

Digital Manufacturing

Food Printers

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How to Construct and Assemble a Food Printer

Table of Contents:

1. Bill of Materials	3
2. Interfacing with Duet	5
3. Attaching the Build Plate to the Base	8
4. Mount the Casing of Duet Wifi to the Printer	10
5. Mount the Panel Due Displays	12
6. Attach Holder and Motors together	15
7. Wiring	17
8. Configuration:	22
9. Citations/References	23

Link to Current File Folder:

<https://drive.google.com/drive/folders/1u5yPOI9jMXkpe5W2SME4JdBrJHtZCvVm?usp=sharing>

1. Bill of Materials

No.	Bill of Materials			
1	Part Name	Part #	Description	Quantity
2	Genmitsu 3018-PROVer CNC		Pre-assembled CNC machine used for basis of Printer	1
3	Duet Wifi Board		Electronic controller for 3D printers and other CNC machines	1
4	Wifi Board Mount		3D printed mount for Duet Wifi Board	1
5	Spacers/Standoffs		M3*12 plastic spacers	4
6	Spacers/Standoffs		M3*4 plastic spacers	4
7	Wifi Board Shield		Laser Cut (Transparent) Acrylic Plate	1
8	PanelDue 7i		Graphical control panel for printers	1
9	Teggs Flat Ribbon Connector		1m Flat Ribbon cable to connect Duet Wifi Board to PanelDue 7i F-F 10 slot	1
10	Panel Mount Top		3D Printed panel mount for PanelDue 7i	1
11	Panel Mount Bottom		3D Printed panel mount for PanelDue 7i	1
12	Syringe Holder		3D Printed Syringe Holder and Motor Mount	1
13	Nema-11 Stepper	11LS13-075	Linear stepper motor	2

	Motors	4N-150C		
14	Heat Sinks		25x25x10mm Heat Sink	4
15	Linear Screw	Tr 5.56x4.8768	Lead Screw connected to motors and plungers for extrusion stock:150mm custom:350mm	2
16	Plunger Top		3D Printed dove-tailed connector piece from thread to plunger	2
17	Plunger Bottom		3D Printed dove-tailed plunger	2
18	10cc Clear Barrel		Syringe Barrel	2
19	10cc Piston		Piston to attach to Plunger Bottom	2
20	Flat Base Plate		Laser Cut Acrylic Plate for CNC Bed	1
21	Flat Screw	91263A838	M6*16 for Acrylic Base Plate	4
22	Self Aligning T-Nut		M6 - Available in CNC Tool Box	4
23	Round Head Screws	95836A220	M3*14 for Board Mount	4
24	Round Head Screws	92000A118	M3*8 for Panel Mount	8
25	Socket Head Screws	91290A232	M5*16 for Mounting Panel Holder to CNC	4
26	Socket Head Screws	91290A101	M2.5*6 for Motor Mount	8
27	Washers	98689A111	M2.5	8
28	Limit Switch Extenders		1m Long extension cables (come with 6pc Genmitsu CNC Limit Switches on Amazon)	3

29	Profile Slot Covers		Plastic Covering for CNC rails	2-4
30	E-Stop Button/Casing		10A Emergency Stop Button	1
31	AC/DC Power Adapter		100-240V to 24V - Configured from Power Supply given with CNC	1
32	16 Gauge Wire		16 AWG Red/Black	1
33	Scotch Weld		Plastic and Rubber Adhesive	2
34	Misc. Cable Management		Various zip ties, wireholders, etc	2-6

2. Interfacing with Duet

Duet Wifi / Duet Ethernet Connections

v1.0 to v1.04

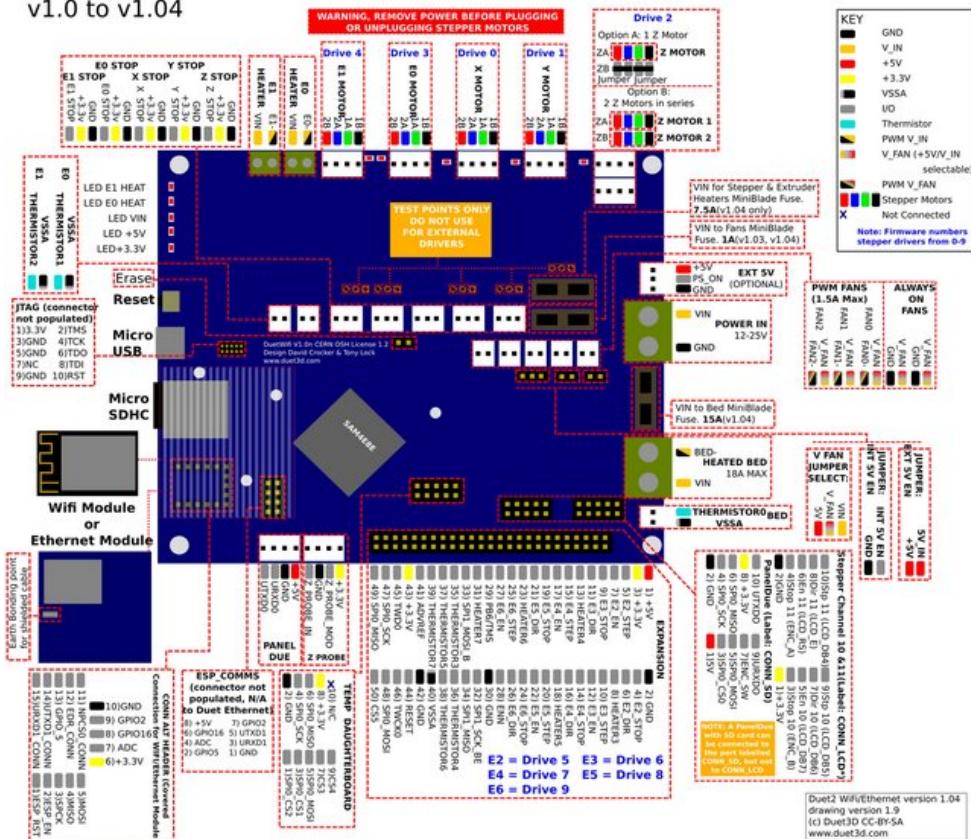


Fig 1. Duet Wiring Diagram

Useful Links:

Getting connected:

[https://duet3d.dozuki.com/Guide/1.\)+Getting+Connected+to+your+Duet/7](https://duet3d.dozuki.com/Guide/1.)

Getting started:

https://duet3d.dozuki.com/Wiki/Step_by_step_guide

Gcode dictionary:

<https://duet3d.dozuki.com/Wiki/Gcode>

Paneldue documentation:

<https://duet3d.dozuki.com/Wiki/PanelDue>

Configuring RepRap firmware:

<https://duet3d.dozuki.com/Wiki/ConfiguringRepRapFirmwareCartesianPrinter>

<https://configtool.reprapfirmware.org/Start>

(custom configuration)

Wiring:

https://duet3d.dozuki.com/Wiki/Duet_Wiring_Diagrams

[https://duet3d.dozuki.com/Guide/2.\)+Wiring+your+Duet+2+WiFi-Ethernet/](https://duet3d.dozuki.com/Guide/2.)

Getting Connected

[https://duet3d.dozuki.com/Guide/1.\)+Getting+Connected+to+your+Duet/7](https://duet3d.dozuki.com/Guide/1.)

Duet can be connected to via the following:

- Micro USB
- Wifi
- Ethernet (not supported on our version)

Connecting through USB:

Windows:

- Install the USB Drivers from here:
<https://github.com/Duet3D/RepRapFirmware/blob/dev/Driver/WindowsDriverFile.s.zip>
- Open Device Manager Look for any devices with a yellow triangle, or for any "Generic USB" devices which would indicate that the Duet driver is not installed.
- If a USB device does show the yellow triangle, or as a Generic USB device, right click on the device. Click Install Driver and browse to the location of the driver that was downloaded at the beginning of this step. Continue setup by clicking "Next" until the device driver has been installed.
(reference for above steps: [Link](#))
- Download and install the YAT or PUTTY (YAT Recommended)
- Select the correct COM as the serial port
- Set YAT to use <LF> as the end of line character. This will improve the readability of the messages coming from the Duet.
- Click "Text Settings" in the "Terminal Settings" and change "EOL sequence:" to <LF>. Click "OK" to close Text Settings. Click "OK" again to close Terminal Settings.
- Select the "Terminal" menu, then "Open/Start" to connect to your Duet. Or click the green tick in the toolbar. If you are connecting to a Duet 2 WiFi or Duet 3 Mini 5+ WiFi, you may see lots of "WiFi" including 5 GHz and connect to the desired.

(Reference: [https://duet3d.dozuki.com/Guide/1.\)+Getting+Connected+to+your+Duet/7](https://duet3d.dozuki.com/Guide/1.)+Getting+Connected+to+your+Duet/7))

Mac:

- No USB drivers to install
- Install SerialTools from the app store
- Set Baud Rate to 115200. Set local echo.
- Under "Serial Port," select duet (something like usbmodem1411)
- Connect

Useful commands:

M115: check firmware version

M552 S-1: stop wifi

M552: check wifi module status

M552 S0: set wifi module to idle
M552 S1: set wifi module to on
M587: list remembered networks
M587 S"Network ID" P"Network Password": add network

*Make sure duet is idle before adding a network

*Double quotation marks must be sent as straight

To get straight double quotes on mac:

- System preferences > Keyboard > Text. Change double quote setting to straight

When connected to a network, sending M552 will return the IP address of the Duet. Typing this into a browser will pull up the web dashboard to control the Duet. You can also find the IP address via the console on the Paneldue. The IP address is dynamically assigned by the network via DHCP, so it may need to be retrieved again on subsequent uses.

3. Attaching the Build Plate to the Base

(a) Bill of Materials to attach build plate to the base:

Sl. No.	Part Name	Description	Qty
1.	Flat Screw	M6*16 - Flat head screws	4
2.	Flat Base Plate (1/4 inch)	Acrylic Plate - Laser Cut (White)	1
3.	Self Aligning T Nut	M6 - Available in CNC Tool Box	4

**All these quantities above mentioned are required to build one printer.*

(b) CAD Files of the Build Plate:

The CAD file of the build plate can be found at:

<https://drive.google.com/file/d/1Zp3ZYUXGiai7xT61lAGZ4jAmze8Gh87j/view?usp=sharing>

(c) Procedure to attach the build plate

- The CAD file is to be saved in the .dxf file, as most of the laser cutters support Auto CAD
- Scaling of the CAD is to be done according to the laser cutter requirements
- Laser Cut the Build plate as per the CAD file. The recommended material to laser cut is acrylic sheet of $\frac{1}{4}$ inch thickness
- The laser cut build plate is to be cleaned and sanitized before placing on to the printer
- Countersunk the holes to accommodate the flat screws
- Clean the countersunk holes to avoid accumulation of acrylic material
- Place the self aligning nuts inside the T-slots of the printer base. These nuts are provided in the tool box of the CNC machine
- Align the holes of the build plate to that of the t-nut's
- All the nuts before screwing in are to be aligned to make sure proper mounting

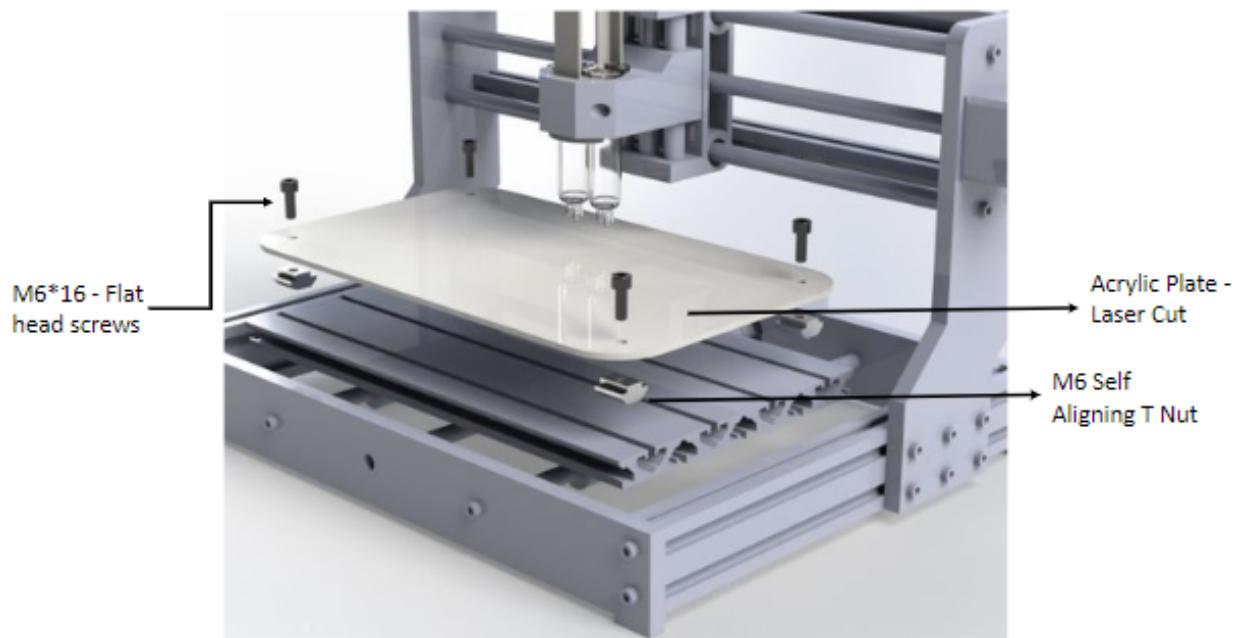


Figure 2: Sequence of Fixing the build plate to the printer

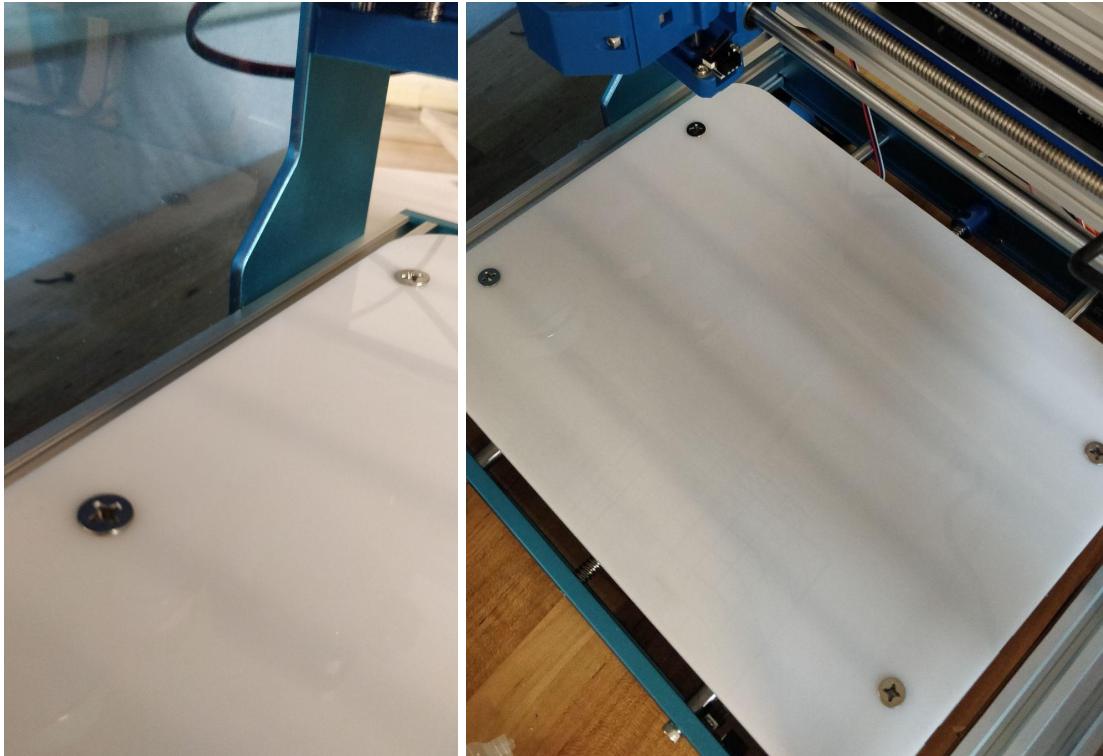


Figure 3: Final Mounted Flat Head Screws to Build Plate

4. Mount the Casing of Duet Wifi to the Printer

(a) Bill of Materials to Mount the Casing of Duet Wifi to Printer

Sl. No.	Part Name	Description	Qty
1.	Round Head Screw	M3*8	4
2.	Duet Wifi Mount Cover	Acrylic Plate - Laser Cut (Transparent)	1
3.	Duet Wifi		1
4.	Duet Wifi Mount	3D Printed Mount	1
5.	Spacers/Standoffs	M3*4 plastic spacers	4
6.	Spacers/Standoffs	M3*8 plastic spacers	4
7.	Round Head Screws	M3*14	4

*All these quantities above mentioned are required to build one printer.

(b) CAD Files:

- CAD file of Duet Wifi Mount can be found at
https://drive.google.com/file/d/1Toj1mO74-CeWhhOKK4VhNy3N_GATRnHz/view?usp=sharing
- CAD file of Duet Wifi Mount Cover can be found at
https://drive.google.com/file/d/1Toj1mO74-CeWhhOKK4VhNy3N_GATRnHz/view?usp=sharing

(c) Procedure:

- The CAD file of Duet Wifi mount is to be printed with an infill of 40%
- This printed mount is to be mounted to the printer using the self aligning 3mm t-slot nut provided in the tool box of CNC machine
- Before mounting the board the 4mm long spacers are to be mounted
- The Duet Wifi board is to be mounted with the help of spacers. Using M3 screws these need to be fixed to the mount
- The dxf file of Mount cover is to be used to laser cut the cover mount. The cover mount after laser cut must be finished to obtain smooth finish in case if there are sharp edges.
- Using the M3 screws the mount should be affixed in order to protect the Duet Wifi board from any sort of damage.

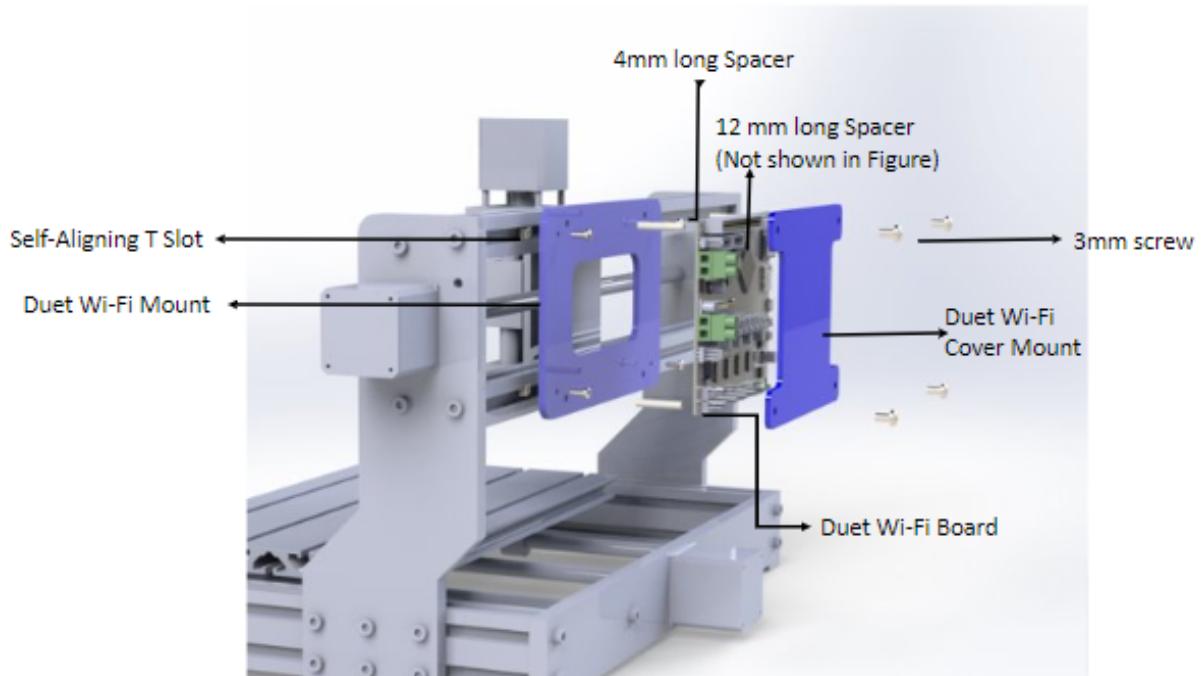


Figure 4: Parts and Sequence in order to mount Duet Wifi to the printer

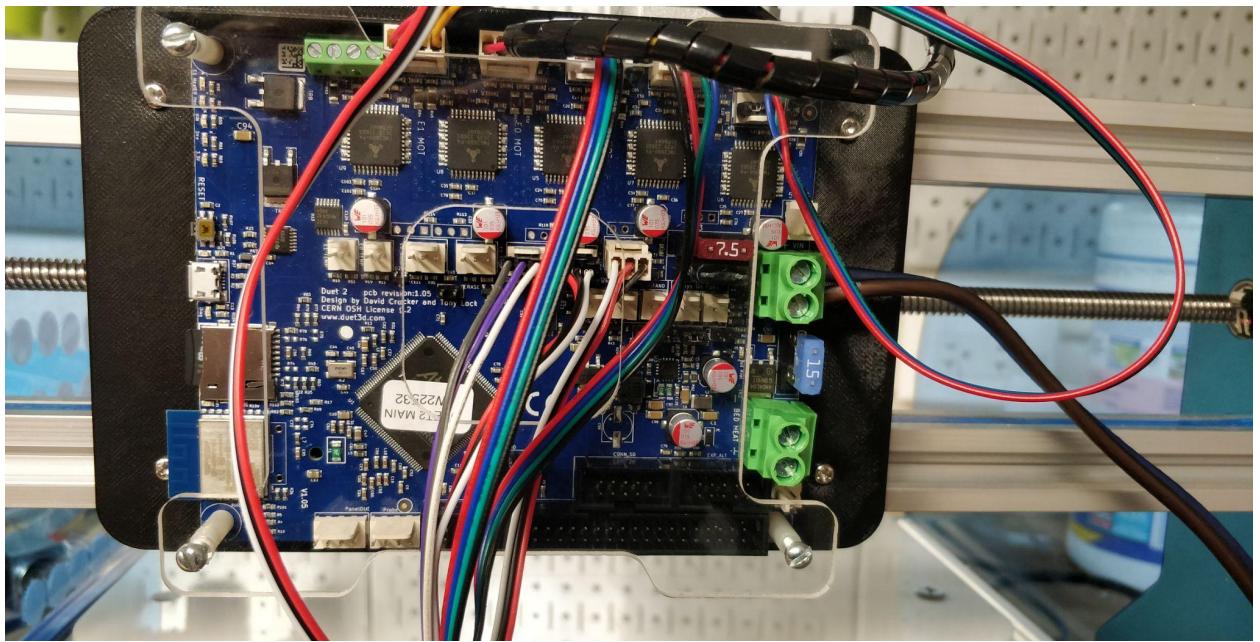


Figure 5: Mounted Duet Wi-Fi after mounting and wiring

5. Mount the Panel Due Displays

(a) Bill of Materials to Mount the Panel Due to Printer:

Sl. No.	Part Name	Description	Qty
1.	Round Head Screw	M3*8	8
2.	Panel Due	Touch Display Screen	1
3.	Panel Due Top Cover	3D Printed Part	1
4.	Panel Due Bottom Cover	3 Printed Part	1
5.	Socket head screws (To mount to the printer)	M5*16	4
6.	Cable Holders	For Cable Management and Pull protection	4

(b) CAD Files for the Panel Due Top cover can be found at:

(i) For 7i Panel Due:

[https://drive.google.com/file/d/1yZUqPT_J3U-scQNqSzYJW7bX35qljtj/
view?usp=sharing](https://drive.google.com/file/d/1yZUqPT_J3U-scQNqSzYJW7bX35qljtj/view?usp=sharing)

(ii) For 5i Panel Due:

[https://drive.google.com/file/d/1IxRGR6xhzeEskuzSdr8sVBEwhPG3MgzZ/
view?usp=sharing](https://drive.google.com/file/d/1IxRGR6xhzeEskuzSdr8sVBEwhPG3MgzZ/view?usp=sharing)

- CAD Files for the Panel Due Bottom Cover can be found at:

(i) For 7i Panel Due:

[https://drive.google.com/file/d/1yZUqPT_J3U-scQNqSzYJW7bX35qljtj/
view?usp=sharing](https://drive.google.com/file/d/1yZUqPT_J3U-scQNqSzYJW7bX35qljtj/view?usp=sharing)

(ii) For 5i Panel Due:

[https://drive.google.com/file/d/18ehC7LIQu6RbhglB6zBZ4SCfnFrBV1Y8/
view?usp=sharing](https://drive.google.com/file/d/18ehC7LIQu6RbhglB6zBZ4SCfnFrBV1Y8/view?usp=sharing)

(c) Procedure:

- The Top cover and Bottom cover CAD provided for either 5i or 7i is to be 3D printed. The infill for the bottom cover must be at least 50% since it holds the weight of top cover and the panel due
- Using the 3mm screw the panel-due is mounted to the top cover
- After mounting then the wiring is to be done as per the instructions given in the wiring of panel-due's
- After completing the wiring, using the cable holder we can provide cable management and pull protection
- On completion of wiring and pull protection the bottom cover is to be mounted using 3mm screws
- Using M5*16 socket head screws the mount must be connected to the T-slot on the sides of the printer

(The same procedure is followed for both 5i/7i, only CAD files are different)

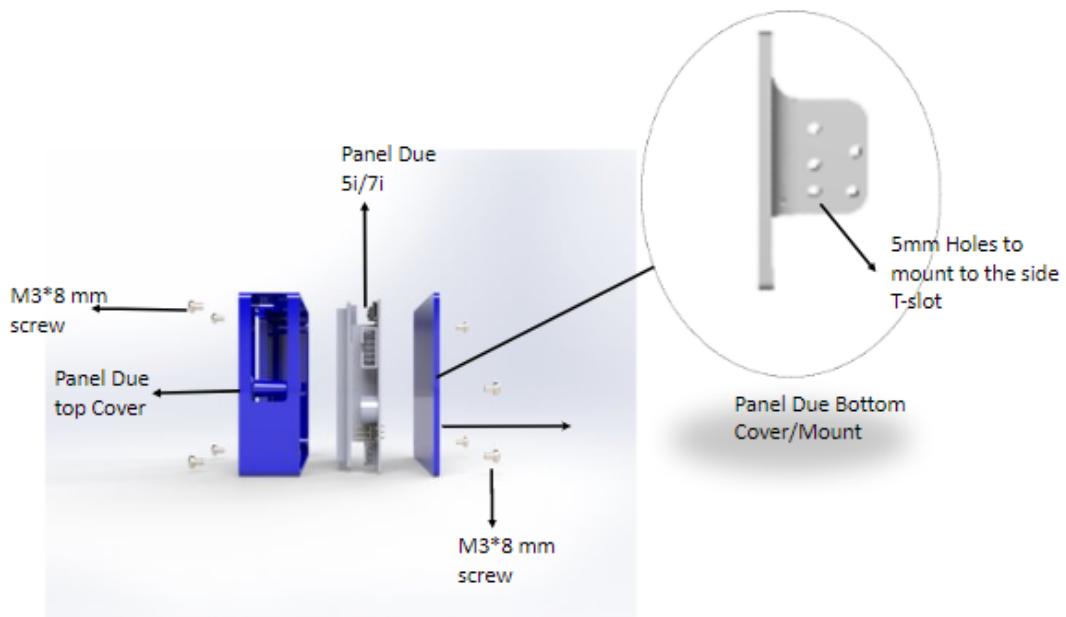


Figure 6: Sequence on mounting the casing to the Panel Due and mounting it to the Printer



Figure 7: After Mounting and Wiring Panel Due

6. Attach Holder and Motors together

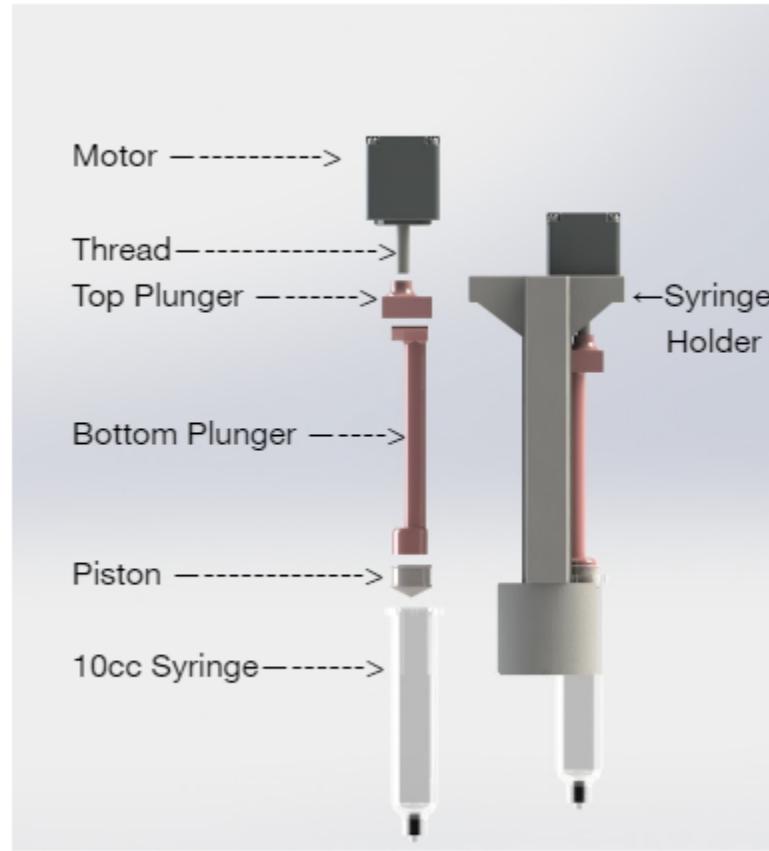


Figure 8 : Exploded View of Syringe Holder with all Components

(a.) All CAD Files can be found via

Motor:

<https://drive.google.com/file/d/1iKHU6jiDQoE3bDNRmVKPL-fqfvGb86ka/view?usp=sharing>

Thread:

https://drive.google.com/file/d/10LSIZvalmO4_L1w-sryk7olllhBKHZIL/view?usp=sharing

Top Plunger:

https://drive.google.com/file/d/1Y8sqXqTitMQrhKxZFy_Mj_DGWhqho_C4/view?usp=sharing

Bottom Plunger:

https://drive.google.com/file/d/10ZT1JloZhoY3qSZ_G6qxMtw8ywxsyj9m/view?usp=sharing

Piston:

https://drive.google.com/file/d/1bq61ftfqgih_QZ_RpoEI96DT25IXHdV7/view?usp=sharing

Syringe:

<https://drive.google.com/file/d/1Ipc3gcdM94bT285Ov0wjKb8utNqq7iy/view?usp=sharing>

Syringe Holder:

https://drive.google.com/file/d/1_CjEzdo_rpa8XEE_isj8GESurUTTvQ26/view?usp=sharing

(c.) Procedure

- Place Syringe Holder into CNC Machine
- Align Motors into Syringe Holder with backs of motors facing the back of the CNC machine
- Screw on Motors to Syringe Holder using M2.5 Hex screws and washers
- Insert Thread into Motors and glue Top Plunger to Thread
- Glue Piston to Bottom Plunger
- Insert Syringe into Syringe Holder
- Insert Bottom Plunger into Top Plunger

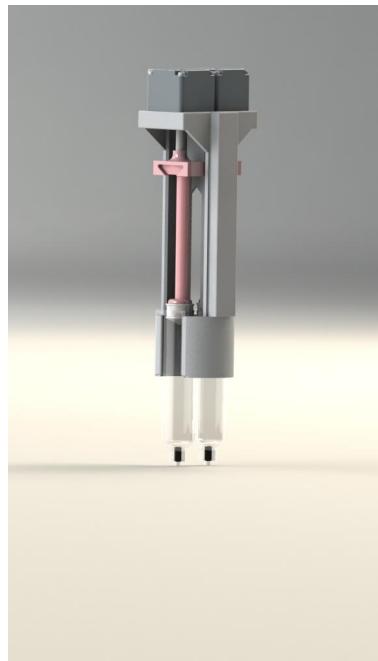


Figure 9 : Fully Assembled Syringe Holder

**Notes

There is a version of the Syringe Holder that has a mounting spot for fans found here:
https://drive.google.com/file/d/1JWWW_vj45iK6z4jro8Dk9y_ijq8M5Hoj/view?usp=sharing

Also, not shown in the rendering is the addition of heat sinks to the motors that should be applied to both front faces and the right and left face on the respective motor.

Wiring gets in the way of placing them on the back face.

7. Wiring

General wiring best practices:

- Turn off the Duet before making any changes to the wiring
- Make sure wires are in the correct position. Don't assume orientation
- Wire management is important, especially on a 3D printer
- Try to add pull protection for vulnerable connections
- Make sure wires do not get in the way of moving parts

Motors:

All motors used are stepper motors. Stepper motors have 4 wires corresponding to 2 pairs in different phases as shown in Fig 2. Since two wires of the same phase are connected, one can determine whether two given wires are in phase using an ohmmeter. If the ohmmeter reads a measurable resistance, the two wires are in phase and should be wired according to Fig 3.

*It does not matter which pair is Phase A and which is Phase B. Getting the orientation wrong will only result in a reversed direction motor which can be addressed via config.

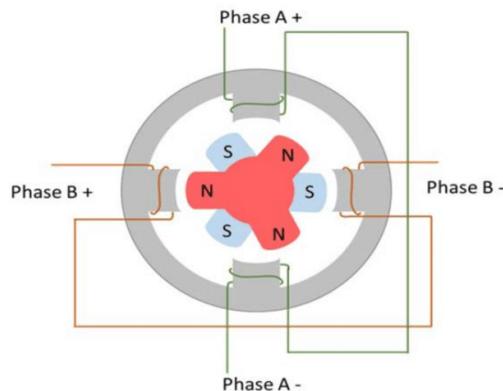


Figure 10: Stepper Motor Diagram by Karadeniz et al.

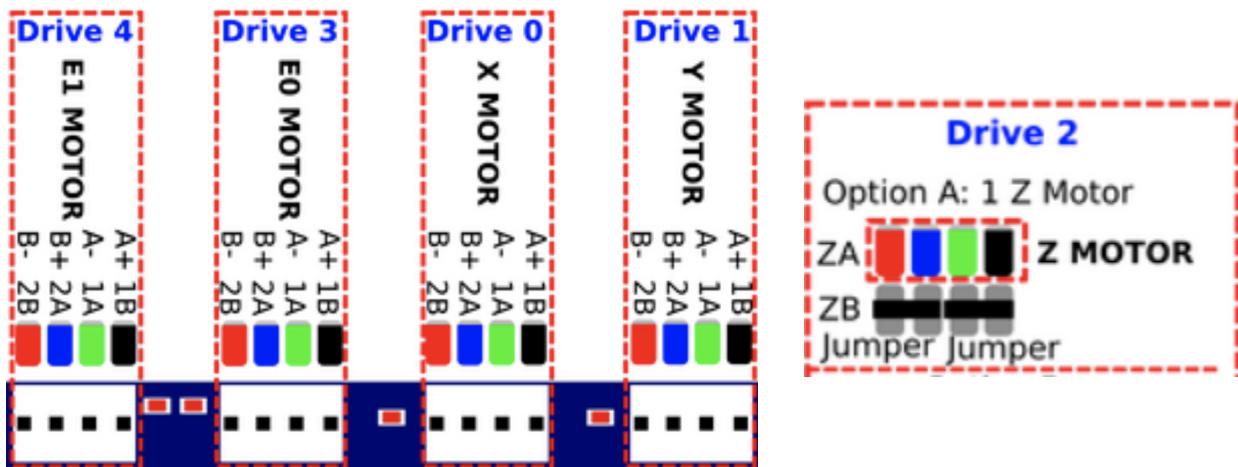


Figure 11: Motor Wiring

Limit Switches:

Limit switch wiring should be fairly straightforward. Follow Fig 4.

*The limit switches we use have the incorrect orientation for ground and voltage and must be recrimped for the correct orientation.

To test a limit switch, open the duet web interface, go to console and send M119.

Press the limit switch and hold. Send another M119.

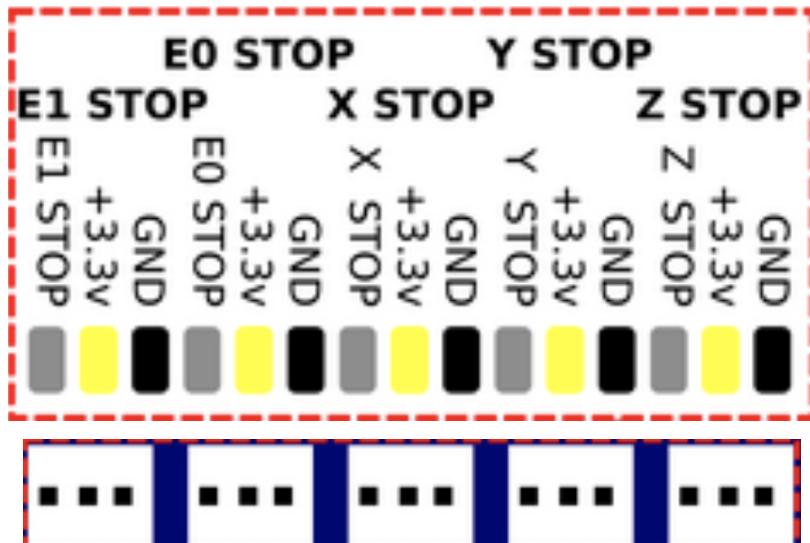


Figure 12: Wiring Limit Switches

Quick note on limit switches:

The Duet is configured such that limit switches are only active during homing (i.e. they will not prevent movement if triggered during use of the machine). If the duet is configured properly, it will only allow movement after homing and prevent movement outside of the machine dimensions.

*Because of the way the encoders are configured, it is important that G92 is never inputted as a command when running a Gcode file. This will set the current location to the origin and allow for movement outside of the machine dimensions.

Emergency Stops

The emergency stop buttons we use have two channels with opposite behavior as exhibited in Fig 5. Channel A will short a connection when the button is pressed, and channel B will break a connection when the button is pressed. The functionality of each channel can be verified using an ohmmeter.

We use channel B and place the button in series with the positive voltage wire of the power supply such that pressing the button will break the connection with this wire (it can alternatively be placed in series with the ground wire). This can be done by attaching the positive voltage wire of the power supply to one end of channel B. We then take a strip of wire (14-18 awg) - solder the ground wires together and attach the positive voltage wire to the other end of channel B.

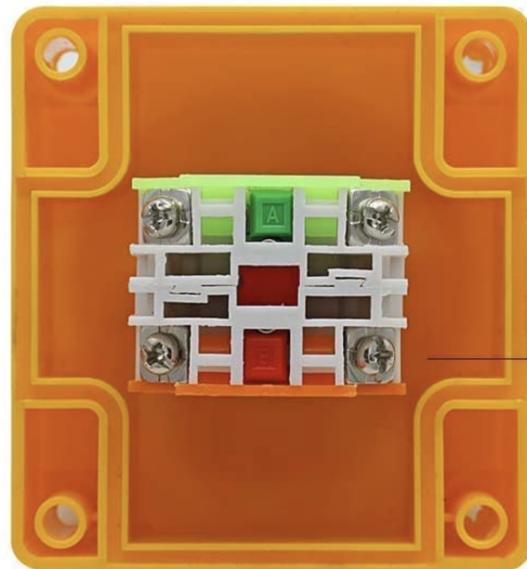


Figure 13: Emergency Stop Button

Fans

Wiring and using fans:

https://duet3d.dozuki.com/Wiki/Connecting_and_configuring_fans

Fan jumpers:

<https://forum.duet3d.com/topic/163/fan-connection-documentation>

Currently, we do not use fans. However, they can be added if overheating of the extruder motors is a problem in the future. Each machine currently has an extension cord for a fan to be wired in if necessary. It is important when wiring a fan to make sure that the jumper is set correctly. V Fan Jumper Select should be set between 5V and V_FAN if using a 5V fan or between VIN and V_FAN if using a 12V fan.

Follow the above forum if unsure.

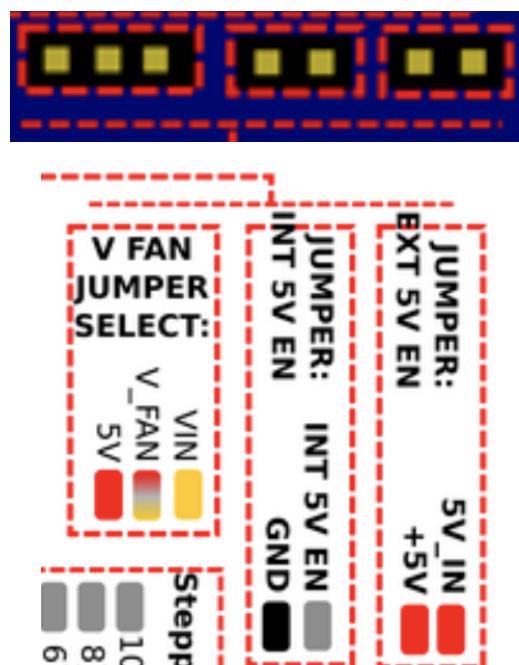


Figure 14: Fan Jumpers

Paneldue

We use Paneldue 5i and 7i versions - 1 for any given machine. 5i is larger and has a microSD slot. 7i is smaller and has an SD card slot. Both versions should be connected by 1 flat ribbon connector to the slot labeled CONN_SD as shown in Fig 7. This slot can be found toward the bottom of the board just above the large expansion slot. If you are using the 5i version, you will also need to add a MicroSD to SD card extender.

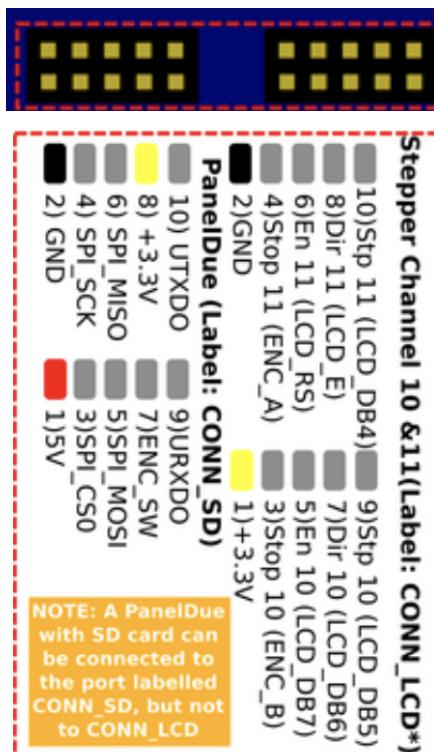


Figure 15: Paneldue Wiring

8. Configuration:

Configuration files can be found here:

<https://drive.google.com/drive/folders/1voXK-aQNyHwWoTPbL85qkzxjY96YFyOx?usp=sharing>

The above drive contains the following:

- config.g: the main configuration file, specifying machine dimensions, motor behavior, defining limit switches, etc.
- Homing.zip: A zip file containing altered homing procedures for Homeall, Homex, Homey, and Homez. The procedures are altered such that the position of the gantry is set to x=50 y=30 after homing. This is to minimize syringe leakage over the edge of the build plate.
- pause.g: altered pause functionality such that movements are more exaggerated to prevent interference with printed material. Also set the position to x=50 Y=0 while paused.
- resume.g: altered resume functionality to directly reverse pause behavior

If changes need to be made, files can be edited directly through the Duet web interface or another version can be uploaded, overwriting the version currently stored on the Duet.

This tool can be used to create a new set of configuration files. Refer to current configuration files for values to be inputted.

<https://configtool.reprapfirmware.org/Start>

9. Citations/References

- Duet Wiring: https://duet3d.dozuki.com/Wiki/Duet_Wiring_Diagrams
- Duet Connecting to Wi-Fi:
[https://duet3d.dozuki.com/Guide/1.\)+Getting+Connected+to+your+Duet/7](https://duet3d.dozuki.com/Guide/1.)+Getting+Connected+to+your+Duet/7)
- Panel Due Documentation: <https://duet3d.dozuki.com/Wiki/PanelDue>
- Duet Wi-Fi Manual: <https://duet3d.dozuki.com/c/Root>
- Karadeniz, Ahmet & Alkayyali, Malek & Szemes, Péter. (2018). Modeling and Simulation of Stepper Motor For Position Control Using LabVIEW. Recent Innovations in Mechatronics. 5. 10.17667/riim.2018.1/7.