Button Press : Treat Express

A Part of Dog Toy Complex

August 13, 2018

Contents

1 Overview

1.0.1 Description

Button Press : Treat Express is an interactive toy with a wooden structure; electronics manage buttons and treat dispensing. Various games can be programmed; the default game is to press the lit button, then a bottle is rotated to dispense treats.

1.0.2 Project's Goals and Priorities

Button Press : Treat Express is meant to be able to be used independently, be educational, and be entertaining. Its design is customizable and simple enough to be built by anyone. Documentation and models are provided gratis and libre so that users can be unburdened and knowledge can be shared to grow the project and its users.

2 Components

2.1 Discussion on Components

The list of required components used in this project are what I used; it's not a list of universally available products nor was there any attempt to find replacements for parts I had on hand. This isn't a great way to make a parts list. Ideally the components would all be purchased from some international distributor like Digi-Key or Mouser. When this project is fully integrated into the Dog Toy Complex and component overlap is taken into account on design my plan is to create a universal list. As for now, it's not unreasonable for a user to source parts and make adjustments accordingly. I did try to purchase the components from only a handful of locations and they are listed.

2.1.1 Discussion on Adafruit Latching Mini Relay FeatherWing

I chose to use a prebuilt relay circuit from Adafruit since many of the components were being purchased there. A prototype of Button Press : Treat Express had a different treat dispensing mechanism that used a sensor to detect a full cycle of rotation and at that time I figured a latching relay would be best. It likely doesn't matter if a latching or non latching relay is used. I chose to use a mechanical relay rather than a solid state relay or a simple transistor due to its simplicity and current carrying capacity. The clicking noise can also benefit dog-toy interaction as it provides an automatic audio cue denoting success.

2.1.2 Discussion on the SimpleLink MSP432P401R LaunchPad

I chose the Texas Instruments SimpleLink MSP432P401R Launchpad to fulfill multiple purposes. I wanted to program on an ARM Cortex M, I wanted a powerful board that is capable of being used in other projects, and I wanted it all to be on an inexpensive platform.

2.2 Table of Components

The table of components lists the necessary parts and the reason for their use. If the exact component can't be sourced, then only the reason needs to be fulfilled.

Table 2.1: Components

Amount	Component	Reason	Purchase Location
1	Geared motor	Rotates treat bottle to dispense treats	
1	SimpleLink MSP432P401R LaunchPad	Takes input and activates relay	www.ti.com/tool/msp-exp432p401r
1	Adafruit Latching Mini Relay FeatherWing	For switching power to motor	https://www.adafruit.com/product/2923
1	20 Gauge Copper Stranded Wire 40 Feet	Wiring, uses a little less than 40 feet	Hobby store, model train section
1	Adafruit Perma-Proto Quarter-sized	Board for the two circuits	https://www.adafruit.com/product/1608
1	Arcade Button with LED - 30mm Translucent Clear	Input	https://www.adafruit.com/product/3491
1	Arcade Button with LED - 30mm Translucent Blue	Input	https://www.adafruit.com/product/3490
1	Arcade Button with LED - 30mm Translucent Yellow	Input	https://www.adafruit.com/product/3488
3	PN2222 NPN Bipolar Transistor	Switches for LEDs in arcade buttons	https://www.adafruit.com/product/3599
3	1K Ohm Resistor 1K Ohm 1/4 Watt Resistor	Pull up resistor for transistor switches	
21 1	Male Header Pins Solder	For connections on electronics boards For creating electronics boards	Off of Adafruit Mini Relay FeatherWing
1	Electronics Parts Mount	For mounting electronics to stand	
10	2.5mm x 12mm Bolt	For mounting electronics boards	Hardware Store
10	2.5mm Nut	For mounting electronics boards	Hardware Store
12	Female Spade 2.8mm Open Barrel Crimp Terminal	Wiring	amzn.com/B01MQ31H7Z
32	Mini PV 2.54mm	Wiring	
32	Mini PV 2.54mm Housing	Wiring	https://mod-one.com/
11	Male ATX Terminal	Wiring	https://mod-one.com/
1	Male ATX Connector	Wiring	https://mod-one.com/
1	ATX power supply	Power	
1	ATX power supply cable	Power	
1	1” x 8” x 6’ Common Board	Structural	Hardware store
12	#8 x 1.5 inch	Fasteners to join the wood	Hardware store
4	Hook and Loop cable ties	Mount bottle, manage cables	Hardware store
1	8.5 oz Al Coke bottle	Treat dispenser	
1	Soda bottle lid that fits bottle	Treat dispenser	
1	Printed electronics mount	Mount electronics	3D printed
1	Printed bottle mount	Mount bottle	3D printed

3 Tools

3.1 Discussion on Tools

Not a lot of tools are required for this project. Cutting and fastening the wood requires basic woodworking tools. The electronics can be assembled using an inexpensive soldering iron and flux.

3.1.1 Tools I Used and Recommended Upgrades

The major tools in my case that I already had were a pull saw, a 3/8" drill driver and drills, two rulers (one short, one long), and an inexpensive soldering iron with a tip cut with a diamond wheel. In an attempt to keep cost low I only purchased two 6" bar clamps; they seem to perform much better on wood than the clamps I had. On the prototype I used self driving spade drills and they were a disaster; the feed rate was uncontrollable so the holes' finish was miserable and the drill consistently stalled. I upgraded to multi-purpose hole saws; drilling and hole finish was greatly improved, but at an increased cost. In the prototype I soldered all of the connections and purchased pre-made cables. This limited my options and was a bit ugly so I decided to invest in cable crimping skills.

A better set of tools would include; enough clamps to set the entire stand up for its fasteners, a robust soldering iron with proper tips, a square for drawing orthogonal lines consistently and quickly, helping hands or a vise to manage the components and Perma-Proto Board, .

3.1.2 Notes About the MDPC MD-CTX3 Crimping Tool

For this project I used the MDPC MD-CTX3 crimp tool (https://www.cable-sleeving.com/crimping-tool). It's about two to four times more expensive than some of the cheaper models found around the internet, but it's also significantly cheaper then the official tools. I reasoned this was a good compromise when venturing into terminal crimping and that I would use it frequently in the future. Quality tools can also result in better crimps.

3.2 Table of Tools

This table lists general descriptions of the tools used in to create this project; it does not specify where to source the tools since user preference helps pick through the numerous options.

Table 3.1: Components

Tool	**Reason**
Wood Saw	To cut the board into parts
Wire Stripper for 20ga stranded	To strip wires for terminal crimping
Wire Cutter	Cutting wires to length
5/64” twist drill for soft wood	For drilling pilot holes
11/64” twist drill for soft wood	For drilling clearance holes
1-3/4” (44 mm) hole saw	For cutting the motor hole
1-1/8” (29 mm)	For cutting the arcade button holes
5/8” spade drill	For cutting the treat dispensing hole
Open Barrel Terminal Crimp Tool	For crimping the terminals
Bit for #8 screws	To drive the screws
Bit for electronics’ mount bolts	To drive the bolts
Clamps for wood	To position the wood for fastener application
Soldering iron	To solder the electronics components
Soldering flux	Used to control oxidation on solder joints
Handle for holding driver bit	For tightening wood screws and electronics mounting screws
Electronic drill driver	For driving wood screws quickly and making holes
Medium grit sand paper (P40-P120)	For light finishing of the wood
Marking tools	To draw locating marks and write labels
Ruler	To measure board dimensions and locating marks
PPE	Protect eyes, respiratory, hands, hearing
Computer	To program the Launchpad
USB Micro B to USB A	To program the Launchpad
3D Printer	To print the bottle mount and electronics mount

4 Software

4.1 Software Used

4.1.1 Blender

Blender (https://www.blender.org/) was used to model the stand and design the 3D printed components. The models are split into two files one with units in USCS (inches) and the other in SI (mm). At some point the models can be ported to parametric modeling software.

4.1.2 Code Composer Studio

Code Composer Studio (http://www.ti.com/tool/CCSTUDIO) was used to program the TI Launchpad.

4.1.3 LaTeX and Texmaker

The documentation is written with LaTeX, using MiKTeX (https://miktex.org/) with Texmaker (http://www.xm1math.net/texmaker/) as the graphical interface.

5 Instructions

5.1 Notes on instructions

These instructions offer tips and tricks, but do not dictate the exact methods to construct Button Press : Treat Express. There are a number of resources that offer clear instruction on specific topics involved in this project including sourcing parts, woodworking, electronics, terminal crimping, soldering, and programming. Each instruction should contain enough information that experience or light research will be enough of a guide. It's my hope that these instructions will be improved through clarification of confusion and questions.

5.2 Constructing the Wooden Stand

5.2.1 Notes about the Wooden Stand

Wood Quality

The wooden stand is built with inexpensive softwood which is easily scratched and dented. A hardwood would likely be better, but the cost is significantly more. Finishing techniques like shaping, sanding, and jointing to improve board dimensions can improve fitment.

Clean Cuts

The markings do not compensate for the saw's kerf. This isn't terribly important as the relative dimensions and the way the stand is connected make it all work. This does make it more complicated to produce cleaner cuts. To reduce splintering when sawing it's a common practice to cover the area to be cut with masking tape and use a razor to cut surface deep and parallel to the cut to be made, but a distance away from the cut line; this isn't taken into account in the markings.

Pilot and Clearance Holes

Best practice for using screws is to drill pilot and clearance holes. Pilot holes are drilled into the portion of wood the screw threads will pull towards the screw head. The threads should not touch the portion that the screw head uses as a bearing surface, many screws take this into account by having a section of the shaft without threads. If this is not the case it's good practice to drill clearance holes that provide enough distance around the screw to allow for the threads to pass without touching the walls. In this project drilling pilot holes helps with alignment and can help keep the screws straight.

Clamping

Constructing the wooden stand piecemeal has its challenges, so it's likely best to clamp all of the boards together and apply the screws. The provided images display locating marks without all of the boards in position for a clearer image.

Fastener Location

Since the screws aren't supporting much shear stress from gravity and dog interaction the fastener location isn't terribly critical. The marks have them located in a way that subdivides the surface evenly, but structurally a better way would to have them spaced apart to resist torque applied to the board.

5.2.2 Mark the 1” x 8” x 6’ common board

Mark the common board for cut marks, drill marks, and board locating marks. The marks were designed to fit large dogs (about 50 - 90 lbs), but the height can be adjusted by varying the leg height. At this size there is about a 2 inch buffer for bad ends or skipping cuts around knots.

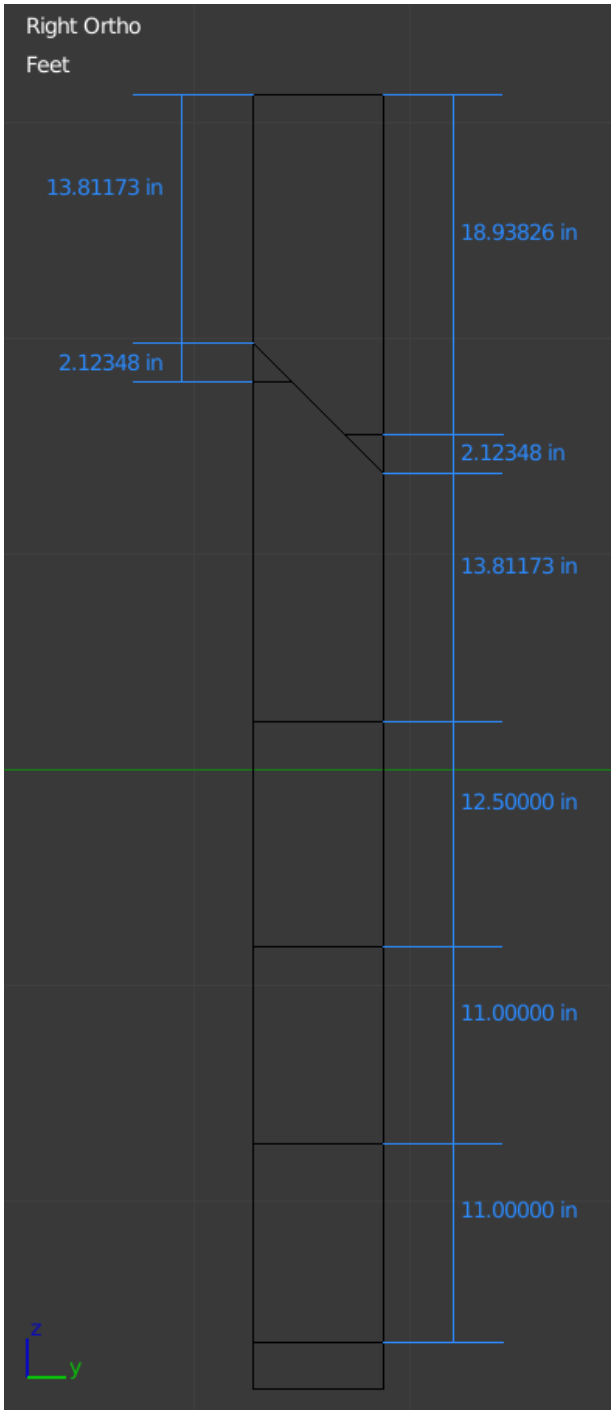

Figure 5.1: Marks to cut the board into its pieces.

5.2.3 Cut the common board

Cut the common board along the marks. Covering the cut lines in masking tape can help reduce splintering. Any leftover parts can be saved for later use.

5.2.4 Drill top board and motor mount board holes

Drill ADD DIMENSIONS pilot holes and the arcade button holes on the marks for the top board and drill the motor hole on the motor mount board. It's not completely necessary to drill the holes before clamping but it can be easier to drill orthogonally when the board isn't mounted.

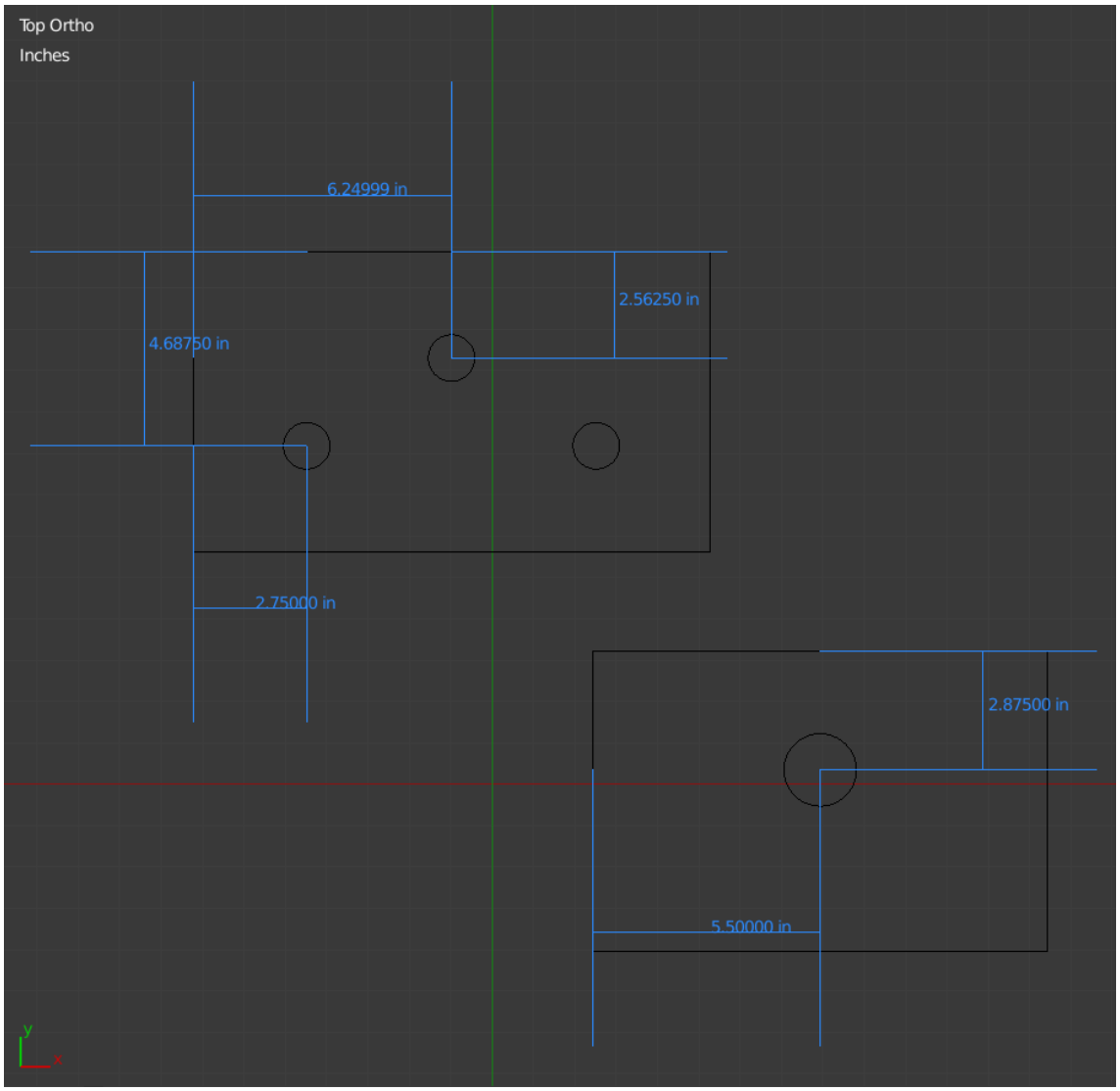

Figure 5.2: Locations of holes for the arcade buttons and motor.

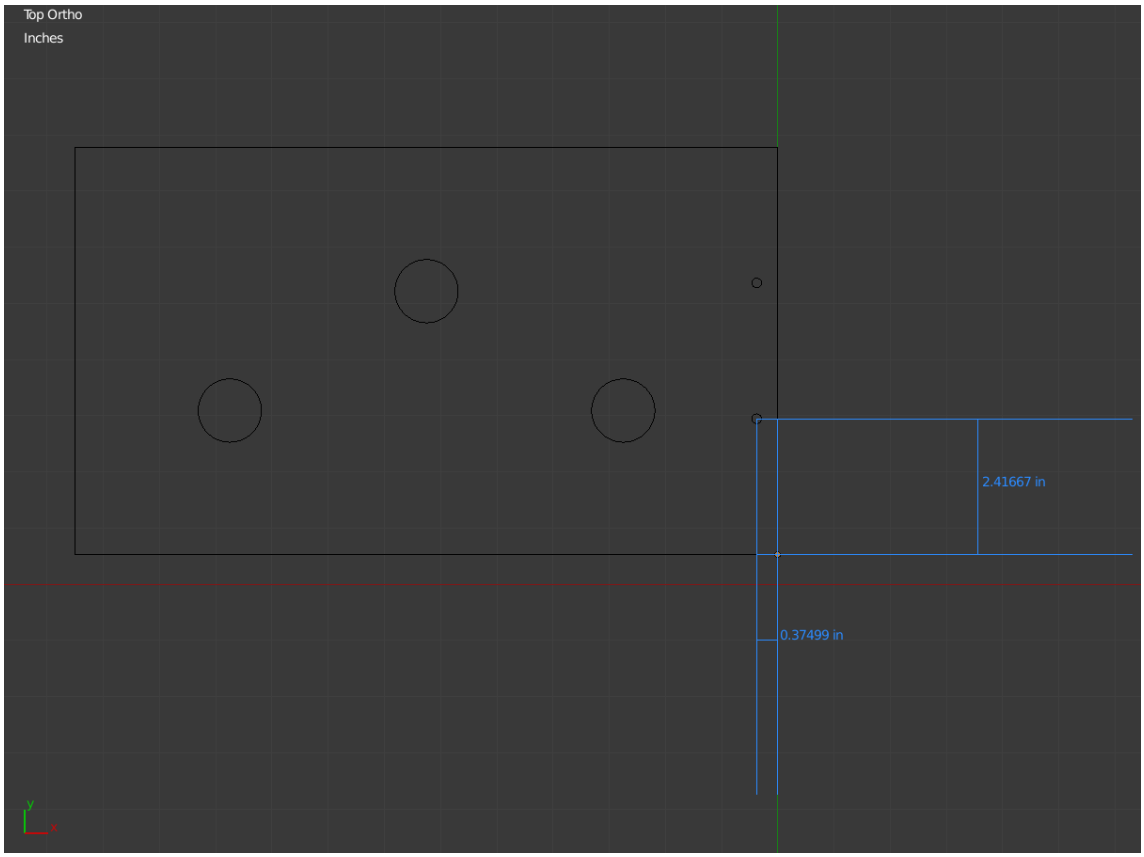

Figure 5.3: Locations of pilot/clearance holes in top board.

5.2.5 Sand the pieces

Clean up the boards' edges with coarse to fine grit (approximately P40 to P120) sand paper as necessary to clean the cuts and smooth away sharp edges.

5.2.6 Clamp the pieces

Clamp the boards together using the locating marks. It's a good policy to find the optimal arrangement of the boards by testing fit. One edge of a board may fit better in position than another way. It's not completely necessary to clamp all of the parts together at once, but it is likely the optimal method.

5.2.7 Drill the rest of the holes

Dill the rest of the pilot holes; drilling after clamping helps to keep alignment of the holes. Drill clearance holes if necessary.

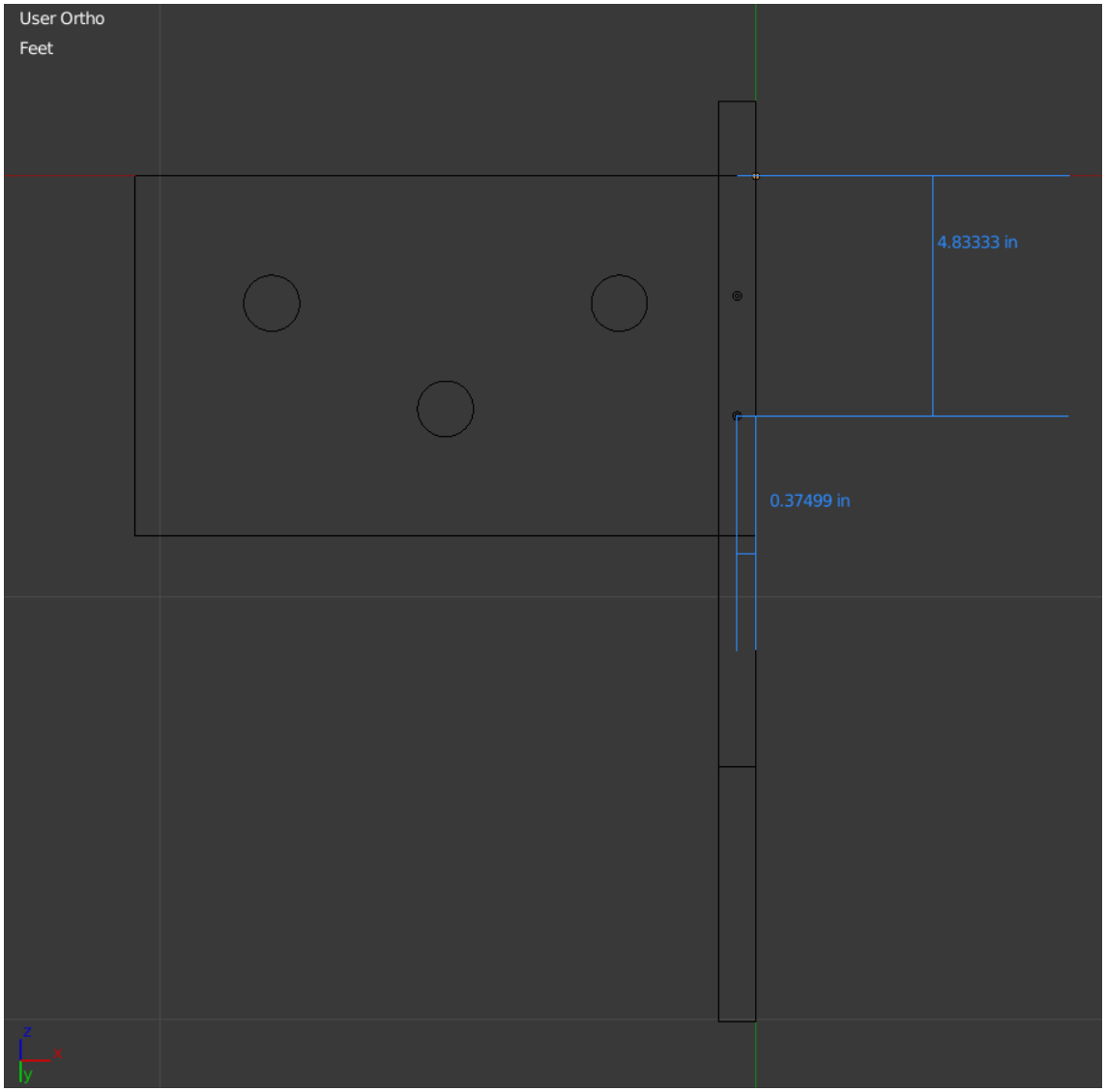

Figure 5.4: Locations of pilot/clearance holes in top board.

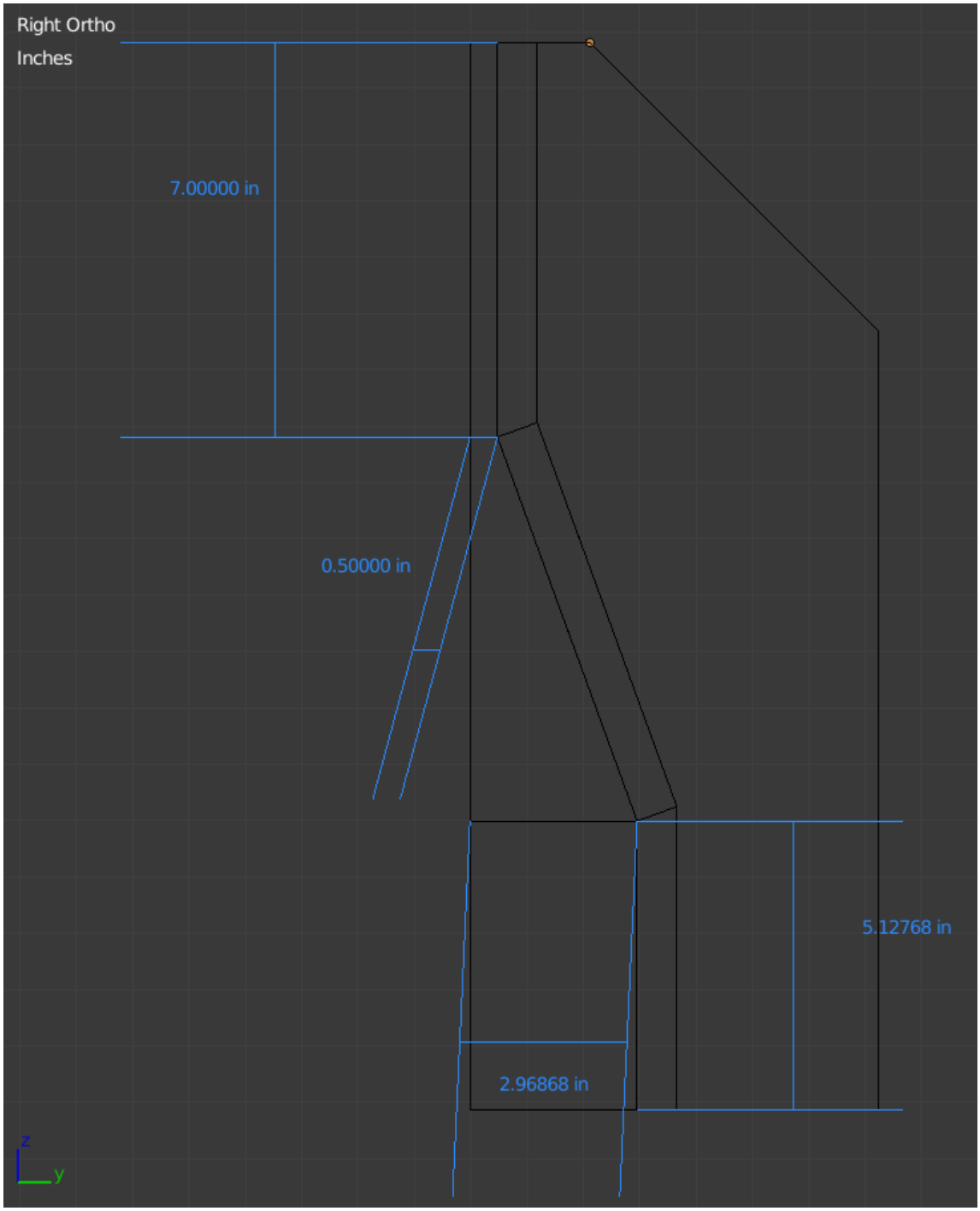

Figure 5.5: Locations of the back corners of the motor board relative to the left leg.

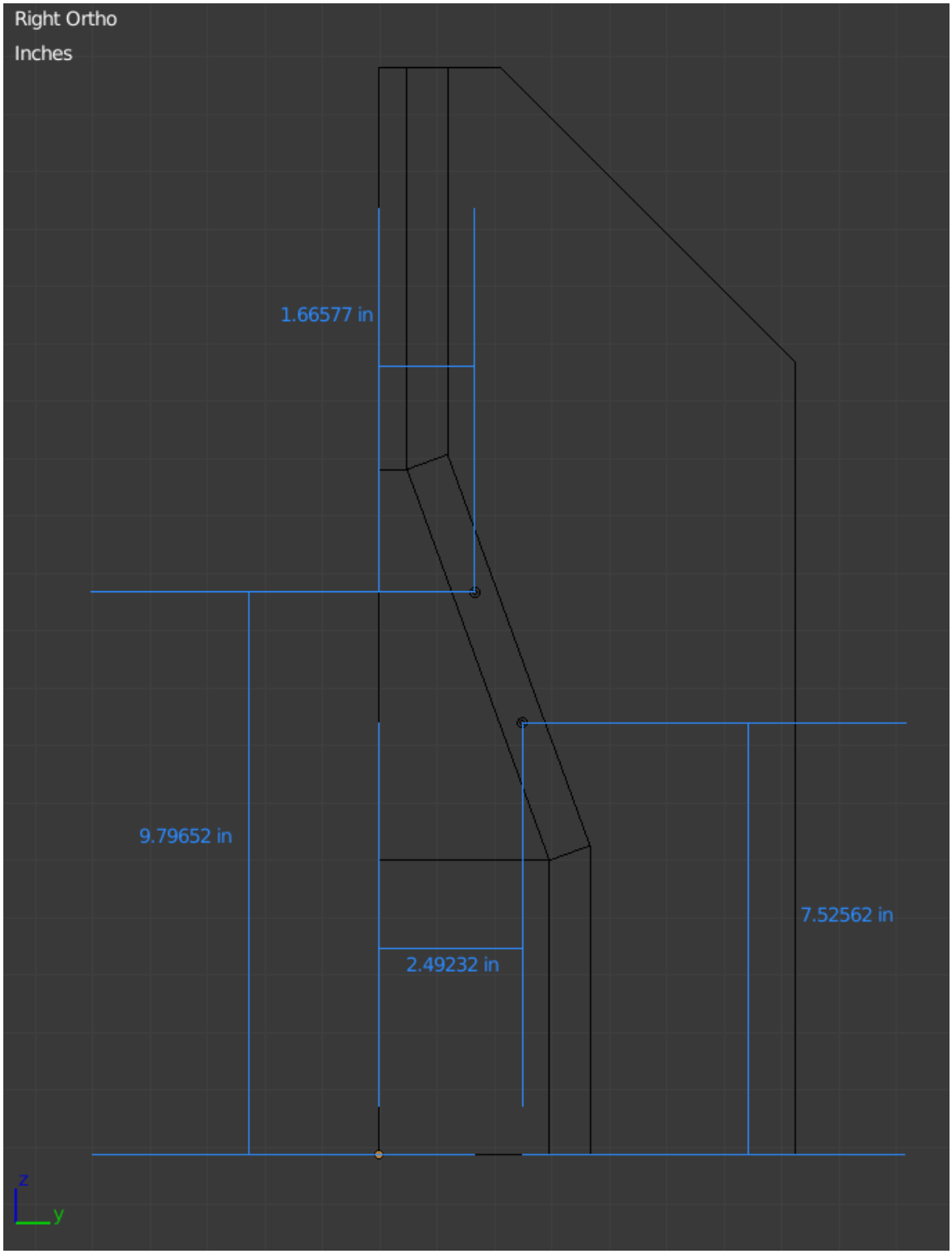

Figure 5.6: Locations of pilot/clearance holes in the leg for the motor mount board.

5.2.8 Join boards with screws

Drive the screws into the pilot holes; it's okay to use an electric drill for the majority of the screw length, but it's best to hand tighten the screws to prevent over tightening. Softwood is especially vulnerable to compression.

5.2.9 Remove clamps

Remove the clamps and check the tightness of the screws hand tightening as necessary.

5.2.10 Models of the Wooden Stand

The wooden stand is now ready for the electronics.

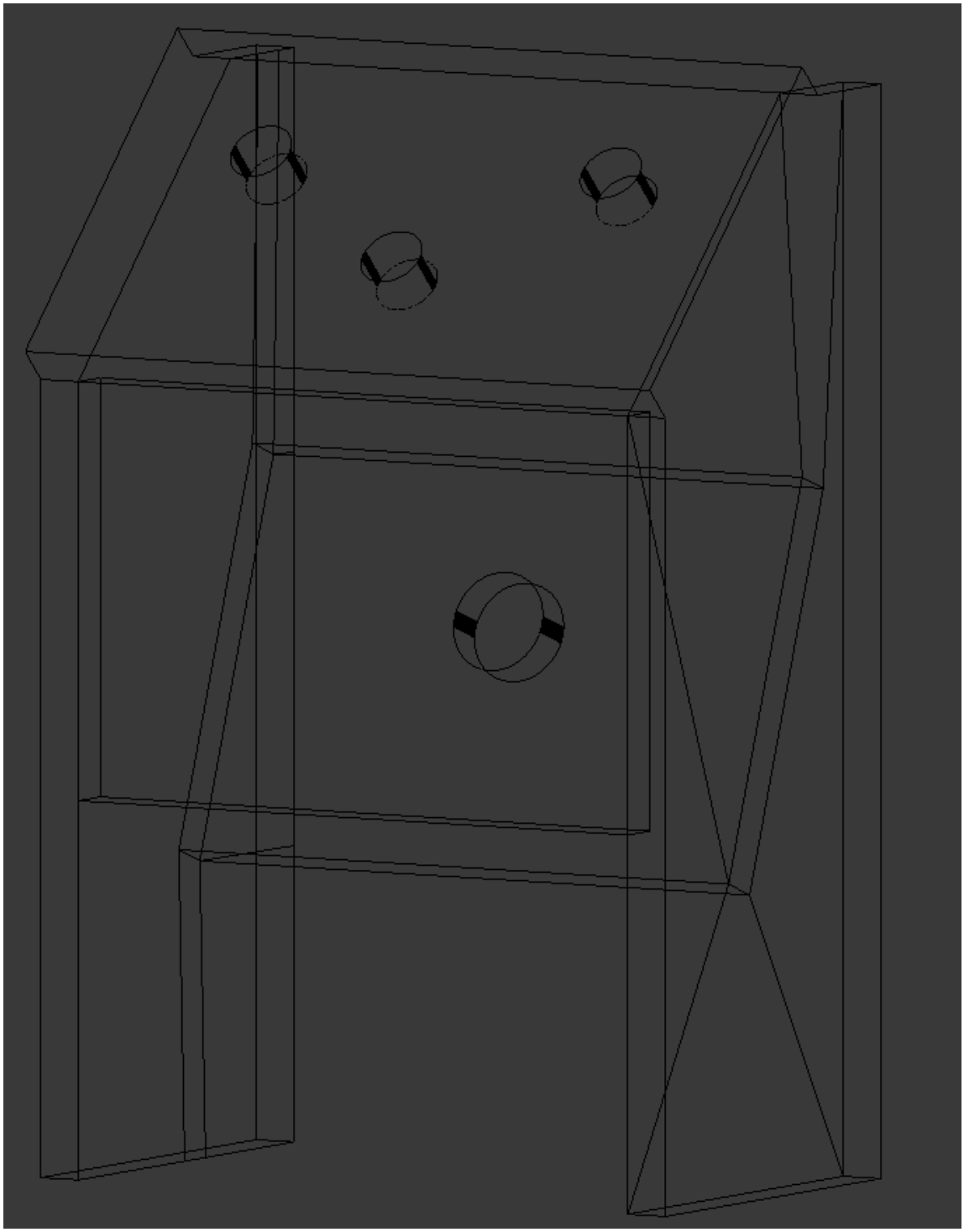

Figure 5.7: Transparent view of the wooden stand.

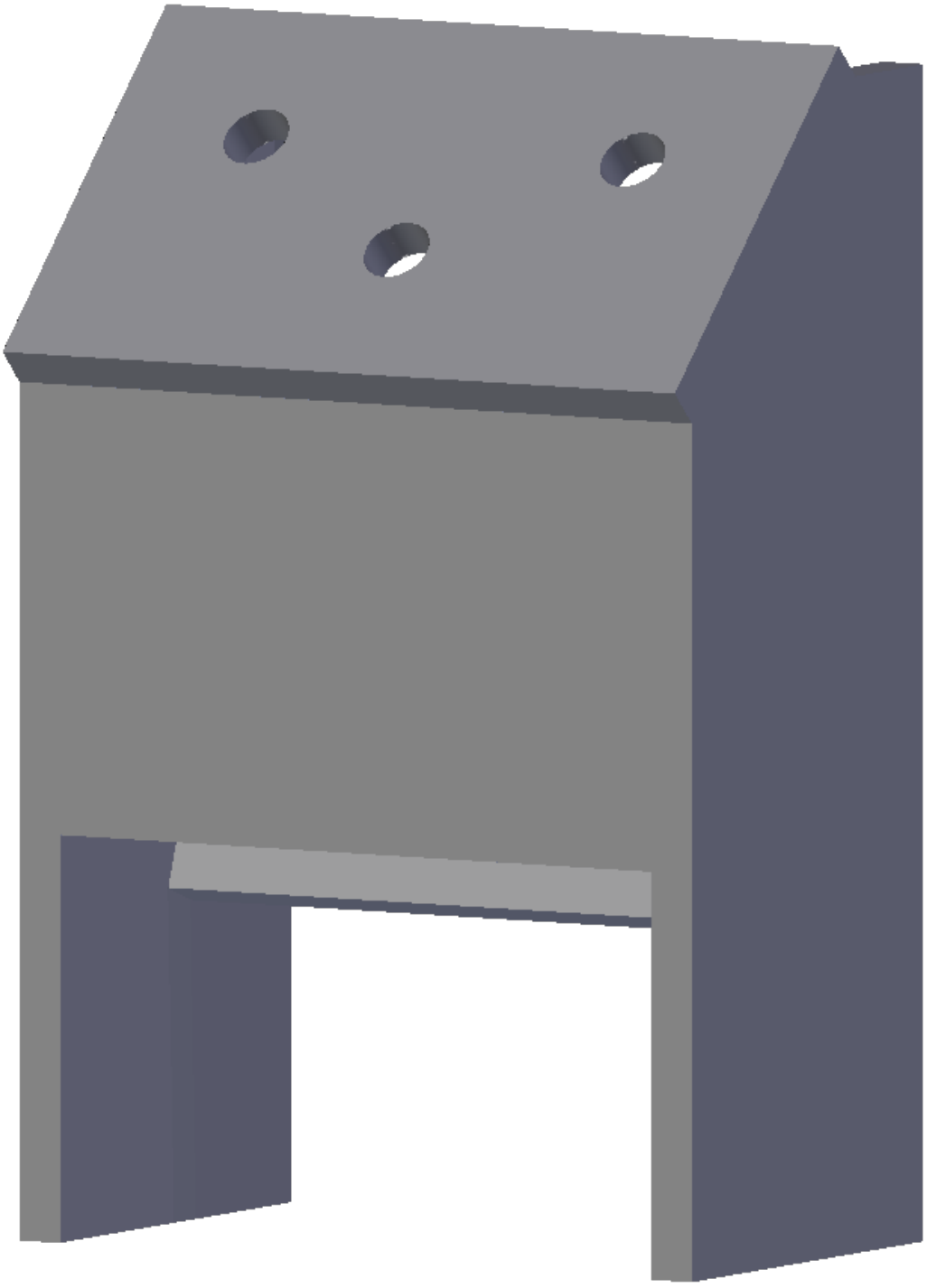

Figure 5.8: View of the wooden stand.

5.3 Constructing the Transistor Switches Board

5.3.1 Notes about Transistor Switches Board

The transistor switches board is used to switch 5V to the LEDs in the arcade buttons. The Launchpad can not be used to switch 5V for powering devices as it is uses 3.3V logic; in general these pins should not be used for powering devices as they are not designed to supply very much current.

Programming the board

5.3.2 Place components in the Perma-Proto Board

Place the components into the Perma-Proto board as the circuit diagrams depict.

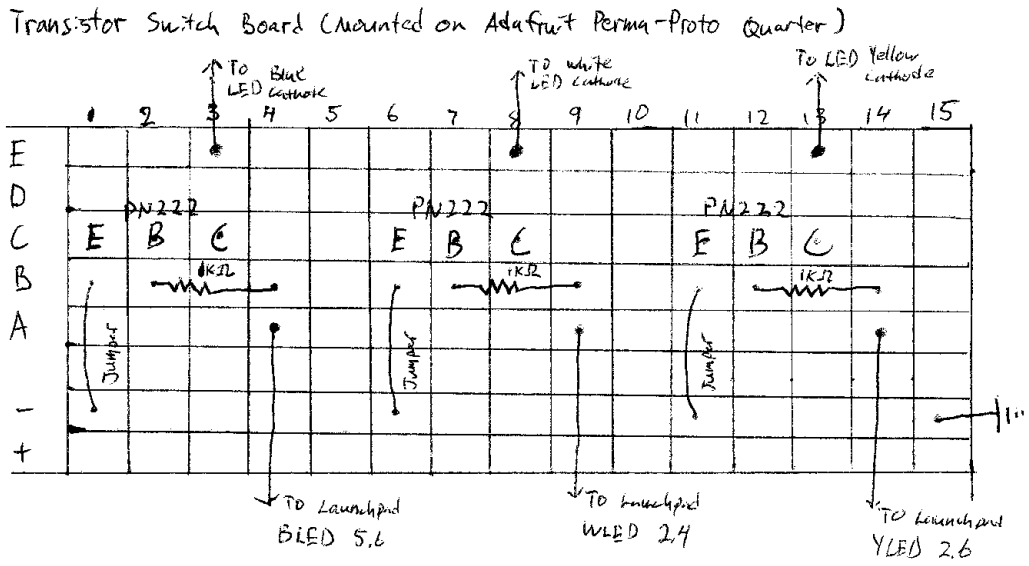

Figure 5.9: Transistor switches board circuit diagram.

5.3.3 Solder

Apply flux and then solder the components. Check the solder joints and then clean off the flux.

5.3.4 Test the circuit

Test the circuit to make sure everything is working. This can be accomplished by using a power supply and test LED. The transistor switches board requires a ground and a 3V line to switch the transistor. Attach the test LED using alligator clips to the transistor switches board (negative side of LED) and a 5V line (positive side of LED). The LEDs in the arcade buttons can handle the 5V, make sure the test LED can too. Attach the power supply ground to the transistor switches board and use a 3V line to turn the LED on and off. If the board is working correctly the LED should turn on with the application of the 3V line and off when the 3V line is disconnected.

5.3.5 Trim the excess length of the legs

Trim the excess length off the legs on the transistor switches board.

5.4 Constructing the Distribution Board

5.4.1 Place components in the Perma-Proto Board

Place the components into the Perma-Proto board as the circuit diagram depicts.

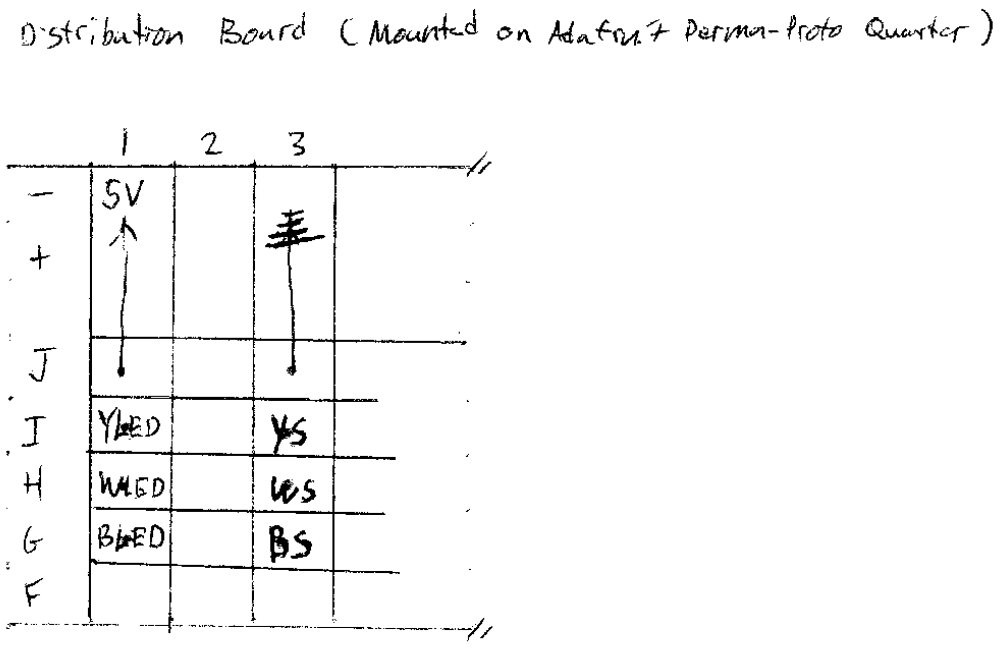

Figure 5.10: Circuit diagram for distributing power.

5.4.2 Solder

Apply flux and then solder the components. Check the solder joints and then clean off the flux.

5.4.3 Test the circuit

This part of the circuit is to distribute a 5V line and a ground line so the functionality is guaranteed with good solder joints and an undamaged board.

5.5 Setting up the SimpleLink MSP432P401R LaunchPad

5.5.1 Install Code Composer Studio

Code Composer Studio can be installed on Windows, Mac OS, and Linux. Follow the latest documentation listed on the website to setup the software for the device you are using.
LOTS TO TALK ABOUT ABOUT SOFTWARE SIDE BUT IT'S KIND OF A PAIN
have to talk about switching headers so that the power can work from desktop psu

5.5.2 Load the buttonPress_treatExpress_software into Code Composer

Open buttonPress_treatExpress_software in Code Composer Studio and make the necessary adjustments for your project configuration.

5.5.3 Flash the SimpleLink MSP432P401R LaunchPad

Plug in the Launchpad and flash the program using Code Composer Studio.

5.5.4 Remove the Ground and 3V3 Headers from the Jumper Isolation Block

With the Ground and 3V3 headers removed the Launchpad can be powered using the ATX power supply. See the documentation for the specific model Launchpad to confirm the headers and how to power the Launchpad.

5.6 Mounting the Electronics

5.6.1 Notes about Mounting the Electronics

Motor Mounting

Given that the motor used in this project is unique an alternative mounting method is likely to be required. It should be simple enough to compensate in methods matching the motor.

Electronic Parts' Base

The Electronic Parts' Base is not necessary. It was devised so that the electronics can easily be removed from the wooden stand with minimal cost and without compromising the board. Without access to a 3D printer mounting the electronics can be accomplished with threaded inserts and bolts or screws.

5.6.2 Mount Arcade Buttons

Insert the arcade buttons into the top board's holes and screw their nuts to tighten them. The order is not particularly important, but was devised in hopes to favor dogs' vision.

5.6.3 Mount Motor

Fit the motor into the motor hole and mount as needed. The hole may need sanding to fit the motor.

5.6.4 Attach 3M Command 17204 To Electronic Parts' Base

Place two Command strips locking mechanism side together. Remove one adhesive protector and press it firmly against the portion of the plastic parts' base designed for the strip. Remove the last adhesive protector and place the parts' base on the board aligned with the markings; press firmly along the strip. Do not attempt to immediately disconnect the two strips as the adhesive requires time to bond.

5.6.5 Mount the Parts on the Electronic Parts' Base

Detach the mount from the wooden board and press the nuts into the holes. Align the part with their holes and drop the bolt in and tighten. The 3M Command strip adds space between the parts base and the wooden board, but I tightened the bolts until they were flush with the nut.

5.7 Creating The Wiring

5.7.1 Notes about Creating The Wiring

Wire Crimping

Given that the connections are crimp terminal accessible it's a great opportunity to create custom wiring, but it's not completely necessary. Wires with appropriate connectors can be purchased or wires can be soldered. It's good practice to complete test crimps and adjust the settings on the tool to the terminals and wire used.

5.7.2 List and Number of Terminal Pairs

The list of terminal pairs is designed to help keep track of how many terminals need to be crimped of each type. When used with table 5.1 it helps keep track of wire creation.

Female Spade 2.8mm to Mini PV 2.54mm (12) ☐☐☐☐☐☐☐☐☐☐☐☐
Mini PV 2.54mm to Mini PV 2.54mm (11) ☐☐☐☐☐☐☐☐☐☐☐
Male ATX Terminal to Mini PV 2.54mm (9) ☐☐☐☐☐☐☐☐☐
Male ATX Terminal to Male ATX Terminal (1) ☐

5.7.3 Measure Wires

With all of the electronic components in place, measure and cut a generous amount of wire between all of the points that need to be connected. Cut the wires as cleanly as possible to create even ends when stripped. Since they are of custom length it's best to use a method to keep track of which wire is for which connection or immediately crimp and mark the terminals.

5.7.4 Strip the Wires and Crimp The Terminals

Strip off the appropriate length of insulation for the terminal used and then crimp the terminal. Push the housing onto the terminal if necessary.

5.7.5 Attach Wires

Plug the wires into their appropriate locations using table 5.1 as a guide. The confirm boxes are for making a note if the wire is complete and hooked up; they can also be used to keep track of the wires, as in a mark on the wire is traceable to the table to know what the wire was prepared for.

Table 5.1: Connection Pairs

Terminal Pair	**Connection A**	**Connection B**	**Confirm**
PV to Spade	Launchpad 2.5	Yellow Switch	
PV to PV	Power Distribution Ground	Yellow Switch	
PV to PV	Power Distribution 5V	YLED Anode	
PV to PV	Launchpad 2.6	Switch Board A14 YLED	
PV to Spade	Switches Board E13	YLED Cathode	
PV to Spade	Launchpad 3.0	White Switch	
PV to PV	Power Distribution Ground	White Switch	
PV to PV	Power Distribution 5V	WLED Anode	
PV to PV	Launchpad 2.4	Switches Board A9 WLED	
PV to Spade	Switch Board E8	WLED Cathode	
PV to Spade	Launchpad 5.7	Blue Switch	
PV to PV	Power Distribution Ground	Blue Switch	
PV to PV	Power Distribution 5V	BLED Anode	
PV to PV	Launchpad 5.6	Switches Board A4 BLED	
PV to Spade	Switch Board E3	BLED Cathode	
PV to PV	Launchpad 3.6	Relay Set	
PV to PV	Launchpad 3.7	Relay Unset	
ATX to PV	ATX Pin 13 (+3.3V)	Relay Power	
ATX to PV	ATX Pin 15 (Ground)	Relay Ground	
ATX to PV	ATX Pin 2 (+3.3V)	Launchpad Power	
ATX to PV	ATX Pin 3 (Ground)	Launchpad Ground	
ATX to PV	ATX Pin 4 (+5V)	Distribution Board J1	
ATX to PV	ATX Pin 5 (Ground)	Distribution Board J3	
ATX to PV	ATX Pin 18 (Ground)	Switches Board -15	
ATX to PV	ATX Pin 6 (5V)	Relay Switched To Motor	
ATX to PV	ATX Pin 7 (Ground)	Motor Ground	
ATX to ATX	ATX Pin 15 (Ground)	ATX 16 (PS ON)	

5.7.6 Wiring the 24 Pin ATX Connector

Plug in the terminals into the connector so that they match appropriatly to the power supply as shown in the pin diagram.

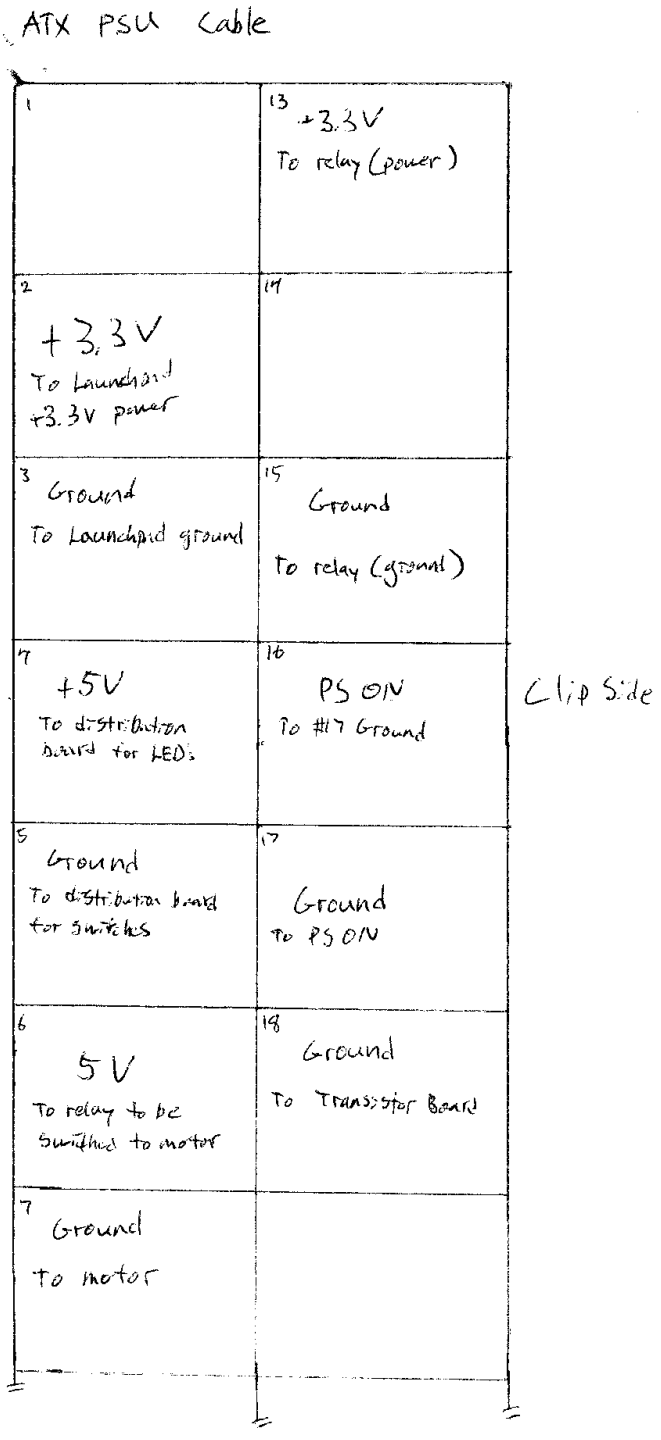

Figure 5.11: ATX connector pin diagram.

6 Final Assembly

6.0.1 Notes about Final Assembly

Notes On Attaching The Bottle Mount To The Motor

The hole for the shaft on the plastic motor mount may need to be adapted to the motor used. As of now it doesn't need a set screw to hold it onto the shaft, but that can also be added.

Notes on the Treat Bottle's Lid

I used a simple plastic soda bottle lid and saved the aluminum one that comes with the treat dispensing bottle for closing the bottle for storage. The hole is engineered to dispense treats of a certain shape and size. The 5/8" hole is designed for Blue Buffalo brand adult-large breed dry dog food without "Lifesource Bits". Larger holes tend to dump too many treats and smaller holes tend to clog without dispensing.

6.0.2 Prepare the Bottle Mount

Attach two straps together to form a longer strap. Slide the strap through both of the holes in the bottle rotation mount; form a loop so that the bottle can fit inside. Use the bottle, specifically the area around its rotational center, to measure how tight the straps needs to be to hold the bottle firmly.

6.0.3 Attach Bottle Mount To Motor

Slide the bottle mount onto the motor's shaft.

6.0.4 Drill the Lid on the Dispensing Bottle

Drill a 5/8" hole in the center of a lid that fits the bottle. It's easiest to hold the lid by screwing it onto another bottle that won't hold treats. Use an awl to punch a hole in the center of the lid to guide the drill.

6.0.5 Fill the Bottle with Treats

Fill the bottle with treats; not so many that will make the motor struggle or the dog overindulged. Screw on the lid.

6.0.6 Attach Bottle to Bottle Mount

Slide the bottle into the bottle mount; it should be easy to slide in but tight enough to hold the bottle in place.

7 Final Discussion

7.1 Analysis of Treat Dispensing

Using approximately 125 mL of Blue Buffalo brand adult-large breed dry dog food without "Lifesource Bits" I ran the toy until the treat dispensing bottle was empty. The toy ran for 60 button presses with 47 presses dispensing treats and 13 not. Each treat drop dispensed 1 to 4 treats. If this trial is statistically relevant to the normal operation of Button Press : Treat Express then treats are dispensed approximately 80% of the time.

7.2 Improvements

7.2.1 Improve the Software

Working with example code made writing the software quite simple, but it's messy and full of unnecessary components. I would like to completely rewrite the code; making it concise and independent of any other copyright. Full documentation will make it so that anyone can understand it.

7.2.2 Improve Treat Dispensing

I tested three different but similar methods of dispensing treats. The current method of treat dispensing is very simple, but it isn't 100% consistent; sometimes no treats are dispensed and other times too many are. The design is heavily dependent on treat shape which is generally uncontrollable. I would like to reduce the time it takes to dispense treats as dogs prefer to accomplish an action and immediately receive a treat; even patient dogs may find the wait unpleasant.

7.2.3 Make the Parts Universally Available

Currently the parts are not fully sourced through stores; I would like to make it so that the parts can be purchased internationally, but that is impractical unless individuals from their countries get involved. As I harvested the motor from another project others will need to source it from a reliable distributor and I would like to have those sources built into the project.

7.2.4 Electronics Optimization

It would be great to have the electronics reduced to one board; the parts are simple enough and fabricating a single board doesn't seem to cost that much these days. It would be interesting to create a boosterpack for the TI Launchpad that carries a set of switches and distribution points, replacing the individual boards. I sourced an ATX power supply to power the components and it impacts the project's design; the power supply is reliable, inexpensive, and safe, but I would like to establish a universal method to power the multiple projects that make up the Dog Treat Complex. The current design protects the electronics pretty well, but encasing them and having protected wiring would be safer.

7.2.5 Improving the Documentation

I'd like to improve the electronics schematics by porting the hand written designs into EDA software. The documentation can also use an editor to streamline and correct. The instructions need to be tested by various users and input can help remove confusion. The documentation's source file can also be optimized.

7.3 The Future of the Button Press : Treat Express

As the Button Press : Treat Express is used design improvements will become apparent; this is not the final state of this project.

7.3.1 Integrating into the Dog Toy Complex

Since Button Press : Treat Express is part of the Dog Toy Complex it might be necessary to make changes so that it works better with other toys. It's likely that the bottom of the legs will have threaded inserts or holes for pins so that it can be mounted and dismounted as needed.

7.3.2 Dog Testing

As other dogs use the Button Press : Treat Express behaviors and abilities can be accommodated and integrated into the design. Some dogs may have preferences in using paws or snouts for pressing the buttons and height adjustments will need to be made. Additionally the location of the treat dispensing may prove difficult for dogs who can't reach underneath the structure. Button size may need to be enlarged and indicating the necessary button may require redesign for dogs that do not show interest in a lit up button.

7.3.3 Additional Modes

It's important to stimulate a dogs intelligence through unique and challenging situations. Adding different game modes like; hit the button within the time limit, Simon Says with memory, audio mode that uses noises to indicate buttons, etc.

7.3.4 Testing Dogs

A customized offshoot of Button Press : Treat Express could be used for canine research. Testing memory, visual acuity, reward denial, and dog-computer interaction can all be explored. Since Button Press : Treat Express is libre researchers can get started with a proven design using minimal effort and with no restrictions.

8 Abbreviations Used in Documentation

Table 8.1: Abbreviations

Full	**Abbreviation**
Yellow Switch	YS
Yellow LED	YLED
White Switch	WS
White LED	WLED
Blue Switch	BS
Blue LED	BLED
Female Spade 2.8mm	Spade
Mini PV 2.54mm	PV
Male ATX Terminal	ATX
Transistor Switches Board	Switch Board
Personal Protection Equipment	PPE

9 Helpful Information

9.1 Fraction to Decimal Conversion for Working with USCS

Table 9.1: $\frac{n}{64}$ fractions to decimals

n	Decimal	n	Decimal	n	Decimal	n	Decimal
1	0.015625	17	0.265625	33	0.515625	49	0.765625
2	0.03125	18	0.28125	34	0.53125	50	0.78125
3	0.046875	19	0.296875	35	0.546875	51	0.796875
4	0.0625	20	0.3125	36	0.5625	52	0.8125
5	0.078125	21	0.328125	37	0.578125	53	0.828125
6	0.09375	22	0.34375	38	0.59375	54	0.84375
7	0.109375	23	0.359375	39	0.609375	55	0.859375
8	0.125	24	0.375	40	0.625	56	0.875
9	0.140625	25	0.390625	41	0.640625	57	0.890625
10	0.15625	26	0.40625	42	0.65625	58	0.90625
11	0.171875	27	0.421875	43	0.671875	59	0.921875
12	0.1875	28	0.4375	44	0.6875	60	0.9375
13	0.203125	29	0.453125	45	0.703125	61	0.953125
14	0.21875	30	0.46875	46	0.71875	62	0.96875
15	0.234375	31	0.484375	47	0.734375	63	0.984375
16	0.25	32	0.5	48	0.75	64	1

10 References

10.1 Transistors, Sparkfun (Jimb0)

https://learn.sparkfun.com/tutorials/transistors/applications-i-switches

10.2 SimpleLink MSP432P401R high-precision ADC LaunchPad Development Kit, Texas Instruments

http://www.ti.com/tool/msp-exp432p401r

10.3 Mini Relay FeatherWings, Adafruit (laday ada)

https://learn.adafruit.com/mini-relay-featherwings/overview

10.4 Power supply unit (computer) , Wikipedia

https://en.wikipedia.org/wiki/Power_supply_unit_(computer)#Wiring_diagrams

10.5 US Wood Screws - Pilot Holes, Engineering Toolbox

https://www.engineeringtoolbox.com/wood-screws-holes-d_1519.html

10.6 Quality Crimping Handbook, Molex

https://www.molex.com/pdm_docs/ats/TM-638000029.pdf