The Can Crusher

Group 12

Stanley Andrews

Brandon Jefferson

Senior Design

Fall 2013

August 1, 2013

Table of Contents

1. Executive Summary 1
2. Projection Description 1
2.1. Objectives 2
2.1.1. Sensors 2
2.1.2. Wireless Control 3
2.1.3. Microcontroller 3
2.1.4. Motor 3
3. Research Related to Project Objectives 3
3.1. Research 3
3.1.1. Variety of Sensors 3
3.1.2. Analog vs. Digital Sensors 10
3.1.3. Power Supply 12
3.1.4. Motor 15
3.1.4.1. Air Compressor 15
3.1.4.2. Electric Motor 16
3.1.5. Can Crusher 18
3.1.6. Cylinder Types 21
3.1.6.1. Pneumatic Cylinder 22
3.1.6.1.1. Single- Acting Cylinder 22
3.1.6.1.2. Double-Acting Cylinder 23
3.1.7. Solenoid Valve 23
3.1.8. The Sorter 25
3.1.9. Commercial vs. Household 32
3.1.9.1. Commercial 32
3.1.9.2. Household 35
3.1.10. Storage Bin 36
3.1.10.1. Storage Bin Sensors Placement 37
3.1.11. LEDs 41

3.1.12. Board Types 43
4. Design Layout 45
4.1. Design Requirements 45
4.1. Hopper 45
4.2. Can Crusher 45
4.3. Sorter 45
4.4. Sensors 45
4.5. Power Supply 47
4.6. Motor 50
4.7. LED 50
4.8. PCB 52
4.2. Design Summary 55
5. Building and Testing 57
5.1. Element Testing 58
5.2. Sorter Testing 58
5.3.Storage Bin 58
5.4. Angle Distance 59
5.5. Power Testing 59
5.6. LED Testing 59
5.7. Board Testing 59
5.8. Microcontroller Testing 60
6.Administrative Contents 60
6.1. Milestones 60
6.2. Project Budget and Finance 61
7. Appendix 66
7.1.Permissions 66
7.2. References 71

Table of Figures

Figure 1: Reflective Optical Sensor TCRT5000 7
Figure 2: Banner SM2A312LV 8
Figure 3: Ultrasonic sensor front and back 9
Figure 4: Triad Transformer……………………………………………………………..14
Figure 5: Transformer connected to the PCB…………………………………………14
Figure 6: Block Diagram of the Power Supply 13
Figure 7: Possible Handmade PVC Design.. 20
Figure 8 : Kevinkrusher 1.5 20
Figure 9: Kevinkrusher 1.5 21
Figure 10: Can Crusher Pneumatic Cylinder……………………………………….21
Figure 11 : How a Cylinder is built 22
Figure 12 : Mounted Solenoids 24
Figure: 13 The Hopper……………………………………………………………………..25
Figure: 14 Inside View of the Hopper ……………………………………………………25
Figure 15. View Inside the Hopper…………………………………………………….27
Figure :16 The "Sorter" for the Automatic Can Crusher…………………………………..27
Figure: 17 The Sorter……………………………………………………………………28
Figure :18 Regular 12oz. cans 28
Figure :19 Typical size water bottle 28
Figure 20 : 8 FL Oz water bottle 29
Figure: 21 Slot for objects to pass through…………………………………………….29
Figure 22: 6" inch Actuator 31
Figure 23: Swinging Method Considering.. 32
Figure 24: Office Building Recycle Trashcan 33
Figure 25: Commercial Size Trashcan 34
Figure: 27 Automatic Can Crusher Storage Compartment………………………………..35

Figure 28: Image of GP2Y0A02YK0F 37
Figure 29: Visual View of GP2Y0A02YK0F 38
Figure 30: Reflectance Ratio 39
Figure 31: Ideal Storage Bin to be use in project 39
Figure 32: “Trash Talk” idea of sensors placing 40
Figure 33: Storage bins cut outs for storage sensors 41
Figure 34: Placement of the storage sensors 41
Figure 35: of Multi-Color LEDs 42
Figure 36: Miniature LEDs 43
Figure: 37 PCB mounted inside cabinet……………………………………………………….44
Figure 38: Block Diagram of Sensors design layout 46
Figure 39: Power Supply Design... 48
Figure 40: Schematic of power supply 49
Figure 41: Schematic of 5 volt power supply rail 49
Figure 42: Air compressor for the project 50
Figure 43: The LED Display 51
Figure 44: Circuit for each LED 52
Figure 45: PCB Design.. 52
Figure 46: Microcontroller ATMega328 53
Figure 47: Architecture for our Design.. 54
Figure 48: Block Diagram Microcontroller layout... 55
Figure 49: Initial Projected Budget Pie Chart 64

Table of Tables

Table 1: Specifications for Reflective Optical Sensor TCRT5000 7
Table 2: Specifications for the Banner SM2A312LV 8
Table 3: Specification for the Ultrasonic sensor 10
Table 4: Advantages and Disadvantages of AC/DC Excitation 11
Table 5: List of possible Air Compressor... 16
Table 6: List of possible Electric Motors 17
Table 7: List of Can Crusher Specifications 19
Table 8: Specifications of the Pneumatic Solenoid Valve... 23
Table 9: Trashcan Specific... 34
Table 10: Specifications of GP2Y0A02YK0F 38
Table 11: List of Can Crusher Specifications 47
Table 12: List of Final LED lights.. 51
Table 13: Microcontroller Specifications... 55
Table 14: Truth Table 56
Table 15: List of Components and Responsible Team Members.................................. 60
Table 16: Milestones with Goal Dates.. 61
Table 17: Milestone Table with Start and Finish Dates 61
Table 18: Initial Budget.. 62
Table 19: Final Project Budget 63
Table 20: Final Budget ……………………………………………………………………..67

1. Executive Summary

We derived our design from a YouTube demonstration of the Can crusher. After a few videos we gathered that this seemed to be something concrete that could be replicated but the questioned arose of "How could we improve upon the design?" Our senior design project is to build an operable automatic Can Crusher enclosed inside a trash can. The Can Crusher would allow for a person to simply place the can inside the trash can, or throw it away as a user would typically do, and the Can Crusher would crush the can and dispose of the can into a storage department.

The Can Crusher will be able to

- Detect and sort aluminum cans from plastic bottles and glass bottles (not crushing the non-aluminum cans)
- Have sensors to activate the Can Crusher once a can is placed inside the trash can
- Notify the proper personal that the storage bin is full
- Have LCD display, using green and red lights. Green means operational and Red means trash is full and Yellow indicating a standby mode
- Have a storage bin with easy access to empty
- The ability to turn on and off through wireless feature (Android app)
- Standby mode

For the Can Crusher to work we'll need one air compressor. Typically the models we've seen used a 150 psi air compressor to generate enough power to crush the can. By selecting an air compressor we will have to attack the design difficulty of having an air compressor enclosed inside the trash can. We also chose to buy the "Pneumatic Aluminum Can Crusher". Since our project is focused on electrical design we felt no need to try and arrange and build several parts separately avoiding welding and activities of that nature. Microcontroller/controllers will also be ordered to control sensors, LEDs, and interface with the Can Crusher as well. Our Can Crusher will also implement wireless communication.

This paper will encompass each phase of the process to build the Automatic Can Crusher. We will attempt to address each individual area of the project from design obstacles that we foresee; such as Heat, power, interconnectivity between devices, spacing constraints, hardware, software. We'll record results of operational tests that are performed and modifications made. This paper was made to illustrate the conceptual decisions and rationale of the group on the road to creating and designing and improving an existing design.

2. Project Description

In previous products Can Crushers have been shown using pneumatic, linear activators, pitman drive, and stepper motors. Each design had its own pros and cons. We chose to design our model using the pneumatic aluminum Can Crusher, since it seemed to be more efficient for our intended use and location. Typically the Can Crusher has been shown used mainly for households. The design of the pitman drive forced it to be used outside because of its bulky design. Our concept is to use the same idea of the Pneumatic Aluminum Can Crusher and combine it with the idea that it can act as a recycle bin. Originally, we were going to do just a Can Crusher but we needed to add design features, the Can Crusher itself is mostly mechanical in its design. This realization led to the idea that the Can Crusher should be enclosed inside of a trash can. This would create some constraints mechanically but electronically if it were enclosed it may broaden our feature set. Now we can add storage, sensors around the trash can lid, and displays. The enclosed look would also make the design appear cleaner (hiding the houses from the air compressor). The user would simply walk by and place the can into the trash can and the can crusher completes its task discretely. The Can Crusher would need to be placed against the wall near and outlet for power.

We envisioned that the Can Crusher could be used for commercial use. Once emptied, the Can crusher would have properly sorted out plastic bottles and aluminum cans. The properly placed items in the storage bin can easily be dispensed from the Can Crusher. The Can Crusher would have a display screen where the user can easily identify whether or not the Can Crusher is operational. The Can Crusher has three modes: standby- signaled by a yellow LED light, operational- signaled by a green LED light, and stop- signaled by a red LED light. The Can crusher will usually be in the standby mode and can only be placed in the operational mode once a can is dropped into the trash can. The Can Crusher will only go into a “stop” mode when there is a glass placed in the trash can accidently or when the bin is full. All modes will coordinate with the Can Crusher and the LED display. Once full the Can Crusher can wirelessly notify the correct personal to empty out the storage bin. The storage bin will be easily detachable from the trash can. This would mean that for our design, we will have to segment the trash can into layers due to the Aluminum Can Crusher and its equipment (hoses, air compressor, and power supply).

Once a can is placed in the trash and it will be immediately be detected by the sensors around the lid of the trash can. There will be several sensors throughout the trash can and on the Aluminum Can Crusher itself. The sensors will be controlled by the microcontroller. The microcontroller will also interface with the wireless and LEDs

2.1. Objectives

The objectives that follow are a broad description of the goals of the Aluminum Can Crusher based on our design and features that we have chosen to implement into our design

2.1.1. Sensors

The following are the objectives that directly pertain to the use of the sensors in the Aluminum Can Crusher

- Sensors should be able to detect the can

- Distinguish between an aluminum can, a bottle, and glass bottle
- Signal which mode the can is in (either operational, standby , or stop mode)

2.1.2. Wireless Control

The following are the objectives that directly pertain to the use of the wireless control features in the Aluminum Can Crusher

- The wireless app should be able to control the Aluminum Can Crusher
- Should be able to monitor the storage bin
- Should be alerted when the storage bin is full

2.1.3. Microcontroller

The following are the objectives that directly pertain to the use of the microcontroller features in the Aluminum Can Crusher

- Control the Aluminum Can Crusher
- Coordinate with sensors, LED, and wireless app

2.1.4. Motor

The following are the objectives that directly pertain to the use of the motor control features in the Aluminum Can Crusher

- Be able to crush the can
- Filter the bottle and aluminum can
- Be able to move horizontally to dispense the can or bottle into proper bin
- Be able to hold the can or bottle
- Be able to eject the glass bottle

3. Research Related to Project Objectives

3.1.1. Variety of Sensors

Omron Industrial Automation is a manufacturer of “sensing and control technology”. For our project advance the original model of the Aluminum Can Crusher we’ll need to implement several different types of sensors for different functions. Our end goal is to detect aluminum cans, glass or plastic bottles, and measure the weight of each. We’ll need sensors to open or close the current; if it is closed it will send 12V to the air cylinder.

The Omron Industrial Automation produces all types of the sensors that we would ideally like to incorporate into our design. We will begin our research here to develop our understanding of the different types of sensors. Here are lists of possible sensors we may need:

Photoelectric Sensors

The definition of photoelectric sensors provided by Omron is, a photoelectric sensor detects photo-optical work pieces. This simply means that this type of sensor detects distance, presence or lack of presence, of an object by the use of an infrared beam. The sensor has a receiver that transmits a beam, if the receiver is blocked the sensor has now been tripped. The receiver and the transmitter can be in the same place which the use of a reflector would be needed to reflect the light beam back from the transmitter to the receiver. This mode is called “retro-reflective”.

Proximity Sensors

Another mode is called proximity sensing in which a beam must reflect off of the object and back to the receiver. Contrary to the retro-reflective where it detects the object based on if the beam is blocked and does not reach the receiver. The proximity sensor where the object is detected, only if the receiver is in line of sight of the transmitted source.

Photo-micro Sensors

Has the same application as the photoelectric sensors but on a smaller scale. It has a standard U-shaped design but it can come in a variety of shapes.

Pressure Sensors

A pressure sensor detects a range of pressure. Omron manufactures its pressure sensors to convert the measured value, based on the difference in electrical resistance which is changed by an external force, into an electrical signal as an output. The other method is measuring the change in capacitance which is distorted when an external force is applied. The presence of a capacitor forms a movable electrode that is affected once it comes in contact with a force.

Basic Switch

For the Aluminum to Can Crusher to work automatically we’ll need a basic switch. A basic switch is composed of five parts the actuator, contact section, case, terminal section, and snap-action mechanism. The actuator is the motor. The contact section opens and closes the electrical circuit. The terminal section connects to the external circuits. The case acts as a protective feature.

Other Technologies

We mentioned the Omron products to get a good understanding of what top of the line products would provide. Since finances are a factor we’d like to draw some comparisons with other compatible products that are still efficient for our use. As we dive deeper into possible sensors for our projects let us look at a sub category of proximity sensors called triangulation sensors.

Triangular Sensors

A triangular sensor is commonly used at your local neighborhood grocery store. You'll notice as you walk up and get close enough to the entrance that the sliding door opens automatically and close automatically behind you as well. This is due to the triangular sensors. There are four categories of triangular sensors; Microwave sensors, reflective optical sensors, camera based sensors, and triangulation sensors.

Here's how it works,

The optical triangulation sensors placed at the top of the door frame, concealed inside aluminum tube with an optical window facing towards the floor. A LED light emitted from the sensor, reflects off the floor and received by a photodiode placed next to the LED source. A second photodiode is placed farther along the sensor. The light is reflected off the floor it is angled in such a way that it almost solely is captured by the first photodiode. When a person enters the store his/her body changes the angle of reflection and also disrupts the magnitude so that not the entire light source is capture by the photodiode. Once the remaining light is received by the photodiode, a signal is sent to the automatic door controller.

Passive Infrared Sensors

The passive infrared (PIR) motion detector picks up on temperature, unseen radiation that is given off from an object as a result of its core temperature. Within the motion detector are pyroelectric materials, once exposed to heat these materials generate energy. The PIR sensor would be placed in a particular area for detection. Once an object invades that area it will emit a particular radiation disrupting the temperature balance established before the object arrived. This disruption in the temperature is what triggers the pyroelectric materials and from there the motion detector is alerted.

Most common PIRs have Frensel lenses. These lenses are patterned in such a way that affects the PIRs sensitivity. Usually these sensors would have to be mounted which may be an obstacle for our project but we will go into detail in the design section about potential issues. The PIR sensors will need to be placed in an area that is by the entrance of the opening at the top of the lid where the aluminum cans will enter. We'll need to detect the radiation that stems from the object. If for example the PIR sensor is placed too far away from the lid of the trash can when a bottle or aluminum can is dropped in, its energy may not be detected by the sensor. We did mention sensitivity as a characteristic of the Frensel lenses that could cause another issue. Often times in buildings the air temperature might fluctuate or the occasional passer byer may be running and blow a cooler or hotter gust of wind. If the PIRs are too close to the opening of the lid could we have a few possible false alarms? This is something we'll need to test out because it's expected that with any motion detection device you'll have a cases of false alarms. We discovered that the PIR sensors work well for detecting when an object has entered a room or left. They also have versatility because they are easy to interface with.

The question we need to ask ourselves is will an aluminum can or glass or water bottle generate enough of a radiation to be detected by the motion detector. Often times when a person throws aluminum can into the trash can there hand is nowhere close to the lid. So people literally throw there bottle in and others may place it near the lid before dropping it in.

We have mentioned sensitivity several times during our discussion of PIR sensors. The PIR sensors would need to “see” the bottle before detecting it. A question comes to mind. Is the area of detection large enough? Since it only has such a brief time from when the bottle reaches the lid and breaks the space and then lands into the hopper (which is the holding area of the cans before being crushed). Do we need to look at a more sensitive detector? A can does not emit nearly as much heat as a person does. If the sensor does not detect the can when it enters the trash can, where the aluminum can might sit long enough to where it becomes the same temperature as its surrounding area thus not being able to be detected.

Frensel Lenses

Again we go back to the discussion of the Frensel lenses because there is such a small window and a short time to detect the aluminum can or bottle or glass. This is why the topic of Frensel lenses is so important.

The detector has two halves, two slots. The Frensel lenses are patterned in such a way that there are not many blind spots in the area that the detector is placed for a specified range. The detector only needs to face the area where the can will fall into. More blind spots are found on the sides of the sensor than straight ahead. If we chose to use this sensor we would have to consider the position to put it in. We’ll also have to consider which sensors work best with glass. These criteria will help narrow the selection of possible sensors for us. Let’s continue our exploration.

Now we have not yet determined if we are going to use one specific type of sensor however we are certain that we will need multiples sensors. We would ideally like to be energy efficient. We want the Can Crusher to stay in standby mode. So it will go back and forth between operational mode and standby mode. It will occasionally be in stop mode but not for long.

Ultrasonic Sensors

In comparison to PIR sensors, Ultrasonic sensors (US) are said to be more sensitive than PIR sensors by TXU energy. The passive infrared sensors pick up energy unlike US sensors which are active. US sensors actively send out a signal at a particular frequency. The object has its own intrinsic properties so it will react to the signal alerting the sensors. The US sensors might be too sensitive for our use. We will have a lot of movement in a confined space and the only thing we need to detect is the aluminum cans entering the trash can. If the US is actively sending out signals it might constantly be alerted once the process of crushing the can begins.

Hall Effect Sensors

Hall Effect sensors use magnetic fields. They have many different applications. The primary use seems to be as a switch and not so much as a detection device for what we want. Ironically, within the pneumatic cylinder there are Hall Effect sensors.

A Hall Effect sensor uses a component called a transducer. A transducer converts a signal in one form of energy to another. Because it converts a signal it's a sensor. The essential key to Hall Effect sensors are that they depend on magnetic fields. Hall Effect is not a single component it must be in partner with some additional electronics. So for instance if the sensor was connected to the mechanics of the Aluminum Can Crusher or another type of sensor then it could achieve its goal. Most of the examples test a Hall Effect by using a magnet. To relate that to our project the can would have to emit some sort of magnetic field or have a current running through it that's perpendicular to the sensor to be able to sense it. This is very unlikely for our case. Our typical scenario would be a can is just dropped into the trash can and needs to be detected. We are not adding anything external to the aluminum can so I am not sure how we would be able to utilize this sensor.

Possible Project Sensors

Shown in Figure: 1, below, is one of the sensors we are considering using. On eBay it costs anywhere from a $1 to $10. This would be the component that we use to distinguish a water bottle from an aluminum can. The downfall of the device is that its operating distance, shown in table : 1, is very short compared to other devices of its kind. So if we used this sensor we would have to mount it pretty close to the hopper.

Reflective Optical Sensor	
Detector type	**Phototransistor**
Dimensions	10.2 x 5.8 x 7 (mm)
Peak operating distance	2.5mm
Output current	1mA
Emitter Wavelength	950nm
Voltage	5 V

Figure 1: Reflective Optical Sensor TCRT5000

Permission Granted

Table1: Specifications for Reflective Optical Sensor TCRT5000

Shown in Figure: 2, below, is another one of the sensors we are considering using. On eBay it costs anywhere from a 12$ to 50$. The amount of voltage that is used may become a concern, shown in table 2. At this point however we are not sure what effect or adjustments we might have to make based on using this device.

Another alternative is to use a laser pointer as the infrared beam and then to point it towards a photodiode that is connected to a LED. When the infrared beam is interrupted the LED shuts off. The example was shown on a YouTube video and seemed to work effectively. This would be very cost efficient if we could do it this way. The laser pointer would not need much energy. LEDs and photodiodes do not cost much at all. For this idea to be implemented we would have to structure the positioning of the hopper and also it would need a transparent background. The photodiode would have to be placed in the background and in the line of sight of the laser pointer. Once an aluminum can broke the beam the LED would go off. Our hopes are that the laser pointer can shoot thru the water bottle since it is a clear object that does not reflect much. As we expected in Senior Design II we used the TCRT5000 Reflective Optical Sensor. We did experience difficulties while using this sensor. In Senior Design I we expected our issue to be proximity to the object whether a aluminum can or water bottle, however, that was not the case. In Senior Design II we experienced most problems as a result of ambient light. The TCRT5000 Reflective Optical Sensor is very sensitive to ambient light due to its Infrared LED. Adding a higher resistor value reduced its detection towards objects but that did not counter the effect of ambient light. As a result during several tests we would have to manipulate the readings for the microcontroller to properly detect what is an aluminum can and what is a water bottle. The labels for the water bottles did not have as much affect as we thought they would. In the end we decided to remove the labels all together. Even when the labels were removed sometimes we would still experience some stalling issues. We blew several of the Reflective Sensors while testing but because of their inexpensive cost we only bought 10 throughout the entire project.

The circuit design was not easy to begin with. Along with getting accustom to the sensor we search online for how to connect the circuit properly. We didn’t always find the datasheets useful. Reflecting back the circuit connection was not as difficult as we made it, we were simply inexperience and allowed for trial and error to be our best lesson

Banner SM2A312LV	
Detector type	**Retro-reflective**
Dimensions	66 x 12.2 x 30.7 (mm)
Peak operating distance	50mm – 2m
Output current	Minimum of 5 mA

Voltage	24-240 V AC

Figure 2: Banner SM2A312LV

Permission Granted from EBay user: todd1455

Table 2: Specifications for the Banner SM2A312LV

The final sensor we will be considering using, the PING Ultra sensor, shown in Figure 3. We will be using this to tell when the object has entered the trash can. This device will not be the one to distinguish the difference of the water bottle and the aluminum can, it will just be acting as a redundant device to the optical sensor.

In Senior Design II we did not have major difficulties with the Ultrasonic Sensors. At the very end, the day before the final presentation, due to an unknown reason the Ultrasonic sensor would not turn on. We troubleshot, checking voltages, regulators, and making sure connections were strong. The leads were connected through connectors, assuming that might have caused the problem we cut the connectors and tied the leads directly to the pins of the Ultrasonic Sensor; still the sensor did not turn on. We were receiving proper voltage from the power supply but still the Ultrasonic Sensor was not powering. We believe the issue was in the code. After modifying the code approximately two hours before the final presentation the Ultrasonic Sensors begin to work properly once again.

As for as detecting the object whether aluminum can or water bottle we experienced zero problems. The idea worked as expected, as we adhered to the specifications shown in Table 3, which was very satisfying knowing that we made a successful plan beforehand.

The circuit design was also fairly easily. The Ultrasonic Sensor was not at all complicated and with several resources from Arduino as well as google it was put together quickly.

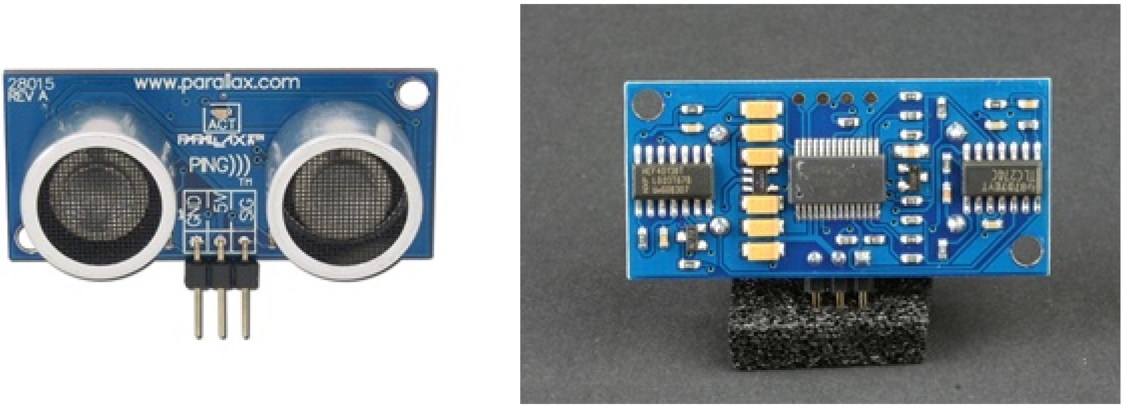


Figure 3: Ultrasonic sensor front and back

Permission Requested from Parallax.com

PING Ultrasonic Sensor	
Detector type	**Ultrasonic**
Dimensions	16 x 46 x 22 (mm)
Peak operating distance	2 -3 (cm)
Supply current	30 mA
Voltage	5 V

Table 3: Specification for the Ultrasonic sensor

3.1.2. Analog vs. Digital Sensors

To determine which sensor we'll have to use we'll have to discuss the board type we plan on using and the sensor type whether it's digital or analog. We can also discuss different applications of the use for example robots use infrared sensors for object detection. Within the configuration of the sensors we must determine from our microcontroller if there is an analog to digital converter (A/D) which most micro controllers now have or if for such reason our microcontroller does not have a A/D converter.

So in this section we will discuss what components and connections our sensor (that has yet to be determine) will need and work best with. As we discuss our components we'll be mindful of the costs and external parts we might need in conjunction to our sensor, microcontroller, and board type. Hopefully this strategy will allow us to pick a specific sensor.

A lot of options come to mind for our project and what route is the best route to take. We need to take an action "aluminum can dropping into a designated area "and convert it into a signal to notify our device that "there is an object in the area". In the future we will need another sensor to tell us "Is this object aluminum can or is it something else?" Then we will need to make a decision "if this object is an aluminum can then crush it if not move it elsewhere". It is the priority of the sensor to first notify us "is there anything in this space?" To make this declaration this signal can be carried as either an analog signal or a digital signal.

The "Difference Between.net" defines the difference between analog and digital signals to be, analog is a continuous electrical signal and digital is a non-continuous electrical signal. The "Difference Between.net" suggests that analog varies in time and are a product of non-electrical signals whereas digital varies in a single steps characterized by individual distinct levels. So a specified value will remain the same until a change in the next value. More benefits are expressed in the use of digital than analog.

Let's get a better understanding in analog than has been given us by "Difference Between.net".

Another source goes into a better detail description of Analog signals. "wiseGeek.org" tell us what an analog signal is. It defines the method of passing information is the major difference between analog and digital. Analog uses "small fluctuations" whereas digital uses numbers to pass information. Analog signals replicate the actual signal but in the process of replicating the original signal it's done in a different medium. This is the complication of using analog and the main disadvantage. However, there are solutions for retain the signal whiles it's being transmitted.

Applications

The accuracy is determined by the path of the analog signal. Since wiring resistances and noise pickup are the most known discussed unattractive characteristics with sensors let's discuss some other techniques that may be of use if we choose to use analog signal. This discussion is for a transducer based sensor which will have applications that we may want to consider. The transducer may be embedded into the sensor so we will not have to add it externally to a circuit.

When deciding whether or not to use active or passive sensors we need to distinguish the fundamental difference. The main differences between passive and active sensors are there need for excitation. We must decide how we want the output to be defined by either current or voltage. Depending on the desired response there are different approaches. The designer can choose AC or DC and both have their advantages and disadvantages. There are two defining factors in choosing an excitation source for the well-being of the system. Illustrated by Albert D' Grady in "Transducer/Sensor Excitation and Measurement Techniques", are resolution and power level. Even the slightest change in the target's output from the transducer should outweigh the noise and offset in the system, this is resolution. The other factor is for resistive based sensors. We don't want the temperature to have damaging effects on the result.

AC Excitation		DC Excitation	
Advantages	**Disadvantages**	**Advantages**	**Disadvantages**
Remove offset errors	More expensive	Simple Implementation	Separating actual signal from undesired responses
Decreased sensitivity to noise		Low cost	DC offsets are not fixed
Much lower excitation current or voltage			Unpredictable due to temperature drift
Self-heating effects of current flow reduced			
More immunity to RF interference			

Table 4: Advantages and Disadvantages of AC/DC Excitation

Some if not all of the ultrasonic sensors will have transducers embedded in the system. We are not the designers so we will not have to worry about how to configure the transducer because the manufacturer will have already configured it and laid out its limitations and proper uses. Therefore when using the transducer based device it is important to know that we'll have several different paths of uses and different anthropologies.

Ultrasonic sensors can also be used for "clear object" detection such as a water bottle in our case. It is up to our group to decide whether we want to use digital or analog. While researching the topic I did want to find out why overwhelmingly people choose digital over analog. During our discussion I was able to look up some ultrasonic sensor demos that suggested that analog output was the easiest. Engineer at Sparkfun, Jim Lindbom illustrates a demo where he discusses the use of ultrasonic sensors at Sparkfun. He mentions that they are composed of a transducer and amplifying circuit and mentions there use of communication, through sound waves, and there applications. An important note to make is that Jim mentions that the sensors have three possible outputs; analog output (voltage), serial signal (RS232) and pulse with modulated output (good for digital pins). Of these possible outputs he says that the analog output is the easiest. In his demo he uses an Arduino. We have not determined what board we will use or if we can even use an Arduino. Jim's statement is solely optional the determination of ease really depends on what we feel most comfortable with. The opinion however does state that sometimes analog can be chosen over digital. We'll discuss as a group to make the best decision. Our programmer will need to take the information received by the sensors, read it, and then assign a task, and then use the same information to send wirelessly. All these factors will come into play when determining the best output. How compatible the output will be with not just the microcontroller but also the other interfaces that we need to use. As a group we expect to see some equipment that we personally prefer but for the benefit of the group we may need to compromise based on price, functionality. So we will each present our findings and several alternate findings and we'll make a decision.

We saw that an ultrasonic range finder LV-EZ1 supplied by Sparkfun is $25.95. Our personal opinion was that it was a bit on the high side but still a reasonable price. In comparison to purchasing it from the manufacturer to looking the item up on eBay we did not see a price change.

Many of the items from eBay will come from china so the delivery of the item is usually always 2 weeks. When coming down to ordering it we need to make sure to use manufacture instead. Just in case we encounter some problems. The money spent will not waste because we can have open communication with the manufacturer or technical support is well worth the price.

3.1.3. Power Supply

At the beginning of the project, there wasn't a way to predict how much power would be needed or required to function for each component. We wouldn't be able to know what type of voltages the project would need until we research and make certain selection for the electrical design. Since our project didn't have a focus on a low power device or restrictions on power. We are able to keep our opinions open on how and what we want to use to as power supply for the project. When it comes to choosing the power supply we have to make sure it can withstand demand and accuracy that project requires. There are many possible power supplies that can be for this design to supply power to project. We have chance explore whether we want to use different battery approaches or using a basic house power AC outlet for the design.

We are explore the options of using an air compressor or electric motor to power the can crusher, it be best to use the power run off either one of these component we chose. While both the compressor and motor would need a stand power outlet, which is a stand a 120 V and 60 Hz. By going with this method we would run into a few problems with this because most of the components and PCB board we are researching runs off of DC voltage. In order to use the stand power outlet we will have to accomplish a way to convert AC to DC conversion as well as DC-to-DC conversion.

In order to do that we need to do a number of steps to start the conversion process, first step would be to convert the power from the compressor or to motor coming from the outlet.

We will need to figure out how to diverge enough power from the AC coming to the DC voltage components. This would call for us to us a relay which is an electrically operated switch; many relays use an electromagnet to operate a switching mechanism mechanically [Encyclopedia Britannica]. Relays are used where it is necessary to control a circuit by a low-power signal which completes electrical isolation between control and controlled circuits, or where several circuits must be controlled by one signal.

The next step we will take would be to control the AC to DC voltages coming from the relay. In order to do that we would need to use a voltage regulator which is an electrical or electronic device that maintains the voltage of a power source within acceptable limits. The voltage regulator is needed to keep voltages within the prescribed range that can be tolerated by the electrical equipment using that voltage. Such a device is widely used in motor vehicles of all types to match the output voltage of the generator to the electrical load and to the charging requirements of the battery. Voltage regulators also are used in electronic equipment in which excessive variations in voltage would be detrimental.

The block diagram below, in Figure: 4, shows displays the power supply we believed would be needed to converted the AC voltage outlet to DC voltage. We would need to use a 120 V Relay to connect to the outlet and compressor or motor. The relay would be place there to help the regulators convert the AC to DC conversion. The regulator then

Figure: 4 Triad Transformer

will supply the DC voltage to the PCB boards that will power the time delays, microcontroller, LED and LED status. Also the regulator will power the sensors place throughout the project locates like the can crusher and storage bin. We decided to use a transformer, more specially we used a Triad 36VPS-700 transformer, Figure : 4, connected in parallel. We connected a plug to the outlet and spliced the ends that are connected to the primary of the transformer. The “Live” wire run in series into a fuse and was connected to a switch.The secondary of the transformer produced 18 volts and 1.5 amps. This was more than enough to power all of our devices. We then used a bridge rectifier to supply the DC current. The figure below shows the Triad 36 VPS-700 transformer connected in parallel. We decided to use female connectors instead of soldering the leads directly to the transformer because we liked this presentation better and felt the design was cleaner. We only chose to solder out of necessity.

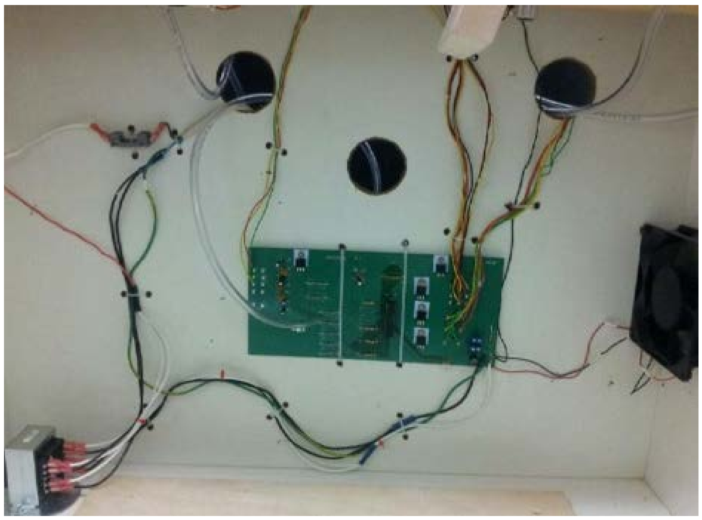


Figure: 5 Transformer connected to the PCB

In Figure 5 you can see the transformer connected to the PCB as well as other components that were used in our design. We did add a fan because of the 7805 regulator would get hot even with the heat sink. In the figure you can also see the fuse which was in series with the “live” wire which ran to a switch that would turn the system on or off.

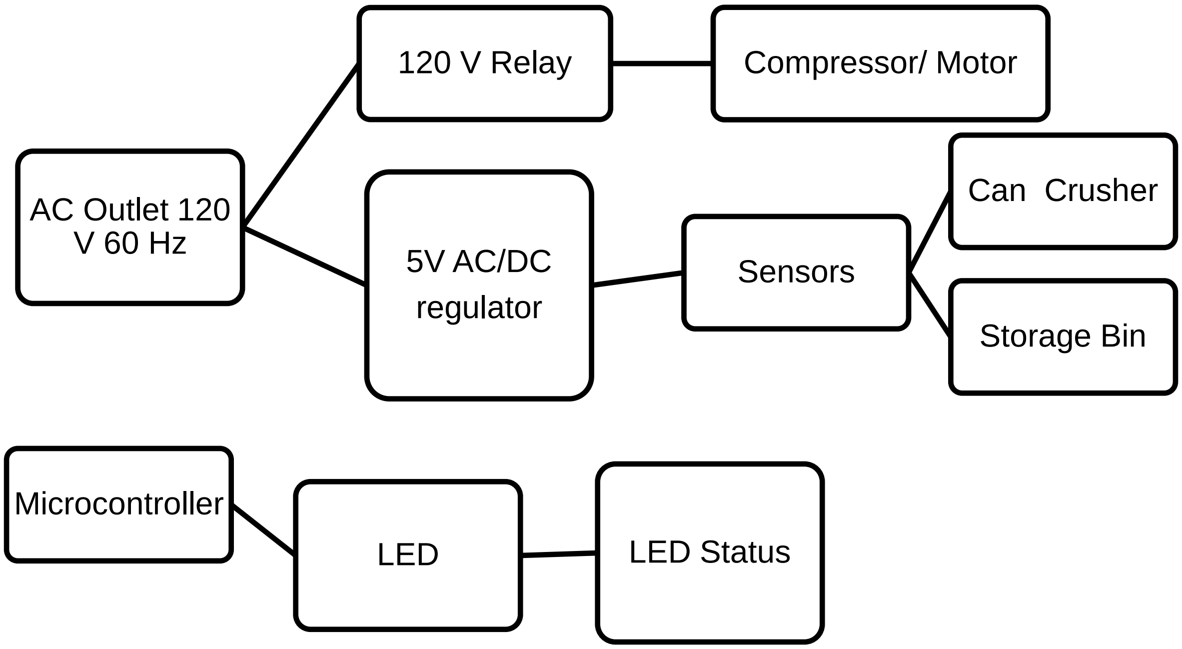


Figure 6: Block Diagram of the Power Supply

3.1.4. Motor

The motor is key element at the project. It will be required to apply enough power to generate a force to crush the can, and discard into the storage bin. The motor would be installed into the crushing device we choose at a later date. The motor will be by one the two methods listed below:

3.1.4.1. Air compressor

An air compressor is a device that converts power into kinetic energy by compressing and pressurizing air. Compressed air is able to do work because as you compress air you transform one form of energy into another form of energy which you then store for later use. There are three commonly used energy sources for industry.

- Compressed Air (Fluid Power) Energy
- Hydraulic (Fluid Power) Energy
- Electrical Energy

Compressed air is the energy source of choice for doing much of our nation’s industrial work. It’s an energy source that is relatively easy to store, non-flammable, very powerful, and can generate high speed in a variety of ways. Compressed air can be carried anywhere with an appropriate pressure vessel sometimes called an air hog or air pig. Compressed air is relatively safe because if compressed air was to leak or spill, it doesn't leave a mess and is non-flammable. If the force would be required for an air compressor using appropriately air valves and pneumatic actuators can generate this project. By choosing an air compressed as are energy source over hydraulics would be a simply choice because compressed air components are less expensive and in are budget. Since using hydraulic energy is more expensive to generate energy to do the work, and the cost of the components to use hydraulic force. We do not need the immense pressures and force that hydraulics would give us; it doesn't make sense to pay for that capability [Bill Wade]. An air compressor would be one of the methods to use, as air compressor is a device in which converts power into kinetic energy by compressing and pressing air into a tank. The air compressor would be attaching to pneumatic cylinder (SEE PAGE). This would allow the cylinder to have an enough pressure to crush the can. Once the can is crushed the air would be released from the cylinder allow the can to drop into the storage bin. Depending on the size of the pneumatic cylinder we, would determine how much psi is needed to crush the can. Once we can determine the psi we can select an air compressor, which would best fit for the project. Below is a chart with a list of air compressor that we found on www.lowes.com which will be choosing from:

Air Compressor	PSI	Tank Size (Gallon)	Voltage	Amps	Price
Portable Cable	150	6	120V	10A	$99.99
Kobalt	120	0	120 V	15 A	$99.99
Kobalt	155	6	120 V	2 A	$129.00
Campbell Hausfeld	100	2	120 V	2 A	$89.00
Blue Hawk	100	2	120 V	2 A	$89.98
Senco	135	2.5	115 V	8 A	$135.00
Dewalt	125	4	120 V	12 A	$358.53
Dewalt	200	4.5	120 V	15 A	$299.00

Table 5:
List of possible Air Compressor

<u>3.1.4.2. Electric Motor</u>

An electric motor is a machine which converts electrical energy into mechanical energy. There build with rotating coils of wires which are driven by the magnetic force exerted by a magnetic field on an electric current. Electric motor can come manufactured as either AC o DC motor. Both motors do the same function of converting electrical energy in to mechanical energy they just do it with using different method.

The way a DC motor operates is it use electric current which pass through a coil in a magnetic field which produce torque that turns the DC motor. DC motors are mainly powered by source such as batteries or AC-o DC power converter. One downfall to DC motor is brushes and commutates which the motors are built out of; this required a lot of maintenance. The life expectancy of DC motor isn't very long and the speed of the motor is very limited.

The AC motor operates in a total different matter than the DC motor complete. AC motor is power by a sample AC power like a standard AC outlet. Unlike DC motor, Ac motors does not use brushes which make them more rugged and they life expectant are a lot longer than the DC motors. The biggest and most important different from each is that the AC speed is controlled by varying the frequency, which usually done with an adjustable drive control. After compare the two motor it clear that AC motor is the better motor to go with, list in table below are possible AC motor that will be consider for this project.

AC Motor	Mfr. Model Number	Number of Speeds	Motor Size	Voltage	Current 60 Hz	Price
Dayton	6K376	1	¾ HP	115/230V	9.8 A	$218.44
Dayton	6K321	1	1 HP	115/208-230V	13.6 A	$226.31
Dayton	6XH65	1	¼ HP	115 V	5.3 A	$148.65
MARATHON MOTORS	5K35MNB114-G	1	½ HP	208-230 V	2.1 A	$273.75
DAYTON	6XJ35	1	0 HP	115 V	5.3 A	$94.25
BALDOR ELECTRIC	L3406	1	1/3 HP	115/230 V	2 A	$422.50

Table 6: List of possible Electric Motors

After researching the air compressor and electric motor and comparing the two see each motor pros and cons for this project.

Air compressor

Pros

- Uses a Standard Outlet
- Able to adjust the air pressure
- Ability to control the speed of the motor by the PSI
- Option to convert AC to DC
- Not too expensive economy for the budget
- Can use air solenoid valves that can control of a multiple operated air pressure components

Cons

- Tank will have to be refilled when low on air
- Will need multiple air hoses
- Very big hard to hide and maneuver
- Very loud when filling up the tank

AC motor

Pros

- Uses Standard Outlet
- Option to convert AC to DC
- Very Compact and small to maneuver and place anywhere

Cons

- Most motors only have one speed
- No way to speed up or slow down the project
- Very Expenses for high power motors
- Only can

3.1.5. Can Crusher

The can crusher can be manufacturing by hand within the group or bought already assembled and ready to use from online. If the can crusher is to be building it by hand they're many ways to go about construction that may be more economical for the budget rather than purchasing a pre-assembled Can Crusher. With building it by hand all the items will have to be purchase for assembly, which require workshop with a welding station. We have to build a box frame big enough to hold aluminum can and withstand the force of air compressor or electric motor. The frame will need to also have a little slot built in to the end of frame on the opposite side of cylinder so that can exiting the crusher once it has been crush. After the frame is built around end cap will need to weld to the piston rod, the cap must also be as the size aluminum can or a little bit bigger in order to apply an even amount of pressure to crush can in one single motion and also fitting through the slot for the can to exiting into the storage bin.

The alternative route that can choose will be to buy a pre-assembled can crusher. Which is completely built and ready to be use the only thing we would have to do is connect an air pressure to the Pneumatic cylinder explain in section 3.2.9.1. By going this route an air compressor would have to be used instead of the electric motor. The problem with method is that can crusher is operated by a push button switch which triggers the can crusher to extend the piston rod of the cylinder to crush the can. The goal would be to modify the switch, so that it automatic triggers to crush the can once the sensor in can crusher is break.

	Hand –Made	Kevinkrusher 1.5	KevinKrusher II.0
Chamber Length	6 1/2" minimum	6 1/2" minimum	6 1/2" minimum
Chamber Length	6 1/2" minimum	6 1/2" minimum	6 1/2" minimum
PSI	unknown	110-120	60 -120
Cylinder Type	Double action Bore : 25mm x Stroke : 200mm	double action 1.50 bore x 6.0 stroke cylinder	Double action 2.0 bore x 6.0 stroke cylinder
Mounted	Vertical or Horizontal	Vertical or Horizontal	Vertical or Horizontal
Price	$60 .00	$121.00	$157.00

Table 7: List of Can Crusher Specifications

The picture below is a possible sample of what our handmade can crusher out of PVC pipe can look at.

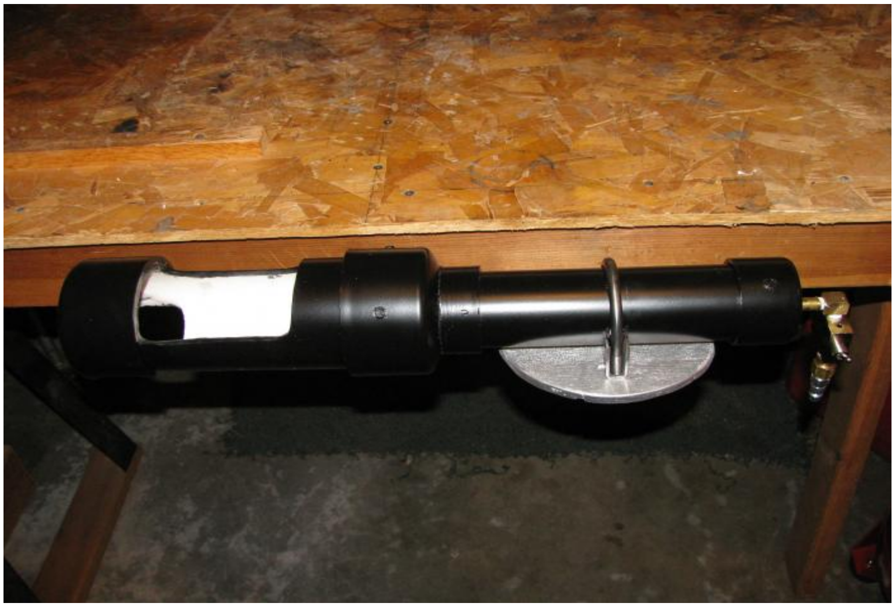


Figure 7: Possible Handmade PVC Design

Permission Grant by Preston Smidt

The two pictures below are of the already built and completed can crusher we are looking into purchasing.

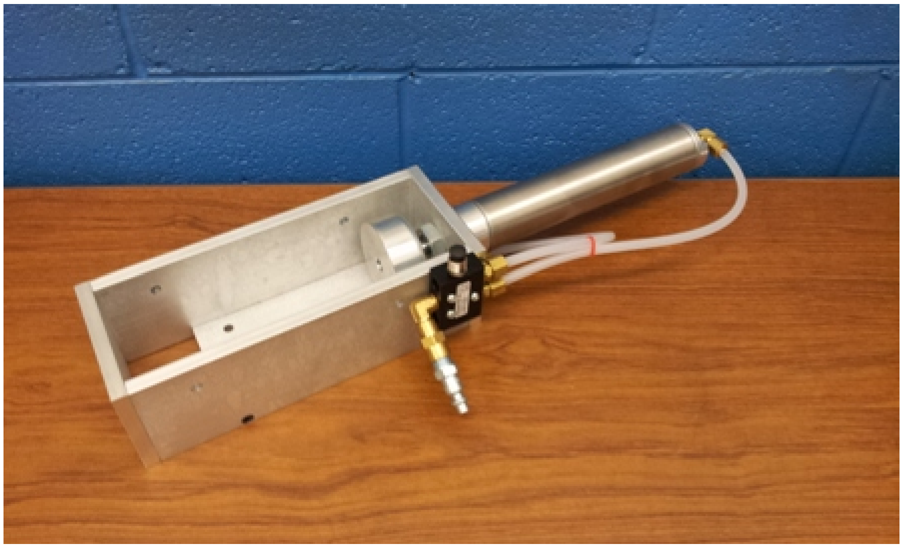


Figure 8: Kevinkrusher 1.5

Permission Grant by Kevin Michaelis

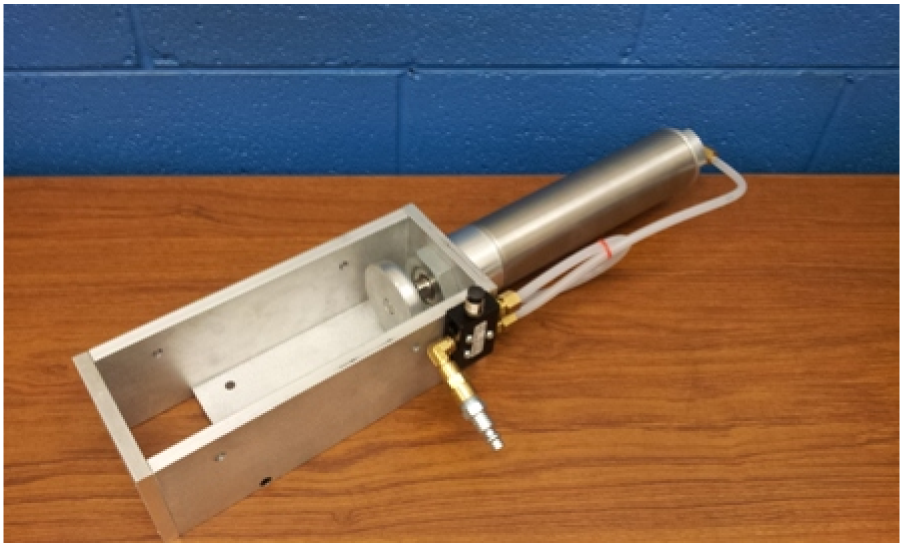


Figure 9: Kevinkrusher 1.5

Permission Grant by Kevin Michaelis

We decided to make our own design for the can crusher. After researching several others in Senior design one. The figure below shows the can crusher we decided to use. We simply purchased the pneumatic cylinder and enclosed it within a casing made from wood.

Figure 10: Can Crusher Pneumatic Cylinder

3.1.6. Cylinder Types

3.1.6.1 Pneumatic cylinder

Pneumatic cylinder plays a key part of the can crusher project. This will provide a push or pull movement that has to be use with compressed air. A pneumatic cylinder is made up of a cylinder with plunger to the exact fit of the cylinder to make an air tight seal. The plunger is then attached to a piston rod which moves the plunger back and forth with the cylinder. There are many types of pneumatic cylinders we can use but we mainly focus on single and double-acting cylinders.

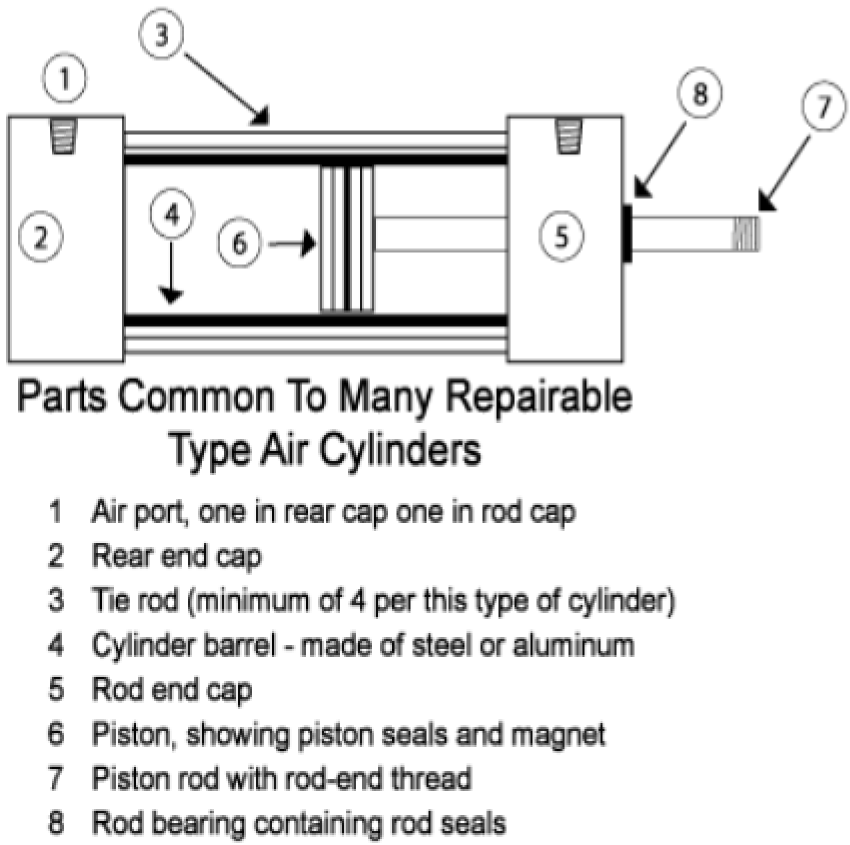


Figure 11: How a Cylinder is built

Permission Grant by Bill Wade

3.1.6.1.1. Single- Acting Cylinder

A single acting cylinder has one port in which the compressed air enters the cylinder. With the cylinder only having one port the compressed air must create a driving force in one direction usually an out. Since there is only one direction to go we must rely on a built in spring to return the plunger to the home position. Some single-acting cylinder does not have a built in spring in that case we would have to rely on gravity to return the plunger to its home position.

3.1.6.1.2. Double-acting Cylinder

A double-acting cylinder has a two-port on the cylinder, which is located at both ends of the cylinder. With the double-acting cylinder having two airports this would allow the cylinder to move in both extend and retract directions. Basically only one port of the cylinder is pumped with compressed air and the other port is used as an exhausted. The double-acting cylinder can also be used like a single-acting cylinder as long as there is no spring return is required. The only down fall to a double-acting cylinder is that air compressed going through the tables is not calculated right, and that may cause the piston rod to be more vulnerable to bucking and bending.

3.1.7. Solenoid Valve

If pneumatic cylinder are chosen to be used for the project, a device would be need to control when air need to enter and exit the cylinder. To do this a solenoid valve is going to be need for the project. A solenoid valve is electromechanically operated valve, which is controlled by an electric current that flow a solenoid and switches the solenoid from on to off. In the case of this project it will be an air valve solenoid which will turn air on and off when need to operate a component for the project. A solenoid is device that is picture in Figure 9, is a possible chooses to go with for this design. Depending on how many devices will need air to operate will depend on how many air solenoids will need to be order for the project.

Product Name	Pneumatic Solenoid Valve
Model	4V110-06
Working Medium	40 Micron Filtered Air
Motion Pattern	Inner Guide Type
Type	2 Position 5 Way
Material	Resin, Plastic
Working Voltage/Power	DC12V, 2.5W
Temperature	Rise 35°C
Operating Pressure	1.5 ~ 8kgf/cm²
Effective Area	12mm²
Port Connection	Air Inlet =Air Outlet=Exhaust =PT 1/8
Air Inlet/ Exhaust Diameter	0.87cm/ 0.34"
Cable Length	42cm/ 16.5"
Wiring Form	Direct Lead 0Wire or Connector
Total Size (Approx.)	9.8 x 2.7 x 1.8cm / 3.9" x 1.1" x 0.6" (L * W * T)
Color	White, Black
Weight	109g
Package Content	1 x Pneumatic Solenoid Valve
Price	$ 10.57

Table 8: Specifications of the Pneumatic Solenoid Valve

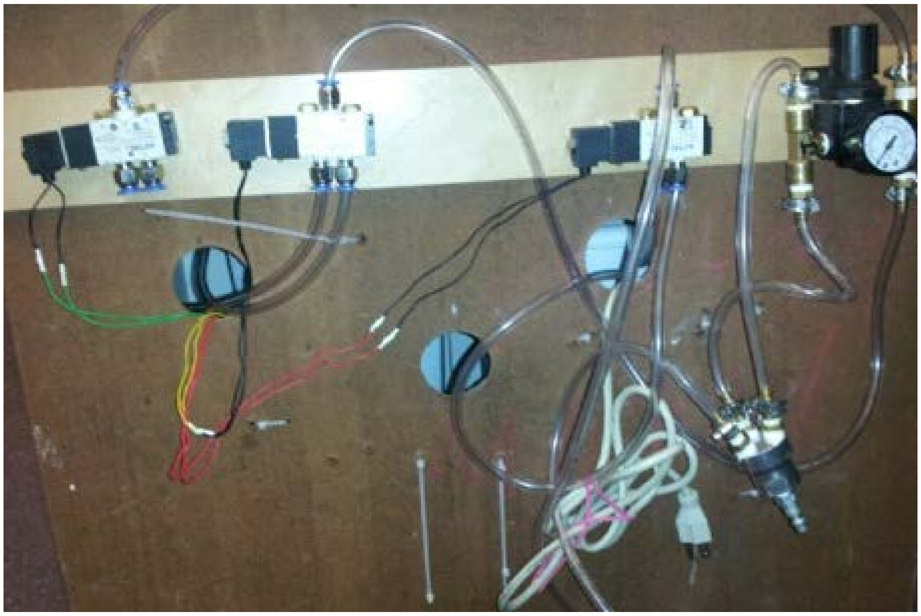


Figure 12: Mounted Solenoids

Figure: 12 Shows the three solenoids, positioned on the back of the cabinet, we used throughout the project to power the pneumatic cylinders. Holes were made in the cabinet to facilitate the wires and hoses needed to be ran to critical areas of the project

Hopper

One feature that will be need for this project is a device, which will need to hold numerous of aluminum cans or water bottles. By having this device it will allow the user the option of not loading the machine one idea at a time. The hopper is the name giving to this device, which will be used for this part of the project. The hopper will also act a stopping point, so that sensors can read each object and determine whether the object is a can or bottle.

The Figure: 13, shows the hopper in its entirety, this is where the objects will be placed and crushed. The pneumatic cylinder that crushes the can is also shown in the figure below.

Figure 14, shows the sensors integrated into the design of the hopper, so that they can detect the object.

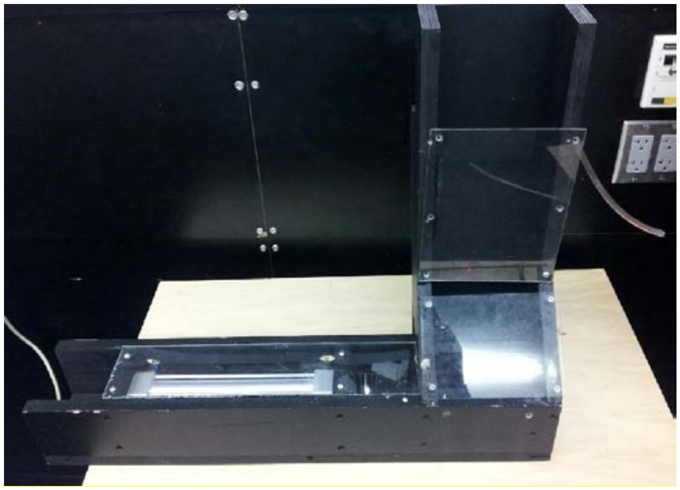


Figure: 13 The Hopper

Figure: 14 Inside View of the Hopper

Rotation Cylinder

With the hopper being the stopping point for an object another device is need to take the either the water or can from the hopper. This will keep the process going for rest of the project whether to be sorter in a bin or crush, in order to do this we will require a rotating cylinder. Rotating cylinder is a small compact pneumatic actuator that produces a rotation motion. It would need to rotate the object from out of the hopper an on to the ramp to continue with design of the project. Since the rotating cylinder which is a pneumatic actuator that is control by compressed air.

3.1.8. The Sorter

Our idea to distinguish the aluminum bottles and the water bottles is to use an infrared optical sensor and an ultrasonic sensor. We hope that the combination of the two will permit the able to tell if there is aluminum can or a water bottle. The typical water bottle is usually clear except for the label. So for this part we are going to make an assumption. The infrared (IR) optical sensor does not sense clear objects. In the models on YouTube the designers have all use white tape and some tape that has a color change, say striped tape. The IR optical sensor will sense the color tape and light up whereas the white tape or clear tape it will not sense and does not light up. Since the water bottles will be horizontal as they come thru the hopper we're assuming that no labels will be in direct sight of the IR optical sensor. So the idea is that if the IR optical sensor does not sense anything then there is a water bottle in its place. We know that there is an object there because of the ultrasonic sensor. The ultrasonic sensor will sense both water bottles and aluminum cans.

Another alternative is to approach the problem of sensing the water bottle the opposite way. We can use the fact that IR optical sensor will sense colors, so if in fact it does sense a color it will signal that "this is an aluminum can". Again this is another approximation that most aluminum cans will or may have color on them. The ultrasonic sensor will just tell us that there is an object here. The only task we would need to figure out is the placement of these sensors, which can be reference in Figure 14 and Figure 15.

In our earlier discussion of using the IR optical sensor's disadvantage to our advantage we were assuming that the water bottle would be in the position but the IR would be pointing through the bottle the long way. However, if the aluminum can is facing the same direction as the water bottle than the result would both be the same, the IR sensor wouldn't sense either the water bottle or the aluminum can. Therefore if we use our alternative idea, using the IR sensor on the aluminum cans rather than the water bottle, the aluminum cans pictured below can be place the same direction as the water bottle.

In Senior Design 2 we handled this obstactle show below in Figure: 15 , by placing the IR such that the objects whether water bottle or aluminum can would sit on top the of the IR. With this approach we eliminated the possible of too much distance between the object and the IR. As well as drilled two holes into the sides of the hopper and stuck the ultrasonic sensor . With our design we were able to house two sensors inside the hopper taking advantage of the IR's disadvantage and maximizing optimal space within the hopper. We removed the labels from the water bottles as a precautionary tactic. The two arrows shown in Figure: Show where the IR and Ultrasonic sensor are located inside the hopper.

We had great success detecting the objects using this design. We spray painted the entire hopper black to help with the ambient light.

Figure 15. Shows view inside the hopper

Shows the sorter fully extended allowing for the water bottles to be sorted to the far left, once object is read by sensors. This design originally evolved from the “swinging lid”. We found this design to be better because in our original idea we thought we would use a ramp to allow the water bottles and aluminum cans to route in order to get to the objects designated bins. Instead with this design the objects are crushed and go directly to their dedicated bin. A much more compact design for the constraints of our design.

Figure :16 The “Sorter” for the Automatic Can Crusher

Shows the sorter not extended allowing aluminum cans to drop directly from the can crusher into their designated storage bin once object is read by sensors. This figure would demonstrate if the object was an aluminum can. The pneumatic cylinder would only extend if the IR detected that there was a water bottle present.

Figure: 17 The Sorter

Figure 18: Regular 12oz. cans　　Figure 19: Typical size water bottle

If we use our alternative method the IR will point directly into the aluminum can. We do run the risk that since the water bottle is laying in the same direction the IR may directly come into contact with the label on the water bottle. If that is the case the IR will incorrectly tell us that it is aluminum can. Since our technique will not be full proof will we assume that we will have some errors in testing because it is not certain where the label will be on the water bottle. Some labels may be lower or wider as shown in the figure below. It will be to ambiguous to determine where the label will be on the bottle because that depends on the brand and we have no way of filtering out what brands will be placed in the trash can.

As you can see displayed in the Figure 20 below are various brands of water bottles. From this picture we can make a generalization that there is a portion of free space between the mouth of the bottle and where the shortest label may start. If the IR can somehow be place in that range then we will have a sure way to better predict whether the object is a bottle or if it is aluminum can.

Figure 20: 8 FL Oz water bottle

Figure: 21 Slot for objects to pass through

We changed the size of the water bottle due to size complications**.** The larger size water bottles were becoming even more difficult to crush inside the can crusher. The water bottle would actually contract once crushed and then expand once the pneumatic cylinder no longer applied pressure to the bottle. As a result the water bottles would not fit through the slit that was mechanically cut out.We ended up selecting 8 Fl ounce water bottles instead of the size above. During our testing this seemed to give us less trouble. One thing we did notice was once the bottle was placed into the hopper and was ejected into the can crusher sometimes it would slip through the cut that was made. This issue only created an obstacle when coding. Because we do not want items mixed in a storage bin we would make the pneumatic cylinder immediately extend once a water bottle was read allowing for “just in case” the bottle continued to go through the opening and did not get crushed. This precaution worked perfectly for us and the variability of how the water bottle would fall into the can crusher area. Figure: 21 shows image of slot for cans and water bottles to slide through to empty into the storage bins.

What we need to know for the Sorter to work effectively

- A typical water bottle serving size is 16.9 FL ounces anything larger than that size will not be accepted
- Bottles need to be placed horizontally into the trash can for easy transition into the hopper
- IR optical sensor will need to be place according the dimension between where the label starts and the mouth of the bottle
- Aluminum cans must be placed horizontally into the hopper
- Aluminum can cannot exceed a usual serving size of 12FL ounces
- Hopper will be large enough to contain up 6 containers at once
- If more than 6 containers are in the hopper, lid to trash can will close until Can Crusher has crushed and sorted all remaining cans and bottles

How we plan to sort the water bottles from the aluminum cans

A great emphasis has been put into determining how we will sort the aluminum cans and the bottles. We feel that this is a major implementation in our project that we have set to improve upon. Previous models have been one dimensional in just crushing the aluminum can.

So the idea we would like to apply involves adding to our design a pneumatic actuator. The pneumatic actuator is about 5 inches and it has a piston that will extend and retract. The use of the piston is what will allow us to direct the water bottles one way and the aluminum can the other way. Our idea is that we want the pneumatic actuator to always be in a retracted mode. Once the sensors have declared that there is a water bottle in the area the pneumatic actuator will extend directing the water bottle to a separate storage bin.

Since we have an air compressor to power the can crusher we’ll have to find a way that when the can crusher is not in use to redirect the air to the pneumatic actuator to allow the control of the piston which will need to extend. These pneumatic cylinder can be found on eBay for fewer than 30 dollars.

Figure 22: 6” inch Pneumatic Cylinder

The figure 22, above is a pneumatic cylinder. It’s shown here without any mounting brackets or any external components; however this is what we will be looking for. The pneumatic cylinder on eBay can be purchased with the mounting brackets and valves.

We can either order them from eBay or we could also order them from the manufacturer. If we choose to order them from eBay we may have to make additional modifications to the device; possibly having to modify the hose fittings for the valves.

The second part of the theory is to borrow the idea of lid on a trash can. On some trash cans there is a swinging lid that once pressure is applied to one side, it rotates over its axle and one side becomes available for use. The idea is to use this theory in conjunction with the pneumatic cylinder. We’ll extend the pneumatic cylinders piston to one side of the swinging lid and it will close off entrance to the can crusher and route the water bottle into its proper bin. In essence the water bottle will just slide down into its bin. Once an aluminum can is placed into the trash can, the lid will retract allowing for the aluminum can to slip through a designated path with specific dimensions, which is just the appropriate size for a typical aluminum can to fit, and into the Can Crusher where it can be crushed and disposed of into its proper bin.

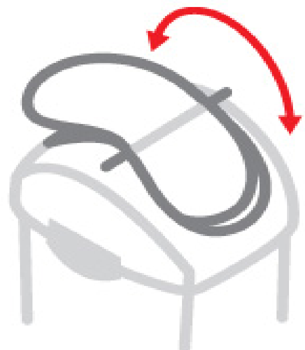


Figure 23: Swinging Method Considering

Permission requested from simplehuman.com

We will need to make modifications to the swinging lid. First we may need to fabricate this piece because the swinging lid for the trash can be too big for our confined space. This may mean that we might have to get a piece wielded on possibly. This also suggests that we will bend a piece of material because we most likely don't expect to use the same material that is in use with our trash can. You can find trash cans that are primarily made of plastic. We need a durable material, something sturdy. Once we make the shape that we wish to make (look at figure 23) we'll need to make some brackets to allow the lid to swivel (also seen in the figure 23). The lid will at least be the five inches, which is the same length as our pneumatic actuator. We have not yet determined how our internal design, the flow from the hopper (where the aluminum cans our stored) to the Can Crusher and then into the storage bin will be yet. Making use of the space we have will be very important aspect of our design along with placing the electrical components and keeping a clean appeal to the consumer.

The implementation of the design did not quite go as we planned it. In our senior design 2 implementation we didn't use an axle as depicted above. Shown in the above Figure:16 However, even with the slight change in design the concept worked as expected with no difficulties

3.1.9. Commercial vs. Household

3.1.9.1. Commercial

In the design it is something our group thought could be used in a schools or an office building. As a group we feel that we can make recycling look a lot cooler. Hopefully, more people on a regular basis doing day to day things will feel the need use it. Building this trashcan in a commercial environment we are going to run into a lot of restrictions. One restriction would be that most public trash cans in a building or school are not be big not big enough to hold the design. If our groups built the Aluminum can crusher we would need a bigger trash can to account for air compressor or electric motor that we would place inside the trashcan. We would also need a storage bin inside the trashcan that we can dispense of the crushed cans in an easy way. For commercial use we may have to modify the common trashcan or use bigger types of trashcans (figure 24) are common size commercial recycle bins. By using the cans below we would have to cut the can and make a storage bin to store the crushed cans. Our group will need the trashcans to be located near a power outlet since the power supply relies on the outlet to power the whole device. This may cause a big problem because not all trashcans in public places have access to an outlet.

Figure 24: Office Building Recycle Trashcan

Figure 25: Commercial Size Trashcan

The minimum specifications of the trashcan for the prototype are outlined in the Table 9.

	Figure 1 (square)	Figure 2 (square)
Dimensions (inches)	40H x 20W X 18D	30H x 20D
Capacity (gallons)	64	33

Table 9: Trashcan Specific

The type of trashcan that would be the most beneficial to use out of the two cans would be the bigger square (Figure 25) plastic trash. This can has space for mounting everything and it is able to hide the air composer. This trashcan will need to have a hole cut in the top of the lid so the cans can be place in the bin. But due to limited budget we might have to go another route from commercial side of trashcan. By doing the commercial option our group will have to modify the trashcan in many ways. This might cost a lot of money and time that may not be available.

3.1.9.2. Household

Another method to consider besides commercial trashcan, figure 15, was making it a household design. This design would mainly be marketable for homeowners whom are heavily into drinking soda or adult beverage made of aluminum. It will also appeal to homeowners who live in rural areas and who have to take their recycled aluminum cans to the recycle center to cash in for money. By making this design it would make it a lot easy for them to compact there cans, in turn this would result in fewer trips to the recycle center. The ideal design for this would be to use a cabinet, which can be placed in a kitchen or a garage and where it will fit in with all other household items. The cabinet would be a great foundation to being building from since it has a lot of room to mount and hide everything; table 10 shows the cabinet dimensions. This design shouldn't have to many restrict since it be in a house where an outlet would be more convenient to be near, to plug the air compressor or electric motor for power. Since the cabinet will be equipped with doors that storage bins will be able to hide behind the doors and a lot easy to access and empty. The one thing that will need to be modified will be the counter top, which will need to a hole or entrance to place the can or bottles into.

Figure: 27 Automatic Can Crusher Storage Compartment

Due to our design changes in Senior Design 2 we decided on Figure 27, as our final design. The cabinet would house two storage bins, to keep the bins in the position needed to collect contents we place a plank besides each bin as shown in the figure. Choosing to go with this design would make our product more of a household product, which we were okay with.

3.1.10 Storage Bin

A bin may be used to hold items of supplies and equipment in an individual compartment or subdivision of a storage unit in less than bulk quantities. In this project are bin will be used to store are crushed aluminum cans and recycle water bottles. There is a variety of things we can use as a storage bin. The bin is where all the crushed aluminum cans will be deposited after exiting the can crusher. The size of the bin will matter a lot. It would need to be big enough to hold a large amount of crushed aluminum cans. It will have to be easy to man handle in and out the design to empty the bin, with quick efficiency for the user. The best example to explain this feature of the bin is a paper shredder. The paper shredder would be are can crusher and once the paper is shredded it goes into the trash or bin right underneath. Once the bin is full the user is able to pull the bin out and discard of the shred paper in a quick and efficiency way. That’s the method of are storage bin is to be able slide in and out of a hided compartment and be empty with simply process. The bin will have to require a location where a sensor or sensors can be mount throughout the bin without stopping the machine every time a can enter the bin. This design can be referenced in Figure:

3.1.10.1. Storage Bin Sensors placement

Now we look at the sensor or sensors for the storage bin. To do this we’ll reference how “Trash Talk”, a previous senior design project that implemented sensors in their design to measure when a trash can would be full. We have not yet chosen our dimensions for our trash can and thus cannot be too specific on how much room will be allocated for the storage bin. How we use the trash cans space has yet to be determined because there’s a lot of equipment to account for that will need to be enclosed within the trash can.

“Trash Talk” wanted their sensors to have a range of over 100 centimeters because their trash can was 76 centimeters tall.

Another thing we have to be aware of is compatibility since we will definitely have multiple sensors and some are used for object detection others that we are focusing on now are depth sensing, using through beam or planar sensors. So do we wish to add another type of sensor and push to have a diverse sensor set or will we use a pre-discussed sensor in alternative way?

The price for the GP2Y0A02YK0F Distance Measuring sensor is very good, Figure 28. On eBay we found it for under 20$. Even though there were a number of concerns dealing with clear objects we do not feel like that will be a concern when determining the storage sensor. According to (www.elecfreaks.com) and the datasheet that is provided for the Sharp GP2Y0A02YK0F, the voltage output corresponds to the distance relative to the object. The larger the distance the less output voltage you see. The closer the image the higher the voltage you can see. Jaycon Systems did an experiment comparing the PING Ultrasonic sensor on YouTube. This can also be used as a distance-measuring sensor, to the Sharp Distance measuring sensor. The voltage output is displayed in this example by a LED. As Jay moves his hand further away from the sensor the LED gets dimmer and as he moves his hand closer the LEDs get brighter. The Sharp device used in the demonstration was actually more responsive to shorter distances compared to the PING ultrasonic sensor, according to Jay.

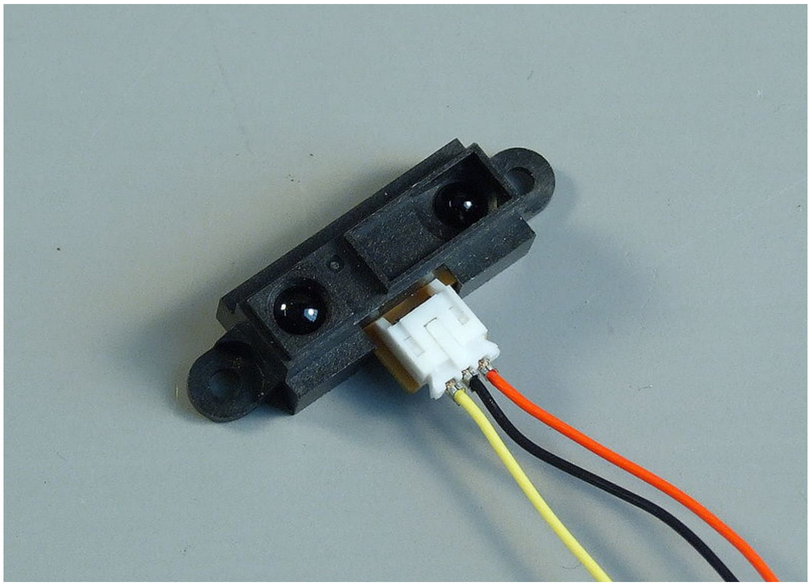


Figure 28: Image of GP2Y0A02YK0F

Distance Measuring Sensor		
Model (Sharp)	**GP2Y0A02YK0F**	**GP2Y0D21YK**
Distance measuring range	20-150 cm	0-130 cm
Type	Analog	Digital
Consumption Current	33mA	30mA
Supply Voltage	4.5-5.5 V	4.5 V -5.5 V

Table 10: Specifications of GP2Y0A02YK0F

Placing of these sensors must be precise to get accurate readings of when an object is blocking the sensor. The Figure 29, below, gives a better visual view.

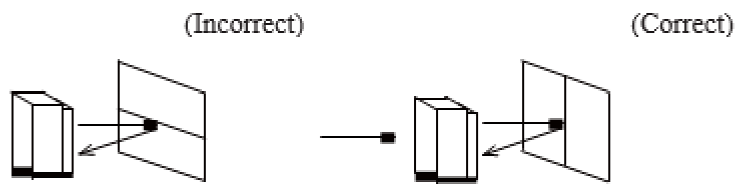


Figure 29: Visual View of GP2Y0A02YK0F

Permission Requested from Sharp

The Figure 30, below shows the expected reflectance ratio of the image sensor. Distance to reflective objects verse the output voltage. As we discussed earlier the further the object is from the sensor the less voltage is displayed. Also it is suggested to decrease variation of measuring distance the sensor should face the boundary line of emitter center and detector center.

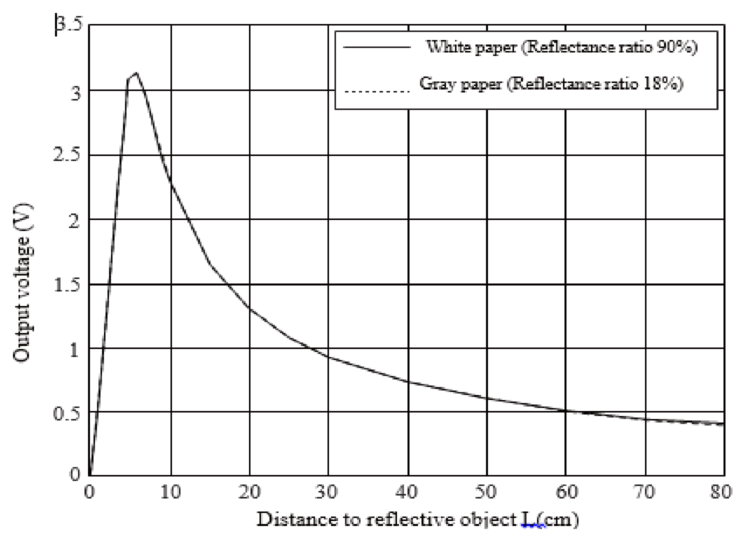


Figure 30: Reflectance Ratio Permission Requested from Sharp

As of right now I am estimating that the depth of our stage bin will not be that past 40 centimeters. Although we would like to be efficient in the amount of storage space we have to keep from returning several times throughout the day to empty out the storage bin. We foresee that we may have to compromise for that desired level of efficiency and have a smaller storage space.

Figure 31: Ideal Storage Bin to be use in project

This Figure 31, above is the size of a typical recycle bin. The depth of this bin is 16 inches. An approximation would be that our storage bin would be half that size.

Another decision we could make that would also compromise our space to storage would be if we would split the recycle bin in half and choose half of one side to hold soda cans and the other half to hold water bottles. Or we will just use two separate recycle bins? If we use two separate recycle bins we can be fairly okay with limiting the number of trips to empty the storage bin.

"Trash Talk" a recent senior design project who considered using this sensor, was concerned on the amount of ambient light and how it would interfere with the accuracy of measurement. There project was built for a commercial function, placed outside in the conditions. The operation of the image sensor is by LED which sends a signal down (assuming that it was pointed downward) and the signal is reflected back towards the light detector side. If high amounts of light is visible to the image sensor the rays of the light might alter the angle of reflection of the LED signal sent.

We will not have to worry about this aspect of the design because our concept will be placed indoors and never in direct contact with light. There will always be windows, walls, and various other elements that will refract light that it will be degraded by the time light reaches the sensor it will be dim. Also our sensors will be enclosed which was part of our design unintentionally initially but later evolved to being one of the key aspects we wanted to implement. So if used the image sensor will not be exposed to high amounts of light.

If we decide to use this sensor there is also an external component that will need to be used. We would need a 3 pin JST connector to connect with the sensor and circuit board. The connector is used to help with providing power and connectivity between the sensor and the circuit board. The JST connector stretches 12 inches in length, according to [http://www.junun.org/MarkIII/Info.jsp?item=38]. It is shown in the figure 18 above. The black wire is for ground, red wire is for power and white or yellowish wire is for signal output and it cost and addition $1.10.

One of the reasons “Trash Talk” is so comparable to our project is that they encountered the same obstacles that we foresee our group facing. Let’s suggest that somehow within the storage bin the water bottles are uneven and may even be sanding straight up on one side compared to the other side. As a result one side is stacking filling faster whereas the other is not. If we only have one sensor we may not be able to detect this. The idea that “Trash Talk” used was to implement planar sensors and use two sensors at the midpoint of the storage bin to determine with the contents in the storage bin has reached the 50% mark and two sensor s at the top to determine if the storage bin is full.

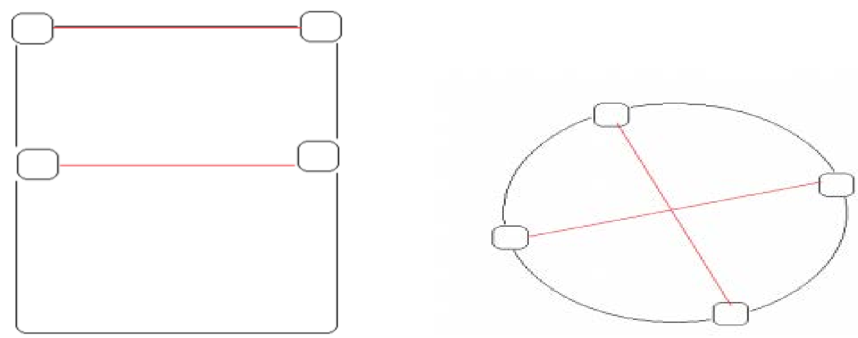


Figure 32: “Trash Talk” idea of sensors placing

Shown in Figure 32, above are the side view and top view of sensor placement used by the “Trash Talk” group. For our design we feel that we will only use a sensor placed at the top of the storage bin. We won’t concern ourselves with whether or not the bin is half full because we will only be emptying out the bin when it is completely full. However, the strategy of the “Trash Talk” could be used to some extent. We may not need to be so redundant for the storage bin design. Spending money for one aspect of redundancy that can be utilized elsewhere. Another idea was to have the sensor facing downwards. As the aluminum cans and water bottles pile up they will reach the sensor. The sensor will read the distance as it begins to decrease and measure the distance. At a particular distance the sensor will communicate with the microcontroller that it is now time to put the Can Crusher in stop mode to empty the storage bin. The sensors display a voltage output at each specified distance, from 5 volts being the farthest away to 0 volts being the closest. We believe we should check at 3 different levels. We expect this to be a trail in error task.

Figure: 33 Storage bins cut outs for storage sensors

The Figure 33, shows the one idea we were wrestling with versus another. We decided to go with the latter option, having the Ultrasonic Sensor looking directly at the contents of the storage bin. We felt this would be far better than having the sensors integrated into the storage bin itself. On one hand the contents of the storage bin would only come into reference when the contents were parallel to the Ultrasonic sensor versus the contents of the storage bin always being within line of sight and constantly receiving a reading from the objects.

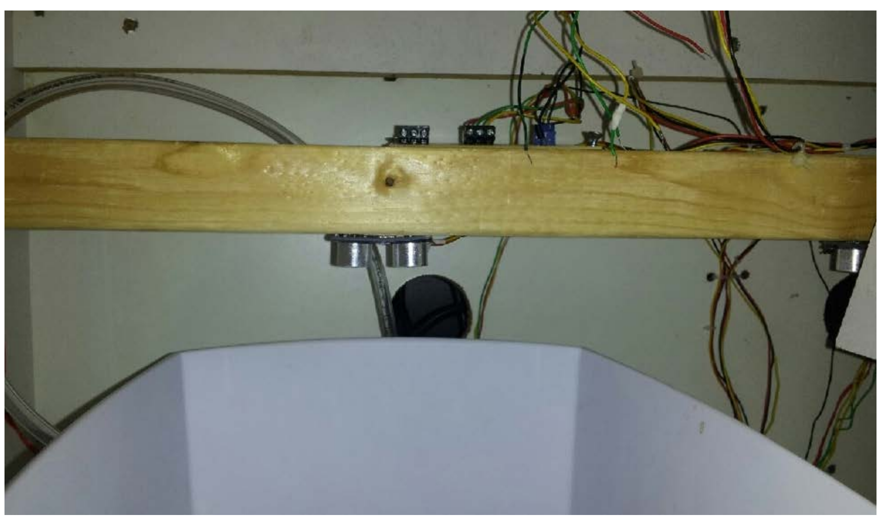


Figure 34: Placement of the storage sensors

We decided to go with this particular structure for the storage bin sensors. Figure: 34 shows ultrasonic sensor facing towards contents in the storage bin

3.1.11. LED

For this project will relay on LED to indicate the user on many things, which will be place on deck of the projects. The plan would be to use multiple LEDs require for certain step throughout the process of the project we will need to look into which will best fit are design and vision for these project.

First thing is what is an LED; is light-emitting diode (LED), in electronics, in which a semiconductor device that emits infrared or visible light when charged with an electric current. Visible LEDs are used in many electronic devices as indicator lamps, in automobiles as rear-window and brake lights, and on billboards and signs as alphanumeric displays or even full-color posters. [LED]There are many types of LEDs that can use for this project but were only focusing on two; here are list of possible LEDs we can use:

- Multi-Color LEDs
- Miniature LEDs
- Mid-Range LEDs
- High-power LEDs

Multi-color LEDs

Another two common types are the Bi-color and Tri-color LED lights. Those photodiode components emit two or three colors instead of one. This is because the bi-color LED lights are connected to one lead and the tri color LED lights which are connected to two leads. Each light can light up simultaneously and is controlled using the microcontroller. The use of this type of LEDs is not necessary for the track detector since only one color is needed to light up at once. Shown in Figure 35

Figure 35: of Multi-Color LEDs

Miniature

Is mostly single-die LEDs used as indicators, and they come in various sizes from 2 mm to 8 mm, and can be mounting to a through hole or a surface mount board. This type requires a low constant current to light, the typical current ratings ranges from around the minimum of 1 mA to the max of 20 mA. The forward voltage range for those LEDs differs by the manufacturer and the color output. The average range of the lower voltage to the upper voltage is +/- 0.2 V depending on the color choice and manufacturer, the most common color such as the green LED light required a forward voltage from 3.2 V to 3.4 V, shown in figure 26.

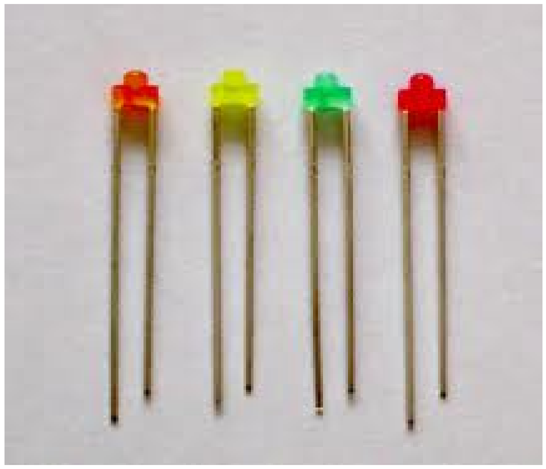


Figure 36: Miniature LEDs

Mid-Range LEDs

Mid-Range LEDs mainly through-hole-mounted LEDs which need to solder to a board and mostly utilized when an output of just a few lumen is needed. They sometimes have the diode mounted to four leads to insure for better heat conduction and carry an integrated lens. These LEDs are known to contain a lot metal in them, which give them the able to handle a higher current up to 100mA unlike the miniature LEDs and multi-color LEDs.

High-Power LEDs

High Power LEDs are used to driven high currents, which can range from mA all the way to Ampere. Since the project doesn't call for a lot of current a High-power LED would be usually to use at this point.

After review all the option of these LEDs they only two LEDs type that will be an ideal for this project, which are multi-color and miniature LEDs. Since the mid-range and high power LEDs required more current then the project is expect to produce those options could be eliminate right away. As for the miniature and multi-color LEDs is still in consideration depending on which PCB is choosing for the project. Depending on the board that is pick miniature LED might be better to go with it since them able to be surface mount to the PCB. However the multi- color and the miniature can still be use, since both are through-hole components given the ability to mount and solder the LEDs anywhere that best fit for the project is

3.1.12. Board Types

One of the boards we were considering to use was the Arduino. From what our group observed from past projects and YouTube, the Arduino is a good board to use for beginners and less than complicated designs. There are a wide variety of boards underneath the umbrella of Arduino. Of the most important features we chose analog pins. For the implementation of the sensors we wanted the output to be analog. We have come to find out that our project has an extensive amount of sensors more so than we expected from the initial idea. Operating voltage and input voltage is also a notable characteristic. We don't expect much focus to be put on the memory because we will be conducting simple instructions. There is plenty of resources on the Arduino website which is also why we considering using this board. Support will be very essential to our success.

Since we plan to model the Arduino Uno for the printed circuit board it is useful to know its architecture, however, right now due to lack of experience with its architecture we do not expect to know in detail its full software uses and capabilities. For this portion of senior design we have outlined the architecture we would like to use. We feel that the board we build will utilize most of the components needed to not only control but run our project efficiently. Once we run more tests with our board with all our equipment in hand and we determine that in some way we can be more efficient and there are parts of our module that we do not need we will act accordingly. With brief exposure to the software design and lack of experience with the project we have concluded that we expect our board architecture to look like this model shown in figure 36. We expect there to be changes after we buy the board. We expect to use a through hole board or a surface mount board, this will allow for use to make those changes needed in our design or wiring.

In Senior Design 1 we really did not have a concept of what the board would look like. After further researching and developing our design using Eagle we were able to complete our power design. Fortunately, since we took our time we only ordered one board. We did not have any problems with the one board we ordered. We did not see the need to order two initially because we felt like if we had one board that was designed incorrectly than we would only be multiplying that error. In the event that we our initial board did not work we allowed enough time to rush deliver the second if need be. Figure 37, shows our finished board design that was designed with the Eagle software

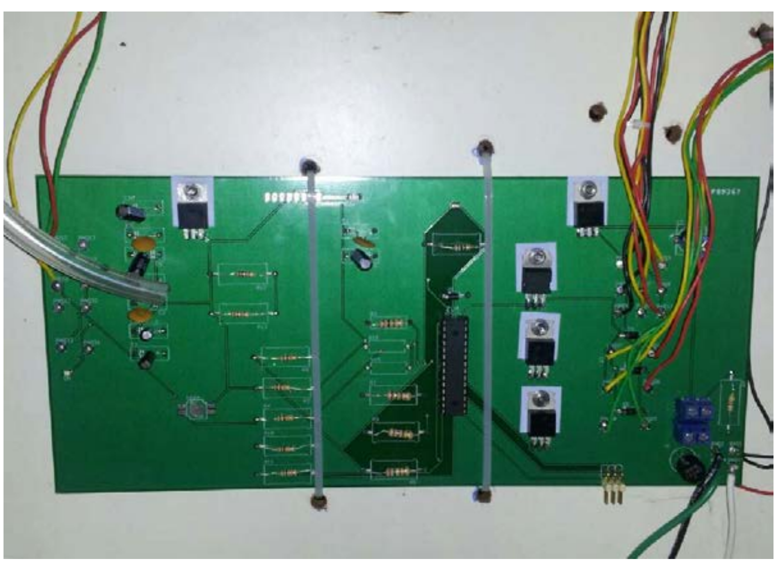


Figure: 37 PCB mounted inside cabinet

4. Design Layout

4.1 Design Requirements

4.1.1. Hopper

The hopper is the part of that design which will hold the object being place into the machine. The hopper will require certain measure in order to work probably, one thing it will need to made by hand to hold aluminum can for size of 12 oz. to 16 0z. It will also need to be big enough to hold a 16.9 FL oz. water bottle. The hopper will also need to be able the support two sensors which will be place in the hopper in order to read the object, which will then start the process of the machine. The hopper can be made out of number things like one thing is aluminum sheet metal or even wood. The best choice for the hopper will be wood because it's easier to put together with nails and hammer. Unlike aluminum sheet metal, which requires a welding machine, which we don't have access to; wooden will be easier option to go with. The hopper will be design into a box, with three sides that will be wood and the front of the box enclosed in Plexiglas.

4.1.2. Can Crusher

The original idea was to choose the KevinKrusher 11.0, which is already pre-assembled can crusher, table 14, shows the specifications. This can crusher can be purchase online from www.kevinkrusher.com. This model that were looking to order is the biggest model which can be brought off this site, the reason we choose this model is to be sure we have more than enough force that will be need to crush the can. This model can easily be control with PSI regulator, which can regulator the air that goes to the crusher. Instead we chose to buy a single pneumatic cylinder that would have a large enough capacity to crush our objects of choice. This decision did not affect the budget very much. We chose not to haggle with the KevinKrusher 11.0, its design came with a push valve button control and we would have needed to make a toggle switch and connection to an air solenoid to trigger the toggle switch back and forth every time the microcontroller triggers the can crusher to crush the can.

4.1.3.Sorter

In Senior Design 2 we did not use a ramp in our design. It seemed rather too complicated and we felt that we could make the route the object would take more simplistic. We chose to make the design more concise from the hopper directly to the can crusher. Originally we did not plan to crush the water bottles but soon changed our design due to class feedback after our initial presentation.

4.1.4. Sensors

The layout design is showed in the block diagram picture below, in Figure 38. Since are goal of this project to make it full automatic can crusher and sorter. We will need to have number of sensors throughout the design to make this goal attainable. Each sensor would play a key part in the project; therefore placement of each sensor is going to be very important. The arrows indicated where the sensors will be located.

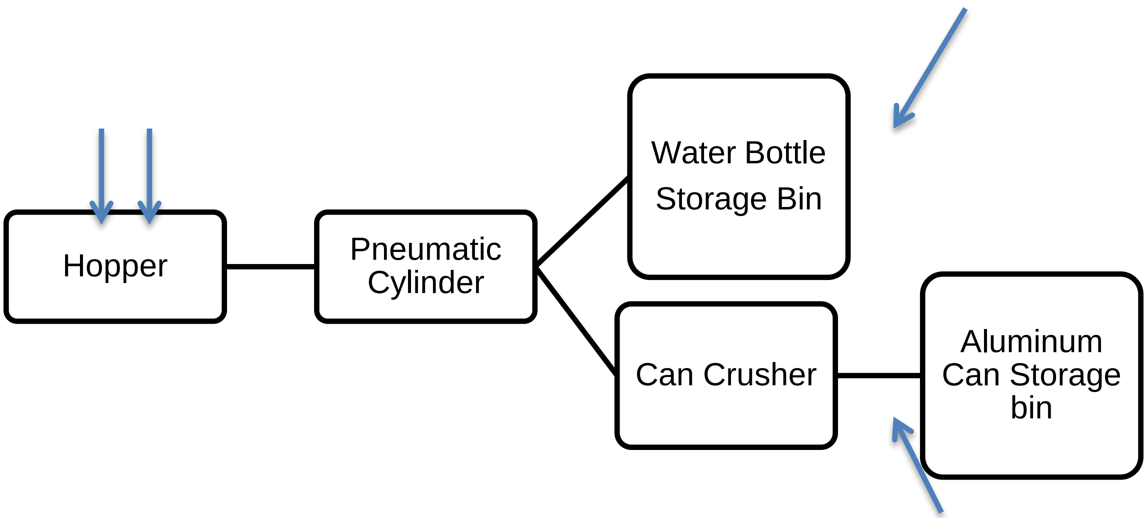


Figure 38: Block Diagram of Sensors design layout

The first step in the design will be the hopper, the user would be able to place a can or water bottle into the opened on top the hopper. It would be able to hold numerous items at a time so that user can load multiple ideas into the hopper. In order to make this automatic we would have to place sensors into the hopper that would start the whole process of the project. There would be two types of sensors that will be mounting an Optical sensor and Ultrasonic Sensor. These two sensors will we have to work simultaneous. The Ultrasonic sensor will detect if an object is in the hopper, while Optical sensor will detect whether if its aluminum can. It will work like if both ultrasonic sensor and the optical sensor detect an object we know that there is aluminum can in the hopper. Since optical sensor can't not see clear objects. We would know then the ultrasonic sensor detects an object in the hopper but the optical sensor doesn't detect anything we know that the object is a water. Once the sensors have ran diagnose the rotator cylinder will take the object out of the hopper and place on to a ramp.

The next step would be the pneumatic actuator part of the design, which will use as a switch or door. This is where the sorting part of the project would come in and the cans will be separated from bottles. The bottles will automatic go to a storage bin made just for the recycle bottle, while the cans will go on to the can crusher to be crush. We will be using the results for the sensors in the hopper to trigger the door of the pneumatic actuator. In order to do this we need the door to open and close the door just off the readings of the sensors. Since our project is about crushing a can we always leave the door assuming it's crushing a can every time an object is load. However when the results from the hopper come in and the ultrasonic sensor picks up and object, but the optical doesn't pick up an object we know have a water bottle in the hopper. If the sensors results come in will need to trigger the pneumatic actuator to close the door so that bottle can go to its rightful storage bin. Once the bottle as pass the door will automatically reset set to default open position assuming the next item will be a can every time.

After sensors have read the object to be aluminum can the pneumatic actuator will not have to be trigger since is automatic set to load the object into the can crusher. The can crusher will be on a time delay, once the sensors identify it as a can, the crusher will be set to crush the can in a timely matter. The can crusher will have another sensor mount to it well; this sensor will be for a safety hazard of the project.

The sensor will be mechanical switch relay that would be attached to the cabinet door. This feature is for the safety of the user when emptying the storage bin. When a user opens the door of the cabinet it will trip the sensor relay that will immobilize the can crusher, while also putting the machine in to standby mode. By putting this in we can make sure that no bodily harm is done to the user from any objects falling from the crush nor is there a chance for the user hand to get caught in the crusher. By putting the project into standby it make sure that no object will be going into the water bottle storage bin as well.

The two ultrasonic left from the budget list will be place in each of the storage bin. Theses sensors will be used to indicate when either bin is full of ideas. In order to accomplish this will need to mount the sensor a spot of the bins, so that whenever an item is deposit into the bin the sensors would not be tripped and send a false reading out. By mount them in curtaining spot that can only be tripping when the bins reach their capacities. When either storage bins reach their capacity the sensors will send a signal to microcontroller, which will then send a signal out for an LED light on top of the board to indicate the user to empty which ever bin that is meant its capacity.

	Ultrasonic	Optical
Brand	Parallax's PING	Vishay
Voltage	+5 VDC	+5V
Current	20 mA	1ma
Part Number	276-136	TCRT5000
Company	Radio Shack	EBay

Table 11: Specifications of Sensors

4.1.5. Power Supply

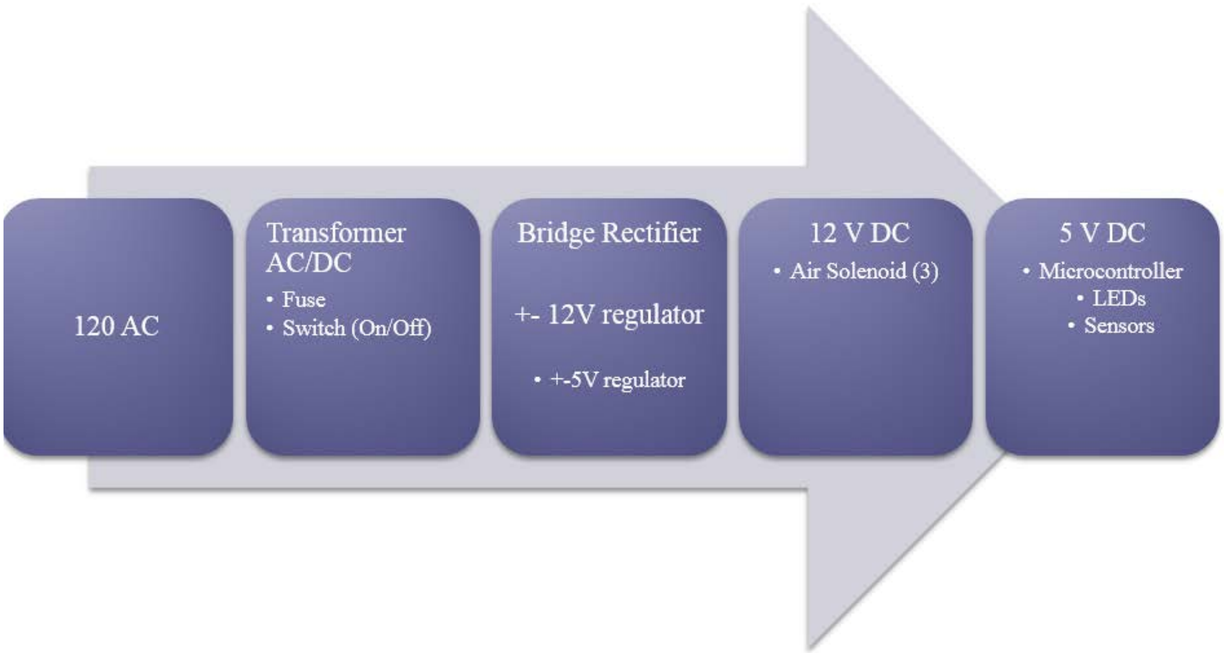


Figure: 39 Power Supply Design

In our previous design it was mentioned that we may use a relay. While researching various approaches we chose to stray away from the relays instead we used transistors to trigger the solenoids. Transistors required far less power. Connecting the emitter to the microcontroller and sending a signal via the microcontroller was all that was needed to trigger the solenoids. The power design that was implemented is shown in Figure: 39.

AC to DC converting

To convert the AC to DC we used a bridge rectifier, directly connecting the leads from the secondary of the transformer to the AC pins of the rectifier and then having two leads connect to the DC pins of the rectifier to connect to our board.

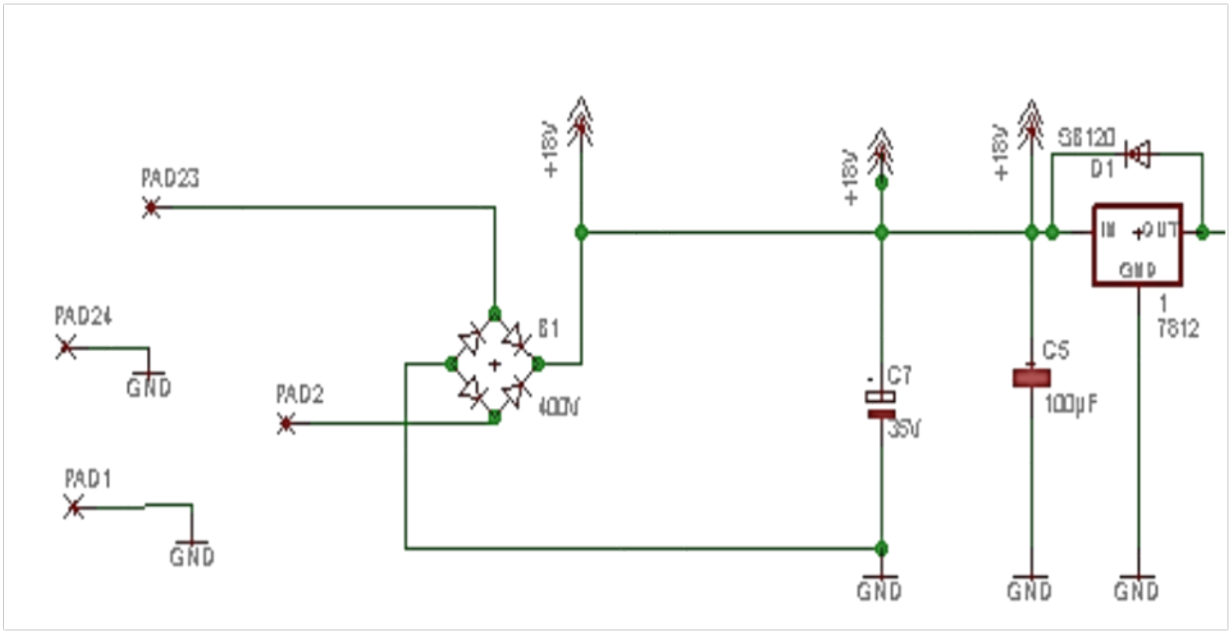


Figure: 40 Schematic of power supply

Figure: 40 shows the PADs 23 and 2 connected to the AC pins of the bridge rectifier coming from the secondary of the transformer feeding the rest of the circuit.

Our power design required two regulators, a 12 volt regulator and a 5 volt regulator. The voltage coming from the bridge rectifier is 18 volts. These 18 volts are enough to power our entire design. The 12 volt regulator feeds our solenoids and the 5 volt regulator feeds our sensors, and ATmega328 microcontroller

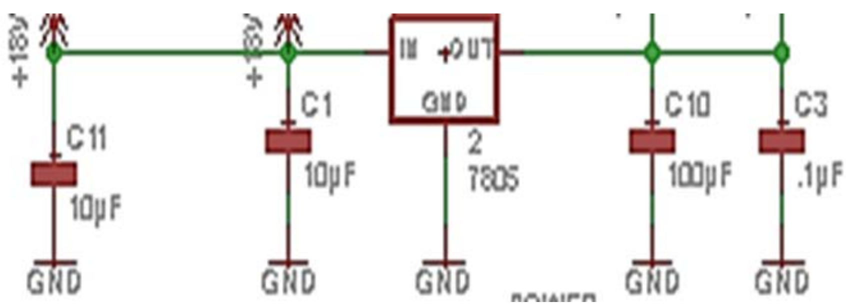


Figure: 41 Schematic of 5 volt power supply rail

Figure: 41 above shows the 5 volt power supply rail, regulated by a 7805 regulator.

4.1.6. Motor

For the motor design we chose to go with the air compressor. The air compressor that was chosen is shown in Figure 42. This compressor has a large enough tank and applies more than an enough PSI for the project; it is also compact enough to fit in the cabinet with no problem leaving enough room for both storage bins.

Figure 42: Air compressor for the project

4.1.7. LED

The LED design layout that we our going with would require the use of five-separated LEDs. The five in LEDs would be a green, yellow, red and two blinking red LEDs. Table 18, is a list of LEDs that can be purchase through www.radioshack.com or pick up in a local RadioShack store in two LEDs per package. Figure: 43 shows our implantation of the LED display for the Automatic Can Crusher.

LED color	Green	Yellow	Red	Blinking Red
Size	5mm	5mm	5mm	5mm
Voltage	2.2	2.15	2.25	2.225
Voltage max.	2.4	2.6	2.6	2.6
Current	10 mA	36mA	28mA	90 mA
Part number	276-022	276-021	276-041	276-036
Store	RadioShack	RadioShack	RadioShack	Radio Shack
Price	$1.99	$1.99	$1.99	$1.99

Table 12: List of Final LED lights

- Red (Stop) - Will flash red when either one of storage bins are full
- Yellow (StandBy) –The machine is either crushing or sorting an item
- Green (Go - When the hopper is ready to be loaded

Figure 43: The LED Display

The four figures that are in Figure 44, show the complete circuit of each LED light and resistor that will be needed for this project. All of the LEDs will be build individual as the circuit show how much resist each LED will need to support the voltage and current of the that particular LED. The reason why each LED circuit will be built separately is so that each circuit can be assign to their own output port of the microcontroller. By doing this it will allow the microcontroller to light the LED when a particular response input response comes into the microcontroller.

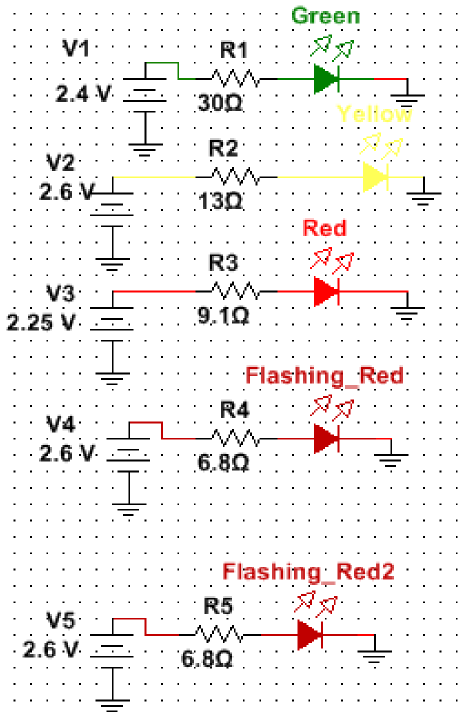


Figure 44: Circuit for each LED

4.1.8. PCB

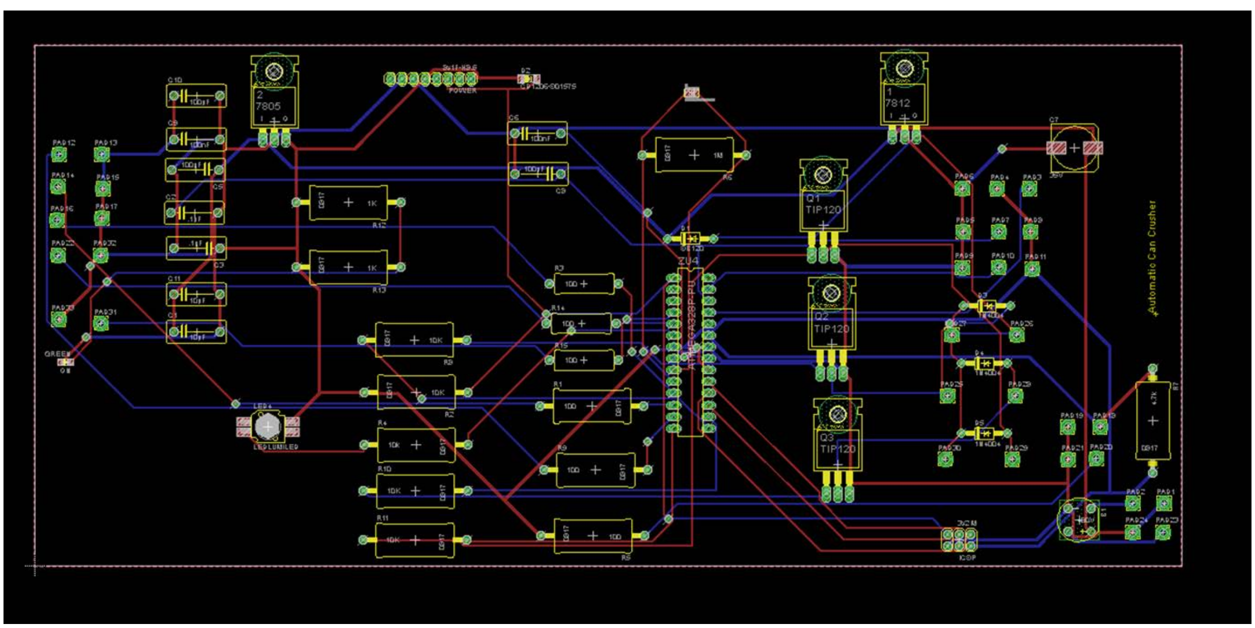


Figure 45: PCB Design

Our idea to use the existing Arduino Uno schematic and remove unnecessary components worked pretty well for us. We did not have any complications with our finished product. It did require in depth research of the existing design to figure out what was not needed. During testing we used the Arduino Uno development board to configure our sensors and solenoids to the correct pins dedicated the microcontroller. Testing alone ,however, did not answer the question "what don't we need from the existing design". Figure: 47 shows our finished design using the board file from Eagle.

Calculating the Duty Cycle

Duty Cycle= [ON_TIME/ (ON_TIME + OFF_TIME)]*100

Output Voltage = Duty Cycle * Input Voltage

Essentially with these formulas we can affect how an analog device behaves. There are 6 PWM outputs on the ATMega328, two are located on each timer/counter. Shown in, Figure 48, of the ATMega328. The PWM pins are located to the back left.

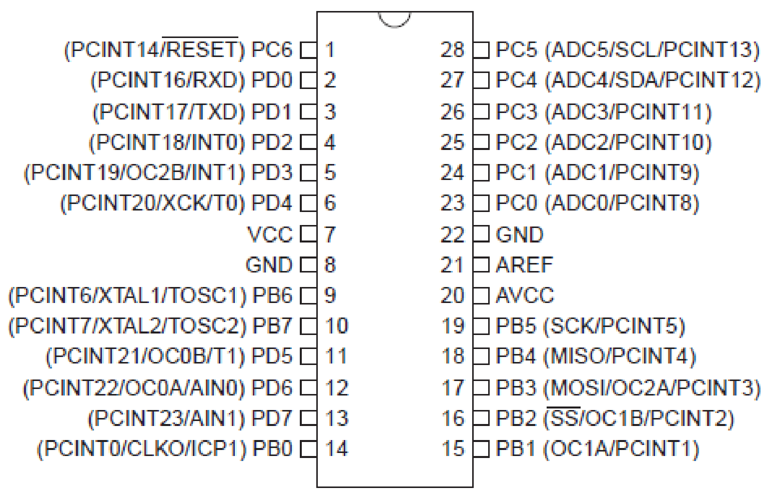


Figure 46:Microcontoller ATMega328

Permission Granted from Atmel.com

We didn't use any PWM settings for our design. During our testing and further research we found out that it was not need. All together we used ten pins, four of which were analog. We were correct in assuming that our design would involve a degree of executed timing. Overall the ATmega328 along with Arudino's support was very helpful . As it was challenging to learn to program while designing the Automatic Can Crusher. Figure: 47 shows the architecture in our design. You can also view the pins that were connected as well.

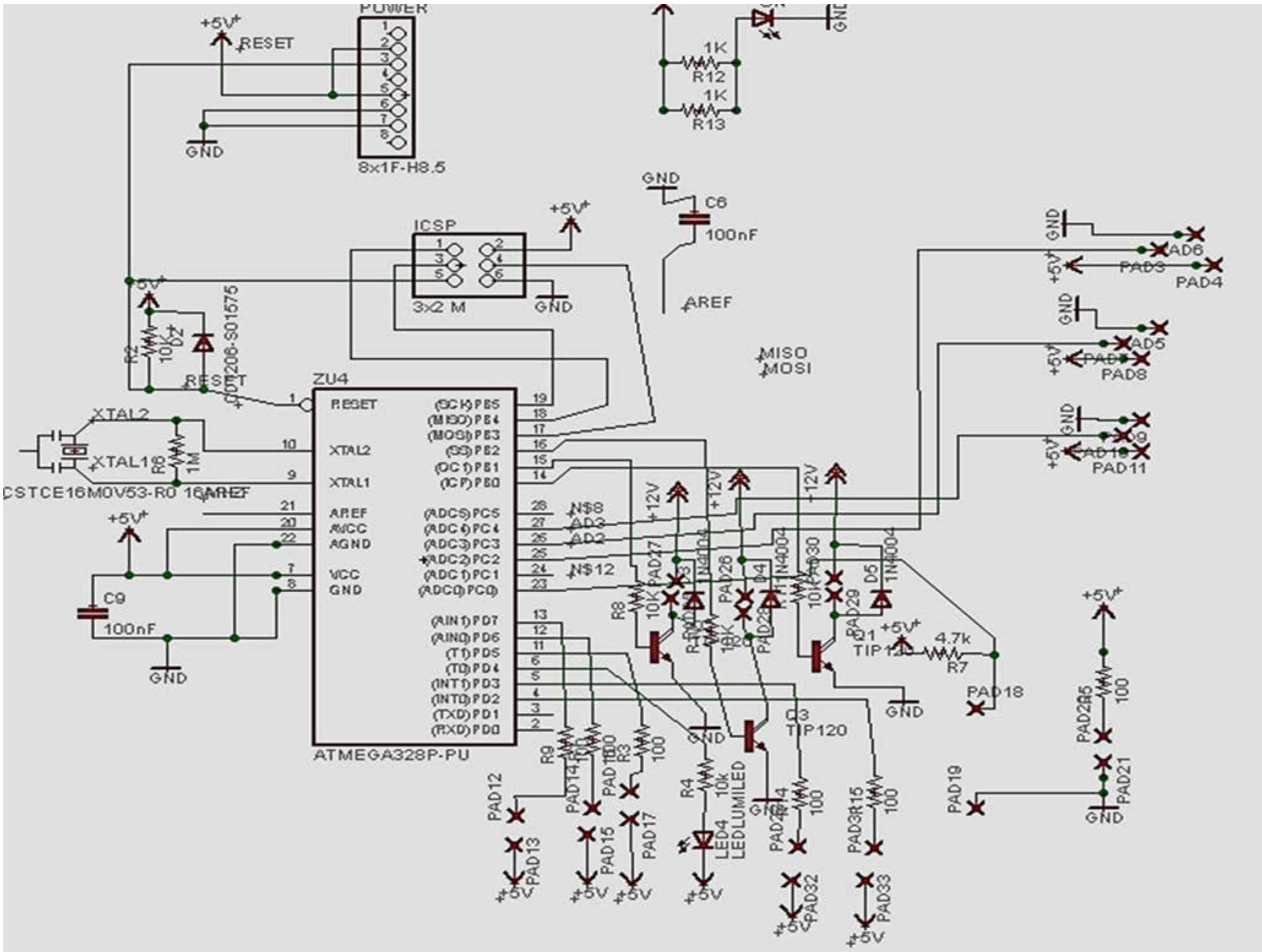


Figure 47:Architecture for our Design

Parts ID	Description
Microcontroller	ATmega328
Operating Voltage	5V
Input Voltage (recommended)	7-12V
Input Voltage (limits)	6-20V
Digital I/O Pins	14
Analog Input Pins	6
DC Current per I/O Pin	40mA
DC Current for 3.3V Pin	50mA
Flash Memory	32KB
SRAM	2KB
EEPROM	1KB
Clock Speed	16

Table 13: Microcontroller Specifications

We used “Eagle” to design the printed circuit board. After touring the website and looking at different programs, we have found a liking to Eagle. We also heard about its use via other classmates as well, having references is definitely a plus.

Eagle utilizes schematics and has a board file to design and customize your board. From personal use one of the inconveniences of transitioning from the schematic to the board file is that once the design is made in schematic once it is transferred into the board where it is then printed, you have to arrange the schematic design once again. Eagle, does offer a large library that has the components needed to make the printed circuit board. You can also make a build of materials within Eagle which is very convenient. Our overall experience with eagle went well there was a slight complication with our determining what Gerber files we needed in order to place our order but we were able to figure it out

The Figure 48, is a block diagram on how the components will ideal is connects to the microcontroller.

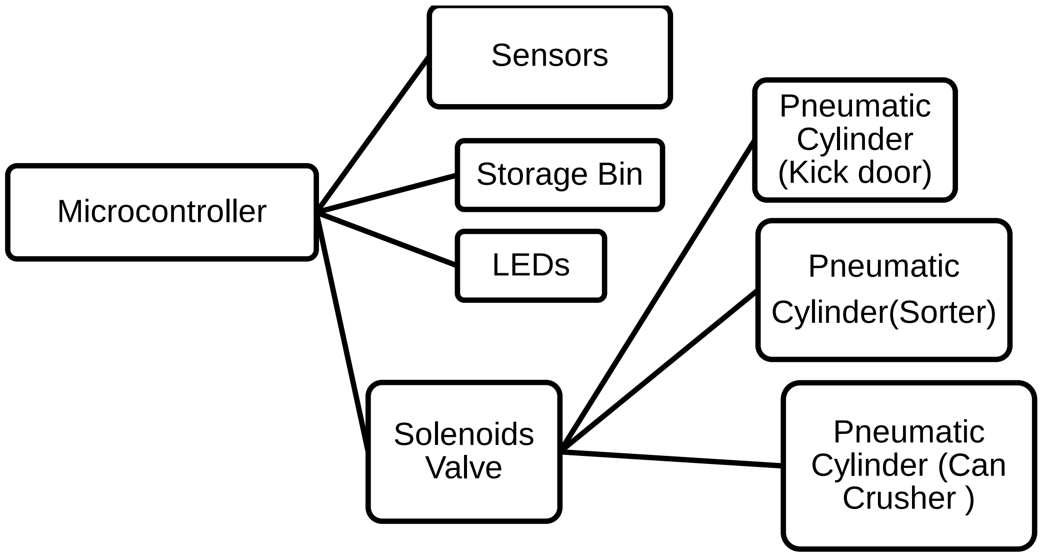


Figure 48: Block Diagram Microcontroller layout

4.2. Design Summary

The goal of this project is to make fully functional Automatic Can Crusher that stores the cans in a recycle bin. This design must also be able to sort water bottles. These will also be loaded into the machine as well, but not crushed like the cans will be. The objective of the design is to be able to load the hopper and that the machine automatically sorts the cans from the bottles into each of their recycle bin. The difference between the bins will be that water bottles will be left as normal bottles just sort in to plastic recycle bin. The cans on the other hand will be crushed.

To begin the user must first load the hopper with aluminum cans or water bottles. The aluminum cans, will not be greater than 16oz, and the water bottles cannot be greater 8 FL oz. Once in the hopper the object will be stopped by the rotating cylinder which will be positioned to hold the object from not moving until the sensor has detected whether the object is plastic or aluminum. The hopper will require two sensors to place it in, an optical sensors and ultrasonic sensors. The ultrasonic sensor is designed to pick up any object that is blocking the way, leaving this sensor to pick up each item that drops into the hopper. While an optical sensor also does the same thing, the only difference is that optical sensors cannot see clear objects such as plastic water bottles. By having these two sensors we can determine whether the object is aluminum or plastic. The truth table, table 20, explains how the sensors would read an answer to the microcontroller.

	Option 1	Option 2
Optical Sensor	Detects object	Does not detect object
Ultrasonic Sensor	Detects object	Detects object
	Aluminum Can	Plastic Bottle

Table 14: Truth Table

The next step once the sensors detects if it's plastic or aluminum, the sensors with send a response to the microcontroller. Once the microcontroller has got a responds it relays a command to air solenoid that is controlling the pneumatic actuator. The pneumatic actuator will be controlling the ramp door, since the projects main focus is the crusher the door will always be open to the can crusher at all times. If the microcontroller gets the reading that there is a plastic bottle in the hopper it will send a signal to the air solenoid to close the door. Once the door is closed, the rotating cylinder will receive a signal from its own air solenoid controller. This will take the bottle out of the hopper and let bottle slide down the ramp and into the recycle bin. When Option 1 occurs the sensors read back to the microcontroller that it is aluminum can. Then the rotating cylinder will take the can out of the hopper and release it down the ramp. Since the door is always opened the can will automatic go straight into the can crusher. The can crusher will be set to a timer on when to release the air to crush the can, since we won't be able to set the timer until we start build and testing of the prototype the exact time is unknown. Once the can is crushed it will drop from a slot in the can crusher into a storage bin right beneath the slot. Each storage bin will be having ultrasonic sensors mount to it to detect when either bin is full to capacity. Once either bin is full a LED that we being to flash to indicate to the user that bins are full.

The fountain of the project will be built out of a bathroom cabinet. By using a cabinet instead of a trashcan we have room to modify the project as need. These also allow use the cabinet doors to hide the storage bins, air compressor, and the brains of the project. Our plan is to build the can crusher and sorter on top the cabinet .The design is not set in stone because things can change once we start building. For safety hazards the can crusher and ramp will be enclosed in a box shape with three walls the back and two sides. A piece of Plexiglas will be place as the final piece of the box in the front, this way no object comes failing out to cause harm to any bystanders. The feature of the Plexiglas also always gives the user the option to view every step that the object will travel from the hopper to the bins. Another safety feature that will be added to the project will be when a user opens the cabinet doors the machine automatic shutdowns. Below is an ideal prototype and possible blueprint for the final design.

5. Building and Testing

Testing of the project design will involve testing each component individually to make sure it reaches its designed task. We will test the subsystems in phases until the project can completely be assembled and works collectively as a whole with complete symphony. The tests will mostly consist of functionality and trouble-shooting until we reach the desired function. We fell that is will be easier to test each individual component, check whether it's working and then pair components together. In this manner we'll know that if the components do not work together, the problem must be the assembly or wiring of the components collectively and not individually. We expect to make many adjustments as it is our first time working with these different technologies simultaneously.

First, a necessary test to run is if the optical sensor will or will not pick up the clear objects, which for us will be the water bottles. If it does not pick up the clear objects we will be satisfied.

As of now we are not sure of an alternative approach if in fact it does pick up the clear objects. Our research shows however that the weak point or disadvantage of the optical sensor is that it will not in cases detect clear objects.

The second test we expect the ultrasound sensor to be able to detect the water bottle. We do not expect any difficulties, because of our findings from research. Again, if we run into an unexpected problem we will have to go back and research more sensors. Also the sensors are adjustable for sensitivity so there are adjustments we can attempt to make.

One obstacle we do foresee is mounting and object placement, how the contents (water bottles and aluminum cans) enter the hopper and are detected. This is an important observation for us to make especially with dealing with the water bottles. We have a certain area that needs to be targeted on the water bottle. Any variation of the target can result in misplacing the object into the wrong bin. We feel like their will be many trail and errors to determine just the right placement and angle. Being able to consistently control the direction of the bottle or aluminum can will be extremely important in our success. It is the control that will determine what bin the can or bottle will go into. We will need to design a ramp that leads into the bin at the right angle. The "flow" of the design is quite tricky granted the space that we have to operate in.

We will need to conduct testing for first phase of sensors as well as the last phase of sensors, which are located in the storage bin. These sensors are distance measuring sensors. We have considered but not come to a definite decision on what sensor we will use. We do feel after research that the ultrasonic sensor which can also be used as a distance measuring sensor, may be the best sensor to use. Its functionality is basic and its assembly should also be as simple.

5.1. Element test

Sunlight

The sensors will never be directly exposed to sunlight but they will indirectly be exposed. We will be measuring and observing data based on exposure to determine what affects will be observed

- Expose Retro-reflective sensor to indirect sunlight
- Measure clear object detection
- Measure reflective object
- Measure at 2.5 millimeters
- Measure object at 3 millimeters
- Measure object detection with ultrasonic sensor at 1 centimeters
- Measure object detection with ultrasonic sensor at 2 centimeters
- Measure object detection with ultrasonic sensor at 3 centimeters
- Measure object detection with ultrasonic sensor at 4 centimeters

Artificial Light

- Repeat steps for Artificial light

5.2. Sorter

- Test pneumatic actuator, make sure sorter appropriately blocks water bottles from going into the can Crusher
- Test motion of Sorter

5.3. Storage Bin

We want to see if the sensor in storage bin can detect distance of single and multiple objects. We want to be able to attain an accurate reading from distance between object to designated area

- Place clear object in bin, observe output reading
- Fill storage bin 50% (clear object) observe output reading
- Fill storage bin 100% (clear object) observe output reading
- Place reflective object in bin, observe output reading
- Fill storage bin 50% (reflective object) observe output reading
- Fill storage bin 100% (reflective object) observe output reading

5.4. Angle Distance

- Place clear object 10 degrees above center line of the sensor and 1 millimeter in front of sensor
- Place clear object 15 degrees above center line of the sensor and 1 millimeter in front of sensor

- Place clear object 20 degrees above center line of the sensor and 1 millimeter in front of sensor
- Place clear object 25 degrees above center line of the sensor and 1 millimeter in front of sensor
- Place clear object 30 degrees above center line of the sensor and 1 millimeter in front of sensor
- Place clear object 35 degrees above center line of the sensor and 1 millimeter in front of sensor
- Place clear object 40 degrees above center line of the sensor and 1 millimeter in front of sensor
- Place clear object 45 degrees above center line of the sensor and 1 millimeter in front of sensor
- Repeat at a distance of 2 millimeters
- Repeat at a distance of 2.5 millimeters
-

5.5. Power Testing

- Place can inside the Can Crusher make sure it has appropriate pressure to crush can
- Place water bottle in the hopper make sure pneumatic actuator extends moving the sorter to one side closing access to Can Crusher
- Place can/water bottle in hopper, check to see rotating cylinder, rotates and collects contents and dumps contents into the ramp
- Test solenoids make valves work properly to control pneumatic actuator and rotating cylinder
- Measure the voltage from relays, observe and make adjustments accordingly

5.6. LED Testing

- Check for standby mode, default mode (yellow LED)
- Check for stop mode, when storage bin is full (Red LED)
- Check for operational mode, when object is detected (Green LED)

5.7. Board Testing

- Check operating voltage
- Testing Analog and Digital pins
- Proper connections support electrical functions
- Board is accessible to all components

5.8. Microcontroller Testing

- LED coordinates with sensors
- Microcontroller receives proper information
- Microcontroller performs proper instruction
- Microcontroller triggers Can Crusher

- Microcontroller controls pneumatic actuator
- Microcontroller controls rotating cylinder
- Microcontroller communicates with storage sensor

6. Administrative Content

6.1 Milestones

Tasks Assignments:

In Table 15, list the different components of the Can Crusher and which team member is responsible for that section.

Component	Team Member
Power Supply	Brandon Jefferson
Solenoids/Cylinders	Stanley Andrews
Sensors	Brandon Jefferson/ Stanley Andrews
Printed Circuit Board	Brandon Jefferson
Software Implementation	Stanley Andrews

Table 15: List of Components and Responsible Team Members

MILESTONE

Table 17 is a list of milestones we have set for this project. The dates shown in the table 16, are the goal dates that the team pre-made for the project. The Research and Design of the project will take approximately about two and half months.

Goal	Date
Rough Draft of Paper	July 9,2013
Final Paper	August 1, 2013
Begin Building	August 10,2013
Test Phase	September 23, 2013
Complete	November 20,2013

Table 16: Milestones with Goal Dates

The implementation of the project building and testing will take about four months. The table 17, is a new list of milestones. We found ourselves a little behind in Senior Design 1 but this did not prohibit us from reaching our deadlines. We met all deadlines because we were committed to completing the project on time.

	Start	Date
The Can Crusher	May 28,2013	December 2,2013
Senior Design 1 Paper	May 28,2013	August 1, 2013
Power Supply Research	May 28,2013	July 28,2013
Cabinet/Sensors/LED Research	May 28,2013	July 28,2013
Board Research	May 28,2013	July 28,2013
Software Research	May 28,2013	July 28, 2013
Order Parts	August 3, 2013	August 23,2013
Build Prototype	August 15,2013	October 23,2013
Software Development	August 3, 2013	November 20,2013
Hardware Development	August 3, 2013	November 20,2013
Testing	September 5,2013	November 25,2013
Presentation	December 2, 2013	December 10,2013

Table 17: Milestone Table with Start and Finish Dates

6.2. Project Budget and Finance

Due to choice of our project and the short summer term, finding someone who would sponsor us is a difficult task. After a long discussion and choosing this project, the whole group went into this project knowing that we will have to finance it with our own money. The main objective was to approach this project as a real scenario if possible taking to market for mass production. With that being the main focus the project will need the lowest possible budget, but with the best quality parts to make a great product. With budget playing a key role in the project, choosing the cheapest parts may result in a poorly made product that will make it unmarketable or competitive. The budget and selection of the parts needed for the project will have to be treating with equal priority. The estimate cost set for this project is $750 just to make sure we have enough money to cover all cost of required supplies for the design we manufacturing. The initial budget, which the group collectively put together, was created solely on common knowledge and scheming through previous project without deep research. List below in Table 18 is the early draft of the budget by each component, the estimated project will cost for single building of a prototype and the final product. The total cost that was estimated to be $1,040.00; amount the group expected to pay to build and complete the project before analyze and research on any components needed for the project.

Once the research on each component is complete led the group would categories and sort the parts by the ranking product for particular component. The parts would be ranked by the best to worst component to fit the project. Meaning the best would the ideal perfect part for the project and the worst would be the imperfect part for that will not work. After ranking the components we can look at the ranking for each component we will need for this project and select the best part that budget will allow. By sticking to a selection process for the best component for each step of the project it should be easy to complete this project with the best parts without excluding the budget.

	Nomenclature	Cost(ea.)
1	Air Compressor	$150
2	Air Powered Pneumatic (Already Built)	$160
3	Air Powered Pneumatic (Built by hand)	$50
4	Bluetooth/ Wireless	$5
5	Sensors	$10
7	Microcontroller	$60
8	PCB Board	$160
9	LED	$5
10	Commercial Trashcan	$200
11	Miscellaneous items(wire, solder and other items)	$60
	Total	$1,040

Table 18: Initial Budget

After research the different components the selection process was complete, the new list of the components and budget was compiled in Table 19. The new budget shows the most economical and logical option for the group to pursuit to complete the project in a timely matter. Although the parts selected for project were financial in the budget but not the top notch of the partial component. The budget total is subject to change and maybe altered throughout the actual time of building. These changes may be due to the possibility of newfound alternatives, which may be more economical or overall a better fit for the project.

	Nomenclature	Cost(ea.)	Quantity	Total Cost
1	Air Compressor	$150	1	$150
2	Air Powered Pneumatic	$160	1	$160
3	Cabinet	Free	1	$0
4	Storage Bin	$5	2	$10
5	Relay (115 V)	$17.94	1	$53.82
6	Regulator AC/DC (5V)	$1.99	5	$9.95
7	Microcontroller	$12	1	$12
8	PCB Board	$30	1	$30
9	LED	$1.99	4	$7.96
10	Sensors	$15	4	$15
11	Miscellaneous items	n/a	n/a	$100
12	Air Solenoid	$10.57	3	$31.71
			Total	$625.44

Table 19: Final Project Budget

<u>Initial Project Budget</u>

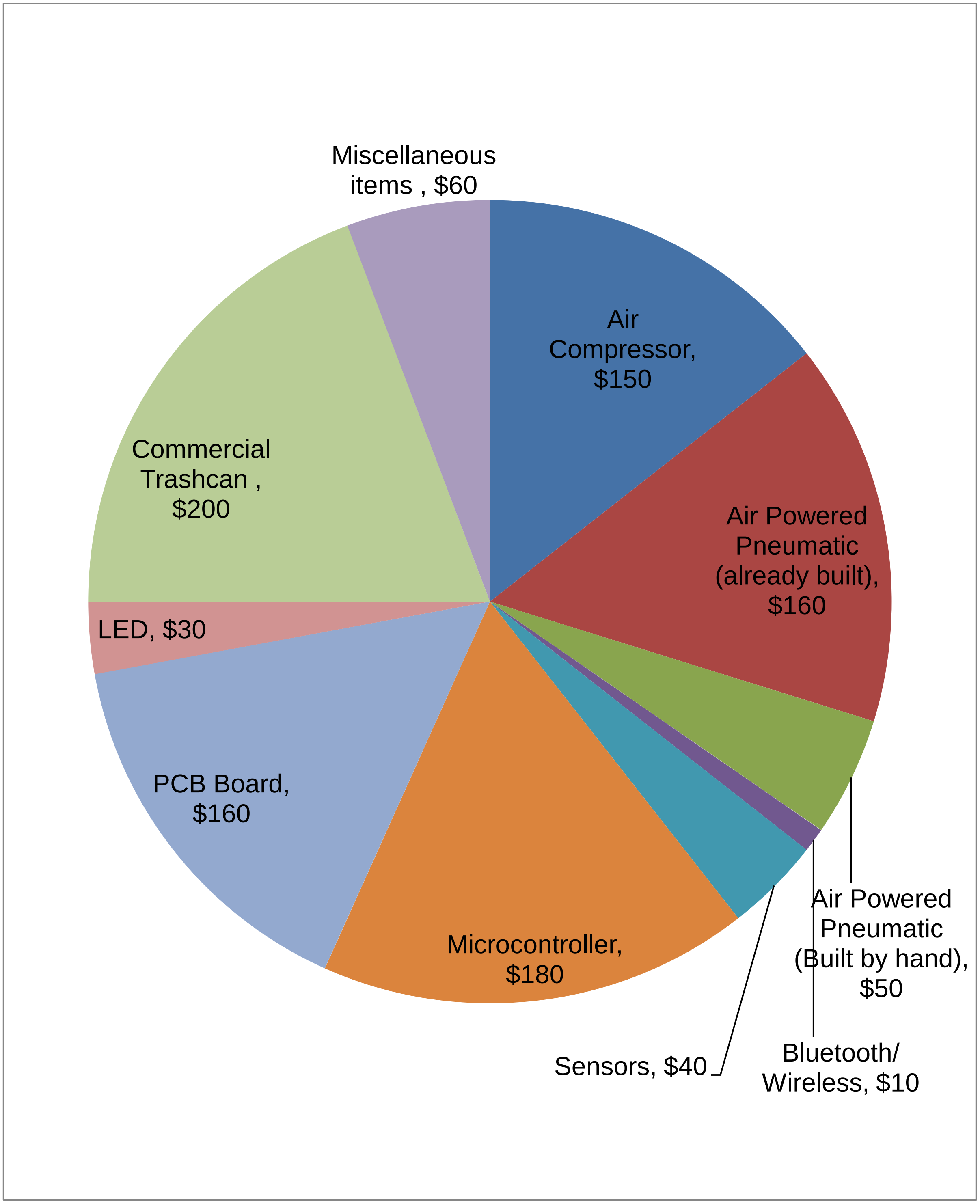


Figure 49: Initial Projected Budget Pie Chart

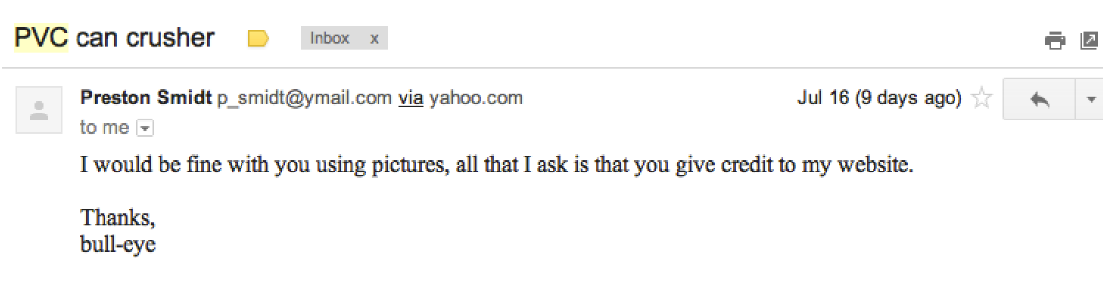
Final Budget

Nomenclature	Cost (each)	Number	Total Cost
Optical Sensor	$29.99	3	95.35
TCRT5000 Reflective Sensor	$1.00	10	$10.00
Double Acting Cylinder	$37.50	2	$38.46
Mini Cylinder	$16.47	1	$21.61
Air Solenoid	$11.39	4	$57.54
Air Valve Fittings	$1.48	14	$26.63
Air Valve Mufflers	$1.19	8	$15.05
LEDs	$1.99-$3.50	5	$20.00
Development Board	$12	1	$14.78
Air Compressor	$99.99	1	Free
PCB	$65.00	1	$65.00
Air Regulator	$19.99	1	21.18
Transfomer	$30.00	1	$30.00
Miscellaneous			$140.00
Total Cost	$1040		$554.42

Table 20: Final Budget

7. Appendix

7.1. Permissions


PVC can crusher Inbox x

Preston Smidt p_smidt@ymail.com via yahoo.com Jul 16 (9 days ago)
to me

I would be fine with you using pictures, all that I ask is that you give credit to my website.

Thanks,
bull-eye

Stanley Andrews <sandrews1987@gmail.com> Jul 17 (8 days ago)
to Kevin

Kevin Michaelis,

I am currently doing my senior design project at University of Central Florida and would like to incorporate a couple picture of your Can crusher in my project design. I would to ask permission to use picture and exacting info which were post online. I will surely references your website and your name to the picture design.

Another question I'm looking to purchase your product to make it automatic for my project. I notice that you have a little black button switch to operate the cylinder is there another way I can have it built or can I can modify it myself?

Thank you in advance

...

Kevin Michaelis Jul 17 (8 days ago)
to me

Stanley, I see no reason not to allow you to use information from my website but preferable only as a class project, I would also be interested in information pertaining to your project that relates to my can crusher, I wouldn't need complete details

depending on the modifications you are looking for would make my decision on modifying things for you or going ahead and doing it yourself, I do make changes in these units fairly often to accommodate other applications

If your looking for the most powerful unit you would want to purchase the II.0 unit, I have both units in stock at all times

thank yo Kevin

SourcingMap

Department is currently unavailable. Please leave a message.

Name: stanley andrews

Email: sandrews1987@gmail.com

Subject: Permission to Copyright pictures

Message: To whom may concern,
Im doing a project for my senior class at UCF, I would to know if can get a photo to use in my

Send Email

Re: [Ticket#2013072510002281] Permission to Copyright pictures Inbox x

info@sourcingmap.com <info@sourcingmap.com> Jul 26 (4 days ago)

to me

Dear customer,

Thank you for your inquiry.

Yes, you could use the photo in that way. By the way, we would like to attach some new photos for your reference.

Best regards,

Jimmy
SourcingMap customer service
http://www.sourcingmap.com

stanley andrews <welcome@sourcingmap.com> wrote:

> Live Support Message Delivery:
> --
>
> To whom may concern,
> Im doing a project for my senior class at UCF, I would to know if can get a
> photo to use in my report a publish quality photo of the link.
> http://m4.sourcingmap.com/photo_new/20110521/g/ux_a11052100ux0122_ux_g03.jpg
>
> Thank You in Advance,
>
> Stanley Andrews

Please note that all fields followed by an asterisk must be filled in.

First Name* Stanley

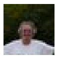
Last Name Andrews

E-mail Address* sandrews1987@gmail.com

Please enter your message, question or suggestion here:

I am currently doing my senior design project at University of Central Florida and would like to incorporate a couple picture of your air actuators in my project design. I would to ask permission to use picture and exacting info which were post online. I will surely references you your online and your name to the picture design. Thank you in advance

RE: Submission from about-air-compressors.com



Bill Wade <wrw001@gmail.com> Jul 5
to me

Stanley...

I apologize for the delay in responding.

" and would like to incorporate a couple picture of your air actuators in my project design" is this to be an on-line design, or a paper for submission to your prof's?

If it is to be pulbished on line I would prefer you not use my material or graphics.

If it is a written paper, then please do use photos and text with accreditation to my site.

Cheers,

Bill Wade
Publisher
www.About-Air-Compressors.com

eBay Member: todd1455 <todd14_krib2829tg@members.ebay.com>
to me

Images are not displayed. Display images below - Always display images from todd14_krib2829tg@members

eBay

eBay sent this message to brandon jefferson (bboyhoops2013).
Your registered name is included to show this message originated from eBay. Learn more.

Seller has responded to your question about this item

Do not respond to the sender if this message requests that you complete the transaction outsid

Dear bboyhoops2013,

No problem. You have my permission to use the photo. Thank you for asking. Good luck with your project.

Todd

\- **todd1455**

Permission Requested to use figure

Inbox x

brandon jefferson
Hi, My name is Brandon I am a student at the University of Central Florida. I...

Errol Bozel
to me, jaquanslim21, rahn.lassiter, Paula

As long as its clearly documented that it was taken from our paper, you have our permission.

Sent from my iPhone

On Jul 28, 2013, at 5:03 PM, "brandon jefferson" <bboyhoops@gmail.com> wrote:

Hi

Permission request to use datasheet picture of Arduino pins

Inbox x

brandon jefferson Jul 24 (7 days ago)
Hi, My name is Brandon Jefferson I am a student at the University of Central ...

Mata, Cecilia Jul 25 (6 days ago)
Hello Team, Please find attached email request for permission to use picture ...

Chugh, Paramjyot <Paramjyot.Chugh@atmel.com> Jul 25 (6 days ago)
to Leo, Linda, me

Brandon,

Thanks for your email. We appreciate your checking with us for the permission to use our copyrighted material from our website/datasheets. Since the kind of reproduction you described, could be considered as the type of permitted copyright "fair use", no formal approval is required from Atmel. We only ask you to attribute the source of material you use in your project paper.

Thank you for your interest in Atmel products.

Regards,

Paramjyot Chugh | Intellectual Property Portfolio Manager

[Arduino] Re: Requesting permission to use arduino uno schematic

Inbox x

cgerbino <notifications-support@arduino.zendesk.com>
to me

##- Please type your reply above this line -##

Ticket #2907: Requesting permission to use arduino uno

Your request (#2907) has been solved. To reopen this request, reply to this email or click the link below:
http://arduino.zendesk.com/tickets/2907

cgerbino, Jul 25 19:22 (CEST):

Hi,

yes you can use it because it ie released in CC-BY-SA 3.0 meaning you have to mention the source.

Logo is not permitted.

Best

Regards,

Christian

The Arduino Store Team

Bboyhoops, Jul 24 23:13 (CEST):

Hi,
My name is Brandon Jefferson I am a student at the University of Central Florida. I am conducting a senior design project as part of my Enginee

Please confirm permission for the use of the Arduino Uno schematic for my senior design paper

Thanks

Request permission for design Inbox x

brandon jefferson <bboyhoops@gmail.com>
to contact, bok.egizmo

Hi,
My name is Brandon, I am a student at the University of Central Florida. I am working on a senior design project and would lik
associated printed circuit board design and pictures located on your site.
Can you confirm my request?

Thanks

Contact ElectroSchematics.com
to me

Yes, you can use them and send some pictures with your work if you are kind.

Thank you,

Popescu Marian.

...

Enrison Hilario
to me

yes sir.. no problem you can use it since its a open source design..

...

Permission to use picture of GP2Y0A02YK0F Inbox x

brandon jefferson
Dear Robin, My name is Brandon I am a senior at the University of Central Flo...

Robin Shoop <rshoop@andrew.cmu.edu>
to me

Hello Brandon,

Feel free to use this picture.

Regards, Robin

Optical sensor pictures Inbox x

DataCenter <DataCenter@digikey.com>
to me

Hello Brandon,

Thank you for contacting Digi-Key.

Attached are the photos to the Vishay optical sensors we discussed today. I hope these photos a week to help with any questions you may have.

To help us provide continual improvement to Digi-Key's level of Technical Support, please fill out

7.2. References

"Voltage regulator". Encyclopedia Britannica. Encyclopedia Britannica Online.

Encyclopedia Britannica Inc., 2013. Website. 25 Jul. 2013

http://www.britannica.com/EBchecked/topic/632467/voltage-regulator

"Sheet, Aluminum, 8/125 X 6 X 12 in." GRAINGER APPROVED VENDOR., 01 June 2013. Website. 25 July 2013.

"Amico MAL25 X 200 Double Acting Single Rod Pneumatic Cylinder." Amazon.com. N.p., n.d. Website. 25 July 2013.

http://www.ehow.com/how-does_5715162_single-action-air-cylinder-work_.html

Condy, Sienna. "How Does a Single Action Air Cylinder Work?" EHow. Demand Media, 03 Dec. 2009. Website. 25 July 2013.

"Single Acting Air Cylinders." Single Acting Air Cylinders. Bill Wade 2012. Website. 25 July 2013.

http://www.about-air-compressors.com/singleacting.html

"Double Acting Air Cylinders." Double Acting Air Cylinders. Bill Wade, 2012. Website. 25 July 2013.
http://www.about-air-compressors.com/Double-acting.html

“Electronic Components.” RadioShack. 2013.Website. 25 July 2013

www.RadioShack.com

“Air Compressors.” Lowe’s Home Improvement. 2013.Website. 25 July 2013
www.Lowes.com

“Home of KevinKrusher.’’ Kevin Michaelis, 2012. Website. 28 July 2013

http://www.kevinkrusher.com

“DIY PVC Can Crusher Guide” Preston Smidt, 2011. Website 28 July 2013

http://cancrusherguide.webs.com

"TCRT5000 sensor Bajdi.com." *www.bajdi.com*. 03042012 at 2352 Web.
31 07 2013. <http://www.bajdi.com/tcrt5000-sensor/>.

"ADNS3060 datasheet pdf Agilent Technologies Optical Mouse Sensor datasheet4u.com." *www.datasheet4u.com*. n.d. Web.
31 07 2013. <http://www.datasheet4u.com/datasheet/A/D/N/ADNS-3060_AvagoTechnologies.pdf.html>.

"Arduino Boards CircuitsHome." *www.circuitsathome.com*. n.d. Web.
01 08 2013. <http://www.circuitsathome.com/products-page/arduino-boards>.

"AVR 8bit and 32bit Microcontroller." *www.atmel.com*. n.d. Web.
01 08 2013. <http://www.atmel.com/products/microcontrollers/avr/default.aspx>.

"Honeywell Sensing and Control." *sensing.honeywell.com*. n.d. Web.
01 08 2013. <http://sensing.honeywell.com/>.

"Occupancy Sensors Business Energy Efficiency TXU Energy." *www.txu.com*. n.d. Web.
31 07 2013. <http://www.txu.com/en/Business/esource-biz/buying-equipment/lighting/occupancy-sensors.aspx>.

"PING Ultrasonic Sensor." *www.makershed.com*. n.d. Web.
31 07 2013. <http://www.makershed.com/product_p/mkpx5.htm>.

"Welcome to electroniclessons.com!." *www.electroniclessons.com*. n.d. Web. 01 08 2013. <http://www.electroniclessons.com/>.

"eGizmo Mechatronix Central." *www.e-gizmo.com*. n.d. Web. 31 07 2013. <http://www.e-gizmo.com/>.

"PDF From www.clrwtr.com." *www.clrwtr.com*. n.d. Web. 01 08 2013. <http://www.clrwtr.com/PDF/Banner/Banner-MINI-BEAM-DC-Retroreflective-Sensors.pdf>.

What is Analog Signal Processing?." *www.wisegeek.com*. n.d. Web. 31 07 2013. <http://www.wisegeek.com/what-is-analog-signal-processing.htm>.

"Difference Between Analog and Digital Signals Difference Between Analog vs. Digital Signals." *www.differencebetween.net*. 2013 Web. 31 07 2013. <http://www.differencebetween.net/technology/difference-between-analog-and-digital-signals/>.

"Vishay Semiconductors General Semiconductor Distributor Mouser." *www.mouser.com*. n.d. Web. 31 07 2013. <http://www.mouser.com/vishaysemiconductors/>.