Fall
2012

Team 29 Ability One
Cardboard Cutter & Banding Strip Counter F12-29-AONE

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21 April 2013

Specialized Training for Adult Rehabilitation
Attn: Kathy Baumann, Executive Director
P.O. BOX 938
20 North 13th Street
Murphysboro, Illinois 62966

Dear Mrs. Baumann,

As of January 14, 2013 the Ability One team began the complete design and construction of a cardboard cutting mechanism and banding strips counter prototype to be implemented into the workplace at S.T.A.R.T, in Murphysboro, IL. On behalf of the Ability One team I would like to thank you for the opportunity to proceed with this design project. The following includes is an extensive design report that defines our engineering designs and constructed deliverables.

The members of this team were given the opportunity, through the courtesy of the NISH, to compete in the Ability One Design Challenge. The Ability One team simultaneously completed a comprehensive report which was submitted to NISH as of April 18, 2012, which highlighted the benefits of our constructed prototype. These projects allowed this team to provide aid to the lives of severely disabled individuals through the use of these innovative prototypes

. The goal of the mechanical system design is to be able to create cardboard cutting rapidly and easily through the use of creative blade motion. Also, the goal of the electronic counter is to provide quick and simple readings for the operator about the number of strips that have been cut. The constructed prototype provides a 60.1% of the total saving time. The total cost associated with this project is $344.58, which includes the cost of labor and machining. The counter system's total cost was $80.29 with all labor done on-site. The estimated time of manufacturing and implementation into S.T.A.R.T.'s facility is 5 working days for the cardboard system and 3 days for the counter system.

Once again, I would like to take this opportunity to thank you for your consideration.

Sincerely,

Khaled Alnamasi
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(618) 303-9921

Acknowledgements (KA)

We would like to thank the following individuals, companies and departments for their contributions to this project:

- Faculty Advisor: Matthew Bolin
- S.T.A.R.T. – Carl Hartman - Murphysboro, IL
- SIUC Mechanical Engineering workshop.
- SIUC Mechanical Engineering Department
- SIUC Electric and Computer Engineering Department
- Tim Attig, in the Mechanical Engineering Machine Shop for his assistance and the use of his machines

Individual Contributions:

Khaled Alnamasi – Transmittal Letter, Acknowledgements, Introduction, Project Description, User's Guide

Saleh Almarri – Executive Summary, Conclusions & Recommendations, Technical Manual

Daaikan Almarri – Cost, Implementation Schedule, General Appendices

Chigozie Opara – Engineering Drawings, Ergonomic Handle, Blade Type, Cutting Operation, and efficiency

Tim Hendricks – Website design and maintenance, Counter sections of Project Description, Conclusion, User's Guide, and Appendices

Syed Huq – Guidelines, Subsystems for Counter, Counter Technical Manual, Technical Drawings

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General Section: A

Executive Summary (SA)

The AbilityOne design challenge develop engineering students to use their skills in order to design devices that help those with disabilities in their work field for the nonprofit organization (NPO) S.T.A.R.T located in Murphysboro, IL. The objective of this project is to design a cardboard cutting device that is easy to use by people who are differently abled and minimize the effort use with more production results. However, this device is designed to cut cardboards with a fixed 42" width from a simple hand pull lever with the initial stroke. This device was made to improve the cutting process and cut the work time by 60%. The project device is designed with a fixed blade that is attached to an ergonomic handle and they move in a straight line on a linear bearing with two shafts underneath it which will increase the efficiency, safety, and precision. However, the total cost of this project with labor and parts was $344.58 and it takes 19 hours to build it.

Meanwhile, a project designed to assist with the process of counting aluminum banding strips will be developed. The previous system has become non-functional and supervisors are tasked to count the strips by hand, taking between 1 and 2 seconds for up to 3 strips, depending on the counter. In a batch of 250 strips, this process can take approximately 3 minutes if the count is 100% accurate on the first attempt. The secondary project intends to create a system that is 100% accurate on every cut strip and will have a running total, eliminating the need for manual counting. This project is also intended to begin January 2013 and complete May 2013 at the cost of $82.90.

Project Description

Cardboard Cutter: (KA)

The project concept is to design a device that cuts cardboards with 42 in fixed width and length between 9 in - 42 in which is the desired length. This project is designed especially for disabilities that work in START in order to make their job safer and more accurate. The devise is also designed to replace the current cardboard cutter in START which is a utility knife and a lever to hold the cardboard. The average over all process for the current devise takes 34.7 s while this project was designed to do the same job in less than 14.8 s. However, this devise can be divided to four main subsystems; ergonomic handle, blade type, cutting operation, and safety. See Figure 1 below.
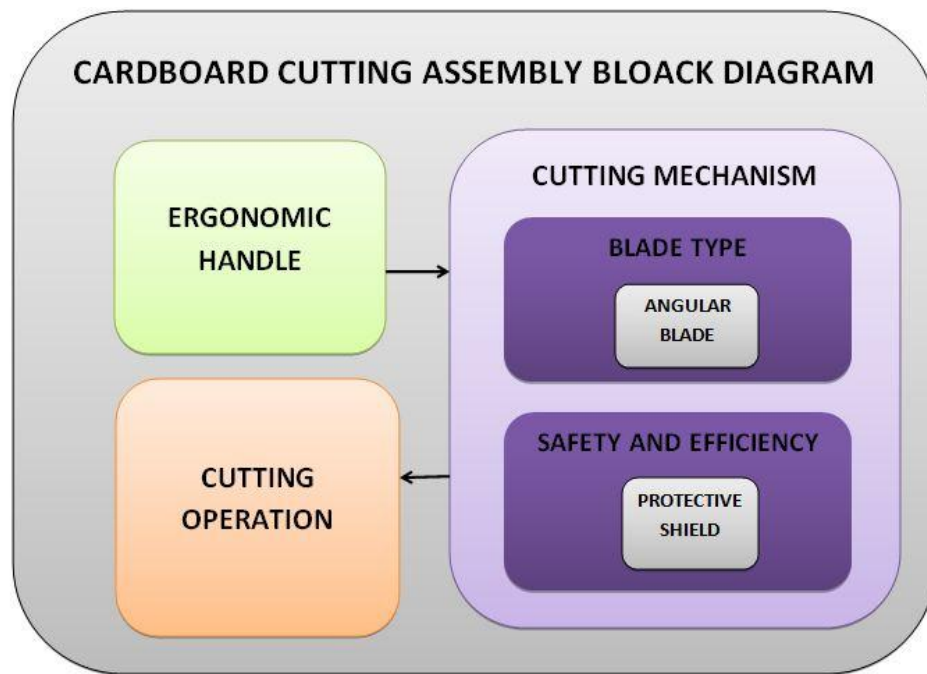
Figure A01: Subsystems Block Diagram

The design is constructed to start with the ergonomic handle as the input for the system. The handle was made up of a steel AISI 4140 as a strong material for this heavy duty task. It is a 13.1 in

long by 2 in width as an average length for users who work in the cardboard cutting task. The handle part will add an important advantage to the design which is solving the strength limitation for the previous design. At one end a 5.8 in long cylindrical grip was welded to the handle so the user can grab the handle and apply a pulling motion to process the cut. The cutting mechanism is attached to the side of the ergonomic handle and acts as a shear cutting device to cut the sample of the cardboard. It includes two subsystems in terms of blade type and safety and efficiency. The blade type uses mechanical advantage to decrease the amount of the input force by 2/3 of the old force used process the cut. The frame consists of 3 blades placed in different elevation levels. If the cardboard thickness is divided into 3 layers, the first blade will cut the first layer of the cardboard, the second blade will cut the second layer and the third blade will complete the cutting process. The safety is included as a shield that covers the blade frame. It is made up of light sheet metal that does not significantly increase the weight of the frame. The cutting operation was constructed as an output for the system where the final stage is done to complete the cut. It incorporates the frame and the handle parts into a linear bearing which carries these two parts. The linear bearing unit is fitted on two 60 in long steel shafts. The user is supposed to pull the linear baring and slid it on the upper face of the cardboard. The linear baring allows only one degree of freedom in terms of back and forth motion which results in having an accurate cut.

Some options were considered while constructing the design in terms of the slider system and blades types and assembly. One consideration was having two 18 in long drawer slider welded together to work as a 46 in long slider. However, the slider failed after several trials due to the weakness of the materials used to construct drawer slides. In addition, a disc blade was considered to process the cut but it did not success because this kind of blades requires both pressure and sliding features to maintain its maximum performance.

If this design is to be implemented at START the client can expect to receive a device that can simultaneously cut different lengths of the cardboard folds founded in the workshop. The overall performance data collected showed an increase in the cut accuracy and time saving resulting in a significant increase in productivity. The overall time saving was measured using both the existing device at START and new prototype and the values are compared in Table A01 and Table A02.

Table A01: Time-Motion Trials for the previous system

Trial	Time (s)
1	15
2	26
3	24
4	26.4
5	82
Total	173.4
Average time:	34.7 s.

Table A02: Time-Motion Trails for the new prototype

Trial	Time (s)
1	13.3
2	17.4
3	15.2
4	14.1
5	14.4
Total	74.4
Average time:	14.8 s.

The limitation for the new prototype is the fixed length of the slider. In other word, the cardboard width has to be 46'' or less in order to be slid under the cutting device. Fault analysis for the old prototypes can be summarized in the length of the slider and the type of blade used. Both of these

were corrected in the new prototype by changing the disc blade and extending the shafts length. Ultimately we were able to implement a new production process that is safe for our clients to use, reliable, efficient, and ultimately meets our top goal of improving the lives of those with disabilities

Counter: (TH)

The project is a design in order to facilitate the accurate counting of aluminum banding strips of which the system designed for the accurate and timely manner to cut said strips is already in place. Before implementation of the designed system, the clients had START employees cut an unknown quantity of strips and then have a shift supervisor return to the station later and manually count the cut strips and separate any strips that would have exceeded the required number from the batch to be packaged. The current system allows for an accurate count during the process of cutting the strips. In the current system, the workers will continue to operate on the same system that they have been. The additions to the ramp and cutting operation are transparent to the normal use of the system and will have no effect on the manner in which the workers are used to operating. Once the workers have placed their strips into the chute, then our sensors will come into play, allowing for a simple, accurate count of the number of strips ready for packaging.
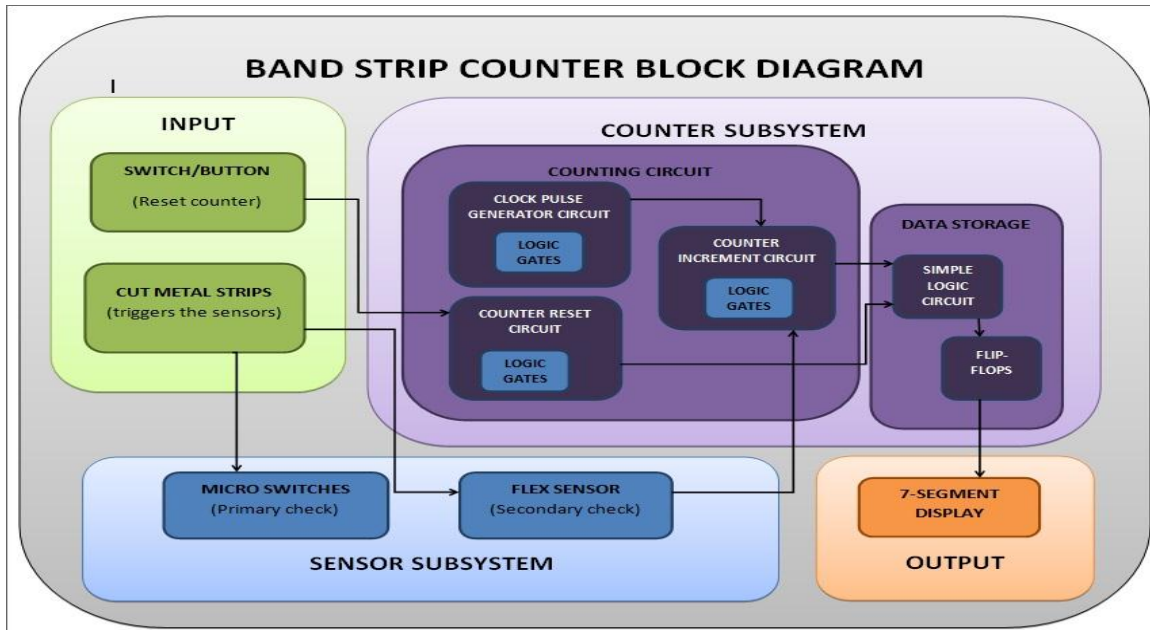
Figure A02: Block Diagram Counter Systems

The counting system was divided into several subsystems to facilitate an accurate system with minimal interaction by the START employees so that they can continue to function without the need for new methods for their system. The counter's subsystems consist of a trigger system, a counter system, and the sensors and switches. For each subsystem that is listed, there will be a description of how that system functions and in what way it interacts with the other systems. The trigger mentions how the system allows for the setup for the initialization of a count without permitting the system to count multiple times per cut operation. The sensors and switches system will mention how each sensor or switch will tie into the entire circuit to provide both accuracy and dependability. The counter system description will detail how both previous subsystems tie together and how the counter functions up to 4 digits.

Initially, a design using a microcontroller and a system of metal detectors was considered for use as the counter system. This system would have used the metal detectors to sense when the aluminum strips entered the ramp and then triggered a response that the micro-controller would have detected and

output an updated count to the display. However, due to the complexity and the temperamental nature of the micro-controller being fed by the metal detector and the cost of implementing such a system, the design was changed. The current design consists of an electrical contact sensor and a set of micro switches. This design was chosen to be ideally simplistic in that the circuit will only function in one way when setup and any errors that might possibly occur would be both obvious and easily identifiable.

The current design is about 95% accurate under normal conditions. Due to the constraints of using the in-place ramp system and making the system transparent to the workers, the switches do not always engage to increment the count if the worker makes an irregular throw down the ramp. However, if the workers engage in a consistent pattern of sending strips down the ramp, the counter should be able to handle the load without errors. In the extreme case where errors occur, the design facilitates the use of a manual increment switch on the control box that allows for the addition of a single count per button press. This will allow both the workers and the supervisors to force a count if they notice something went wrong and will have the added benefit of resetting the trigger subsystem for the next count.

There are some concerns with long term use of the switches and ramp system. The method that was used to activate the switches has not been heavily stress tested and is possible that it may malfunction. Repairs to said system should, however, be easily fixed or replaced. Also due to the sensitive nature of the circuit, any overload of the circuit, such as a power surge from outside storm, could cause hardware failure in the circuit. The design allows for the easy replacement of the majority of the chips in the system in such a failure, but there was no way to test for such a scenario in our time constraints.

Cost to Implement

Cardboard Cutter: (DA)

The total materials costs for the final product are estimated at $ 179.26. The majority of the pieces used to create the product were made on hand with the use of heavy machining equipment. The frame of the blade required a lathe to cut the groove in it. The steel pieces were cut with band saw. The majority of the aluminum pieces were crafted with a cad aided mill. A regular drill was used to drill the wholes of the screws. Auto CAD Inventor was used to create the parametric drawings attached in the appendix. The total cost estimate including labor and the time spent using the machining equipment and Auto CAD inventor comes out to roughly two times the price of the materials. The Final cost estimates is $344.58 per unit.

Table A03: Cardboard Cutter Price Breakdown

CARDBOARD CUTTING DEVICE					
Project Parts	ITEM NO.	ITEM TYPE	QUANTITY	UNIT PRICE	SUBTOTAL
Blade Frame	1	plates	2	$3.50	$7.00
	2	Screws Tightens	3	$2.00	$6.00
	3	Blades	2	$15.00	$15.00
Shafts	1	Sliders	2	$39.13	$ 78.26
	2	BOLTS AND SCREWS	10	$2.00	$20.00
	3				
	4	End Blocks	2	$15.00	$30.00
	5	Rubbers	4	$2.00	$8.00
Handle	1	Grip	1		$15.00
TOTAL PRICE					$179.26

Counter: (TH)

The ramp system that was built for a previous project was left largely intact and lightly modified to accommodate the new counter system. The total cost for prototyping and implementing the system was $80.29.

Table A04: List of Parts and Prices

Item	Quantity	Unit Price	Total(s)
IC's			
74ls192	4	$3.49	$13.96
CD4511	4	$0.45	$1.80
7 SEG Disp CC	4	$1.09	$4.36
LM555CN	1	$0.19	$0.19
74ls32	1	$0.45	$0.45
74LS00	1	$0.45	$0.45
74ls74	1	$0.45	$0.45
MicroSwitches	4	$1.57	$6.28
Sub Total			$27.94
[1]			
Materials			
Protoboard(s)	2	$2.49	$4.98
Control Box	1	$15.00	$15.00
Screws	6	$0.20	$1.20
Hinges	4	$1.18	$4.72
Epoxy	1	$4.50	$4.50
Acrylic	2	$5.00	$10.00
DIP Sockets	60	Varies	$11.95
Wire Mesh	4" x 4" square	$5.00	$5.00
Sub Total			$52.35
[2]			
Grand Total			$80.29

[1] – Parts listed as bought individually form Jameco Electronics:

http://www.jameco.com

[2] – Parts listed as bought from RadioShack retail pricing:

http://www.radioshack.com

Schedule of Implementation

Cardboard Implementation Schedule: (DA)

Table A05: Cardboard Cutter Implementation Schedule

	1-June	2-June	3-June	4-June	5-June
Organize Parts	■				
Cut and Drill Blade Frame	■				
Drill Holes into the Frame and End Blocks		■			
Insert Blades into Frame			■		
Cut the Sliders			■		
Weld the Shafts to the End Block			■		
Cut Rubber Stoppers to Size and Affix to End Blocks				■	
Weld and Connect the Handle to Frame				■	
Attach Grip to Handle				■	
Test and Tweak System as Needed					■

Counter Implementation Schedule: (TH)

Table A06: Counter System Implementation Schedule

	1-June	2-June	3-June
Hinge and Switch Assembly	███		
Wire Mesh/Contact Sensor Assembly	███		
Protoboard/DIP socket - assembly/soldering		███	
Protoboard Mount into Control Box		███	
System Testing Before Installation		███	
Wiring Switches/Sensor to Ramp			███
Attaching Wiring to Control System			███
Full System Testing and Minor Tweaking for Performance			███

Section B: Cardboard Cutter Subsystems

Cutting Mechanism: (CO)

Introduction

The cutting mechanism system is used for cutting cardboard papers that will account for a fixed width of 42 in and length ranging between 9 in - 42 in. This project is designed to complete a cardboard cutting operation in 15 s. this system is designed to be securely mounted on a table surface with a grove in which the blades fit into. It comprises of mostly metal work which minimizes failure of the system. An engineering drawing of the complete assembly could be seen in Drawing no. 4 (Title: Cutting Mechanism Assembly).

Ergonomic handle Assembly: (CO)

The components in Drawing no. 1 (Title: Ergonomic Handle and Blade Frame Holder) is what makes the built system useable, it comprises of a 5.8 in height aluminum handle assembled onto a 13.1 in long metal for the blade frame attachment respectively. The length of the blade attachment was determined by the average arm length of six people. The diameter and length of the aluminum handle was based on the hand grip of a regular bicycle.

There was several different design options discussed to make this part. One of which was to make the handle from polished wood. One of the disadvantages of the wood was how long it will last and the maintenance involved also the unreliable means in which it would have been attached to the metallic blade attachment, which might have been prone to failure of the system. The price of the handle grip used in this system cost about $15 which is cost economical in contrast to making use of a wooden handle.

Cutting Mechanism Assembly: (CO)

Blade:

In the cutting mechanism assembly it consists of the blade frame shown in Drawing no. 6 (Title: Blade Frame Details) and metallic Connector A in Drawing no. 2 (Title: Assembly Connectors). The blade frame is made of two rectangular shaped metal sheets with a chamfered end as seen in the Drawing no. 6 (Title: Blade Frame Details), on one side of the frame it is designed to allow the insertion and firm grip of 3 utility blades and varying heights at an angle 38° From the horizontal. Drawing no. 2 (Title: Blade Frame Details) shows a detailed view of the design.

In the course of producing the project, the use of wood rather than metal was thought of but the cons of using the wood was the means in which it will be attached to the metal parts of the cutting mechanism system as well as the maintenance involved in the use of wood. Also the cost of the 2 metal sheets was $7.00 which helped cut down the cost of buy wood and polishing it.

Safety and Efficiency: (CO)

The safety shield Shown in Drawing no. 5 (Title: Safety Shield) is to serve as an eliminator to any possible means of injury while using the cutting mechanism system. The safety shield is made of bendable aluminum material. It is attached to the system by the use of screws on the metal Connector A in Drawing no. 2 (Title: Assembly Connectors) to the blade frame attachment Drawing no. 1 (Title: Ergonomic Handle and Blade Frame Holder). The safety shield acts as a barrier to any means in which the fingers can get in contact with the blades.

An alternative design considered was a safety shield made of plastic that will be fixed at the same point as the finished design. The aluminum was used because it complements the entire project being a metal work.

Cutting operation Assembly: (CO)

The cutting operation comprises of the linear bearing and 2 shafts shown in Drawing no. 3 (Title: Shaft, Bearing and Bearing Component). The linear bearing is assembled to the blade frame by a metallic Connector B Shown in Drawing no.2 (Title: Assembly Connectors) making use of nuts and bolts. The linear bearing is made of metal with two holes for the shafts. The main aim of the linear bearing is to implement back and forth sliding effect on the two shafts, while moving the entire blade frame and ergonomic handle assembly. The 2 shafts seen in Drawing no. 3 (Title: shaft, Bearing and Bearing Component) are made of polished steel which helps minimize friction between the linear bearing and the 2 shafts. These shafts go through the holes in the holes of the linear bearing.

One of the design options that were not used for the cutting operation was the use of sliders. This was eliminated from the options reasons being that it was light weight and the durability was low. Using the steel shaft is more reasonable considering is long lasting to the amount of force that will be constantly applied to it and it cost about $78.26.

Training Aids:

To enable our clients to be able to use the cutting mechanism system a user guide is provided. The user guide is to ensure the safety of our client and proper use of the system. The user guide consists of pictorial description on step by step explanation on how to use each subsystem and the entire system to produce desired results. The aim of the user guide is to create awareness for employers with no knowledge about the system.

Design Options:

They were several design options during the construction of the system. The design options were categorized in terms of durability, cost, safety and purpose. For the design goal to be achieved an

analysis of the material type featured the design option category (durability, cost, safety and purpose). Other design options which included the use of wood or plastics were eliminated because the failed to implement enough force onto the blade to enable the cutting of the cardboard. Metal work material used is considered more durable to the wood and plastic, also the cost was worth the durability. In terms of safety of the metal material used, it was designed to avoid any injury or hazardous.

Fault Analysis

In the system there are things that can go wrong: this includes the blade becoming blunt after a period of usage, there is also the possibility that all the screwed and bolted parts of the system could get lose after a period of time, which could easily tightened making use of a screw driver. Also the linear bearing could gain more friction over time which can be corrected by using lubricant on the bearing to reduce friction. In this system a stopper is installed at both ends of the shaft track to prevent excess force that can lead to the breaking apart of the system. The only way in which the system will total break apart is if it is being misused but the training aid manual will accommodate for any unforeseen misuse by the end users.

Environmental and Societal Issues

There is always a need for end-users of a product to adapt to a new mechanism and procedures when a new product improvement is applied on a workspace. This system is designed to be user-friendly, increased work production for the end user, reduction the waste of cardboard as a result of inaccuracy and the safety of the end user is covered in contrast to using the old system at S.T.A.R.T. This solution is a safer, reliable and efficient than the old system at S.T.A.R.T. This will minimize the amount of cardboard waste also all past of the cutting mechanism system can be recycled for parts or scrap metal (i.e. metal and the rubber grip).

Section C: Counter Subsystem

Sensors & Switches Subsystem: (SH)

Design Options

The input subsystem is in place to detect an aluminum strip passing through the ramp, and generate a pulse or a signal to increment the count. Many ideas were considered during the design process. Some ideas included using magnetic oscillators and magnetic circuits were discarded because they would be more complex to create as well as repair, and it was assumed that it may not be as accurate as desired, since aluminum is not very magnetic. Break-beam sensors and other light-based sensors were discarded because repairs would be harder, and in certain cases, the circuit would be more prone to double-counts and miscounts.

Finally, the team decided to go with two separate input systems to reduce redundancy while keeping things simple. One input was an electrical contact switch, created by using a pair of wire-meshes that the strip encounters halfway down the ramp. The meshes are rectangular, measuring 3 inches by about 5 inches, hanging from the ceiling of the ramp, and are separated by about half a foot from each other and the mesh on one side is connected to a higher potential than the mesh on the other side (Figure C01 and C02). Since aluminum is conductive, when the strip comes into contact with both the meshes, it will momentarily create a contact, creating a momentary current flow. This will generate the voltage that is used as the pulse to increment the count.

To help augment the electrical conduction sensor, there is also a pair of micro switches attached to the bottom of the ramp. These switches allow the system to have some flexibility and redundancy in dealing with erratic patterns of behavior from the employees at START. These switches are augmented by the use of 2 acrylic door flaps placed on hinges and secured with a pair of low tension springs. These

serve only to make sure the flaps come back to their default resting positions and not maintain pressure on the switches. While the whole system could have been accomplished using only the micro-switches, early testing showed that it was possible for the system to double count using them and they create a single point of failure. With the contact sensor and micro-switches, the system will only allow one increment of the counter per strip that passes through.
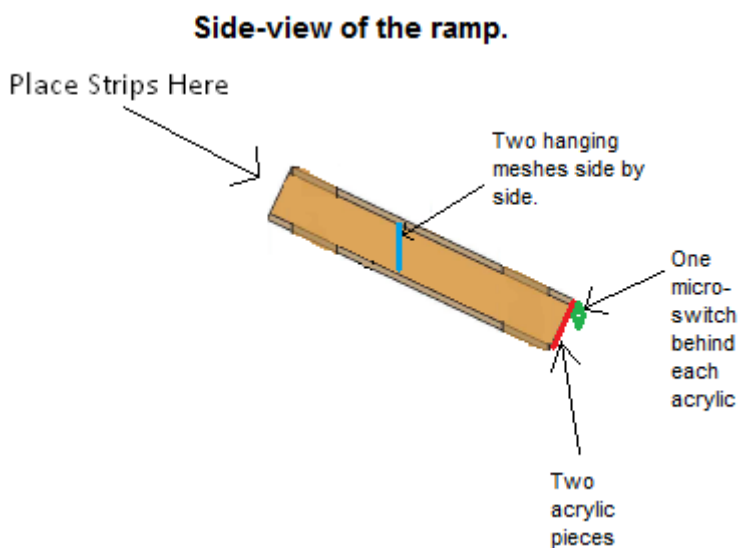
Side-view of the ramp.

Place Strips Here

Two hanging meshes side by side.

One micro-switch behind each acrylic

Two acrylic pieces

Figure C01: Ramp Side View with Sensors

Contact Sensor

Acrylic Door Flaps

Figure C02: Transparent Overview of Ramp with Sensors

Fault Analysis

Because of the way the micro-switches are mounted to the ramp system, there is the possibility that the strips that have been cut do not trigger the counter. This is both due to the orientation of the switches mounted and the irregularity of the method that the worker uses to send the strips down the ramp. Another possibility would have been to limit the speed at which the strips could have come down the ramp and also mount a trigger for the micro-switches to the bottom of the ramp so that they would be counted as they exited.
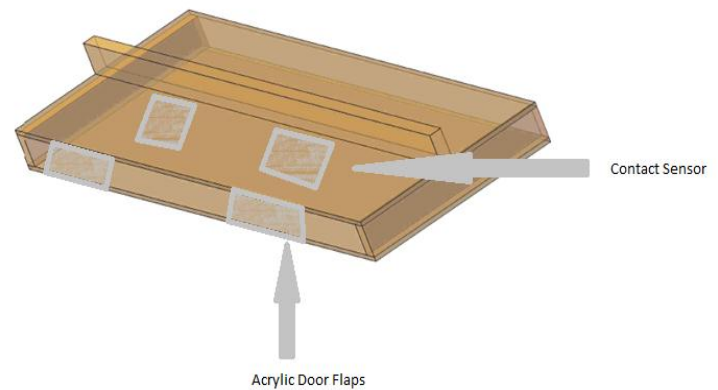
Also, there is the chance that the springs that hold the acrylic flaps in place get weak and thus do not have the strength to pull the acrylic flap back to its base position, which is essential to proper functioning of the circuit.

One very real but infrequent possibility of no count would be if, due to an erratic throw, the strip turns 90° at some point and thus misses either one of the switches. This could be solved by adding a thirds flap in the middle. This problem is unlikely to occur since the acrylic flaps used are very wide.

It is also possible for the micro-switches or the wire-meshes to become bent or displaced. Such issues may cause errors in count, but the fix is usually very easy, like bend the mesh or trigger back into shape.

Safety and Efficiency

The current design is very safe in terms of electrical risk. The input voltage to the entire system is 6 V DC, while the maximum recorded current was less than 200 mA.

The only possibility of injury is if the operator has to touch the wire-meshes, in case of the strip getting stuck at the mesh, due to the mesh having sharp edges. The edges were trimmed as much as possible, but precaution must still be taken during operation.

Trigger Subsystem: (SH)

Design Options

The purpose of the trigger circuit is to receive the input signals generated from the switches, and use it to decide when and how to increment the counter. The primary reason for requiring a trigger circuit is because the input signal does not come in steadily, since the switches are not perfect. Thus, without a circuit to "stabilize" the input signal, there will necessarily be multiple counts for each strip.

Several designs were considered, and some were tested out in Xilinx Design Suite, and some others were tested out further on a breadboard. The team attempted to implement various designs using MUX's, JK flip-flops, and custom built SR-latches (See Appendices B-3 and B-4). Initial designs were scrapped due to glitches inherent to the designs.

Currently, the trigger circuit is set up to use both the signals from the contact switches and the micro-switches to make sure that one strip is counted only once, while sending the right signal to the counter subsystem at the right time to increment the count (See Appendix B-1).

The signal from the contact switches go through an OR-gate (IC 74LS32) and are then passed on to a D flip-flop, setting the flip-flop to HIGH. The chip used was 74LS74. The "reset" input of the flip-flop is connected to the OR-ed output of the micro-switches behind the acrylic piece. The output of the flip-flop goes into a two input NAND-gate (IC 74LS00), whose other input is connected to the micro-switches. The output of this NAND-gate is always HIGH, except for the moment when the micro-switches are activated. The NAND gate puts out a LOW momentarily before going back to a HIGH when the flip-flop changes state to LOW. This output of the NAND gate is fed in to the (Active-Low) input of the monostable (IC NE555), which triggers the monostable to output a very stable HIGH for a fixed period of time, which is fixed by the equation:

$T = 1.1 * R * C;$

where R : resistance to pin 7.

C : capacitance to pin 6.

This output is fed into the Counter subsystem, and this pulse directly increments the count.

Fault Analysis

The Trigger circuit is very stable and not very prone to failures, as long as the input systems work well. The only other possibility of failure is in case of a voltage fluctuation which may cause chips or resistors to get damaged or burnt. Such a scenario is unlikely. In case of such a situation occurring, the parts can be replaced very easily and cheaply.

Safety and Efficiency

The circuit is safe for voltage and current considerations. The only safety issue would be if the operator were to touch a chip that has gotten extremely hot. Such a scenario is unlikely, since the team has introduced resistors in places to prevent high currents from flowing, and repeated testing since has not caused the chips to get hot.

Counter Subsystem: (TH)

Design Options

Table C02: Comparison of Features for Counter IC's

	74LS192	74LS90
Speed	40MHz	42MHz
Power Dissipation	95mW	45mW
Master Reset	Asynchronous	Synchronous
Presetable Inputs	Yes	No
Reversible Count	Yes	No

The counter subsystem being used is actually a series of pre-built Binary Coded Decimal counter Integrated Circuits. This design was chosen because it was cheaper to use the single chip IC's and would be both simpler to build and repair. These counters are capable of 40MHz count speed which well exceeds the requirements. Due to the limiting process of our trigger system, the fastest these counters

should increment is about 1.1Hz. During the initial design stage of this system, the 74LS192 IC was chosen because of its quick count time, and ability to support pre-load inputs. However, after asking START about the requirements that they had for the counter project as a whole, the pre-load function was determined to be unnecessarily complex for the majority of the workers at START and a likely un-used feature for the supervisors, so the feature was removed. However, we maintained use of the 74LS192 to allow for the possibility of later expansion on circuit at START's discretion.

The counter subsystem consists of four 74LS192 IC's cascaded in an asynchronous system (See Appendix B-1). The least most significant bit on the display would be tied to the most significant counter IC. There is no clock signal anywhere in the circuit which allows the circuit to operate under impulse indirectly provided by the START workers. The count will only be triggered from the triggering system. While testing the counters, it was discovered that because of it quick count times, the trigger mechanism built into each IC was too sensitive and would count in burst of 10 or more each time the trigger was activated.

Each 74LS192 outputs its current count to a CD4511 Binary to Binary Coded Decimal driver. This IC exists solely to convert the 4-bit binary number into an output that can be shown using the 7-segment displays. These 7-segment displays are the sole visual outputs of the system as they are always on whenever there is power to the system and can show immediately if there is a malfunction with the system.

Fault Analysis

The most likely cause of failure is that the 7-segment displays tend to be sensitive to voltage and current fluctuations. But in case of failure, replacement is cheap and simple. Any other possible failures

are simple chip failures as well, and all the chips are very cheap and easy to replace. Fluctuations in the input voltage may damage the chips.

Safety and Efficiency

The circuit is safe for the operator in terms of voltage and current levels. As in the Trigger subsystem, some chips may get hot in case of voltage or current fluctuations, but such are unlikely to happen.

Section D: Conclusions

Cardboard Cutter Conclusion: (SA)

The main goal of this project was to build a device that helps disabilities people in S.TA.R.T company in order to make their job easier. However, the project has accomplished what is it made for and reach the results desired.   . The device will assist in the manufacturing of cardboard cutter. There were many design thoughts that were accounted for during the development of this project. Ergonomic, simple, and low cost design was particularly important as it will be regularly used in a workplace by clients with limited physical and mental disabilities.

This project uses many mechanical advantage of the system in order to increases the force output and decreases friction resistance. The linear bearing was used reduce friction making operation easier for the user while increasing the longevity of the prototype. Also, a customize blades holder was built with a capable of holding three blades in a row with different heights which leads to a better precision cut. The handle was set in a specific height and length in order to provide a perfect pull. In addition, the handle has an ergonomic grip which leads to firm grip and comfortable pull.

The development project is a friendly user to the environment, health, and society. The cardboard cutter is an environment friendly because it is 100% recyclable and does not produce any dangerous waste. The project is has no issues with societal due to the ease of use. The employees adapted to it right away since it is work with just one pull. For the manufacturability, the cardboard cutter was meant to increase the production and save time. However, the life-cycle of this project could last up to 5 years due to the strong metals that used and the heavy duty design.

There were many issues during the design review such as blades types, and track mechanism. A disk blade was in mind but it was not used during to the complicity of building a customize blade holder. Also, a special table with specific measurements that has a groove in the middle would be perfect in order to make the cardboard cutter works at its maximum efficiency. However, START Company has no space for the new table and they would like the project to be placed on their old table.

Counter Conclusion: (TH)

While no conclusive data has been gathered on the increase in effectiveness of the new design and system, there is an obvious subjective increase. The current design removes the separate step of counting finished strips and integrates it into the cutting process. This both allows for the workers to monitor the number of final products that they are trying to achieve and also prevents the system from being taken offline while a supervisor counts the current product. While the counting device maintains consistency, it will allow the supervisors at START to devote less time micro-managing the station and allow them to focus on other areas of their production environment.

While the design did not focus on the ramp and cutting station, there were some improvements that needed to be made in order to facilitate our new design. One unintended benefit was the addition of doors on the bottom of the ramp that trigger the second set of switches to increment the count. These doors, while triggering our system, also force the strips to exit the ramp in a more controlled fashion than before, and help keep the final product a little more organized.

Future improvements to the system could include more accurate contact sensors. The method currently used depends on the strip conducting a portion of the available current across the sensors and does not guarantee success. However, testing has shown a very small rate of failure with more extreme conditions tending to increase error rate. An alternative would be to make the contact sensor a constant contact that is broken when the strip is sent down the ramp. Further analysis would be needed to determine if irregularity to the voltage supply would cause a fluctuation in the sensor that would trigger a false count.

Safety was one of the primary concerns in the system due to the use of electric current in a relatively open environment. The whole system uses less than 200mA under full load and any part that

has an electric current applied to it is either encased to prevent easy access or insulated so that there is minimal contact with persons and materials. Also, the design allows for a very simple replacement system for a burnt or damaged integrated circuit chip which may occur over the life of the design.

Section E: Appendices

Appendix A: Counter System User Guide (TH)

Proper Initialization and Use Guide

1. Plug AC adapter into socket
2. Flip primary power switch located on control box
3. Wait 2-5 seconds for system to initialize
4. Press the system Reset Button and hold for 2 seconds
5. Cut aluminum strip to desired length
6. Without excessive force, drop/throw strip into chute
   a. Count will automatically increment
   b. If errors are noticed, press the manual increment button on top of control box
7. When count reaches desired number:
   a. Package box
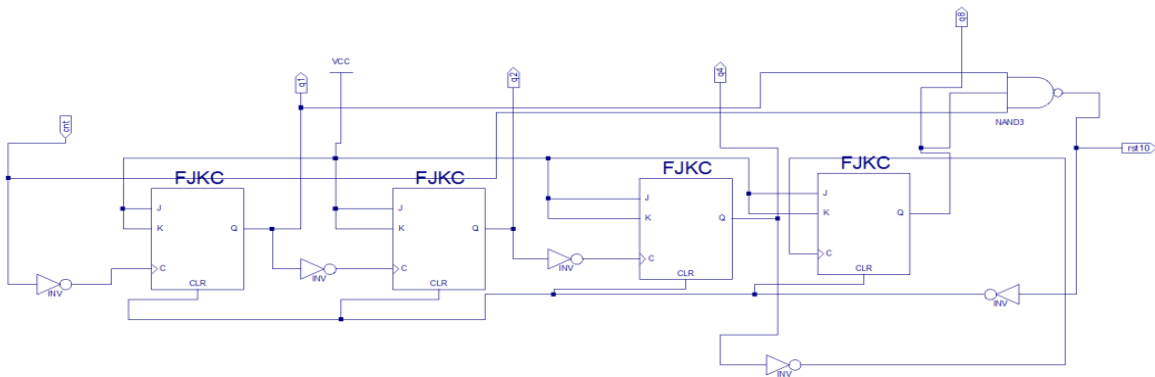   b. Start from Step 4 to start new count
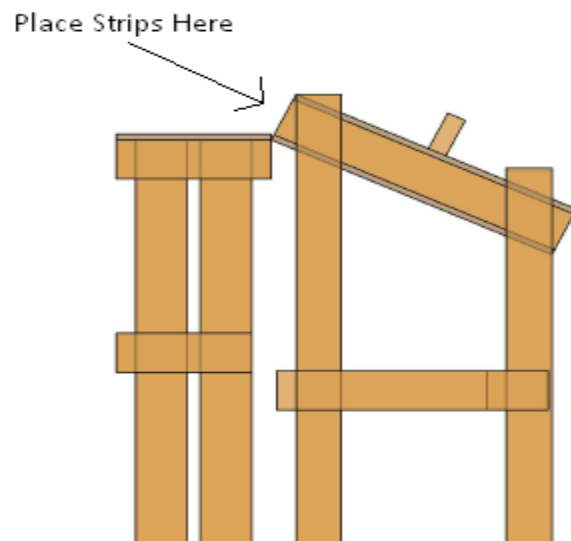
Appendix B: Counter Circuit Diagrams (TH & SH)
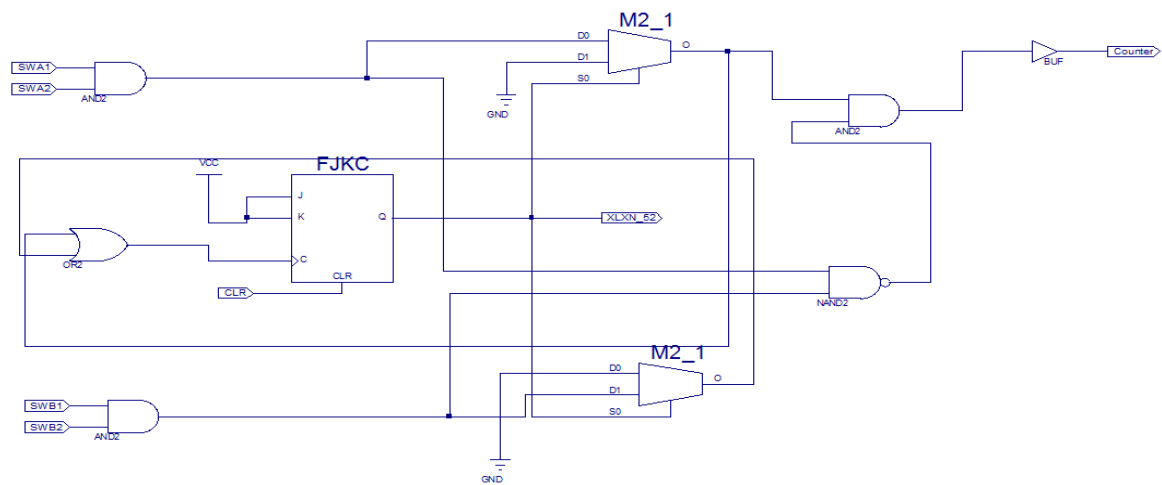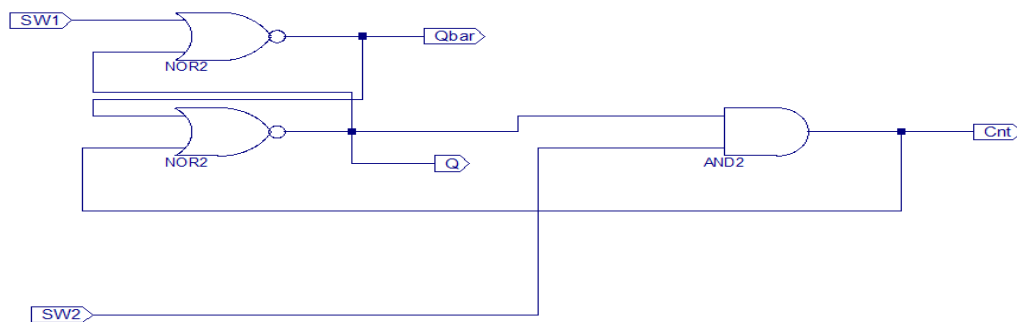
Counter Wiring Diagram
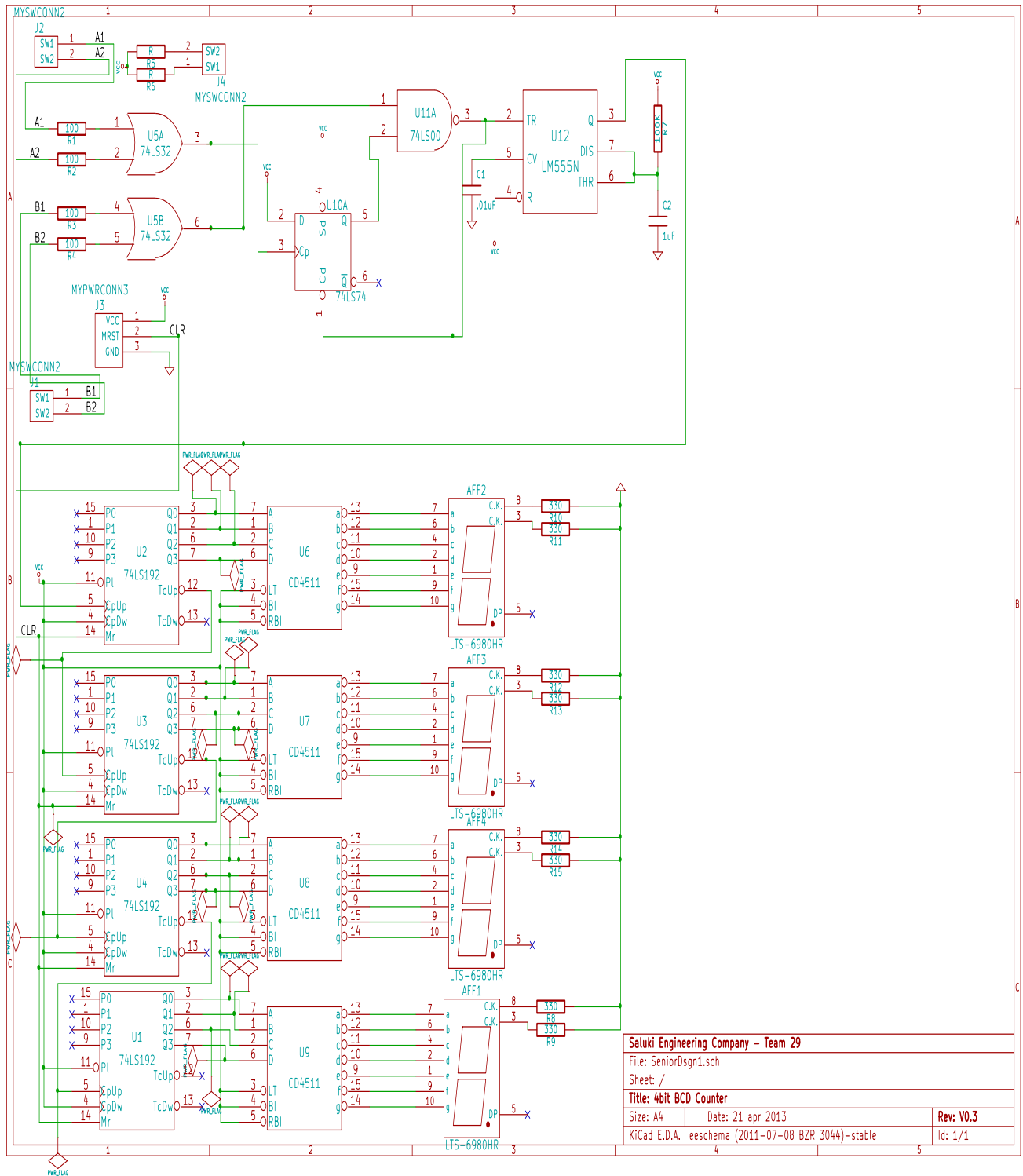
Counter with JK Flip-flops

Trigger Circuit with JK Flip-flops

Trigger Circuit with custom-built SR Flip-flops

Appendix C: Technical Manual for Cardboard Cutter (SA)

Cutting Track Assembly:

The cutting track is constructed with a two steel shafts of 60 in. All of the force from the cutting mechanism is applied on the shafts which are attached to two bases. These bases have two holes on the bottom of them in order to mount them on a table. The shafts have a linear bearing that slides back and forth all along the shafts. The linear bearing has two holes of 0.9 in that slides through the shafts and stops whenever it hits one of the rubbers that are attached to the two bases. However, these shafts are able to handle up to 45 lb.

Blades Holder Assembly:

The blades holder function is to ensure that the three blades in the cutting mechanism will cut through the cardboards. The blades holder is made of steel and it has a rectangular shape of two plates that attached to each other 7.1in x 4 in. Also, it has a smooth curve in the front of the blades holder that leads it to run smoothly on top of the card board. The three blades has been placed on a curved groove on one the plates from the inside which enables the blades to fit exactly in. In addition, the other plate has four screws to tighten them up to each other and make the blades unmovable. The three blades are attached in different heights and specific angles to maximize the accuracy of the cut and minimize the force required. The firs blade has only 5mm exposed to the cardboard, the second blade has 8mm, and the third has 15mm. using this method allowed a better cut for the cardboard.

Safety Box Assembly:

The safety box is constructed entirely of steel. It is attached to the handle through two small screws from the top. The safety box covers the blades holder and the blades themselves. Also, it allows

the cutting mechanism to fully function while preventing the operator from putting his or her hand near the cutting plate.

Handle Assembly:

The handle mechanism was constructed from heavy steel and it has a length of 13.1 in. The handle was built with strong and heavy steel in order to pass the resistance of the cardboard. Also, it was built with two pieces to allow the handle raise up and down in order to replace the blades and to slide the cardboard beneath it. Additionally, there is an ergonomic handle grip placed at the edge of the horizontal part that allows firm and comfortable grip.

Appendix D: User Manual for Cardboard Cutter (KA)

User Manual for Cardboard Cutting Mechanism

1. Place the linear bearing at the end of the slider.

2. Ensure the handle is elevated to make a space for the cardboard to be slid.

3. Pull out the cardboard to the wanted size.

4. Ensure the cardboard is placed between the two metal tracks which allow the cardboard to move in one direction.

5. Pull down the handle and press it on the cardboard to make sure that the last two blades are passed through the cardboard.

6. Process the cut by pulling the linear bearing on the surface of the cardboard.

   - You can use both hands to exert the pulling force if it is too hard to pull.

7. Remove the cardboard piece from the table, and repeat process from step 1.

Appendix E: Recommended Vendor List

Cardboard Cutter System (DA)

I.   Recommended Vendors

    a.   McMaster-Carr

      P.O. Box 54960
      Los Angeles, CA 90054-0960

      (562) 692-5911

      www.mcmaster.com

    b.   MEEP Machine Shop

      1230 Lincoln Drive
      Carbondale, IL 62901

      (618) 536-2396

      tattig@engr.siu.edu

    c.   Lowe's

      1170 Rendleman Rd
      Carbondale, Il 62901

      (618) 529-8400

      www.lowes.com

Counter Systems (TH)

I.   Recommended Vendors

    a.   Jameco Electronics

      1355 Shoreway Road
      Belmont, CA 94002

      www.jameco.com

    b.   RadioShack

      1707 W Main St
      Carbondale, IL 62901

      www.radioshack.com

Appendix F: Communications

Date: Mon, 1 Oct 2012 17:36:10 -0500
Subject: Re: SIU Ability One team
From: carlhartmann1@gmail.com
To: k.sa3don@hotmail.com
I will not be in the office tomorrow. You can still come to START, but
please ask for Brandy.
On Mon, Oct 1, 2012 at 2:16 PM, Khaled Alnamasi <k.sa3don@hotmail.com> wrote:
Hi Carl,
As I referred in the phone call, we have to record a video while workers work on the
cardboard task. Our best time to do that is tomorrow Tuesday Oct. 2nd at 11:10 am.
Please inform me if that's work with you.

Thank you

Khaled Alnamasi
Mechanical Engineering
College of Engineering
Southern Illinois University at Carbondale

Carbondale, IL 62901-6603
Tel: 618-303-9921
Email: K.sa3don@siu.edu

---------- Forwarded message ----------
From: Carl Hartmann <carlhartmann1@gmail.com>
Date: Tue, Apr 2, 2013 at 12:39 PM
Subject: Re: Possibility of working at START location
To: "Tim H." <thendricks@siu.edu>

Anytime between 8:00 - 3:30. We will work around your
schedule. If we could only have that work station down for
a couple of days, that would be great.!!

On Tue, Apr 2, 2013 at 11:02 AM, Tim H. <thendricks@siu.edu> wrote:
Hey Carl, it's Tim again from SIU senior design. I was just checking to see if you got my
last email about scheduling some time to work on our project at the START facility?

On Wed, Mar 27, 2013 at 6:17 PM, Tim H. <thendricks@siu.edu> wrote:
Hey Carl, I know that you are out of the office now, but I have a question for you that
does not require an answer right this minute. Syed and myself have run some tests
and simulations on a cardboard ramp that we mocked up to simulate the real thing, but
it doesn't quite match up to what we plan on eventually doing. What I was wondering
is how often you use the binding strips station. We would like to start coming out to

START to do some work on the ramp and maybe modify the wood structure to some
extent, but I am not completely sure about times yet and was wondering what was the
longest length of time we could put that system out of commission while we are working
on it. I will keep in contact about the plans we are attempting to make so we don't just
show up and surprise you or your staff. Thanks for your help.

--
- Tim Hendricks

Computer Engineering Student
Southern Illinois University

---------- Forwarded message ----------
From: Carl Hartmann <carlhartmann1@gmail.com>

Date: Wed, Oct 31, 2012 at 1:29 PM
Subject: Re: Visit
To: "Tim H." <thendricks@siu.edu>

No Problem... Tomorrow is fine...

On Wed, Oct 31, 2012 at 1:04 PM, Tim H. <thendricks@siu.edu> wrote:
Hey Carl, sorry about the late response, but I had something come up today and the
other member of the team was working on studying for a test so we were not able to
get out there today. However, I would like to try again tomorrow around 11 again. All we
really need to do while we are out there is to grab some materials to perform our tests
on, so I don't believe that it will take a lot of time. Thank you so much for you help.

---------- Forwarded message ----------
From: Tim Hendricks <tinyt777@gmail.com>
Date: Thu, Feb 28, 2013 at 1:09 PM
Subject: Re: SIU Senior Design
To: Carl Hartmann <carlhartmann1@gmail.com>

Hey Carl, sorry it took so long to get back to you. I'll be heading out to START here in
a few minutes to get some measurement and footage and maybe discuss out design
ideas with you.

On Feb 27, 2013 10:53 AM, "Carl Hartmann" <carlhartmann1@gmail.com> wrote:
Tomorrow after 1 would be great. We usually have that station running in the
afternoons, so if tomorrow does not work, any day next week.

FYI... Our clients only work until 2:30. If you need a video / picture it has to
be before then.

On Wed, Feb 27, 2013 at 10:11 AM, Tim Hendricks <tinyt777@gmail.com> wrote:
Hey Carl, I know you haven't heard from me or the group in a couple weeks, but I just

wanted to ask a quick question. We need to get footage of you working the banding strip cutter so we can do a time analysis and also possibly get some measurements so when we build our replica to test our system, we get it as accurate as possible. When is the next time you plan on having that station manned and worked? Members of the group should be available tomorrow after 1 or various times next week. Just let me know when you plan on running the station next and we will work around your schedule. Thanks.

--
- Tim Hendricks

Computer Engineering Student
Southern Illinois University

Date: Fri, 1 Feb 2013 19:29:02 +0000
From: notify@egnyte.com
To: k.sa3don@siu.edu
Subject: I would like to share files with you

Thank
you for registering with the AbilityOne Network Design Challenge. When you log into Egnyte, you will find a folder
with the coach's last name on
it – you can use that to upload your final report and supporting
information. Or if you are an instructor,
that folder can be used for your student or team or teams. If you have
multiple teams please create additional folders within your
one folder for each team.

For
program information and requirements go to: www.a1designchallenge.org and select Challenge Requirements in the
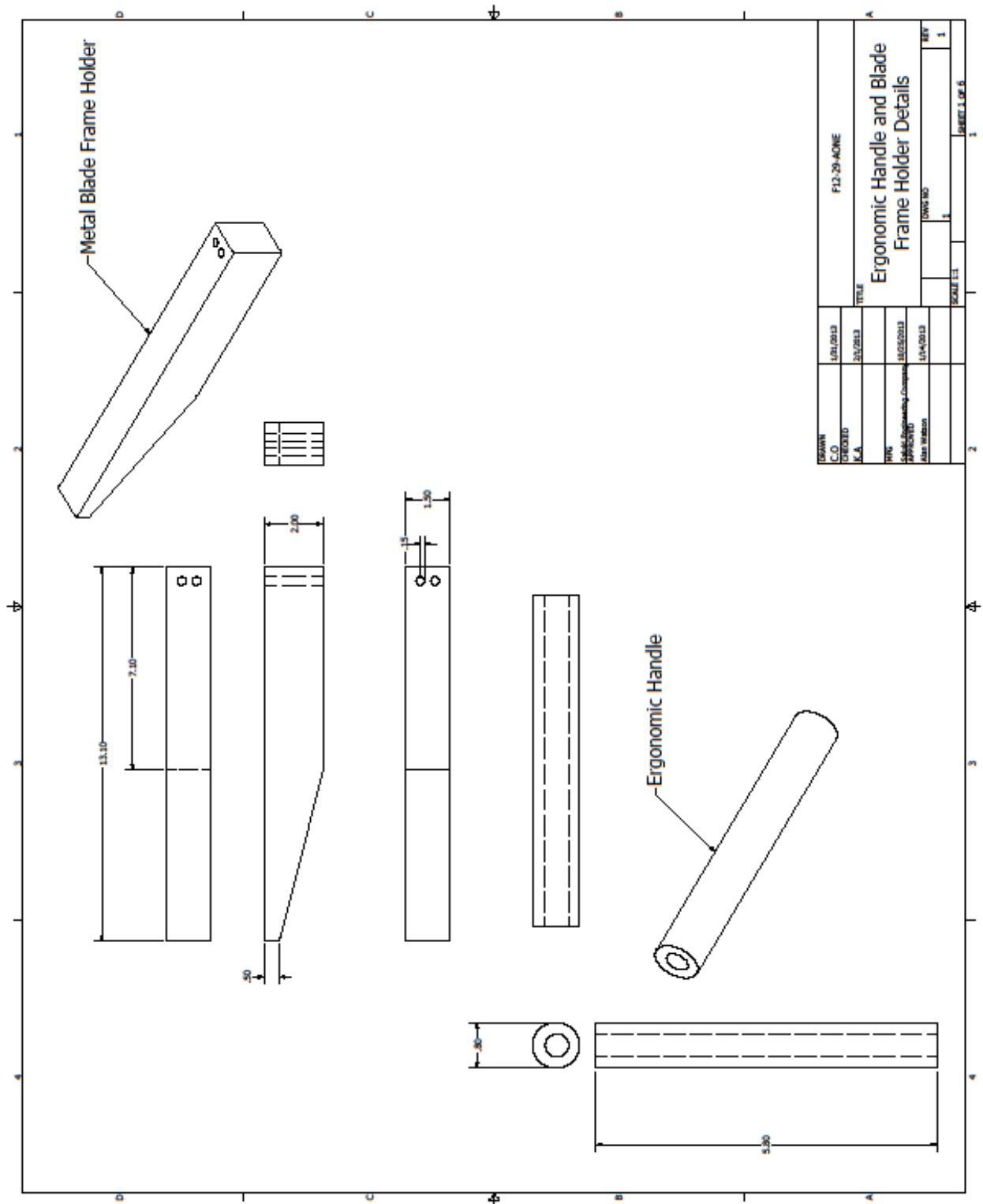menu. Upload all required material through Egnyte per the
instructions.

Finally,
please see the Financial Assistance Program for University Students – Assistive Technology Development brochure (FAP-Brochure-2012.pdf) in the Egnyte
directory: Shared\2012-2013 College Design Challenge Registrants

If
you have any question, feel free to contact me at shurd@nish.org.

Stephanie
Hurd

Appendix G: Mechanical Drawings

Metal Blade Frame Holder

Ergonomic Handle

Ergonomic Handle and Blade Frame Holder Details

Connector A

Connector B

Shaft

Bearing Component

Bearing

60.00

2.50

1.50

4.00

.90

.50

.50

.50

1.20

1.50

Complete Assembly of Cutting System

Aluminum Sheet Metal

8.50

4.50

4.50

4.32

Assembled Blade Frame

Sheet Metal

Blade Stopper (for the 6 holes)

Blade

Blade Frame Details

4.00

2.14

2.14

7.10

DRAWN		F12-29-AONE		REV
C.O	1/01/2013			1
CHECKED				
K.A	2/5/2013	TITLE		
MFG		Blade Frame Details		
Sakdi Engineering Company	10/25/2012			
APPROVED		DWG NO		
Alex Watson	1/14/2013	6		
		SCALE 1:1	SHEET 6 OF 6	

Appendix H: Technical Manual for Counter System (SH)

Electrical Contact switch assembly:

Two wire-meshes, about 3 inches by 6 inches, are to be hung form the "ceiling" of the ramp about halfway down. These are to be about 10 inches apart from each other. These are to be connected using small hinges attached to the ceiling, while making sure that the attachment is not too tight to let the hinges move freely.

A second set of wire meshes, about 5 inches by 10 inches, are attached to the floor of the ramp. These are to be laid down flat on the floor of the ramp.

One of the hanging meshes and the corresponding mesh on the floor should be connected to a high voltage (6 volts max). The two meshes on the other side are to be connected to ground.

The signal coming off of these switches are tied together and assigned to the "set" input of the custom D flip-flop in the trigger circuit.

Acrylic Slab and Micro-switch Assembly:

Two acrylic slabs, about 3.5 inches by 14 inches, are attached to the end of the ramp. These are also hung from the top surface using similar or identical hinges as the ones used to connect the wire-meshes.

The acrylics are attached to springs which are connected to the top surface of the ramp. These springs make sure that the acrylic is back in position as soon as the strip passes through.

The micro-switches are positioned right behind the acrylic, and are held there by a piece of a coat-hanger, about 7 inches long, cut and shaped into a "U". The micro-switch has two perforations

through which the two ends of the piece of the hanger go through. The piece of the hanger is held tightly by two cable-organizers, and is very steady so that the switch stays in place.

Trigger Circuit Design:

The two outputs from the wire-meshes are OR-ed together using chip 74LS32 and fed into the input of a D flip-flop, chip 74LS74. The two outputs from the two micro-switches are OR-ed together using the same chip above, and the output of the OR gate is fed in to the "reset" input of the flip-flop.

The flip-flop is made with two NOR gates, for which the chip used was 74LS02. The output of each NOR-gate is an output by itself, as well as an input to the other NOR-gate.

The output of the D flip-flop is fed into a two-input NAND gate, whose other input is tied to "reset" input of the same flip-flop. The IC used was 74LS00. The output of this NAND gate is fed into the monostable.

The chip used for the monostable is LM555. The chip has 8 pins. They are connected as follows:

- Pin 1: GND
- Pin 2: Output of the said NAND gate.
- Pin 3: This is the output of the Trigger circuit, and is to be fed into the counter circuit.
- Pin 4: Vcc
- Pin 5: 10nF capacitor, whose other end is grounded.
- Pin 6: This pin is connected to the junction of an 820 kΩ resistor whose other end is connected to Vcc, and a 1 µF capacitor whose other end is connected to ground.
- Pin 7: Tied to Pin 6.
- Pin 8: Tied to Pin 4.

The output of the monostable comes out of pin 2, which will be used as the input to the counter circuit.

Counter Circuit Design:

This part of the circuit is responsible for the counting and displaying the current count. The IC's used for the counter are 74LS192. These are four-bit BCD counters. It has a "count up" input which is where the output of the Trigger circuit is fed into, and a "count down" input which is held to HIGH. Whenever there is a rising-edge in the "count-up" input, there is an increment in the current count, until 9 (or 1001) after which the count goes to 0 (or 0000). At that time, the "terminal count up" output goes HIGH. This output is used as the input to the next counter, representing the next decimal digit, until there are four counters.

The "Master Reset" input of all the counters are connected to a single push button. All other inputs can be grounded and outputs ignored.

The four output bits signifying the current count are to be fed into a display driver chip CD4511. This chip converts the digit into proper signals that can be fed into a 7 segment display.

The chip used for the 7-segment display is MAN71A. This is a common-cathode device.