P2C2: Portable Personal Cluster Computer

PART 1: Hardware

Tony von Ruden Copyright **March 15, 2015**

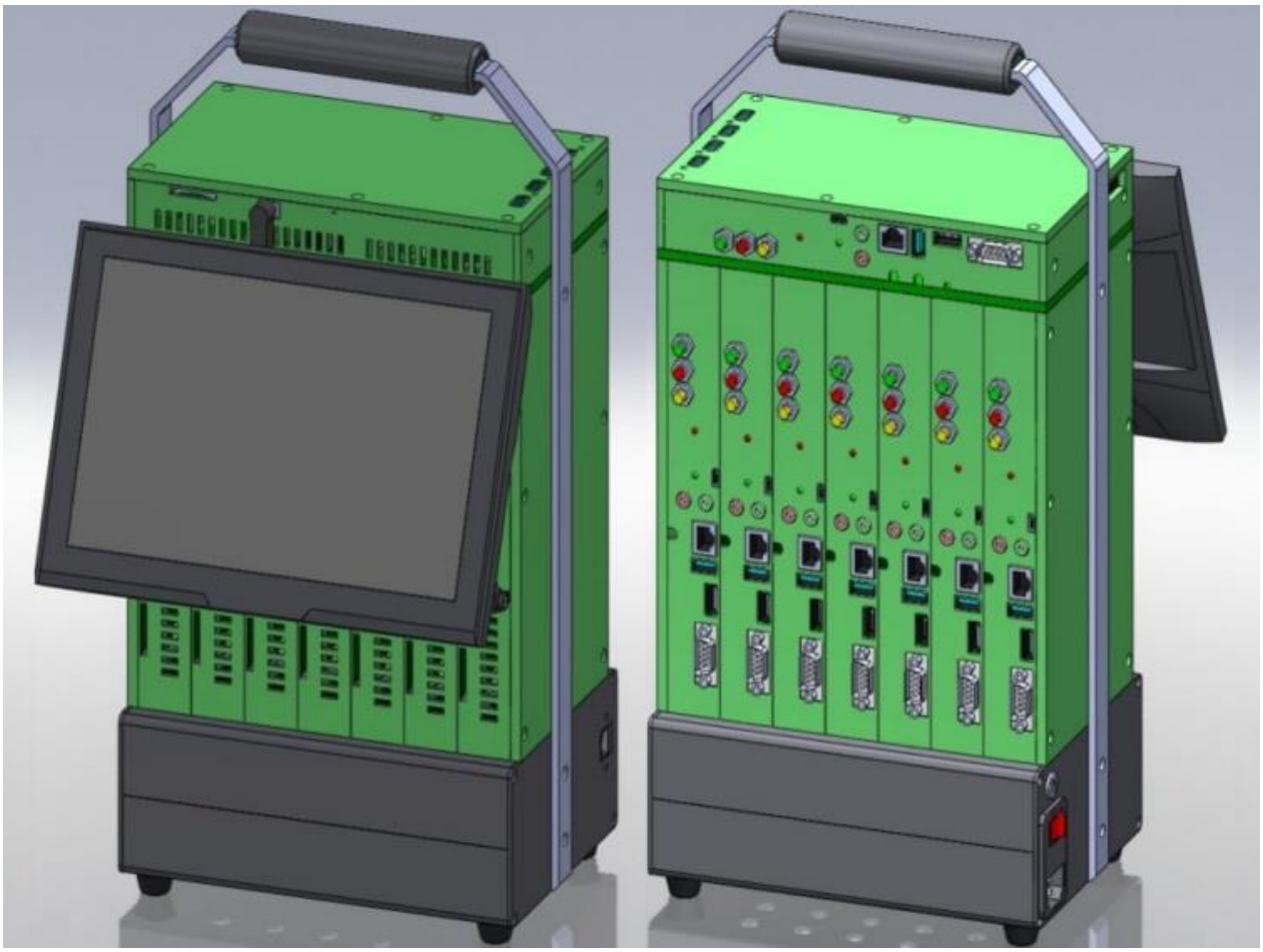


Figure 1: CAD Drawings of the completed project.

1.0 Introduction

I have wanted to build my own portable personal cluster computer (P2C2) ever since I read the article "The Ultimate Linux Lunchbox" by Ron Minnich, which appeared in the Linux Journal about 10 years ago (http://www.linuxjournal.com/article/8177?page=0,0). I've tried a dozen or so single board computers in the intervening years, but it wasn't until I was read about Nvidia's Jetson-TK1 board here (http://wits-hep.blogspot.tw/2014/11/new-nvidia-jetson-tk1-cluster.html) that I found an embedded computer with the performance and efficiency to make the effort worthwhile.

This is the first in a series of papers I hope to write about making the desktop computer exciting again (ironically, by using cheap, low-power technology developed for mobile products!). This paper (Part I) will document the parts I used, and the build process. Part 2 will document the software configuration and development workflow that I favor after playing around the P2C2 a while. Part 3 will document an as-yet-to-be-decided-upon non-trivial example application.

Strictly speaking, you don't NEED a 3D printer to build your own Jetson-TK1 P2C2. Indeed, my first thought was to get a classic 'Jetsons' lunchbox on ebay (Figure 2), and fill it full of boards.

Figure 2. The Classic 1963 Jetsons Lunchbox Escapes Mutilation.

Unfortunately, in a major design oversight, Nvidia made the Jetson-TK1 too wide to fit. Also, I discovered that the Smithsonian Institution selected this lunchbox for their 1960's exhibit, and I feared that I might be violating a national treasure. The result is the project documented here. I hope you enjoy reading about it -- or even better – making one of your own.

2.0 What You Will Need to Build the P2C2

2.1 Tools

The most exotic tool we will need to build the P2C2 is a 3D-Printer capable of making 220mm x 130mm parts (about 9" x 5.25"). Other than that, it can be built with simple hand tools you probably already have:

- PanaVise, or other Small Vise
- Electric Hand Drill (or Drill Press) and Drill Bits
- Hardened Scribe / Hole Punch
- Hammer
- Hacksaw (or Band Saw)
- Flat and Round Files
- Sandpaper (or Belt or Disk Sander)
- Xacto Knife and Blades
- Screwdrivers and Allen Wrenches
- Hot Glue Gun and Glue
- Soldering Iron and Solder
- Wire Cutter
- Wire Stripper
- Needle-Nose Pliers
- Multimeter

2.2 Other Supplies

You will also need various other supplies, which you may already have handy as well:

- 5-Minute Epoxy
- Kapton Tape
- Cable-Ties
- Heat-Shrink Tubing
- 3v Coin Cell Lithium Battery
- Screws and other Assorted Hardware
- Thermal Grease

2.3 Printed Parts

I have listed the printed parts required in Section 9.1

2.4 Purchased Parts

I have listed the parts I purchased, where to buy them, and the prices in Section 9.2. I spent around $3500 on this project. You can reduce the costs considerably by omitting the Solid State Drives and the built-in monitor, however. You might also just start with 3 or 4 Jetson-TK1 boards, adding more later.

3.0 Assembling the Vertical (Slave) Nodes 1 to 7

This section may be rather tedious, so peek ahead to Figure 10 for additional motivation.

3.1 Print Vertical 'Node' parts

Print one 'Jetson_node_left.STL' (9.1.1) and 'Jetson_node_right.STL' (9.1.2), and seven 'Jetson_node_front.STL' (9.1.3), and 'Jetson_node_back.STL' (9.1.4) parts in the glow-in-the dark-Nvidia-green color of your choice (9.2.1).

3.2 Cut the Aluminum Standoffs to Length of 28mm, and Add Slot

While we are waiting for the parts above to print, we can be preparing the aluminum standoffs. For Node1, we need 6 F/F standoffs (9.2.2), and for the rest of the nodes we will require 42 M/F standoffs (9.2.3). Note that metric M3 standoffs can be substituted if they are easier to get than 4-40 standoffs. Use a hacksaw or band saw and file or sandpaper to shorten the hexagonal portion of the standoffs to 28mm. Once to length, cut a slot for a screwdriver on the end of each standoff to facilitate assembly later (Figure 3).

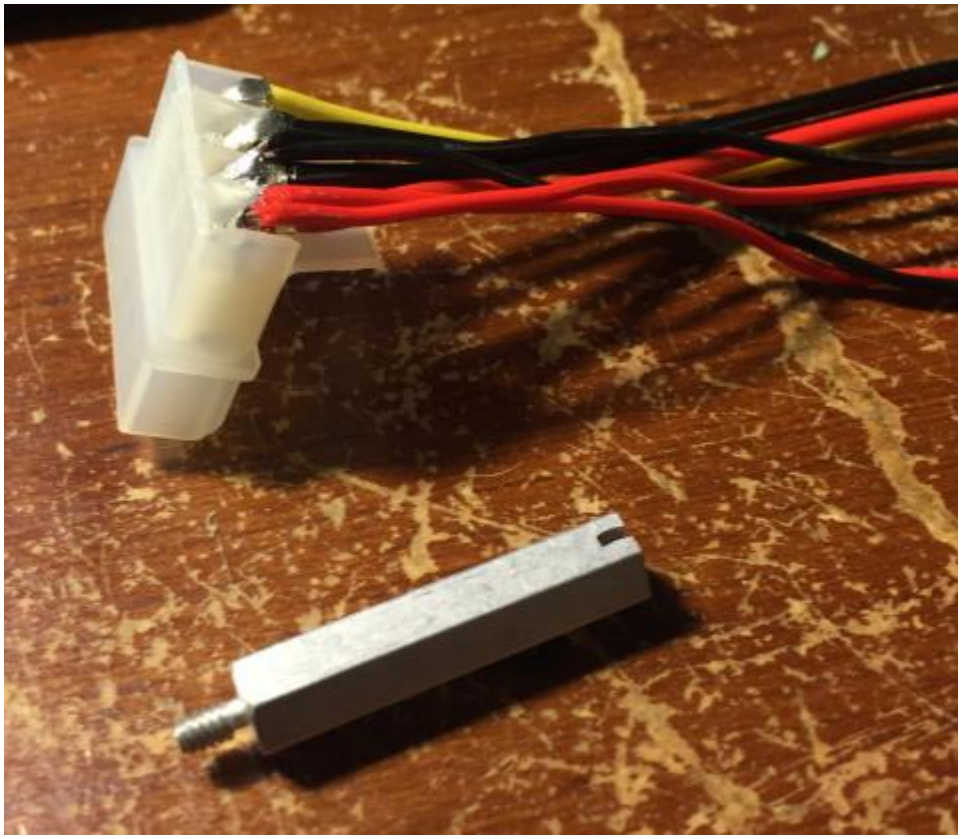


Figure 3. Modified Standoff and Molex Connector.

3.3 Modify MOLEX Connector on SATA Drive Power Cable

We next need to modify the big white MOLEX connector on all 8 SATA drive Power cables (9.2.4). We want to make them right-angle connectors, with the wires running toward the D-edge (Figure 3).

With an Xacto knife, carefully slit the plastic on the connector as far as you can to make 4 little plastic 'tongues', then bend them over. Now use a small screwdriver as a lever to bend the metal crimping the wires over the tongues, forming the right angle we need. Tape the wires to the tongues to keep everything in place. Using a small wire cutter, trim about ½ the height of the plastic on the other side of the connector and between the wires. Finally, mix some 5-minute epoxy and fill the remaining wire cavity. Once hardened, you will have a low profile 90-degree power connector for the SATA SSD.

3.4 Attach Cables to SSD

Attach the power cable (9.2.4) we just modified to the SATA Solid State Drive (SSD) (9.2.6). Attach the SATA data cable (9.2.5) to the SSD as well. Carefully bend the cables as compactly as practical towards the face of the SSD that has the screw holes. Secure the cables in this position with one or more cable ties going around the wires and the cable connectors (Figure 4).

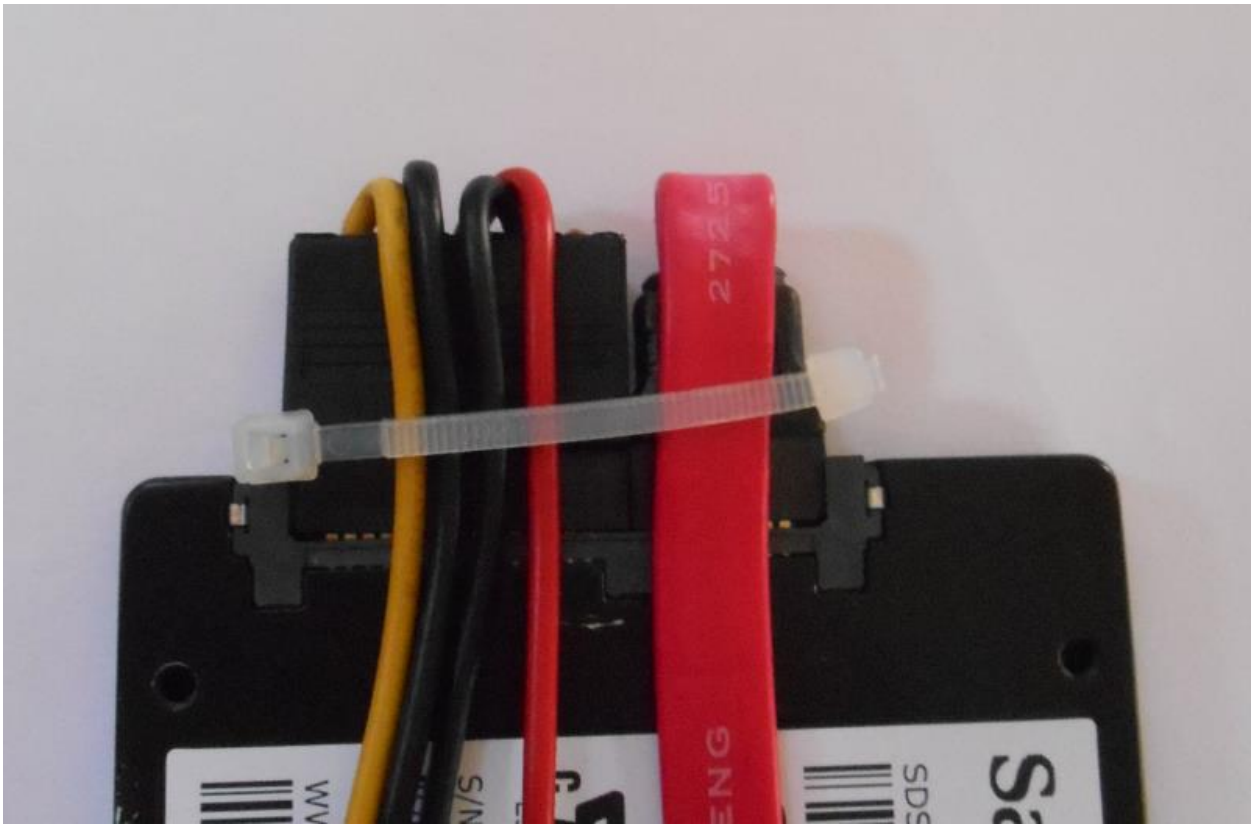


Figure 4. SATA Cables Attached.

3.5 Attach the Jetson-TK1 PCB to the Jetson Node Left Plate

OK, the Jetson Node Left plate (9.1.1) is finally printed, so let's attach the Jetson-TK1 board (9.2.7) to it. First, insert 4 flat-head 4-40 screws (or M3 screws if we used M3 standoffs) through the PCB mounting holes in the Left Plate. (These are the bottom 4 holes around the hogged out section of the plate). Observing electrostatic precautions, open the Jetson-TK1 bag and remove the board. Be careful to

orient the board correctly! With the Left plate at our left (duh!) and the Jetson-TK1 at the bottom, the power connector for the board should be facing us. Attach the Jetson-TK1 to the left plate with 4 of the F/F standoffs (9.2.2) prepared earlier. Hold off installing the top 2 standoffs for the moment.

3.6 Install the SSD into the Jetson Node Front Plate

Once the Jetson Node Front plate (9.1.3) has finished printing, check that the rectangular socket for the SSD is clean, clearing any excess plastic out with an Xacto knife if not. Insert the SSD into the Front plate, and loosely fasten with two M3 screws.

3.7 Fasten the Jetson Node Front Plate Assembly to the Left Plate Assembly

We can now slip the Front Plate assembly down over the front two standoffs in the Jetson Left plate until it nests around the Jetson-TK1 PCB. Check for a proper fit, and trim the part with an Xacto knife if required. The front plate edge should lay flush against the left plate, and the power connector and SD slot of the PCB should align with the holes in the Front plate. Secure the Front plate to the Left plate loosely using a flat-head screw and F/F standoff.

3.8 Check the Jetson Node Back Plate for Fit

Once the Jetson Node Back plate (9.1.4) has finished printing, we need to check it for fit. Remove the standoffs at the rear of the Jetson-TK1 PCB, and carefully check the fit of the Back plate around all the connectors. Also check and make sure the SSD fits smoothly into the mating arm. Trim any excess plastic away with a Xacto knife. When we are happy with the fit, remove the Jetson Node Back plate so we can add a few more parts to it.

3.9 Install Pushbutton Switches into Jetson Node Back Plate

Install Green (9.2.8), Red (9.2.9), and Yellow (9.2.10) momentary contact pushbutton switches into the appropriate holes (See Figure 1) of the Jetson Node Back plate (9.1.4). After checking that they actually work with a resistance meter, secure them with a dab of hot glue or 5-minute epoxy.

3.10 Install LEDs into Jetson Node Back Plate

Install a Green LED (9.2.11) and a Red LED (9.2.12) into the Jetson Node Back plate (9.1.4). The Green LED goes into a small hole in the center of the Back plate, and the Red LED goes in similar hole above it (See Figure 1). After making sure that the LEDs actually work using a 3v coin cell lithium battery, secure them with a dab of hot glue or 5-minute epoxy. Once set, trim the leads of the LEDs to a few millimeters, but make the anode (+) lead a little longer than the other, so we can tell the polarity later.

Figure 5 shows the Pushbuttons and LEDS installed.

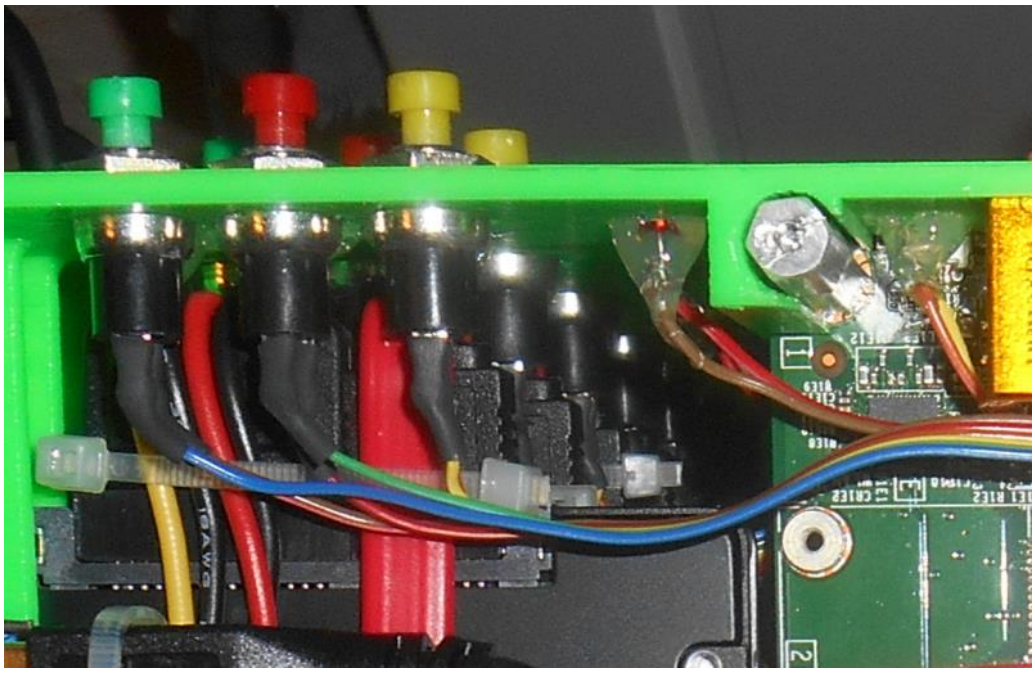


Figure 5. Push Button Switches and LEDS.

3.11 Make a Cable for the LEDs

Cut a 6" piece of 10-conductor ribbon cable (9.2.13). Crimp a 10-pin connector (9.2.14) to one end. (I use a small PanaVice to do this). Solder Pin1 to RedLED+, Pin3 to RedLED-, Pin4 to GrnLED+, and Pin8 to GrnLED-. (Consult Figure 7).

After testing for short circuits, add a glob of hot glue to reinforce and insulate the solder joints.

3.12 Make a Cable for the Pushbutton Switches

Cut a 10" piece of 10-conductor ribbon cable (9.2.13). Peel off 4 wires, leaving 6.

3.12.1 Soldering the Header End of the 6-Wire Ribbon Cable

Cut one of the 10-pin 2mm headers (9.2.15) in half, so we have 5 pins. Clip off the short side of 4th pin of the header. Solder Wire1 of the ribbon cable to the short side of Pin1 on the header. Solder Wire2 of the ribbon cable to Pin2 of the header. Solder Wire3 to Pin3 of the header. Finally twist Wire4, Wire5, and Wire6 of the ribbon cable together, then solder them all to Pin5 on the header. (Consult Figure 7).

After soldering, coat all the connections on the header with a glob of hot glue, to insulate and reinforce the joints. (Don't get any on the lower half of the pins)! After the hot glue sets, fold the ribbon cable over at a diagonal so that we form a right-hand connector with the wires going off TOWARD Pin1 of the header. Secure this fold with a bit more hot glue (Figure 6).

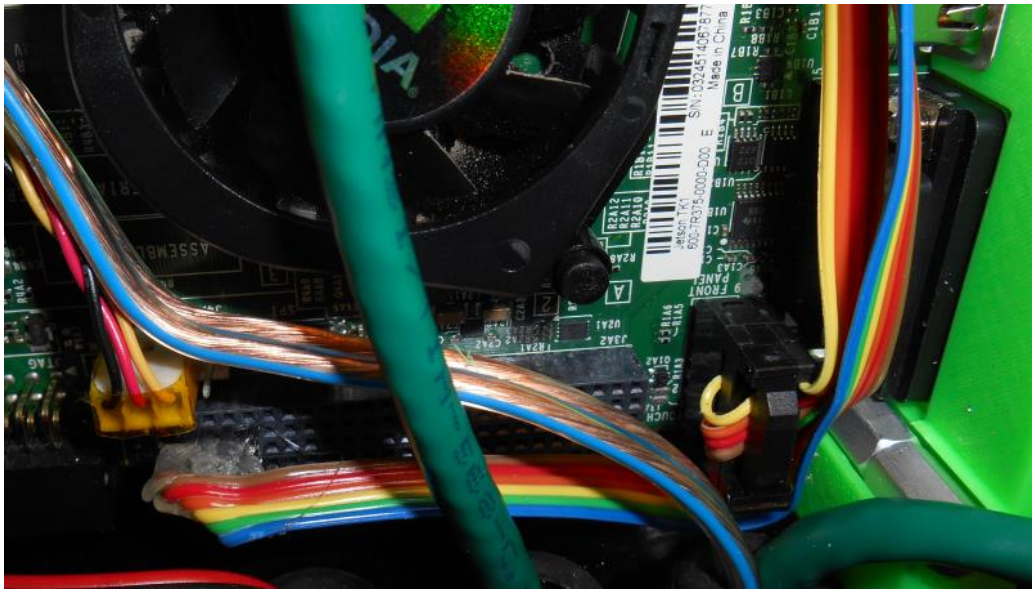


Figure 6. Ribbon Cable Connectors.

3.12.2 Soldering the Pushbutton End of the 6-Wire Ribbon Cable

Before soldering, thread a bit of heat-shrink tubing over each wire. We will use it to reinforce and insulate the connection after soldering.

Solder Wire1 of the ribbon cable to the Green Pushbutton Switch. Solder Wire2 of the ribbon to the Red Switch. Solder Wire3 of the ribbon cable to the Yellow Switch. Solder Wire4 of the ribbon cable to the other side of the Yellow Switch. Solder Wire5 to the other side of the Red Switch. Finally, solder Wire6 to the other side of the Green Switch. (Consult Figure 7).

After soldering, slide the heat-shrink tubing over each joint, then heat it to lock it into place.

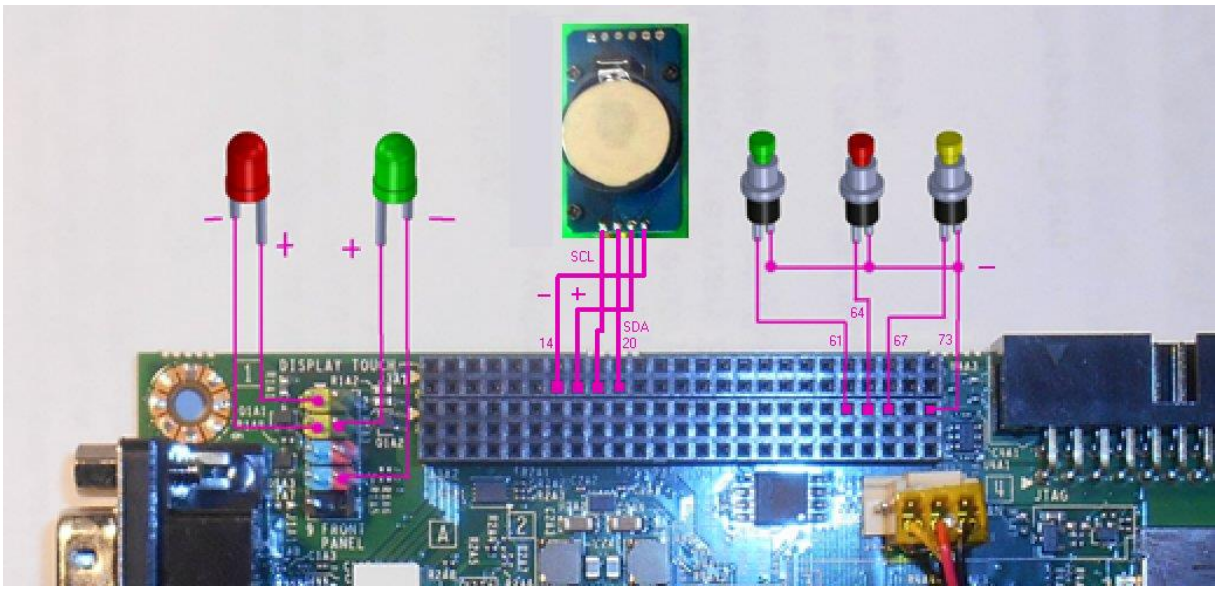


Figure 7. Wiring Diagram

3.13 Attach Jetson Node Back Plate Assembly

We are at last ready to complete assembly of our first node. Figure 10 shows a completed Node7.

Fit the Jetson Node Back plate over the Jetson-TK1 connectors, and guide the SSD into the mating arm. Secure the SSD with one more M3 screw. Insert and gently tighten all the standoffs and screws. Don't overdo it or we will crack the plastic.

Carefully plug the SSD's SATA data and power connectors into the Jetson-TK1.

Plug the LED cable into the J1A1 header on the Jetson-TK1. The little triangle denotes Pin1 on the connector.

Finally, plug the 5-pin header for the buttons into the correct holes of the 'General Expansion Header' (J3A2). We want pin 5 of our connector to go into hole 73 (GND), which is marked on the top of the PCB, near the fan connector. Pin3 (Yellow Button) goes in hole 67 (FORCE_RECOVERY_L). Pin2 (Red Button) goes in hole 64 (PMU_RESET_IN_L). Pin1 (Green button) goes to hole 61 (ONKEY_L).

Figure 7 should help you install the 5-pin header into the correct holes of the expansion connector.

3.16 Test the Node

Now it is time to test our node. Connect our HDMI monitor (9.2.16) to the HDMI port of the Jetson-TK1. Insert the wireless mouse and keyboard dongle (9.2.17) into the Jetson's USB3 port. Power up the HDMI monitor, then connect the 12 volt power brick to the Jetson. Refer to the Jetson-TK1 Wiki to get started:

http://elinux.org/Jetson_TK1

Once you have an internet connection, I'd recommend downloading the graphical disk partition editor in order to partition and format your SSD (appearing at /dev/sda):

Type "`sudo apt-get install gparted`" in a terminal session.

Once that's done, here's a list of things to test:

- Make sure you can see and access the Solid State Drive.
- Carefully insert an SD card, and make sure you can see and access it.
- The Green LED we connected should be on when the board is powered up.
- The Red LED we connected should blink during SSD access.
- Pressing the Green Pushbutton should pop up a shutdown dialog.
- Pressing the Red Pushbutton should reset the Jetson-TK1.
- Holding down the Yellow Pushbutton during a reset should let us enter 'Flash" mode.

3.14 Make a 12 Volt Power Cable

Cut a 2 foot length of 18 GA gauge Red/Black speaker wire (9.2.18) and solder it to the Right Angle 5.5mmx2.1mm Male Plug (9.2.19). The red wire should go the center terminal of the plug (Figure 8).

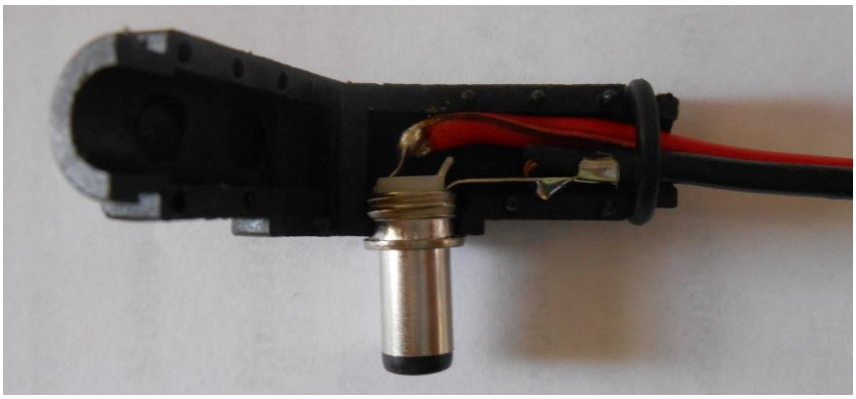


Figure 8. The 12 volt DC Power Plug

3.15 Make an Ethernet Cable

Cut a 2 foot length of CAT6 Ethernet cable (9.2.20) and crimp an RJ-45 jack (9.2.21) to one end. The wire order is brown, brown-stripe, green, blue-stripe, blue, green-stripe, orange, orange-stripe. I'd never done this before, but it was easy and kind of fun.

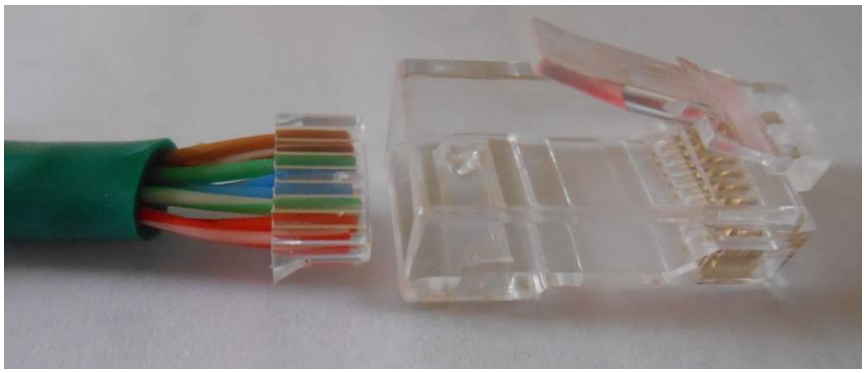


Figure 9. Making an Ethernet Cable

3.16 Install the Power and Ethernet Cables

Put the cables in the appropriate sockets of the Jetson-TK1, then bend them back into the interior of the case and insert them into the notches provided for them in the Front and Back Node Plates. The free ends of the cables should run out the bottom of the Node.

3.17 Make Vertical (Slave) Nodes 2 through 7

Repeat steps 3.3 through 3.16 six more times. Sorry.

Figure 10 shows the completed Node 7. Note the extra blue circuit board and its cables – this is the USB3 Hub that we will be installing as part of our Master Node Zero. There is also an extra green Ethernet cable from Node Zero visible in the photo. These don't affect the assembly of Node 7. They just slip down past the SSD and Jetson board.

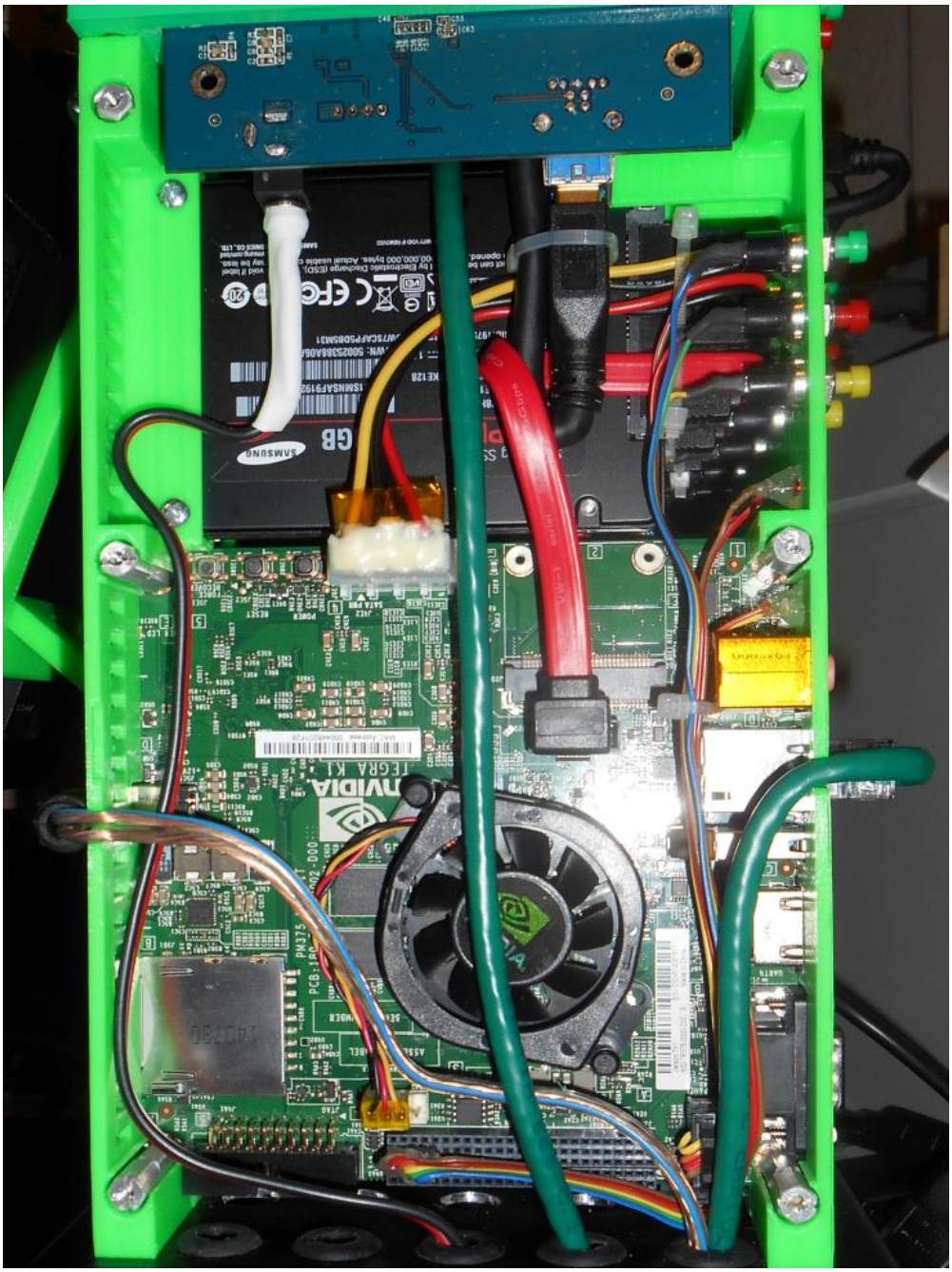


Figure 10. Node7, Complete!

3.18 Attach the Jetson Node Right Plate

Insert 6 flat-head 4-40 screws (or M3 screws if we used M3 standoffs) through the Jetson Node Right Plate, and screw them into the standoffs in Node 7.

Congratulations – we made it through Section 3!

4.0 Assembling the Monitor Support

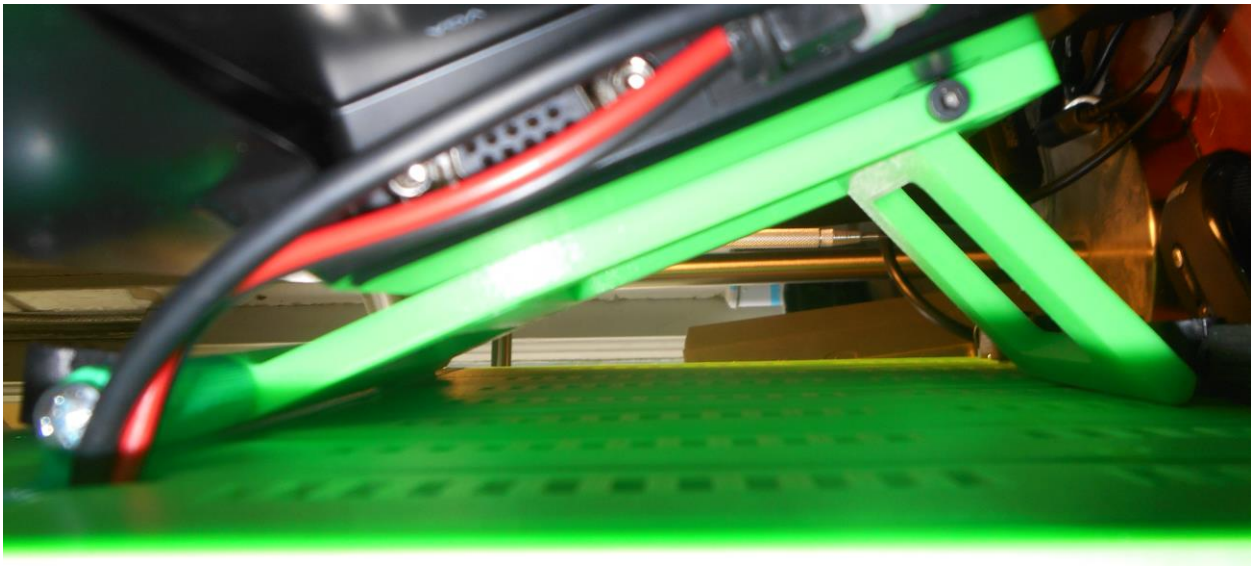


Figure 11. The Montor Support Assembly

4.1 Print the Monitor Support Parts

When I came to this point in the project I had run out of the fluorescent green I was using, so I decided to print the "jetson_top_rim.STL" part (9.1.5) in a darker green that I had. I wound up really liking the way this looked.

We also need to print "monitor_bracket.STL" (9.1.6) and "monitor_leg.STL" (9.1.7) parts.

4.2 Install the Top Rim

Clean out the 6 holes for the standoffs with an Xacto knife. Press a 4-40 nut in each hexagonal recess at the bottom of the part. Install and finger tighten a standoff into each nut from the top side of the part.

Note that the Monitor Cables shown in Figure 11 run underneath the Top Rim piece. This is no longer the case, as I have added notches for them in the Node Zero Front Plate. We won't need to worry about them until we assemble Jetson Node Zero.

Screw this assembly to the top of the Vertical Nodes with the Monitor Hinge on the front (the side with all the ventilation slots). I used 0.11" diameter x .75" long (3mm x 10mm) sheet metal screws for this purpose.

4.3 Assemble the Monitor Bracket

Attach the Monitor Leg part to the Monitor Bracket using two M3 x 20mm cap screws.

Attach the Monitor Bracket to the back of the Monitor (9.2.16) with four M4 x 8mm cap screws. Note that the bulge for the hinge should face the back of the Monitor.

We will assemble the hinge using two M4 x 40mm screws during final assembly.

5.0 Assembling the Horizontal (Master) Node 'Zero'

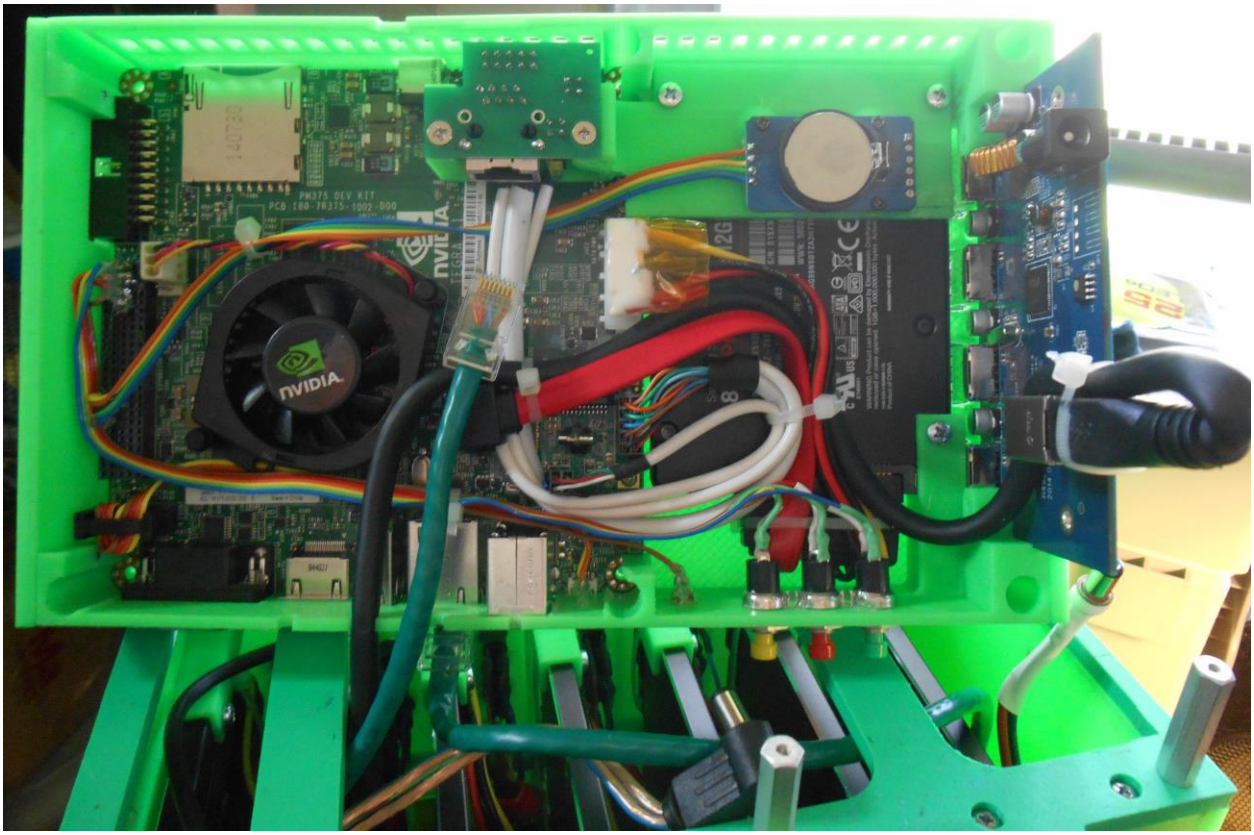


Figure 12. Node Zero

As you can see from Figure 12, Node Zero is just like Nodes 1 through 7, but more crowded. We have added the powered USB3 Hub (9.2.22) at right, a Gigabit Ethernet Mini-PCIE Module and its connector (9.2.24) at center, and a battery backed I2C Real-Time Clock Module (9.2.25) between them.

5.1 Print the Jetson Node Zero Parts

Print one each of "Jetson_node_zero_left.STL" (9.1.9), "Jetson_node_zero_right.STL" (9.1.10), "Jetson_node_zero_front.STL" (9.1.11), "Jetson_node_zero_back.STL" (9.1.12), "Jetson_node_zero_top.STL" (9.1.13), and "RTC_RJ45_Bracket.STL" (9.1.14).

Notice that one section of the RTC-RJ45 Bracket is hollow. Remove this section with an Xacto knife. It was just there to support the bracket during printing. Removing it allows the RTC cable to run straight to the Jetson Expansion Connector (J3A1). See Figure 12.

5.2 Prepare the USB3 Hub

We are going to do some serious warranty-voiding to the Anker AH111 USB 3.0 4-Port Hub. I chose this hub because it wants 12 volt power, like all of our other components. It has another surprise feature inside, it turns out. The PCB designer anticipated our desire to have the LEDs oriented in the same direction as the ports, and thoughtfully left some unpopulated holes for this purpose!

Remove the covers and throw them out. Cut out the existing blue LEDs. We can either re-solder them to point forward, or use some new green 3mm LEDs (9.2.11) which go much better with the green plastic of our case.

Check the fit of the USB3 Hub connectors and new LEDs into the Node Zero Top Plate, and trim or file any obstructing plastic as required.

Check that the USB3 Hub still functions under power, then unplug the power adapter from AC and cut the power cord near the wall wart. We will re-use the remaining portion of the cord to power the hub once it is installed in the P2C2.

5.3 Insert the Gigabyte Ethernet Mini-PCIE Module into the Jetson-TK1

Before assembling Node Zero, we need to remember to install the Mini-PCIE Ethernet module into the Jetson-TK1 board.

5.3 Assemble the Node

Follow all the steps in Section 3 to build Node Zero, except defer testing until Section 5.8, below. (Oh, so much less typing this time around!)

We may want to secure the Jetson-TK1 PCB to the Top Plate with standoffs temporarily, if we have spares.

I installed the 512GB SSD in Node Zero.

We need to be very careful installing the Left and Right Plates for Node Zero, as the plastic is thin and fragile near the mounting holes in the Front and Back Plates.

Make the Power and Ethernet cables a foot longer for Node Zero.

This reminds me -- we need to make an additional 12 volt Power cable for our HDMI Monitor, and an additional Ethernet cable for our additional Ethernet Module. Make these 3 feet long as well.

5.4 Make an I2C Cable for the RTC Module

Clip off the existing header from the RTC Module. Solder a 1 foot length of 4-conductor ribbon cable in the empty holes on the other end of the PCB. Solder the far end of the ribbon cable to a 4 pin piece of 2mm header. See the Figure 7 Wiring Diagram for the mapping of PCB pins to header pins. Insulate and reinforce the solder joints at header with a glob of hot glue, like we do for the Pushbuttons Switches.

5.5 Assemble and Install the RTC-RJ45 Bracket

Remove the metal PC Case mounting bracket from the Ethernet Daughter Board. Mount the little PCB upside down in the RTC-RJ45 Bracket, with the cables already installed and exiting on the same side as the jack (Figure 13).

Find some really tiny screws somewhere (sorry, I'm not sure what size) and, with the bracket side clamped in a vice, screw in the RTC module. The vice keeps the bracket from splitting at the hole near the edge.

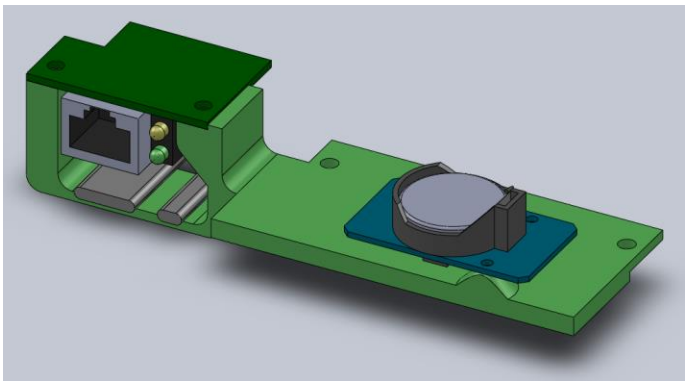


Figure 13. RTC-RJ45 Bracket Assembly

Remove the M3 screws holding the SSD to the Node Zero Front Plate. Position the RTC-RJ45 Bracket Assembly over the empty holes, and install M3 screws to hold the bracket in place. We might need slightly longer screws.

5.6 Connect the Ethernet Module and RTC Cables

We now need to connect the cables from the Ethernet Jack Daughter Board to the Mini-PCIE Ethernet Module PCB (consulting vender documentation to get this right). We then need to plug our SPI RTC cable into the correct holes of the Jetson's Expansion Header. We want pins 14 to 20 of header J3A1, as shown in Figure 7.

5.7 Attach the USB3 Hub and Right Plate

Remove the Node Zero Right Plate. Using flat-headed 4-40 or M3 screws, carefully fasten the USB Hub PCB to the lugs provided on the Front and Back Plates. Reattach the Node Zero Right Plate.

5.8 Test Node Zero

We now should test Node Zero. Since the Real-Time Clock drivers aren't in Nvidia's Linux release for the Jetson, we should install Santyago's custom kernel 19.3.8, 'The Grinch' per instructions found here:

https://devtalk.nvidia.com/default/topic/766303/embedded-systems/-customkernel-the-grinch-19-3-8-for-jetson-tk1/

His directions for getting the RTC Module going are here:

https://devtalk.nvidia.com/default/topic/769727/embedded-systems/-howto-battery-backup-rtc/

Run through all the other tests in section 3.16 as well.

5.9 Attach Node Zero to the Jetson Top Rim Plate

It's now time for the Master Node to meet its Slaves.

First tape the Node Zero Top Plate to Left and Right Side Plates to hold it in place, then remove the temporary standoffs and screws.

Next, let's make sure we have all our cables in order:

- Plug the short HDMI cable we ordered (9.2.26) into the HDMI socket of the Jetson-TK1. Route the cable into Node Zero through the slot provided in the back plate, across Node Zero, and back out through the leftmost slot provided in the Node Zero Front Plate.
- Plug one of the Ethernet cables we made into the Jetson-TK1's built-in jack, and route the cable through the notch in the Node Zero Back Plate, as we did for all the other Nodes.
- Plug the other Ethernet cable into the jack in the Ethernet Daughter Board.
- Plug one of 12 volt Power cables we made in the Jetson-TK1, and route it back into Node Zero through the notch in the Node Zero Front Plate, as we did for all the other Nodes.
- We will use the other 12 volt cable we made to power the HDMI monitor. There is a wide notch provided in the Jetson Front Plate (shared with the HDMI cable) to run it inside the Jetson nodes and down to our Power Supply. We want the plug dangling about 4.5" outside of Node Zero.
- Plug the short USB3 cable we ordered (9.2.23) into the USB3 Hub. Bend it back on itself and secure with a cable tie. (See Figure 12). Plug the other end of the cable into the USB3 socket of the Jetson-TK1. Route the cable through the notch provided for it in Node Zero Back Plate.
- Plug the USB3 power cable we cut off in step 5.2 into the USB3 Hub, if it is not still there.

Run the USB3 Power cable and the Ethernet cable connected to the Jetson's built-in jack down the Node 7 (at the right).

Run the Jetson's Power cable, the other Ethernet cable, and the Monitor's power cable down Node 1 (at the left).

Slide the Node Zero Assembly down over the standoffs in the Rim Plate. Fasten with 6 flat-head screws.

Congratulations! All eight Jetson-TK1 Nodes have been assembled and tested individually. Let's assemble the Base and bring the P2C2 to life!

6.0 Assembling the Base

The P2C2 Base consists of an 8-Port Gigabit Ethernet Switch (9.2.28) and a 12 volt Power Supply (9.2.29) housed in a very nice off-the-shelf Aluminum Enclosure (9.2.27). We have to modify the Box. We will use 3D-printed templates to help us position all required holes and cutouts in the Box.

6.1 Print the Box Templates

Print one each of "Box_drill_guide_Top.STL" (9.1.15), "Box_drill_guide_Bottom.STL" (9.1.16), "Box_left_side_template.STL" (9.1.17), and "Box_right_side_template.STL" (9.1.18). Use any color plastic available, because we will throw them out after we use them.

6.2 Modify the Box

The first step in modifying the Enclosure is to drill lots of holes. In general, we want to use a hammer and punch at drill center locations to keep the drill bits from wandering. Another trick is to drill small pilot holes before drilling larger holes. The Box Top and Bottom Templates have 3.5mm pilot holes for this purpose.

6.2.1 Modify the Box Side Plates

Use the Right and Left Box Side Templates to mark cutout locations and hole centers on the Box Side Plates. Refer to for the hole sizes. For the cutouts, we want to remove as much of the metal first by drilling large holes, to save filing later.

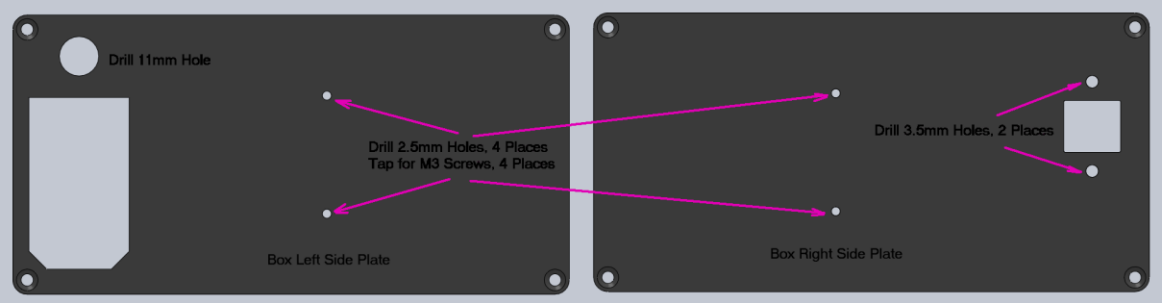


Figure 14. Box Side Plate Modifications

Tap the four 2.5mm centrally located holes with an M3 tap. These are for mounting a handle strap.

File the cutout area in the Box Right Side Plate to fit the RJ-45 Panel Mount Socket (9.2.32). Install the part when the correct fit is achieved.

File the cutout area in the Box Left Side Plate to fit the AC Socket w/ Switch and Fuse (9.2.33). Install the part when the correct fit is achieved. Don't forget to install a 10 Amp fuse (9.2.34) and a spare.

Install the auxiliary 2.1mm x 5.5mm 12v DC Power Jack (9.2.35) in the Box Left Side Plate as well.

6.2.2 Modify the Box Top and Bottom

First we need to mark the front side of the Box Top and Bottom by checking that the tongue and groove mesh as desired when we close the clamshell case. We want the Box Bottom to have the tongue in front, and the Box Bottom to have the groove in front (or vice versa).

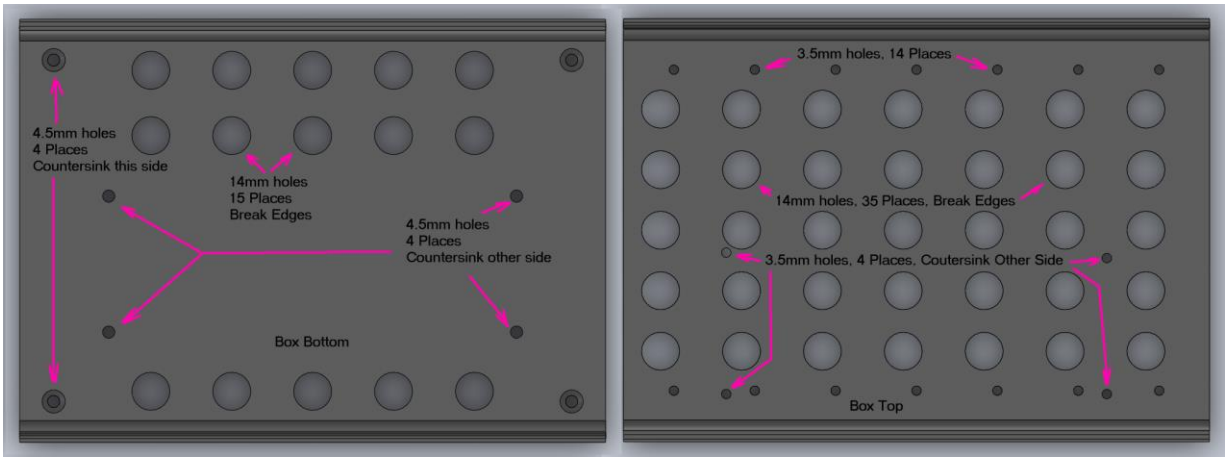


Figure 15. Box Top and Bottom Modifications

Use the templates to drill all the 3.5mm pilot holes in the Box Top and Bottom. Then refer to Figure 15 and drill to final size. Countersink the holes for flat-headed screws, as specified.

6.3 Install the Feet

Use four M4 flat head screws and matching nuts to install the Black Rubber Feet (9.2.31) to the Box Bottom.

6.5 Install the Power Supply

Apply thermal grease or some other heat-transferring material to the bottom of the 12 volt Power Supply (9.2.29). Orient the Power Supply so that the terminals are at the right side of the Box Bottom. Fasten the Power Supply to the Box Bottom using four flat-headed M4 screws.

Fasten the Box Left Side to the Box Bottom using two of the black sheet metal screws supplied with the box. Wire the 120v AC circuit, so the Power Supply gets input. I insulated all connections with heat-shrink tubing where possible, and with hot glue where not.

Insert the 10 ft. Right angle AC cable (9.2.30) and turn on the Power Supply. Measure the DC output voltage with a multi-meter. Adjust the voltage using the potentiometer on the Power Supply, if necessary, until it is 12 volts. Now we need to turn off the power supply and unplug the AC cord from the wall and the power supply.

Next we need to connect a 12 GA lead to each of the six DC terminals (3 @ +12 volts and 3 @ GND). I used a crimp-on circular lug to connect each wire, bending each up at a right angle so I could install the Box Right Plate. After all wires were connected, I insulated the terminals with hot glue, and added a layer of Kapton tape to the Box Right Plate for good measure.

6.6 Install the 8-Port Ethernet Switch

Leaving the Box Bottom for the moment, let's work on the Box top.

First we need to make four F/F 4-40 (or M3) standoffs (9.2.2) of length 15.5mm. Fasten these to the inside of the Box Top using four 4-40 (or M3) flat head screws.

Feed the Ethernet cable and 12 volt DC cable from each of Nodes 1-7 through a hole at the rear of the Box Top. Feed the cables from Node Zero in the side holes. Now fasten the Box Top to the bottom of the Vertical Nodes using the same sheet metal screws we used for the Top Rim Plate.

Now we need to void another warranty by removing the 8-Port Gigabit Ethernet Switch (9.2.28) from its case, and mounting it upside down on the standoffs we added to the Box Top.

We don't have room for the Ethernet Switch's power jack, so we will have to hard-wire it. Solder a 1 foot length of our red and black 2-conductor wire to the power jack connector pins on the Ethernet Switch, making sure the red wire goes to the center pin of the jack.

Cover the entire back of the PCB with a layer of Kapton Tape, to prevent shorts.

Finally, cut each Ethernet Cable from the Nodes to an appropriate length and crimp on an RJ45. Plug them all in to the Ethernet Switch. The Ethernet cable from Node Zero's additional Ethernet port should plug in to the RJ-45 socket in the Box Right Side.

6.7 Wire All the 12 volt Connections

After wiring up all the 12 connections, our assembly should be looking pretty much like Figure 16.

Let's close up the Base using the remaining black sheet metal screws supplied with the Box.

Figure 16. Inside the P2C2 Base

7.0 Assembling the Handle

7.1 Bend and Drill the Handle Strap

Bend and drill the 1/8” x 3/4” flat aluminum bar stock (9.2.36) using the dimensions shown below (Figure 17). All dimensions are in millimeters. Note that 3 digits of precision are probably not required. Countersink the side holes so that M3 flat head screw heads wind up flush to the surface.

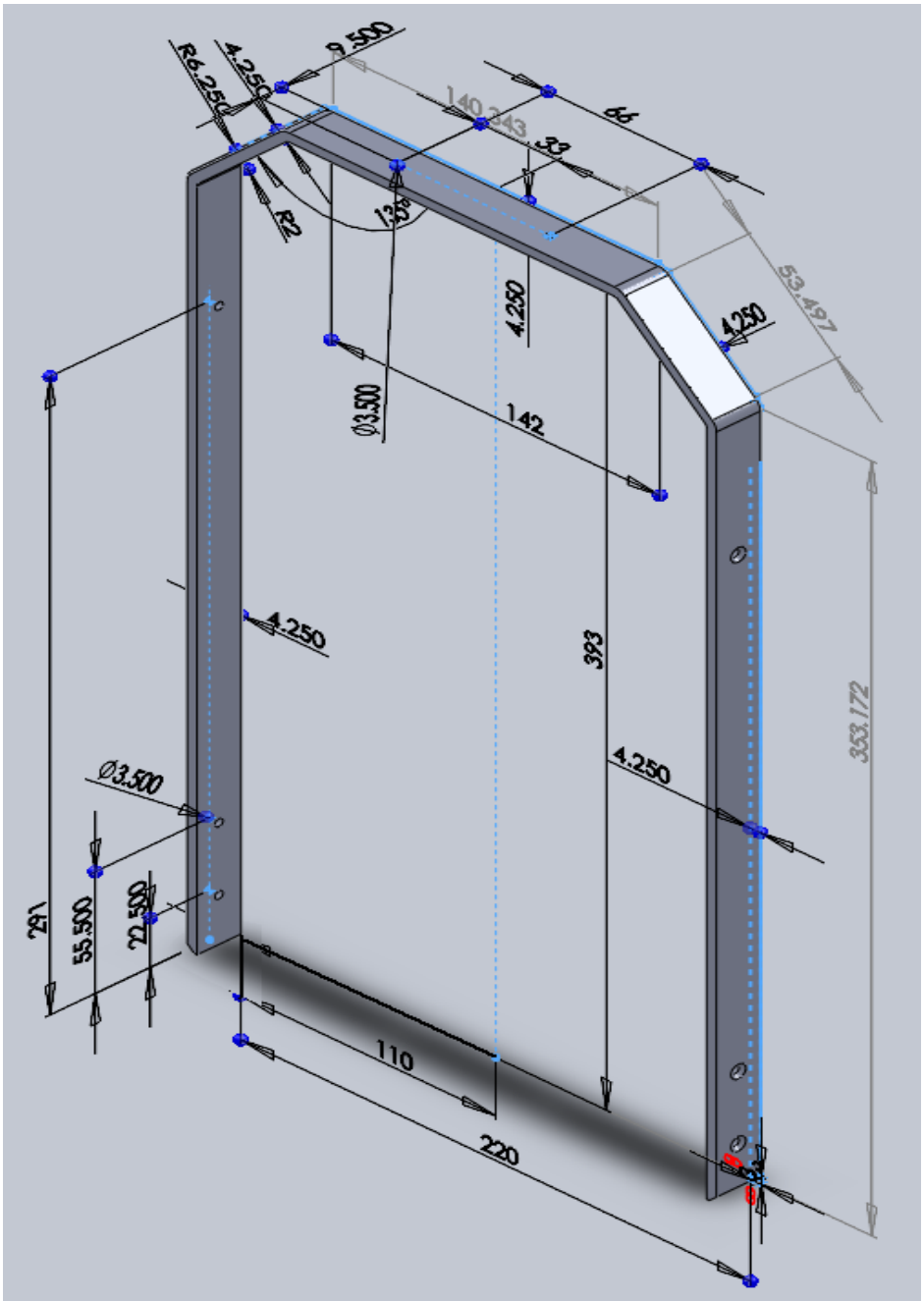


Figure 17. Handle Strap Dimensions

7.2 Print the Handle Shims

Print the “Handle_Shim_Pair.STL” part (9.1.8) in black. Once finished, separate the two semicircular halves, and cut away any waste plastic. The two pieces should sandwich the top of the strap. The bumps on the flat sides of the pieces should fit neatly into the two holes drilled in the strap.

7.3 Slip on the Handle Grip

Slide one of the Black Silicone Bike Grips (9.2.37) up the Handle Strap, and around the two Handle Shims, locking them in place.

7.4 Attach the Handle Assembly

Attach the Handle Assembly to the P2C2 Base and Node Side Plates using 6 flat head M3 screws. Use 5mm log screws for the Base, and 10mm long screws for the plastic Plates.

8.0 Final Assembly

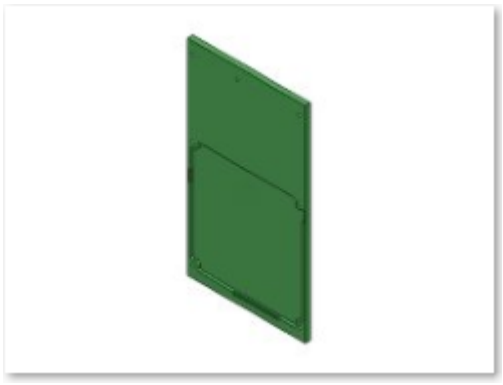
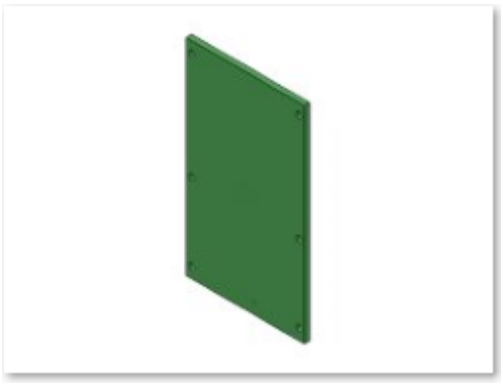
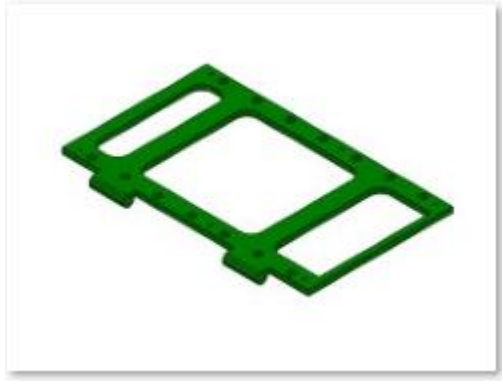
Attach the Monitor, insert the Mouse/Keyboard and USB Wireless dongles (9.2.38), plug it in, and ….

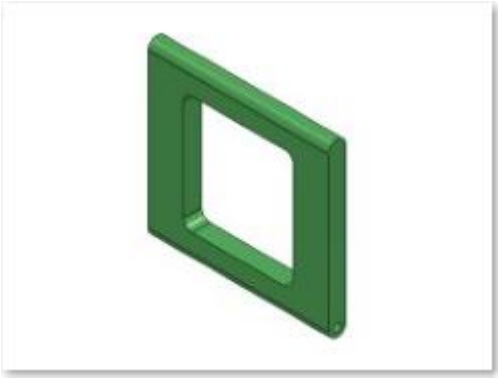
Wow!

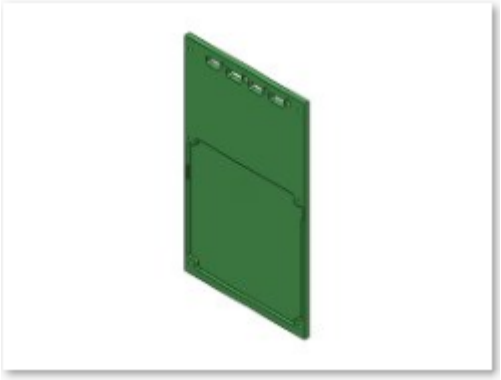
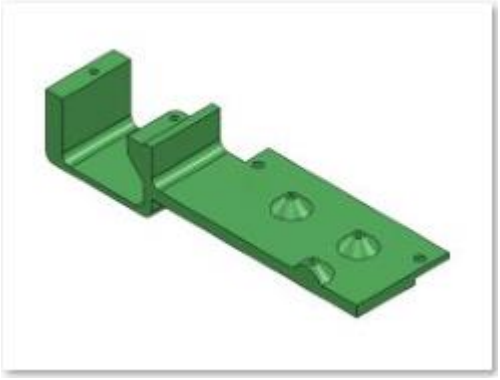
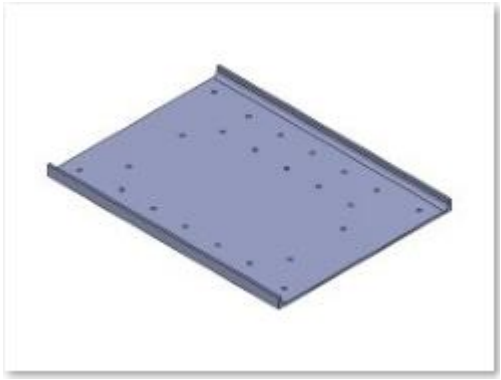
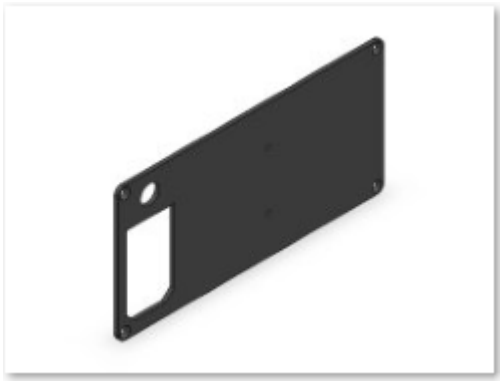
Figure 18. It's Alive and Running CUDA

9.0 Parts List

9.1 Printed Parts

9.1.1  JETSON_NODE_LEFT.STL, Quantity 1	9.1.2  JETSON_NODE_RIGHT.STL, Quantity 1
9.1.3  JETSON_NODE_FRONT.STL, Quantity 7	9.1.4  JETSON_NODE_BACK.STL, Quantity 7
9.1.5  JETSON_TOP_RIM.STL, Quantity 1	9.1.6  MONITOR_BRACKET.STL, Quantity 1

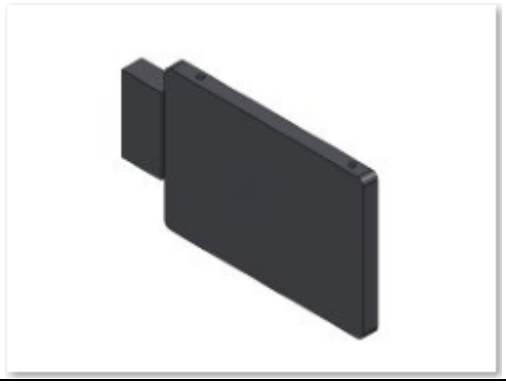
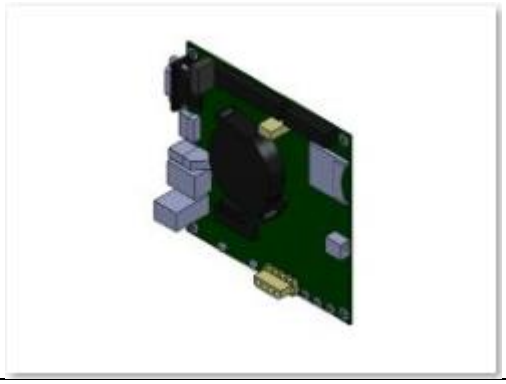
9.1.7  MONITOR_LEG.STL, Quantity 1	9.1.8  HANDLE_SHIM_PAIR.STL, Quantity 1
9.1.9  JETSON_NODE_ZERO_LEFT.STL, Quantity 1	9.1.10  JETSON_NODE_ZERO_RIGHT.STL, Quantity 1
9.1.11  JETSON_NODE_ZERO_FRONT.STL, Quantity 1	9.1.12  JETSON_NODE_ZERO_BACK.STL, Quantity 1

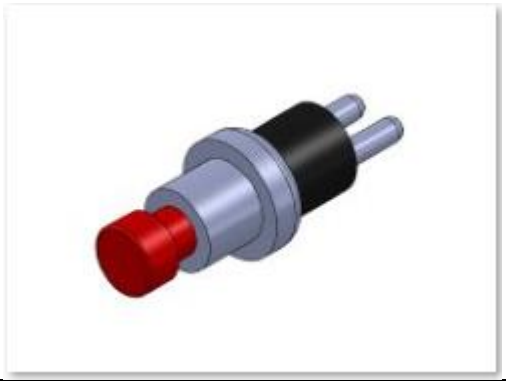
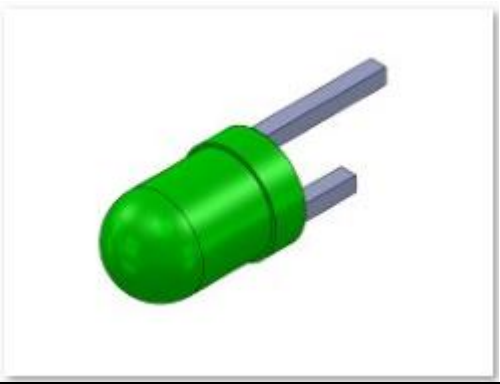
9.1.13  JETSON_NODE_ZERO_TOP.STL, Quantity 1	9.1.14  RTC_RJ45_BRACKET.STL, Quantity 1
9.1.15  BOX_DRILL_GUIDE_BOTTOM.STL, Quantity 1	9.1.16  BOX_DRILL_GUIDE_TOP.STL, Quantity 1
9.1.17  BOX_LEFT_SIDE_TEMPLATE.STL, Quantity 1	9.1.18  BOX_RIGHT_SIDE_TEMPLATE.STL, Quantity 1

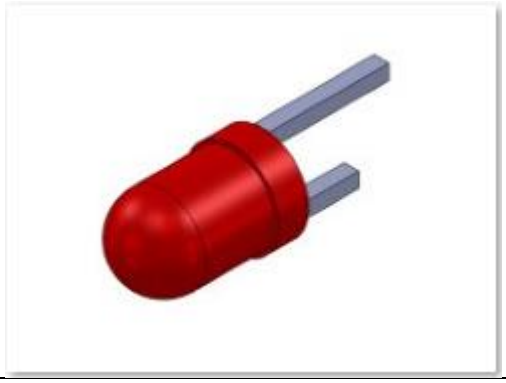
9.2 Purchased Parts

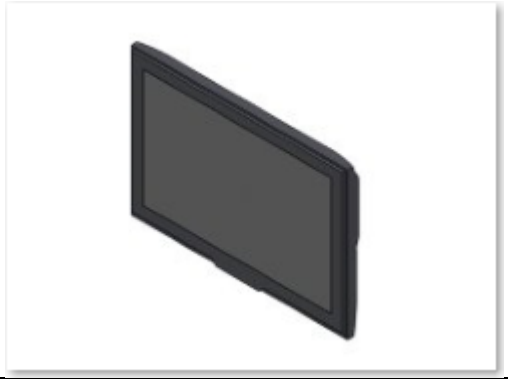
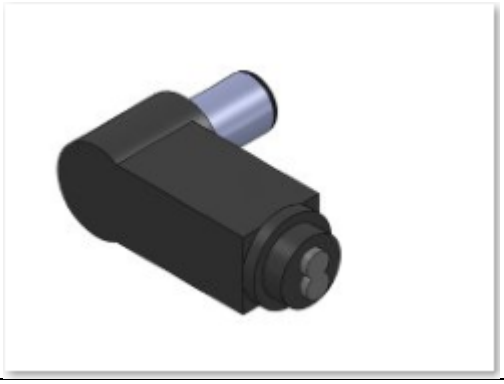
The grand total for all purchased parts listed here is $3424.49, not including glues, tapes, cable ties, screws, etc. So let's say I spent about **$3500 + tax + shipping**.

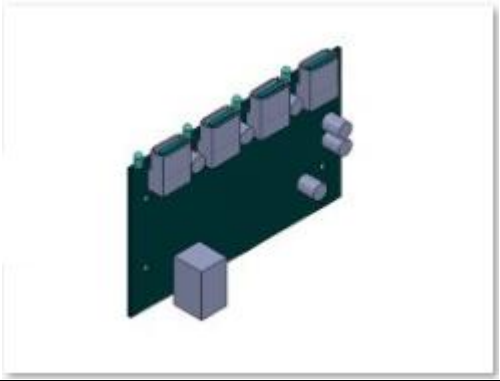
9.2.1 	1.7mm PLA Filament – Green .5KG Quantity 2 @ $19.99 each http://www.frys.com/product/8126675#detailed
9.2.2 	Aluminum F/F Standoff 4-40 x 1.5" long **(Cut 6 to 28mm, Cut Screwdriver Slot 1 End)** **(Cut 4 to 15.5mm)** Quantity 10 @ $0.93 each http://www.mouser.com/ProductDetail/Keystone-Electronics/2206/?qs=%2fha2pyFadugftCl4iYz3wA5HKn%252bMLnFbGaA0wZFre%252bg%3d
9.2.3 	Aluminum M/F Standoff 4-40 x 1.125" long **(Cut to 28mm, Cut Screwdriver Slot in Flat End)** Quantity 42 @ $0.80 each http://www.mouser.com/ProductDetail/Keystone-Electronics/8406/?qs=1eFRaVyeUDWSElh1VosoQg==

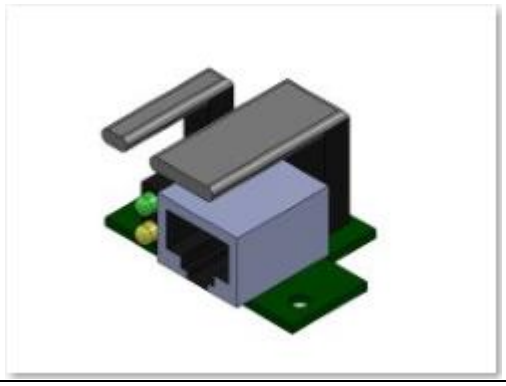
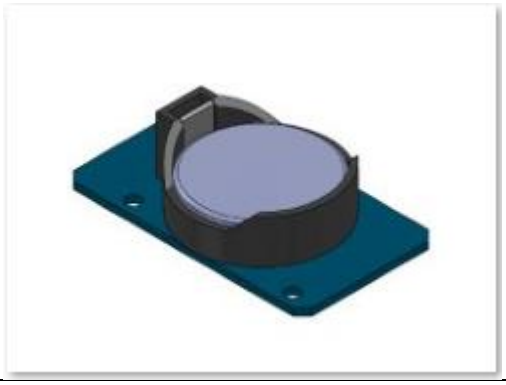
9.2.4 	6”” 4 Pin Molex to SATA Power Cable Adapter **(Modify to Make MOLEX End Right Angle)** Quantity 8 @ $1.99 each http://www.amazon.com/gp/product/B00009YFTI/ref=oh_aui_detailpage_o03_s01?ie=UTF8&psc=1
9.2.5 	SATA III 6.0 Gbps Cable, 6 Inch, Right Angle Quantity 8 @ $6.99 each http://www.amazon.com/gp/product/B00K1JGU40/ref=oh_aui_detailpage_o03_s02?ie=UTF8&psc=1
9.2.6 	Samsung 850 Pro 2.5” Solid State Drives 512 Gigabytes: Quantity 1 @ $319.99 128 Gigabytes: Quantity 7 @ $109.99 each http://www.newegg.com/Product/Product.aspx?Item=9SIA3FA2EV1099&cm_re=MZ-7ke512bw-_-20-147-361-_-Product
9.2.7 	NVIDIA JETSON-TK1 Development Kit Quantity 8 @ $192.00 each http://www.newegg.com/Product/Product.aspx?Item=N82E16813190005&cm_re=JETSON-TK1-_-13-190-005-_-Product

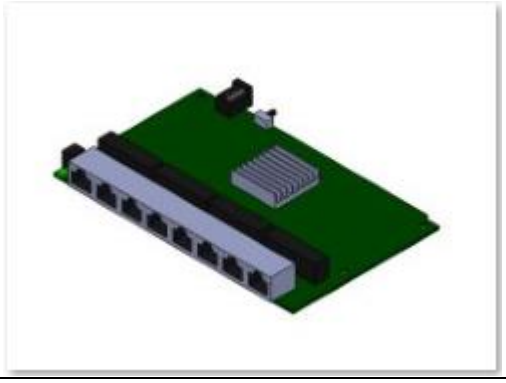
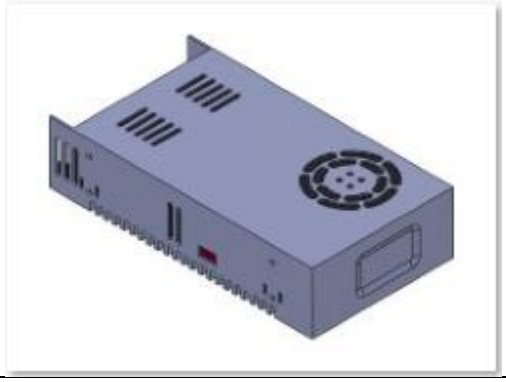
9.2.8 	Green Momentary Pushbutton Switch Quantity 8 @ $0.95 each https://www.sparkfun.com/products/11993
9.2.9 	Red Momentary Pushbutton Switch Quantity 8 @ $0.95 each https://www.sparkfun.com/products/11992
9.2.10 	Yellow Momentary Pushbutton Switch Quantity 8 @ $0.95 each https://www.sparkfun.com/products/11995
9.2.11 	Green 3mm LED Quantity 8 @ $.35 each https://www.sparkfun.com/products/9650

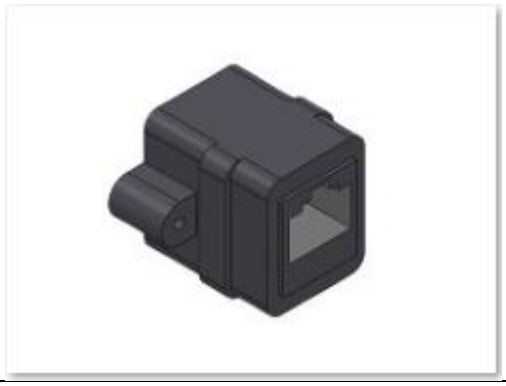
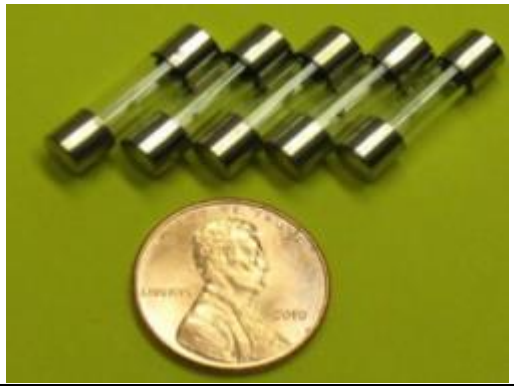
9.2.12 	Red 3mm LED Quantity 8 @ $.35 each https://www.sparkfun.com/products/533
9.2.13 	10 conductor Ribbon Cable 15 ft. @ $4.95 https://www.sparkfun.com/products/10647
9.2.14 	Ribbon Crimp Connector - 10-pin (2x5, Female) 10 @ $0.50 each https://www.sparkfun.com/products/10650
9.2.15 	2mm 10-pin header (Cut Each Piece in Half –> 5 pins) Quantity 5 @ $0.95 each https://www.sparkfun.com/products/10112

9.2.16 	LILLIPUT FA1014-NP/C/T 10.1” HDMI Monitor Quantity 1 @ $275.00 each http://www.newegg.com/Product/Product.aspx?Item=9SIA3052C48223
9.2.17 	USB Wireless Keyboard and Mouse Combo Quantity 1 @ $29.99 http://www.amazon.com/dp/B00EQ32YPG?psc=1
9.2.18 	18 GA gauge Red/Black speaker wire 100 ft. @ $12.95 http://www.amazon.com/Audiopipe-Gauge-Black-Conductor-Speaker/dp/B00J38SGTW/ref=sr_1_9?s=electronics&ie=UTF8&qid=1425272479&sr=1-9&keywords=18+gauge+speaker+wire
9.2.19 	Right Angle 5.5mmx2.1mm Male Plug Quantity 15 @ $4.90 for all http://www.amazon.com/gp/product/B00O9Y64LM/ref=oh_aui_detailpage_o07_s00?ie=UTF8&psc=1

9.2.20 	CAT6 Ethernet cable **(Cut to appropriate lengths)** 50 ft. @ $11.99 http://www.amazon.com/Cable-Matters-Snagless-Ethernet-Patch/dp/B00B3VL3SS/ref=sr_1_20?ie=UTF8&qid=1425301221&sr=8-20&keywords=cat+6+ethernet+cable+50+ft
9.2.21 	RJ-45 Crimper Kit Quantity 1 @ $11.97 http://www.amazon.com/Wild-us-Tester-Crimper-Connector-Network/dp/B008UY5WL0/ref=sr_1_2?ie=UTF8&qid=1425300265&sr=8-2&keywords=rj45+crimp+tool+kit
9.2.22 	Anker AH111 USB 3.0 4-Port Hub **(Remove Case, Move LEDS to point forward)** Quantity 1 @ $25.99 http://www.amazon.com/Anker%C2%AE-AH111-4-Port-Adapter-Chipset/dp/B005QWY3PU/ref=sr_1_1?ie=UTF8&qid=1425308991&sr=8-1&keywords=anker+AH111
9.2.23 	1.5 Ft. USB 3.0 A Male to B Male Cable Quantity 1 @ $2.50 each http://www.newegg.com/Product/Product.aspx?Item=N82E16812422968

9.2.24 	Gigabit Ethernet Mini-PCIE Module **(Remove Mounting Bracket)** Quantity 1 @ $23.99 each http://www.amazon.com/Syba-Gigabit-Ethernet-Controller-SD-MPE24031/dp/B00B524102
9.2.25 	I2C Real-Time Clock Module **(Remove header and solder wires to other end)** Quantity 1 @ $2.54 each http://www.dx.com/p/ds3231-high-precision-real-time-clock-module-blue-3-3-5-5v-222910#.VPSBTi7Fqjw
9.2.26 	1.5 ft. Thin HDMI Cable Quantity 1 @ $7.95 each http://www.amazon.com/gp/product/B00CKZK4G8/ref=oh_aui_detailpage_o01_s00?ie=UTF8&psc=1
9.2.27 	6016H-8.5B Black Aluminum Box w/ Plain Ends 8.5” L x 6.144” W x 3.090” H Quantity 1 @ $41.95 each http://www.scienceshopusa.com/product-p/ce-50180.htm

9.2.28 	NETGEAR ProSAFE GS108 8-Port Gigabit Switch Quantity 1 @ $44.99 each http://www.amazon.com/NETGEAR-ProSAFE-Gigabit-Desktop-GS108-400NAS/dp/B00MPVR50A/ref=sr_1_1?s=electronics&ie=UTF8&qid=1425835556&sr=1-1&keywords=netgear+8+port+gigabit+switch
9.2.29 	12 volt Power Supply MegaWatt S-400-12v x 36 Amps 430 Watts Quantity 1 @ $69.00 http://www.amazon.com/gp/product/B00LIBRKQM/ref=oh_aui_detailpage_o01_s00?ie=UTF8&psc=1
9.2.30 	10 ft. Right angle AC cable Quantity 1 @ $10.99 each http://www.amazon.com/CablesOnline-Right-Angle-3-Conductor-Connector-PC-310R/dp/B00E25WRFK/ref=sr_1_cc_2?s=aps&ie=UTF8&qid=1425835280&sr=1-2-catcorr&keywords=right-angle+ac+cord
9.2.31 	Black Rubber Foot Quantity 10 @ $4.23 for all http://www.amazon.com/gp/product/B008LTY1NO/ref=oh_aui_detailpage_o07_s01?ie=UTF8&psc=1

9.2.32 	RJ-45 Panel Mount Socket Quantity 1 @ $4.00 each http://www.amazon.com/gp/product/B00PYX3IWK/ref=oh_aui_detailpage_o09_s00?ie=UTF8&psc=1
9.2.33 	AC Socket w/ Switch and Fuse Quantity 1 @ $4.81 each http://www.amazon.com/gp/product/B00511QVVK/ref=oh_aui_detailpage_o04_s00?ie=UTF8&psc=1
9.2.34 	Fast-Blow Fuse 10 Amp 250v GMA10A 5-Pack @ $5.77 for all http://www.amazon.com/gp/product/B004HLYUE0/ref=oh_aui_detailpage_o09_s00?ie=UTF8&psc=1
9.2.35 	2.1mm x 5.5mm 12v DC Power Jack Quantity 3 @ $9.23 for all http://www.amazon.com/gp/product/B00JR591DG/ref=oh_aui_detailpage_o09_s02?ie=UTF8&psc=1

9.2.36 	1/8” x ¾” x 72” flat Aluminum Bar Quantity 1 @ $9.76 http://www.amazon.com/National-Mfg-N247049-Aluminum-Rectangular/dp/B002CU55RO/ref=sr_1_4?s=industrial&ie=UTF8&qid=1425836585&sr=1-4&keywords=1%2F8%22x3%2F4%22+aluminum+flat+bar
9.2.37 	Black Silicone Bike Grip 1 Pair @ $16.24 http://www.amazon.com/ESI-Chunky-MTB-Grip-Black/dp/B003FAGDNK/ref=sr_1_cc_1?s=aps&ie=UTF8&qid=1425835141&sr=1-1-catcorr&keywords=Black+silicone+bike+grips+ESIgrips
9.2.38 	Wireless-N USB Adapter /w Antenna Quantity 1 @ $19.99 each http://www.amazon.com/Panda-300Mbps-Wireless-N-Adapter-button/dp/B00JDVRCI0/ref=pd_cp_pc_0/184-6218321-2294305