SMART AUTOMATIC RECYCLING TRASH BASKET

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Abstract

Did you know that Americans use over 100 million steel cans and over 200 million aluminum beverage cans every day? So we brought up this idea to save the time for recycling and to keep the earth green. This report contains the way that how users can easily recycle trash depending on metal or paper by using this trash basket. Smart automatic recycling trash basket will help especially for those who are office worker or students because this is smaller than usual one.

The most attractive thing for this project is that we tried to make this with whole automatic motion movement. First, the main lid of trash basket will act automatically as some object approaches to the motion sensor. Second, the sorting plate will play a role to recycle whether the object is metal or paper. Third, once the trash basket is full, the capacity check LED will warn you to change inner plastic bag.

We hope that readers enjoy this idea by reading with imagination that you are using this trash basket in your place.

Content

1. Introduction

This project is to design a smart automatic recycling trash basket, and it is an interesting solution to an everyday inconvenience that comes from recycling between metal and paper, introducing its practical uses. By using this, we hope that the convenience of a recycling trash basket that helps its user sort materials will encourage more people to recycle. Even, this is one of approach method to keep user's hand clean by not touching lid of trash basket.

1.1 Purpose

The goal of this project is to essentially create a recycling bin that is for students and office workers who usually work or study sitting on the small size of desk, and they do not want to spend some time to recycle steel or plastic cans everyday. Even, because plastic cans waste more space than small paper in trash basket, people need to spend more time to recycle it. This project makes this new solution as affordable as possible to achieve widespread use.

1.2 Advantage

The trash basket must be convenient as it is intended for practical use in everyday life, and some of these conveniences include the following:

1) Being able to sort recyclables automatically
2) Automatic lid for ease of use
3) Warning light indication when a basket is nearly full

1.3 Features

Automatic movement that is pivotal role for the trash basket by sensitive sensor is accomplished through the use of the following features:

1) Motor-operated lid that opens when it detects a nearby object
2) Motor-operated tilting plate that closes off one bin to ensure proper disposal
3) Internal infrared sensors that detect when either bin is getting full
4) Lid-mounted LED display that indicates when one or both baskets are full

1.4 Subprojects

The system consists of main three subprojects, and each performs a specific task. Overall system diagram can be seen from Figure 1.

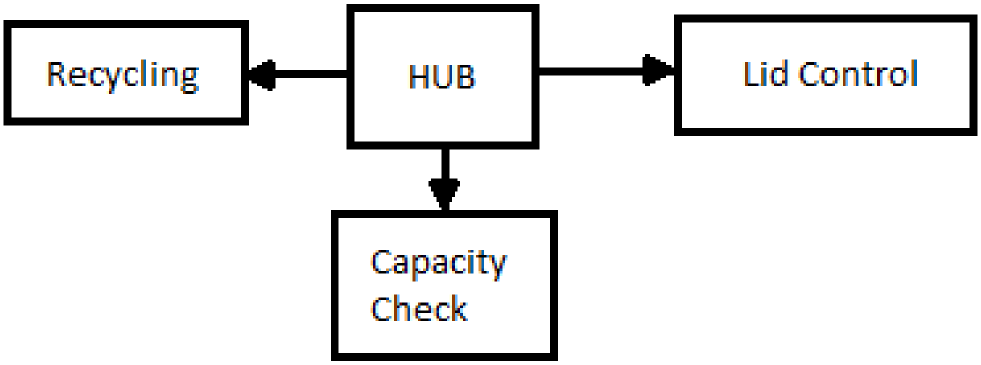


Figure 1 Overall System

The subprojects are described as below:

1.4.1 Motion Sensor

Motion sensor plays an important role in this system since the trash basket will work, as it is intended after main lid opens. Once some object by hand approaches to the main lid, the signal comes from the movement of object will give different voltage value that is connected to the Ultra-sonic sensor. Before move on to little bit complicated explanation, readers need to understand what Ultra-sonic sensor is and why this sensor is good for use in this project. Ultra-sonic sensor provides a very low-cost and easy method of distance measurement. This sensor is perfect for any number of applications that require performing measurements between moving or stationary objects. Basically, Ultra-sonic sensor that is set up in front of main lid has mainly two sub parts that are signal generator and signal receiver. The stable signal with 50 Hz that comes from signal generator meets some object, and the signal bounces back to the signal receiver part. An Ultra-sonic proximity sensor uses a piezoelectric transducer to send and detect sound waves. In other word, Transducer generates high frequency sound waves and evaluates the echo by the detector that is received back after reflecting off the target. Sensors calculate the time interval between sending the signal and receiving the echo to determine the distance to the target. This explanation will be easily understood by looking at Figure 2.

Figure 2

There are couples of advantages when Ultrasonic sensor is used. First, no physical contact with the object to be detected is needed, resulting no friction and wear. Second, there are unlimited operating cycles since there is no mechanical contact with the target. Third, Ultra-sonic sensor is not affected by target material or atmospheric dust, snow, rain in the air. Lastly, sensing distance is farther away compared to inductive or capacitive proximity sensors. However the fact that the sensor has a blind zone of several millimeters in front of it would be on of defect when it is used.

1.4.2 Metal Detector

This project has a sorting plate to recycle depending on trash whether it is metal or paper. To distinguish between them, metal detector (sensor) will be most efficient way giving a signal to micro controller. Since the sizes of trash people use are different, metal detection is needed to be accurate regardless of any size of metal. Metal detector is designed for metallic body detection by sensing the variations in high Eddy current losses. Using an externally tuned circuit, device acts as an oscillator. An approaching metallic object changes the output signal level. Output signal is determined by supply current changes. Independent of supply voltage, this current is high or low according to the presence or the absence of a close metallic object. The important thing is that the low or high signal should be enough to get desired value for micro controller. There is one LED that offers a visual indication of presence or absence of a metal around the coil. The coil has variety values based on how much the trash basket can detect metal, and this coil is attached to the upper part of trash basket with electronic tape. To adjust the circuit it is required to make sure there is no metal near the coil and set the fine adjustment to a “Mid position”.

1.4.3 Capacity Check LED

This trash basket has capacity check function to alert users when the trash basket is full. The Infra red LED sensor communicates with Diode, and if bins reach the horizontal “Full” level and start block the light, and any one of the diode is off, it turned the NOR gate On to light up the corresponding LED and also sent to “Full” signal back to micro controller.

2. Design

2.1 General Design Alternatives

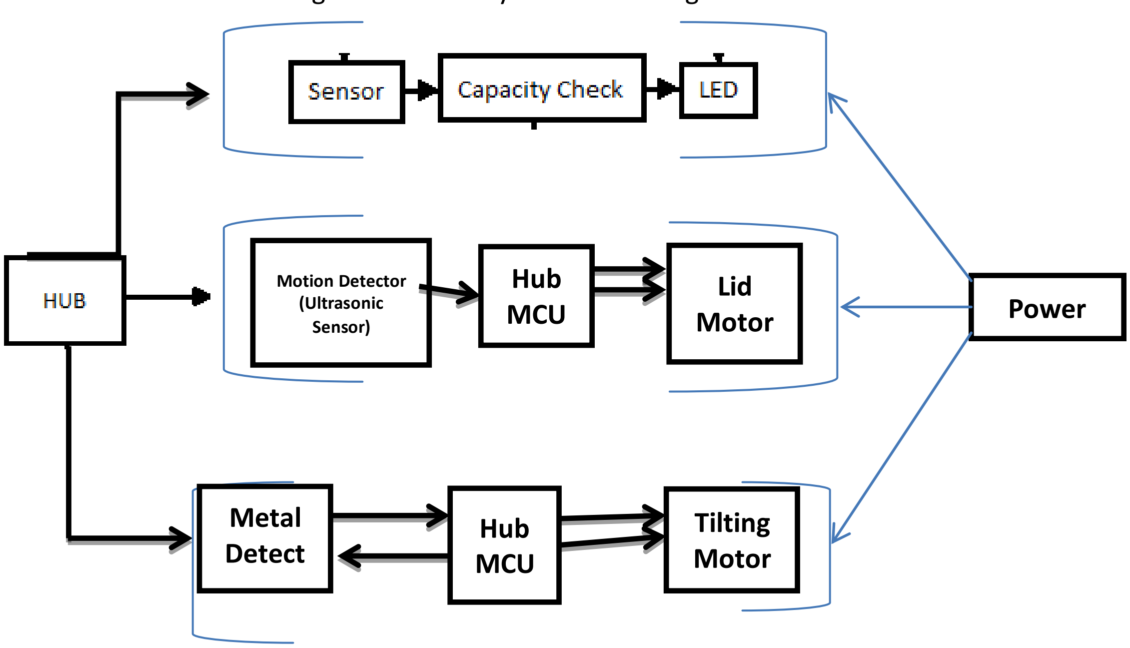
There were some things to consider with respect to the design of the device. First, some additional internal space has to be occupied from trash basket for setting up sorting equipment. Then, two separate trash bins with sensors to check available capacity are necessary to equip in the rest space due to the purposes of sorting and space alert. Initially, the design included a dual-directional gate circuit to drive the dc motors, the intended design was altered since microcontroller applied was able to create PWM by programing the performance of digital outputs, it eliminated our need to bi-directional drive system and replace the dc motors with servo motors which can be controlled by PWM. At the beginning of the software design phase the ATmega 128 seemed like a proper microcontroller fit for the application at hand. It was initially thought that the Uno had various type of outputs includes timer function that satisfies all the system needs. It became simpler though Arduino UNO was enough for the project due to small amount of I/O pins as well as memory is going to be used.

2.2 design procedure

The over system diagram below describes the various blocks of the automatic recycling trash basket and their relationships to each other. Three separate sensors detect if an object is present, the type of object to be recycled, and whether the basket is full or not. The capacity check circuitry will activate the LED display when full.

As for the functionality of the basket itself, the basket lid and the tilting plate are operated by motors, and as such are only activated when their control circuitry indicates to do so. The interaction between the two control circuits allows for a set amount of time that the basket lid is open.

Figure 3 Overall system Block Diagram



2.2.1 Motion Detector

The Obstacle detection sensor circuit are divided into two function parts as Ultrasonic Generator and Ultrasonic Receiver with processer. It works through two ultrasonic set at 40 KHz central frequency to detect any conspicuous objects blocked within certain distance. And proceed the signal of presence/absence into analogue output High/Low and turn on RED LED in the meantime as a visual symbol. The generator keep sending the detecting signal to the front area of the smart trash basket, while the receiver is getting reflected signal from object ahead of basket.

2.2.2 Tilting Motor/Lid Motor

The servo motors use for tilting plate is the same model used for Lid, they can be either powered with 6 V DC supplies or battery, each one requires one output pin from MCU as the third input (yellow wire) to be used to drive the motors with 3 different signals relates to 3 motion position in total.

2.2.3 Metal Detector

The metal detector circuit was designed base on monolithic integrated TDA0161, and developed to detect any common metallic bodiess in a very short detecting distance. Output signal level is altered by an approaching metallic object.

2.2.4 Capacity Check

The sensors working in the capacity checking are consists of infrared LEDs and photodiodes. Each LED is work in pair with one photodiode, every photodiode is going to detect one of the infrared LED in horizontal. If bins fill in full with trash, the circuit will proceed the changing from sensors into digital output, and light up the LED for the correspond bin.

2.2.5 HUB MCU

The microcontroller unit relays signals between the various parts of the waste basket and determines when each sensor and motor is turned on based on the current state. It has a complete loop prepare with Corresponding results to motors for all combination of inputs value at all times.

2.3 Design Details

2.3.1 Motion Detector

The purpose of the generator is to keep sending the detecting signal to the front area of the smart trash basket. If any significant object(like human body) stand ahead, the sound wave will reflect back by hit the object and back. The backing signal will received by the Ultrasonic Receiver.

2.3.1.1 Sensor Generator

From the schematic plot in Figure 11, *Appendix B*, The generator part based on the 555 IC timer with variable resistor(Rvar_1) to control the output signal to change the generating distance of the Transducer, at 40KHz frequency (determined by R_{var_1} and C_1).

LM555CN IC TIMER

• Timing from Microseconds to Hours

• Adjustable Duty Cycle

• Astable or Monostable Operation

• TTL-Compatible Output Can Sink or Source up to 200 mA

Table 1 LM555CN Function Table

RESET	TRIGGER VOLTAGE(1)	THRESHOLD VOLTAGE(1)	OUTPUT	DISCHARGE SWITCH
Low	Irrelevant	Irrelevant	Low	On
High	<1/3 V_{CC}	Irrelevant	High	Off
High	>1/3 V_{CC}	>2/3 V_{CC}	Low	On
High	>1/3 V_{CC}	<2/3 V_{CC}	As previously established	

(1) Voltage levels shown are nominal.

These devices are precision timing circuits capable of producing accurate time delays or oscillation. In the astable mode of operation, the frequency and duty cycle can be controlled independently with two external resistors(consists of Rvar_1) and a single external capacitor (C1). With a 5-V supply, output levels are compatible with TTL inputs.

The threshold and trigger levels normally are two-thirds and one-third, respectively, of VCC. These levels can be altered by use of the control-voltage terminal. When the trigger input falls below the trigger level, the flip-flop is set, and the output goes high. If the trigger input is above the trigger level and the threshold input is above the threshold level, the flip-flop is reset and the output is low. The reset (RESET) input can override all other inputs and can be used to initiate a new timing cycle. When RESET goes low, the flip-flop is reset, and the output goes low.

As shown from schematic, trigger (pin 2) and threshold (pin 6) pins that share a common node. Hence the capacitor is charged through R_1 and R_2, and discharged only through R_2, since pin 7 has low impedance to ground during output low intervals of the cycle, therefore discharging the capacitor. Ctrl Node(pin 5) will not be used in the performance and is connect through 0.1uF C_2 to the GND.

Under this operation, the frequency of the pulse stream depends on the values of R_1, R_2 and C:

$$f = \frac{1}{\ln(2) \cdot C_1 \cdot (R_{var_1} + 10\text{K}\Omega)}$$

The high time from each pulse is given by:

$$T_{high} = \ln(2) \cdot (R_{var_1} + 10\text{K}\Omega) \cdot C_1$$

and the low time from each pulse is given by:

$$T_{low} = \ln(2) \cdot 10K\Omega \cdot C_1$$

2.3.1.2 Sensor Receiver

As the ultrasonic detection signal hit the Obstacle back, if any change happened in the feedback of sound, the transducer (UTR2) will represent the signal into levels of voltage as the input to the amplifier U1 by pin 3 in Figure 12, *Appendix B*. This feedback voltage is varies in mV based on the distance of the block object caused the reflecting ultrasonic signal.

The pin2 is used as V_2 from the step down output(V_1) by R_3 & R_4. The first amplifier U1 of LM358N is design as signal booster for input, and the change in voltage signal made by UTR to the pin3 will output a Changing signal to U2. Pin1 the set up through another variable resistor and the adjust value is the determination of the max detection distance of sensor system. U2 is design as comparator to let boosted input voltage match with V_{ref} and given corresponding output to drive the BJT.

$$V_1 = V_3(\text{input})\ \text{x}\ \left(1 + \frac{R_3}{R_4}\right) = 221V_3$$

$$V_7\ (output) = (V5 - V6) * G_{open\_circuit}$$

Regardless of the value of the V_1 because the output of LM358n is need either in High or Low (in case of $V_5 < V_6$, output will be 0), once in HIGH, BJT will be ON and node at <input_2>

will be high.

2.3.2 Tilting Motor/Lid Motor

It can been seen from figure 14, *Appendix B*, there are three inputs on the HS-311 motor with 2 inputs (red/black) connected to the power supply of 6V (in design testing 6V DC power was applied instead of using batteries). One input left (yellow) is the control signal that should drive by HUB MCU.

HS-311 Servo Motor

Control System:	+Pulse Width Control 1500usec Neutral
Required Pulse:	3-5 Volt Peak to Peak Square Wave
Operating Voltage:	6.0 Volts
Operating Temperature Range:	-20 to +60 Degree C
Operating Speed (6.0V):	**0.15sec/60° at no load**
Stall Torque (6.0V):	**51 oz/in (3.7 kg/cm)**
Current Drain (6.0V):	7.7 mA/idle, 180mA no load operating
Dead Band Width:	5 usec
Operating Angle:	45° one side pulse traveling 450usec
Direction:	Multi-directional

The Arduino UNO drives these motors through its digital pin 12 & 13 by program the outputs between high and low to simulate PWM in different duty cycle.

2.3.3 Metal Detector

These monolithic integrated circuits in Figure15, *Appendix B* is design for metallic objects detection by detecting the variations in high frequency Eddy current losses. With an external tuned circuit they act as oscillators. Output signal is determined by supply current changes. Independent of supply voltage, this current is high or low according to the presence or the absence of a close metallic object.

Table 2 TDA0161 PIN Connection

Node Name in internal reference At Figure * *Appendix B*	Corresponding Pin Number
Vcc^+	1
Adjustment	2
Detector Hot Point / A	3
Adjustment	4
Filtering	5
Output	6
Detector/ E	7

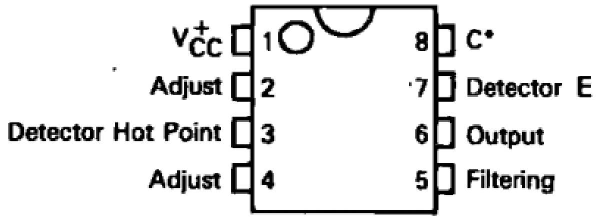


Figure 4 Pin Layout

OPERATING MODE

According to the internal reference of TDA0161 schematic diagram in Figure 16, *Appendix B,* between terminals A and E, the integrated circuit acts like a negative resistance equal to the external resistor R1 connected between terminals B and H. The oscillation stops when loss resistance Rp of tuned circuit becomes smaller than R1. Then, the supply current will be I_{CC} = 10 mA (pins G and D). The oscillation sustains when loss resistance Rp of tuned circuit becomes higher than R1. Then, the supply current will be ICC 1 mA (pins G and D).

Table 3 Typical Application Values

Detection Range (*)	L1 (μH)	C1 (pF)	f_{osc} (kHz)	R1 (kΩ)	C2 pF
2mm	30 (1)	120	2650	6.8	47
5mm	300 (2)	470	425	27	470
10mm	2160 (3)	4700	50	27	3300

(*) Ingot steel target

Actual value of C1 R1 C2 will been adjusted depends on the value of inductor L1 made to satisfies the size of basket.

2.3.4 Capacity Check

With schematic shown in Figure17, *Appendix B,* there are two lines of IR LEDs and IR sensors applied into circuit for checking capacity of two separate bins (paper and metal), each line contains 5 of IR LEDs in parallel or Sensors in series, which will transformed into PCB bars for final set up on basket. The bar of LEDs and the bar of sensors should be placed face to face in the same level at the top area of each trash bin, so when bin is full and starts to block IR light signal goes into sensor to cause a significant drop of voltage at V1/V2. V1/V2 will be compared with the reference voltage stands for end side value of the sensors' line when nothing blocks the IR light. After that the digital output from comparator LM393 perform High/Low signals base on the compare result, and finally drive LEDs ON through NOR gates

2.3.5 HUB MCU.

The microcontroller unit (Arduino UNO) relays signals between the various parts of the waste basket and determines when each sensor and motor is turned on based on the current state. As working exactly follow the flow chat Figure 18 in *Appendix B*, when the waste basket is initially powered on, the microcontroller regards all of its outputs to zero and sits in a standby state. The microcontroller does not turn on the external LED display. That is handled by the internal sensor circuitry. PWM, is a technique for getting analog results with digital means we going to use for control the servo motors. Digital control is used to create a square wave, a signal switched between on and off. This on-off pattern can simulate voltages in between full on (5 Volts) and off (0 Volts) by changing the portion of the time the signal spends on versus the time that the signal spends off. The duration/percentage of "on time" is called the pulse width/duty cycle.

The ultrasonic sensor continually scans the area in front of it for an object until it finds one. Once it does, it relays this to the microcontroller through Analogue A0, which sets pin 13 acting as PWN, opening the lid in the process. After a set time delay, pin 13 is zeroed out, halting the motion of the lid. A timer program within the microcontroller is start during a window of time during which an object may be placed in the waste basket. After timing for delay, it will close the lid and read the output of the metal detector (analogue A1) to determine the composition of the material. Note that "metal on" is merely used as internal signals in the Arduino UNO for the sake of keeping track of states.

After determining if the material is metal or paper, the microcontroller sets the tilting motor to turn the plate in the appropriate direction while turning off the metal detector. As the "metal" signal is a product of the metal detector, a dummy variable known as "paper" is used to simplify the states in the upcoming process. Regardless of the material, the motor is stopped after a brief delay, and then held at its tilted angle for three seconds to allow for the material to fall into the bin. After this delay, the microcontroller uses the Paper signal to correctly tilt the plate back to its original position, where it then stops moving. This returns the microcontroller to its standby state, and the process repeats.

Expected PWN signals from Arduino UNO:

Table 4 PIN 13 PWM

Command	Signal(example)
Open(80^o)	50Hz, Positive Pulse, 10% Duty Cycle
Hold	Keep 80^o signal
Close	50Hz, Positive Pulse, 5% Duty Cycle

Table 5 PIN 12 PWM

Duty Cycle @ 50 Hz, 5 V pk to pk	Corresponding Angle
1%	0^o
7%	≈95^o
13%	180^o

3. Design Verification

The original requirements and verification procedures are shown in Appendix A. However, a new requirements and verification table had to be made to incorporate the hurdles in the design, which is also shown in Appendix A. All of the changes were made to the module requirements; the verification procedures remained the same. The changes made did not affect the overall requirement of the system much, but were necessary based upon the actual components performed in most stable way.

3.1 Testing

The test procedures and results for all of the modules in the system are shown below. For a complete explanation of the requirements and verification procedures for each module, refer to *Appendix A*.

3.1.1 Motion Detector

3.1.1.1 Signal Generator

The inputs of this circuit is supplied by Vcc, to get the 40 Khz oscillating square wave, adjusting the R_{var_1} to the corresponding value(8.03KΩ) and measure the output from oscillator and compare the result with calculated value from equation.

Set up V_{cc} = 5V the initial output frequency is about 46KHz which is not matched 40Khz from calculation. By adjust the variable resistor forward up to 9.84KΩ, finally the frequency falls to 40KHz as wanted.

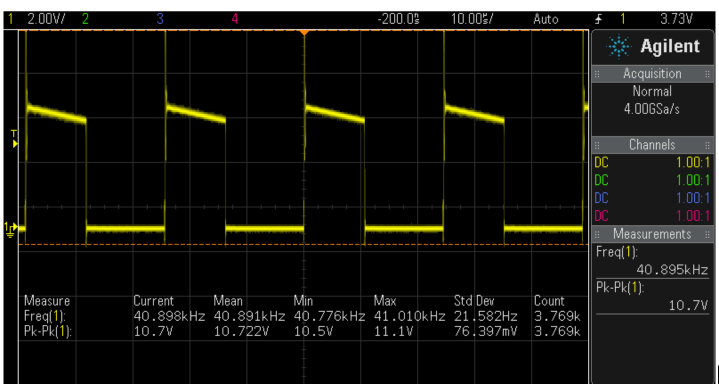


Figure 5 US1 testing signal

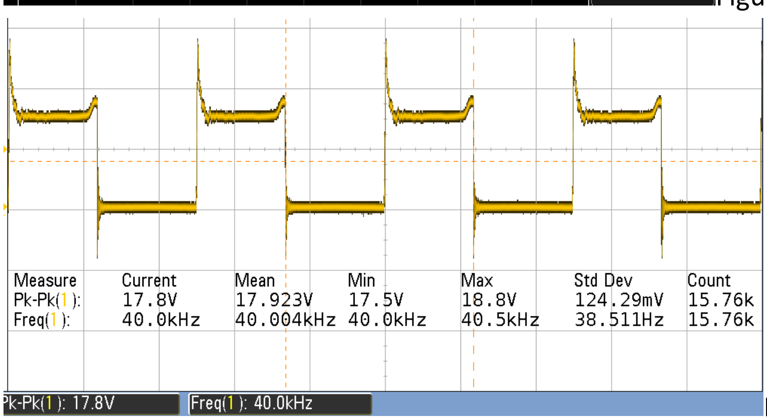


Figure 6 US1 PCB signal

After PCB soldering, there is slightly change on the signal with less peak ripple but longer distortion. Which is caused by the ultrasonic connected to the output pin3 of the timer, it has 2000 pF self-capacitance that's why the peak ripple has been absorbed and extended. And the peak-peak voltage is also changed due to 9V DC supply instead using 5V.

3.1.1.2 Signal Receiver

The input of this circuit is come from transducer, using Vdc generator in design lab to replace function of transducer in circuit testing. Consider about high gain that applied in the circuit, the outputs of U1&U2 will easily reach its max value when given input in 0.01-0.02V, start testing Vin from 0.001V to 0.1V and see the variation in output of U1 and U2; compare the result gain measured of U1 with calculated value 221.

To ensure the performance of logic signal at the end side, insert LED at node of <input_2>. So LED On = "1", and OFF = "0".

Actual Components applied:

R2 = 17.89 KΩ, R3 = 2.212 MΩ, R4 = 9.94 KΩ, R5 = 0.992 KΩ, C3 = 0.1 uF, R6 = 9.97 KΩ, $R_{var\_2(total)}$ = 10 KΩ
Then get real Gain = 223.5

Table 6 Test on U1

V3(V)	V1(V)	Gain	V3(V)	V1(V)	Gain
0.001	0.397	397	0.03	3.803	126.8
0.002	0.582	291	0.04	3.803	95.1
0.005	1.249	249.8	0.05	3.803	76.06
0.008	1.976	247	0.08	3.803	47.5
0.01	2.400	240	0.1	3.803	38.03
0.015	3.548	236.5			
0.02	3.803	190.15			

Set Reference voltage V6 at 2.215V by adjust the R_{var_2} value. Start test V5 from 2.215V to 2.4V and measure the output V7, get $G_{open\_circuit}$

Table 7 Test on U2

V5(V)	ΔV(V)	Output V7(V)	$Gain_{os}$
2.215	0	0.011	N/A
2.216	0.001	0.149	149
2.218	0.003	0.577	192.3
2.219	0.004	1.493	373.3
2.220	0.005	2.658	531.6
2.225	0.01	3.972	397.2
2.24	0.025	3.974	159
2.4	0.185	3.974	21.5

Input Signal from ultrasonic set when:

Figure 7 Nothing Detect

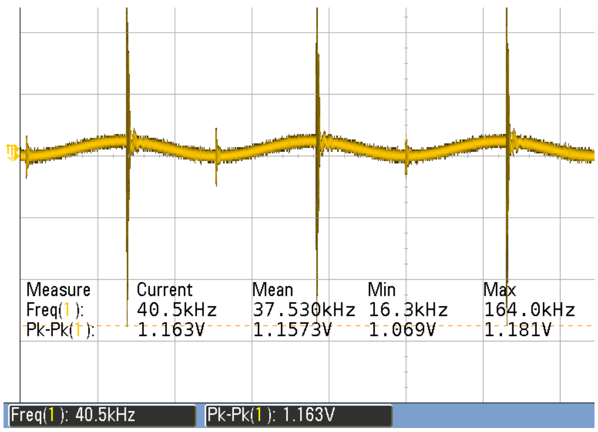
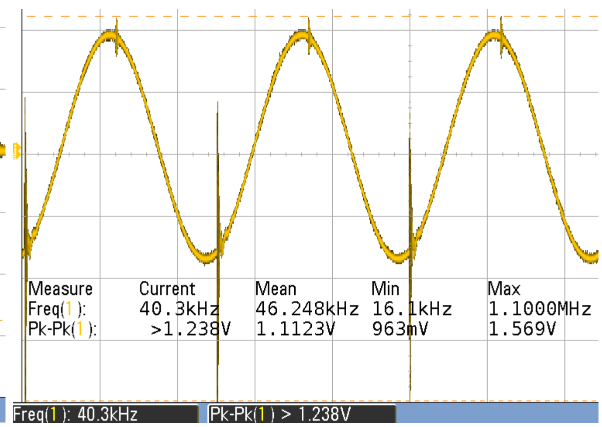


Figure 8 Object Founded



3.1.2 Tilting Motor/Lid Motor

Testing will require multiple benchmarks to be reached. Desired turning angle is about 80 degrees, which must be accounted for in the placement of objects beneath the plates. Testing will revolve around adjusting turning speed and PWM siganl to match the angle set in the tilting plate requirements

Table 8 ACTUAL PWM USED:

LID **Tilting**

Open	10% Duty Cycle @50Hz	Left	35% Duty Cycle @ 500Hz
Close	4% Duty Cycle @50Hz	Middle	67.5% Duty Cycle @ 500Hz
		Right	96.5% Duty Cycle @ 500 Hz

3.1.3 Metal Detector

The signal inside the core varies sensitive as metallic body approach to the core closely as required from 2.3.3. The metal detector's range only cover the tilting plate so won't receive interference from outside sources.

Siganl in L1:

Figure 9 Normal state

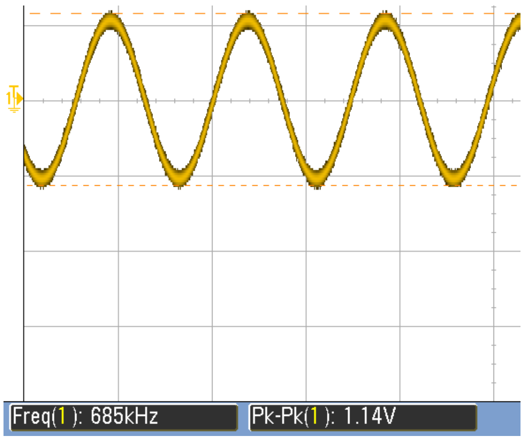
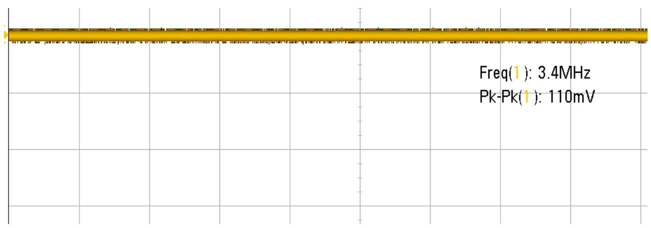


Figure 10 Metal Approached



Please check Appendix C for further testing results of size of detectable metallic bodies.

3.1.4 HUB MCU

Testing primarily concerned minimizing signal propagation delay and adjusting intentional delays between signal transmission to match the desired time delays (i.e. between detecting an object and activating the metal detector). According to the two different frequency of PWM used for two motors, different programming has applied to ensure the accuracy of Duty Cycle.

Table 9 PWM Program

4% Duty Cycle @50Hz	Float dutycycle = 0.04; Digitalwrite(PIN 13, LOW); Delay(20*(1-dutycycle)); Digitalwrite(PIN 13, HIGH); Delay(20*dutycycle)
10% Duty Cycle @50Hz	Float duty cycle = 0.1; As above

35% Duty Cycle @ 500Hz	Digitalwrite(PIN 12, HIGH);
	delayMicroseconds(700);
	Digitalwrite(PIN 12, LOW);
	delayMicroseconds(2000-700);

67.5% Duty Cycle @ 500Hz	delayMicroseconds(1480);
96.5% Duty Cycle @ 500 Hz	delayMicroseconds(1930);

4. Costs

4.1 Parts

The costs mainly came from buying the body of trash basket, TDA 0161 metal detector sensor, and ultra-sonic sensor. Except for those components, using components from electronic shop makes the trash basket. Specific information for each cost of component can be look up from Table X.

Table X Parts Costs

Part	Manufacturer	Retail Cost ($)	Quantity	Actual Cost ($)
NE556N	FAIRCHILD	$0.40	2	$0
Resistors	10K(7), 1K(7), 5K(5) 120(1), 2.2M(1), 500(1)	$1.10	22	$0
LM358	NATIONAL	$0.64	2	$0.64
XDR-24	All Electronics	$2.50	2	$0
Capacitor	1.5nF, 0.1uF(2), 10nF(2)	$0.25	5	$0
Trash Basket	JANIBELL	$43.00	1	$43.00
Tilt-able Plate	Self-Made	$5.00	1	$5.00
HS-311	BPHOBBIES.COM	$15.10	2	$0
2N2222A	STMICROELECTRONICS	$0.45	3	$0
2N2905A	MULTICOMP	$1.74	3	$0
VTP1188SH	EG&G	$21.4	10	$0
ILED-8	All Electronics Corp	$2.6	10	$0
HLMP3301	AVAGO TECHNOLOGIES	$0.15	1	$0
HLMP3507	AVAGO TECHNOLOGIES	$0.15	1	$0
SN74AHCT02N	TEXAS INSTRUMENTS	$1.00	2	$0
TDA 0161	STMicroelectronics	$27.60	2	$27.60
Ultra Sonic sensor	PING COMPANY	$26.99	1	$26.99
Total		$150.07		$103.23

4.2 Labor

Total labor cost = Hourly Rate x 2.5 x Total Hours invested

By using a rate of $20.00 and estimated length of 200 hours each, the total is

Total = $20.00 x 2.5 x 200 x 2

= $20,000.00

5. Conclusion

5.1 Accomplishments

All the parts such as automatic main lid, sorting plate, and capacity check are successfully conducted and the system works perfectly as desired. Even though our team 31 lost one of partner during this project, we realized that we could finish all the things for this project. By using this, users do not need to open by hand that helps keep hands clean, and the trash basket can sort metal or aluminum cans can recycle either way to different bins. On top of that, once the trash basket is full, the LED alerts users to change or refresh the bins right away. We are able to achieve our goal by asking engineer staffs who works in electronic shop. They were incredibly helpful. As the slogan “He can do. She can do. Why not me”, we recognized our potential through this project, and this experience will give a lot of motivation for the entire life.

5.2 Uncertainties

The trash basket used 3 different voltage supplies to give power for main lid, sorting plate, and capacity check. Especially, main lid and sorting plate has different adjustable frequency value by varying variable resistor, and these different values depend on the power supplies. Even though our team tried to use one battery, but it did not make the circuit stable.

5.3 Ethical considerations (IEEE codes for Electrical Engineering)

Ethics is a set of moral principles or values to govern the conduct of an individual belonging to a group or profession on the basis of honesty, fairness, and justice. (IEEE) Electrical engineers must take caution in releasing new products to the public as well as in the technology that they themselves use, in order to ensure that no one will be hurt by the use of this technology. Here are several codes of ethic that are needed.

First, accepting responsibility in making decisions consistent with the safety, health, and welfare of the public and to disclose promptly factors that might endanger the public or the environment.

The goal of this project is to make a smart automatic recycling trash basket. As it is intended for commercial use, the price is an important factor. To account for that, each component that is not expensive as well as efficient is used. Also, since the trash basket is used batteries for power, the batteries also need to be safe, efficient, and have a long lifetime. Using a standby time when the trash basket is not in use, batteries last longer than just keep on it all day.

Second, to improve the understanding of technology, its appropriate application, potential consequences should be considered. This project utilizes several complex parts, which will require rigorous testing to successfully implement. The design combines electrical and mechanical parts to accomplish a task that could not be done as easily by only using one or the other.

Third, to seek, accept, and offer honest criticism of technical work, to acknowledge and correct errors, and to credit properly the contributions of others, we fulfill this requirement of the IEEE code by getting feedback and criticism through the peer review and design review and presentations. We need to mention any used information to give proper credit. Also, team members will give each other constructive criticism along the way to ultimately improve the finished product.

5.4 Future work

This project can be further developed to make it more recycling for a lot of different trash type by adding more type of sensor to detect different type of materials, having more bins to recycle will make user friendly. On top of that, by using waterproof setting on the all sensors, the trash basket will resist from any liquid trash from cans. The trash basket should not be very expensive to buy, so using more efficient sensor can do this, not just cheap and low efficiency. Team 31 is very glad to finish this project well despite of hardship during this semester.

6. Reference

[1] Texas Instruments, “PRECISION TIMERS”, NE555 datasheet, SEP 1973 - REVISED JUN 2010;

[2] Jameco Electronics, “STANDARD SERVO”, HS-311 datasheet, Apr 2002

[3] SGS-THOMSON Microelectronics, “PROXIMITY DETECTORS”, TD0161 datasheet, Apr 1993

[4] ZX-METAL. “The metal detector module”, metal dectector module documentation, 2009

[5] PerkinElmer Optoelectronics, “VTP Process Photodiodes”, VTP1188SH Datasheet

[6] futurlec, “Infrared Detector 940nm 5mm Round LED”, Dimension Drawing, [Online] at: http://www.futurlec.com/LED/INFD5940.shtml

[7] Institute of Electrical and Electronics Engineers, Inc. (2012, September 10) IEEE Policies, Section 7

[Online]at: http://www.ieee.org/about/corporate/governance/p7-8.html

7. Appendix A Requirement and Verification Table

Table 10: Final System Requirements and Verifications

Module	Requirement	Verification	Verification Status(Y/N)
Motion Detector	1. Receive the sensor signal by programmable chip and transfer command signal to Motor to start mechanical motion(Open) 2. Stop proceed action signal to motor for certain seconds 3. Send second command to motor to achieve the CLOSE action 4. Proceed another signal to active Detection Controller 5. Wait until receive feedback signal from detection controller to start new cycle again. 6. If there is a signal from capacity monitor, turn to STOP status and let the lid closing until the signal is disappears	Test the coded chip with standard inputs(1/0) to different pins and measure the corresponding out pins result by oscillator equipment in school lab Use stop watch to check the waiting periods Set opening time to 3s That T(open) = Tm+Tw = 4s; Tm = time motor takes to complete the action on lid, set Tm ⩽ 0.75s by control the speed of motor Tw = time the controller wait for the trash to be thrown in. While T(close) = Tm	Y
Recycling Control	1.Start a operation cycle after the signal from Lid controller 2.Actions depends on the sensor inside the basket, if nothing has detected, call END signal back to Lid controller; if anything detected, active	Test the chip with 1/0 inputs to pins to simulate all the state situations and check the correctness of responded outputs. Check certain waiting period between two states with stopwatch. T(open) = Tm T(close) = Tm	Y

	metal detector. 3.Detector find metal, proceed to motor to open metal bin(tilt the plate to metal side) 4.Detector didn't find, proceed to motor to open paper bin(tilt the plate to paper side) 5.Wait certain seconds(T[open]) to let OPEN action done 6.Call motor to close the bin, and send END signal back to Lid controller when the bin closed.	Set Tm ⩽ 0.75s by control the speed of motor Plate is fixed in horizontal before motor start by controller. It need to be strong enough to hold heavy metal trash. Test with maximum load of 5kg to decide the materials & structure of the plate and its holder. Plate should tilts over 60^0 to open big enough and let larger pieces drop in bins	
Plate motor	1. Able to receive two different signals from controller and response in opposite movement 2. Need to be drive by DC source like batteries.	Motor Condition synchronous servo motor Vdc = 1.5-4.5V(drived by 1-3 batteries) Higher Efficiency: Higher speed to reduce Tm with less power consumed	Y
Lid motor	1. Able to receive two different signals from controller and response in	Motor Condition synchronous servo motor Vdc = 5V(drived by dc supply) Higher Efficiency: Higher speed to reduce Tm with less power consumed	Y

	opposite movement 2. Need to be drive by DC source like batteries.		
Front Sensor	1. It need to detect presence of objects in front of the wastebasket within 50 cm.	Sensor Condition: Ultrasonic Stable operation and lower failure rate, tests form in different testing distance and content sizes Less Reaction time: T ≤ 0.5s	Y
Capacity Sensors	1. 2 detector should focus on the available capacity in each sub-basket, and give a signal back to the circuit if they are full.	Use one like lid sensor but has less detection distance within 2cm Place the sensor on top of the bins and detect anything pile up to the top	Y
Oscillator	1. Be able to generate alternating current into coil from dc current supply by DC power supply	Current need to be operates in a certain level that the magnetic field would be affected by any existing metal inside the bin at the bottom	Y
Coils	1. One coil used to	Fixed the coil size to keep the	Y

	generate magnetic field with oscillating current 2. One coil for measuring the electric field as a magnetometer, the change in the magnetic field due to the metallic object can be detected	measuring range around the area above the tilt-able plate	

8. Appendix B Extra Data Tables and Layouts

Figure 11 Signal Generator

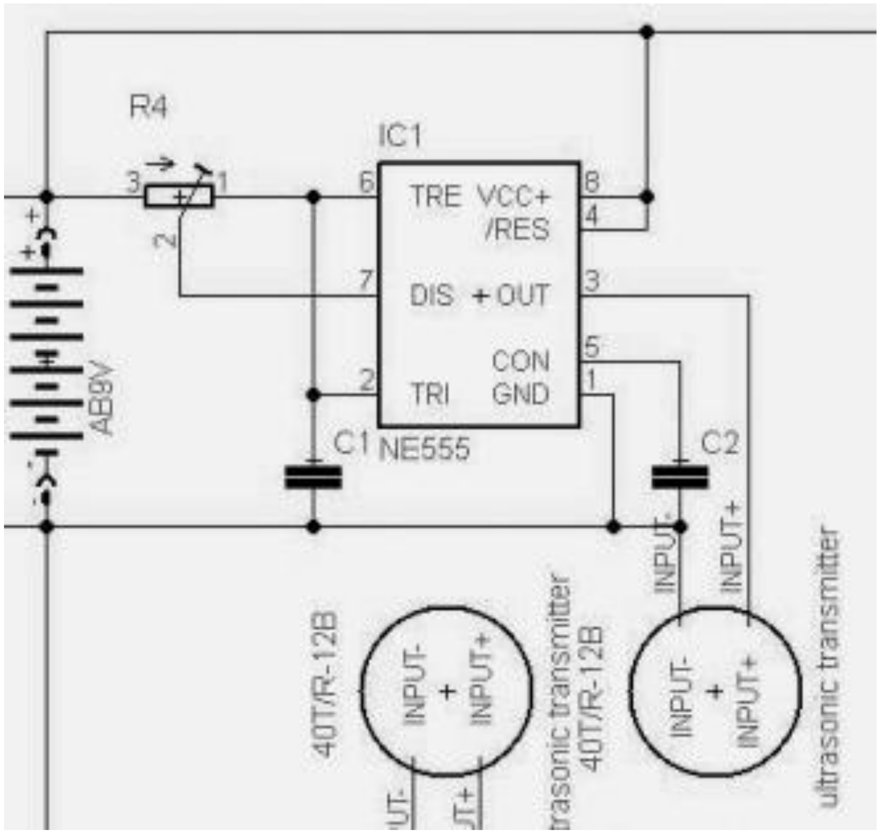


Figure 12 Signal Receiver

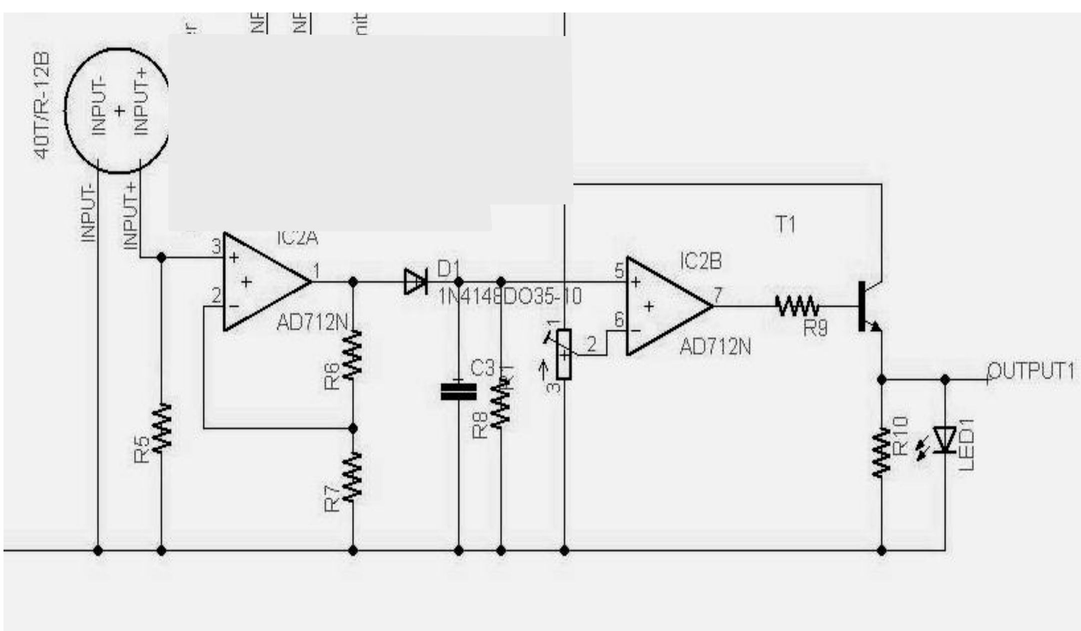


Figure 13 Motion Detector on PCB

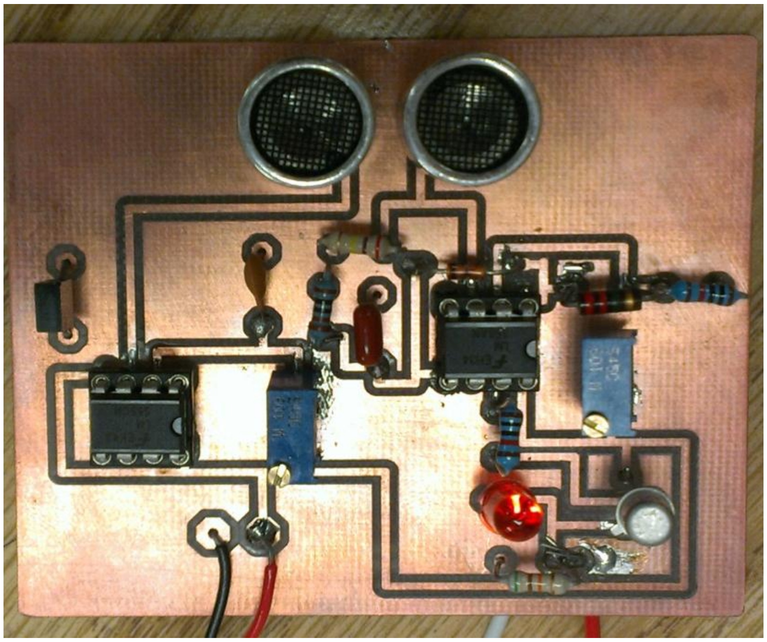


Figure 14 HS-311

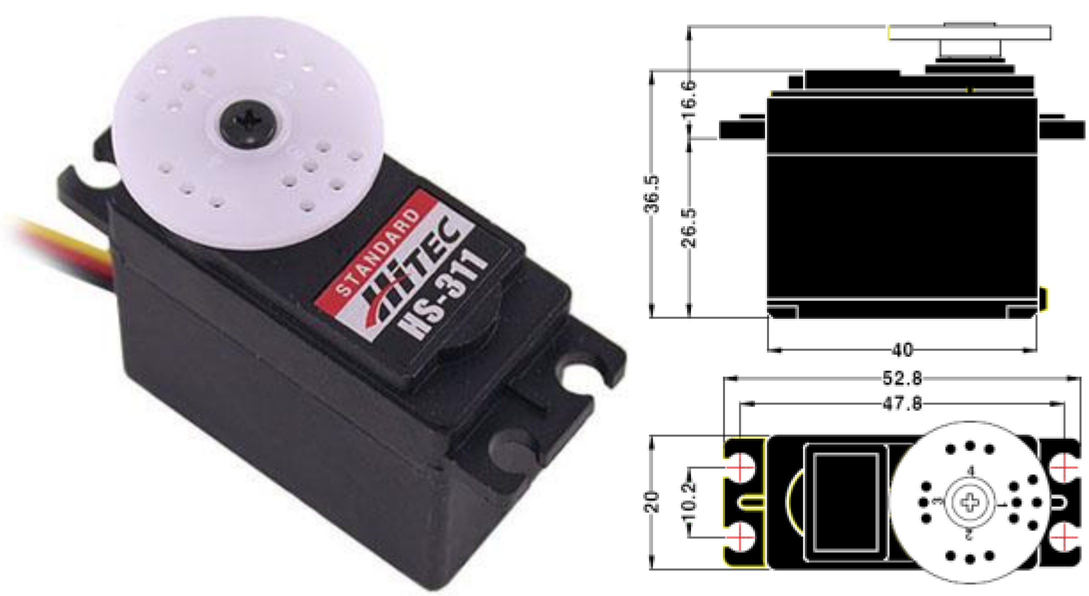


Figure 15. Metal Detector Schematic

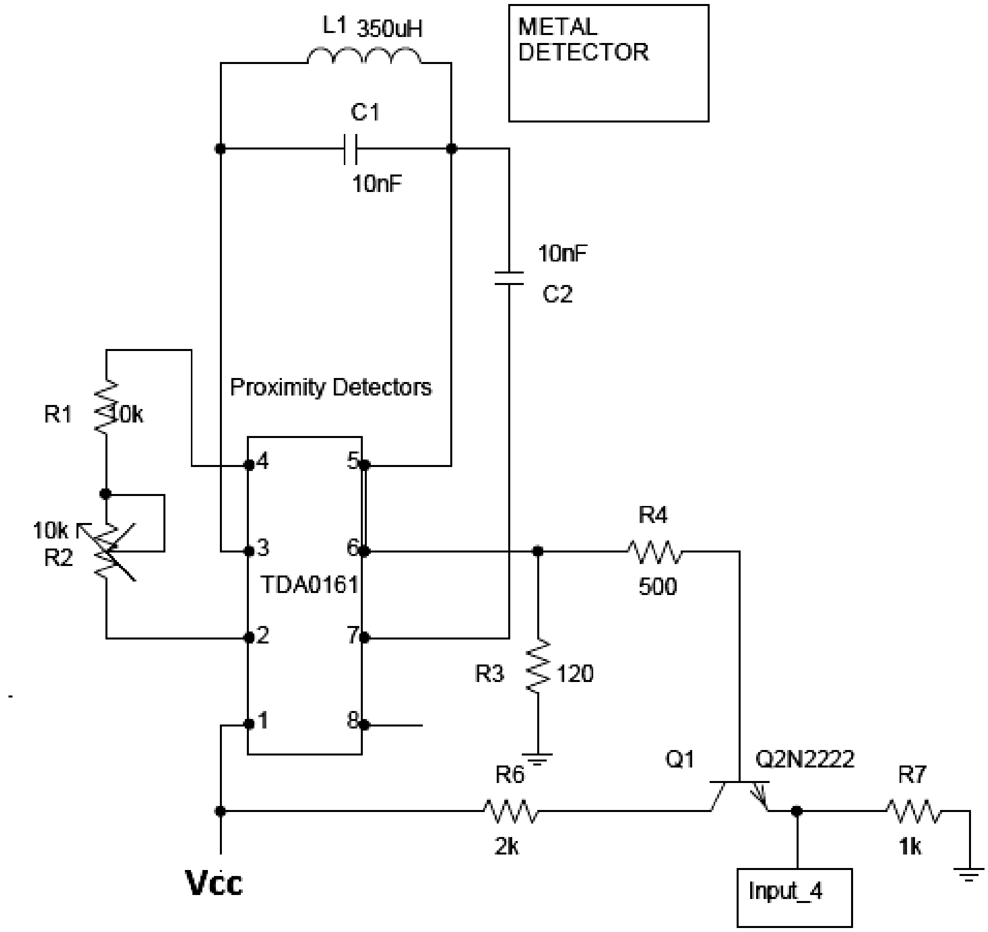


Figure 16 Internal Reference

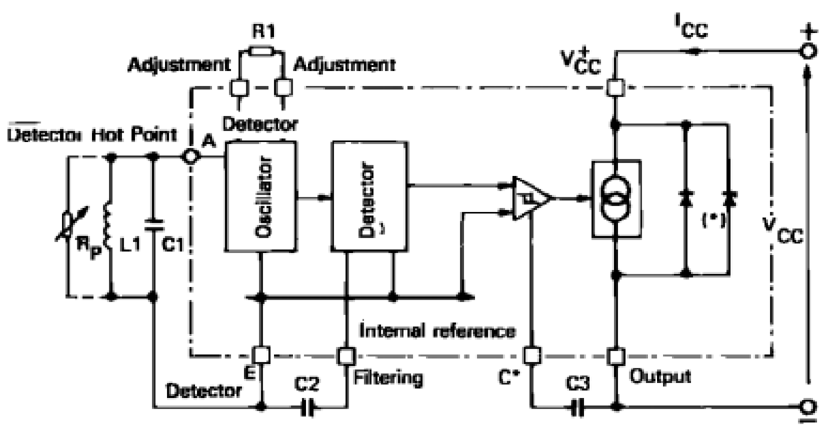


Figure 17. Capacity Check Schematic

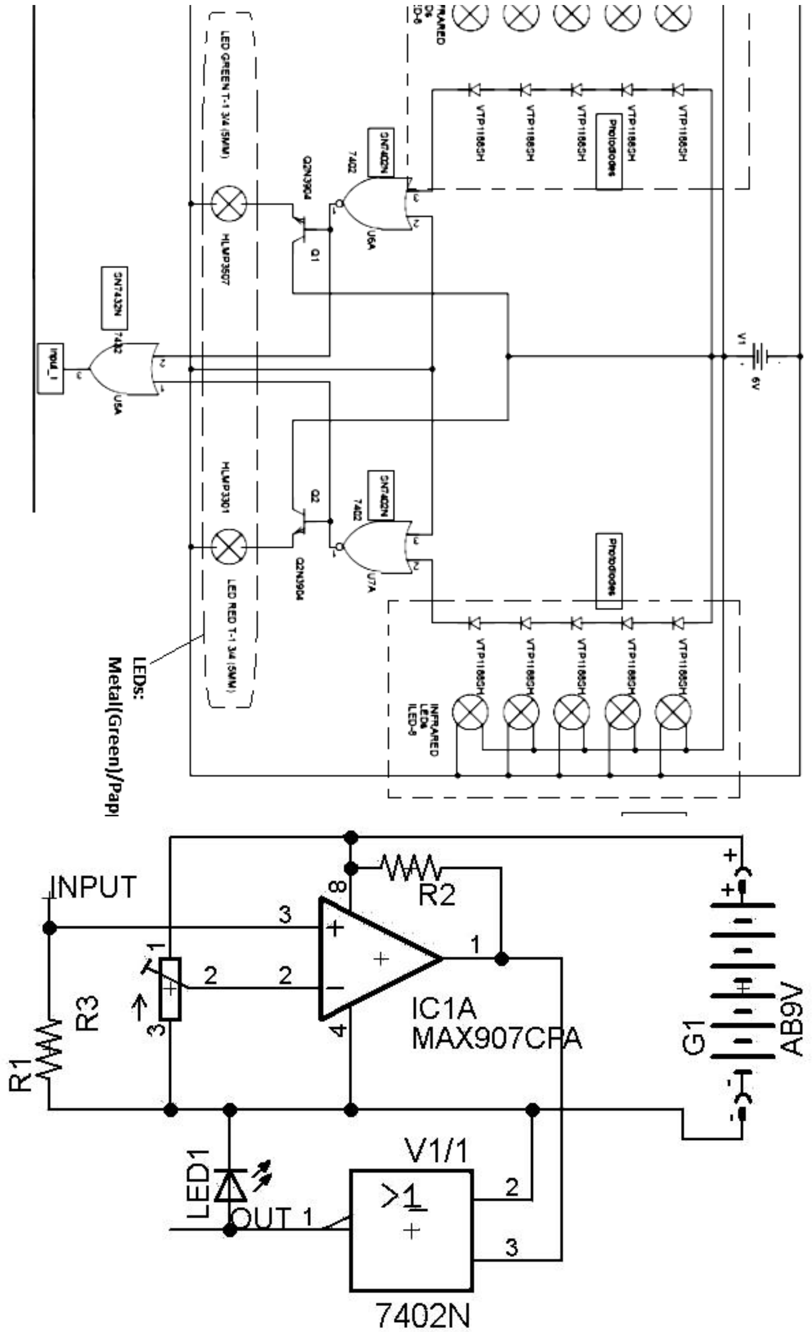
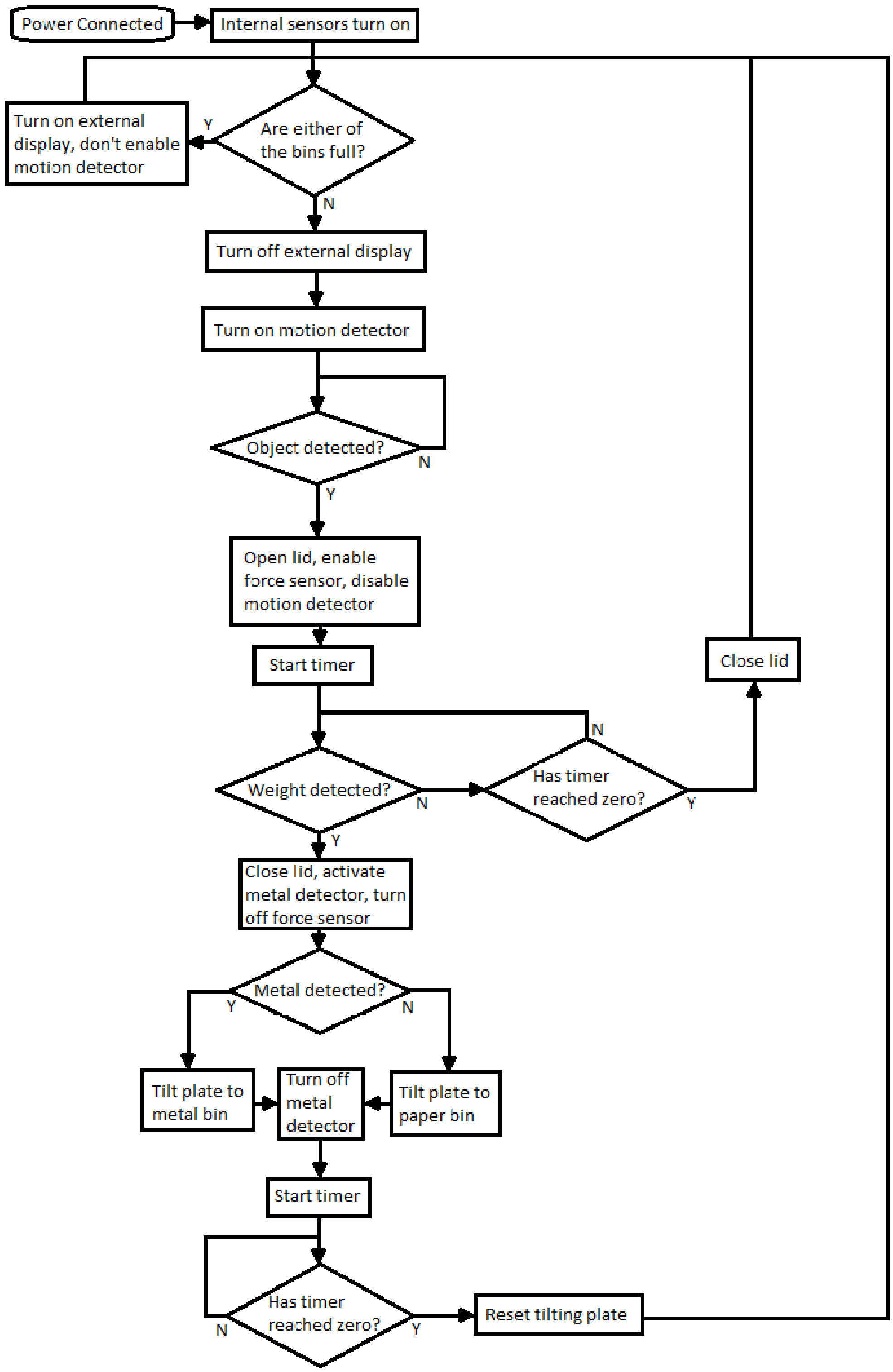
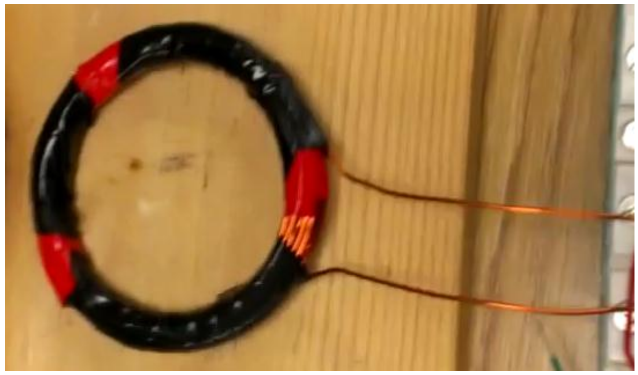
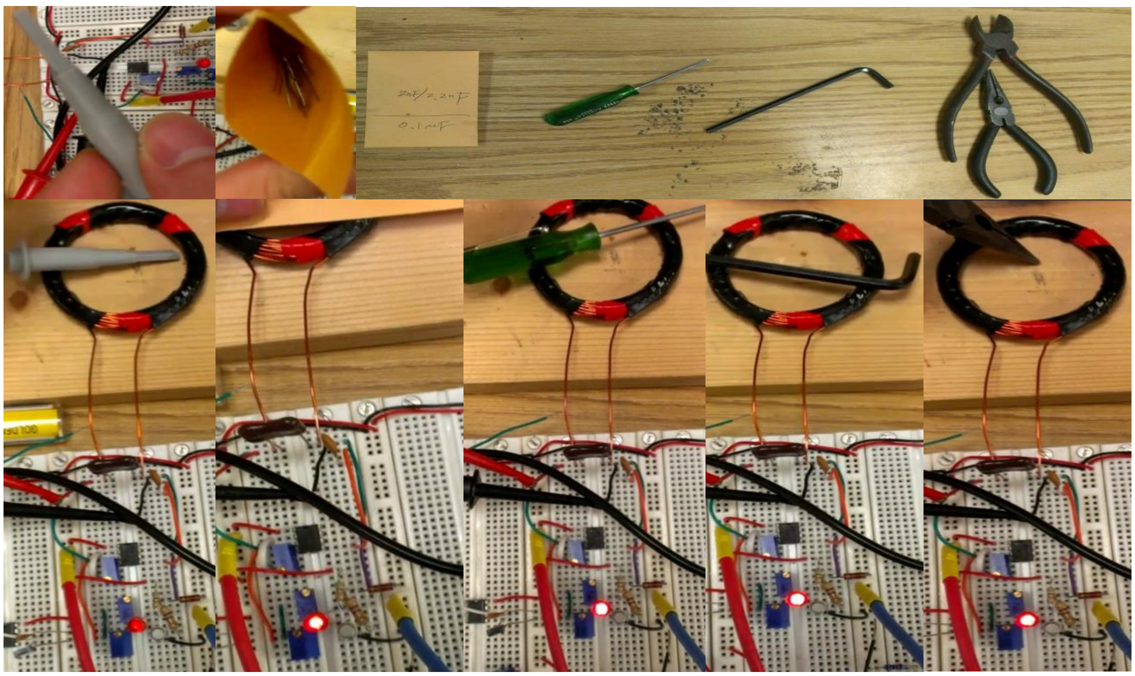


Figure 18 Algorithm Flow Chart



9. Appendix C Detectable Metal Size for Metal detector





Bigger core increase the detection range but lower sensitivity to find out small metal objects