Design for manufacturing and assembly was a large deciding factor in choosing the material that the winding drum would be made from. The stainless steel was chosen for its relatively high machinability. Additional design considerations can be seen in the actual design of the threads. The threads are designed to be cut with tooling that we have available in the lab which makes them slightly oversized for the cable that we chose. However, the size of the grooves will not affect the functionality of the drum. The original design of the winding drum called for two separate threads, one standard and one reverse. A revision was made to have one standard thread that will incorporate both the winding and unwinding motions by simply moving the spot at which the cables are attached to the drum. A prototype winding drum was machined out of PVC tube stock. This prototype allowed us to test and ensure that the drum will wind and unwind properly when built full scale out of the much more costly stainless steel.

7.0.6 Electrical System

The electrical system is the driving force behind the operation of the system. The system consists of two dependent momentary start buttons that power a series of relays and switches. An emergency stop button acts as the main power switch and is the twist to release type. The indicator light functions a visible indication of when the system has power.

There were two main driving factors used in the decision making process of designing the electrical system. The two driving factors were safety and reliability. The DFS method showed a significant risk of electrical shock hazard to the operator. The outcome of using this method suggested improvements in the area of electronics enclosure. Enclosing the electronics serves multiple purposes. Enclosing the electronics effectively reduces the risk of electrical shock to near zero. Also, the large amount of dust created from cutting cardboard is no longer a factor if the electronics are enclosed.

An additional concern involved with the electrical system is the reliability of the system. Not only the reliability is a concern, but the maintenance and adaptability of the system is also a concern. In order to remedy the reliability concern electromechanical components such that the mechanical life expectancy is much greater than the expected life of other system components. If there is a failure of an electrical component, the method of replacing the component is very easy. The system was designed for the components to be of the plug-in/out variety. The electrical components are also rated much higher in voltage and current than levels that will be seen everyday-use.

7.1 How does it work?

A. How to Operate System

1. Rotate the emergency stop (E-stop) clockwise until the button releases. The red indicator light will illuminate. The illumination of this light indicates the system is in the powered on state.
2. To activate the saw and perform a cut press the two green, start buttons simultaneously. The momentary start buttons are wired in parallel to avoid the accidental starting of the saw. Once the buttons are pressed, the saw will begin to spin and the saw will move in the forward direction to cut the cardboard. Upon completion of the cutting, the saw carriage with contact a limit switch and the actuation of this switch will reverse the direction of the saw. The actuation of the limit switch will also cut power to the saw.

3. If at any time a safety concern arises the E-stop button can be pressed. Pressing this button will kill power to the saw and stop the translation of the carriage near instantaneously.

**Warning: Keep Hands Clear of Cutting Area!!**

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**B. How the System Works**

1. The E-stop is turned to bring power to the system. When power is running to the system the red indicator light will illuminate.
2. To activate the saw and perform the cut, the start buttons need to be pushed simultaneously. This will cause the saw to turn on and the winding drum to rotate. There is a slight delay in the electrical system that allows the saw to get to full RPM before the winding drum begins to rotate. To ensure smooth movement of the saw and winding without binding the drum has a square thread used as a guide for the cable that is pulling the saw carriage.

3. Once the saw is in motion it will move forward to cut the cardboard until it reaches switch 1, reference Table 7.1.

4. When the saw hits switch 1 a 35 ohm, 25 watt power resistor dissipates the power left in the rotating motor shaft. After a variable delay, default setting of ~1 sec, a double pole double throw relay in the electrical system will reverse the direction of the winding drum to pull the saw back to its starting position.

5. As the saw is traveling back to its starting position it will hit switch 2, which turns off the motor and resets the system so it is ready for its next cut.

![Figure 2: Cardboard Cutting System](image)
Table 7.1: System Parts with Corresponding Numbers

<table>
<thead>
<tr>
<th>System Drawing #</th>
<th>Description</th>
<th>Color</th>
</tr>
</thead>
<tbody>
<tr>
<td>A1</td>
<td>Electrical Box</td>
<td>Grey</td>
</tr>
<tr>
<td>A2</td>
<td>Base Plate</td>
<td>Red</td>
</tr>
<tr>
<td>A3</td>
<td>Switch 1</td>
<td>Grey</td>
</tr>
<tr>
<td>A4</td>
<td>Winding Drum</td>
<td>Green</td>
</tr>
<tr>
<td>A5</td>
<td>Switch 2</td>
<td>Grey</td>
</tr>
<tr>
<td>A6</td>
<td>Motor</td>
<td>Purple</td>
</tr>
</tbody>
</table>

C. Maintenance

- **Electrical System**

  All electrical system components can be replaced relatively easy. All relays are secured in a relay socket for easy removal. The trouble shooting for the electrical system is summarized below. Please refer to Figure 7a for each individual part number.

  - **Item 1 – DPDT Power relay** This relay controls power to the saw and also latches in power to the motor in the forward direction. If the motor only gets power when the start buttons are pressed check this relay for loose connections. This relay can be changed by removing tab connectors and removing mounting screws. Pay careful attention to reinstall connectors on the same numbered tabs from which they were removed.

  - **Item 2 – DPDT relay** This relay latches in power to itself and the motor voltage supply. Input voltage to the supply is 120 Vac and output voltage is 90 Vdc with speed resistor set to maximum. If this relay becomes inoperable the supply voltage of to the controller will be zero.

  - **Item 3 – DPDT relay** This relay initializes power to Item 2 and also latches in power to Item 4.

  - **Item 4 – DPDT relay** This relay uses both its normally open contacts and its normally closed contacts. The normally open contacts provide power to the forward DPDT relay. The normally closed contacts provide power to the reversing DPDT relay.
• **Item 5 – Forward DPDT relay** This relay connects the armature leads to the motor. If the motor starts in the wrong direction the armature leads may need to be switched of the output on the motor voltage supply.

• **Item 6 – Reverse DPDT time-delay relay** This relay functions as a time delay before the motor turns in the opposite direction. This relay also connects the armature voltage leads to the motor but the polarity is opposite that of the forward relay. The time before reversing can be change from 0.1 sec to 90 hours. The default setting on the relay is approximately 1 sec. This setting allows sufficient time for the motor to dissipate power before reversing direction.

• **Item 7 – 25 Watt, 35 Ohm Power resistor** Indication that the resistor has gone bad is if the motor does not stop at the far end of travel or if the motor does not stop near instantaneously when the E-stop button is pressed. To replace the resistor the two leads must be soldered on as it is currently assembled.

• **Item 8 – Start buttons** If the start buttons were to fail the system would not operate at all. Ensure the indicator light is illuminated and press the buttons. If the system does not operate the start button switches may have malfunctioned. The actual switch is located behind the front panel of the control box. Refer to manufacturer’s instructions fro changing out the switch.

• **Item 9 – E-stop button** The e-stop button controls power to the whole system. If the switch is rotated and no power is given to the system, the e-stop button has failed. Refer to manufacturer’s instructions fro changing out the switch.

• **Item 10 – Motor Voltage Supply** Please refer to supplemental manufacturer’s literature for troubleshooting the voltage supply for the motor.

• **Cable System**
  - If becomes loose and needs to be tightened there might be slack in the cable or the cable might not be properly positioned in the grooves of the winding drum. This could cause binding in the winding drum and the system will no longer run smoothly.
    - **Steps to tighten cable**
      1. Locate the eyebolts on both sides of the base plate that connect the cable to the base plate.
      2. There are two nuts on each eyebolt. Turn the nuts until the cable is no longer loose.
Steps to rewind the cable around the drum

1. Loosen eyebolts until the thimble can easily be removed from the hook on the end of the eyebolt. The thimble is what helps keep the cable in a loop so it can easily come off and on the end of the eyebolt. Refer to figures 3 and 4.

2. Remove the pins from the pulleys and pull out the center rod so the pulleys can be removed. This makes it so the cable doesn’t have to be fed through each pulley. Refer to figure

3. Unwind the cable around the winding drum until you reach the center and you can no longer unwind.

4. Move the base plate/saw to the starting position (Shown in figure 2).

5. Starting from the center, wrap each side of the cable 3 times around.

6. Wrap one side of the cable about 9 times around following the grooves and wrap the opposite cable about 3 times around following the grooves going the opposite direction (Shown in figure 3).

7. The shorter cable goes towards the end with the base plate and the longer cable goes toward the opposite end.

8. Feed the cable around the pulley mounts then place the pulleys and the pins back into the mounts making sure the cable is behind the pulleys. Refer to figure 6.

9. Hook one thimble on the eyebolt (it doesn’t matter which side is hooked first).

10. Pull the cable tightly and hook the other thimble on the opposite eyebolt

11. Tighten the nuts on the eyebolt until the cable is tight and secure.

12. If the system is running the opposite direction look at maintenance for the electrical system.

Table 2: Parts in Maintenance for Cable System

<table>
<thead>
<tr>
<th>Drawing #</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>P1</td>
<td>Eyebolt</td>
</tr>
<tr>
<td>P2</td>
<td>Pin</td>
</tr>
<tr>
<td>P3</td>
<td>Pulley Rod</td>
</tr>
<tr>
<td>P4</td>
<td>Thimble</td>
</tr>
</tbody>
</table>
Figure 3: Parts used in Cable System

Figure 4: Base Plate Showing Location of Parts
• **How to Remove Saw from Base Plate**
  
  o Locate the 4 clamps that are holding the saw in place. Refer to figure 7.
  
  o Unscrew the 4 horizontal bolts in the clamps. Refer to figure 7.
  
  o Fully remove the clamps.
  
  o Remove the saw.
Part Replacement

- Refer to section 7.2.
- Table 7j shows part numbers.