20
GPIO21
GPIO26
GPIO22
GPIO11
GPIO27
GPIO10
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SEG-B
SEG-C
SEG-D
SEG-E
SEG-F
SEG-G
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C2
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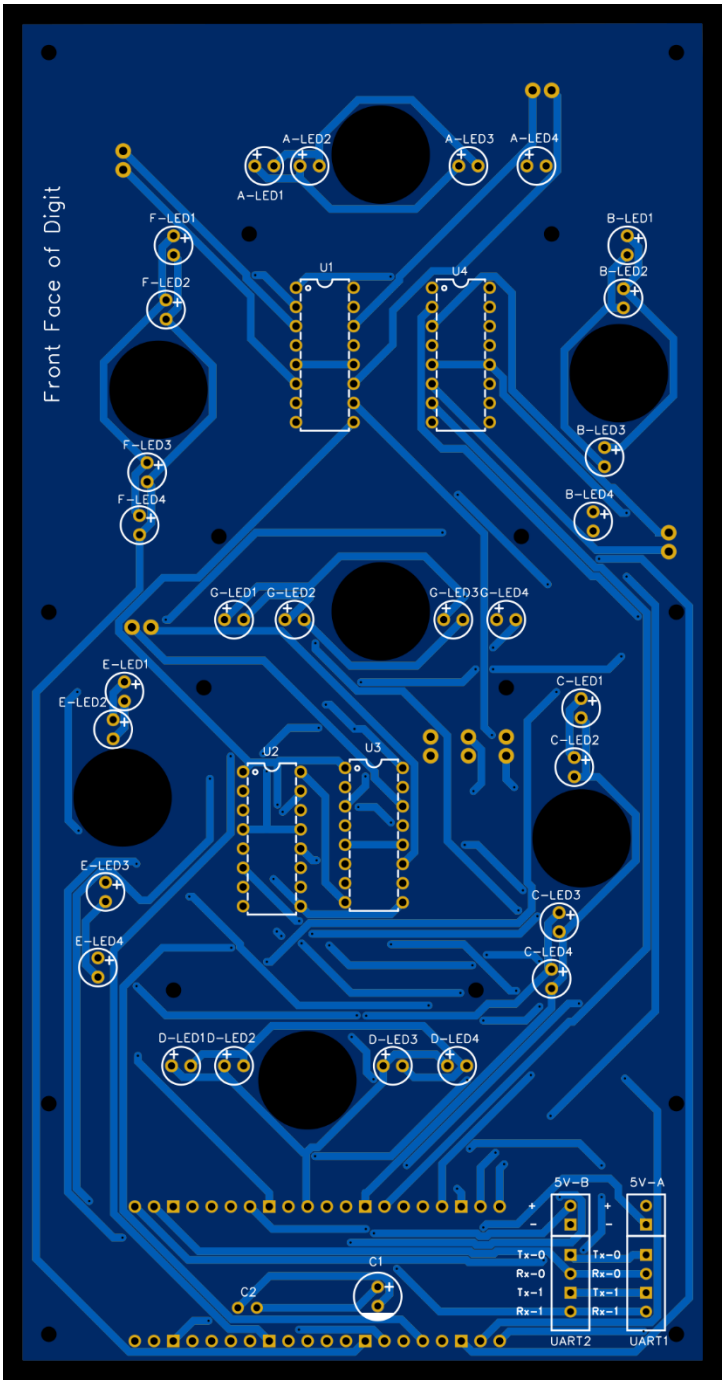
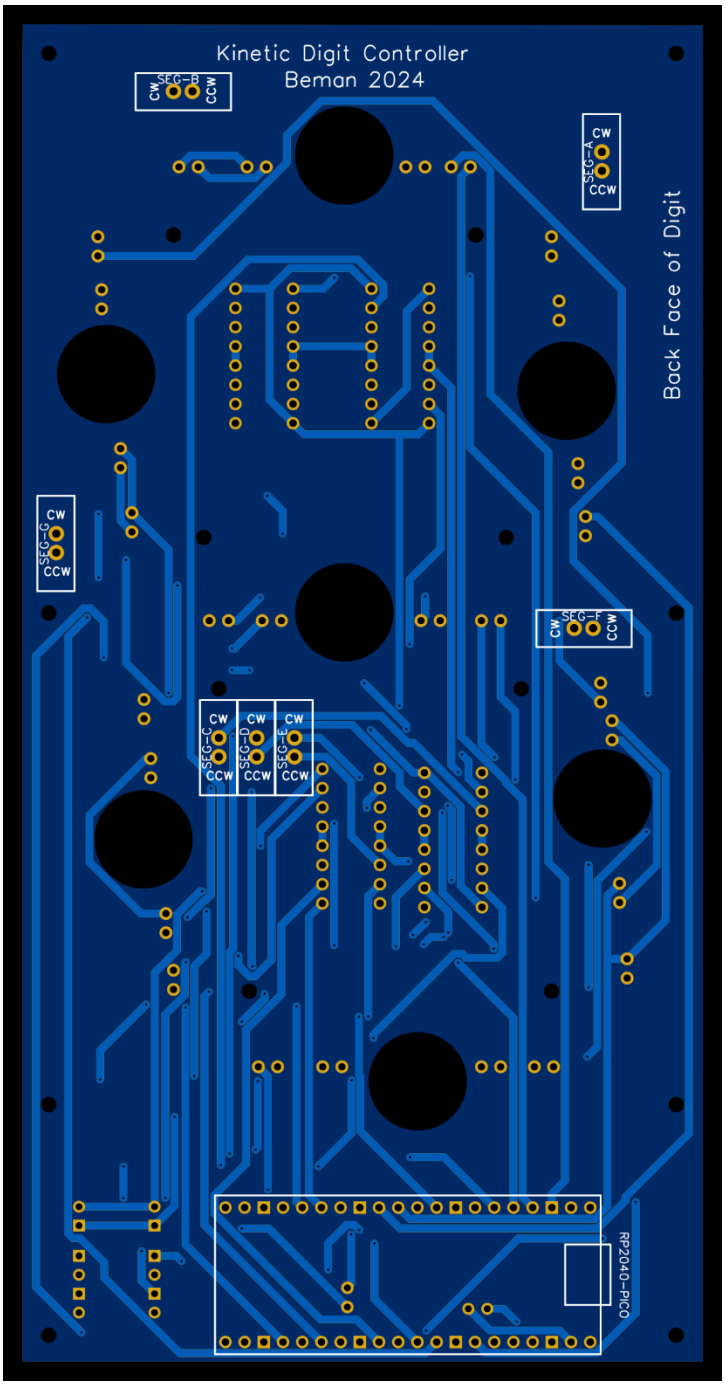
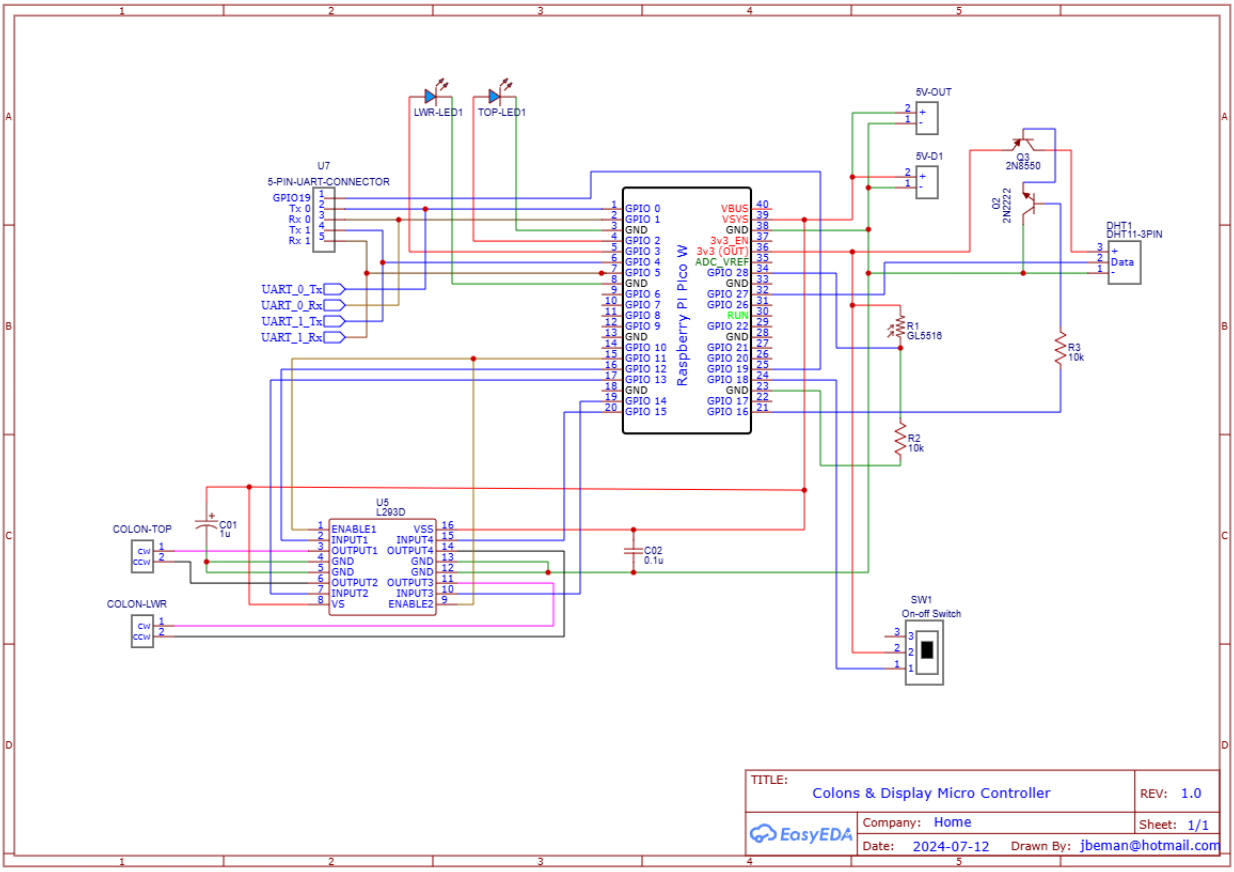
Sheet: 1/1
Date: 2024-03-05
Drawn By: jbeman@hotmail.com

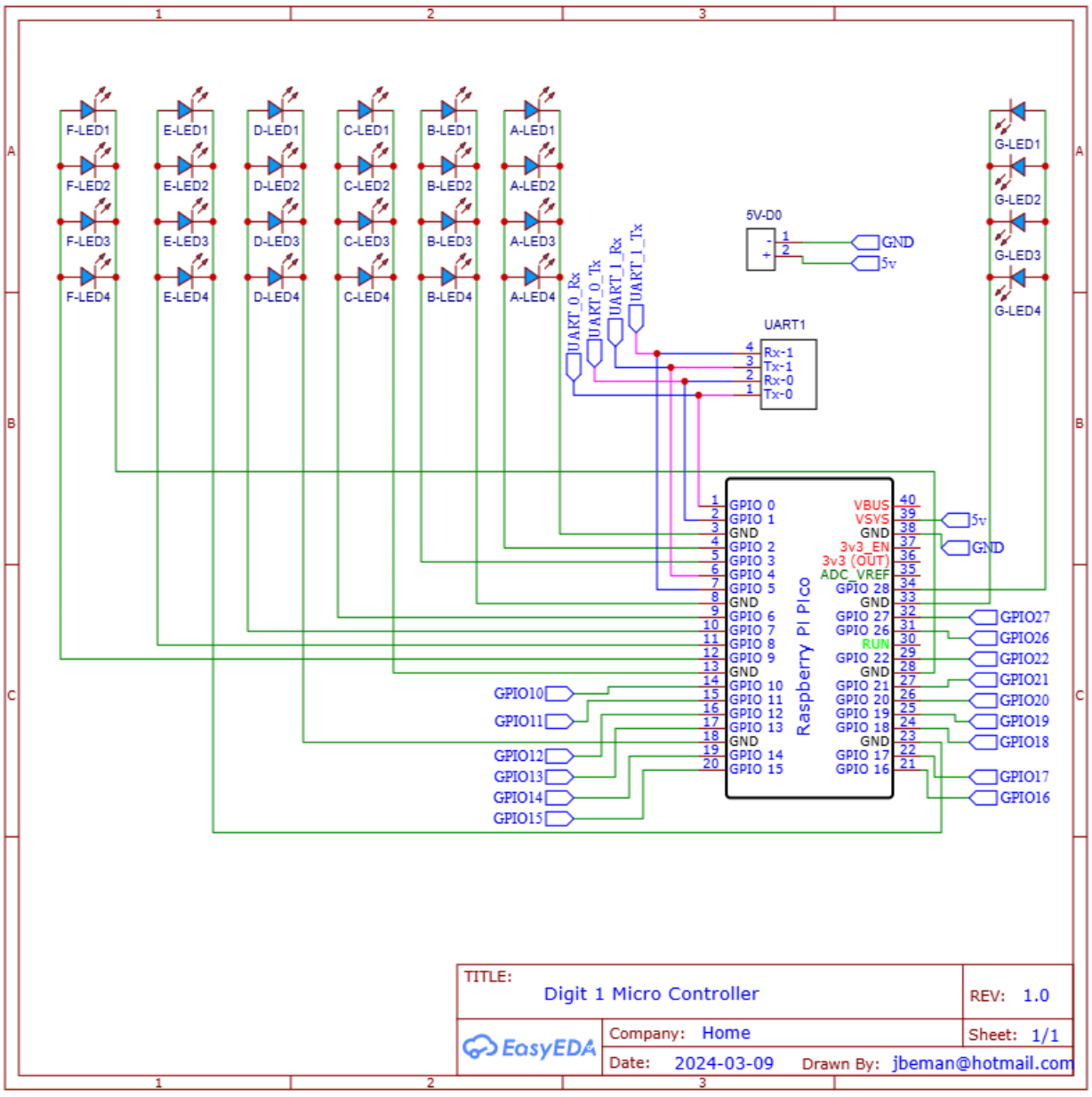
PCB for Digits 0, 2, 3




Kinetic Digit Controller
Beman 2024
Back Face of Digit
CW
SEG-B
CCW
CW
SEG-A
CCW
CW
SEG-G
CCW
CW
SEG-F
CCW
CW
SEG-C
CCW
CW
SEG-D
CCW
CW
SEG-E
CCW
RP2040-PICO

Schematics for Digit 1 and Colons

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F-LED4
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E-LED3
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C-LED2
C-LED3
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A-LED2
A-LED3
A-LED4
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G-LED2
G-LED3
G-LED4
5V-D0
GND
5v
UART_0_Rx
UART_0_Tx
UART_1_Rx
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UART1
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Tx-1
Rx-0
Tx-0
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GPIO 1
GND
GPIO 2
GPIO 3
GPIO 4
GPIO 5
GND
GPIO 6
GPIO 7
GPIO 8
GPIO 9
GND
GPIO 10
GPIO 11
GPIO 12
GPIO 13
GND
GPIO 14
GPIO 15
Raspberry PI Pico
VBUS
VSYS
GND
3v3_EN
3v3 (OUT)
ADC_VREF
GPIO 28
GND
GPIO 27
GPIO 26
RUN
GPIO 22
GND
GPIO 21
GPIO 20
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GPIO 17
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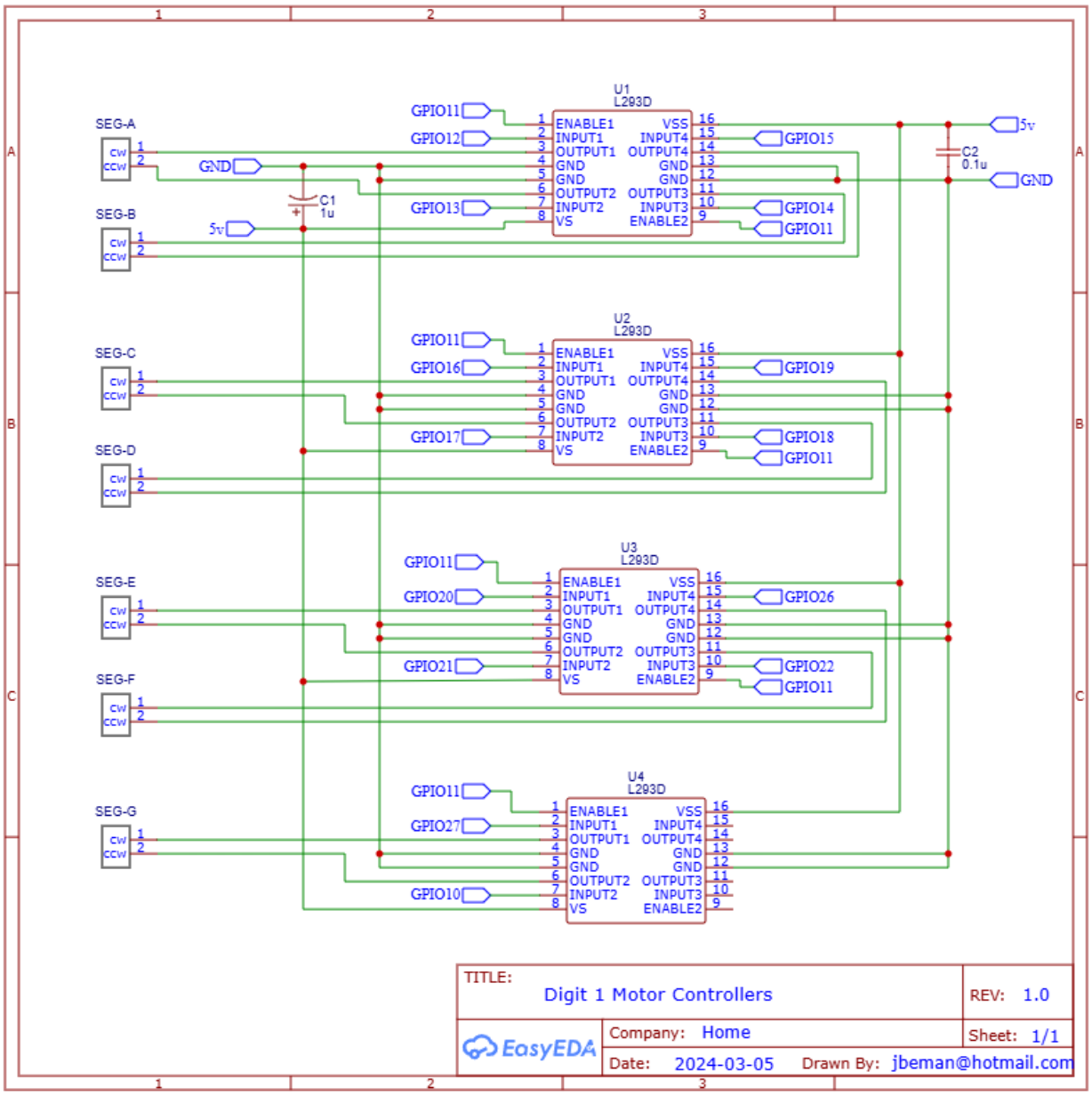
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L293D
U2
L293D
U3
L293D
U4
L293D
ENABLE1
INPUT1
OUTPUT1
GND
GND
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INPUT2
VS
VSS
INPUT4
OUTPUT4
GND
GND
OUTPUT3
INPUT3
ENABLE2
GPIO11
GPIO12
GPIO13
GPIO15
GPIO14
GPIO11
GPIO16
GPIO17
GPIO19
GPIO18
GPIO11
GPIO20
GPIO21
GPIO26
GPIO22
GPIO11
GPIO27
GPIO10
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SEG-B
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SEG-D
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SEG-F
SEG-G
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GND
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1u
C2
0.1u
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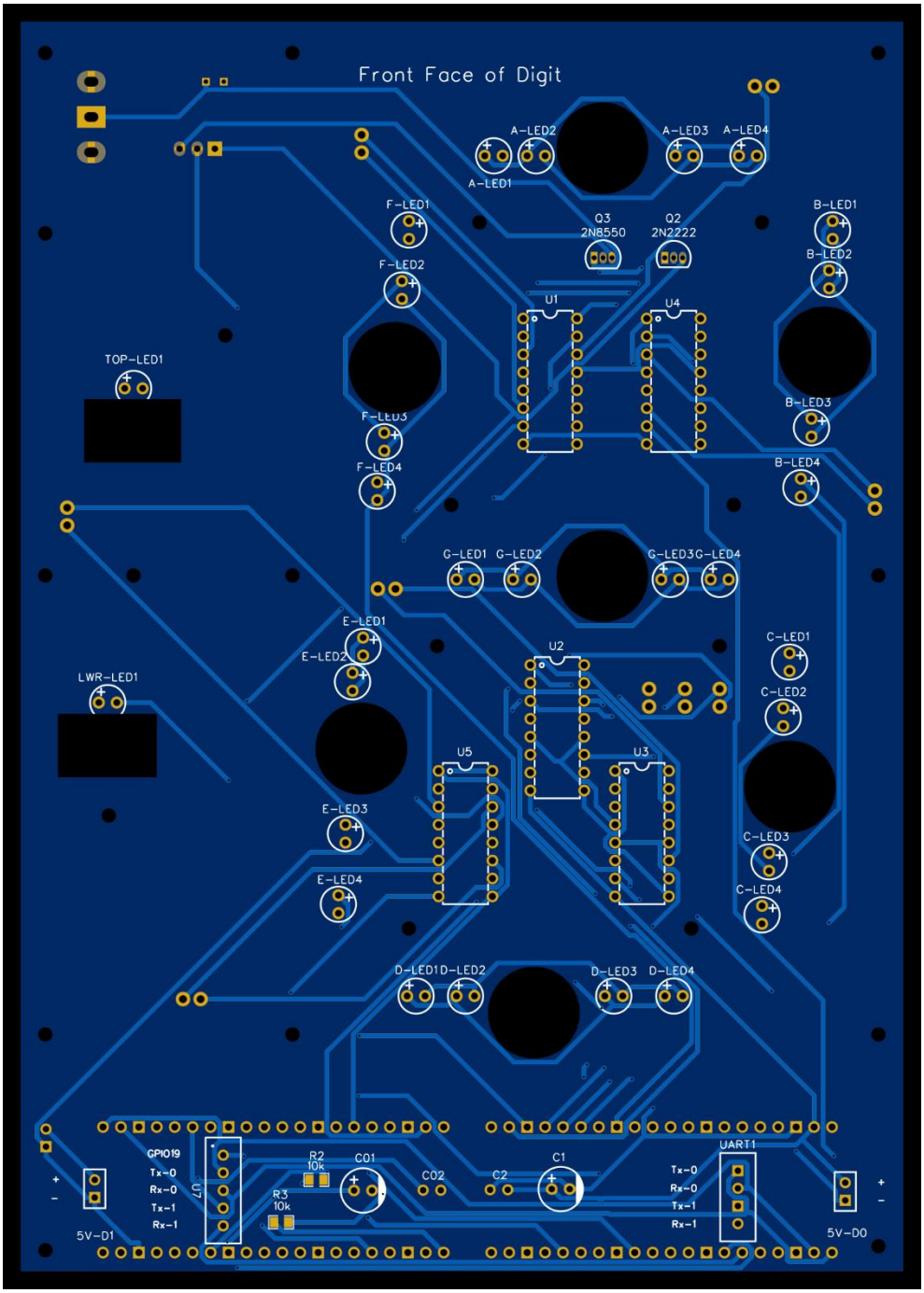
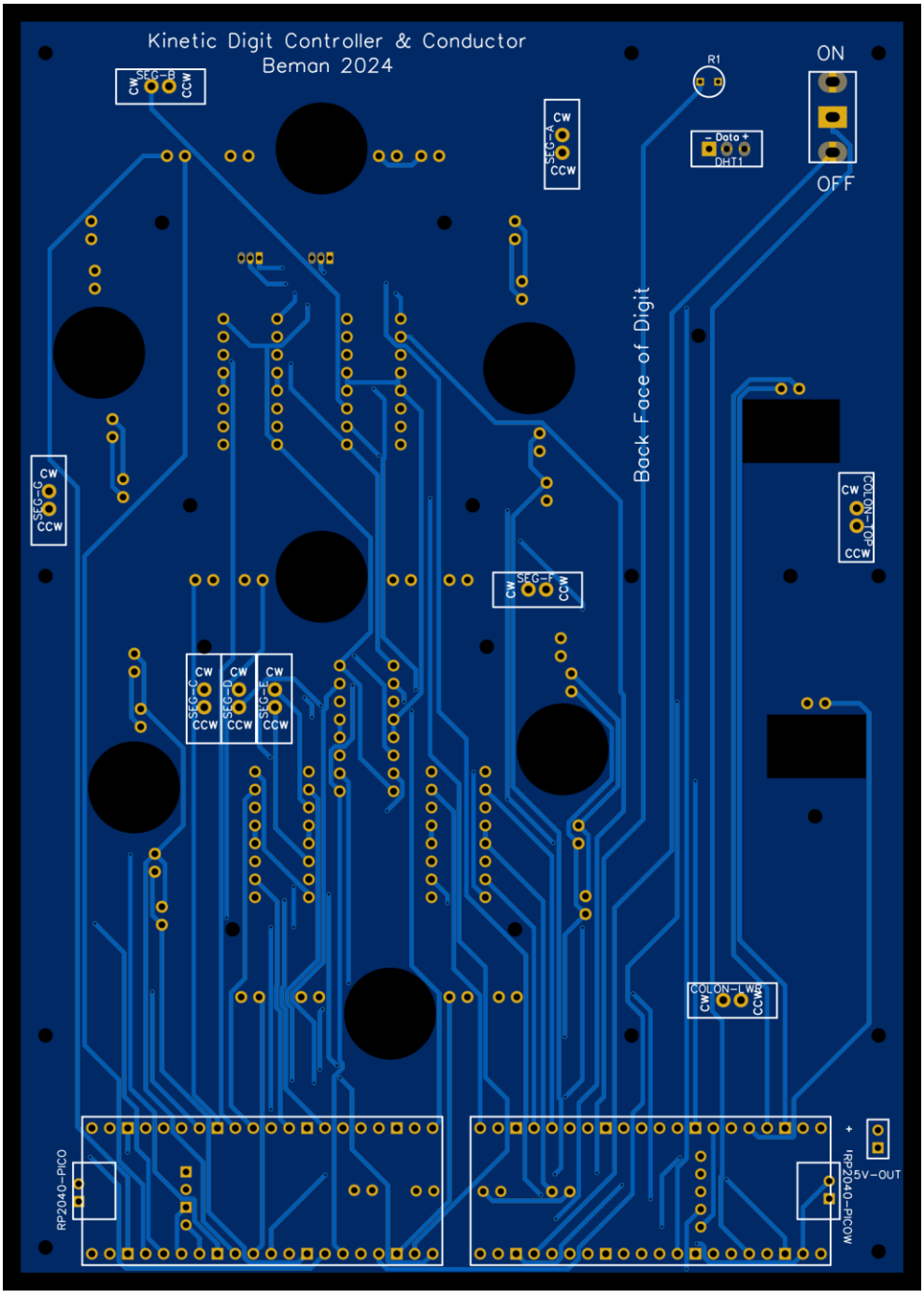
Date: 2024-03-05
Drawn By: jbeman@hotmail.com

PCB for Digit 1 & Colons




Kinetic Digit Controller & Conductor
Beman 2024
SEG-B
CW
CCW
SEG-A
CW
CCW
R1
ON
OFF
- Data +
DHT1
Back Face of Digit
SEG-G
CW
CCW
COLON_TOP
CW
CCW
SEG-F
CW
CCW
SEG-C
SEG-D
SEG-E
COLON_LWR
RP2040-PICO
RP2040-PICOW
+5V-OUT