Smart Bio-hazard Waste Bin

ECE445 Spring 2013

Design Review

Yanqiu Yin
Qiong Hu
Zekun Liu

TA: Dennis Yuan

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1. INTRODUCTION:

1.1. STATEMENT OF PURPOSE:

This project was chosen because we noticed that the waste bins which possibly contain biohazard waste in most hospitals and labs can be modified to be more efficient and much safer. Medical waste from hospital, if not processed properly, can bring huge damage to the environment and people around it. The final product should be able to open the lid automatically when someone is trying to throw something in and store it in a much more secure garbage bag. When the bag is full it will be heat-sealed and a LCD screen will show the time when this bag was set and when it is sealed. There will also be leak detection sensors on the bottom of the waste bin so an warning message will appear on the LCD screen when there is a leak. We believe this will be a great help to the hospitals and the labs.

1.2. BENEFITS AND FEATURES:

Currently most bio-hazard waste bins have to be opened manually to throw garbage in. This is a disadvantage because we want to minimize the contact we have with the biohazard waste bin. With the infrared sensor we are installing on the lid, the lid will open automatically when someone approaches. And our waste bin can provide proper seal of each bag to prevent the bacteria from spreading. There will also be an LCD display screen on the side of the waste bin.
On the LCD screen the following information will be displayed:

- The exact time when this garbage bag was set
- The current time
- The current weight of the garbage bag
- Whether the current bag is sealed
- The time of the current bad has been placed
- The number of times the lid opens and closes
- A warning message when there is a leakage detected in the garbage bag

These information displayed on the LCD screen and recorded in the microchip will provide some data for analysis if there is a problem.

1.2.1. BENEFITS:

- No one has to touch the waste bin to open the lid or to throw the bag, minimizing the chance of infection through contact
- Weight limit of each bag prevent any bag from overflowing
- Proper sealing of each bag prevents the bacteria from spreading
- Liquid leakage detection will provide one extra safety precaution
- Data in microchip will provide information for future analysis

1.2.2. Features:

- IR Proximity Sensor
- Force Sensing Resistor
- Water Leak Detector

- LCD Display Panel with LCD Controller
- Metal Guide Plate covered by teflon coating, heated by Nichrome wire and driven by sealing motors
- Lid mechanics driven by lid motors
- ARDUINO Board
- AC/DC Power Supply and DC/DC Converters

2. DESIGN

2.1. BLOCK DIAGRRAM:

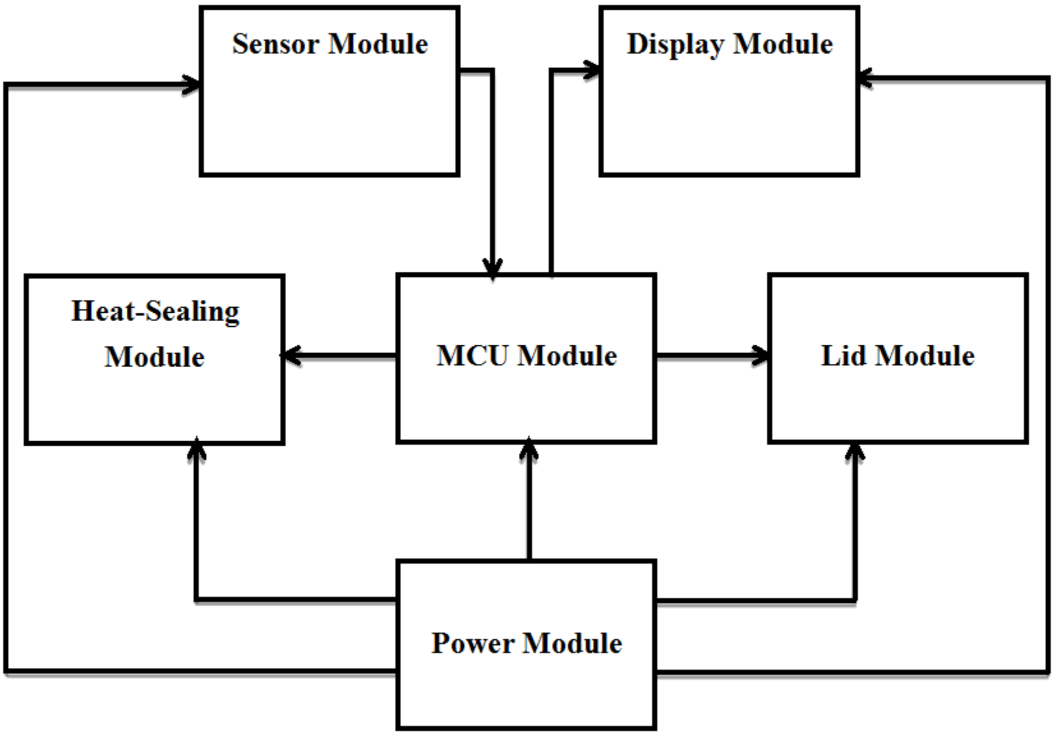


Fig 2.1 Top Level Block Diagram

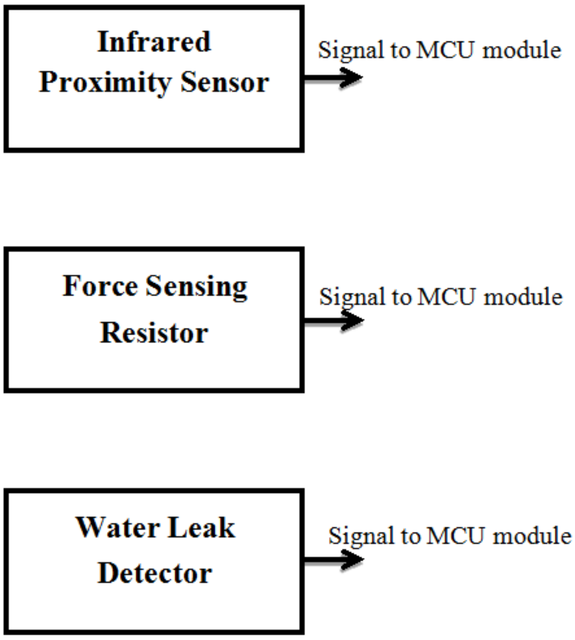


Fig 2.2 Sensor Module Block Diagram

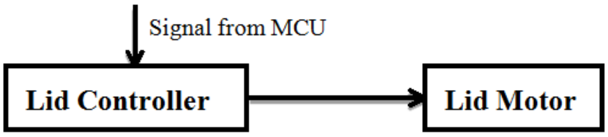


Fig 2.3 Lid Module Block Diagram

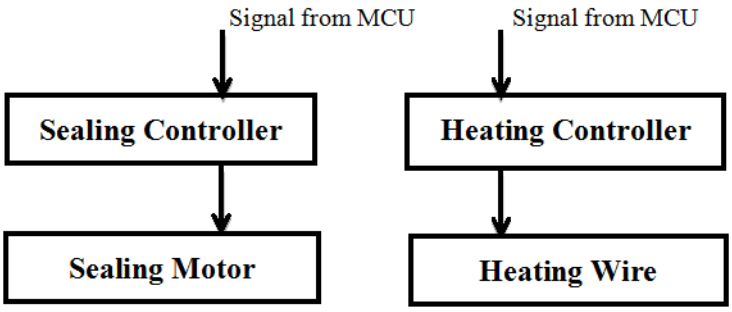


Fig 2.4 Heat-Sealing Module Block Diagram

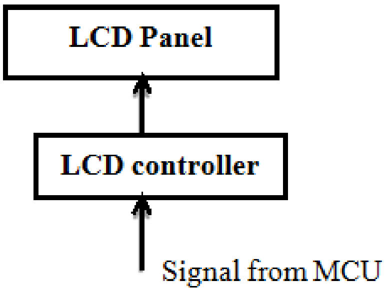


Fig 2.5 LCD Display Module Block Diagram

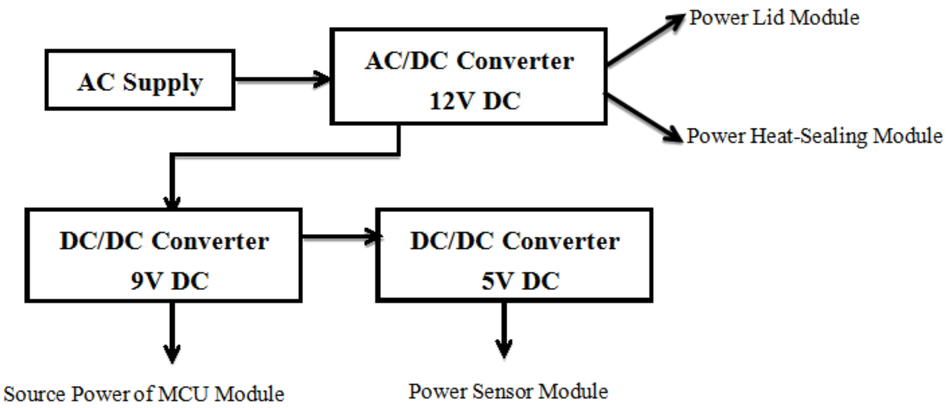


Fig 2.6 Power Module Block Diagram

2.2. BLOCK DESCRIPTION

2.2.1. OVERALL SUMMARY:

- **SENSOR MODULE:** Sensor Module, also known as Detector Module measures physical quantity and converts them into signals which can be read by the MCU module (ARDUINO). Here three types of sensors are implemented, which are Infrared Proximity Sensor, Force Sensing Resistor and Water Leak Detector. The outputs of these sensors are implemented as inputs to the MCU module. The MCU module receives analog data and converts them to digital data. The sensors are powered by connecting to the Power Module.
- **MCU MODULE:** The MCU Module is implemented using an ARDUINO Board. ARDUINO Board is an open-source electronics prototyping platform based on flexible, easy-to-use hardware and software. ARDUINO senses the environment by receiving input from the IR Proximity Sensor, the Force Sensing Resistor and the Water Leak Detector. After the MCU module receives analog data from the Sensor Module, it converts them to digital data. Then it gives out the digital data to the Lid Module, Heat-Sealing Module and the LCD Display Module. The MCU Module is programmed using the ARDUINO programming language and the ARDUINO development environment. The ARDUINO is powered by connecting to the Power Module.
- **LID MODULE:** The Lid Module contains lid controller and lid motors. The lid controller receives signals from the MCU Module and drives the lid motors accordingly so that the lid motors can either open the lid or close it.
- **HEAT-SEALING MODULE:** The Heat-Sealing Module contains sealing controller and sealing motors. The sealing controller receives signals from the MCU Module and drives the sealing motors accordingly. The sealing motors move the guide plate back and forth inside the waste bin. The guide plate is rounded by Nichrome wires, which are covered with teflon coating. The Heat-Sealing Module also contains heating controller. The heating controller receives signals from the MCU module and heat up the teflon coating accordingly.
- **DISPLAY MODULE:** the LCD Display Module receives data from the MCU Module and displays weight, date, time, whether if the current bag of trash has already been sealed and how many times the lid has been open or closed for current bag of trash. Also, the LCD display panel will tell if there is any liquid leakage.
- **POWER MODULE:** The Power Module converts AC power supply to DC voltages and powers each module with respect to their requirements accordingly.

2.2.2. SENSOR MODULE:

- **IR PROXIMITY SENSOR:** We chose Sharp GP2Y0A21YK IR Distance Sensor. The Sharp GP2Y0A21YK is an Infrared proximity Sensor. The Sharp GP2Y0A21YK IR Distance Sensor is placed on the movable lid of the waste bin. As a human body passes in front of the waste bin, the temperature at that point will rise from room temperature to body temperature, and then back again. This quick change triggers the detection of the IR Proximity sensor. As IR Proximity sensor detects a user, it will pass a signal to the MCU Module.

- **DESCRIPTION AND CONNECTION:**
  The Sharp GP2Y0A21YK detects human motions within a range from 10 to 80 cm. The detection area diameter at 80 cm is 12cm. A typical response time 39 ms, which is quick enough to neglect. The Sharp GP2Y0A21YK gives a digital output directly to the ARDUINO Board. The connection schematic is shown as below:

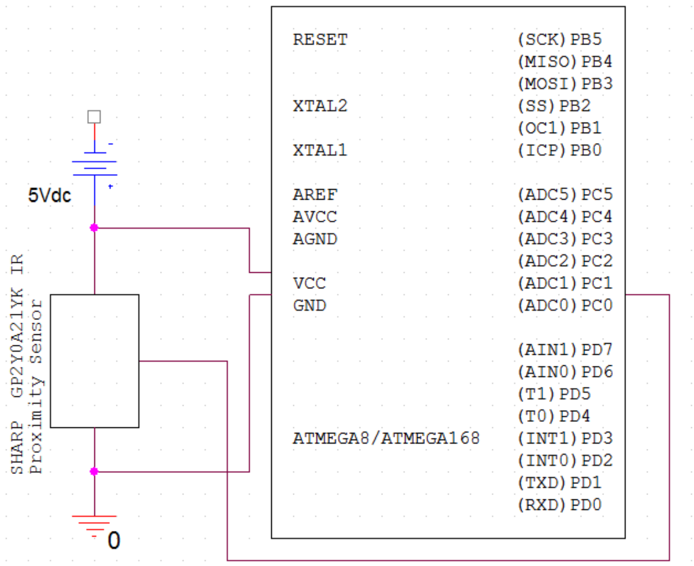


Fig 2.7 Schematics of Connection between Sharp GP2Y0A21YK IR and the ARDUINO Board

- **ELECTRICAL SPECIFICATIONS AND OUTPUT DISTANCE CHARACTERISTICS:**

Ta = 25℃, V_{CC} = 5 VDC

PARAMETER	SYMBOL	RATING	UNIT
Supply Voltage	V_{CC}	-0.3 to +7	V
Output Terminal Voltage	V_O	-0.3 to (V_{CC} +0.3)	V
Measuring Distance Range	ΔL	10 to 80	cm
Output Terminal Voltage (L = 80 cm)	V_O	0.4	V
Average Supply Current I_{CC} (L = 80 cm)	I_{CC}	30	mA

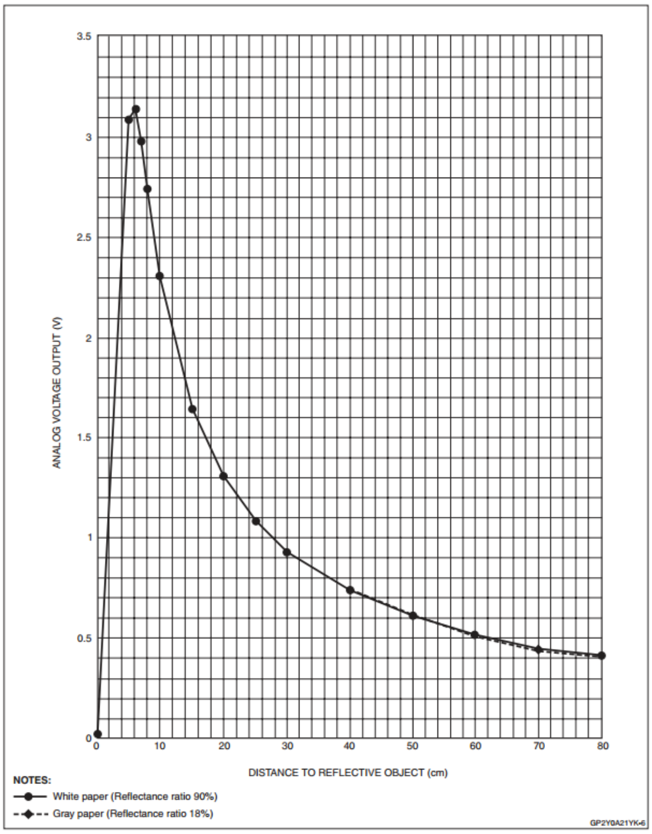


Fig 2.8 Sharp GP2Y0A21YK IR Output Distance [1] Characteristics

Taken reference from the data sheet, the supply voltage we are looking for from the Power Module should be 5 VDC. Also as indicated from the graph of output distance characteristics, at 6 cm there exits a sharp break-down. Hence, the threshold distance would be set around 6 cm by the MCU Module. Humans within a range of 6 cm will be identified as potential users.

In addition, distance within the range of 10 cm to 80 cm vs. output voltage gives a mathematical function. Although humans within a range of 10 cm to 80 cm will not be identified as users, a record of their distance will be produced by the MCU Module.

- **FORCE SENSING RESISTOR:** We chose FSR Part No. 406. FSR to detect the weight of the dispose. The FSR is place at the bottom inside the waste bin. This FSR will vary its resistance depending on how much pressure is being applied to the sensing area. The harder the force, the lower the resistance. When no pressure is being applied to the FSR its resistance will be larger than 1MΩ. This FSR can sense applied force anywhere in the range of 100g-10kg. Two pins extend from the bottom of the sensor as pitch. There is a peel-and-stick rubber backing on the other side of the sensing area to mount the FSR. The connection schematic between the FSR and the ARDUINO Board is shown as below:

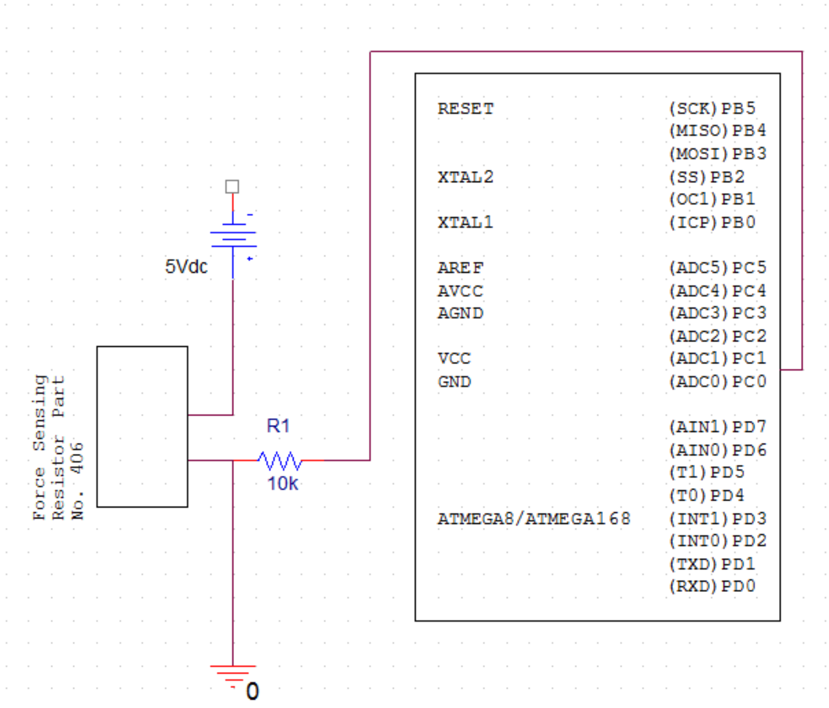


Fig 2.9 Schematics of Connection between FIR Part No. 406 and the ARDUINO Board

- **DESCRIPTIONS AND DIMENSIONS:**

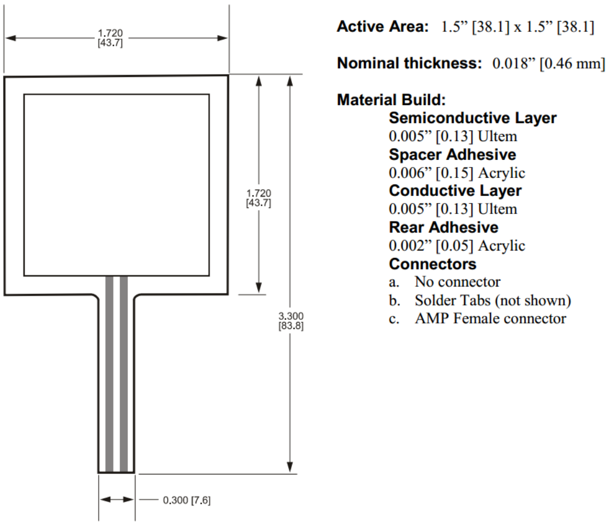


Fig 2.10 FSR Part No. 406 [2]

- **FORCE VS. RESISTANCE:** The force vs. resistance characteristic shown below as Fig 2.11 provides an overview of FSR typical response behavior. The force vs. resistance data is plotted on a log/log format. In general, FSR response approximately follows an inverse power-law characteristic (roughly 1/R).

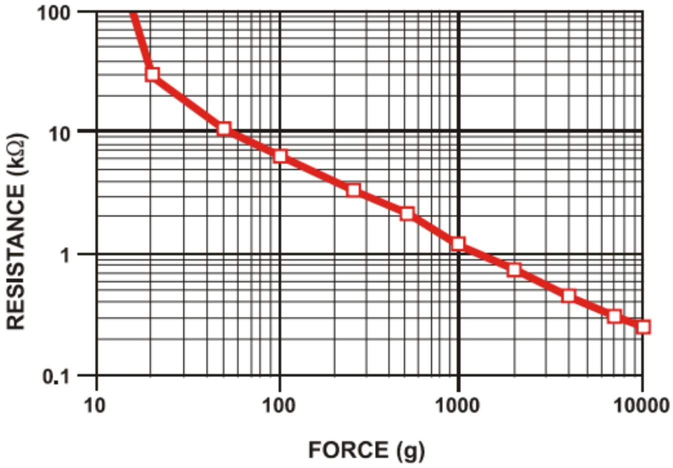


Fig 2.11 Resistance vs. Force [3]

Referring to the figure 2.11 above, at the low force end of the force-resistance characteristic, a switch-like response is evident. This turn-on threshold, or ‘break force”, that swings the resistance from greater than 100 kΩ to about 10 kΩ, which does not give a certain pattern between Force vs. Resistance. Hence, forces under 100 g are not in consideration. In another word, dispose under 100 g will not be recorded by the MCU Module.

At the high force end of the dynamic range, the response deviates from the power-law behavior, and eventually saturates to a point where increases in force yield little or no decrease in resistance. Under these conditions, this saturation force is beyond 10 kg. Hence, dispose with weight only within the range from 100 g to 10 kg will be recorded by the MCU Module.

- **FORCE VS. CONDUCTANCE:**
  The conductance is plotted vs. force (the inverse of resistance: 1/R). This format allows interpretation on a linear scale. For reference, the corresponding resistance values are also included on the right vertical axis. A simple circuit called a current-to-voltage converter as shown in figure 2.12 gives a voltage output directly proportional to FSR conductance and can be useful where response linearity is desired. The figure 2.12 also includes a typical part-to-part repeatability envelope. This error band determines the maximum accuracy of any general force measurement.

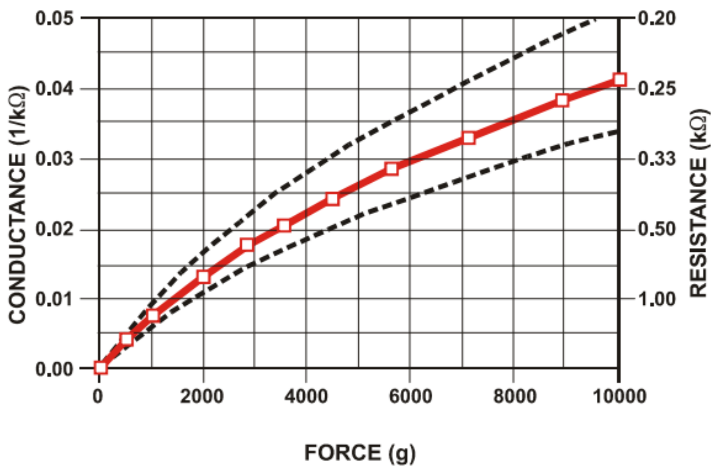


Fig 2.12 Conductance vs. Force [4]

- **FSR CURRENT-TO-VOLTAGE CONVERTER**
  In this circuit, the FSR device is the input of a current-to-voltage converter as shown in figure Fig 2.13. The output of this amplifier is described by the equation:

$$VOUT = VREF \cdot [-RG/RFSR]$$

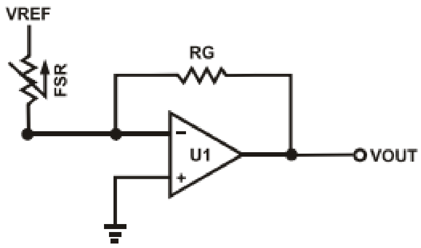


Fig 2.13 FSR Current-to-Voltage Converter [5]

With a positive reference voltage, the output of the op-amp must be able to swing below ground, from 0V to –VREF, therefore dual sided supplies are necessary. A negative reference voltage will yield a positive output swing, from 0V to +VREF. VOUT = (-RG • VREF) /RFSR. VOUT is inversely proportional to RFSR. Changing RG and/or VREF changes the response slope. For testing the circuit and choosing component values and output swing:

For a human-to-machine variable control device, the maximum force applied to the FSR is about 1kg. Testing of a typical FSR shows that the corresponding FSR at 1kg is about 4.6kΩ. If VREF is –5V, and an output swing of 0V to +5V is desired, then RG should be approximately equal to this minimum RFSR. RG is set at 4.7kΩ. A full swing of 0V to +5V is thus achieved. A set of FORCE vs. VOUT curves is shown in figure 2.14 for a standard FSR using this interface with a variety of RG values. The current through the FSR device should be limited to less than 1 mA/square cm of applied force. As with the voltage divider circuit, adding a resistor in parallel with RFSR will give a definite rest voltage, which is essentially a zero-force intercept value. This can be useful when resolution at low forces is desired.

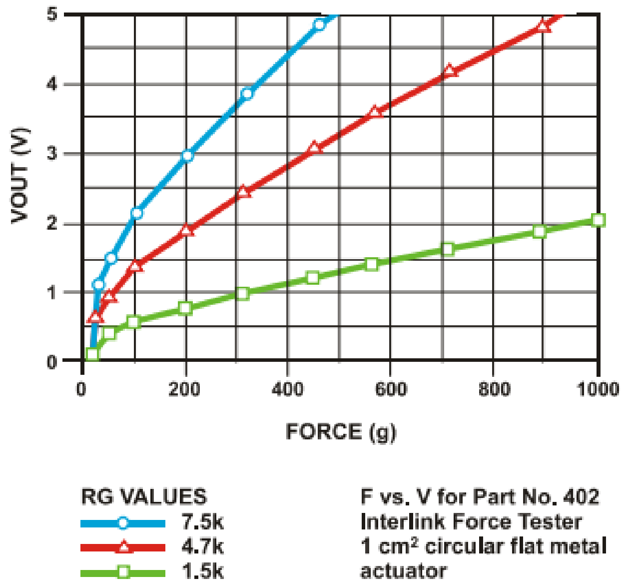


Fig 2.14 F vs. V for Part No. 406 Interlink Force Tester 1 cm^2 circular flat metal actuator [6]

- **WATER LEAK DETECTOR:** The water leak detector serves to solve the problem that there is water leaking. The detector is made of a designed circuit and sponges with dimension 10 inches time 15 inches. The schematic of the circuit is shown as in the figure 2.15 as below:

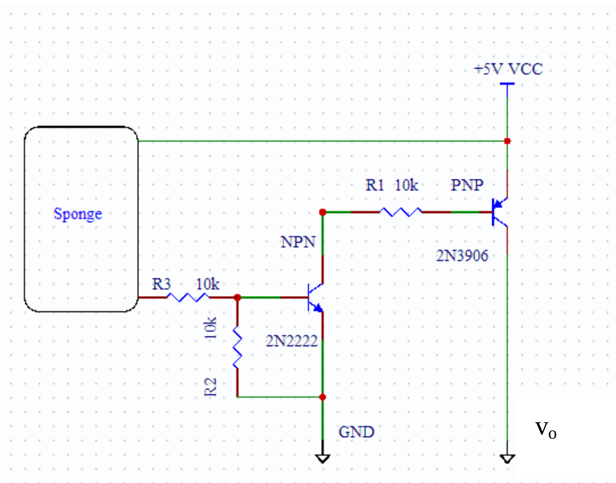


Fig 2.15 schematic of water leak detector

- **RELAVENT PARTS:**
  - Transistor, PNP 2N3906
  - Transistor, NPN 2N2222A
  - Resistors of 10kΩ × 3
  - Wire, insulated, 18-22 gauge stranded, multiple colors
  - Wire, solid copper, insulated, 18-20 gauge
  - Sponges, 10 inch × 15 inch

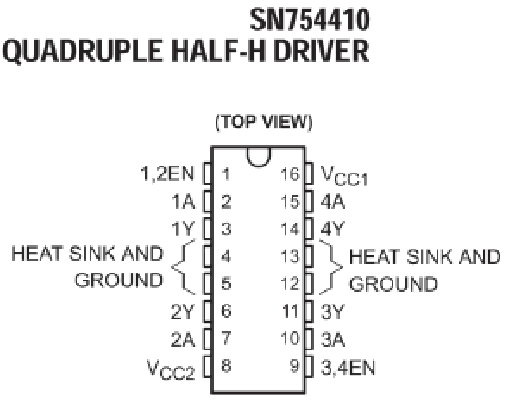
- **DSCRIPTION:**
  Use the this schematic for assembling the water leak detector circuit. The input power supply is 5V DC, which gives an output voltage when the sponges are wetting or saturating. When water leaks and is absorbed by the sponges, the resistance of the sponges drop to about 1MΩ or less. This forward-biases the 2 transistors and causes output voltage varying. The output voltage will be analyzed by the MCU Module.

2.2.3. MCU MODULE:

- **Arduino Board:** The Arduino Uno R3 board we are using as micro controller is what is really holding all the parts together. As shown in the high level block diagram, the MCU Module will interface with the LCD Display Module, the Lid Module, the Heat Sealing Module and the Sensors Module.
- **Interfacing with the Sensors Module:** When the infrared sensor on the lid detects human movement within range, or when the force sensor detects sufficient force, or when the leak detection sensor on the bottom of the waste bin detects a leak, they will all send a signal to the MCU Module, and the MCU module will decide what to do next, respectively.
- **Interfacing with the Lid Module:** After the MCU Module receives a signal from the infrared sensor indicating that human movement within range is detected, a signal will be sent from the MCU Module to the Lid Module to tell it to open the lid automatically and close it after 3 seconds.
- **Interfacing with the Heat Sealing Module:** After the MCU Module receives a signal from the force sensor indicating that the specific weight of the waste bag has been achieved; the MCU Module will send a signal to the Heat Sealing Module to tell it that it is time to seal the current bag.
- **Interfacing with the LCD Display Module:** The Arduino board will be outputting message to the LCD Display Module for it to display on the LCD screen at all time. The specific message displayed on the LCD screen is explained in 2.2.6.
- **RTC Chip:** This is the Real Time Clock chip that we will use to calculate the delay time for the Lid Module. This will also be the signal to output to the LCD Display Module for the time display.

2.2.4. LID MODULE:

- **LID MOTOR:** The lid motor is a brush gear motor which contains an electric motor and a reduction gear train integrated into one package. We choose our motor to be Pittman GM9434 gear motor which has two permanent poles and can rotate smoothly at 105 rpm. This speed is appropriate for our design that it is either too fast or too slow to open the lid.
- **LID CONTROLLER:** It contains both a software and hardware part. On the software side, we do a program in MCU that controls the time: when do we want the motor to be running and when to stop; on the hardware side, we use a single chip to control the direction of the motor since we want it to be bidirectional.
- **H-BRIDGE:** We have a two-pole motor which means that if we want the motor to be bidirectional, we can only reverse the direction of current that goes through. In accordance with our ARDUINO design, we choose to use an H-bridge to make this work in a simple way. An H bridge is an electronic circuit that enables a voltage to be applied across a load in either direction. We choose SN754410 motor driver IC in our case, the data pin of which is shown in figure 2.16. We connect 1,2 EN to 5V power supply on ARDUINO, and we use pin 2 and pin 15 as PWM (pulse-width modulation) to set the motor I "full speed" and "brake" mode. If 1A is high and 2A is low, then 1Y, which is the power output is high, and 2Y is low, current flows from 1Y to 2Y; controversially if 1A is low and 2A is high then current flow from 2Y to 1Y. Therefore we have two directions of current flow based on signals of 1A and 2A, we connect the motor to 1Y and 2Y, it is then able to rotate in two opposite directions. If both 1A and 2A are high then motor is in "brake" mode.



FUNCTION TABLE
(each driver)

INPUTS†		OUTPUT
A	EN	Y
H	H	H
L	H	L
X	L	Z

H = high-level, L = low-level
X = irrelevant
Z = high-impedance (off)
† In the thermal shutdown mode, the output is in a high-impedance state regardless of the input levels.

Fig 2.16 pin layout of H-bridge SN754410 [7]

- **MCU Timer:** We want the lid open when someone is throwing wastes. MCU will receive a signal from sensor and tell the timer to start to count. With this timer, the MCU will tell the motor when to run forward, backward or stop as we want.

- **FLOW CHART OF LID MODULE:**

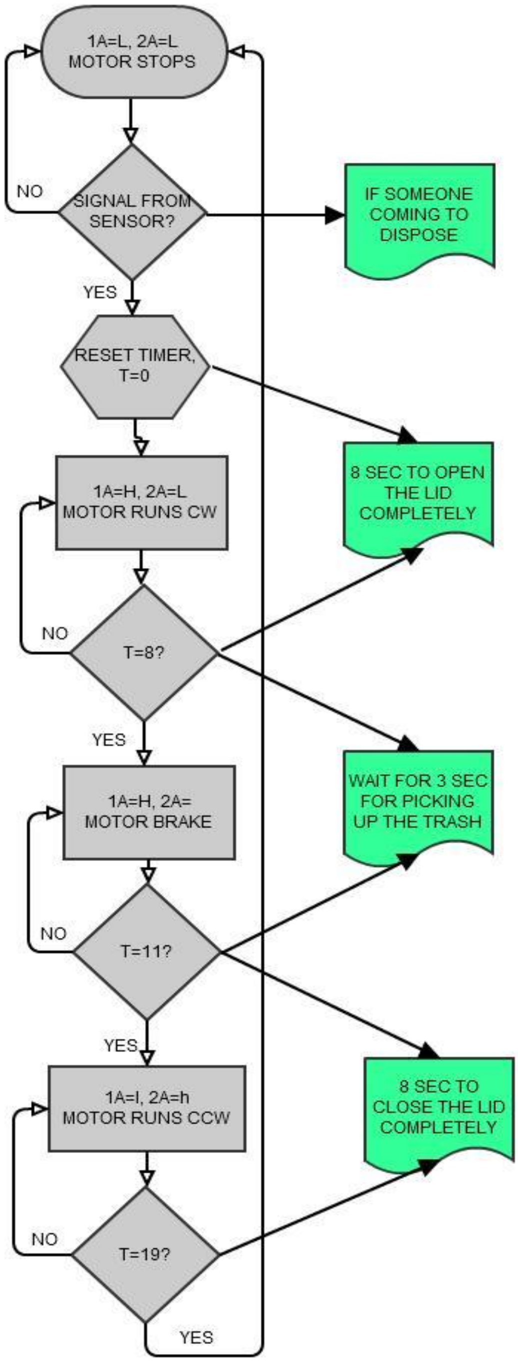
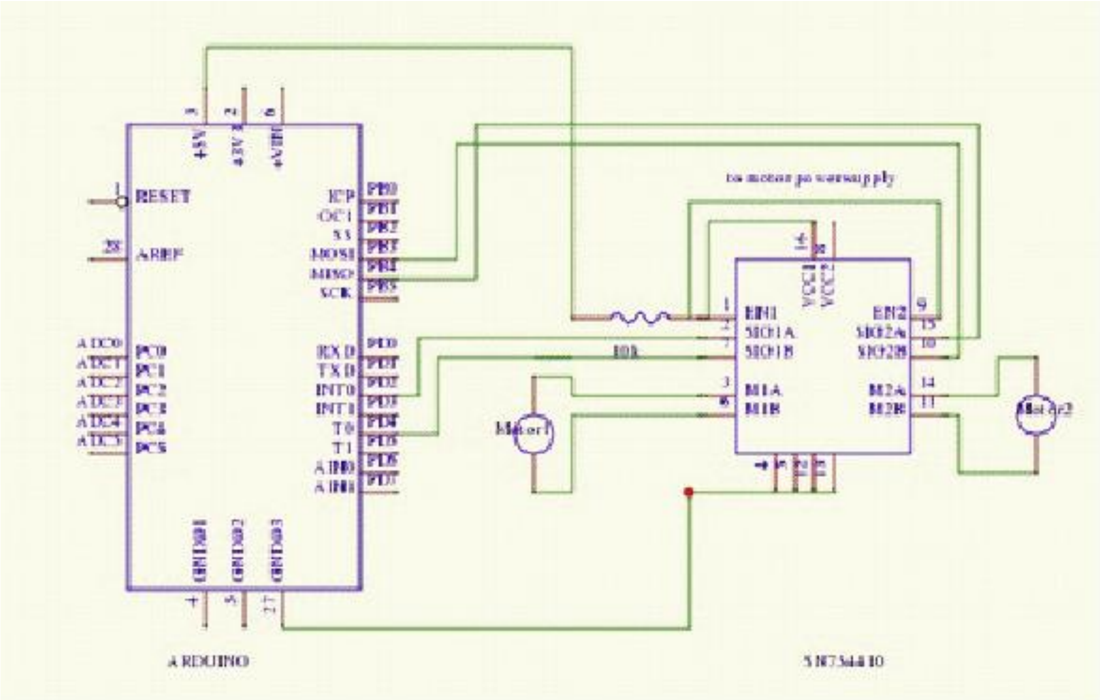


Fig 2.17 flowchart of lid module

SCHEMATICS

1) Lid & seal motor with Arduino



2.2.5. HEAT-SEALING MODULE:

- **SEAL CONTROLLER & SEAL MOTOR:** The seal controller and motor work almost the same compare with the lid controller and motor. There's difference made in MCU that we need a different timer program. Motor type and controller chip is all the same.

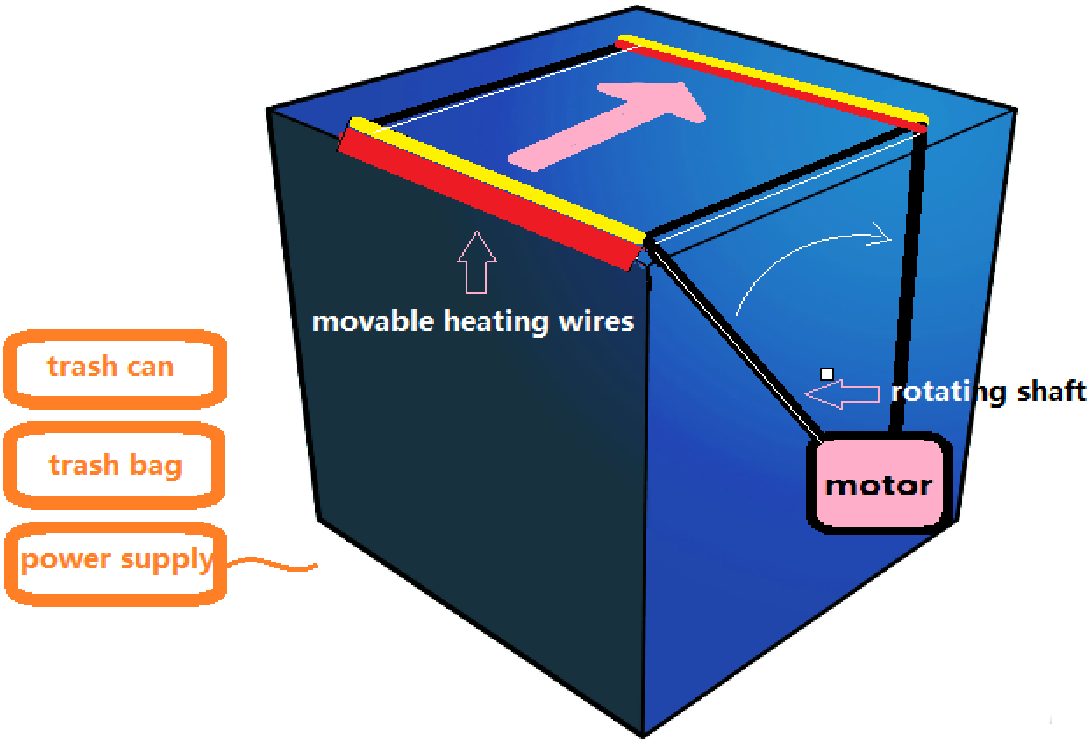


Fig 2.18 Heat sealing mechanics

- **HEATING CONTRLLER:** This part contains a MCU program that is basically a timer. Between time W1 and W2, the MCU will continuously send signals to the power supply and ask for current to go through the heating wire. W1 is when heating wire is move to the right side and W2 is when finished sealing. This time period is known after tests of real heat sealing function. In the lid module, we let the lid open for 3 sec for people to dispose waste, in the heating module, we will need (W2-W1) seconds to seal the trash bag, in a way that the heating controller is embed in the motor motion.
- **HEATING WIRE:** nichrome wire is has a specific characteristic that it heats up when electricity apply. It can be heated up to 900 degree Celsius that is capable to melt trash bags at 100~120 degree Celsius.

- **FLOW CHART OF HEAT-SEALING MODULE:**

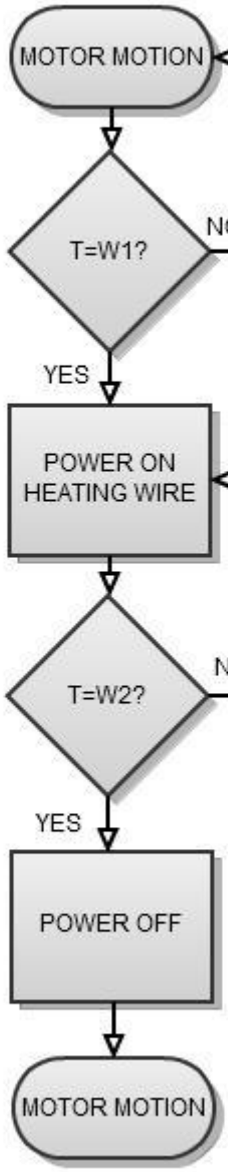


Fig 2.19 flowchart of heat-sealing module

2.2.6. <u>DISPLAY MODULE:</u>

- LCD Screen: The LCD screen we are using is a 20x4 LCD screen based on HD44780. It shows white characters on blue background, and it has 4 rows and 20 characters in each row. It will display different information in different situations. It will get its signal from the MCU Module, and the connections between the LCD screen and the Arduino board in the MCU Module are shown below:

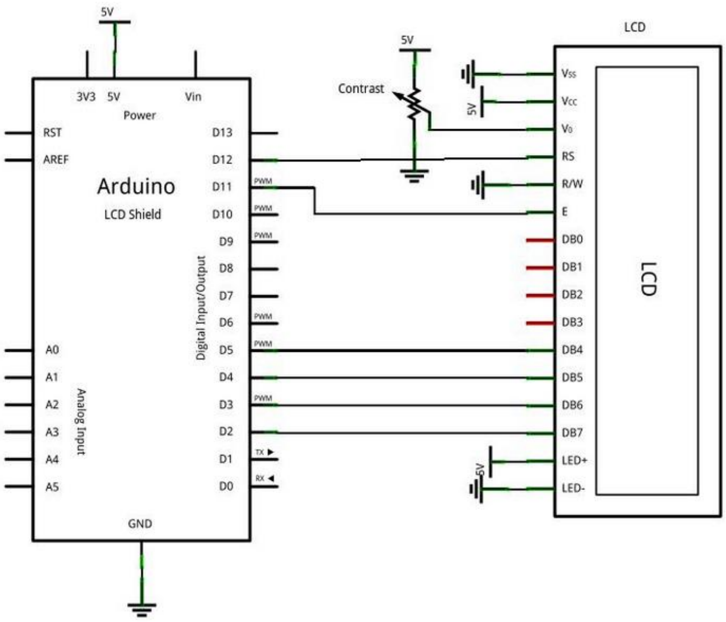


Fig 2.20 LCD screen connection schematic

When the current bag in the waste bin has already been sealed, the LCD screen will display the time when the bag was set, the time when the bag was sealed, and the weight of the bag. It is shown below:

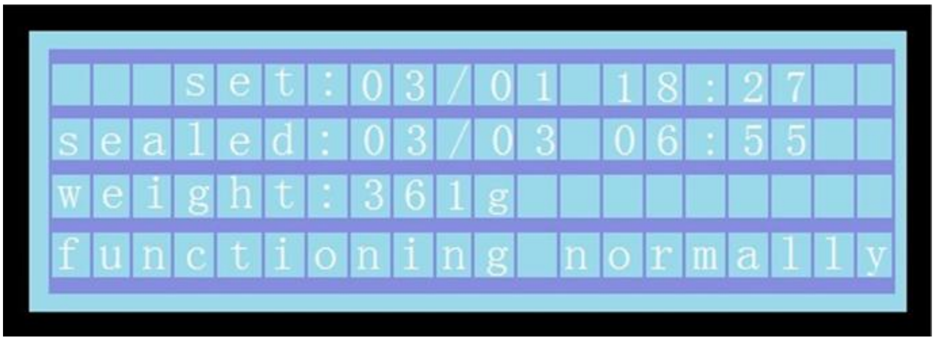


Fig 2.21 LCD Display 1

When the current bag is not yet sealed, the second line will be replaced by the current time. It is shown below:

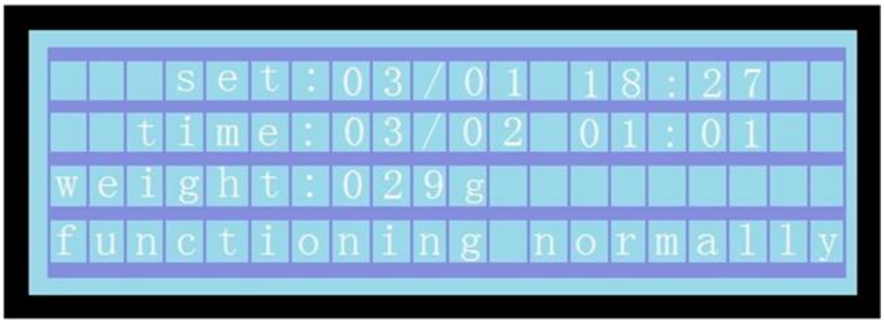


Fig 2.22 LCD Display 2

When there is a leak happening on the bottom of the waste bin, the bottom line of the LCD display will be replaced by a warning message, as shown below:

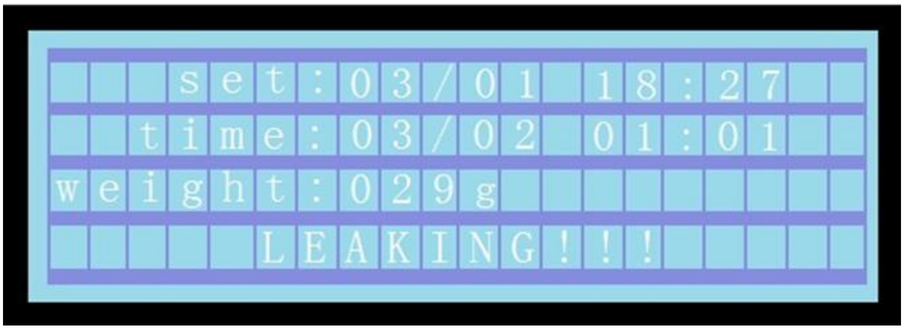


Fig 2.23 LCD Display 3

2.2.7. POWER MODULE:

- **AC/DC CONVERTER:** We need an AC/DC adapter to convert constantly changing polarity type electricity into battery type electricity. From 110V to 12V.
- **DC/DC CONVERTER:** We need also a DC/DC converter to step down 12V to 5V. 5V is supplied to ARDUINO, sensors and heating. We use LM317 to regulate our power supply. The maximum Input-Output Voltage Differential if 40V of LM317 and minimum output voltage is 1.5V. Output current is up to 1.5A. All parameters satisfy our need of usage.
- **TABLE OF LISTED FEATURES WITH THEIR REQUIRED POWER SUPPLES:**

FEATURES	**REQUIREMENTS FOR DC POWER SUPPLY**	**UNIT**
Sharp GP2Y0A21YK IR Sensor	5	V
FSR Part No. 406	5	V
Water Leak Detector	5	V
Lid Motors	12	V
Heat-sealing Motors	12	V
Heating wire	5	V
ARDUINO	9	V
LCD HD44780	5	V

- **SCHEMATICS OF THE POWER MODULE:**

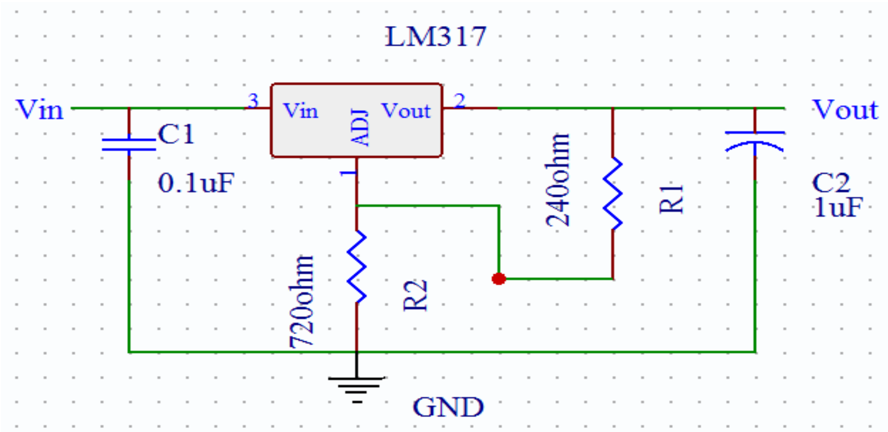


Fig 2.24 schematics of the power module

2.3. SIMULATIONS AND CALCULATIONS:

- **SIMULATIONS OF IR OUTPUT VOLTAGE VS. DISTANCE:**

By placing the data values into MATLAB, I got the following graph as shown in figure. The x-axis displays distance (cm) and the y-axis displays output voltage. As the curve fitted by MATLAB. The graph most closely resembled a polynomial function. Hence, for quadratic fitting, the best-fitting line equation was

$$y = 0.00092x^2 - 0.11x + 3.4.$$

For cubic fitting, the best-fitting line equation was

$$y = -2.3 \cdot 10^{-5} x^3 + 0.0038x^2 - 0.2x + 4.1.$$

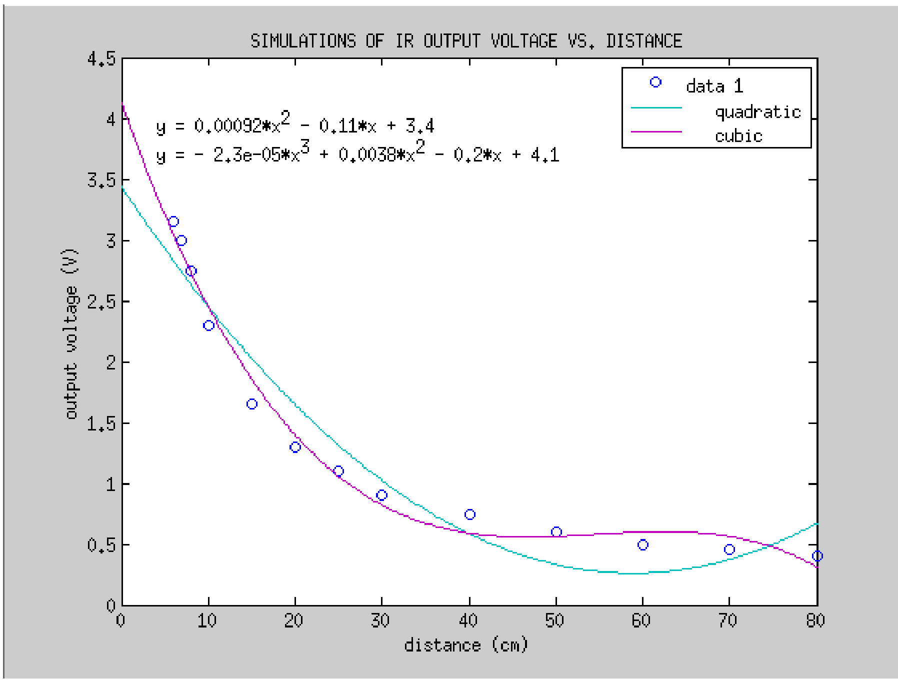


Fig 2.25 simulation of IR output voltage vs. distance

- **SIMULATIONS OF FORCE SENSING RESISTOR:**

By placing the data values into MATLAB, I got the following graph as shown in figure. The x-axis displays Force (g) and the y-axis displays conductance , also known as 1/R (1/kΩ). As the curve fitted by MATLAB. The graph most closely resembled a linear function. Hence, for linear fitting, the best-fitting line equation was

$$y = 4 \cdot 10^{-6} x + 0.0041.$$

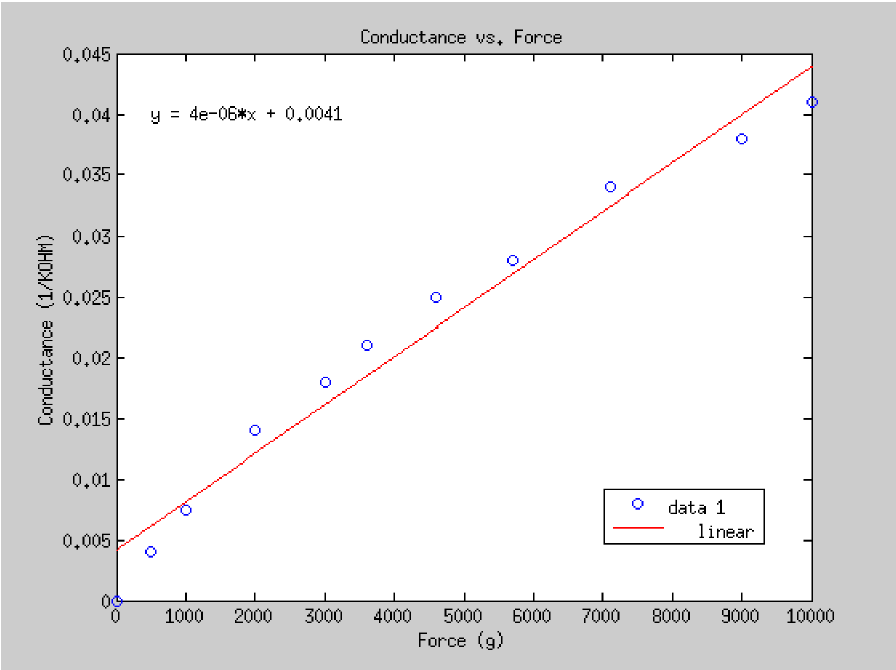


Fig 2.26 simulation of IR output voltage vs. Distance

By placing the data values into MATLAB, I got the following graph as shown in figure. The x-axis displays Force (g) and the y-axis displays VOUT based on the circuit schematic in figure 2.13. As the curve fitted by MATLAB. The graph most closely resembled a linear function. Hence, for linear fitting, the best-fitting line equation was simple, which is

$$y = 0.0001x + 0.1.$$

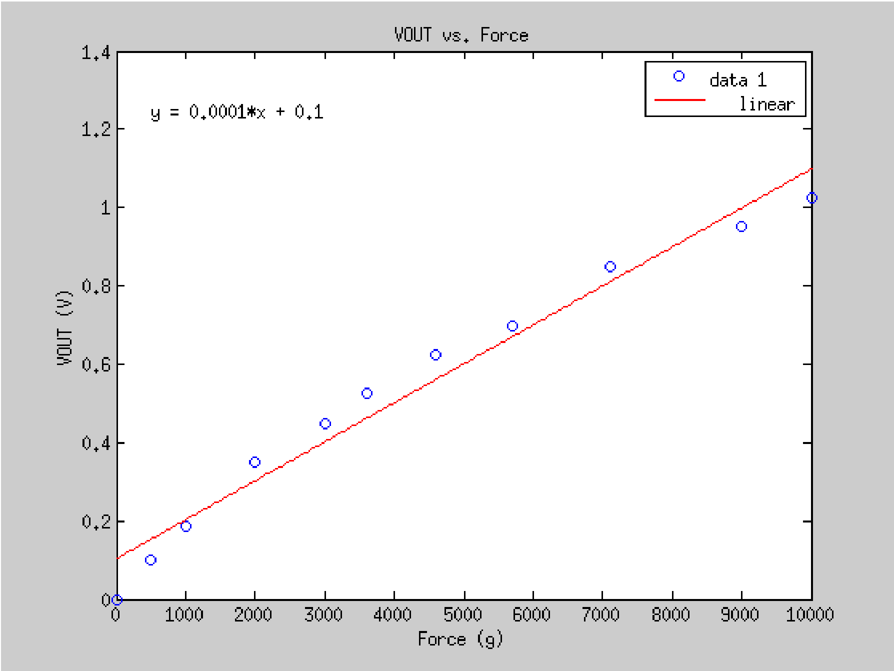


Fig 2.27 simulation of IR output voltage vs. distance

- **LID OPEN TIME ESTIMATION:**

  Pittman GM9434 motor shaft has a diameter of 0.50cm. If works under 12 V at 05 rpm, it rotates for a total distance of

  $$2 \times 0.50\text{cm} \times pi \times 105 = 329.8672\text{cm}$$

  per minute. Suppose we want the lid to be open at 90 degree from horizontal, the arc length would be

  $$\frac{30\text{cm} \times 2 \times pi}{4} = 47.1239\text{cm}$$

  where 30 cm is the length of the lid. Then ideally, it takes

  $$\frac{47.1239}{329.8672} \times 60s / min = 8.57\sec$$

  to open the lid completely. This is a little bit slow but still acceptable as long as it is less than 10 seconds.

- **HEATING WIRE CALCULATION:**

  Calculation of nichrome wire can be done online via Jacbos online: The heating wire we have has the gauge 26 and we deliberately select the voltage to be 5V which is more convenient and safe. The variables left are then length and temperature. If we have a wire of 15 inch, long then the temperature it will be heated up to is 137 degree Celsius which is a little high that may cut the trash bag directly. In this way, we can either have a longer wire or we may apply a thicker layer of teflon coating that isolate the trash bag from touching the wire directly.

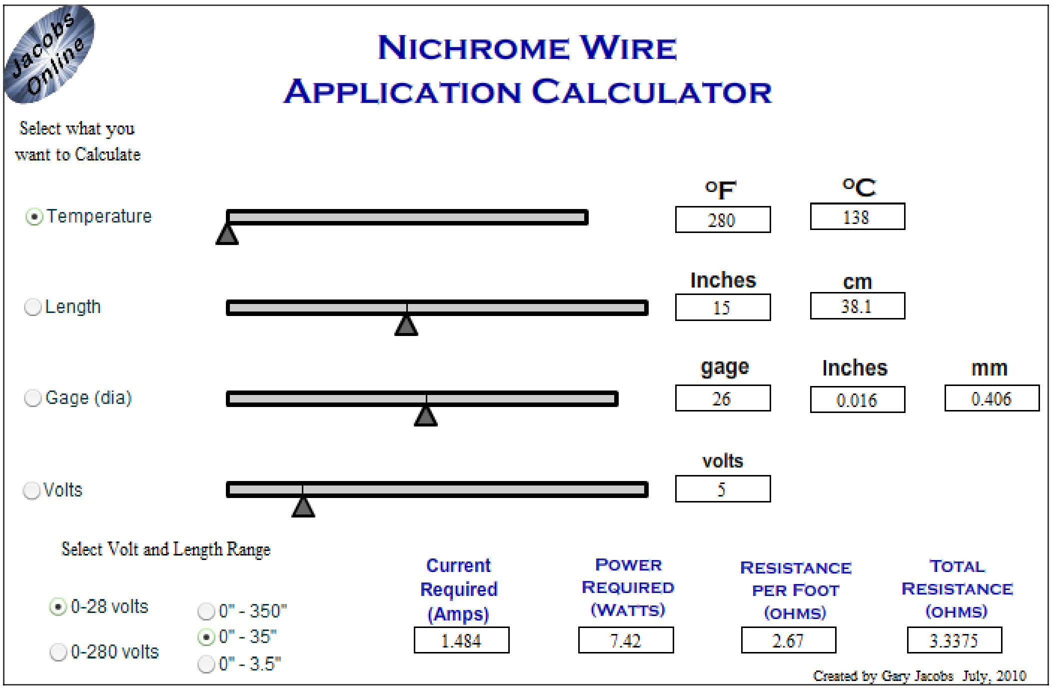


Fig 2.28 Nichrome calculation

- **POWER MODULE RESISTANCE CALCULATION:**
  For the circuit layout, we set R1 to be 240ohm and we select the value for R2. R2 is usually a slide rheostat but since we only want 5V dc, we find a constant value resistor.

  $$V_{out} = 1.25\mathrm{V} \times \left(1 + \frac{R2}{R1}\right) = 5\mathrm{V} = 1.25\mathrm{V} \times \left(1 + \frac{R2}{240\mathrm{ohm}}\right)$$

  Therefore R2= 720ohm.

3. REQUIREMENTS AND VERIFICATIONS:

3.1. REQUIREMENTS AND VERIFICATIONS:

3.1.1. SENSOR MODULE:

Block	Requirements	Verifications
Infrared Proximity Sensor	a. Is able to be powered at 5 V. b. Is able to recognize potential user within the distance of 6 cm. c. Is able to pass digital output to the MCU Module.	a. Connect the Sharp GP2Y0A21YK IR Proximity sensor Output Distance to the infrared sensor Jumper Wire - 3-Pin JST. Then connect the Sharp GP2Y0A21YK IR Proximity sensor to the ARDUINO as the schematic shown in figure 2.7. Then lead the output pin to the multimeter. b. Perform movements back and forth around 6 cm and testify if the output voltages achieves 3.15 Volts. c. Perform movements in front of the sensor within a range of 10 to 80 cm. Testify the relationship between the distance versus the output voltage according to the data sheet of Sharp GP2Y0A21YK IR Proximity sensor using ARDUINO.
Force Sensing Resistor	a. The conductance of which is able to respond to forces within the range of 100 g to 10 kg linearly. b. Is able to pass digital output to the MCU Module.	a. Connect the FSR Part No. 406 into a multimeter. Apply varying forces on the FSR. Record the produced resistance. Calculate out the corresponding conductance (inverse of resistance). Testify if the relationship between the the forces and the conductance matches the data sheet of FSR Part No. 406. b. Connect the FSR Part No. 406 to the ARDUINO as the schematic shown in the figure 2.9. Apply varying forces on the FSR. Record the produced resistance. Use ARDUINO to testify if the relationship between the forces and the resistance matches data sheet

		of FSR Part No. 406.

3.1.2. MCU MODULE:

Block	Requirements	Verifications
	a. Is able to be driven at 12V. b. Is able to send signal to Lid Module, Heat Sealing Module and LCD screen. c. Is able to receive signals from electric scale and Sensor Module	a. Connect the Arduino board to a 12V power source, the green LED should be on indicating that the board is getting power. b. For the Lid Module and the Heat Sealing Module, a program can be written on the Arduino board to send a specific sequence of signal, and the oscilloscope will be used at the receiving end to check if the signal is received. For the LCD screen, after checking the voltage of VDD, which should be 5V, and the connection of the other pins, an message will be transmitted from the Arduino board to the LCD screen to check if it will display. c. The output of the electric scale and the Sensor Module will be changed, and the oscilloscope will be used at the MCU Module side to check if there is a clear spike in the signal

3.1.3. LID MODULE:

Block	Requirements	Verifications
sealing motor	a. Is able to receive signals from MCU. b. Rotates cw or ccw according to the signal. c. Is able to stay still quickly after power off. d. Is able to be driven at12V DC.	a. Connect the input of motor to the output of the MCU, using function generator to generate square wave signals and check the response of the motor. b. Switch the input pins and check that after switch, the motor rotates in the other direction. c. Turn on the motor, make sure it’s running constantly and then shut off the power, check if the motor stops simultaneously or at least within an acceptable delay at 1~2 sec, use oscilloscope to check the wave form of the motor after power off. d. Connect the motor to a 12V DC power supply to see if it works steadily.

sealing controller	a. Is able to be driven at 5V. b. Is able to receive signals from MCU.	a. Connect H-bridge directly to 5V on bread, use multimeter to test that output current is 1A with 5% error. b. Check signal receiving ability. a) Connect H-bridge on bread board with 2 LEDs at two output terminals. b) Connect H-bridge with Arduino, use test program to change the signal input, check if only one LED is on each time. c) Do multiple switches check that LED lights are correct.

3.1.4. HEAT-SEALING MODULE:

Block	Requirements	Verifications
sealing motor	a. Is able to receive signals from MCU. b. Rotates cw or ccw according to the signal. c. Is able to stay still quickly after power off. d. Is able to be driven at12V DC.	e. Connect the input of motor to the output of the MCU, using function generator to generate square wave signals and check the response of the motor. f. Switch the input pins and check that after switch, the motor rotates in the other direction. g. Turn on the motor, make sure it's running constantly and then shut off the power, check if the motor stops simultaneously or at least within an acceptable delay at 1~2 sec, use oscilloscope to check the wave form of the motor after power off. h. Connect the motor to a 12V DC power supply to see if it works steadily.
sealing controller	a. Is able to be driven at 5V. b. Is able to receive signals from MCU.	c. Connect H-bridge directly to 5V on bread, use multimeter to test that output current is 1A with 5% error. d. Check signal receiving ability. a) Connect H-bridge on bread board with 2 LEDs at two output terminals. b) Connect H-bridge with Arduino, use test program to change the signal input, check if only one LED is on each time. c) Do multiple switches check that LED lights are correct.

Heating wire	a. Heats up to 130 ºC (130 degree Celsius is higher than the melting point of PVC bag) at 5V. b. Current goes through is under 1.5A.	1) Record the temperature a) Use thermometer to test the temperature of the nichrome wire after connects to a 5V dc power supply. b) Record the temperature until it heats up to 150 ºC, record at a period of 2 sec. 2) Connect the wire to 5V dc power supply, use multimeter to test a section of wire to check if it is under 1.5A.

3.1.5. DISPLAY MODULE:

Block	Requirements	Verifications
LCD Screen	a. Is able to be driven at 5V. b. Is able to display the desired information.	a. First the connection and voltage at VDD and Backlight+ pin will be checked, then the LCD screen will be turned on from the Arduino board, and the backlight of the LCD screen should be on b. An message will be transmitted from the Arduino board to the LCD screen to check if the display function works fine.

3.1.6. POWER MODULE:

Block	Requirements	Verifications
Power	a. voltage is constant and steady b. voltage is regulated down to 5V and 12V c. different voltage is connected to different components in need d. after power off, there’s no energy left in the	a. use an oscilloscope todetect whether voltage is constant at desirable value during a period of time b. use an oscilloscope to check the voltage outputs separately from AC/DC or DC/DC

	wire or other conductors	converters see if they match our needs c. use multimeter to check voltage at the inputs of each module d. use oscilloscope to test current at nodes of each module after power is off, make sure that capacitors in the circuit (if there is one) does not store voltage

3.2. TOLERANCE ANALYSIS:

An important feature of our design is the heat sealing part. We use a nichrome wire to seal the bag. We want the temperature to go as high as 130 degree Celsius. Voltage applied to it is 5V from a dc/dc converter. This converter chip works at a maximum of 1.5A. From fig. 2.13 we see that the current required to heat up the wire is 1.484A which is very close to 1.5A. Since this is a theoretical calculation, we want to make sure that under 1.5A, the heating power is able to supply enough energy to heat up the wire to 130 degree. If a desired temperature is not achieved by this limitation, then we could shorten the length of the wire, as long as it is above 30 cm, the heat sealing function will work well.

3.3. ETHICAL ISSUES:

Our project is to design a bio-hazard medical trash can for hospitals and school labs. We want it to safe and clean, helps protect people from bacteria and we use AC supply instead of using batteries to help protect the environment. With such functionality, we design our project consistently with the first code of the IEEE Code of Ethics:

1. to accept 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;

We introduce heat sealing into medical device. Although it has been used in other medical equipment before, it’s the first time that it comes to the trash can. We have to organize the heat sealing mechanism to suit our trash can and we use MCU to control the it and its consequences.

5. to improve the understanding of technology; its appropriate application, and potential consequences;

We do get peer reviewing and feedbacks from others and we are sincerely thankful to their help and we are willing to correct our mistakes. Also, we're willing to give suggestions to each other and to other groups if we know any.

7. to seek, accept, and offer honest criticism of technical work, to acknowledge and correct errors, and to credit properly the contributions of others;

3.4. <u>SAFETY:</u>

In order to make a worthwhile bio-hazard waste bin, we will have to make sure that it will be safe for the consumers to own and use. And for a bio-hazard waste bin, the most important safety hazard is the leak of the hazardous material. This matters to both the people using it and the people just walking by. To make sure that the hazardous material will be safely contained in the waste bin, we have taken three precautions:

- The lid will be kept closed when no one is using it. It will not be allowed to be propped open and the lid module will make sure of that.
- After a bag is full, the bag will be head sealed, preventing the hazardous material to spread before the bag is picked up by professional waste management personnel.
- The leak detection sensors on the bottom of the waste bin will immediately notify the MCU module when a leak has occurred in the waste bin, and a warning message will be outputted to the LCD display by MCU module.

Aside from the proper sealing of the waste bin, the electric safety and the safety of the heating elements also have to be considered.

As for the heating module, the main concern is that the heating wires will overheat and cause a fire. To make sure that doesn't happen, first of all during our tests we will figure out how long will it take for the heating wires to be heated to the desired temperature, which is 130° Celsius, and the MCU module will make sure that the heating time will not exceed the necessary time. And we will also add a circuit breaker in the heating module to make sure that the circuit will be protected if something goes wrong.

In order to guarantee circuit safety, the circuits in our design will use proper grounding. The grounding will serve as a means for safety because it can prevent shocks to the people who are using the waste bin in case the electrical insulation fails.

In order to make sure that our waste bin is safe of hazardous material, all the parts used in our design are compliant with the Restriction of Hazardous Substances (RoHS) Directive. And that means all components are free of lead, mercury, cadmium, hexavalent chromium, and other hazardous materials.

4. COST AND SCHEDULE:

4.1. Cost Analysis:

Name	Rate ($/hr)	Hours (hr)	Total ($)
ZEKUN LIU	30	160	30×160×2.5=12000
YANQIU YIN	30	160	30×160×2.5=12000
QIONG HU	30	160	30×160×2.5=12000
Labor Total	36000		

4.2. Parts:

Description	Specification	Manufacturer	Vendor	Price($)	Quantity	Total($)
DC Motor	GM9434G807	Pittman	Ebay	40	2	80
Nichrome 60	Gauge 26; Dia.0.0159 inch	Jacobs online	Jacobs online	3.5	1	3.5
Trash can	Rectangular step trash can	Nine stars	Walmart	20	1	20
Trash bag	4-6 Gal. medium	Glad Tall	Walmart	3	1	3
Power supply ac/dc adapter	110V-12V ac/dc	Sunforce	Amazon	34	1	34
IR sensor	GP2Y0A21Y	Sharp	Sharp	13.95	1	13.95
Force sensitive resistor	Part No. 406	FSR	Conrad	15	1	15
DC motor driver IC	SN754410	All Electronics	Alibaba	0.1	1	0.1
Arduino board	Uno R3		ArduinoECE Store	29.3	1	29.3
LCD Screen	20x4 character	Hacktronic	Amazon	13.83	1	13.83

Parts total is 212.68 USD

Grand total = parts + labor = 36000+212.68=36212.68

4.3 Schedule:

week6	prepare all materials and contact the machine shop to start building the	QIONG
	test program using Arduino	ZEKUN
	build the water leakage detection sensor. Identify the relationship between the amounts of water leaked out with the value of resistance.	YANQIU
week7	begin to write circuits on PCB's; get familiar with Eagle	QIONG
	coding on Arduino for the micro-controller	ZEKUN
	order an infrared sensor. Build applied circuit system based on its threshold.	YANQIU
week8	test and get specific data for the sealing function to work properly; write	QIONG
	finish coding, test and verify program on Arduino;	ZEKUN
	order a load sensor. Build applied circuit system based on its	YANQIU
week9	finish the circuit part, simulate and verify	QIONG
	review circuits for PCB's; order PCB's	ZEKUN
	test and simulate all of the circuit system above in Hspice or EAGLE	YANQIU
week10	spring break	
week11	assemble the PCB's and the trash can; examine auto-open-lid function	QIONG
	assemble the PCB's and the micro-controller; examine the overall functionality	ZEKUN
	order an AC to DC converter. Build a multiple input voltage system using	YANQIU
week12	tolerance analysis and verification of the mechanical function	QIONG
	test and verification of the programming part	ZEKUN
	help with Testing and Verification using lab data	YANQIU
week13	fix remaining issues and prepare for demo	QIONG
	Work on final paper	ZEKUN
	Work for presentation	YANQIU
week14	Demo	QIONG
	Continue work on final paper	ZEKUN
	Continue work for presentation	YANQIU
week15	final paper	ZEKUN
	Clean up devices and all materials	QIONG
	Continue work for presentation	YANQIU
week16	presentation;	YANQIU
	return everything	ZEKUN
	Check out	QIONG

Reference page:

1. http://www.sharpsma.com/webfm_send/1208
2. www.ti.com/lit/ds/symlink/sn754410.pdf
3. www.ti.com/lit/ds/symlink/sn754410.pdf
4. www.ti.com/lit/ds/symlink/sn754410.pdf
5. www.ti.com/lit/ds/symlink/sn754410.pdf
6. www.ti.com/lit/ds/symlink/sn754410.pdf
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8. http://itp.nyu.edu/physcomp/Labs/DCMotorControl
9. http://www.hobbyengineering.com/appHBridge1A.html
10. http://www.ehow.com/about_5313147_gear-motor.html