Smart Aquarium Kit

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The project is designed to build an automatic aquarium kit. The aquarium kit consists of electronic components that control the fish-tank environment by maintaining the parameters such as temperature and PH. The project is very useful for the people who like decorating their houses with an aquarium. Therefore, here the project presents how this smart system works. The smart system has three main functions; food supplying, water filtration, and maintaining system). The food supplier system provides food for the fishes in the aquarium kit automatically. Therefore no effort is required from the user to feed the fishes. The filtration system provides clean water in the aquarium kit. In case if the water gets dirty in the aquarium, then the user will be allowed to enter the system to activate water pump by using manual switch. There is a system in the aquarium kit project to maintain the pH level, humidity level and temperature. The temperature is maintained between 20 and 35 degrees Celsius by the water pump. The water pump recycles the water to cool down the temperature in the system. However if the humidity goes above 20% then the system will run the fan to blow the air in the aquarium in order to reduce the humidity below 20%. In case if the PH level goes above 7 alarm will be activated to alert the user to read the PH level.

Keywords: Aquarium; Filtration; PH level; Water Pump; Smart System

Introduction

Aquarium Kit is a fish-tank filled with water for keeping underwater lives and it generally used for decoration purpose. The aquarium gives stunning look to the area, gives a sense of peace, life and tranquility in the place and it gives the people the feeling of connection to the nature, therefore we can see Aquarium Kit almost in every houses, hospitals and even in the restaurants. Moreover, we can find so many people are interested in petting fish, therefore they collect different types of fishes and provide a proper Aquarium Kit for these creatures, but petting fishes is a hard job as it requires full attention time to time to keep the tank adaptable for the fishes by providing a proper environment. Thus, having a smart Aquarium Kit will help people to take care of their fishes without any effort. This project designs a system that provide the perfect environment in the aquarium water and control the feeding process for the fishes automatically to help the fish live longer and healthier without any need of a direct observation from the person. After the project is completed, the system will be able to generate a perfect environment simulated from the original environment where the fish came from. Moreover the system controls a few important parameters such as temperature roughly between 20 and 30 degrees Celsius, pH about 7, dissolved oxygen, water filtration, humidity and feeding process which should be maintained around 20 to 40 for almost all kinds of fishes. The system has many features as follows:

1. Filtering system for a better environment in the aquarium.
2. Control and maintain the parameters in a proper range automatically such as: temperature, humidity, water level, amount of dissolved oxygen, water filtration and PH.
3. Providing a food supplier system.

While studying the literature review there were few past projects that used similar method or related to the aquarium kit project. However the system still unique because comparing to the other previous projects or systems the system includes few differences and that's what makes the project unique and different compare to other. Therefore, different articles were discussed as follows

This article based on educational reports written by Dr. foster and Dr. Smith. The article includes much information about water pump that it can be used in aquarium or usually used in aquariums. At first the article discusses the uses of the water pump. Moreover the use of water pump that was mentioned in the article is to move the water either to the filtration system or from the filtration system this can be applied in both saltwater and freshwater aquariums. Wet/dry filter system and pressure setup filter system are the two types of filtration setups. In addition to water pump can be used to create a current in the aquarium as well and it can push the water in other devices or fill the tank or drain it. In the second part of the article the writers discuss the flow rate that is proper for an aquarium during certain duration of time. However the level of GPH, shape and size of the tank must be considerate while deciding the flow rate of the pump. Other part discusses how to choose the suitable pump for your aquarium and this based on many different steps as it will be mentioned briefly in the following:

First step the user need to know how many gallons are need it for his/her tank. Secondly the user must determine

Head height (Head highest is the distance between the highest point the water will reach and the pump). By considering the head high, GPH, sharp turns and the tubes, water pump can be chosen successfully.

Literature Review

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Open Aquarium - Aquaponics and Fish Tank Monitoring using Arduino

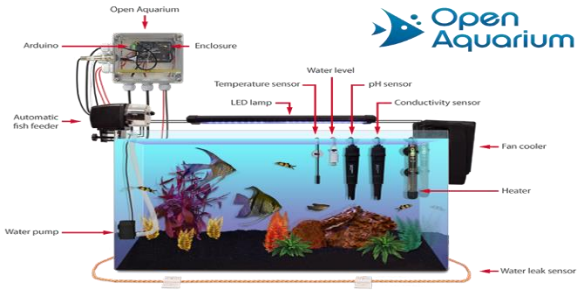

Fig 1.1: open aquarium

The previous parts of the article were really useful and directly related to a very important part of the present system that will be used in the aquarium kit therefore this article was chosen. Open Aquarium - Aquaponics and Fish Tank Monitoring using Arduino.This article is similar to the project; however there are few points that show how much the present aquarium system is different. At first, few important points from the article will be discussed then reasons will be given that will describes how this article helped in carrying out the present project. The title of the article is "Open Aquarium - Aquaponics and Fish Tank Monitoring using Arduino" from the name we can understand that the system of this aquarium is based on the Arduino microcontroller [3].The aquarium includes two different main kits: Aquaponics kit and basic kit along with many different additional accessories.

The system includes three different sensors that measure important variables such as PH, conductivity and temperature, as we know these variable have a major effect on the fish's health. Moreover, there are also four different actuators to maintain the water condition in the kit such as cooling or heating the water to maintain proper water temperature also there is a feeding fish system and water pump for changing water. The system also includes a web application that stores all the gathered data to be stored as well in the user personal phone or device.

The present system is different from the article system because it includes a more effective filter system that will maintain the water clean for a long time and it's also controlled feeding process to organize the feeding fish in the aquarium. The system includes an LCD display screen to show all the required data of the system to give information about different variables that may affect the fish's health instead of using a web application. Also, this system is providing safety and security to aquarium kit because of the keypad that will be attached to give only the user authority to use the kit after applying a certain password that the user saved it in the system memory earlier to change humidity level and temperature degree of the system [6].

Arduino Pump Tutorial - Aquarium Auto Refill

This article shows how to use water pump, but with the help of Arduino microcontroller and float switch. This project article uses a similar concept of the present system but the difference that the present project uses water level sensor instead of float switch and also having two different tubes in the system one to provide clean water and one to push the dirty water out of the tank [3]. The system describes the same method that is used in the present aquarium system. The method in short is to refill the tank once the level of the tank becomes too low and that will happen once the float switch sense the level of the water to activate the water pump. This application can be used also in water fountains. In the present system at first the dirty water will be pushed out of the tank through a specific tube, then the water level sensor will sense the level of water and once the level is too low, the clean water will be refilled in the tank with the help of a water pump. Also the whole process is controlled by a PIC microcontroller [5].

Fish Tank Monitor

This article discusses how to build fish tank monitoring system. The system provided by the article can measure the temperature of the water and air, PH of the water and intensity of the light in the tank. The system of this article works in two versions. The first version is WIFI Bee and SODAQ to send the data through it. The other version uses Ethernet Shield and Arduino Uno to send data as well. In each version there will be few differences in the setup [3]. The materials used in the system are fish tank and all the needed accessories for the tank, sensor for the temperature (DS18B20) sensing as well as PH sensor and a controller board. And one sensor for both humidity and temperature of the water in the tank (DHT22) similar to the one used in the present project, one digital light sensor, OLED display and grove cables [1]. There are two versions as it was mentioned before and in each version there are two types of settings. The first version is Sodaq Version and the two types of this version are Sodaq and WiFi bee. The other version is Arduino Uno Version the two types of this version are Arduino Uno and Ethernet Shield. However, in these two versions there are a few items the user should consider sending data, such as Ethernet cable and Grove Shield [3]. The article discusses the steps for preparing the tank and attaching the sensors. Also, how to choose a proper version of a given system along with a few details about each version. All this information included in the article helped in designing the project because it gives all the important basics to design a proper aquarium kit. This article is very useful for the aquarium kit project because it provides in details about how to build a feeding system in the aquarium. However, the present project uses PIC microcontroller to implement the feeding system. The article mentions seven main steps to follow in order to build a feeding system. The seven steps are described in the following paragraphs briefly.

Figure 1.2: fish tank monitor

Auto Fish Feeder

This article is very useful for the aquarium kit project because it provides in details about how to build a feeding system in the aquarium. However, the present project uses PIC microcontroller to implement the feeding system. The article mentions seven main steps to follow in order to build a feeding system. The seven steps are described in the following paragraphs briefly.

The first step of the article describes the needed materials or items to build the feeding kit. The main components of the system are tool box, power supply of 9 or 12V, a hung up phone switch, timer and Arduino UNO [3]. The second step of the article describes the construction of the system with variable items that can be found easily in any home or store. However, in this step the writer of the article didn't mention any electronic parts to use while building the system. The third step gives few solutions for problems that may occur in the system. The fourth step is electronic parts, this step describes the connection on the breadboard and the Red Board (Arduino UNO) and how all electronic components are connected together along with the timer as well[8]. The fifth step mentions all the necessary codes to run the system. The sixth step includes a video that shows the working principle of the system. However the seventh or last step shows a video for testing the system by providing fish food to the kit [4].

Fig 1.3: auto fish feeder

Project Methodology

It was found that the V-shaped method is the most suitable one to be used in this project because it works according to testing in each and every stage. Also, this methodology is better for the system because while using this model it can be assure that all the steps are going completely correct by testing each step before going to the other step.

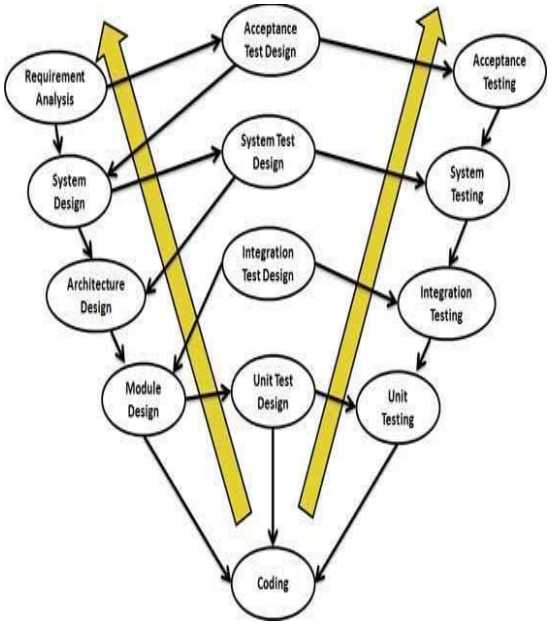

Figure 1.4: V-shape Model

Verification Phases of v-model methodology.

The different phases of the V-shaped method are as follows:

1. Requirement Analysis

As the previous graph shows the first stage is analyzing the requirements. From this stage it can be understood that the system requirements are according to the user need and user perspective. Moreover, this stage includes as well all the ideas about the exact requirements and the user specific expectation about the project. This stage needs to be well managed because in some cases we can find the user is not sure about the exact need of his/her project or system. Therefore, this first stage is required to show all the requirements of the system and to clear all the inputs to make the stage of testing more easily process.

2. System Design

This stage comes after the user is having a clear idea about his/her requirement of the system because it will be easy now to go to the next step and design the system completely. To complete this stage the user must have enough knowledge about the hardware requirement of the system in order to complete the development of the project. Moreover the test of the development plan is according to the design of the system. Therefore, it's better to do this stage earlier to provide more time for testing.

3. Module Design

At this stage the user should make sure that the design of the project or the model of the system is compatible with the other model in the same system based on the other external systems and architecture of these systems. Moreover, this will allow to overall tests and by that the system will be designed without errors because this stage will help to eliminate all the errors and maximum fat that may occur through the process of the project.

4. Coding Phase

This stage is based on the system actual coding and the model designed phase. Moreover the coding phase is taken up by the designed phase. Also, it's about choosing the most suitable programming to help in designing the circuits of the system with considering all the hardware and software requirements. The coding in this stage will be based on the guidelines of the system to provide the desired output. Although the coding is not an easy step, therefore the code may go through numerous review to ensure that the code is suitable, one to make the system to perform perfectly without any errors.

5. Validation Phases

In the following there are the validation phases of V-model:

i) Unit Testing:

During the validation phase the model unit test designed and the model designed are executed in the code. This stage helps in eliminating all the errors from the early stage of the project. Moreover, not all the defects can be uncovered by the unit testing.

ii) Integration Testing:

This phase is only to test the connection and coexistence of the internal models through the system. Moreover, this phase is associated with the architectural design of the system.

iii) System Testing:

System testing is associated with the phase of system design. This system based on testing and checking the complete system according to the functionality and development of the system with external systems. Moreover, all the compatibility issues which the software and hardware can be uncovered in the test execution of the system.

Design of a Proposed System

The following is an initial design of the smart aquarium kit project. Moreover, the output is predicted to be implemented in the next stage.

System Block Diagram

The following block diagram shows all the required input to the microcontroller in order to succeed in producing all the desired output from the system as it's shown in figure.

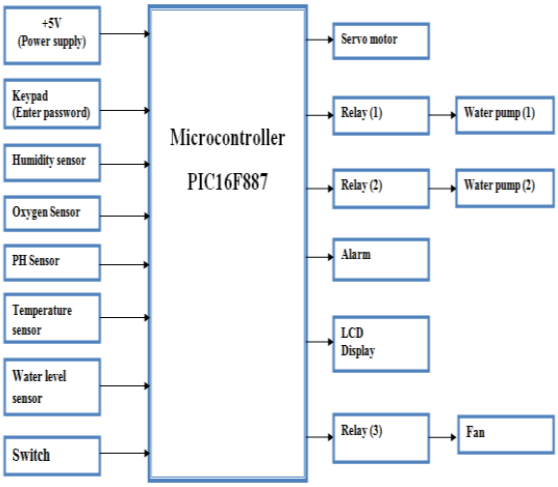

Figure 1.5: system block diagram

As the previous block diagram shows the inputs to the microcontroller are a power supply of 5 Volt, oxygen sensor, PH sensor, temperature sensor, humidity sensor, water level sensor, and keypad and switch [16]. There are different outputs from the PIC microcontroller [13]such as servo motor, alarm, LCD[9], one relay connected to the fan and the other two relays are connected to the water pumps[14]. Each sensor in the input gives a different reading or measurement, for example the oxygen sensor gives the level of the oxygen in the water. Then it sends the data to the microcontroller. The microcontroller will operate to provide an alarm once the level of the PH goes above7. This process is implemented to maintain a proper level of PH in the aquarium [7]. For the filtering system the microcontroller sends the data to the water level sensor and receives from it to refill the aquarium with clean water. The filter is not designed to be activated after certain duration of time. The filter can be activated only if the user activates the water pumps for the filtering process by using the manual switch. In the filtering process water pump (1) will be activated first and all the dirty water will be taken out of the aquarium through it[12], then the water level sensor will sense the drop in the water level and it will activate water pump (2) to refill the aquarium with clean water[2]. The feeding system is basically consisting of two main parts. The first part is the feeding kit refills every three to four days. The other part is the servo motor that attaches to the kit to organize the feeding process. The feeding process will be activated once the system is turned on. Moreover, during the time of feed the servo motor will rotate at an angle of 90 degrees. The food will be released into the water and the process keep on repeating each time the system is switched on. If humidity is not around 40%, then the system will run a specific process to maintain the humidity in a proper range. The system will activate the fan to reduce the humidity in the tank if it is beyond 40% [15].

In case of temperature is high, the system will produce cold water in order to reduce the temperature in the tank to maintain it in a range less than 30 degrees Celsius. Once the user enters the correct password to the keypad, the user will be allowed to enter the main program of the system to change temperature and humidity values so that the system will be running according to the new entered values.

B. Software design

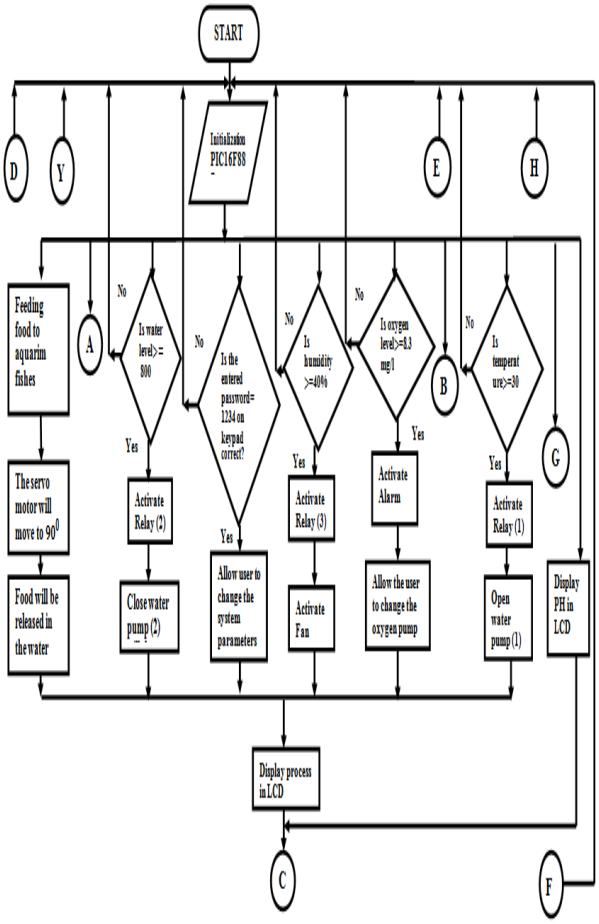

Figure 1.6: system flow chart

This system is based on several executions. The feeding system is based on servo motor rotation as indicated in the flowchart. When the system is turned on the servo motor will be activated to rotate at an angle of $90^0$and the dry food will be released in the water. When the user activates the filtering system by using the manual switch, all the dirty water will be released through the water pump (1) then the level of the water will reduce till 200 liters and the level sensor will sense the decrease in water and it will activate water pump (2) to refill the tank with clean water. If there is an increase in the aquarium temperature above 30 degrees Celsius the system will activate the water pump (1) to reduce the amount of the water in the tank. Then the water level sensor will sense the reducing in the water level and will activate the water pump (3) to refill the system with cold water to maintain the temperature in a proper level.

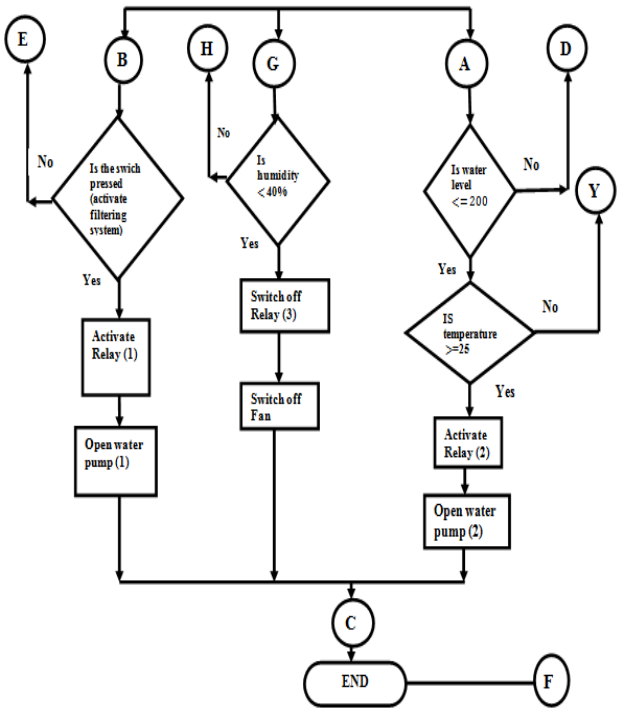

Figure 1.7: system flow chart at reception

As indicated in the flowchart, the user can enter the system to change the parameters (humidity and temperature). If the humidity level is greater or equal to 40%, then the fan will be activated. If the oxygen level is above or equal to 7, then the system will activate the alarm to indicate that there is high percentage in the aquarium water.

Technical Requirements

The technical requirements discuss all the different hardware and software components for which the aquarium consists. There are thirteen main different hardware components and two software components used in the project. The project is implemented by PIC microcontroller. The PIC microcontroller (PIC 16F887) is the heart of the aquarium kit project because it execute all the codes that control different components of the project to get the desired output in order to achieve the objectives of the project. The LCD is used to display variable parameter of the system such as the water level of the aquarium, PH level, oxygen level, humidity level and temperature level of the aquarium [9]. The keypad is used to allow the user to change any required parameter after entering the correct password. The level sensor required in this project to detect the level of the water. By detecting the level of the water the system can understand when it's required to refill the aquarium with clean water and when it's not required. Therefore level sensor is very important in the filtering process. The PH sensor is implemented in the project to help in measuring the level of PH in the water and then display it on the LCD. The servo motor is the main part of the automatic feeding system in the aquarium kit project. Because when the servo motor rotate to an angle of 90^0 the food will be released from the feeding kit into the water. The basic part of the filtering system is the water pumps. The water pump is used in the filtering system for two purposes: The first purpose is to take out all the dirty water from the aquarium and the second purpose is to refill the tank with clean water. DHT11 is implemented in the aquarium kit project to measure two important variables (temperature and humidity). When the DHT11 sense there is increasing in temperature beyond a specific limit (temp greater or equal to 30^0 degree Celsius) the filtering system will be activated to reduce the water temperature. And if the DHT11 sense there is increasing in humidity beyond a specific limit (humidity greater or equal to40%) then the system will activate the fan to reduce humidity [1].The software used in this project is (ISIS) Proteus and mikro C program to simulate the circuit diagram.

System operation

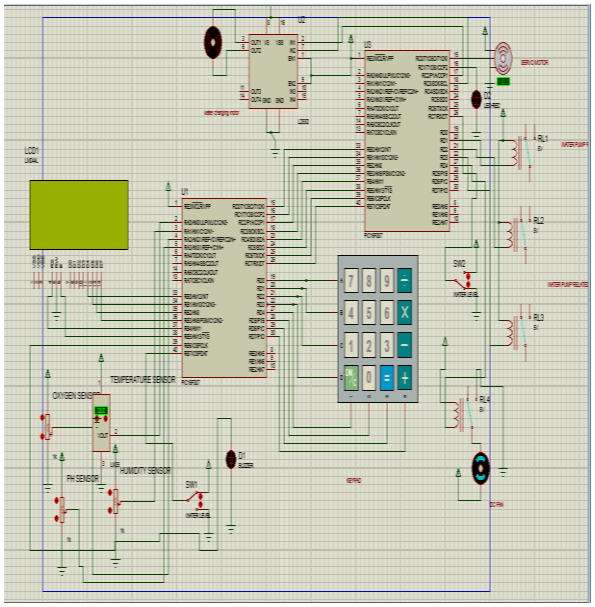

Figure 1.8: Project Schematic diagram

There are three main systems that the aquarium kit project implement. The first system is food supply system for the fish's through a feeding kit that will be attached to the aquarium tank. The feeding kit consists of two main components (servo motor and microcontroller). The servo motor connected to the microcontroller as an output and once the system is turned on the microcontroller will activate the servo motor to rotate at an angle of 45 degrees to release the food in the water.

The second system is filtering the water of the aquarium kit. The concept of the water pump is to take the muddy water out of the tank by using the first water pump (water pump (1)) and to refill the tank with the second water pump (water pump (2)). The number of filtering per week in the aquarium will be according to the user decision. The user will be allowed to activate the filter by using manual switch. The LCD displays all the important variables of the aquarium kit. The readings that will show on the LCD are water level sensor, temperature and humidity sensor (DHT11) [1], PH senor and oxygen sensor. The microcontroller will take all the readings from the different sensors, and varies actions will be implemented. In case if the humidity went above 40% a signal will be sent to the microcontroller then the fan will be activated based on the microcontroller order to circulate the air to decreases the humidity level in the aquarium. In case if the temperature goes

a above 30 degrees Celsius the sensor will indicated that to the microcontroller to send a pulse that will activate the relay (1) to open the water pump (1) and release the water out of the tank. If the level of the water went below 200 ml, then water pump (2) will be activated and it will refill the tank with cold water to maintain proper temperature [2].In case of PH, if the PH level goes above 7 then the sensor will send a signal to the microcontroller in order to activate the alarm. The alarm will alert the user about the increases in PH level.

Results and Discussion

In the project the system simulation is based on two main parts, the first part discuss the software simulation by using ISIS simulation (Proteus 8)the other part is hardware testing and implementation. These two parts are described in the following. Proteus 8 was used to simulate the project circuit and the code was written in mikro C program. Many various components were connected to achieve the objectives of the aquarium kit.

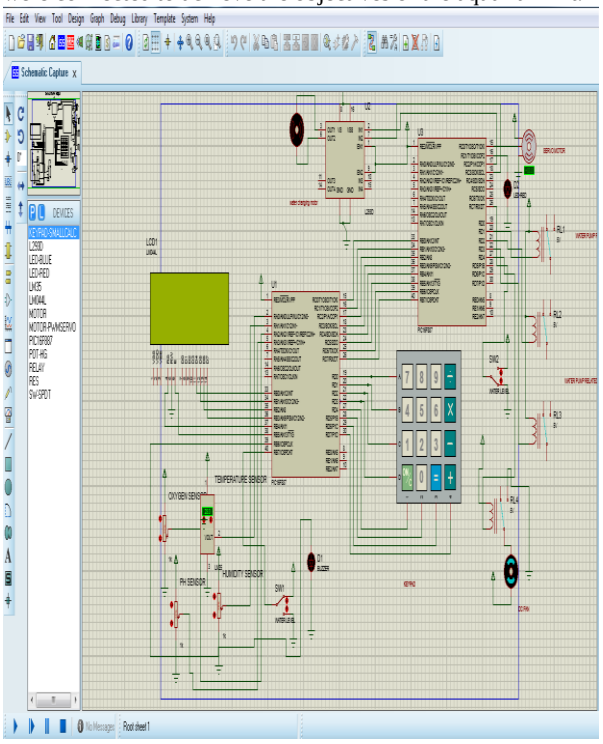

Figure 1.9: circuit diagram

As shown in figure 2.0 two PIC microcontroller of 40 pins are used. Different components such as (LCD, humidity sensor, temperature sensor, oxygen sensor, water level sensor, PH sensor and keypad) are connected to one of the PIC microcontroller through port A, B and D. However port C is connected to the second PIC microcontroller. The second PIC microcontroller is connected to the relays, servo motor, fan and water pumps. From the previous description we can understand that simulating the circuit is an important step to set all the components and to test them to indicate the results or outputs of the system to implement it in the next step. To give a better understanding of the circuit simulation each output of the circuit was simulated on the ISIS simulation platform to make it run according to the objectives of the project and it is explained in the following.

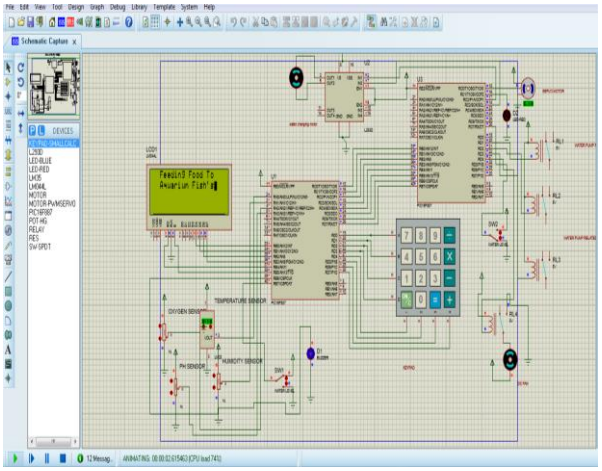

Figure 2.0: feeding process

Once the system is turned on one massage will be displayed in LCD (feeding food to aquarium fishes) to start the feeding system as shown in the figure 2.2 In the same time PIC microcontroller will send a pulse to the servo motor to rotate in an angle of 90 degrees to release the food in the aquarium[11].

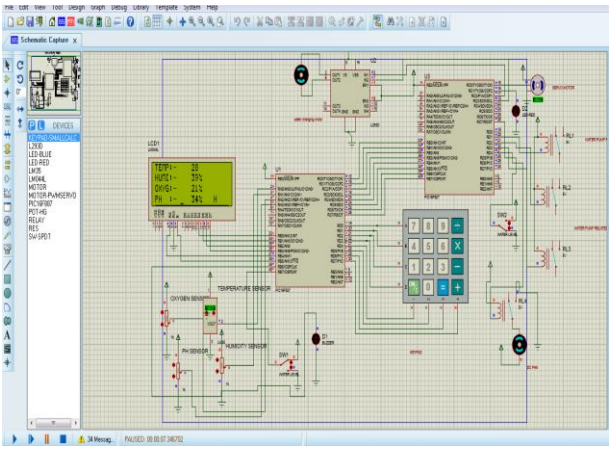

Figure 2.1: feeding process

After a delay of milliseconds another sat of massages will be displayed in the LCD to indicate the readings of different sensors interfaced in the circuit such as humidity sensor, PH sensor, temperature sensor and water level sensor. The previous figure 2.3 shows each sensor reading. One of the important systems in the project is measurement system which includes different sensors that is implemented to keep monitoring any change that may occur in the aquarium water. Notice that the temperature reading is 28 degree and the humidity reading is 39%. If the temperature increased more than 35 degree (as it was entered to the Mikro C program as a proper temperature for the water) the filtering system will be activated to cool down the water through water pumps. Moreover if the humidity increased more than 40% (as it was entered to the Mikro C program as a proper humidity for the water) the fan will be activated to circulate the air in order to reduce humidity in the aquarium. The next paragraphs include disruption about servo motor since it is used in several places to implement the project circuit. Several parameters were controlled through the motors therefore relays were connected in the circuit and interfaced with the motors as shown in the figure 6.4 to get the desired

output. Rotating the servo motor is a very important output to the system since it help in feeding the fishes in the aquarium(once the servo motor rotate at angle of 90 degree the food will be released from the kit to the water through the feeding kit). Moreover in case if the humidity increased in the aquarium then servo motor will rotate the fan to circulate the air in order to decrease the aquarium humidity. Furthermore the servo motor rotation in the circuit that is controlled through three relays is indicating the filtering system process. Servomotor rotates in different angles therefore angles are mention below [10].

Servo motor rotation

1- Rotate at an angle of 45 degree.
2- Rotate at an angle of 90 degree.
3- Rotate at an angle of 180 degree.

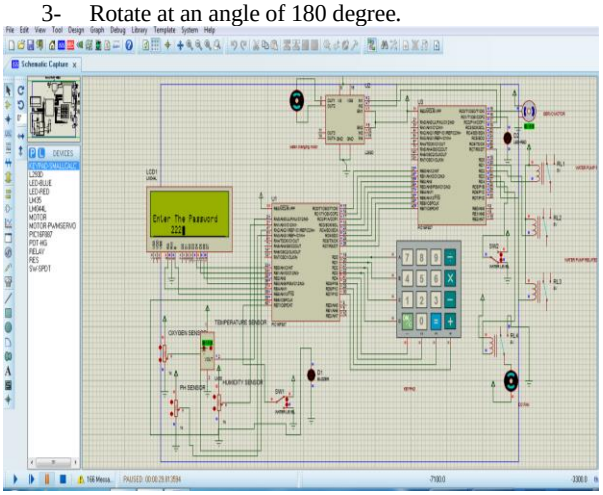

Figure 2.3: enter password

As shown in figure 2.4the displayed massage in LCD is an indication to the user to enter the correct password in order to change humidity and temperature values if it required, because these two parameters are the most important ones to affect the water in the aquarium. Once the user changes the values of temperature and humidity the system will continue operating according to the new values as shown in figure 6.5. Notice that the old value of humidity was 39% and it is changed to 40% and the old value of temperature is 28 degree and it now it is changed to 35 degree.

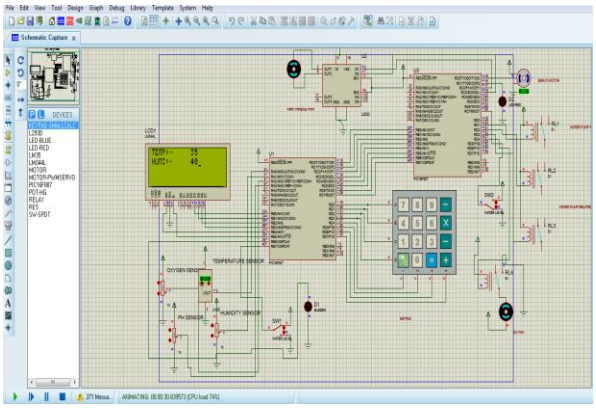

Figure 2.4: change parameters

Hence the correct password to be entered to the keypad is (2222) any other number will not allow the user to enter the system to change any required parameter. In the other hand if the user entered a wrong password a massage will be displayed in the LCD to indicate that and to asks the user to try again as it's shown in figure 6.6.

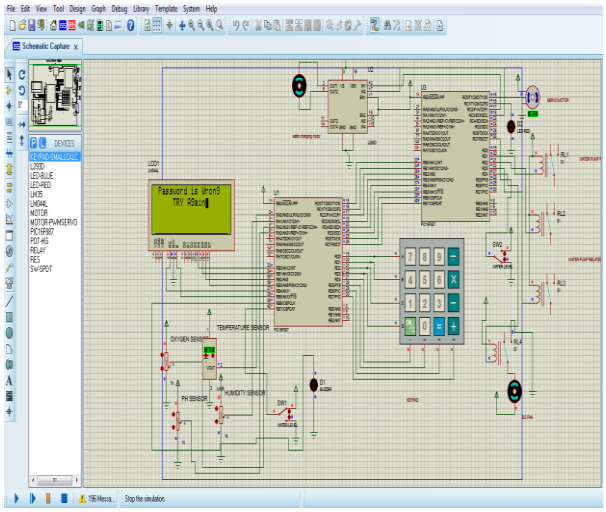

Figure 2.5: wrong password

Bread board implementation

Once the system is switch on the feeding process will be activated by the pic microcontroller. The pic will send a pulse to the servo motor to give it an order to rotate in 90 degree once the system in switch on. The servo will be attached to the feeding kit so that once the servo motor rotate the dry food will be released in the water. As its shown in the above figure according to the data sheet the pic microcontroller is connected to the LCD to indicate the process of the feeding kit.

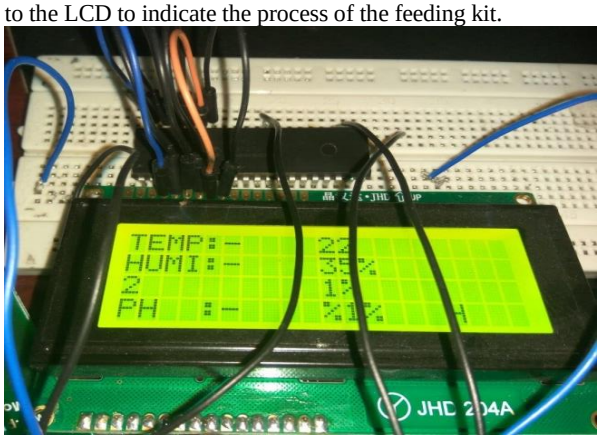

Figure 2.6: measurement system

Once the feeding process is completed the LCD will indicate rest of the varies parameters of the system such as humidity, temperature, PH and water level sensor. If the temperature increased more than 30 degree then filter will be activated. If the humidity increased more than 40% then fan will be activated. If PH level increased then alarm is activated. After entering correct password in the key pad the user will be

allowed to enter the system to make any required changes for temperature value and humidity value.

Conclusion and recommendations

The aquarium kit project is a full system provides a healthy environment to the fishes. Keeping fishes in a healthy condition is not an easy job. Therefore, this project reflects a healthy environment by applying smart system (feeding system, filtration system and measuring system). Feeding system is very important as it provides food to the fish automatically. This system is very useful in case if the user forgets to feed the fishes. The filtration system is a significant function that keeps the aquarium clean. So, the water needs to be kept clean from dirt because the dirty water affects the fish health. Therefore filtering the aquarium every three to four days is compulsory. The filtering system will only run based on the user request. The measuring system consists of two main sensors humidity sensor and oxygen sensor, the oxygen sensor controls the amount of dissolved oxygen in water in the range of 8.3mg/L. In case if the oxygen level went below 8.3mg/l the system will activate the alarm to alert the user to adjust the oxygen content. The humidity is also controlled in 20% and if it goes above the range, the fan will generate air to control the humidity percentage. This project will be more effective if few tasks are performed such as: Improve the food supplier system, because this system provides only dry food. Attach the system with the user mobile phone to make the control of the aquarium easier. Improve the pH controller, because the pH controller cannot adjust the optimum pH value 7 as the sensor shows only the pH reading.

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