

# PHONE CONTROLLED AUTOMATIC PET FEEDER

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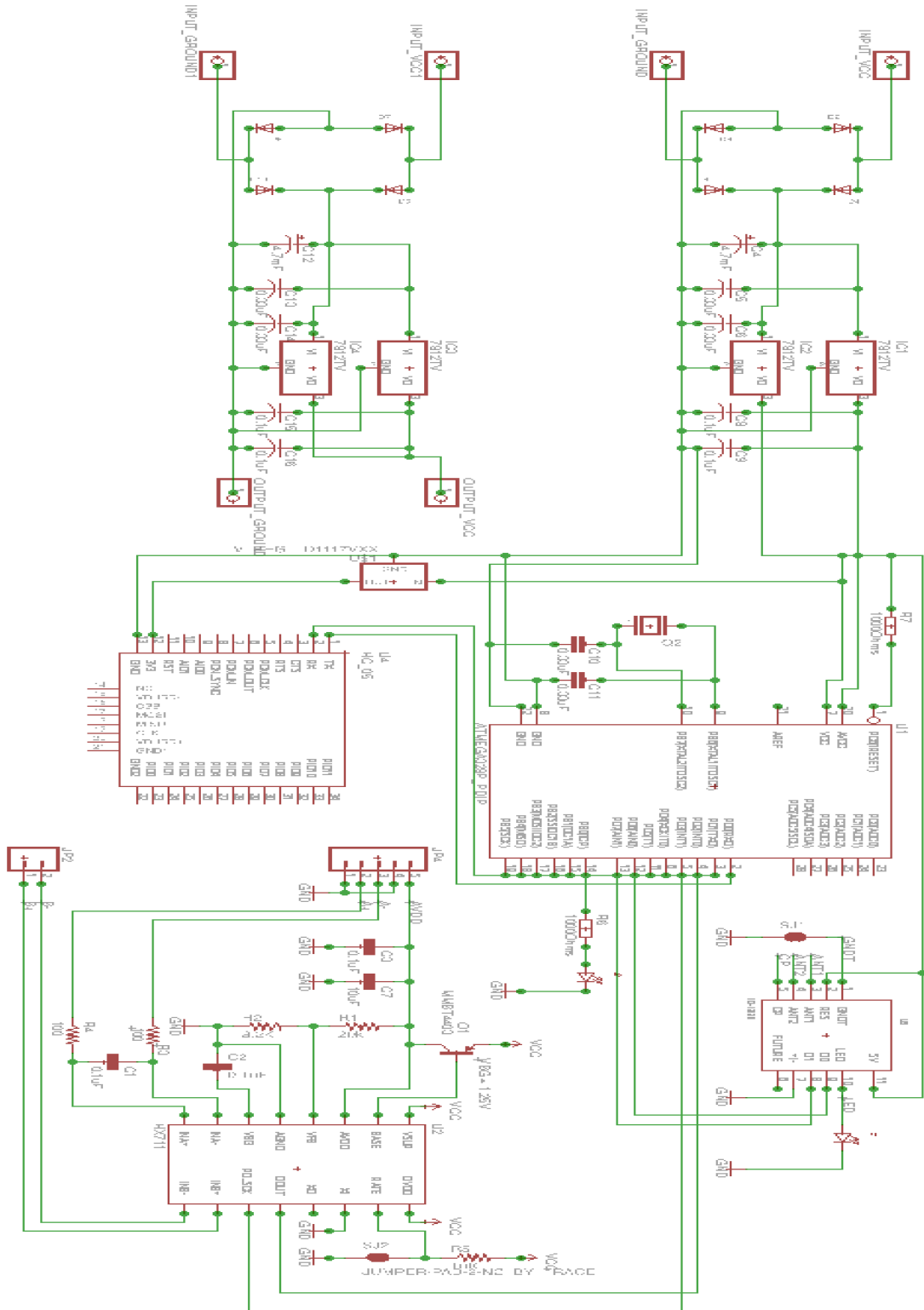
## **Abstract**

The phone controlled automatic pet feeder is meant to provide users to a way to feed their pets precisely and automatically. It consists of two parts: the hardware (actual feeder) and a compatible software running on Android. The software allows users to type in their pet's information including name, weight and feeding amount. The information will then be transmitted to the hardware where the pets can eat their food. A maximum of two pets at one time is supported. The results of the project are successful and encouraging. Testing on both software and hardware provide satisfying results. The device can distinguish different pets within a range of 15cm and dispense a specific amount of food based on the user's input.

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# 1. Introduction

## 1.1 Purpose

Feeding pets responsibly and smartly is difficult for a lot of people. The problem becomes especially obvious when the owners have a heavily occupied personal life. When owners do not have time to feed them on time, they intend to leave the feeder full before leaving. The unhealthy diet will almost always cause health problem for their pets. According to the recent research, one of the top health concerns are overeating and obesity. Younger pets are usually never satisfied and can keep eating until nothing is left. Even adult pets can have a similar habit, which causes a much shorter lifespan for the pets.

The purpose of our project is to provide an easier and more efficient way for the pet owners to feed their pets, even when they are not at home. Specifically, the aim is to build a hardware design which can automatically detect different pets, match the detected pets with the current stored pet profiles and dispense the correct kind of food at the user-specified amount. An important point is that the pet feeder can support pets from different species. The food containers and food plates are all separate so that the user can put different foods for different pets. Also, although the physical design supports only two pets at one time, the user can input multiple pets into the profile and all they need to do is to select two from them as the current feeding pets.

## 1.2 Objectives

### 1.2.1 Benefits to Customer

- More personalized experience of keeping pets
- No longer need to worry about their pets during business trips or vacations.
- No longer need to purchase multiple feeder for multiple pets.
- No longer need to worry about the cross-eating between different pets.

### 1.2.1 Functions and Features

- Allows users to input different pet's profiles into the pet feeder via Android phones.
- Different pets can be distinguished automatically throughout the feeding procedure.
- Different types of food are specified for different pets.
- Protection mode which can prevent pets getting hurt.

## 2 Design

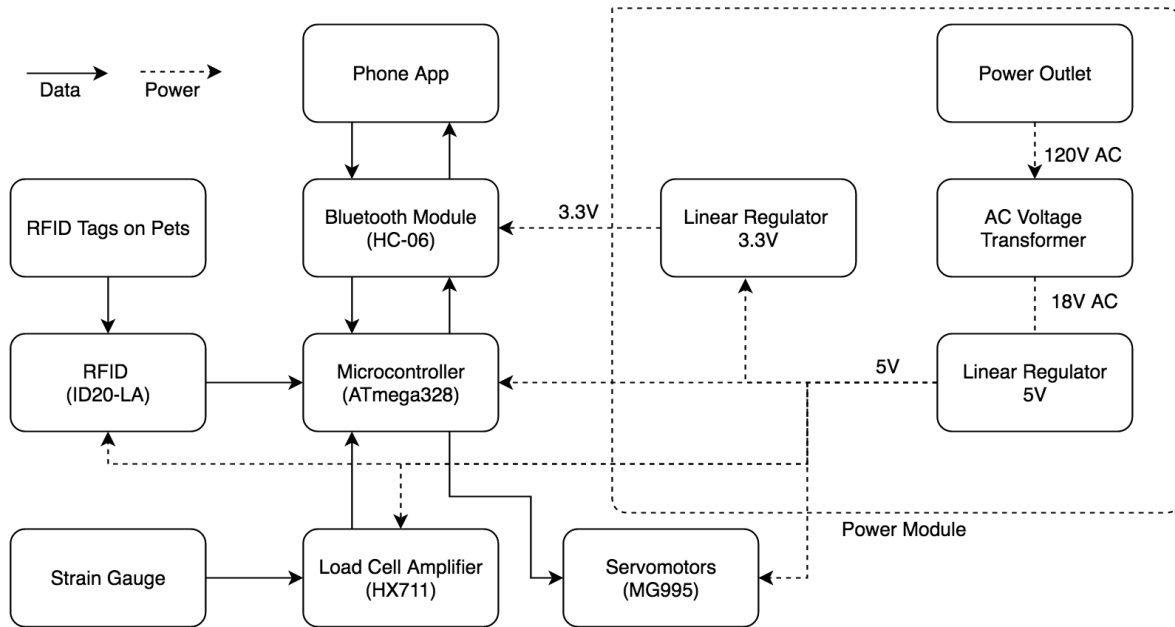


Figure 1 Block diagram for entire system

### 2.1 Power Module

#### 2.1.1 Procedure

The goal of the power module is to provide the whole system sufficient power supply. By using a AC transformer and a DC power supply circuit, we are able to power our whole system successfully. The whole module includes four steps. The first step converts the 120V AC to 18V AC; the second step converts the AC to DC but with a lot of large ripples; the third and fourth steps filtered out the ripples and produce the final output 5V DC voltage.

#### 2.1.2 Detail

The design of our power module includes four parts: AC Power Transformer, Diode Full-Wave Rectifier, Capacitor Filter and Linear Voltage regulator. It could be concluded in the flow chart below.

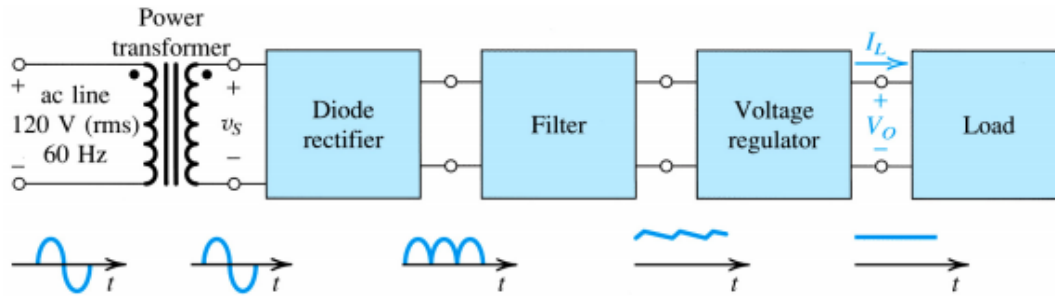


Figure 2: The general layout of the power module [6]

In the first part, an existed power transformer which can convert the 120V AC to a 18V AC was used. Another option was considered initially. It was an AC amplifier with a 4:1 ratio which could provide a 30V AC output. It was given up because we think that lower AC voltage could be more easily transformed to low DC voltage. Also a lower AC voltage would not add too much pressure on the other components. Another advantage of the current AC transformer is that it came with a switch which was used as the general switch of the whole project.

The Diode Rectifier implements a full-wave rectifier. The schematic of the rectifier circuit is shown below.

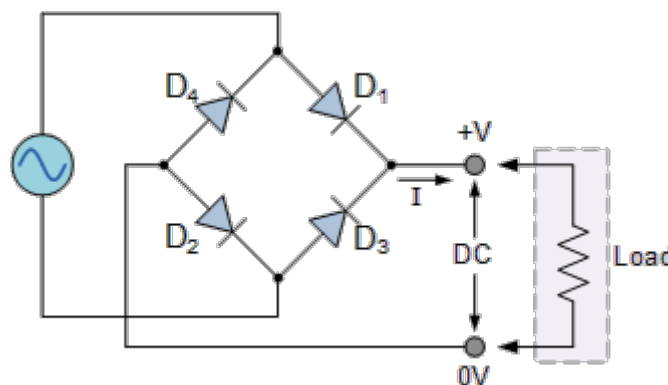


Figure 3: Schematic of the full-wave rectifier

A very large capacitor (4.7 mF) was used as the filter in our circuit. It was aimed to filter out the large ripples coming out from the rectifier and lower the pressure added on the linear regulator, which is the next step.



The linear regulator implemented here is LM7805. It provides a steady output voltage at 5V from input between 5V and 18V DC. An important point here is that two LM7805 were put in parallel in order to provide a larger current for the motors. A Zener diode was tried initially. However, we gave up on that design because the current it allowed was too small, which was not sufficient for our project.

## 2.2 Microcontroller

### 2.2.1 Procedure

The ATmega328P chip is chose as our microcontroller for it's low power consumption and fewer support hardware required comparing to other options. It also supports the in-system programming, pulse width modulation (PWM) and other functionality that fit our project requirement well. Because Arduino Uno board has the same microcontroller chip, we use Arduino Software interface as our programming tool for project building period for the easiness to debug and make changes.

### 2.2.2 Detail

The circuit is set up according to the reference circuit on the datasheet. We can load the program to the microcontroller by connecting the digital output pin 10, 11,12 and 13 to the corresponding ATmega328P. After finishing the upload, we can connect different module to the Arduino. D2-D5 pins are connected to the two load cell, D6 and D7 pins are connected to the RFID reader, D9-D11 pins are connected to the Motors and RX, TX pins are used for communication with Bluetooth. D12 is used to indicate the success of transmission between hardware and software.

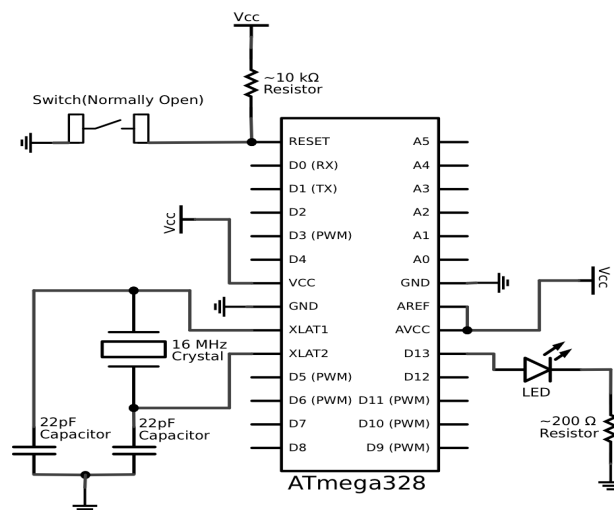


Figure 4: Schematic of the micro-controller [5]

## 2.3 Motors

### 2.3.1 Procedure

Motors are used for controlling two dispensing gates and spinning feed plate. We choose servomotor instead of DC motor because our design requires accurate spinning angle for the food plate. Servomotor is paired with inner encoder to use position feedback to control its motion and final position accurately. More specifically, we choose the MG995 high speed metal gear dual ball bearing servo. It can provide up to 10 kgf-cm stall torque, which is more than enough for our physical design.

### 2.3.2 Detail

Three MG995 motors are used in total for our design. They are all controlled by the PWM signal from microcontroller. Their least operating current draw is 100mA, with load the number will be higher. So we created a separate power source for motors, because the large current draw may compromise the performance of the microcontroller and other modules. Also the PWM input signal and power should share the same ground in order to let the motors to work correctly.

## 2.4 RFID Module

### 2.4.1 Procedure

RFID Module is used to distinguish different pets before dispensing the food. The module consists of the ID20-LA RFID unit. It requires 2.8-5V DC power supply, which is suitable for the rest of our design. It reads at 125kHz frequency and is compatible with most of the RFID tags sold in market. Its reading range is approximately 15cm. It reads the tag number of the first tag entering the reading range. It won't detect another tag until the current tag gets out of the range.

### 2.4.2 Detail

RFID is powered by the 5V DC voltage. The schematic is showed below. Pin 3 and Pin 4 are the digital output pins. They are connected to the micro-controller's digital input pins. Pin 10 is connected to a LED and then to the ground. Every time the reader reads a tag, a voltage pulse will come out from the pin 10 and make the LED blink to indicate the successful reading.

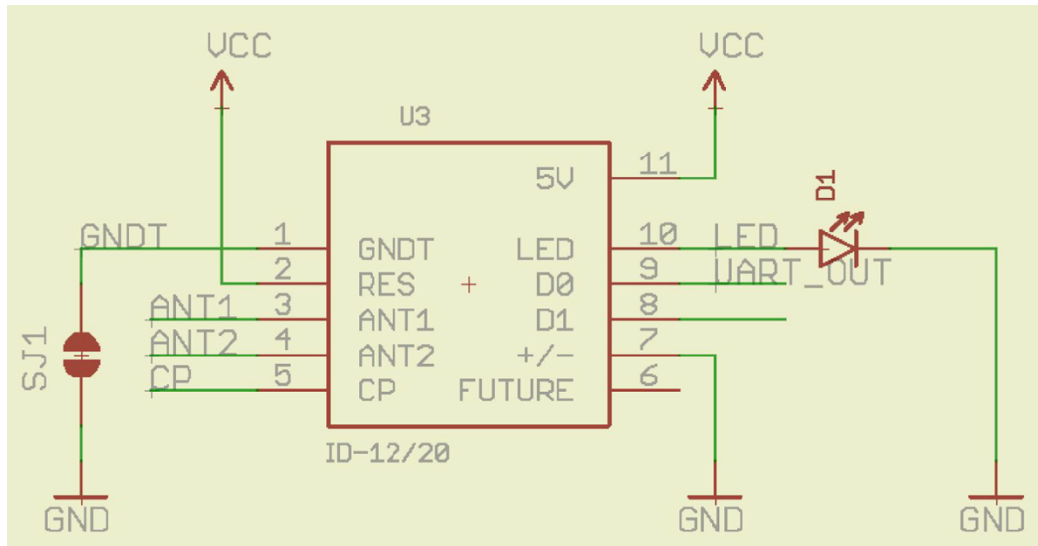


Figure 5: Schematic of the RFID

## 2.5 Load Cell Module

### 2.5.1 Procedure

To dispense the correct amount of food, load cell is needed to measure the weight on the food plate. The load cell must be able to read the weight with certain accuracy in order to allow the microcontroller to respond correctly.

### 2.5.2 Detail

Our load cell consists of two parts. First part is the strain gauge that forms Wheatstone bridge and converts the pressure on the strain gauge to electrical signals. Second part is the amplifying ADC that amplifies the analog signal from strain gauge and converts it to digital signals for microcontroller. We choose the wide bar load cell instead of disc load cell for its stability. HX711 is used for our amplifying ADC. It is designed for weight scales to interface directly with the bridge sensor. It can provide gain of 128 V/V and 24-bit analog to digital converter.

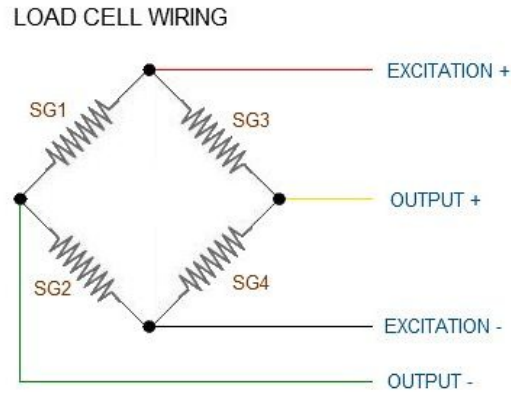


Figure 6: Schematic of the load cell wiring [1]

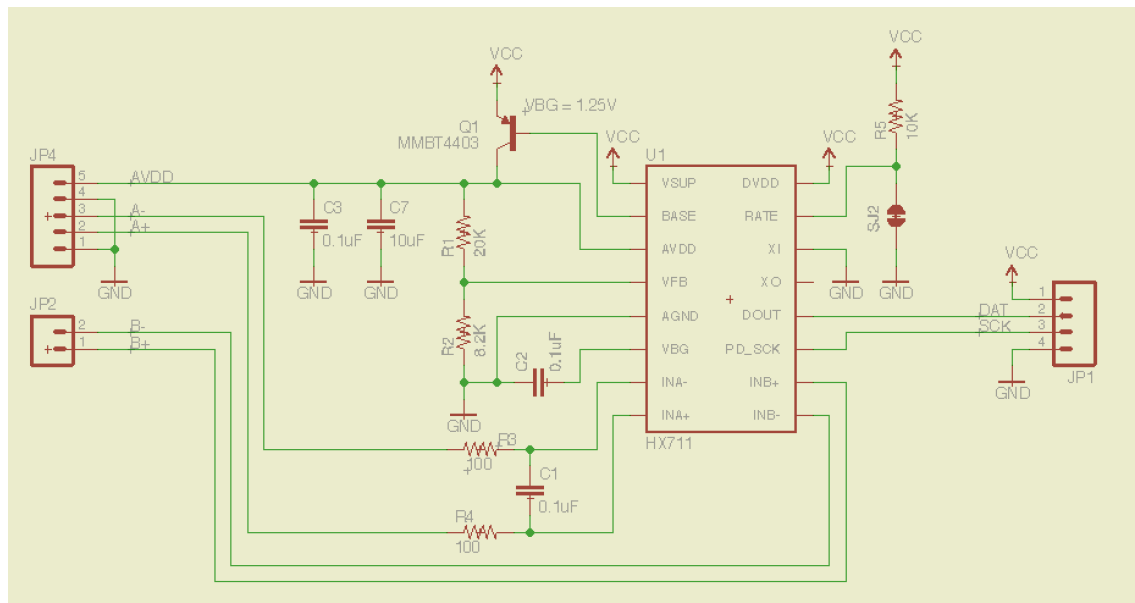


Figure 7: Schematic of the HX711 Amplifier [1]

## 2.6 Software and Bluetooth Module

### 2.6.1 Procedure

Software interface is crucial in the project. It is built in Android operation system and is the connection between the users and the pet feeder. It allows the user to enter the basic information, including the name, corresponding tag number, age, weight and feed amount into the software. The user can then choose the pets they want to transmit (maximum of 2) to the pet feeder. The transmitting is achieved through Bluetooth.

## 2.6.2 Detail

The software is built in Android and developed under Android Studio environment. It supports all the mobile phones and tablets as long as they are running Android 4.4 Kit Kat or newer version. The software homepage, showed in the graph below, has four buttons. The first button is for users to enter the pet profiles. An SQLite database is built to be the database needed for storing all the pet's information. The name of the pet is used as the unique ID in the database and all the other information is tied to this ID. More specifically, the name ID creates a Java object that contains the tag number, age, weight and feed amount values.

The second button is to let users view the pet profiles that they have entered. Technically, every time the second button is clicked, it sends a request to the database for the data. It will display all the stored pets' profiles. The user has the option to click on these pets to modify all the information except for the name. This is because each name is an object name so that it could not be changed inside the database. The user can choose up to two pets as the current selected pets at this page. It is done by clicking on the check-box next to the pet's name.

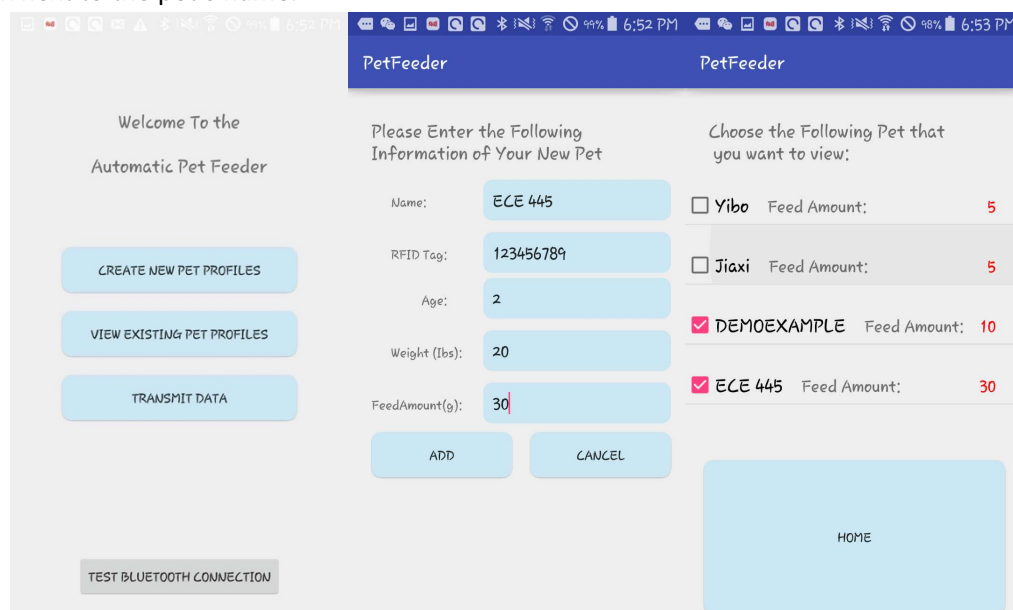


Figure 8: Software Interface

The third button is to transmit the data to the hardware via Bluetooth. The page will only show the pets that have been selected in the View page mentioned above. More specifically, if only one pet is selected, the page will only show one button with the selected pet's name on it; if two pets are selected, two buttons will appear with corresponding names.

The last button, in the grey color, is used to help users verify if the connection is successful. It could turn on or off of the testing LED connected to the micro-controller. The testing function is just an optional feature for users to verify. Because once the pet's information is successfully transmitted, a LED

indicator will be turned on permanently for verification purpose. The page interface after clicking on each button is showed in the graph below.

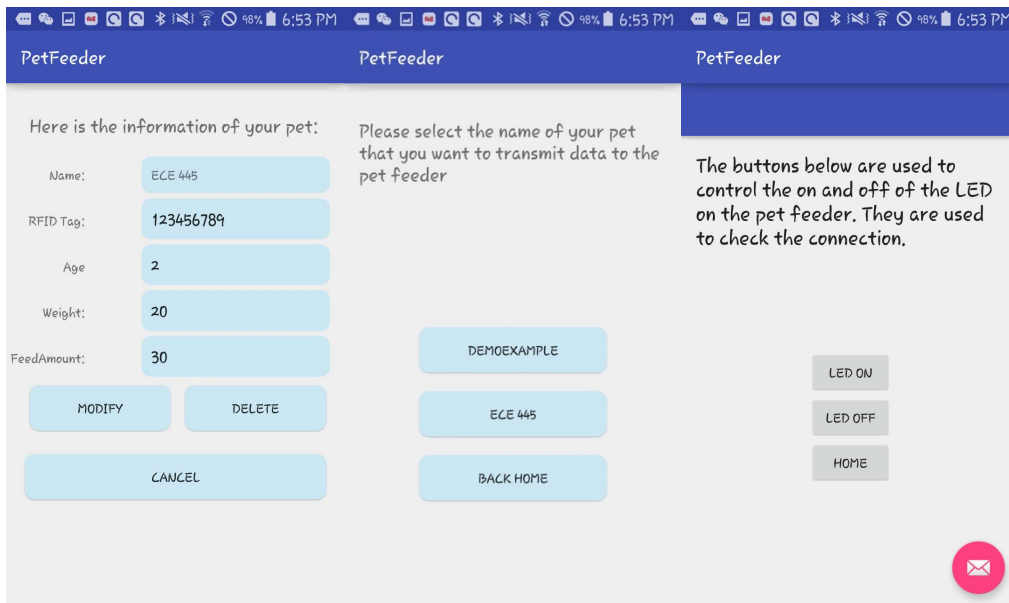


Figure 9: Software Interface

### 3. Design Verification

#### 3.1 Power Module

The output results from our power circuit is showed below.



Figure 10: Output result of the power circuit

It could be easily observed that the output voltage is very stable with a satisfying voltage and reasonably small ripples. In the R&V table, the requirement for the power circuit is to supply 5V power with ripples less than 0.25V. We believe that the requirement is met.

### 3.2 Microcontroller

To test the functionality of microcontroller, we loaded the sample blink code from Arduino library to the chip from our Arduino by ISP. Then we connected one LED to the corresponding digital output pin. The blinking LED indicates that the program has already been successfully loaded.

To test the communication between software and microcontroller, we connected another LED to one of the digital output pin. We then open the software interface, which includes one test tab to control the on and off of the LED. The LED is successfully controlled by the phone, which indicates the communication between software and hardware has already been established.

### 3.3 Motors Module

To test our motors, we wrote a simple test code to instruct the motor to move to different angles between 0 to 180 degrees continuously. The motors performed steadily without any glitches. Even we kept the test code running for ten minutes, the motor still returned to the correct location as instructed precisely.

### 3.4 Load Cell Module

For our load cell module, we require 10 grams to 2000 grams with the accuracy of 1 gram for our project. To verify the standard, we measure the weight of certain amount of pet food first. Then we gradually pour pet food into the container and the reading is responding accordingly. With the test code provided, we are able to display readings on computer through Arduino. The reading is accurate and stable enough to be used by our microcontroller. It can also provide up to 0.1gram accuracy, which is more than enough for our project.

### 3.5 RFID Module

The R&V table requires that the RFID Module should recognize the pets in the range of 5 to 15 cm. As indicated in the table, we tested the RFID module by placing the tag at 5cm, 10cm and 20cm away from the reader. The test was successful. The LED indicator blinked at 5cm and 10cm, but not at 20cm.

### 3.6 Software Module and Bluetooth Module

Three major requirements are listed in the R&V Table. The first one is that the information entered into the phone should be successfully retrieved. The second is that the information could be transmitted to the pet feeder. And the third one is that the application should work fluently with latency less than one second. With the daily testing and demo results, we believe strongly that all of these requirements have been met successfully.

## 4. Costs

### 4.1 Parts

Part	Manufacturer	Retail Cost (\$)
ATMega328P	Atmel	3*7.45
HC-06	JBtek	3*7.99
Solderable Board	ECE Store	30
ID-12LA with breakout board	ID Innovations	32.48
ID-20LA with breakout board	ID Innovations	37.44
RFID Tag	SeeedStudio	3.99
Load Cell	Uxcell	12.59
HX711	Sparkfun	2*9.95
Motors	Seguro	27.99



Arduino Uno kit	Arduino	54.99
PCB	PCB minion	90.00
Total		355.7

Table 1: Parts Cost

## 4.2 Labor

Zhuokai Zhao: \$40/hour \* 2.5 \* 150 hours = \$15,000  
 Fan Ling: \$40/hour \* 2.5 \* 150 hours = \$15,000  
 Total: \$30,000

## 5. Conclusion

### 5.1 Accomplishments

At the end of the project, we had completed a prototype that was capable of dispensing the correct amount food given by software interface, measuring the food plate and transmitting the data back to controller for feedback, detecting different RFID tags as different pets, having complete software interface for users to use and a power system that is able to power our project from wall-outlet.

### 5.2 Safety

#### 5.2.1 Electrical Concerns:

The product is powered by standard power outlet of 120V through a power cord and protected by plastic wrapping around the metal wire. If the power line is exposed to air, users should not contact the power cord directly. Instead they should turn the power off immediately and rewrap and protect the wires before any harm coming to them or their pets.

Do not place the machine in extreme heat conditions. Temperature over 70°C is extremely dangerous for microcontrollers and power system.

#### 5.2.2 Mechanical concerns:

Three servomotors are used in our product. If the exterior of the product is compromised in anyway, please replace the product immediately to prevent any injury may come to you and your pets. In particular, when the food plate is spinning to the right section of the pet food, although we have polished the structure to prevent people/pet from accidentally getting stuck in between the spinning process, please still take cautious when it spins.

## 5.3 Ethical considerations

The IEEE Code of Ethics [2] was used to guide the ethical considerations of this project

1. The Automated Pet Feeder is a pet friendly product that provide customers' pets a safe and healthy environment to feed. Pet's safety is always the top concern during the production.
2. The Automated Pet Feeder will always dispense the correct amount of food within the tolerance. This will be ensured by rigorous experiment and test before our product is being used.
3. Shortcuts in implementation will not be used at the expense of the eventual users of the product.
4. Performance of the Automated Pet Feeder will be based off the available data with honesty and relisticity.
5. All motivation behind this project is from sheer interest of producing a novel useable product. Any other forms of motivation, including bribery, will not be used to alter our desired end goal.

## 5.4 Future work

There are three main points we could improve. First we can improve our range of detection by using an antenna for our RFID reader. It will allow more response time for motors to dispense prior to the arrive of the pet and be more safe. Second we can design our PCB smarter. The size of our PCB can be a lot more space-efficient than our current design. Finally, we can improve our physical design in a more aesthetic way to attract customers. The future direction for our project should be increasing the number of pets supported by single device. We are thinking a staircase-style feeding plate for our design that supports multiple pets. If we will continue our project in the future, more compact PCB and better physical design should be the first thing for use to consider.

## References

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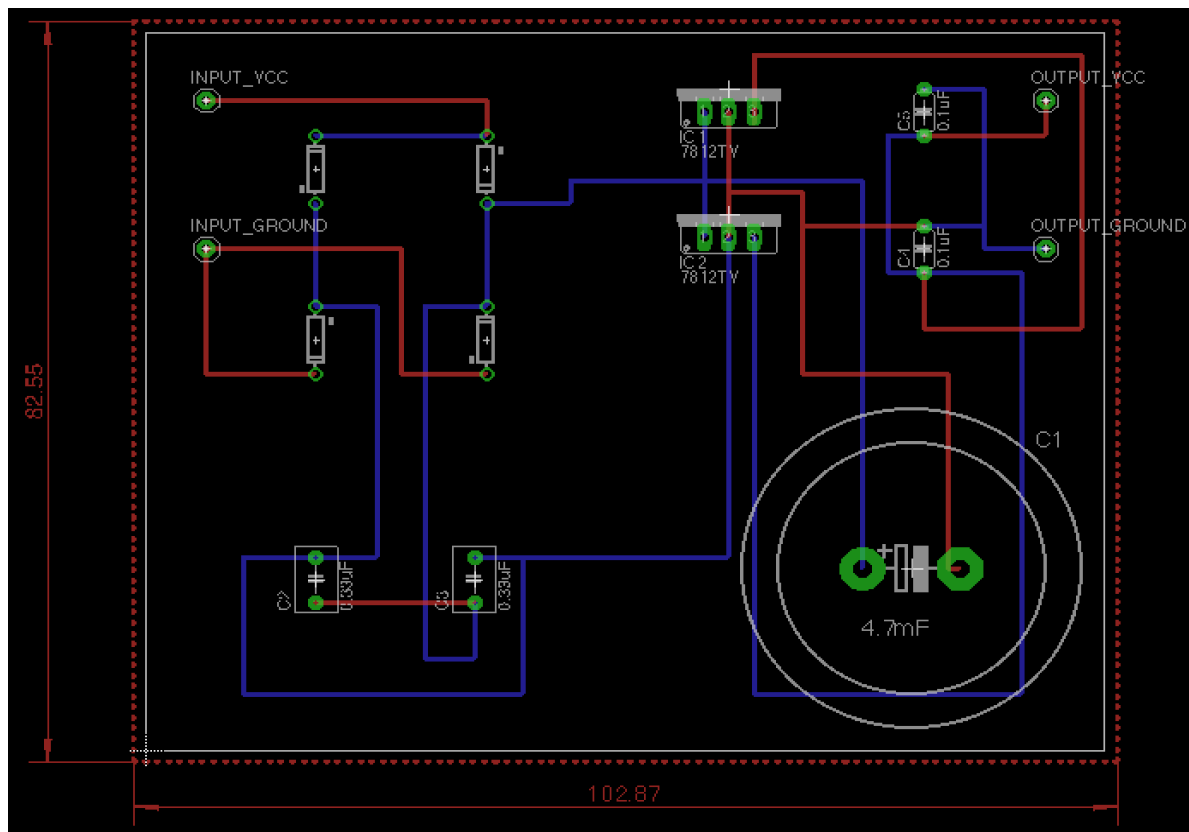
## Appendix A Requirement and Verification Table

**Table 1 System Requirements and Verifications**

Module	Requirement	Verification	Verification status (Y or N)
RFID module	Recognize the pets in the range of 10 cm +/- 5 cm. Module is implemented with a LED as an indicator	Test the RFID module by placing the tag at 5cm, 10cm, 20cm, away from the receiver. Check the functionality of the RFID module by monitoring the LED. If the LED is on only at 5cm and 10cm the functionality of the module is correct.	Y
Sensor Module	Measure the weight from 10 grams to 2000 gram. Respond to the change of weights in food containers in less than 1s.	1. Strain-gauge load cells will convert the load acting on them into electrical signals. Functionality of the module can be tested by measuring the output voltage. 2. Put 10 gram and 2000 gram food on the plate and measure the output voltage. 3. The module's electrical resistance changes in proportion to the load. Information in the datasheet and recorded voltage can be used to calculate measured force in order to ensure functionality  1. Gradually pour food into the container from 10 gram to 2000 gram. 2. Monitor the output voltage to see if there is any discontinuity.	Y
Motor Module	Be able to rotate by 180 degree clockwise or counterclockwise directions and hold. Steady performance	1. Connect the module to a Arduino first because the Motor module contains two digital servo motors that are compatible with Arduino. 2. Send 120/180 degrees and clockwise/counterclockwise direction to the input of the module from test code. 3. Check if the motor perform the corresponding instruction and hold.  1. Perform test a) 10 times	Y

		2. Check if the motor is experiencing any drift by comparing the angle from beginning and end.	
Control Module	The microcontroller should be able to program the Bluetooth module to transmit data to the software. Microcontroller should be able program the Bluetooth module to receive data from software. LED is used to verify the connection	1. Run the test code onto microcontroller via Arduino. 2. Check if the data is received by the software.  1. Send test signal from software to microcontroller 2. Check if the LED is on.	Y
Power Module	Supply 5V +/-0.25V and 3.3V +/-0.25V at a minimum of 1A +/- 0.25A	Place Digital Multimeter in parallel with the power source. Measure the voltage difference across the power source. The voltage should read 5V +/- 0.25V around Motor and 3.3V +/- 0.25V around other component. Place Digital Multimeter in series with the power source and heating elements. Measure the current difference from the power source. The current should read 1A +/- 0.25A	Y
Software Module	Writing and Reading information of the pet matches Orders can be sent to the feeder The app works fluently with latency less than 1s	1. Type (Write) in the data of one pet into the software. 2. Extract (Read) the information from the same animal whose information has just been typed in 3. Compare if the information matches  1. Put a LED on the feeder as indicator. 2. Code into hardware that whenever the input signal from the app is not null, the LED is on. 3. Check if the LED is on when writing in the pet's information  1. Tap on different option tabs, check the latency	Y

## Appendix B Power Module PCB design



## Appendix C Circuit schematic

