

# The Can Crusher

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## **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 question 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 hoses 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 an 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 accidentally 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 personnel 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 "retroreflective".

### **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 retroreflective 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 captured 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 Fresnel 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 Fresnel 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.

### **Fresnel Lenses**

Again we go back to the discussion of the Fresnel 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 Fresnel lenses is so important.

The detector has two halves, two slots. The Fresnel 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 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, Permission Granted from EBay user: todd1455

it costs anywhere from a 12\$ to 50\$. The amount of voltage that is used may become a concern. 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.



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

Table 2: Specifications for the Banner SM2A312LV

The final sensor we will be considering using, the PING Ultra sensor. 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.

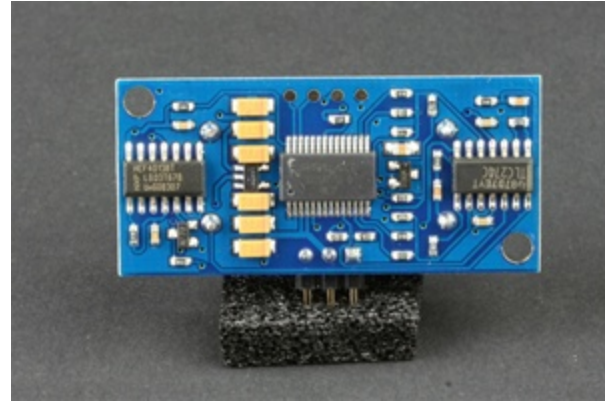


Figure 3: Ultrasonic sensor front and back

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 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 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.

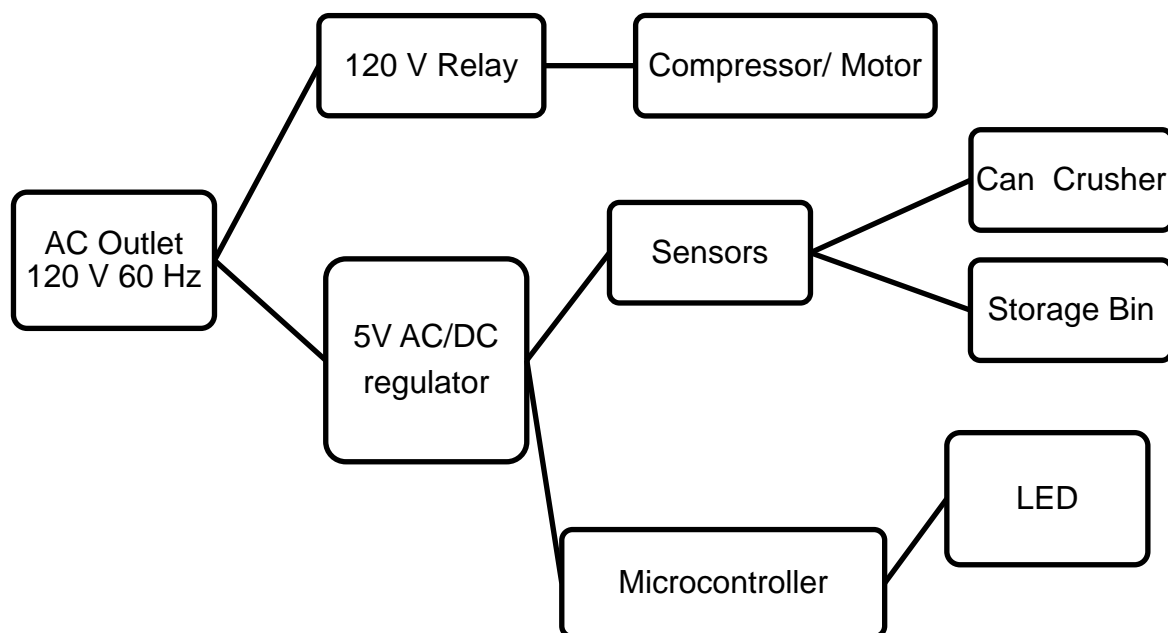


Figure 4: Block Diagram of the Power Supply

#### **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](http://www.lowes.com) which will be choosing from:

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

Table 5: List of possible Air Compressor

### **3.1.4.2. Electric Motor**

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 Expensive 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
<b>Chamber Length</b>	6 1/2" minimum	6 1/2" minimum	6 1/2" minimum
<b>Chamber Length</b>	6 1/2" minimum	6 1/2" minimum	6 1/2" minimum
<b>PSI</b>	unknown	110-120	60 -120
<b>Cylinder Type</b>	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
<b>Mounted</b>	Vertical or Horizontal	Vertical or Horizontal	Vertical or Horizontal
<b>Price</b>	\$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 5: 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.

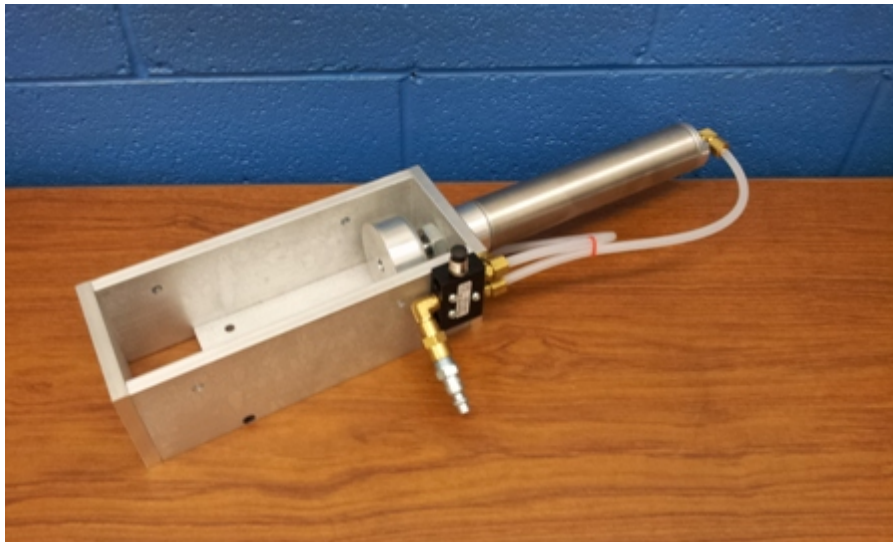


Figure 6: Kevinkrusher 1.5

Permission Grant by Kevin Michaelis

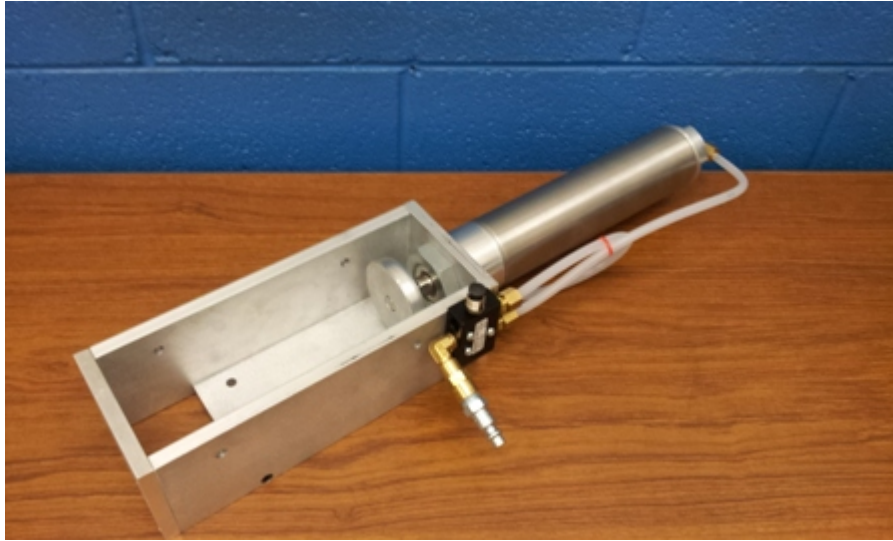


Figure 7: Kevinkrusher 1.5

Permission Grant by Kevin Michaelis

### **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.

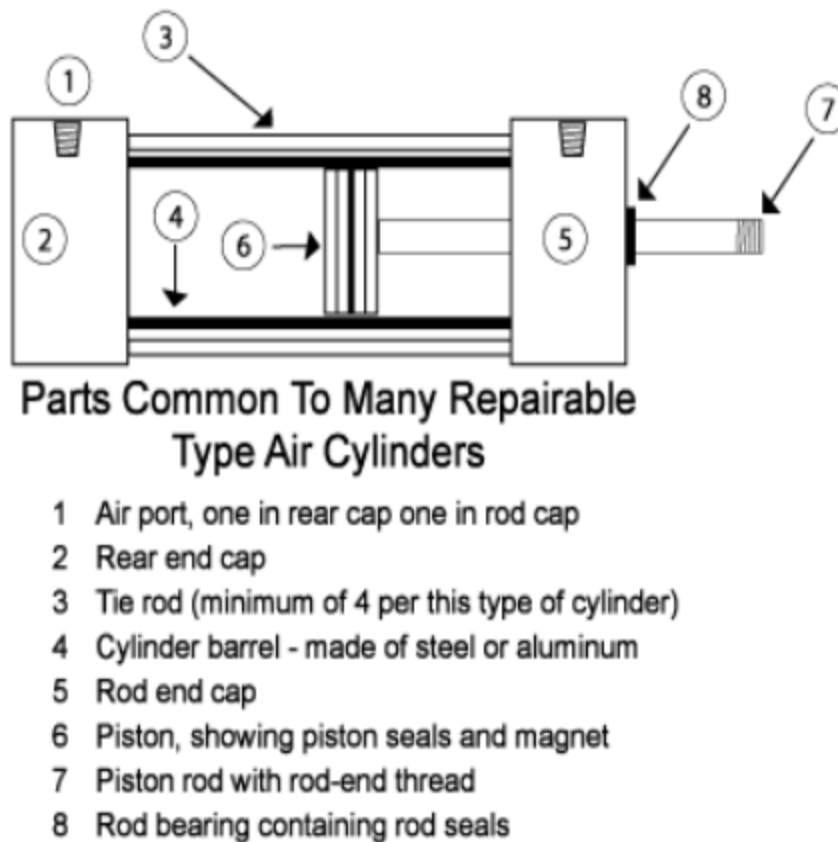


Figure 8: How a Cylinder is built

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.

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

Table 8: Specifications of the Pneumatic Solenoid Valve



Figure 9: Possible Pneumatic Solenoid Valve

Permission Grant by Sourcing Map

### **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.

### **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. 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 as shown in the figure below 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 then 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.



Figure 10: Regular 12oz. cans



Figure 11: 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 too 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 12 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 placed 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 12: Various labeling layout of water bottle

### **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 placed according to 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 actuators can be found on eBay for fewer than 30 dollars.



Figure 13: 6" inch Pneumatic Actuator



The figure 13, above is a pneumatic actuator. It's shown here without any mounting brackets or any external components; however this is what we will be looking for. The pneumatic actuators 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 actuator. We'll extend the pneumatic actuators 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.

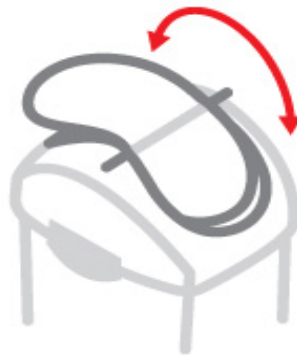


Figure 14: Swinging Method Considering

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 welded 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 14) we'll need to make some

brackets to allow the lid to swivel (also seen in the figure 14). 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 are 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.

### **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 15) 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 15: Office Building Recycle Trashcan



Figure 16: Commercial Size Trashcan

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

	Figure 1 (square)	Figure 2 (square)
<b>Dimensions (inches)</b>	40H x 20W X 18D	30H x 20D
<b>Capacity (gallons)</b>	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 16) 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.

<b>Height</b>	35
<b>Depth</b>	22
<b>Width</b>	31

Table 10: Cabinet Dimensions

### **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.

#### **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 17. 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.electronicsforless.com](http://www.electronicsforless.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.

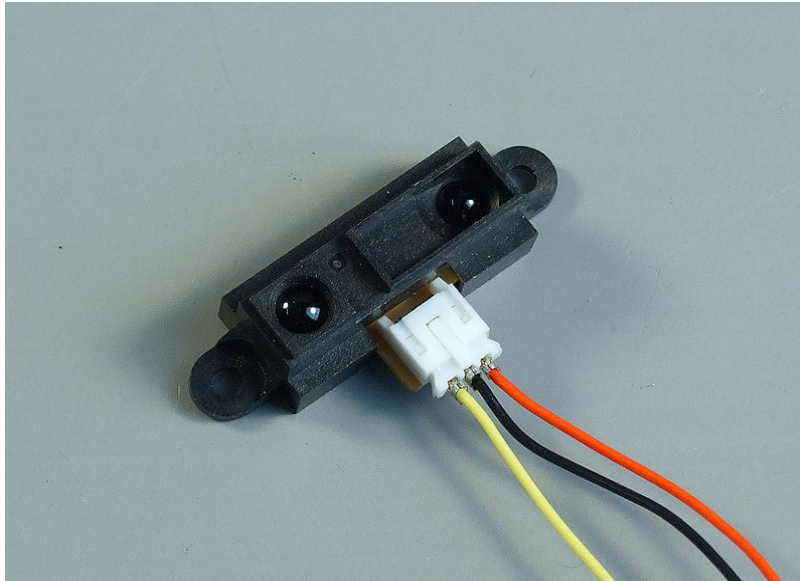


Figure 17: Image of GP2Y0A02YK0F

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 11: Specifications of GP2Y0A02YK0F

Placing of these sensors must be precise to get accurate readings of when an object is blocking the sensor. The figure 18 below gives a better visual view.

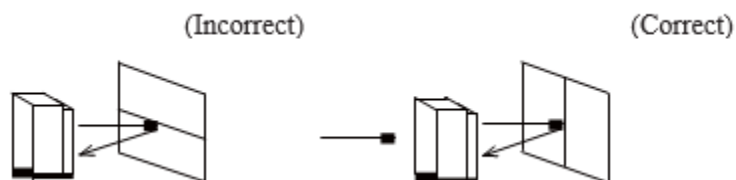


Figure 18: Visual View of GP2Y0A02YK0F

### Permission Requested from Sharp

The figure 19, 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.

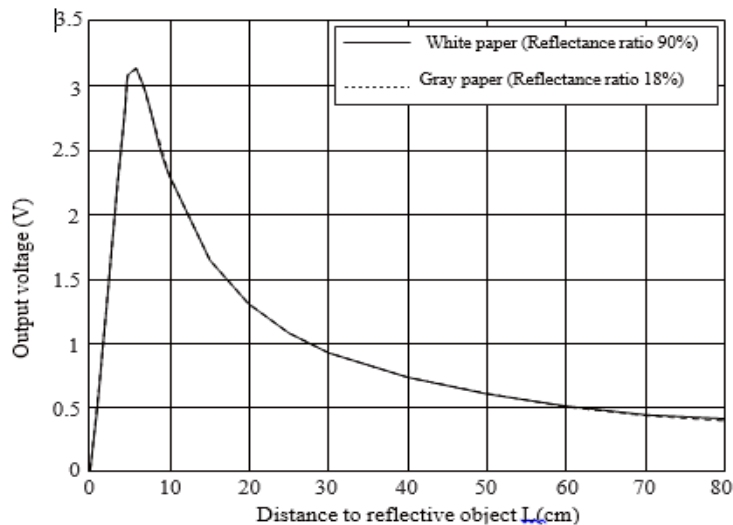


Figure 19: Reflectance Ratio Permission Requested from Sharp

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 20: Ideal Storage Bin to be use in project



This figure 20, 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. Their 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 17 above. The black wire is for ground, red wire is for power and white or yellowish wire is for signal output and it cost an additional \$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 sensors at the top to determine if the storage bin is full.



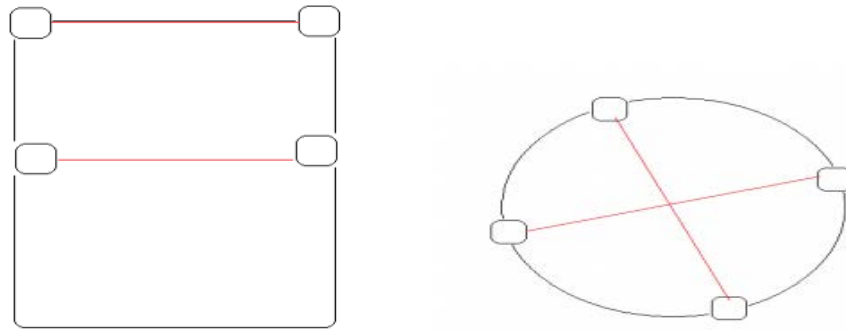


Figure 21: “Trash Talk” idea of sensors placing

Shown in figure 21, 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.

Here are lists of components that could be used along with the through-beam sensor. Below shows the list for emitter and the detector, respectively. A list of components were provided by [[www.e-gizmo.com](http://www.e-gizmo.com)]

These components, table 12, are seen used in the schematic design. The receiver’s main component is the 567 tone decoder IC. The IC is responsible for activating an output however; the frequency of the signal must fall between a certain ranges. The trimmer resistor ( $R_t$ ) and capacitor ( $C_t$ ) sets the operating frequency of the receiver. This is shown in the transmitter schematic figure 23, below.

Parts ID	Description	Quantity
C1	10mF/16V Electrolytic Capacitor	1 pc
C2	1mf/16V Electrolytic Capacitor	1 pc
C3	223 Ceramic Capacitor	1 pc
C4, C5	103 Ceramic Capacitor	2 pcs
Ct	152	1 pc
D1	LED red (3mm)	1 pc
D2	LED green (3mm)	1 pc
J1	Switch	
R1,R2	100 ohms Resistor	2 pcs
R3	27 ohms Resistor	1 pc
R4	10K Resistor	1 pc
Rt	10K trimmer	1 pc
U1	7805	1 pc
U2	LM567	1 pc
U3	IrDA	1 pc

Table 12: Components of Receiver Schematic

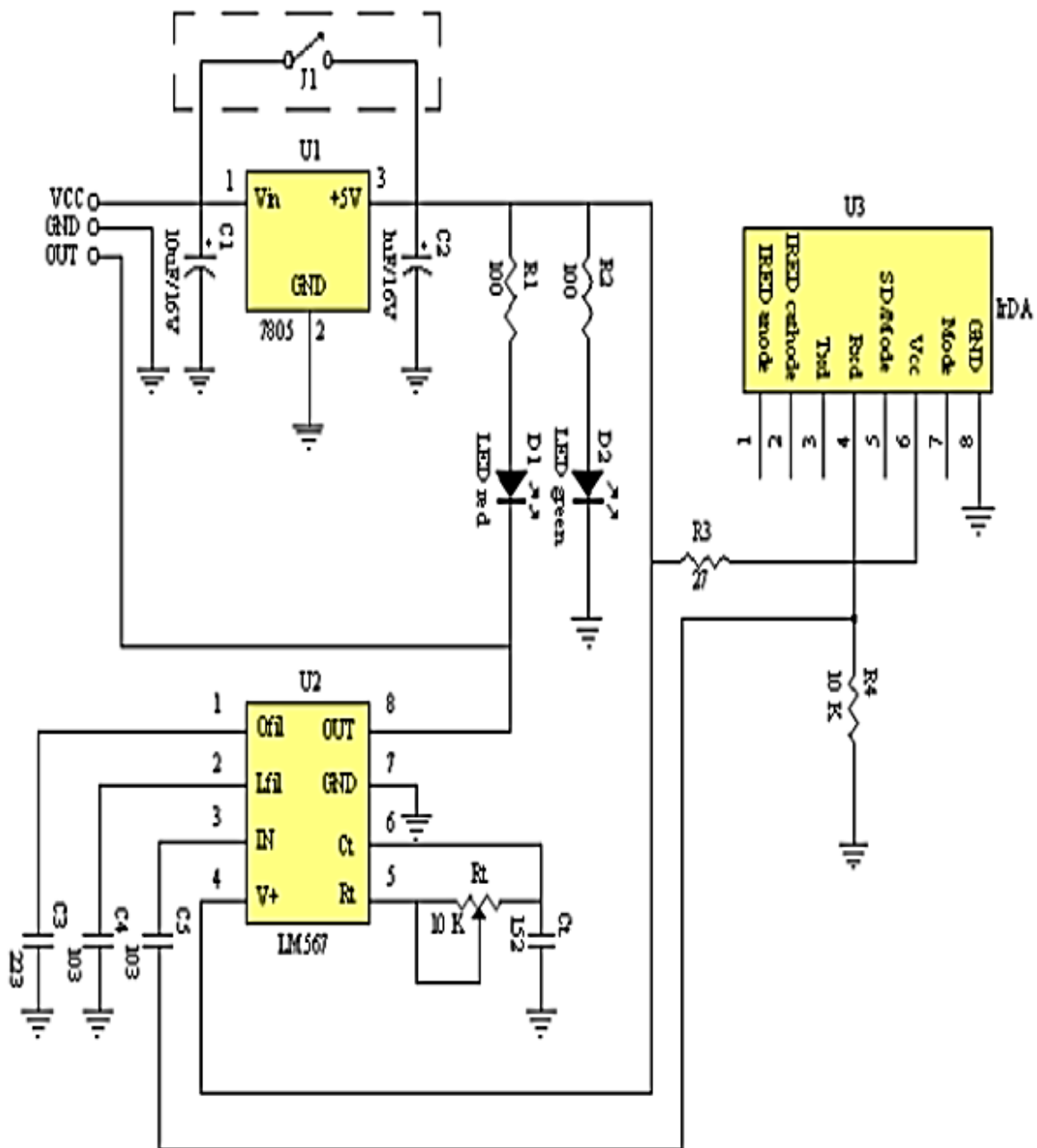


Figure 22: Receiver Schematic

The transmitter main component is the 555 timer. The output will be a continuous square wave, which is the input to the transmitter side of the IrDA. A beam is generated which targets the receiver. This is shown in the receiver schematic, figure 22.

When the receiver, receives the beam it hold its output at a logic low, which is close to zero. This low-high pattern suggests that an object has passed between the receiver and emitter (high).

[www.e-gizmo.com] also offers how to solder the components together as well. We may go on campus to the mechanical engineering to aid with soldering. If we need more assistance there are resources that we can use. There is some degree of mechanical work that we should expect. Tackling that aspect of the project will require us to branch out and ask for advice and help to be cost effective in the end. Below provided by [www.e-gizmo.com] are the schematic designs for the transmitter board layout Figure 23, transmitter board parts layout Figure 24, receiver board layout Figure 25 and receiver board parts layout, table 12.

Parts ID	Description	Quantity
C1	10mF/16V Electrolytic Capacitor	1 pc
C2	1mf/16V Electrolytic Capacitor	1 pc
C3	103 Ceramic Capacitor	1 pc
C4	681 Ceramic Capacitor	1 pcs
D1	LED red (3mm)	1 pc
J1	Switch	
R1,R6	100 ohms Resistor	2 pcs
R3	27 ohms Resistor	2 pc
R4	4.7K Resistor	1 pc
Rt	1.2K trimmer	1 pc
U1	7805	1 pc
U2	LM567	1 pc
U3	IrDA	1 pc

Table 13: Components for Transmitter Schematic

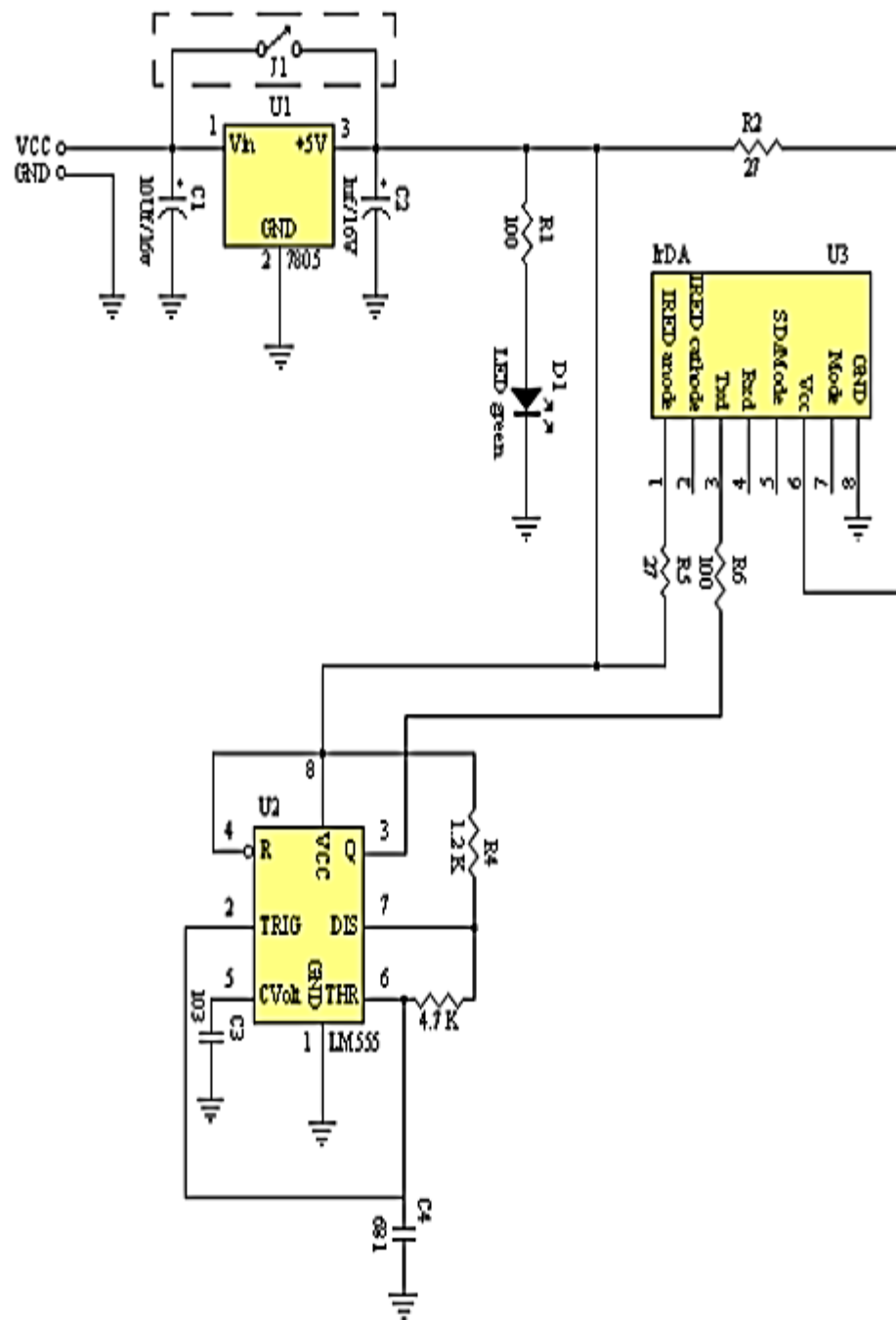


Figure 23: Transmitter Schematic

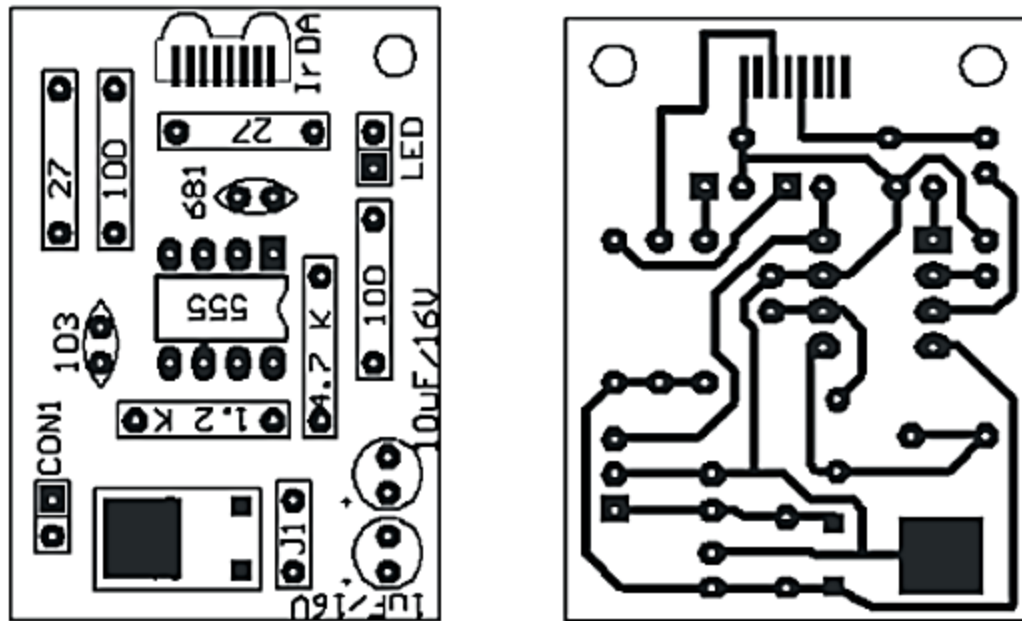


Figure 24: Transmitter PCB layout

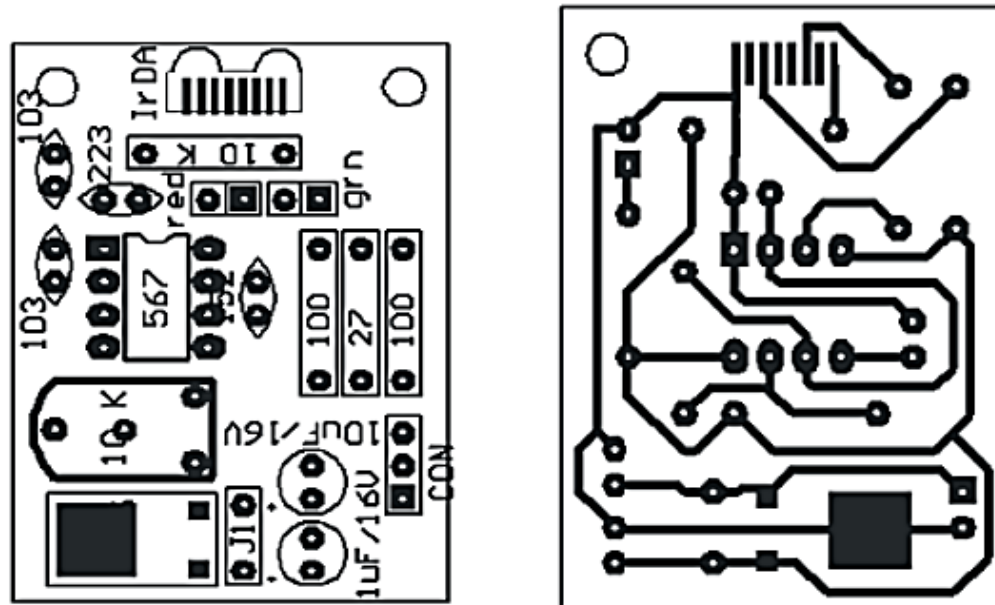


Figure 25: Receiver PCB layout

### **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 26



Figure 26: 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 27.



Figure 27: 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.

## **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 Oz. 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 Can crusher that we choose to go with will be 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](http://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. By going with the big one we know that we will have more of a cushion to play with then falling short of the and needing to order another can crusher since are budget is very tight. The only thing with buying the can crusher will need to make a small modification to it; this one has a push valve button that controls the pneumatic cylinder to crusher. In order for us to use this model will need to get a toggle switch and hookup up to an air solenoid that will trigger the toggle switch back and forth every time the microcontroller triggers the can crusher to crush the can.

	KevinKrusher II.0
<b>Chamber Length</b>	6 1/2" minimum
<b>Chamber Length</b>	6 1/2" minimum
<b>PSI</b>	60 -120
<b>Cylinder Type</b>	Double action 2.0 bore x 6.0 stroke cylinder
<b>Mounted</b>	Vertical or Horizontal
<b>Price</b>	\$157.00

Table 14: List of Can Crusher Specifications

#### **4.1.3.Sorter**

Figure 28, shows the design for the sorter. The hopper (labeled as the shoot in the design) is shown from the perspective of the user looking into it. We have the ramp and as shown the swinging lid will be strategically placed to separate aluminum cans from the water bottles. As you see below the Can Crusher will be the storage bin for the aluminum crushed cans, similarly the storage bin is shown for the water bottles. The

ramp which is shown from another view, on the bottom left, will be angled to allow the contents to roll down and then be directed by the swinging lid to their designated areas.

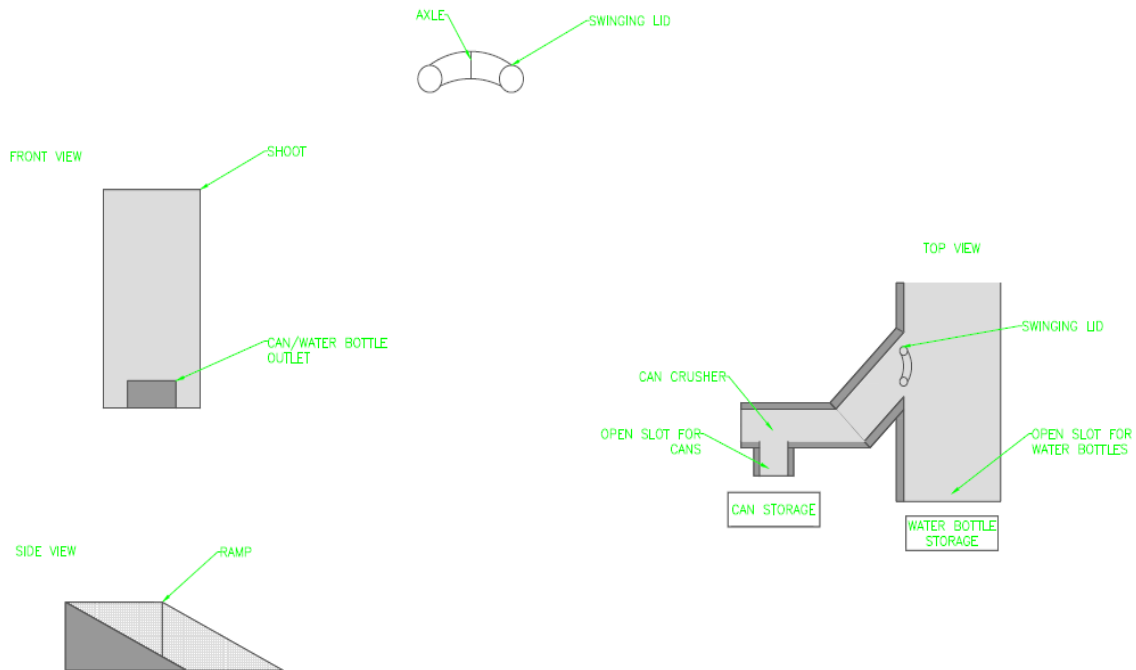


Figure 28: Sorter design

#### **4.1.4. Sensors**

The layout design is showed in the block diagram picture below, in figure 29. 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.

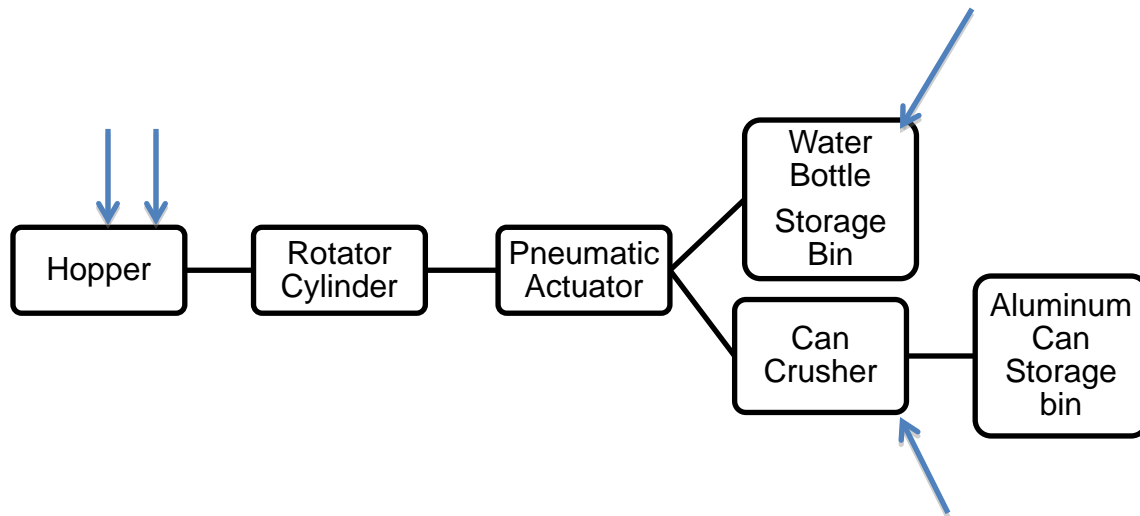


Figure 29: Block Diagram of Sensors design layout

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

Table 15: Specifications of Sensors

#### **4.1.5. Power Supply**

##### **AC Current**

Since all research and components are picked we can ideal setup the power supply with more accuracy details and the way power disturbing will work for the prototype and final project? First thing that will be needed is a 120 V relay, in order to use this relay we

would need to cut the cord of the air compressor and spliced it back together with the relay connect in between outlet and the compressor. In doing this it will allow power to the PCB boards at all time. This relay will allow enough power to turn on the air compressor when needed. Figure 30, below is shows the relay that we will purchase from [www.radioshack.com](http://www.radioshack.com) along with the specifications shown in table 16.



Figure 30: 120V 5Amp Relay

<b>Part number</b>	R12-17A3-120
<b>Coil Voltage</b>	120 V
<b>Power</b>	1.2 VA
<b>Operate time</b>	25 mS
<b>Operating Temperature</b>	-30° C to +55° C
<b>Pole</b>	4 PDT
<b>Price</b>	\$17.46

Table 16: Specifications of 120V 5Amp Relay

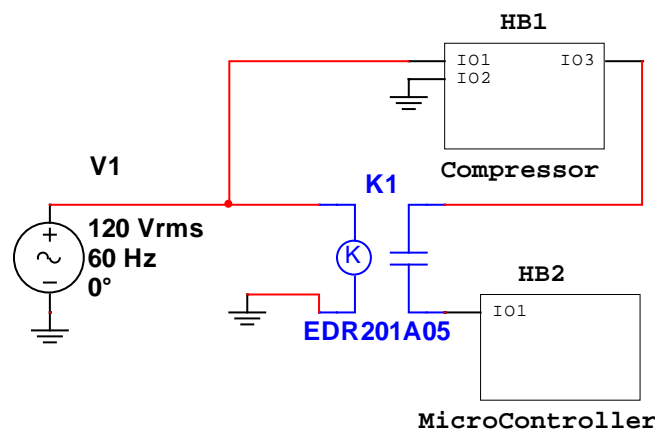


Figure 31: Schematic of the relay

### AC to DC converting

Another way to supply DC from the AC outlet would be to splice the AC cord and wire to an 115V-12V low voltage transformer. This will convert the AC power coming from the wall to the relay to a raw DC power, which will need to power the all the DC components of the design. Since we have three pneumatic control airs solenoid required to control

each of the can crusher, rotating cylinder, and the pneumatic actuator we need to have four 12V transformers feeding off of the relay. Each air solenoid will require 12V of power and 400mA of current in order for them to fully operate. The figure 32 below is a schematic that has been drawn up in Multisim on what we think the final schematic of the AC to DC power supply.

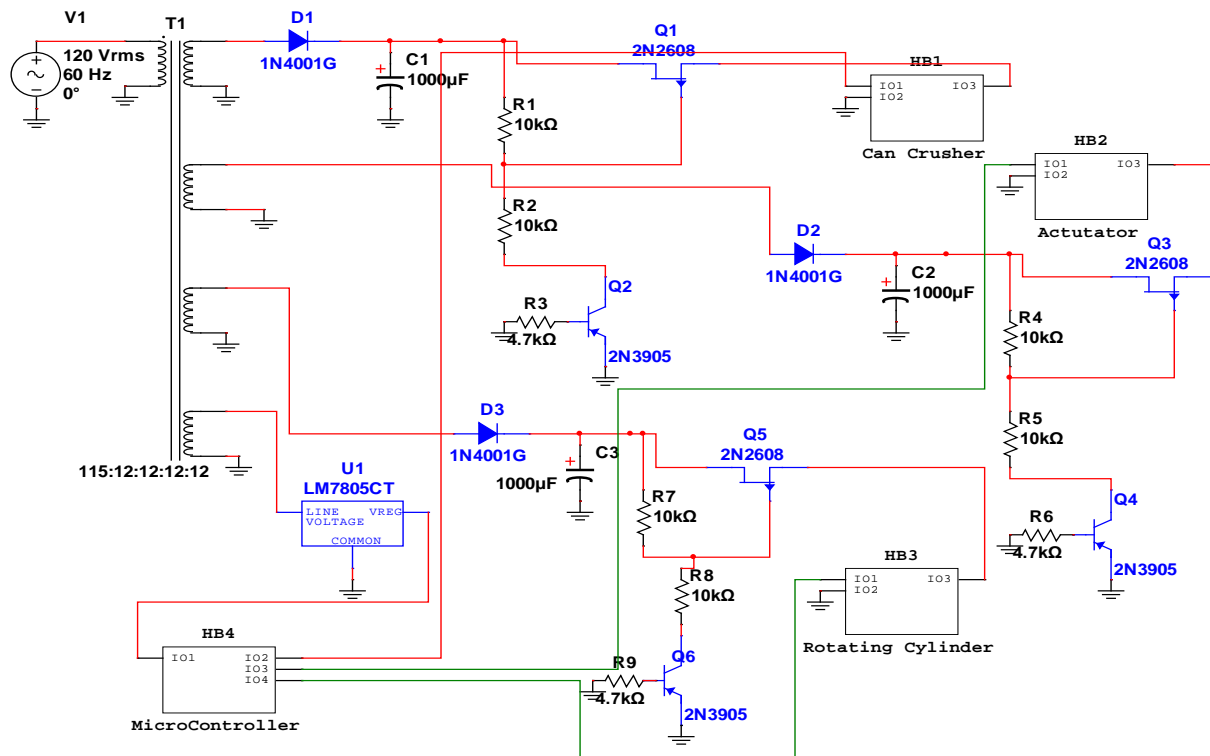


Figure 32: Schematic of AC to DC converting

Once those are wired we need to jump a wire into the wired to 5V voltage regulators (7805) which will convert the raw DC to DC power clean constant 5V, which is needed for the PCB and components. The project should require no more than one regulator to power the DC components. But since we are sure, we will order a couple of extra regulators just in case the project requires more than one. The voltage regulator we use is 5V fixed voltage regulator 7805 is a very common regulator, figure 33, below which has capabilities up to +5V at 1A.



<b>Part number</b>	7805
<b>Company</b>	RadioShack
<b>Price</b>	1.99

Figure 33: Voltage Regulator 7805    Table 17: Information Voltage Regulator 7805

#### **4.1.6. Motor**

For the motor design we chose to go with the air compressor since the can crusher, the rotating cylinder and pneumatic actuator are all operated by compressed air. The air compressor that was choosing is picture in figure 34. 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 34: Air compressor for the project



#### 4.1.7. LED

The LED design layout that we are going with would require the use of five-separated LEDs. The five LEDs would be a green, yellow, red and two blinking red LEDs. Table 18, is a list of LEDs that can be purchased through [www.radioshack.com](http://www.radioshack.com) or pick up in a local RadioShack store in two LEDs per package.

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 18: List of Final LED lights

Our goal for the LED is to have them light up depending on certain input and outputs readings from the microcontroller and sensors. Figure is the LEDs setup that which will be display on the top of the cabinet to indicate to the user the process that project is in.

- Red (Stop)- Will stop when cabinet door is open to empty the storage bin
- Yellow (in Process) –The machine is either crushing or sorting an item
- Green (Ready)- When the hopper is ready to be loaded
- Flashing Red- Will flash red when either one of storage bins are full

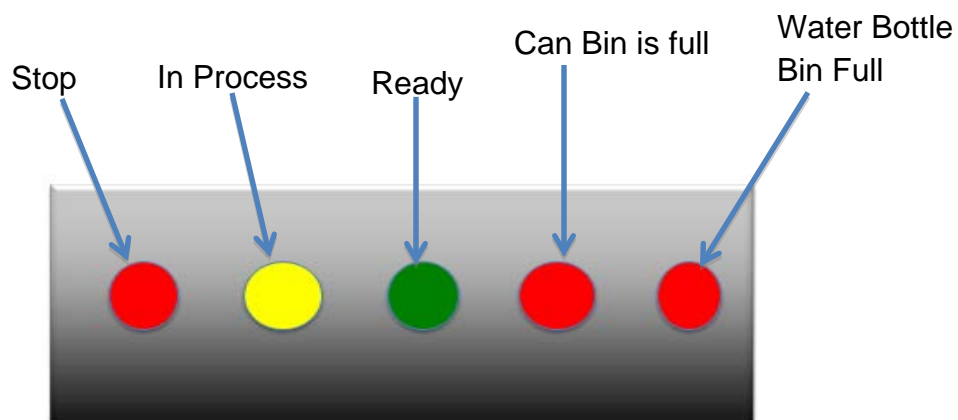


Figure 35: The LED Display

The four figures that are in figure 36, 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.

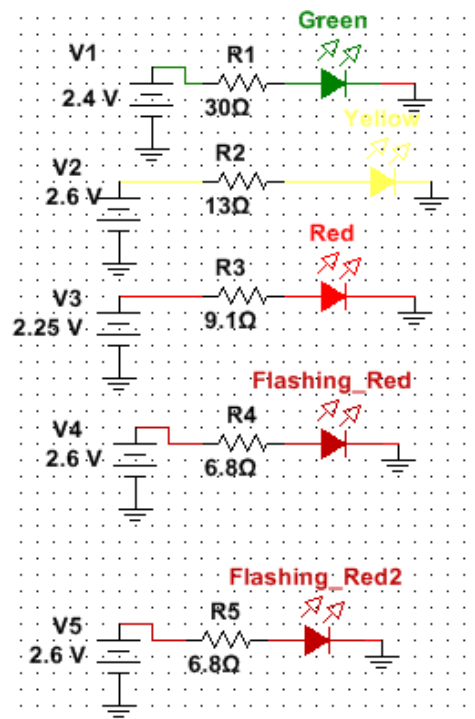


Figure 36: Circuit for each LED

#### **4.1.8. PCB**

The Arduino Uno suggested or paired the ATmega328 microcontroller to use alongside the Arduino Uno. Our project will be using an intricate timing process. We wish to be efficient as well as safe. So we have working parts that trigger other working parts.

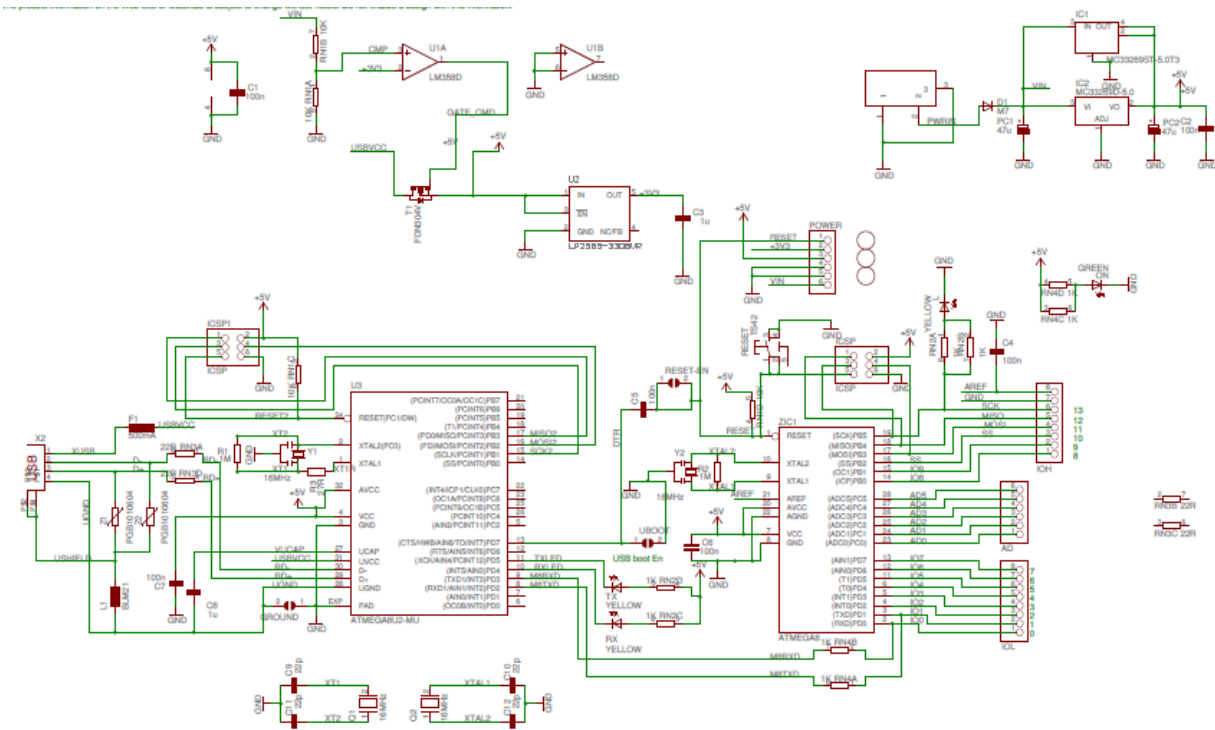


Figure 36: Schematic Arduino Uno  
Permission Requested Arduino

What's significant about the ATmega328 is the Pulse Width Modulation (PWM). One of the purposes of the AVR, a software architecture developed by Atmel, is to allow us to turn outputs off and on. In short, be efficient by controlling/manipulating various aspects of the output. The scenario given by QEEWiki was, what if we want to control how bright and LED was or the speed of a motor? The solution is to change the voltage of the output by connecting and disconnecting the voltage source. The dilemma is it will then be on for a second and then off for a second, which costs time. "But, if we manage to speed this up so that we connect/disconnect the power supply over 1000 times a second we can fool the power supply into thinking that our signal is half the value of the power supply", An alternative solution by QEEWiki [sites.google.com/ site/qeewiki /books/avr-guide /pwm-on-the-atmega328]. This is defined as PWM.

### Calculating the Duty Cycle

$$\text{Duty Cycle} = [\text{ON\_TIME} / (\text{ON\_TIME} + \text{OFF\_TIME})] * 100$$

$$\text{Output Voltage} = \text{Duty Cycle} * \text{Input Voltage}$$

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 38, of the ATmega328. The PWM pins are located to the back left.

(PCINT14/RESET) PC6	1	28	PC5 (ADC5/SCL/PCINT13)
(PCINT16/RXD) PD0	2	27	PC4 (ADC4/SDA/PCINT12)
(PCINT17/TXD) PD1	3	26	PC3 (ADC3/PCINT11)
(PCINT18/INT0) PD2	4	25	PC2 (ADC2/PCINT10)
(PCINT19/OC2B/INT1) PD3	5	24	PC1 (ADC1/PCINT9)
(PCINT20/XCK/T0) PD4	6	23	PC0 (ADC0/PCINT8)
VCC	7	22	GND
GND	8	21	AREF
(PCINT6/XTAL1/TOSC1) PB6	9	20	AVCC
(PCINT7/XTAL2/TOSC2) PB7	10	19	PB5 (SCK/PCINT5)
(PCINT21/OC0B/T1) PD5	11	18	PB4 (MISO/PCINT4)
(PCINT22/OC0A/AIN0) PD6	12	17	PB3 (MOSI/OC2A/PCINT3)
(PCINT23/AIN1) PD7	13	16	PB2 (SS/OC1B/PCINT2)
(PCINT0/CLKO/ICP1) PB0	14	15	PB1 (OC1A/PCINT1)

Figure 37:Microcontoller ATMega328

Permission Granted from Atmel.com

Here shown, in figure 37, are the pins for the Arduino board. On the right side of the board are labeled the digital pins. On the left side of the board are the analog pins and the power. The sensors will be connected to the multiple analog pins. For our power design prototype we used Multisim to see how our circuit would look like but it will be connected to the power portion giving the circuit the consistent operating voltage it will need. Shown below is table 19 of suggested parts paired with the Arduino Uno.



Figure 38:Arduinio Uno

Permission Requested from [Circuits@home.com](http://Circuits@home.com)

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 19: Microcontroller Specifications

We have discussed amongst each other that we will use “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. For beginning users such as our group it seems that Eagle is able to cater to our inexperience. There is other CAD software out there; however, it seems that we will be using Eagle.

The figure 39, is a block diagram on how the components will ideal is connects to the microcontroller.

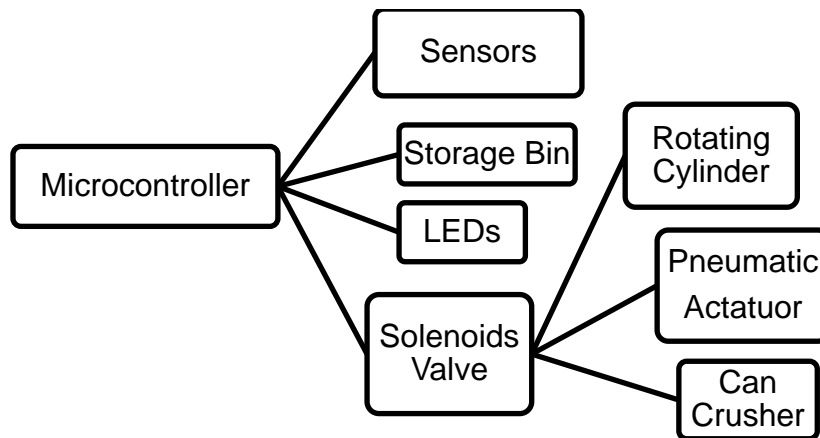


Figure 39: Block Diagram Microcontroller layout

## **4.2. Design Summary**

To summarize the final design of the project as a whole it's an automatic can crusher. 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 16.9 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
<b>Optical Sensor</b>	Detects object	Does not detect object
<b>Ultrasonic Sensor</b>	Detects object	Detects object
	Aluminum Can	Plastic Bottle

Table 20: Truth Table

The next step once the sensors detects if it's plastic or aluminum, the sensors will send a response to the microcontroller. Once the microcontroller has got a response it relays a command to air solenoid that is controlling the pneumatic actuator. The pneumatic actuator will be controlling the ramp door, since the project's 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 automatically 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 mounted to it to detect when either bin is full to capacity. Once either bin is full a LED that we bring 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 placed as the final piece of the box in the front, this way no object comes falling 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 felt that it 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 there will be many trial 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 21, list the different components of the Can Crusher and which team member is responsible for that section.

Component	Team Member
Power Supply	Stanley Andrews
Trashcan/ Cabinet	Stanley Andrews
Can Crush	Stanley Andrews
Storage Bin	Stanley Andrews
Sensors	Brandon Jefferson
Wireless	Brandon Jefferson
Printed Circuit Board	Alex Amoros
LED	Brandon Jefferson
Microcontroller	Alex Amoros
Database	Alex Amoros
User Interface	Alex Amoros
Software Implementation	Alex Amoros

Table 21: List of Components and Responsible Team Members

## **MILESTONE**

Table 22 is a list of milestones we have set for this project. The dates shown in the table 22, 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
<b>Rough Draft of Paper</b>	July 9,2013
<b>Final Paper</b>	August 1, 2013
<b>Begin Building</b>	August 10,2013
<b>Test Phase</b>	September 23, 2013
<b>Complete</b>	November 20,2013

Table 22: Milestones with Goal Dates

The implementation of the project building and testing will take about four months. The table 23, is a new list of milestones.

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

Table 23: 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 4 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 be 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

<b>11</b>	Miscellaneous items(wire, solder and other items)	\$60
	Total	\$1,040

Table 24: Initial Budget

After research the different components the selection process was complete, the new list of the components and budget was compiled in Table 5. The new budget shows the most economical and logical option for the group to pursue 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
<b>1</b>	Air Compressor	\$150	1	\$150
<b>2</b>	Air Powered Pneumatic	\$160	1	\$160
<b>3</b>	Cabinet	Free	1	\$0
<b>4</b>	Storage Bin	\$5	2	\$10
<b>5</b>	Relay (115 V)	\$17.94	1	\$53.82
<b>6</b>	Regulator AC/DC (5V)	\$1.99	5	\$9.95
<b>7</b>	Microcontroller	\$12	1	\$12
<b>8</b>	PCB Board	\$30	1	\$30
<b>9</b>	LED	\$1.99	4	\$7.96
<b>10</b>	Sensors	\$15	4	\$15
<b>11</b>	Miscellaneous items	n/a	n/a	\$100
<b>12</b>	Air Solenoid	\$10.57	3	\$31.71
			Total	\$625.44

Table 25: Final Project Budget

### **Initial Project Budget**

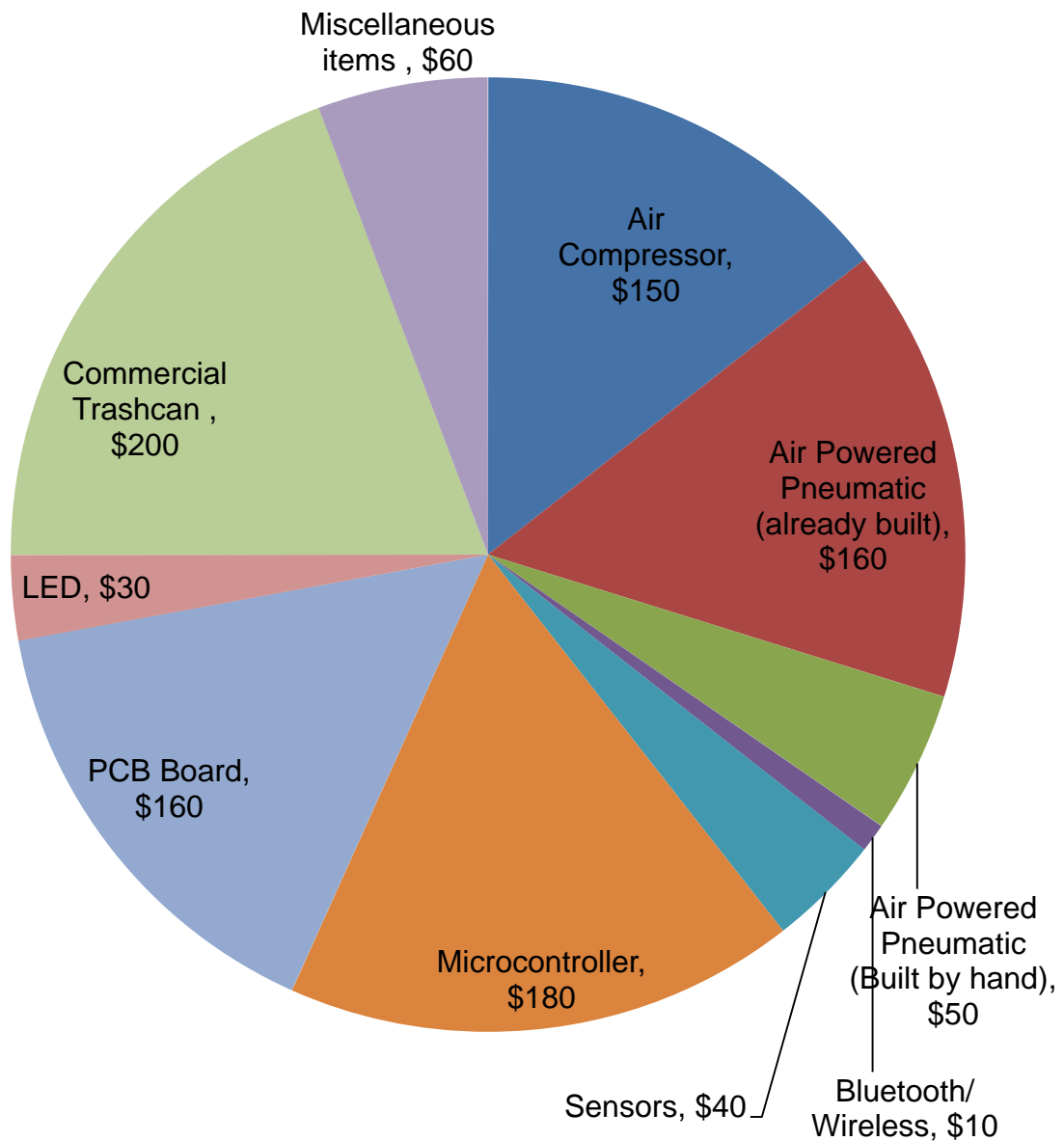


Figure 40: Initial Projected Budget Pie Chart

**Final Budget**



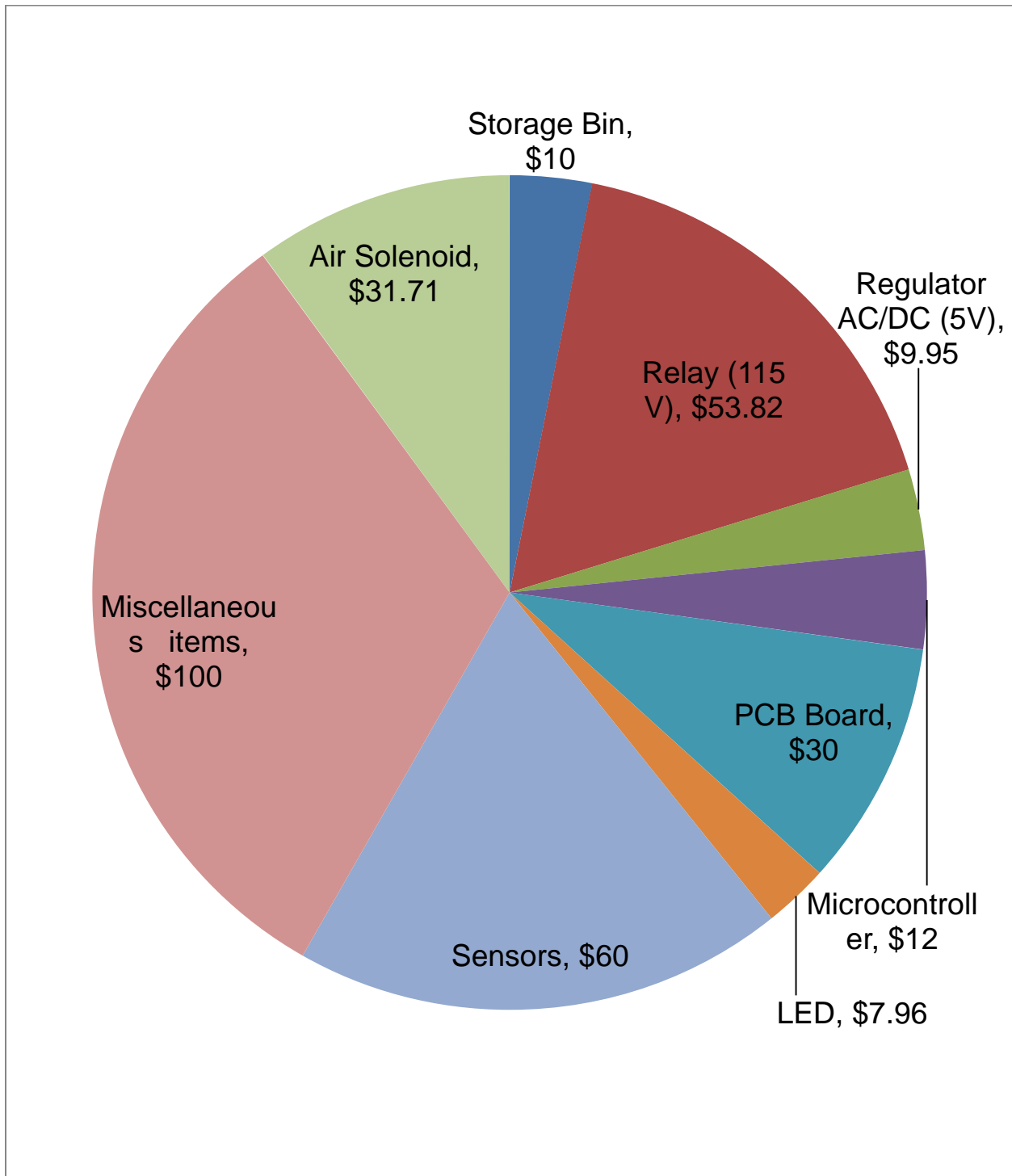



Figure 41: Final Budget Pie Chart

## **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



Department is currently unavailable. Please leave a message.

**Name:**

**Email:**

**Subject:**

**Message:**

Re: [Ticket#2013072510002281] Permission to Copyright pictures



Inbox x



**info@sourcingmap.com** <info@sourcingmap.com>  
to me ▾

Jul 26 (4 days ago)

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](mailto: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](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:**

to whom may concern,  
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 published 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](http://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 outside

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**

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

Jul 24 (7 days ago)



**Mata, Cecilia**

Hello Team, Please find attached email request for permission to use picture ...

Jul 25 (6 days ago)



**Chugh, Paramjyot** <Paramjyot.Chugh@atmel.com>

to Leo, Linda, me ▾

Jul 25 (6 days ago) ☆ ↻

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 is 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 Engineer

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 like 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@digkey.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

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