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Semi-Automated Biodegradation System for Polystyrene-Eating Mealworms with ESP8266 for Wireless Notification System

In Partial Fulfilment of the Course Requirements for the Degree of

Bachelor of Science in Electronics Engineering

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ABSTRACT

Non-biodegradable waste like Styrofoam or polystyrene are not being disposed properly and become together with nature which tends to cause pollution and harm. This became a long-time problem for the country. To aid some for this matter, the proponents created a semi-automated biodegradation system for polystyrene-eating mealworms with ESP8266 for wireless notification. A system that serves as shelter for the whole life cycle of the mealworms while they are degrading the Styrofoam waste. There is a corresponding container according to life stages such as darkling beetle, pupae, mealworms, and eggs. These containers are built with customized acrylic screens for the purpose of segregation by means of the vibrating motor. Two temperature-based exhaust fans are used for proper ventilation inside the system. There is also a dispenser installed with dynamo motors, containing small pieces of Styrofoam. The whole system is controlled by the Arduino Mega. Through ESP8266, there is a wireless notification system that sends information to the application called Blynk. By means of this, the owner or the user gets notified for the time of segregation, weight, and collection of frass. The Styrofoam which is made of polystyrene serves as their food for them to biodegrade it. Their frass will be used as fertilizer for the plants.

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CHAPTER 1

INTRODUCTION

This chapter presents the background of the study, the statement of the problem, the objectives, significance, and the scope and limitations of the study.

1.1 Background of the Study

One of the non-biodegradable wastes is plastic products like grocery bags, plastic bags, water bottles including Styrofoam. This wastes often undergoes a process called combustion to be disposed of. But this process contributes to global warming as it releases smoke that ends up as air pollution and can also be a cause of diseases (Bloch, 2019).

The larvae of darkling beetles are called mealworms. They hatch from eggs and will start to eat a lot to store enough energy to be used when they turn into pupa to become a full-grown beetle. Styrofoam and other plastic types are one of their diets that they can live on apart from oatmeal, cornmeal and other grains crushed into meals (Quarters, 2020). Styrofoam has the same benefit as eating a normal diet on their overall health. Thirty-four to thirty-nine milligrams of Styrofoam can be consumed by a hundred mealworms every day and that is almost 15 grams of Styrofoam every year (Imam, 2016). They can withstand up to 22-37 degree Celsius and still reproduce (Smith, 2020). They are not sensitive and easy to take care of before they turn to pupae up to 1-4 weeks and this period is when they can decompose polystyrene or also called Styrofoam.

Technology is the new aid for global challenges. Through an innovative way of thinking, issues and problems can be resolved. Efficiency of systems could be more improved and developed. Technology has a wide range of versatility. It could be a remedy for problems relating to society, even from healthcare to environmental sustainability (Optus Business, 2017).

There are many types of plastics that are produced and used every day which slowly decays through years. It became a social problem, addressing this by using short term cure and still ended up being a big problem. The discovery that mealworms can biodegrade polystyrene is now a stepping stone on decomposing a non-biodegradable material into a biodegradable one, this study will be successful by using modern technology and providing a system that will continually biodegrade these wastes by providing food and the manual interchanging of the containers for each life cycle stage of the beetle (Yang et al., 2015).

1.2 Statement of the Problem

Fourteen million tons of polystyrene are produced every year around the world and that is about 38.4 thousand tonnes every day (Solyom, 2019) and it takes 500 years or more to decompose a single styrofoam cup. It costs the local government millions to clean the mess which is called “white pollution” (Jones et al., 2020).

Styrofoam is made from polystyrene, which is a petroleum-based plastic (Syren, 2018). Why is it so bidding for the environment? Precisely to its commonality, polystyrene has contaminated and affected both the environment and human health. Styrene is a chemical that can be found in Styrofoam. This is another cause of cancer, vision and hearing loss, impaired memory and concentration and nervous system effects. In being exposed to styrene, the prolonged effects are depression, chronic headaches, fatigue and weakness, and minor effects on kidney function and blood (Lucas, 2014). When thrown away as trash, polystyrene cannot biodegrade or breakdown by other means (Syren, 2018).

It also affects animals in the wild, they have often mistaken the polystyrene as their food and ingest it. This causes them death or harm because of starvation, choking, obstructing their airways, or having buildup of chemicals in their digestive system. This can also threaten their lives by contaminating or polluting their natural habitat with polystyrene waste (Miller et al., 2009). Besides being a threat to wildlife, it can also damage landforms such as forests etc. and be a cause of climate change. That is why it can cause serious illness or can be a cause of death if it will not be eliminated (Syren, 2018).

1.3 Objective of the Study

1.3.1 General Objective:

This study mainly pursues to biodegrade polystyrene with the use of mealworms by providing a system that continually segregates and provides artificial habitat for them to develop from one stage to another and then to reproduce.

1.3.2 Specific Objectives:

The specific objectives of the study are to:

1. To design a segregation system: by modifying a container with mesh screens, gear motors, servo motors and vibrating motor, a ventilation

system; with the use of exhaust fan and thermistor, and an IOT-based notification system using ESP 8266.

2. To create a program that controls the notification system, segregation system and ventilation system using Arduino Mega.
3. To identify the return on investment of the project in selling mealworms and its frass that is used as fertilizer.

1.4 Significance of the Study

The use of polystyrene or commonly known as Styrofoam poses an impact on the environment and ecosystem (John Wiley & Sons, Inc with Andrady, 2003). Biodegradation of such material has long been a global problem as it is non-biodegradable. Eliminating styrofoams through burning emits toxic gases that causes harm to people, animals and even in the environment (Bloch, 2009). Also, burying it to the landfills even causes pollution and occupies most of the space in the area (Collier County, FL, 2020).

Therefore, the proponents introduced a study that will give benefit to the environment (TheWorldCounts, 2020) by helping in reducing the amount of white pollution. This study uses less time and energy in breaking down Styrofoam than using other solutions. Providing a system for the polystyrene-eating mealworms where they can biodegrade Styrofoam.

1.5 Scope and Limitations of the Study

This study pursues to create a device that can be used in decomposing polystyrene with the use of yellow mealworms. The device uses an Arduino Mega to control the installed ventilation fans, the vibrating motor; that segregates the mealworms and its wastes, the servo motors; that will open the platform doors periodically, and the gear motors; that will dispense the food. It also uses ESP 8266 for wireless notification that sends a message to the owner's phone to notify that the manual transferring of the collected mealworms on the movable bin is needed to be done to complete the segregation according to its life stages and that the frass of the mealworms are ready for collection. Expanded Polystyrene (EPS) and Extruded Polystyrene (XPS) are the only plastic that will be fed to the larvae. This may not be a permanent solution but instead it will be an urgent solution to a problem needed to be solved immediately in a faster and more efficient way.

1.6 Definition of Terms

- Darkling Beetle - are considered scavengers and are among the largest insects that infest stored products. Most prefer to feed on decaying grain or milled cereals in damp, poor conditions. These insects are usually found in places not frequently disturbed such as dark corners, under sacks, in bins and where feed is stored. They are robust, black and nearly 3/4-inch-long, resembling many ground beetles in size, shape and color (Bennett, 2003).
- ESP 8266 - can give any microcontroller access to a WiFi network (SparkFun Electronics, 2020).
- Expanded Polystyrene (EPS) - includes the most well-known and common types of polystyrene to include styrofoam and packing peanuts (Rogers, 2015).
- Extruded Polystyrene (XPS)- is a higher density foam typically used in applications like architectural building models (Rogers, 2015).

- Mealworm - has a smooth, highly polished, shiny, elongate, hard, cylindrical (wormlike) body. Yellow mealworm adults are shiny, dark-brown or black, whereas dark mealworm adults are dull, pitchy black (Bennett, 2003).
- Polystyrene - is a petroleum-based plastic made from the styrene monomer (Collier County, FL, 2020).

CHAPTER 2

REVIEW OF RELATED LITERATURE

Mealworms are often used as food for the spiders, rodents, reptiles, birds, fish and small mammals in zoological gardens and aquariums. It is also edible and can be a source of protein for humans. According to Ramos-Elorduy, the conversion of ingested food by the Tenebrio molitors has a higher efficiency than the livestock and chicken. Tenebrio molitor has an efficiency rate of 53-73% while the livestock and chicken have 10-12% and 38-43% respectively. One of the most farmed edible insects in Europe is the mealworm Larvae of Tenebrio molitor (Imathiu, 2020).

2.1 Mealworms

Figure 1. Mealworm

(The Serpentarium, Inc., 2020)

Tenebrio molitor also known as the mealworms in the pet trade is one of the 350,000 species of beetle. Its body is dark yellow and composed of brown stripes or bands. It has six tiny legs which are placed in front of its body and has two tiny antennae. The body of a mealworm looks fluffy on the outside, but it has a hard body called exoskeleton (Swanson, 2019) and its purpose is to protect their inner body when they are burrowing the ground like other worms. Like some animals, mealworms also shed layers of their skin between 10 to 20 times making way for them to grow. This shredded skin also serves as their bedding (Tran et al., 2019).

2.2 Life Cycle of the Mealworm

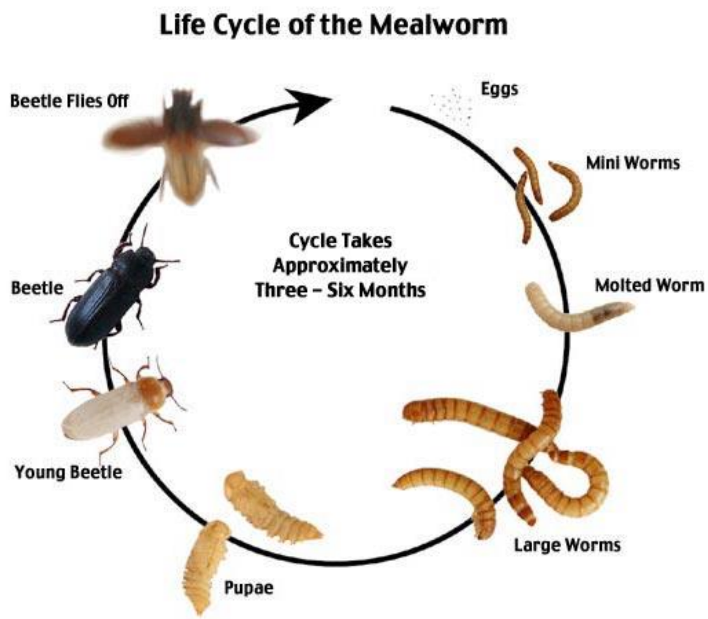


Figure 2. Life Cycle of the Mealworm (eflinch.com, 2020)

A darkling beetle has four distinct stages of life and like butterflies, a darkling beetle also experiences complete metamorphosis. Egg, larva, pupa, and beetle are the four stages. The span of time per stage changes and it depends on how their body reacts to the temperature, food, water, and other environmental factors.

For the adult beetle to produce eggs after it turns out as a beetle from the cocoon, it needs two weeks to mate. Over their entire life, a female beetle can only produce 500 eggs and between 100-200 at a time (Kvassay, 2017). It is necessary to separate the adult beetles from the eggs after laying because they can be mistaken as their food and it takes 1-4 weeks for the eggs to be hatched and the mini mealworms to appear.

As the mealworms undergo molting, it appears white and the new skin hardens quickly and serves as their new protection. It is necessary to separate the large mealworms from the small mealworms because they can be mistaken as their food like the beetle to the eggs. After 7-10 months, the mealworms become pupae. As it molts its last skin, the mealworms curl up its body into its pupal form. This stage takes up to 1-3 weeks and they don't need food neither direct moisture nor humid. The creamy white pupae began to become brown as it approached its hatchling period. 2-3 weeks after having hatched the white beetle turns into brown and they are ready for mating and for producing eggs. During mating, the male injects the female with a packet of semen (Ward's Science, 2008). The eggs mixed in with the poo or frass that is why the eggs must be hatched before segregating it with the poo (Kvassay, 2017).

2.3 Types of Mealworms

Yellow mealworms (Tenebrionidae molitor) and dark mealworms (Tenebrio obscurus) are types of mealworms. There's a distinct habitat for each type. The yellow mealworm is the form generally observed growing in containers of grain and spoiled food. The existence of denser punctures on the head and pronotum than on the yellow can distinguish from dark mealworms. Adults with yellow mealworms are bright, dark-brown or black, while adults with dark mealworms are dull, pitchy black. Eggs are white, bean-like and approximately 1/20 inch long. At first, pupae are white, turning yellow, and in a case or cocoon they are not enclosed. Also, adult beetles are attracted to night lights, strong fliers and found in dark places (Bennett, 2003).

Figure 3 . Types of Mealworms

(Home Quicks & Buzzle.com, Inc., 2020)

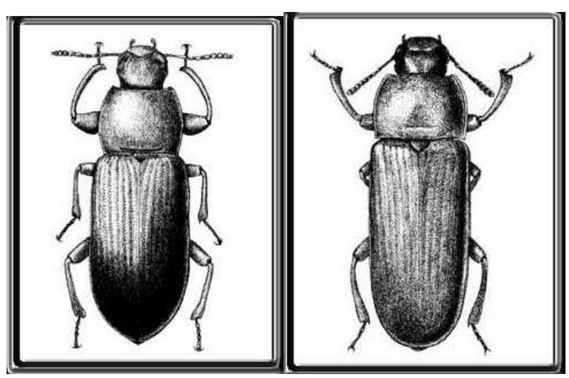


Figure 4. Dark mealworm beetle (left side) and Yellow mealworm beetle (Right side)

(Bennett, 2003)

2.4 Factors that affects the Mealworms

Having polystyrene as their food can cause them a decrease in fecundity. The beetles produce a smaller number of eggs. In relation to their mortality, eating EPS and XPS did not give much of a significant effect. But comparing their weights, the mealworms that eat XPS are lighter than the mealworms that eat EPS. The mealworms are still worth it to be considered as a means for biodegradation of Styrofoam (Kanedi et al., 2017).

Moisture and relative humidity are also a factor that should be considered for the growth of the mealworms. Having too little moisture can cause them to grow slower and having too much moisture will result in producing a mold which is not good for them. The ideal percentage of relative humidity for the beetles to lay more eggs is 70% (55% - 80%). For the mealworms, between 90% to 100% relative humidity can make them more active. They should also eat foods that can be a source of their water like cabbage, potato, carrots, and others. And the dead mealworms, pupae and beetles should be removed to keep the other safe and clean.

Mealworms are known to be ectothermic, which means the regulation of their body temperature depends on the external sources. Their metabolism correlates with the temperature of their environment. When the mealworms are at a high temperature, their metabolic rate is also high. But when they are at a lower temperature, they also have a lower metabolic rate (Bowman et al., 2016).

2.5 Related Literature

2.5.1 Automatic Pet Feeder Using Arduino

Many people nowadays are fond of having their own pet at home. But not all these people are free to just focus on their pet alone. Everyone has different schedules. Despite all the busy schedules, pets still need to be taken care of properly. One of their necessities is food, every pet should not be left to starve even when the owner is busy. Due to this issue, an automatic pet feeding system was introduced to the industry. A machine that could feed a pet even if the owner is not around. It is mainly composed of a servo motor which is used to deliver the food from the storage to the feeding bowl, and the Arduino UNO to control the servo motor. Time could be set when to feed a pet.

The system in this study regarding polystyrene biodegradation, Styrofoam will be fed to the mealworms automatically. Dynamo motor is used instead of servo motor to bring the Styrofoam to different containers according to their life stages. To control the dynamo motor, it is connected to the Arduino Mega and operates based on its programmed time period (Tiwari et al., 2018).

2.5.2 Biodegradation of Polystyrene Waste by Mealworms

It has recently been proven that the larvae of Tenebrio molitor Linnaeus which are the mealworms can eat a common polystyrene product, the Styrofoam. Tenebrio molitor is indigenous in Europe, but cosmopolitan in distribution. They are found to be one of the largest pests in the stored-grain products. Mealworms or the larvae of Tenebrio molitor are efficient for Styrofoam degradation because of the microorganisms in their body. An experiment of biodegrading three types of food packaging plastic by means of mealworms is conducted. The polystyrene (PS), polyvinyl chloride (PVC) and polylactide (PLA). In the experiment, mealworms are divided into three groups and were fed on three different types of plastic, while a different set of mealworms were fed on oatmeal. The factors being assessed in the said experiment are the mass loss, the dry matter content and the biochemical composition of mealworms. Bradford method was used to determine the protein concentration in homogenates of the larvae. Anthrone method for the level of hydrolyzed carbohydrates. And to quantitate the total lipids of the mealworms, sulfo-phospho-vanillin assay (SPVA) was used. The efficiency of the mealworms in decomposing the other types of polymer has been able to compare through the results given by the said experiment and their mechanism in decomposing it. This could contribute to plastic waste disposal by means of mealworms or the larvae of Tenebrio Molitor (Wróbel et al., 2017).

2.5.3 Microbes that Biodegrade Polystyrene on Mealworms' Gut

The proponents of this study have devised a setup that screens the microbes on guts of Tenebrio molitor and Zophobas morio which can feed on and digest polystyrene as its diet. The researchers studied the special microbes with the use of pre-sensitized plate and pre-sensitized turbidity system with time courses. They named the strains collected TM1 and ZM1, respectively using 16S rDNA sequencing.

Data and analyzation through microscope suggest that TM1 and ZM1 were Gram-negative bacteria, cocci-like and short rod shape.

Moreover, the PS plate and turbidity assay tests proved that TM1 and ZM1 could utilize polystyrene as their carbon supply.

The researcher concluded that their study of PS degraded enzyme and cloning sought their attention in solving the problem dealing with yet to be discovered solution to the problem of mealworms ability to digest polystyrene (Tang et al., 2017).

2.5.4 Segregation System using Mesh Screen and Vibrating Motor

In the mining industry, there are several processes to extract the minerals from the ground. Different tools are used for mining, like shovels, pickaxes, chisels, hammers, and others. Nowadays, the machinery for the mining industry continues to develop. High technologies are used to improve the new machinery for mining. Operations are being enhanced by sophisticated technology. In the mining machinery, the vibrating screen machines have a big contribution for the mineral processing. Extracting the minerals from the grounds became more developed because of these vibrating screen machines. This machinery is used to separate the minerals from the ground. This kind of segregation can be an idea in creating a biodegradation system since its main purpose is to set apart things from each other.

In relation to the mealworms as a means for polystyrene biodegradation, this vibrating screen could also be used for the system in separating them in their different life stages. Developing the vibrating screen by applying different sizes of mesh on the screen to be used for sifting them. Separating them according to their stages. The vibrating motor will also help in segregation by putting a vibrating force on the containers causing it to move back and forth while filtering. (Makinde et al., 2015)

2.5.5 Temperature Based Automatic Fan Speed Controller

A simple device with rotating blades that moves the air around which is also called a fan. It usually has different speeds of rotation. Users tend to adjust the rotating speed of the blade as the temperature in the surroundings get higher. The common way of adjusting the fan speed is by manually switching it to another level. This study is all about developing the operation of a fan. Instead of manual operation, they make it automatic. The fan speed changes automatically due to the temperature sensor. This type of sensor reacts according to the environment temperature that it senses. When the temperature gets high or hotter, the fan speed automatically increases. By this newly developed system, the user doesn’t have to adjust the fan manually. It will automatically adjust based on the temperature of the environment (Nigade et al., 2016).

2.5.6 The Hive Explorer: The Smart Insect Farm for Starter

The global increase in demand for meat or beef and the limited land area available prompt the search for alternative protein sources. Edible insect species for food and feed have several advantages. Insects as an alternative protein source of nutrients as human food and animal feed are interesting in terms of high feed conversion efficiency, low greenhouse gas emissions, plant protein resources and crop nutritional improvement.

The Hive Explorer is a smart insect farm and micro-ecosystem for mealworms with educational value and portable to use at home. It helps you to recycle your food waste into fertilizer and protein. Like mealworms it seems difficult and overwhelming for beginners to culture. LIVIN farms empower people to begin farming insects. Their goal is usually to design technology and education value to help feed in a sustainable and healthy way by using farming insects. The device component is a set of microcontrollers and sensors that give the perfect environment for the mealworms to grow effectively. The machine content by lifecycle from beetles into eggs (Nock, 2018).

Figure 5. Mealworms farm upcycle to food waste (LIVIN Farms, 2020)

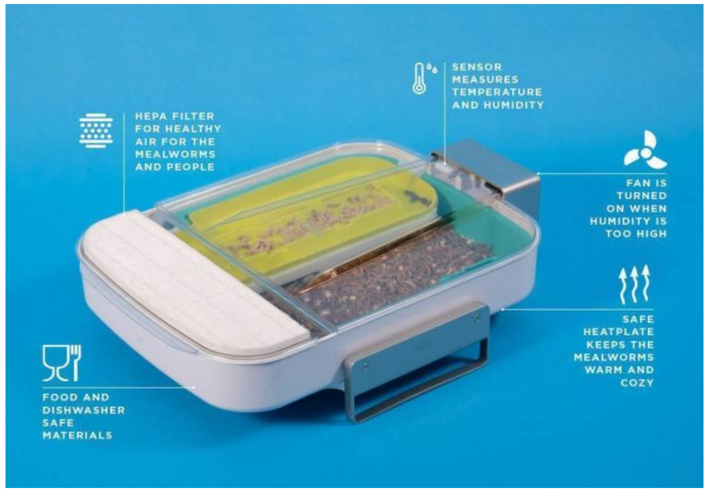


Figure 6. Hive Explorer (LIVIN Farms, 2020)

The LIVIN Farms developed a kitchen appliance for a sustainable and healthy alternative source of protein. The system is fed on vegetable craps and oats, continuously producing 200-500g of mealworms per week. Two billion people around the world commonly found in parts of Africa, Latin America and Asia that usually eat insects as part of their diets.

It uses ventilation fans to maintain the optimum micro-climate and reduce odors it gets from the mealworms dirt trays and sensors to measure the temperature and humidity. The system design is easy to use for raising and harvest mealworms (Irvine, 2015).

In relation to the project study, a semi-automated biodegradation system will be applied. The transferring of the bin will be done manually and the feeding of the mealworms will be automated, together with the controlling of the fan for ventilation, the vibration for separation of the life stages and the wireless notification system for informing the user whether the transferring of the bin is needed to be done and when the frass is to be collected.

2.5.7 Wireless Smoke Detector and Fire Alarm System

One of the major causes of accidents is fire. Precious lives and valuable properties had been lost and greatly damaged because of this unwanted accident. Since fire could spread in just a little period of time, a system was developed to help in preventing the accident from happening by timely detection. This project study is a system that detects smoke through the use of a smoke detector and senses the rise of temperature using LM35. The data gathered by the sensors will be sent to the controller. And by means of the ESP 8266 which is a Wi-Fi module, it provides the android phone and the controller a wireless connection between the two. A command will be sent to the virtual terminal of the android phone of the user to give notification. Then the fan will be activated to remove the smoke in the area. Also, an alarm will buzz to notify the people around the area regarding the near accident to immediately evacuate and perform countermeasures. In relation to the proponents' study, the idea of using ESP 8266 for wireless notification has been adapted. The ESP 8266 is connected to the weight sensor and sends the data to an android mobile application to monitor and notify the user of the project when the frass is ready to be collected. Also, the temperature sensor is being connected to the Wi-Fi module to monitor the temperature inside and to the Arduino Mega which controls the speed of the fan for a well-ventilated system (Shah et al., 2019).

CHAPTER 3

METHODOLOGY

3.1 Introduction

This chapter presents the methods and procedures used for the study which includes needed data and information of the project; development and implementation and other research techniques employed; the materials and equipment used; the software and algorithm; the circuit designs; the design flow processes in making the overall system.

3.2 Theoretical Framework

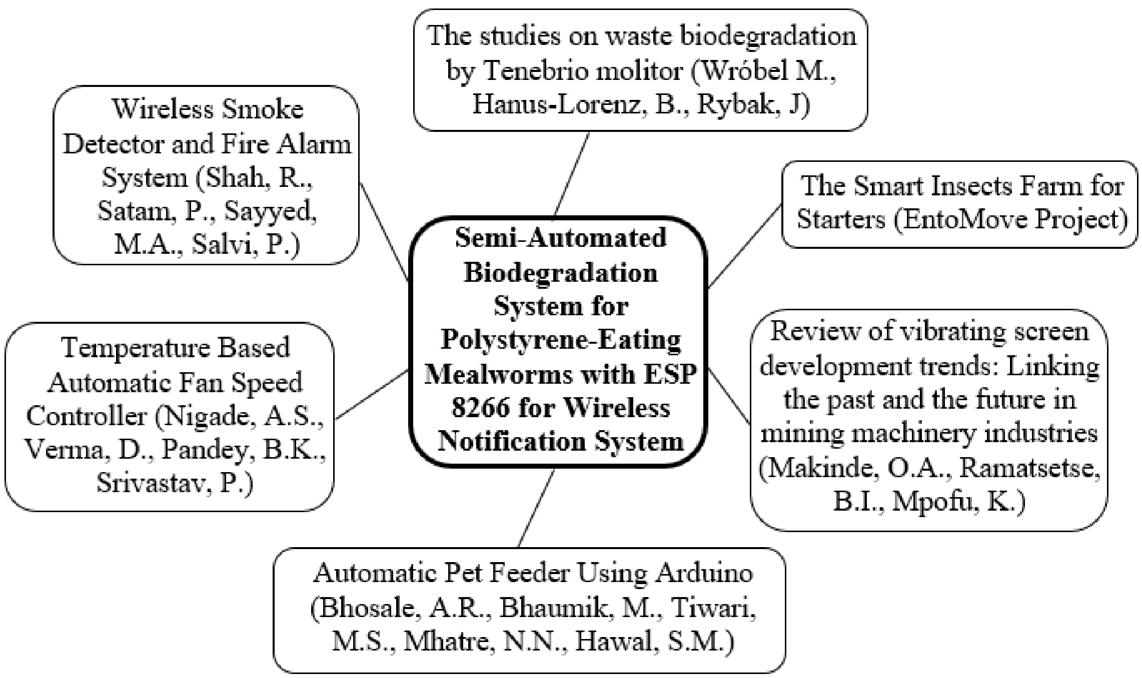


Figure 7. Block Diagram of Related Studies

The presented journals have been used as guides to conduct the research study. These related studies are the sources of information about how mealworms perform biodegradation and how they act on captivity, analyzing vibration and screen system, dispensing food automatically, controlling the speed of a fan, and sending notification to the user.

3.3 Conceptual Framework of the Study

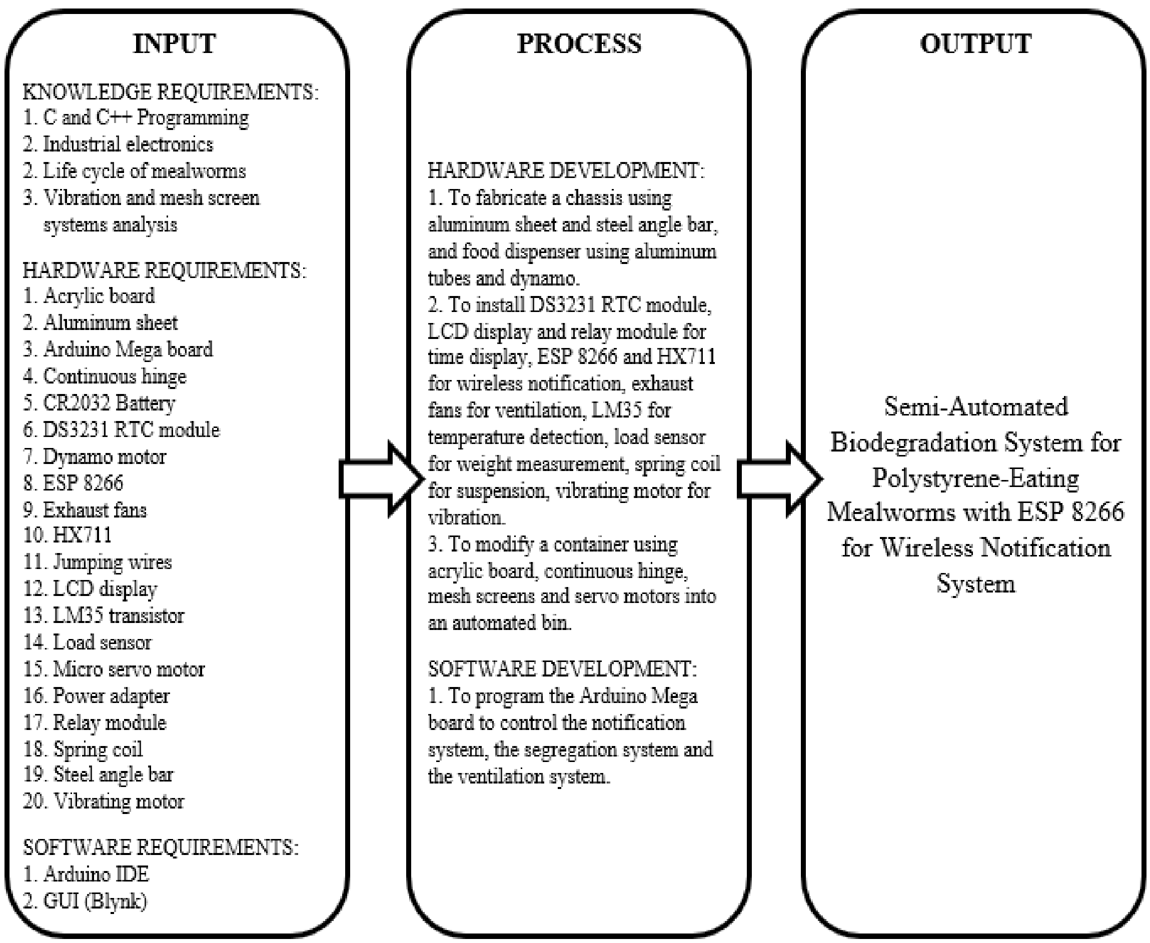


Figure 8. Input-Process-Output Diagram

The main objective of the project is to design a machine that biodegrades polystyrene using mealworms and to culture them at the same time. Knowledge about the life cycle and the factors that affect them is to be considered when taking care of mealworms and is very important in this project. The main components of this machine are Arduino Mega Board with ESP 8266, DS3231 RTC with CR2032 battery, dynamo motors, exhaust fans, jumping wires, power adapter, servo motors and vibrating motor. The system will manage mealworms by feeding them polystyrene which will cause a gradual decrease in its disposal in the environment.

3.4 Research Design

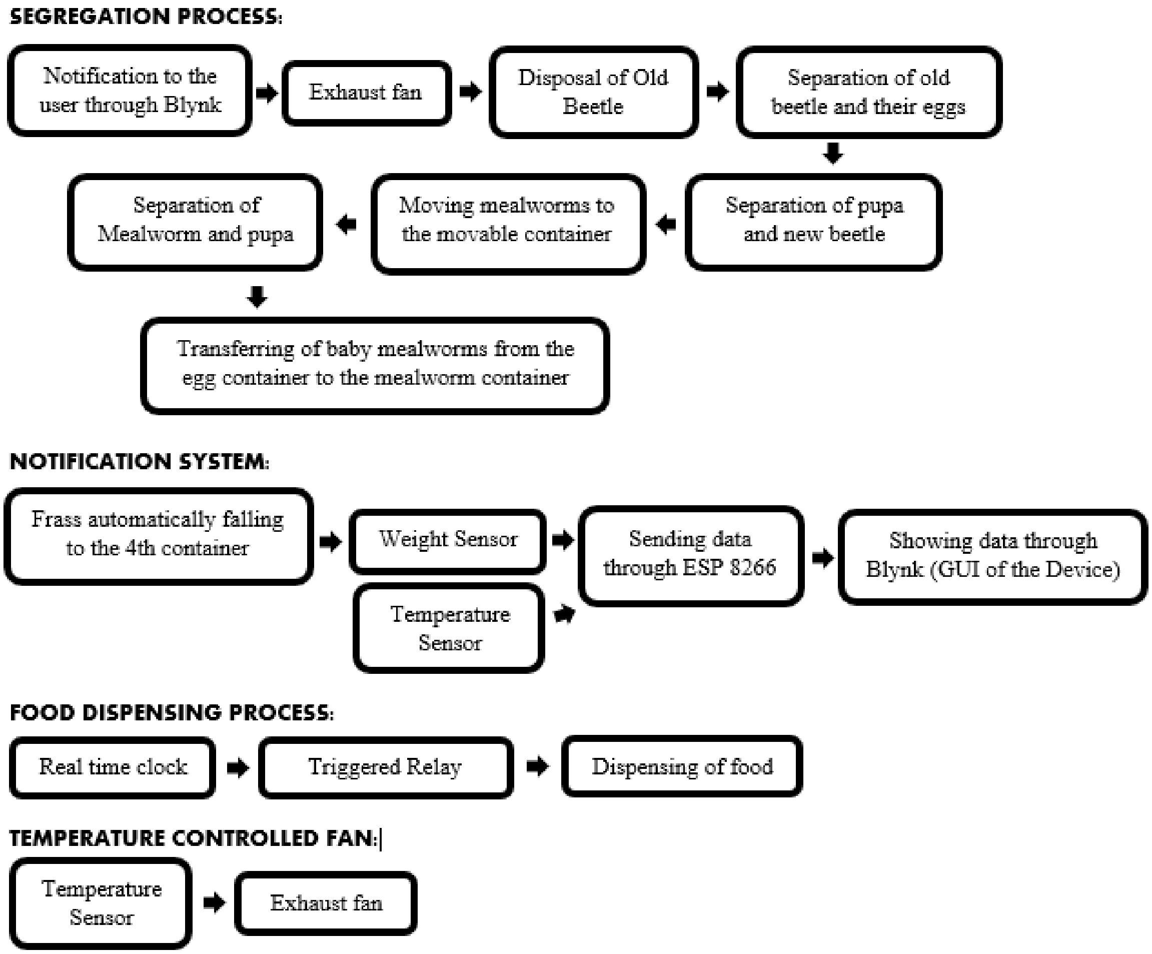


Figure 9. System Block Diagram

The design of the project is a sequence that will feed, segregate, and ventilate the mealworms. It will also inform the owner the status of operation and updates about the mealworms. It would notify the owner, disable the ventilation, dispose of the old beetles, deploy the new beetle, transfer the mealworms, activate the vibration, and then feed the mealworms. The vibration then will stop, and the feeding will start. Lastly, the ventilation will be activated and will be controlled by the sensor once again.

3.4.1 Hardware Construction

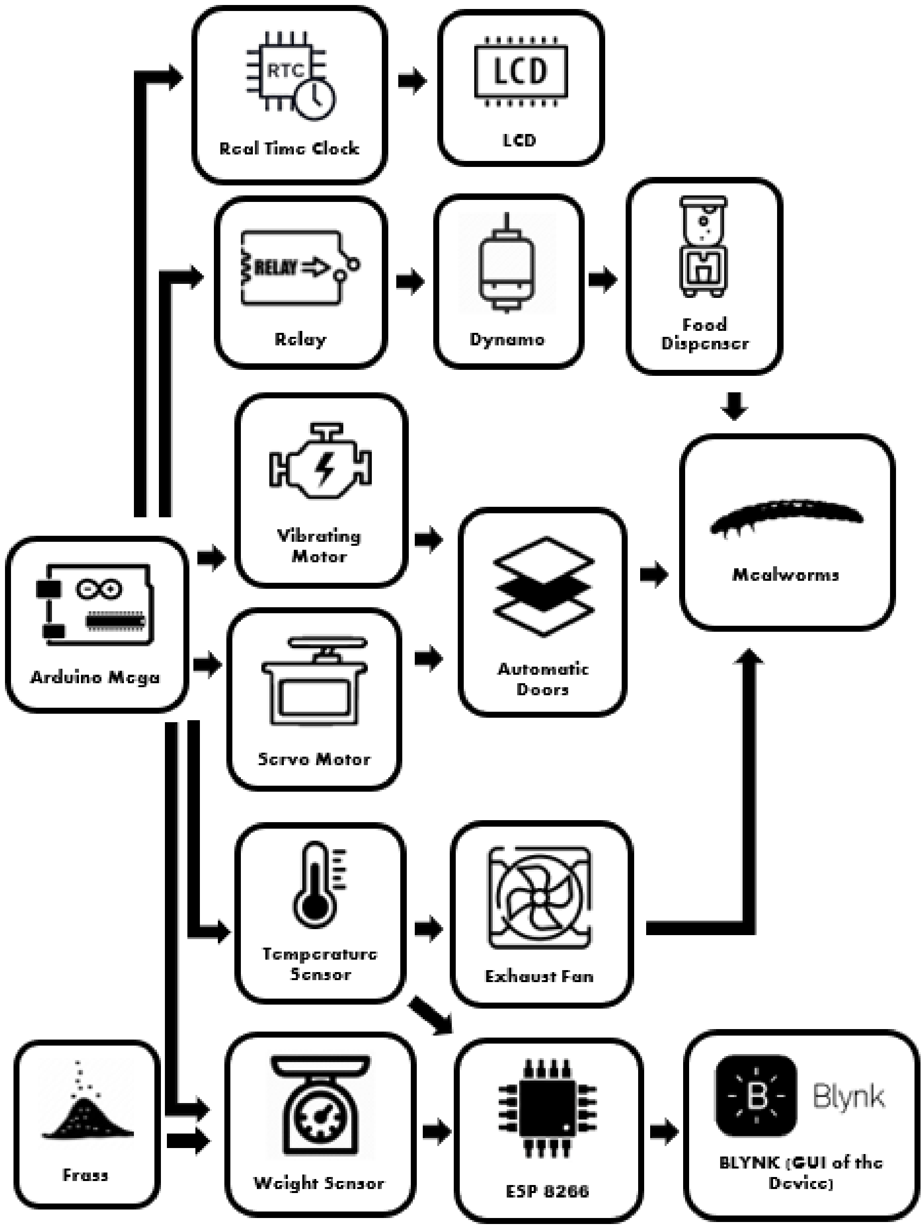


Figure 10. Hardware Block Diagram

The proponents will start by integrating the platforms using dynamo motors, servo motors and a vibrating motor that will be the feeding and segregation mechanism of the system. Then, the fabrication of the main frame with spring coil for suspension and aluminum sheet as chassis. Finally, the installation of the ESP 8266 and HX711 for notification, exhaust fans for ventilation, LM35 for temperature detection, load sensor for weight measurement, vibrating motor for vibration.

(a) (b)

Figure 11. **(a)** Internal Front View and **(b)** Internal Back View of the Hardware Design

(a) (b)

Figure 12. **(a)** Internal Left-side View and **(b)** Internal Right-side View of the Hardware Design

(a) (b)

Figure 13. **(a)** External Front View and **(b)** External Back View of the Hardware Design

Figure 14. Hardware Design: Outer Left-side and Right-side view

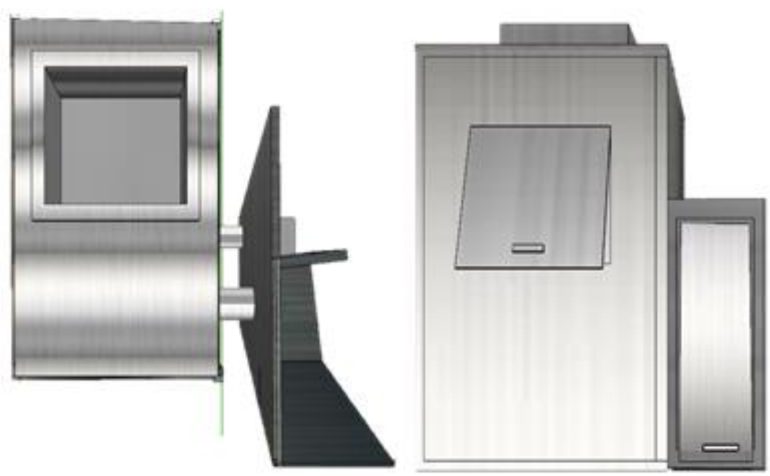
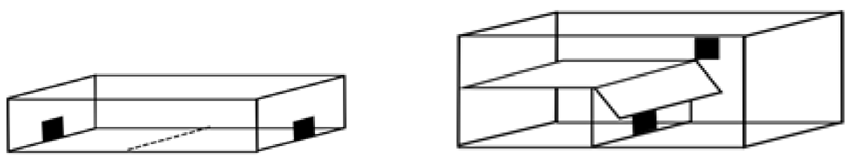


Figure 15. Hardware Design: Inner and Outer Top View

The proposed project will be approximately 1½ feet long, 1 foot wide and 3 feet tall. It will be wider with the food dispenser having around 1½ feet in total width. The chassis will be made out of aluminum sheet to lessen the light exposure of the mealworms for they are more active in the dark.

(a) (b)

Figure 16. Placement of the Main Components



(a) (b)

Figure 17. (a) Mealworm container and **(b)** Beetle and Pupae container

In Figure 16.a, the orange box which represents the temperature sensor is located close to the mealworm container, the yellow box represents the load sensor and is placed under container 4 while the blue box represents the vibrating motor beneath all the platforms. In Figure 16.b, the green box represents the dynamo motors inside the food dispenser tubes that have propellers.

In Figure 17, the black boxes represent servo motors that are placed near the hinges of doors in the mealworm and beetle and pupae container.

3.4.2 Software Development

The Arduino Mega is connected to a Real Time Clock making the system to be time based. When the clock reaches the programmed time, the automatic container gates will open by means of servo motors at a specified period of time and then will close afterwards. At that time, the old beetles will be released by the machine from its container. Then, the vibrating motor that is connected to Arduino Mega will cause the vibration resulting in the execution of the segregation process. The motor will vibrate based on the programmed time to it. The exhaust fans connected to the microcontroller are programmed to turn off when the motor is vibrating and turns on when the segregation is done, and the vibration stops. For the food dispenser, the dynamo motor is automated to rotate for a specific period of time that is responsible for giving the right amount of Styrofoam as their food. Connecting the thermal sensor to the Arduino Mega, the detected temperature will determine the speed of the exhaust fan whether it will be at high or low. For the display, LCD is used and set to state the actual time and date. The ESP8266 which has the Wi-Fi networking functions allows to transfer data from the weight sensor and temperature sensor to a free application called Blynk. This application shows and notify the owner or user regarding the weight of frass, the time when the segregation takes place and when the collection of frass is ready.

3.5 Materials and Equipment

3.5.1 Acrylic Board

Polymethylmethacrylate (PMMA) or acrylic is a type of plastic that is best substitute for glass because of its durability, flexibility and sustainability. This material is easy to fabricate and has many different uses.

Figure 18. Acrylic Board (Proctor, 2017)

3.5.2 Aluminum Sheet

Aluminum is a type of metal that has extensive applications, it could be industrial, residential, or commercial. This metal is light in weight, corrosion resistant, sturdy, good for welding, good conductor of heat.

Figure 19. Aluminum Sheet (Almetals, 2015)

3.5.3 Arduino Mega 2560

The Arduino MEGA 2560 is a microcontroller board that requires more input/output, more sketch memory and more RAM with 54 digital input/output pins and 16 analog inputs. It is programmed by using Arduino Software (IDE).

Figure 20. Arduino Board (Aqeel, 2018)

3.5.4 Continuous Hinge

These are called piano hinges, made out of thin stainless steel. Slightly bendable to suit different applications. Also available without holes which enable the consumer to weld the hinge directly onto the surface.

Figure 21. Continuous Hinge (Amazon, 2020)

3.5.5 CR2032 Battery

CR2032 is a Lithium button cell battery that provides reliable, long lasting power for your specialty devices. It was used on calculators, electronic devices, watches and more (Duracell, 2020).

Figure 22. CR2032 Battery (LogiLink, 2020)

3.5.6 DS3231 RTC Module

The DS3231 is a low cost, highly precautionary Real Time Clock module which counts hours, minutes and seconds including day, month and year information. It can work on either 3.3 or 5 voltages which make it compatible for many development platforms or microcontrollers. In addition, it has automatic compensation for leap-years and for months with fewer than 31 days. An integrated temperature compensated crystal oscillator and working in i2c communication protocol. It is used in different electronic devices like computers, laptops and GPS for high accuracy of time. It has a crystal resonator for long-term accuracy of the devices and reduces piece-cart count in the manufacturing line.

Furthermore, this circuit board gives a reset output and can automatically switch to back up if needed (Nedelkovski, 2016).

Figure 23. DS3231 RTC Module (Nedelkovski, 2016)

3.5.7 Dynamo Motor

This type of motor is a device that creates direct current electric power using electromagnetism (The Edison Tech Center, 2011).

Figure 24. Dynamo Motor (The Edison Tech Center, 2011)

3.5.8 ESP 8266

The ESP 8266 is a device that has a Wi-Fi networking function. Arduino can be used to program this device and can also be connected to a sensor used for notification systems. This Wi-Fi module is very useful and popular for its Internet of Things applications (Sparkfun Electronics, 2020).

Figure 25. ESP8266 (Sparkfun Electronics, 2020)

3.5.9 Exhaust Fan

Exhaust fans pull odors, fumes, and moisture from an area, venting them outdoors for removal. The fan uses a motor to turn its blades, which function to pull air out of the space. The stale, humid, or contaminated air is propelled through the exhaust vent, exiting the spot (Housh, 2017).

Figure 26. Exhaust fan (Twinkle Bay, 2020)

3.5.10 HX711

HX711 is a load cell amplifier that is used for signal conditioning so the signal can be amplified and converted into an output value. This is used when the load cell has measured the load or force.

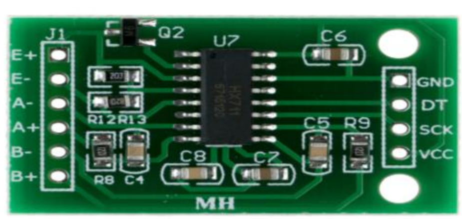


Figure 27. HX711

(NightShade Electronics, 2020)

3.5.11 Jumper Wires

Jumper wires are used for making connections between items on the breadboard or on the header pins of an Arduino board (Blum, 2020).

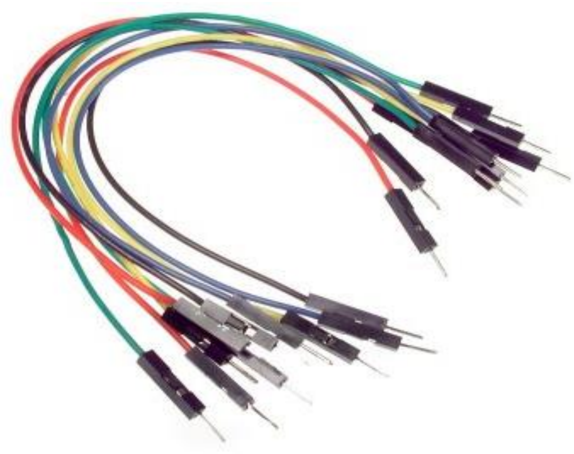


Figure 28. Jumping Wires (Blum, 2020)

3.5.12 LCD Screen

Liquid Crystal Display screen or LCD screen is an electronic display module that can show the status of your project or even the time and date. A 16x2 LCD screen has 2 lines and can display 16 characters for each line (cuitandokter, 2020).

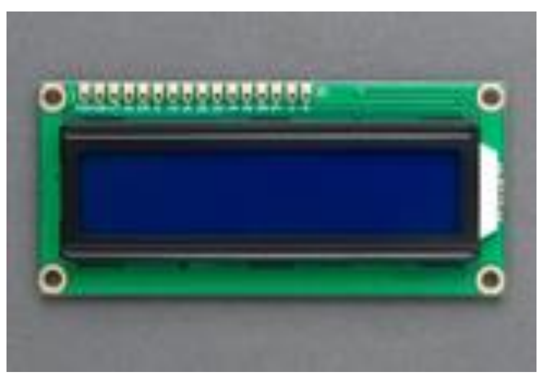


Figure 29. LCD Screen (cuitandokter, 2020)

3.5.13 LM35 Transistor

The LM35 transistor is a precision integrated-circuit temperature device which have linear relation of voltage to centigrade temperature output (Texas Instrument, 2020).

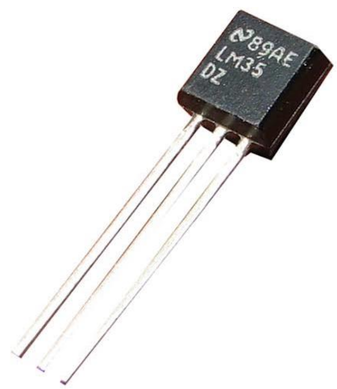


Figure 30. LM35 Transistor (Texas Instrument, 2020)

3.5.14 Load Sensor

Load cells are used to measure pressure and are translated into an electrical signal. These components are made out of aluminum-alloy and are capable of withstanding up to 3kg and can measure pressure unilaterally (Marketlab Electronics, Straight Bar Load Cell 3Kg, 2020).

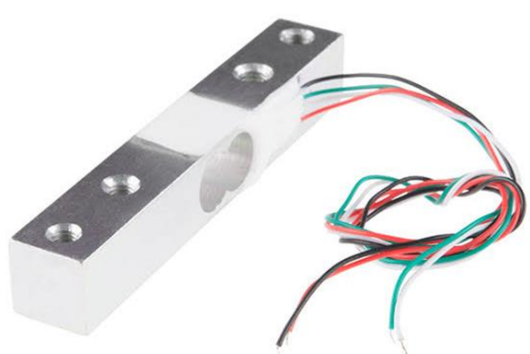


Figure 31. Load Cell (Marketlab Electronics, Straight Bar Load Cell 3Kg, 2020)

3.5.15 Micro Servo Motor

It is tiny and lightweight with high output power. This motor can rotate about 90 degrees in each direction for a total of 180 degrees. One of its uses is precise position control.

Figure 32. Micro Servo Motor (JSUMO, 2020)

3.5.16 Power Adapter

Power adapters come in different configurations depending on the intended use. These devices convert alternating current into direct current for components that are supplied in regulated DC supply (Makerlab Electronics, 12V 1A Power Adapter, 2020).

Figure 33. Power Adapter

(Makerlab Electronics, 12V 1A Power Adapter, 2020)

3.5.17 Relay Module

Relays are switches that utilize electromagnetism to trigger a mechanical switch. This application gives way to controlling high current equipment while using a relatively low voltage, low current to control the trigger of the relay allowing it to be used with Arduino or similar devices (Makerlab Electronics, 8-Channel 5V Relay Module, 2020).

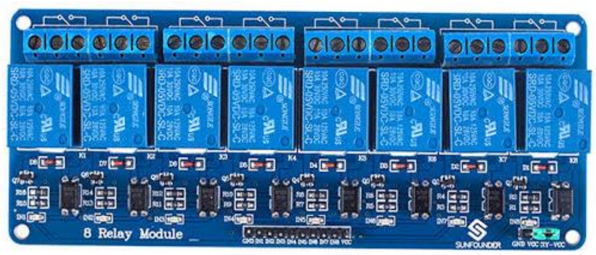


Figure 34. Relay Module

(Makerlab Electronics, 8-Channel 5V Relay Module, 2020)

3.5.18 Spring Coil

Springs are mechanical devices that can store potential energy because of their elasticity. The basic notion underlying the operation of springs is that they will always attempt to return to their initial size or position whenever a force is applied which changes their size, whether that be forces which are from compression, extension, or torsion. Springs are often made of coiled, hardened steel, although non-ferrous metals such as bronze and titanium and even plastic are also used (Thomas Publishing Company, 2020).

Figure 35. Spring coil (Thomas Publishing Company, 2020)

3.5.19 Steel Angle Bar

Steel angle bars are ideal for different applications like structural, general fabrication and repairs. Angle bar is also known as “L-bar”, “L-bracket” or “angle iron. A type of steel metal in the form of a right angle (Anping Lingus Steel Grating Factory, 2020).

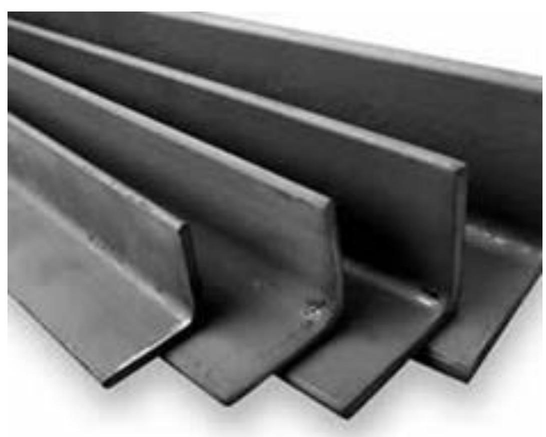


Figure 36. Steel Angle Bar

(Anping Lingus Steel Grating Factory, 2020)

3.5.20 Vibrating Motor

Its purpose is to generate or produce vibration. The unstable mass on its driveshaft is the one who produces or generates vibration (Yoycart.com, 2020).

Figure 37. **Vibrating Motor** (Yoycart.com, 2020)

3.6 Testing Procedure

In testing the system, the mealworms must be placed in the larva container. Based on the thermal sensor reading, the speed of the exhaust fan will depend on the measured temperature. The system is time based; the opening time of the automatic gate in the container will depend on the predetermined time. The manual segregation of mealworms and pupae is done every Monday, Wednesday and Friday, while once a month for the beetles.

Afterwards, the vibration motor will help filter and segregate the larva, pupae, eggs, beetle, and frass. The exhaust fan will stop when the vibration motor starts to vibrate to prevent the frass from being blown away. After segregation, the automatic food dispenser will release food to the containers.

As an output, after continuous cycle, old beetles will be released from the device, new beetles will lay eggs, the eggs will be hatched, and then mealworms. The mealworm will turn into a pupa, and the pupa will be hatched, and a new beetle. The population on each life cycle stage is closely monitored to avoid overpopulation. The ESP 8266 will notify the user through the Blynk app when the system is ready for segregation and for collection of the frass.

3.7 Evaluation Procedure

The proponents will evaluate the data regarding the rate of production of mealworms gathered manually by counting the number of mealworms every after segregation. For the rate of food consumption, the initial weight of Styrofoam will be compared to the weight of the remaining Styrofoam every after segregation. This will determine the adjustment of the systems' setup including the food dispensing and thermal throttling for better ventilation system. The weight of frass excreted by the mealworms which is gathered by the application Blynk through ESP8266 will be studied by the proponents to determine the approximate maximum amount of frass that can be collected every month.

Table 1. Sample Table for Biodegraded Polystyrene

WEEK	Biodegraded Polystyrene (g)
1	
2	
3	
4	
5	
6	
7	
8	
9	
10	
11	
12	

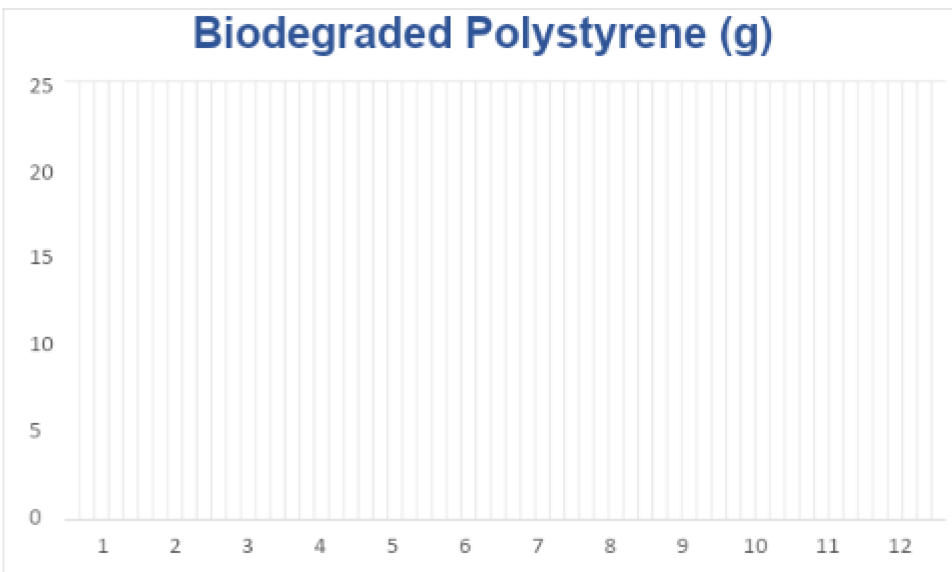


Figure 38. Sample Graph of Data from Table 2

Moreover, the collected frass will be used by the proponents as fertilizer. The growth of a plant with frass as fertilizer will be closely monitored and will be compared to the growth of a plant with organic fertilizer and the growth of a plant without any fertilizer. The proponents will use plant growth rating in comparing each subject (Google Science Fair 2011, 2011). This will be the subject for evaluating the effectiveness of fertilizer produced by the polystyrene-eating mealworms. The behavior and health of the animal that ate the excess mealworms will also be monitored and studied.

Table 2. Sample of Plant Growth Comparison Table

WEEK	Plant with Poly-lizer	Plant with Organic Fertilizer	Plant without Fertilizer
1			
2			
3			
4			
5			
6			
7			
8			
9			
10			
11			
12			

This data will be helpful to measure the effectiveness of the whole project and the duration of return of investment. The frass will be sold as fertilizer for plants and the excess mealworms produced through cultivation will be sold as food for the pets that include mealworms in their normal diet. The proponents will also evaluate the effectiveness of the project by comparing the manual and the semi-automated way of handling and reproduction of mealworms. Euler-Lotka equation will be used in this comparison and for projecting the population growth of the creatures (Leslie, P.H. and Ranson, R.M., 2020).

$$\sum_{x=\alpha}^{\beta} P(x)m(x)e^{-rx} = 1$$

Table 3. Sample of Table for Euler-Lotka Equation

x/week	**m(x)**	**P(x)**
1		
2		
3		
4		
5		
6		
7		
8		
9		
10		
11		
12		

Table 4. Sample of Simple Cost and Return Table

	Estimated Benefits:				Resources needed in Units	Estimated cost:		
Number of beneficiaries						No. of units	Unit value	Total cost
Direct benefits	Year 1	Year 2	Year 3	Direct costs				
1.				1. Utilities				
2.								
3.				Equipment, supplies & materials				
				1. Printed materials				
				Furnishings and fabrication				
Indirect benefits				. Instructional Materials				
1.				4. Travel	Kilometers			
Total Program Benefits				Opportunity costs				
Benefit-cost ratio				1. Food				
Rate of Investment				2. Travel				
Internal Rate of Return (IRR)								
				Total Program Costs				

3.8 Gantt Chart

Table 5. Gantt Chart of the Research Project

Activity	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May
Brainstorming	■												
Research facts about topic	■												
Topic Defense	■												
Interview with experts	■												
Chapter 1, 2 and 3 (Preparation for Title Defense)	■												
Consultation with Adviser	■												
Title Defense	■												
Planning and Design	■	■											
Purchase of Materials and Mealworms	■	■	■	■									
Fabrication of Prototype				■	■	■							
Data Gathering				■	■	■	■	■					
Evaluation and Testing of Prototype				■	■	■	■	■					
Progress Defense								■					
Preparation for Pre-Final Defense								■	■				
Pre-Final Defense										■			
Deployment of Prototype										■	■		
Document Finalization											■		
Preparation for Final Defense											■	■	
Final Defense												■	

Finalization of Thesis Paper												
Revision of Thesis Paper												

CHAPTER 4

RESULTS AND DISCUSSION

4.1 Project Technical Description

The project aims to provide a system that biodegrades polystyrene by containing and maintaining mealworms that can digest Styrofoam into a biodegradable material. The design of the project enables the user to take care of polystyrene-eating mealworms more easily by having a vibration and screen system for maintenance and segregation and it also notifies the operator through the internet using a notification system for the manual part of the segregation. The system is expected to reduce the human errors and effort in handling mealworms and the time needed to process Styrofoam into less hazardous material.

For the hardware part, modified containers are used to contain the creatures and a vibrating motor is utilized to induce vibration for good segregation. Other motors are used for feeding. It has a strong body frame with a lightweight chassis.

For the software part, the Arduino was programmed to control the system to its desired availability of the handler. The graphic user interface used is Blynk, an open source application in making GUIs.

4.2 Project Structural Organization

4.2.1Device

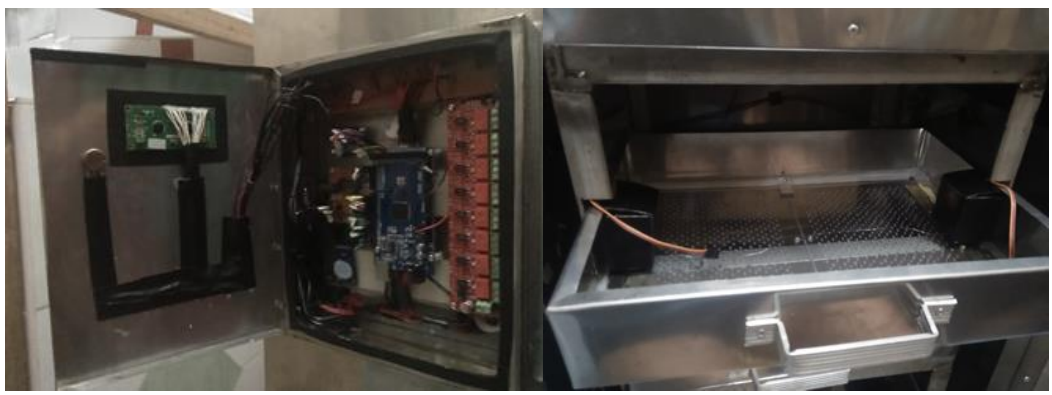
(a) (b)

Figure 39. (a) Front View and **(b)** Back View of the Device

(a) (b)

Figure 40. (a) Left-side View and **(b)** Right-side View of the Device

Figure 41. Top View of the Device



(a) (b)

Figure 42. (a) Panel Board and **(b)** Modified Container of the Device

The final structure of the device is shown in Figure 36 to 39. It has an overall dimension of 58x36x125 cm. In Figure 39.a, the components inside the panel board is shown. The inside view of a modified container was shown in Figure 39.b.

4.2.2 Graphic User Interface

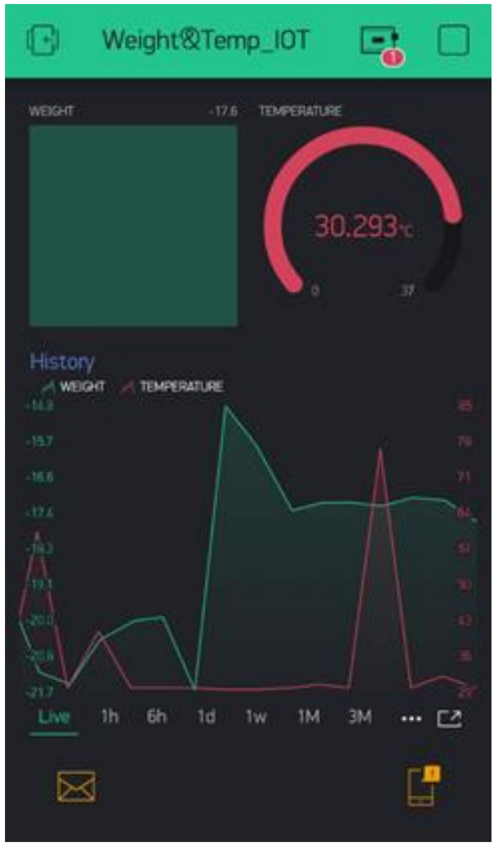


Figure 43. A Preview of Blynk

The GUI of the device will present the data monitored such as the temperature and the weight. The temperature will determine how fast the insects will reproduce while the weight will be the manifestation of the population increase and the indication of the upcoming segregation.

4.3 Project Limitation and Capabilities

The device can only segregate Tenebrio Molitor into its specific lifestage using minimal hand operation and vibration and screen system. It is designed for indoor use and not for exposure on direct sunlight or on rain. Polystyrene is the only type of synthetic material that is to be disposed of using this machine.

4.4 Project Evaluation

The reproductive rate foreseen of the mealworms was 50% with the considered deaths up to ≈50% and an approximate theoretical birth of up to 200 eggs (Bennett, 2003).

$$Reproductive\ rate\ (r) = \frac{(Births - Deaths)}{Population} \times 100\%$$

$$\boldsymbol{r} = \frac{[\big((2{,}500 \times 50\%) \times 200\big) - \big((2{,}500 \times 50\%) \times 200\big) \times 50\%)]}{2{,}500} \times 100\%$$

$$\boldsymbol{r = 50}\%$$

The total number of mealworms used in the device was 2, 500 individuals that consume approximately 0.644mg of polystyrene a day per worm (Yang et al., 2015). The process of degrading Styrofoam within the project was faster which requires just 22.36 hours for a single Styrofoam cup compared to other recycling options that would take at least 500 years or more just to do so (Jones et al., 2020).

Table 6. Simple Cost and Return Table

	Estimated Benefits:				Resources needed in Units	Estimated cost:		
Number of beneficiaries						No. of units	Unit value	Total cost
Direct benefits	Year 1	Year 2	Year 3	Direct costs				
1. Enhanced waste management capability	₱2,400.00	₱2,400.00	₱2,400.00	1. Utilities	Kilowatt-hour/Year	310.68	₱9.40	₱2,920.39
2. Larger material capacity	₱1,200.00	₱1,200.00	₱1,200.00					
3. More effective decomposing method	₱3,600.00	₱3,600.00	₱3,600.00	Equipment, supplies & materials				
Mealworm Sales	₱31,406.25	₱31,406.25	₱31,406.25	1. Printed materials	Pieces	2	₱616.00	₱1,232.00
				Furnishings and fabrication	Pieces	1	₱23,845.00	₱23,845.00
Indirect benefits				. Instructional Materials	Pieces	5	₱4.00	₱20.00
1. Cleaner environment	₱2,400.00	₱2,400.00	₱2,400.00	4. Travel	Kilometers	19.5	₱5.00	₱97.50
Total Program Benefits	**₱41,006.25**	**₱41,006.25**	**₱41,006.25**	Opportunity costs				
Benefit-Cost Ratio	**1.41**	**1.41**	**1.41**	1. Food	Meal/ Person	15	₱30.00	₱450.00
Rate of Investment (ROI)	**41.09%**	**41.09%**	**41.09%**	2. Travel	Person	5	₱100.00	₱500.00
Internal Rate of Return (IRR)	**41.09%**	**108.69%**	**129.40%**					
				Total Program Costs				**₱29,064.89**

The table provides the total program cost, total program benefits, benefit-cost ratio, rate of investment and internal rate of return of the project as a whole. With the total program costs of ₱29, 064.89 and total program benefits of ₱41, 006.25, the calculated return of investment is 41.09% with a projected internal rate of return of 129.40% in the third year.

For Total Program Costs:

$$Total\ Program\ Cost(C) = Labor(L) + Direct\ Costs(K) + Indirect\ Costs(I) - Discount\ Amortization(i)$$

$$C = ₱0.00 + (₱2{,}920.39 + ₱1{,}232.00 + ₱23{,}845.00 + ₱20.00 + ₱97.50 + ₱450.00 + ₱500.00)$$

$$+₱0.00 - ₱0.00$$

$$C = ₱29{,}064.89$$

For Mealworm Sales:

$$Mealworm\ Sales(S) = no.of\ mealworms\ to\ be\ sold \times selling\ price$$

$$S = \{[((2{,}500 \times 50\%) \times 200) \times 50\%] + [(2{,}500 \times 25\%) \times 50\%]\} \times ₱0.50$$

$$S = ₱31{,}406.25$$

For Total Program Benefits:

$$Total\ Program\ Benefits(B) = Cost\ reduction(Cr) + Direct\ Benefits(DB) + Indirect\ Benefits(IB)$$

$$B = ₱0.00 + (₱2{,}400 + ₱3{,}6.00 + ₱1{,}200.00 + ₱3{,}600.00 + ₱31{,}406.25) + ₱2{,}400.00$$

$$B = ₱41{,}006.25$$

For Return of Investment:

$$Return\ of\ Investment(ROI) = \frac{B - C}{C} \times 100\%$$

$$ROI = \frac{₱41{,}000.25 - ₱29{,}064.89}{₱29{,}064.89} \times 100\% = 41.09\%$$

For Internal Rate of Return:

$$C = \frac{B_1}{(1+i)^1} + \cdots + \frac{B_n}{(1+i)^n}$$

$$₱29{,}064.89 = \frac{₱41{,}000.25}{(1+i)^1} + \frac{₱41{,}000.25}{(1+i)^2} + \frac{₱41{,}000.25}{(1+i)^3}$$

$$IRR_3 = i_3 = 129.40\%$$

CHAPTER 5

SUMMARY OF FINDINGS, CONCLUSION, AND RECOMMENDATIONS

5.1 Summary of Findings

The visioned findings showed a good solution on the problem of Styrofoam waste compared to the present waste process. It is highly recommended and is easy to use. The total number from the evaluation of the breeders is slightly lower than those from the staff of the MRF for the breeders care for the creatures more than those from the MRF for the main goal of this kind of facilities is to recycle and reduce all possible wastes. The project was an effective containment for the insects to increase their population. This effect generated enough value of money to return the investment and caused a good profit in a few years.

5.2 Conclusion

1. The whole project was built from an original design and most of it was a new combination of already existing technology.
2. The mesh screen and vibration system used is able to do the expected task of separating the life stage of the creature accordingly. The vibrating motor was purchased overseas, and it took some time before it was used. The designed layers were successful in being a temporary habitat for the subjects. It was created using aluminum for the framing and acrylic board for the flooring.
3. The developed algorithm in this project uses a time-based and pre-scheduled set up. With this, the program can activate the segregation system and ventilation system

and trigger the notification system to inform the operator about the internal temperature of the bin and the weight of the gain product.

4. The GUI displays the monitored data from the sensors that are sent through the ESP 8266. This enables the user to discern the upcoming segregation that is needed to be assisted with a manual effort**.**

With the use of the device, decomposing the non-biodegradable polystyrene was possible and was more environmentally safe than any other methods. Also, the project was the first to use the creatures in a semi-automated biodegradation machine. It has a lot of potential to be developed for industrial or even household use as well as being fully automated.

5.3 Recommendations

To further improve the study, researchers recommend adding a night vision camera with high-definition capability to monitor the mealworms even inside the container. This will be a new parameter to determine if the creatures were populating successfully. It is also recommended to lessen the noise it produces by having a smaller vibrating motor or a different device with enough power of vibration. For industrial use, it is suggested to use a more stable and more durable skeletal frame and chassis. On the other hand, for household use, it was advisable to use a more lightweight and a smaller device. To do so, a low vibrating device should be used and the capacity should be lesser than the previous design. Furthermore, the researchers considered having further study about how effective the frass of the insects is as a fertilizer and if it can be used for consumable plants for agricultural purposes. Another study would also be considered about making the mealworms' diet better than just pure Styrofoam.

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APPENDIX A

Program Codes

Codes for Arduino:

```
#include <DS3231.h> //RTC

#include <LiquidCrystal.h> //LCD

#include <Servo.h> //Servo

#include <thermistor.h> //Temp


//RTC

DS3231  rtc(SDA, SCL);

Time t;


//LCD

LiquidCrystal lcd(1, 2, 3, 5, 6, 7);


//SERVO

Servo myservo;

int Basis = 5;

int DailyBasis = 0;

int SMhourON = 9;

int SMminON = 30;

int SMsecON = 2;


int ChangeHour = 23;

int ChangeMin = 59;
```

```
int ChangeSec = 30;


//TEMP
float temp;
int tempPin = A15;
int tempMin = 23;
int tempMax = 45;
int fan = 10;
int fanSpeed;


//RELAY (DYNAMO 1&2, VMOTOR)
int Relay1 = 11; //DYNAMO 1
int Relay2 = 12; //DYNAMO 2
int Relay3 = 13; //VMOTOR


const int RelayOnHour = 10;
const int RelayOnMin = 10;
const int RelayOnSec = 10;                         ;


const int Relay1OffHour = 10;
const int Relay1OffMin = 10;
const int Relay1OffSec = 15;
```

```
const int Relay2OffHour = 10;
const int Relay2OffMin = 10;
const int Relay2OffSec = 20;

void setup() {
  //RTC & LCD
  rtc.begin();
  lcd.begin(16,2);
  rtc.setDOW(SUNDAY);
  rtc.setTime(9, 0, 0);
  rtc.setDate(08, 02, 2020);

  //SERVO
  myservo.attach(8);
  myservo.attach(9);
  myservo.attach(4);

  //WS & TEMP
  pinMode(fan, OUTPUT);
  pinMode(tempPin, INPUT);

  //RELAY (DYNAMO 1 & 2)
  pinMode(Relay1, OUTPUT);
```

```
 digitalWrite(Relay1, LOW);
 pinMode(Relay2, OUTPUT);
 digitalWrite(Relay2, LOW);

 //VMOTOR
 pinMode(Relay3, OUTPUT);
 digitalWrite(Relay3, LOW); }

void loop() {
 //LCD SCREEN
 //RTC & LCD
 lcd.setCursor(0,0);
 lcd.print("Time:  ");
 lcd.print(rtc.getTimeStr());

 lcd.setCursor(0,1);
 lcd.print("Date: ");
 lcd.print(rtc.getDateStr());

 delay(1000);
 t = rtc.getTime();

 //FOOD DISPENSER
```

```
//RELAY (DYNAMO 1 & 2)
if(t.hour == RelayOnHour && t.min == RelayOnMin && t.sec == RelayOnSec){
 digitalWrite(Relay1,HIGH);
 digitalWrite(Relay2, HIGH);}

//RELAY (GEAR 1)
if(t.hour == Relay1OffHour && t.min == Relay1OffMin && t.sec == Relay1OffSec){
 digitalWrite(Relay1,LOW);}

//RELAY (GEAR 2)
if(t.hour == Relay2OffHour && t.min == Relay2OffMin && t.sec == Relay2OffSec){
 digitalWrite(Relay2,LOW);}

//TEMPERATURE SENSOR
temp = analogRead(tempPin);
temp = (temp *5.0*100.0)/1024.0;
if(temp < tempMin) {
 fanSpeed = 0;
 digitalWrite(fan, LOW);}
if(t.hour != 10 or 11 or 12 or 13 or 14 or 15 or 16){
 digitalWrite(fan, LOW);}
if((temp >= tempMin) && (temp <= tempMax)){fanSpeed = map(temp, tempMin,
tempMax, 0, 100);
```

```
  analogWrite(fan, fanSpeed);  }


 //SERVO
  if(t.hour == Basis){
    DailyBasis = DailyBasis + 1;
    if(DailyBasis == 6 && t.hour == ChangeHour && t.min == ChangeMin && t.sec == 
ChangeSec){ DailyBasis = 0;}
    if(DailyBasis == 1 or 3 or 5 && t.hour == SMhourON  && t.min == SMminON && 
t.sec == SMsecON){
    //Fan OFF
    digitalWrite(fan, LOW);


    //Servo (Beetle)
    myservo.attach(9);
    delay(1000);
    myservo.write(90);
    delay(1000);
    myservo.detach();
    delay(1000);


    //VMOTOR
    digitalWrite(Relay3,HIGH);
    delay(60000);
```

```
digitalWrite(Relay3,LOW);
delay(1000);

myservo.attach(9);
delay(1000);
myservo.write(1);
delay(1000);
myservo.detach();
delay(1000);

//Servo (Pupae)
myservo.attach(8);
delay(1000);
myservo.write(90);
delay(1000);
myservo.detach();
delay(1000);

//VMOTOR
digitalWrite(Relay3,HIGH);
delay(60000);
digitalWrite(Relay3,LOW);
delay(1000);
```

```
myservo.attach(8);
delay(1000);
myservo.write(1);
delay(1000);
myservo.detach();
delay(1000);

//Servo (Mealworms)
myservo.attach(4);
delay(1000);
myservo.write(90);
delay(1000);
myservo.detach();
delay(1000);

//VMOTOR
digitalWrite(Relay3,HIGH);
delay(180000);
digitalWrite(Relay3,LOW);
delay(1000);

myservo.attach(4);
```

```
  delay(1000);

  myservo.write(1);

  delay(1000);

  myservo.detach();

  delay(1000);


  //Separation of Mealworm and Pupae

  //VMOTOR

  digitalWrite(Relay3,HIGH);

  delay(60000);

  digitalWrite(Relay3,LOW);

  //Fan ON

  digitalWrite(fan, HIGH);    }}}
```

Codes for ESP8266:

```
#include <HX711.h>

#include "time.h";

#define BLYNK_PRINT Serial

#include <ESP8266WiFi.h>

#include <BlynkSimpleEsp8266.h>

char auth[] = "gS5oiaDJN4p5ShfP80QN1bySI-mAfCf-";

char ssid[] = "FamilyIsLove";

char pass[] = "stephen1234#";
```

```
#define PIN_UPTIME V6

#define calibration_factor  620

#define DOUT D5

#define CLK  D6


 // NewPing setup of pins and maximum distance.

HX711 scale;

const unsigned int Period = 1000;


BLYNK_READ(PIN_UPTIME)

{  Blynk.virtualWrite(PIN_UPTIME, millis() / 1000);   }



BlynkTimer timer;

int hourtime = 9;

int mintime = 20;

int sectime = 5;


void readings(){

  Blynk.virtualWrite(V2,scale.get_units());

  delay(50);

  Serial.print("Reading: ");

  Serial.print(scale.get_units(20), 3);
```

```
 Serial.print(" kg");
  Serial.println();  }

void notif(){
 if((scale.get_units()) > 200){
Blynk.email("polywormnotification@gmail.com", "Weight Sensor Alert", "The Frass is ready for harvest!");
Blynk.notify("Weight Sensor Alert - The Frass is ready for harvest!");}
if(time_now.hour == hourtime && time_now.min == mintime && time_now.sec == sectime){
Blynk.email("polywormnotification@gmail.com", "10 minutes before seggregation time!!!");
Blynk.notify("10 minutes before seggregation time!!!"); }

void myTimerEvent(){
  int analogValue = analogRead(A0);
  float millivolts = (analogValue/1024.0) * 3300;
  float celsius = millivolts/10;
  Blynk.virtualWrite(V5, celsius); }

void setup(){
  Serial.begin(9600);
  Blynk.begin(auth, ssid, pass);
```

```
  timer.setInterval(1000L, myTimerEvent);


  scale.begin(DOUT, CLK);
  scale.set_scale(calibration_factor);
  scale.tare();


  Serial.println("Readings:");
  // Debug console
  Serial.begin(9600);
  timer.setInterval(Period, readings);
  Blynk.begin(auth, ssid, pass);
  timer.setInterval(1200000L, notif);
  configTime(0,0, "pool.ntp.org","time.nist.gov");
  setenv("PST-8", "EET-2EEST,M3.5.5/0,M10.5.5/0",1); }


String get_time(){
  time_t now;
  time(&now);
  char time_output[30];
  strftime(time_output, 30, "%a %d-%m-%y %T", localtime(&now));
  return String(time_output);  }


void loop(){
```

```
Blynk.run();

timer.run(); }
```

APPENDIX B

Bill of Materials

Bill of Materials

Materials	Description	Quantity	Unit	Unit Cost	Total
Arduino Mega	MEGA2560+CH340	1	pcs	₱570.00	₱570.00
Servo Motor	SG90 9G Micro small Servo motor	4	pcs	₱109.00	₱436.00
Dynamo Motor	Dynamo Motor 6V	2	pcs	₱45.00	₱90.00
LCD Screen	LCD module 16x2	1	pcs	₱89.00	₱89.00
Battery	CMOS/BIOS Battery 3V CR2032	1	pcs	₱36.00	₱36.00
RTC Module	DS3231 AT24C32 IIC Module Precision Real Time Clock	1	pcs	₱89.00	₱89.00
Transistor	LM35 Transistor	1	pcs	₱84.00	₱84.00
Load Cell Amplifier	HX-711 Module	1	pcs	₱69.00	₱69.00
Weight Sensor	3KGLC Weight Sensor	1	pcs	₱486.00	₱486.00
Relay	4 Channel Relay	1	pcs	₱250.00	₱250.00
Power Supply Adapter	AC-DC Adapter 100-240V 50-60Hz 12V 1A	1	pcs	₱150.00	₱150.00
Power supply Adapter	AC-DC Adapter 220V 50-60Hz 3-12V 2A	1	pcs	₱220.00	₱220.00
Vibrating motor	220V 15W Single Phase AC Motor	1	pcs	₱1,782.00	₱1,782.00
Wifi Module	ESP8266	1	pcs	₱215.00	₱215.00
Exhaust Fan	109R1212MH108 DC 4 Pin 12V Brushless Cooling Fan,120mm Black	2	pcs	₱200.00	₱400.00
Hardware Materials	Angle bars and Stainless steel sheets w/labor	-	-	-	₱15,000.00
Spring	Coil Spring	2	pcs	₱150.00	₱300.00
Hinge	Piano Hinge without holes	3	meter	₱279.00	₱279.00
Glass	Acrylic	1	pcs	₱1,300.00	₱1,300.00
	Mealworms	6,000	pcs	₱1,000.00	₱2,000.00
	Total				**₱23,845.00**

APPENDIX C

Specifications and Datasheets

HARDWARE SPECIFICATIONS

Dimension	Length	Width	Height
Skeletal Frame	14 in.	10 in	40 in.
Chassis	23 in.	14 in.	48 in
Containers (Mealworms)	14 in	10 in.	2 in.
Containers (Frass)	14 in.	10 in.	2.5 in
Containers (Pupa and Beetles)	8 in	1 in.	7 in
Containers (segregation)	14 in.	10 in.	2.5 in
Placement of main components	8 in.	-	10 in
Food dispenser	short base- 3 in. long base- 8 in.	short base- 3 in. long base- 5 in.	right side- 11 in. left side- 15 in.

Operating hours	24 hours
Operating system	Arduino Mega

ARDUINO MEGA 2560

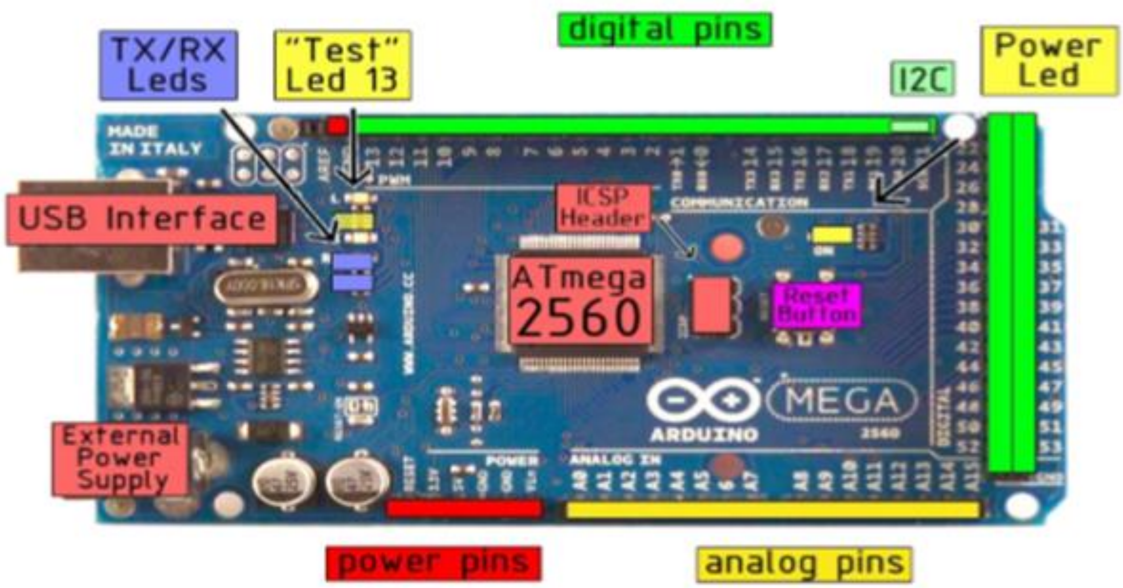
Technical Specification

EAGLE files: arduino-mega2560-reference-design.zip Schematic: arduino-mega2560-schematic.pdf

Summary

Microcontroller	ATmega2560
Operating Voltage	5V
Input Voltage (recommended)	7-12V
Input Voltage (limits)	6-20V
Digital I/O Pins	54 (of which 14 provide PWM output)
Analog Input Pins	16
DC Current per I/O Pin	40 mA
DC Current for 3.3V Pin	50 mA
Flash Memory	256 KB of which 8 KB used by bootloader
SRAM	8 KB
EEPROM	4 KB
Clock Speed	16 MHz

the board



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Memory

The ATmega2560 has 256 KB of flash memory for storing code (of which 8 KB is used for the bootloader), 8 KB of SRAM and 4 KB of EEPROM (which can be read and written with the EEPROM library).

Input and Output

Each of the 54 digital pins on the Mega can be used as an input or output, using pinMode(), digitalWrite(), and digitalRead() functions. They operate at 5 volts. Each pin can provide or receive a maximum of 40 mA and has an internal pull-up resistor (disconnected by default) of 20-50 kOhms. In addition, some pins have specialized functions:

- **Serial: 0 (RX) and 1 (TX); Serial 1: 19 (RX) and 18 (TX); Serial 2: 17 (RX) and 16 (TX); Serial 3: 15 (RX) and 14 (TX).** Used to receive (RX) and transmit (TX) TTL serial data. Pins 0 and 1 are also connected to the corresponding pins of the ATmega8U2 USB-to-TTL Serial chip .
- **External Interrupts: 2 (interrupt 0), 3 (interrupt 1), 18 (interrupt 5), 19 (interrupt 4), 20 (interrupt 3), and 21 (interrupt 2).** These pins can be configured to trigger an interrupt on a low value, a rising or falling edge, or a change in value. See the attachInterrupt() function for details.
- **PWM: 0 to 13.** Provide 8-bit PWM output with the analogWrite() function.
- **SPI: 50 (MISO), 51 (MOSI), 52 (SCK), 53 (SS).** These pins support SPI communication, which, although provided by the underlying hardware, is not currently included in the Arduino language. The SPI pins are also broken out on the ICSP header, which is physically compatible with the Duemilanove and Diecimila.
- **LED: 13.** There is a built-in LED connected to digital pin 13. When the pin is HIGH value, the LED is on, when the pin is LOW, it's off.
- **I²C: 20 (SDA) and 21 (SCL).** Support I²C (TWI) communication using the Wire library (documentation on the Wiring website). Note that these pins are not in the same location as the I²C pins on the Duemilanove.

The Mega2560 has 16 analog inputs, each of which provide 10 bits of resolution (i.e. 1024 different values). By default they measure from ground to 5 volts, though is it possible to change the upper end of their range using the AREF pin and analogReference() function.

There are a couple of other pins on the board:

- **AREF.** Reference voltage for the analog inputs. Used with analogReference().
- **Reset.** Bring this line LOW to reset the microcontroller. Typically used to add a reset button to shields which block the one on the board.

Power

The Arduino Mega2560 can be powered via the USB connection or with an external power supply. The power source is selected automatically. External (non-USB) power can come either from an AC-to-DC adapter (wall-wart) or battery. The adapter can be connected by plugging a 2.1mm center-positive plug into the board's power jack. Leads from a battery can be inserted in the Gnd and Vin pin headers of the POWER connector.

The board can operate on an external supply of 6 to 20 volts. If supplied with less than 7V, however, the 5V pin may supply less than five volts and the board may be unstable. If using more than 12V, the voltage regulator may overheat and damage the board. The recommended range is 7 to 12 volts.

The Mega2560 differs from all preceding boards in that it does not use the FTDI USB-to-serial driver chip. Instead, it features the Atmega8U2 programmed as a USB-to-serial converter.

The power pins are as follows:

- **VIN.** The input voltage to the Arduino board when it's using an external power source (as opposed to 5 volts from the USB connection or other regulated power source). You can supply voltage through this pin, or, if supplying voltage via the power jack, access it through this pin.
- **5V.** The regulated power supply used to power the microcontroller and other components on the board. This can come either from VIN via an on-board regulator, or be supplied by USB or another regulated 5V supply.
- **3V3.** A 3.3 volt supply generated by the on-board regulator. Maximum current draw is 50 mA.
- **GND.** Ground pins.

Communication

The Arduino Mega2560 has a number of facilities for communicating with a computer, another Arduino, or other microcontrollers. The ATmega2560 provides four hardware UARTs for TTL (5V) serial communication. An ATmega8U2 on the board channels one of these over USB and provides a virtual com port to software on the computer (Windows machines will need a .inf file, but OSX and Linux machines will recognize the board as a COM port automatically. The Arduino software includes a serial monitor which allows simple textual data to be sent to and from the board. The RX and TX LEDs on the board will flash when data is being transmitted via the ATmega8U2 chip and USB connection to the computer (but not for serial communication on pins 0 and 1).

A SoftwareSerial library allows for serial communication on any of the Mega's digital pins.

The ATmega2560 also supports I2C (TWI) and SPI communication. The Arduino software includes a Wire library to simplify use of the I2C bus; see the documentation on the Wiring website for details. To use the SPI communication, please see the ATmega2560 datasheet.

Programming

The Arduino Mega2560 can be programmed with the Arduino software (download). For details, see the reference and tutorials.

The Atmega2560 on the Arduino Mega comes preburned with a bootloader that allows you to upload new code to it without the use of an external hardware programmer. It communicates using the original STK500 protocol (reference, C header files).

You can also bypass the bootloader and program the microcontroller through the ICSP (In-Circuit Serial Programming) header; see these instructions for details.

Automatic (Software) Reset

Rather then requiring a physical press of the reset button before an upload, the Arduino Mega2560 is designed in a way that allows it to be reset by software running on a connected computer. One of the hardware flow control lines (DTR) of the ATmega8U2 is connected to the reset line of the ATmega2560 via a 100 nanofarad capacitor. When this line is asserted (taken low), the reset line drops long enough to reset the chip. The Arduino software uses this capability to allow you to upload code by simply pressing the upload button in the Arduino environment. This means that the bootloader can have a shorter timeout, as the lowering of DTR can be well-coordinated with the start of the upload.

This setup has other implications. When the Mega2560 is connected to either a computer running Mac OS X or Linux, it resets each time a connection is made to it from software (via USB). For the following half-second or so, the bootloader is running on the Mega2560. While it is programmed to ignore malformed data (i.e. anything besides an upload of new code), it will intercept the first few bytes of data sent to the board after a connection is opened. If a sketch running on the board receives one-time configuration or other data when it first starts, make sure that the software with which it communicates waits a second after opening the connection and before sending this data.

The Mega contains a trace that can be cut to disable the auto-reset. The pads on either side of the trace can be soldered together to re-enable it. It's labeled "RESET-EN". You may also be able to disable the auto-reset by connecting a 110 ohm resistor from 5V to the reset line; see this forum thread for details.

USB Overcurrent Protection

The Arduino Mega has a resettable polyfuse that protects your computer's USB ports from shorts and overcurrent. Although most computers provide their own internal protection, the fuse provides an extra layer of protection. If more than 500 mA is applied to the USB port, the fuse will automatically break the connection until the short or overload is removed.

Physical Characteristics and Shield Compatibility

The maximum length and width of the Mega PCB are 4 and 2.1 inches respectively, with the USB connector and power jack extending beyond the former dimension. Three screw holes allow the board to be attached to a surface or case. Note that the distance between digital pins 7 and 8 is 160 mil (0.16"), not an even multiple of the 100 mil spacing of the other pins.

The Mega is designed to be compatible with most shields designed for the Diecimila or Duemilanove. Digital pins 0 to 13 (and the adjacent AREF and GND pins), analog inputs 0 to 5, the power header, and ICSP header are all in equivalent locations. Further the main UART (serial port) is located on the same pins (0 and 1), as are external interrupts 0 and 1 (pins 2 and 3 respectively). SPI is available through the ICSP header on both the Mega and Duemilanove / Diecimila. **Please note that I^2C is not located on the same pins on the Mega (20 and 21) as the Duemilanove / Diecimila (analog inputs 4 and 5).**

Espressif Systems' Smart Connectivity Platform (ESCP) demonstrates sophisticated system-level features include fast sleep/wake context switching for energy-efficient VoIP, adaptive radio biasing for low-power operation, advance signal processing, and spur cancellation and radio co-existence features for common cellular, Bluetooth, DDR, LVDS, LCD interference mitigation.

1.2. Features

- 802.11 b/g/n
- Integrated low power 32-bit MCU
- Integrated 10-bit ADC
- Integrated TCP/IP protocol stack
- Integrated TR switch, balun, LNA, power amplifier and matching network
- Integrated PLL, regulators, and power management units
- Supports antenna diversity
- WiFi 2.4 GHz, support WPA/WPA2
- Support STA/AP/STA+AP operation modes
- Support Smart Link Function for both Android and iOS devices
- SDIO 2.0, (H) SPI, UART, I2C, I2S, IR Remote Control, PWM, GPIO
- STBC, 1x1 MIMO, 2x1 MIMO
- A-MPDU & A-MSDU aggregation & 0.4s guard interval
- Deep sleep power <10uA, Power down leakage current < 5uA
- Wake up and transmit packets in < 2ms
- Standby power consumption of < 1.0mW (DTIM3)
- +20 dBm output power in 802.11b mode
- Operating temperature range -40C ~ 125C
- FCC, CE, TELEC, WiFi Alliance, and SRRC certified

1.3. Parameters

Table 1 Parameters

Categories	Items	Values
WiFi Paramters	Certificates	FCC/CE/TELEC/SRRC
	WiFi Protocles	802.11 b/g/n
	Frequency Range	2.4G-2.5G (2400M-2483.5M)
	Tx Power	802.11 b: +20 dBm
		802.11 g: +17 dBm
		802.11 n: +14 dBm
	Rx Sensitivity	802.11 b: -91 dbm (11 Mbps)
		802.11 g: -75 dbm (54 Mbps)
		802.11 n: -72 dbm (MCS7)
	Types of Antenna	PCB Trace, External, IPEX Connector, Ceramic Chip
Hardware Paramaters	Peripheral Bus	UART/SDIO/SPI/I2C/I2S/IR Remote Control
		GPIO/PWM
	Operating Voltage	3.0~3.6V
	Operating Current	Average value: 80mA
	Operating Temperature Range	-40°~125°
	Ambient Temperature Range	Normal temperature
	Package Size	5x5mm
	External Interface	N/A
Software Parameters	WiFi mode	station/softAP/SoftAP+station
	Security	WPA/WPA2
	Encryption	WEP/TKIP/AES
	Firmware Upgrade	UART Download / OTA (via network)
	Ssoftware Development	Supports Cloud Server Development / SDK for custom firmware development
	Network Protocols	IPv4, TCP/UDP/HTTP/FTP
	User Configuration	AT Instruction Set, Cloud Server, Android/ iOS App

Absolute Maximum Ratings (Note 10)

If Military/Aerospace specified devices are required, please contact the National Semiconductor Sales Office/ Distributors for availability and specifications.

Supply Voltage	+35V to −0.2V
Output Voltage	+6V to −1.0V
Output Current	10 mA
Storage Temp.;	
TO-46 Package,	−60°C to +180°C
TO-92 Package,	−60°C to +150°C
SO-8 Package,	−65°C to +150°C
TO-220 Package,	−65°C to +150°C
Lead Temp.: TO-46 Package, (Soldering, 10 seconds)	300°C
TO-92 and TO-220 Package, (Soldering, 10 seconds)	260°C
SO Package (Note 12)	
Vapor Phase (60 seconds)	215°C
Infrared (15 seconds)	220°C
ESD Susceptibility (Note 11)	2500V
Specified Operating Temperature Range: T_{MIN} to T_{MAX} (Note 2)	
LM35, LM35A	−55°C to +150°C
LM35C, LM35CA	−40°C to +110°C
LM35D	0°C to +100°C

Electrical Characteristics

(Notes 1, 6)

Parameter	Conditions	LM35A			LM35CA			Units
		Typical	Tested Limit (Note 4)	Design Limit (Note 5)	Typical	Tested Limit (Note 4)	Design Limit (Note 5)	(Max.)
Accuracy (Note 7)	T_A=+25°C	±0.2	±0.5		±0.2	±0.5		°C
	T_A=−10°C	±0.3			±0.3		±1.0	°C
	T_A=T_{MAX}	±0.4	±1.0		±0.4	±1.0		°C
	T_A=T_{MIN}	±0.4	±1.0		±0.4		±1.5	°C
Nonlinearity (Note 8)	T_{MIN}≤T_A≤T_{MAX}	**±0.18**		**±0.35**	**±0.15**		**±0.3**	°C
Sensor Gain (Average Slope)	T_{MIN}≤T_A≤T_{MAX}	**+10.0**	**+9.9, +10.1**		**+10.0**		**+9.9, +10.1**	mV/°C
Load Regulation (Note 3) 0≤I_L≤1 mA	T_A=+25°C	±0.4	±1.0		±0.4	±1.0		mV/mA
	T_{MIN}≤T_A≤T_{MAX}	**±0.5**		**±3.0**	**±0.5**		**±3.0**	mV/mA
Line Regulation (Note 3)	T_A=+25°C	±0.01	±0.05		±0.01	±0.05		mV/V
	4V≤V_S≤30V	**±0.02**		**±0.1**	**±0.02**		**±0.1**	mV/V
Quiescent Current (Note 9)	V_S=+5V, +25°C	56	67		56	67		µA
	V_S=+5V	**105**		**131**	**91**		**114**	µA
	V_S=+30V, +25°C	56.2	68		56.2	68		µA
	V_S=+30V	**105.5**		**133**	**91.5**		**116**	µA
Change of Quiescent Current (Note 3)	4V≤V_S≤30V, +25°C	0.2	1.0		0.2	1.0		µA
	4V≤V_S≤30V	**0.5**		**2.0**	**0.5**		**2.0**	µA
Temperature Coefficient of Quiescent Current		**+0.39**		**+0.5**	**+0.39**		**+0.5**	µA/°C
Minimum Temperature for Rated Accuracy	In circuit of *Figure 1*, I_L=0	+1.5		+2.0	+1.5		+2.0	°C
Long Term Stability	T_J=T_{MAX}, for 1000 hours	±0.08			±0.08			°C

Electrical Characteristics

(Notes 1, 6)

Parameter	Conditions	LM35 Typical	LM35 Tested Limit (Note 4)	LM35 Design Limit (Note 5)	LM35C, LM35D Typical	LM35C, LM35D Tested Limit (Note 4)	LM35C, LM35D Design Limit (Note 5)	Units (Max.)
Accuracy, LM35, LM35C (Note 7)	T_A=+25°C	±0.4	±1.0		±0.4	±1.0		°C
	T_A=−10°C	±0.5			±0.5		±1.5	°C
	$T_A=T_{MAX}$	±0.8	±1.5		±0.8		±1.5	°C
	$T_A=T_{MIN}$	±0.8		±1.5	±0.8		±2.0	°C
Accuracy, LM35D (Note 7)	T_A=+25°C				±0.6	±1.5		°C
	$T_A=T_{MAX}$				±0.9		±2.0	°C
	$T_A=T_{MIN}$				±0.9		±2.0	°C
Nonlinearity (Note 8)	$T_{MIN} \le T_A \le T_{MAX}$	**±0.3**		**±0.5**	**±0.2**		**±0.5**	°C
Sensor Gain (Average Slope)	$T_{MIN} \le T_A \le T_{MAX}$	**+10.0**	**+9.8, +10.2**		**+10.0**		**+9.8, +10.2**	mV/°C
Load Regulation (Note 3) $0 \le I_L \le 1$ mA	T_A=+25°C	±0.4	±2.0		±0.4	±2.0		mV/mA
	$T_{MIN} \le T_A \le T_{MAX}$	**±0.5**		**±5.0**	**±0.5**		**±5.0**	mV/mA
Line Regulation (Note 3)	T_A=+25°C	±0.01	±0.1		±0.01	±0.1		mV/V
	$4V \le V_S \le 30V$	**±0.02**		**±0.2**	**±0.02**		**±0.2**	mV/V
Quiescent Current (Note 9)	V_S=+5V, +25°C	56	80		56	80		μA
	V_S=+5V	**105**		**158**	**91**		**138**	μA
	V_S=+30V, +25°C	56.2	82		56.2	82		μA
	V_S=+30V	**105.5**		**161**	**91.5**		**141**	μA
Change of Quiescent Current (Note 3)	$4V \le V_S \le 30V$, +25°C	0.2	2.0		0.2	2.0		μA
	$4V \le V_S \le 30V$	**0.5**		**3.0**	**0.5**		**3.0**	μA
Temperature Coefficient of Quiescent Current		**+0.39**		**+0.7**	**+0.39**		**+0.7**	μA/°C
Minimum Temperature for Rated Accuracy	In circuit of *Figure 1*, I_L=0	+1.5		+2.0	+1.5		+2.0	°C
Long Term Stability	$T_J=T_{MAX}$, for 1000 hours	±0.08			±0.08			°C

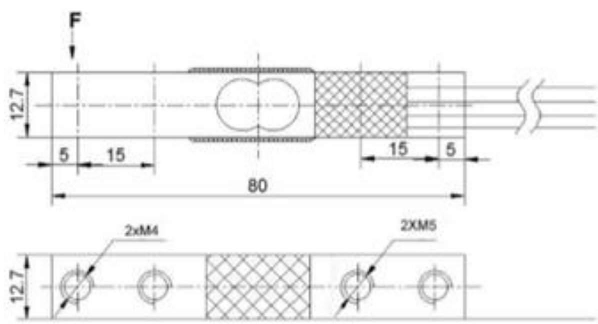
LOAD SENSOR

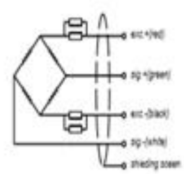
TAL220 **PARALLEL BEAM LOAD CELL**

Features:
◆Capacity： 3-200kg
◆Material: aluminum-alloy or alloy steel
◆Type: Parallel beam type
◆Defend grade: IP65
◆Application : Palm scale, kitchen scale, electronic balance, fishing scale, electronic platform scale and other electronic weighing devices.

WWW.HTC-SENSOR.COM

Electrical connection and Dimensions:(dimension unit: mm)





Specifications:		
capacity	kg	3,5,10,20,25,30,50(aluminum); 80,100,120,200(alloy steel)
safe overload	%FS	120
ultimate overload	%FS	150
rated output	mV/V	1.0 ± 0.15
excitation voltage	Vdc	5 ~ 10
combined error	%FS	± 0.05
zero unbalance	%FS	± 0.1
non-linearity	%FS	± 0.05
hysteresis	%FS	± 0.05
repeatability	%FS	± 0.03
creep	%FS/3min	± 0.05
input resistance	Ω	1000 ± 15
output resistance	Ω	1000 ± 10
insulation resistance	MΩ	≥ 2000
operating temperature range	℃	-10 ~ +55
compensated temperature range	℃	-10 ~ +40
temperature coefficient of SPAN	%FS/10℃	± 0.05
temperature coefficient of ZERO	%FS/10℃	± 0.05
Electrical connection	cable	4 color wire (standard)or 4 shielded PVC cable, Ø0.8 × 220 mm

SINGLE PHASE 15W 220V VIBRATING MOTOR

Technical Specifications:

Color: Orange

Material: Aluminium alloy

- 220V 15W Vibrating Motor - Single Phase

Voltage: 220V

Power: 15W

Current: 0.10A

Force: 10KG

Frequency: 2940Hz (50Hz); 3450Hz (60Hz)

Size: 145x110x75MM (5.7x4.3x3in)

- 220V 30W Vibrating Motor - Single Phase

Voltage: 220V

Power: 30W

Current: 0.13A

Force: 20KG

Frequency: 2940Hz (50Hz); 3450Hz (60Hz)

Size: 145x110x75MM (5.7x4.3x3in)

Features:

Adjustable Eccentricity Block: Adjust the angle of eccentricity block, can stepless adjust the excitation force, meet all kinds of requirements.

Vibrator Motor: AC Vibration Motor 15/30W Industrial Vibrating Asynchronous Vibrator 220V 2940RPM.

Description: Motor adopt of imported bearings, low noise, smooth operation, long service life. High temperature resistance pure copper enameled wire, all copper winding, stator vacuum dip paint, guarantee insulation grade

Features: Aluminum alloy shell, light quality, fast heat dissipation, fast temperature rise. The motor machine shell is precision casting, with o-ring seal on the edge, fully closed structure design, with dustproof and moisture-proof function.

Useful: Motor anti vibration special power cable protection cover to prevent long - time cable vibration damage. Apply in Mining, metallurgy, coal, electricity, construction, chemicals, medical equipment, food machinery, etc.

APPENDIX D

Project Manual

PROPONENTS

Alonzo, Rowella R.
Duñgo, Miralin Grace R.
Laspiña, Racquel R.
Lepasana, Marc Genesis D.
Yasuda, Akira H.

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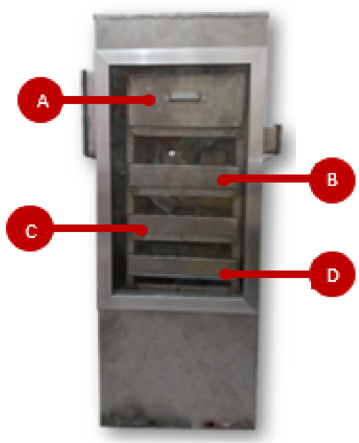
POLYWORM

USER MANUAL



LEGEND

A. Beetle and Pupae container
B. Mealworm container
C. Catcher
D. Frass Container

HOW TO USE

INITIAL SETUP

1. Slide the first drawer labeled "beetles" and "pupae" on the topmost level of the device.
2. Slide the "worms" drawer into the second layer of the device.
3. Slide the "catcher" drawer into the the third layer of the device.
4. Slide the "frass" drawer into the fourth layer of the device.
5. Plug the device to 220V AC power source.
6. Open the top door. Load mealworms on their respective container.
7. Securely close all the doors.

Harvesting the frass:

The app will notify the user through SMS and email when the frass reached 200 grams.

Schedule of automated segregation and feeding:

The device will dispense Styrofoam into the beetles and mealworms every day.

Segregation will commence every Mondays, Wednesdays, and Fridays.

Using the Application:

1. Download the Blynk app.
2. Login the email and password of the Blynk account given by the proponents.

- The real-time temperature and weight of the frass are displayed.

Loading the Styrofoam:

1. Cut the Polystyrene into 1x1x1 cm cubes.
2. Load the Polystyrene in the food dispenser located at the rear of the device. Ensure that the dispenser is filled all the way.
3. Close the cover tightly.

Care and maintenance:

1. Keep the device on cool, dry and if possible, dark place.
2. Avoid subjecting the device to extreme temperature.
3. Check the catch drawer every Sunday and transfer the contents on top of the machine, through the top door.

SAFETY REMINDERS

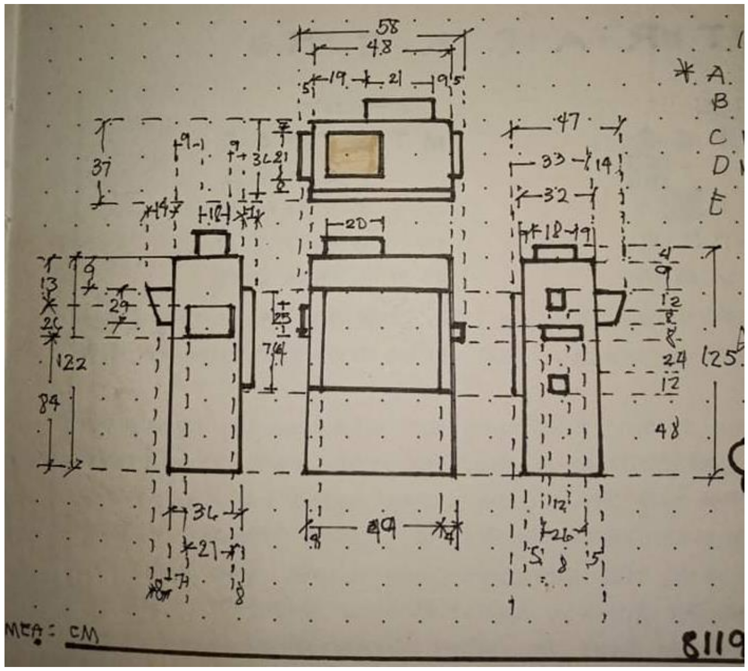
- DO NOT open any door while the vibrating motor is operational.
- Operating voltage:220 V AC, 50-60Hz
- Control panel intentionally sealed.

Transferring drawer contents:

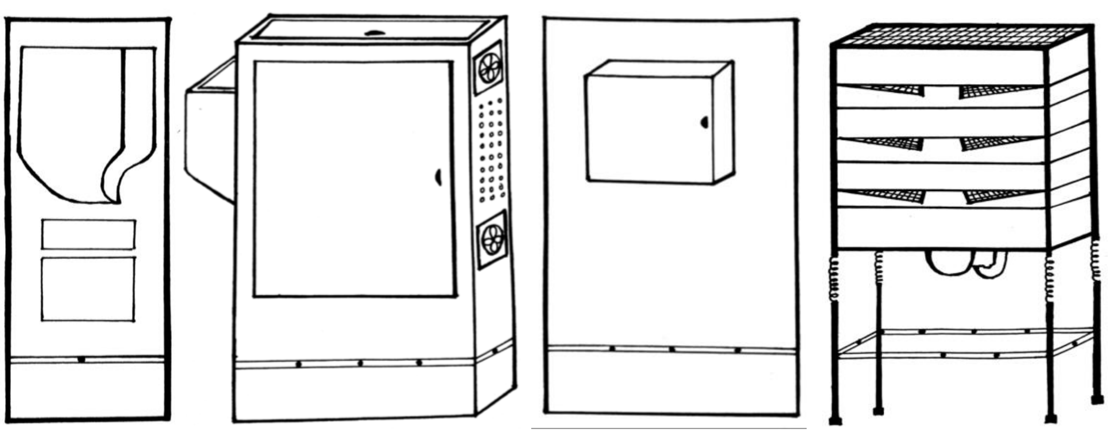
1. Wait for the segregation notification and after the vibration finishes.
2. Open the right side door and insert container to catch the beetles.
3. Separate the beetles from the frass and eggs on the harvest container and return the beetles through the top door.
4. Keep the frass and eggs on a separate container.
5. Wait for the mealworms, second drawers, to transfer on catch drawer.
6. Open the main door and remove the third drawer.
7. Open the door at the top of the device.
8. Transfer the contents, avoiding spills.

APPENDIX E

Project Documentation



Measurement of the device



LEFT **FRONT & RIGHT** **BACK** **INNER VIEW**

Project conceptualization

Design using Sketchup

Construction of the project

Final look and setup of the Prototype

Meeting with the Barangay Captain and MRF staffs

Project Deployment at Barangay Balangkas, Valenzuela

TOPIC DEFENSE

TITLE DEFENSE

PROGRESS PRESENTATION

PRE FINAL DEFENSE

FINAL DEFENSE / ONLINE SYMPOSIUM

APPENDIX F

Certificate of Proofreading

CERTIFICATION

This is to certify that the research work presented in this thesis, **SEMI-AUTOMATED BIODEGRADATION SYSTEM FOR POLYSTYRENE-EATING MEALWORMS WITH ESP8266 FOR WIRELESS NOTIFICATION SYSTEM** by the group of researchers namely Rowella R. Alonzo, Miralin Grace R. Duñgo, Racquel R. Laspiña, Marc Genesis D. Lepasana, and Akira H. Yasuda, aligned with the set of structural rules that govern the composition of sentences, phrases, and words in the English language.

Ms. Christine Mae V. Romblon, LPT
Grammarian

Lic. No. 1835129

January 19, 2021
Date Signed

APPENDIX G

Researcher's Profile

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EDUCATION

Tertiary	TECHNOLOGICAL UNIVERSITY OF THE PHILIPPINES Bachelor of Science in Electronics Engineering Ayala Blvd. Ermita, Manila 2017-Present
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Secondary	BACOOR NATIONAL HIGH SCHOOL-MOLINO MAIN Blk 22-23, San Marino City, Salawag Dasmariñas City, Cavite 2010-2014
Primary	Soldiers Hills 4 Elementary School Molino 6 Bacoor, City Cavite 2008 – 2010
	Bayanan ELementary School Bayanan Bacoor, Cavite 2003-2008

CO-CURRICULAR ACTIVITES

2017-Present	Member, Organization of Electronics Engineer Students Technological University of the Philippines-Manila
2016- 2017	Member, Institute of Electronics Engineers of the Philippines Manila Chapter
January 2020-Present	Secretary, Life Coaching and Leadership Initiative, Technological University of the Philippines – Manila

SEMINARS ATTENDED

March 2018	JOB FAIR 2018 Technological University of the Philippines – Manila
23 February 2019	APPRECIATE: Annual Presentation of Project Research in Electromechanical, Civil, Information and Telecommunications Engineering 2019- "Shaping the World's Future through Engineering Innovations" Technological University of the Philippines-Manila
March 2019	JOB FAIR 2019 Technological University of the Philippines – Manila
13 January-18 May 2020	Integrated Circuit Design, Layout and Simulation for Electronics Students and Professionals
15 January-20 May 2020	AM, FM, TV Broadcasting System and Station Design for Electronics Students and Professionals

PERSONAL INFORMATION

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23 February 2019	APPRECIATE: Annual Presentation of Project Research in Electromechanical, Civil, Information and Telecommunications Engineering 2019- "Shaping the World's Future through Engineering Innovations" Technological University of the Philippines-Manila
8 February 2020	IECEP-MSC Student Summit 2020 "Career Pathways" Justo Alberto Auditorium, Pamantasan ng Lungsod ng Maynila Intramuros, Manila
	IECEP-MSC Student Summit 2020 "Graduate Studies: To Pursue or Not To Pursue" Justo Alberto Auditorium, Pamantasan ng Lungsod ng Maynila Intramuros, Manila
	IECEP-MSC Student Summit 2020 "Redefining Success" Justo Alberto Auditorium, Pamantasan ng Lungsod ng Maynila Intramuros, Manila

SEMINARS ATTENDED

	IECEP-MSC Student Summit 2020 "How to Win Job Interview" Justo Alberto Auditorium, Pamantasan ng Lungsod ng Maynila Intramuros, Manila
24 June 2020	Cybersecurity: The New Normal "Segment 1: Realities of Cyberspace" Department of Information and Communications Technology
	Cybersecurity: The New Normal "Segment 2: Cybertalk with CERT-PH" Department of Information and Communications Technology
	Cybersecurity: The New Normal "Segment 3: PKI and Its Role in the New Normal" Department of Information and Communications Technology
3 July 2020	Publishing Extension Outputs in Research Journals Technological University of the Philippines

PERSONAL BACKGROUND

Date of Birth	:	December 6, 1995
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June 2015-Present	Member, Organization of Electronics Engineering Students, Technological University of the Philippines – Manila
June 2016-Present	Member, Life Coaching and Leadership Initiative, Technological University of the Philippines – Manila

January 2018-Present	ECT Associate Member, Institute of Electronics Engineers of the Philippines

SEMINARS ATTENDED

23 February 2019	APPRECIATE: Annual Presentation of Project Research in Electromechanical, Civil, Information and Telecommunications Engineering 2019- “Shaping the World’s Future through Engineering Innovations” Technological University of the Philippines-Manila
23 February 2018	APPRECIATE: Annual Presentation of Project Research in Electromechanical, Civil, Information and Telecommunications Engineering 2018- “Strengthening the Engineering Research for a Developing World” Technological University of the Philippines- Manila
13 August 2017	IECEP – MSC General Assembly 2017: “Hola! Excelentes y Compasivos Ingenieros” San Andres Sports Complex, Malate, Metro Manila
March 2018	JOB FAIR 2018 Technological University of the Philippines – Manila,
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PERSONAL BACKGROUND

Date of Birth	:	March 7, 1999
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CO-CURRICULAR ACTIVITIES

June 2018-March 2019	General Staff, Organization of Electronics Engineering Students, Technological University of the Philippines – Manila
2019-2020	Member, TUP Manila - Red Cross Youth, Technological University of the Philippines – Manila

SEMINARS ATTENDED

12 February 2019	Introduction to LoraWAN Technology Seminar
16 September 2019	Orientation Program and Performance Management Seminar for the Student Assistants of the University
13 January-18 May 2020	Integrated Circuit Design, Layout and Simulation for Electronics Students and Professionals
15 January-20 May 2020	AM, FM, TV Broadcasting System and Station Design for Electronics Students and Professionals
19 June 2020	Biological Safety Awareness Online Seminar
28 July 2020	Gender Awareness & Gender Sensitivity (During Pandemic)

PERSONAL BACKGROUND

Date of Birth	:	April 26, 1999
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EDUCATION

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Primary	FRANCISCO HOMES ELEMENTARY SCHOOL San Jose Del Monte, Bulacan 2005 – 2011

CO-CURRICULAR ACTIVITIES

January 2015 - Present	Organization of Electronics Engineering Students Member College of Engineering Technological University of the Philippines – Manila
June 2018 – 2019	Organization of Electronics Engineering Students Staff College of Engineering Technological University of the Philippines – Manila

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page 2

SEMINARS ATTENDED

23 February 2019	APPRECIATE: Annual Presentation of Project Research in Electromechanical, Civil, Information and Telecommunications Engineering 2012 - “Shaping the World's Future through Engineering Innovations” Technological University of the Philippines - Manila
13 January - 18 May 2020	Integrated Circuit Design, Layout and Simulation for Electronics Students and Professionals Technological University of the Philippines - Manila

PERSONAL BACKGROUND

Date of Birth	:	July 7, 1998
Place of Birth	:	San Jose Del Monte, Bulacan
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Gender	:	Male