International Journal of Hybrid Information Technology
Vol.9, No.4 (2016), pp. 199-212
http://dx.doi.org/10.14257/ijhit.2016.9.4.18

A Novel Design of Feeder System for Aqua Culture Suitable for Shrimp Farming

Dileep Kumar Appana[1*], Mohammad Wajih Alam[2] and Bigyan Basnet[3]

[1]*Developer, Enersys Energy Solutions Private Limited, Hyderabad, India*
[2]*Department of Electrical and Electronic Engineering, Chittagong University of Engineering and Technology, Chittagong, Bangladesh*
[3]*Department of Electrical Engineering, Tribhuvan University, Katmandu, Nepal*
[1]*dk.appana@gmail.com*, [2]*mewajih5@gmail.com and* [3]*bigyanjung123@gmail.com*

Abstract

Shrimp farming is one of the most important aqua cultural activities, but farmers are facing many serious problems like shrimp diseases partly due to problems with the shrimp having to cope with poor water quality during cultivation. After the long survey with the farmers in different regions about their practices in farming methods, the current paper provides some solutions to ensure our product Auto Switch Aqua Feeder 1(ASAF1) with new technologies replace with automation of the farming methods with their traditional practicing methods unchanged, and designed a user interface convenient and compactable for farming. User interface design, and timer controls are implemented on dsPIC30F5011 for automation of feeding methods and substantially reducing the labor cost and improve the quality of commodity.

Keywords*: Shrimp feeding; Microcontroller; aqua culture; farming and auto feeder.*

1. Aquaculture Shrimp Farming

Shrimp is seafood that is loved by many people across the globe and its cultivation has started to have significant and substantial factor in international trade [1]. Countries across the globe compete ensuring its market ascertained, commercialize product globally and determined with quality assurance at every stage of the export chain. With increased export rules and regulations on food safety and quality, marketers are progressing towards developing safer, hygienic standards by adopting new methodologies in farming utilizing new technologies available.

If you go across the costal line of Andhra Pradesh in India, Shrimp farming is one of the most important aqua cultural activities and manual feeding is the traditional method which has been practiced for a long time. In most shrimp farming, feed cost accounts more than half of total expenses and without efficient feed management practices it is not fully consumed by the shrimp, moreover, it results in deteriorating water and soil quality [2, 3]. So, using auto feeder allows farmers to feed in less amount and more frequent, and maintain the hygiene of pond.

Shrimp normally collects feed in their claws to keep the feed to themselves and swim away. This allows other shrimp to get the opportunity to catch feed. They will not have the area all for themselves. However, shrimp collects the food when it is in the water. Once the food reaches ground, it becomes useless and it will also result in devolving the water quality. Thus, the strategy of feeding influences the quality of water and shrimp health [4-6]. By traditional farming methods, the farmer has to throw the feed manually and cannot dispense feed for larger area. Therefore, shrimp will be competing for feed causing aggressive behavior and stress and get broken. Moreover, the shrimp will not be

[1]Corresponding author. E-mail address: dk.appana@gmail.com

ISSN: 1738-9968 IJHIT

able to consume the complete feed because the ratio of the feed dispensed per time over certain area leaves some residues which results in settling down of food at the pond bedding resulting in deteriorated water quality. If the feed is fed equally, broken shrimp sizes will not occur. The shrimp farming industry around the world are facing increasing challenge and pressure for reducing the broken shrimps and maintain healthier environment for shrimp growth [7]. Installing an auto feeder would help to minimize broken size and also ensures a healthier shrimp due to improved water quality and continuous feeding. Improving water quality will reduce the risks of mortalities or disease outbreak, thus fetching larger profits with additional savings on labor and production costs. Moreover, the feed with top dressing supplement can also be fed with auto feeder, but the feed must be air dried before putting into feed storage.

Unlike manual feeding, automatic feeding helps not only manage feeding more efficiently reducing left over feed but also saves labor costs. Any auto feeder responds to the questions of optimizing feed management efficiently, low feed conversion ratio (FCR), reduce cost, gain more productivity and maximize profits with minimal labor. It specifies the relationship between quantity of feed and effective feed distribution without disturbing the feeding practices.

An auto feeder is an automated system which has options to set frequency and quantity of feed by digital control, controlled by microcontroller installed in the machine. It is easy to use with a touch of a finger. Feeding system works both during day and time. Different feeding rate at different times of the day and night can be pre-set. It helps in excluding usage of labor at night-time. It also comprises of a control panel which can be installed indoor for convenience.

Different types of feeds weigh differently and thus affect the distribution range for pelleted or powdered feed. There are 6 different sizes of feed that are available in Indian markets where the feeders should include adjustment of accuracy control for pelleted or powdered feed with great accuracy.

The feeder dispenses the feed into a generally circular pattern in the pond. It distributes feed in small but frequent doses ideally like rain drops, allowing shrimp to catch the pellets before it reaches the pond bottom. One thing to look at is the spread pattern and the diameter of the throw. Both of these are very important. If the feed is spread evenly, but thrown in a relatively small diameter, shrimps will compete for the feed. Thus, the wider the throw, the better it is. Early feeders would throw the feed only five to ten meters. Recent versions, however, are throwing the feed up to 14 meters and some up to 20 meters. But, from discussions with the farmers, ideal conditions are 14-meter throw is best for most farms. Normally, each Feeder can feed a population of up to 700,000 shrimp depends on the shape and extent of the pond.

After few years of test trail running these feeder systems, as a feedback from farmers' opinion, at initial stage of production, blind feeding is to be practiced as usual while automatic feeder can be operated from the second week onwards. The commitment of feed can be started generally any day between 15 to 25 days after stocking or when shrimp starts to swim around the pond. During first month, the feed is distributed more frequently, but in smaller rations due to shrimp feeding habits. Afterwards, an increasingly larger quantity lapsed with a larger gap is distributed. As a matter of fact, most of the feeders can operate 24 hours a day. You can check the feed tray anytime by checking the characteristics of the left over feed in the tray and the waste from shrimp. This information will help you adjust the amount of feed for the next meal. However, a common practice feeding shrimp for 10 to 14 hours a day on natural food which includes feeding during night time is most advisable. This is to avoid night dissolved oxygen drops. By the way, traditional feeding practices vary from region to region and on farmer's decision.

2. Feeder Model

ASAF1 is designed in such a way that feeders in aqua cultures are automated with digital intelligence to minimize human efforts and to improve feeding methods. It helps farmers to save feed and avoid silt collected at the bottom of pond. The feed from aqua feeder is spread in 12 to 22 meter radius. The complete solution needs very less power to operate. Feeder is incorporated with zero crossing switching of loads to minimize the inrush currents during switching ON/OFF. Settings are not disturbed with power fails or fluctuations. Once the setting is set by a user is saved, it lasts till they are overwritten by the user only.

The feeder consists of mainly 3 areas: *(a) Controller:* A timer controls and allows the user to input the amount of feed and the time to disperse the feed, so that it allows the machine to work automatically. Feeder contains the holding drum which is made of plastic and lid to store and keep the feed. More details of the user interface used are described in the User Interface Design section. *(b)Transferor:* It is made of 4 watt synchronous motor. It releases feed from the holding drum in set amount. The spreading motor (35-watt feed dispenser) receives feed from the transferor and dispenses feed with speed of 2500 rpm. *(c)Metal Legs:* It handles weight from holding drum. Metal legs help position the machine to the desired location.

Figure 1 shows the system model. ASAF1 is light weight and is only 15 kilograms which makes it easy for installing and handling. Feeder's motor used is only 50 watts, which is 10 -15 times less than regular auto feeder that use around 220 – 240 watts. It can disperse at the maximum rate of 1.54 kilograms per minute and up to 2,000 times per day or every 45 seconds.

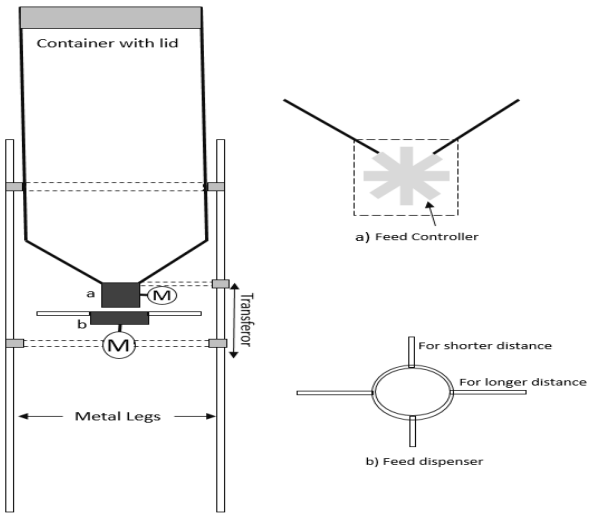


Figure 1. Complete Feeder Setup (a) Transferor Inset Shape of Feed Controller which Controls the Free Fall of Feed (b) Top View of Feed Dispenser Showing Different Length for Ddifferent Radius Throws

The shape of the feed controller is designed as grooved structure so that feed of all sizes can be easily dispensed when the motor is running. The feed dispenser has four pipes from which the feed will be thrown. The lengths of the pipes are varied for distributing the feed eventually across the pond.

Next we have to look at the spread pattern. When placing this feeder in pond; the location of auto feeder at the pond is very important as it directly affects the efficiency of the machine and shrimp health. It is recommended to position the auto feeder at least 15 meters away from the aerators in order to avoid strong water currents and the sludge area

in the pond. A single feeder can feed shrimp in a small pond about 1,000 m^2 with a population about 500,000 shrimp or above. Larger ponds will require multiple auto feeders. Farmers must avoid overlapping their broadcasting areas. In case of very long and narrow ponds auto feeders will be placed on the opposite end of each other. It is recommended to place the auto feeder at least 50 cm above the water surface to cover the required area and works at its highest efficiency. Not only the technique mentioned above but the type of the feed and its size are also relevant to the distribution range of the auto feeder. The larger the feed pellets are; the larger area it will cover. Moreover, shrimp farmers must also consider about the feed type (whether it is crumbled or pelleted feed), different feed sizes, selection of brand, water solubility, etc.

Feeding tray is the traditional way for monitoring shrimp feeding. It is advisable to set two feeding trays per auto feeder. Each feeding tray should be placed about 15 centimeters above the pond bottom to cover the broadcasted area. The first feeding tray should be close to the auto feeder, about 1-2 meters away. The second one should be placed at 6 to 8 meters away from the feeder. Feed ration, time and frequency are adjusted by using feeding tray observations as an indicator. Generally, feed ration is up or down adjusted by 2-3% depending on shrimp feeding, or feeding frequency modified. Theoretical shrimp weight and survival estimations are used as additional information for a more realistic feeding adjustment.

ASAF1 is operated in three modes: Manual mode, Auto mode and Auto+ mode (auto plus). In Auto mode, the user needs to set ON time to switch on load. OFF time is calculated automatically with respect to the feed in kilograms available in drum, number of kgs per cycle and cycle to cycle interval. With user friendly interface which comprise of 20*4 LCD display, 4*4 matrix keypad and manual and reset keys where user can input all the values that are used for feeder. Password protection interface is given for authorized access only. Feeding ON and OFF time and current time are displayed on LCD. Feed available in drum is displayed. Power fail intervals are observed and feeding time is adjusted with intelligence. User can operate feeder with different feed sizes which can be configured on ASAF1. In Auto+ mode, changing to this mode the user will have options to utilize the feeding system for different timing shifts on a particular day and with different quantity dispense settings, whereas in Manual mode, the feeder has to be started normally instead of pre-set time. All the other features remain same as Auto mode.

3. System Hardware

We utilized dsPIC5011, a16-bit microcontroller with flash memory of 66 KB program memory and 4 KB data memory to design this project, which operates at a voltage of 2.5 to 5.5. We programmed it with embedded C language in MPLAB Environment version 8.8 and the C-compiler version 3.2. We have used an external crystal oscillator of 8 MHz with PLLx4 for obtaining more computational efficiency. We have interfaced a 4x4 matrix keypad and a LCD display as shown in figure 2. The LCD display is of Systronix 20x4 character which operates at +5V supply. The brightness, voltage and current of LED backlights can vary widely changing the quality of display. A variable resistor is provided in the top of LCD board in order to control the contrast. The keypad has numeric from 0 to 9, up, down, escape, save, cancel and manual buttons. Separate button is provided for MCLR. We have utilized DS1307 a low power serial real-time clock with full binary coded decimal clock/calendar and 56 bytes of NV SRAM. I^2C protocol is used to transfer the address and data serially. It can manage time functions as it counts in real time seconds, minutes, hours which is valid up to 2100. It consumes power less than 500nA in battery backup mode with oscillator running. For storing data and updates about the feeder, we have used 24LC256 external EEPROM which operates at a voltage of range between 2.5 to 5.5V and a frequency of 400 KHz. It is a 256 KB serial electrically erasable EEPROM with 64-byte page write buffer and maximum write cycles of

1,000,000. It has data retention of 200 years. To communicate over UART (serial communication), we need interface MAX232 with a microcontroller and DE9 pin. It is required for MAX 232 to be properly grounded otherwise we get noise in UART. Figure 3 shows the implemented PCB design and figure 4 shows PCB layout of the project.

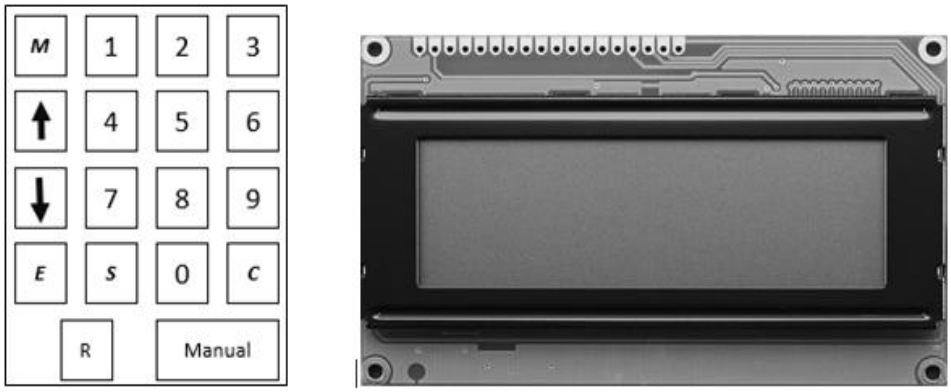


Figure 2. Keypad Layout and LCD Display Used

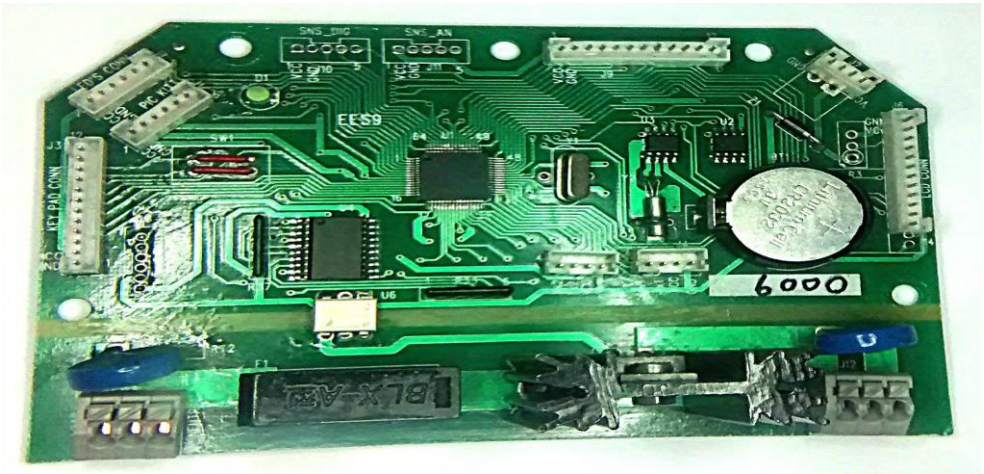
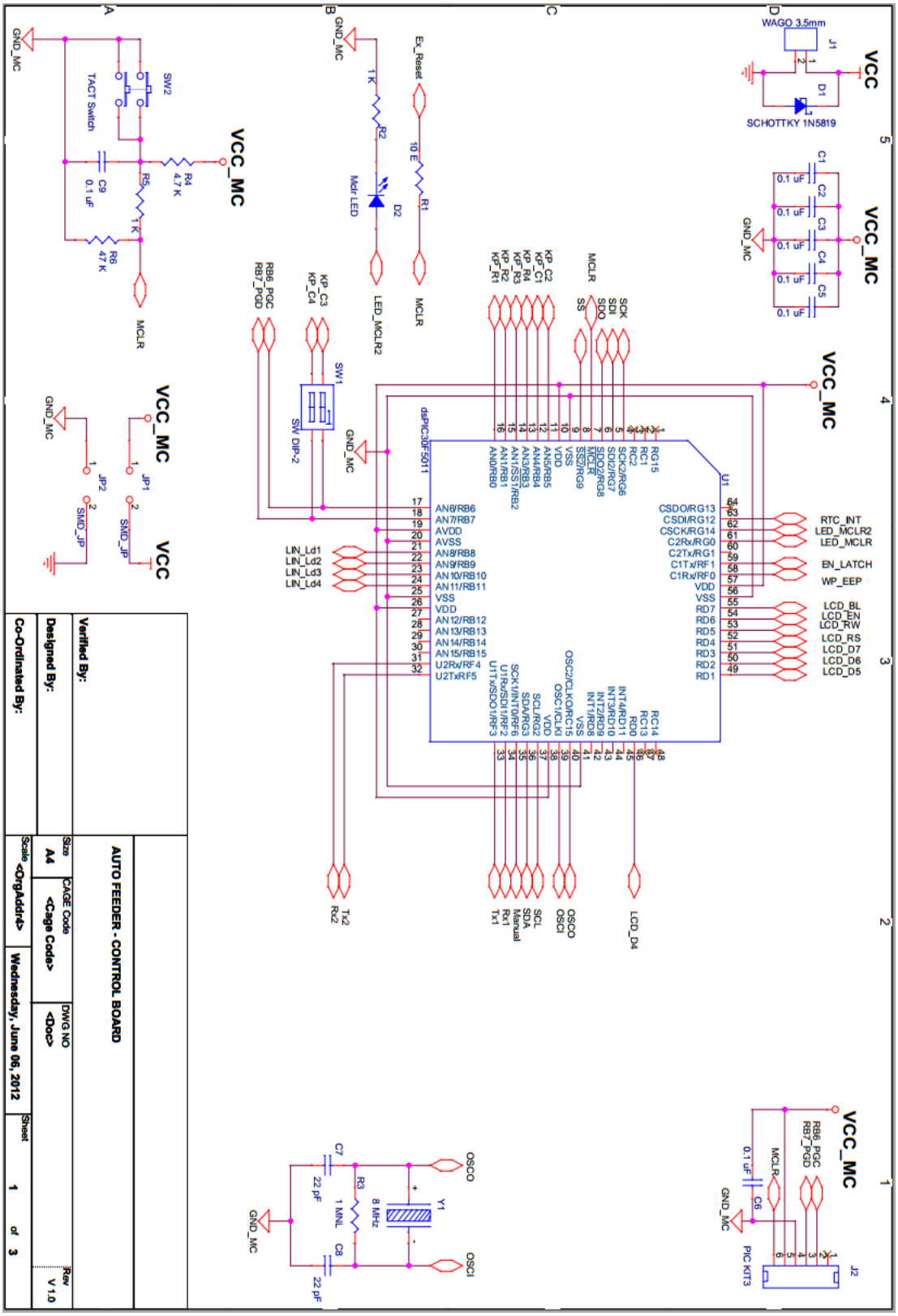
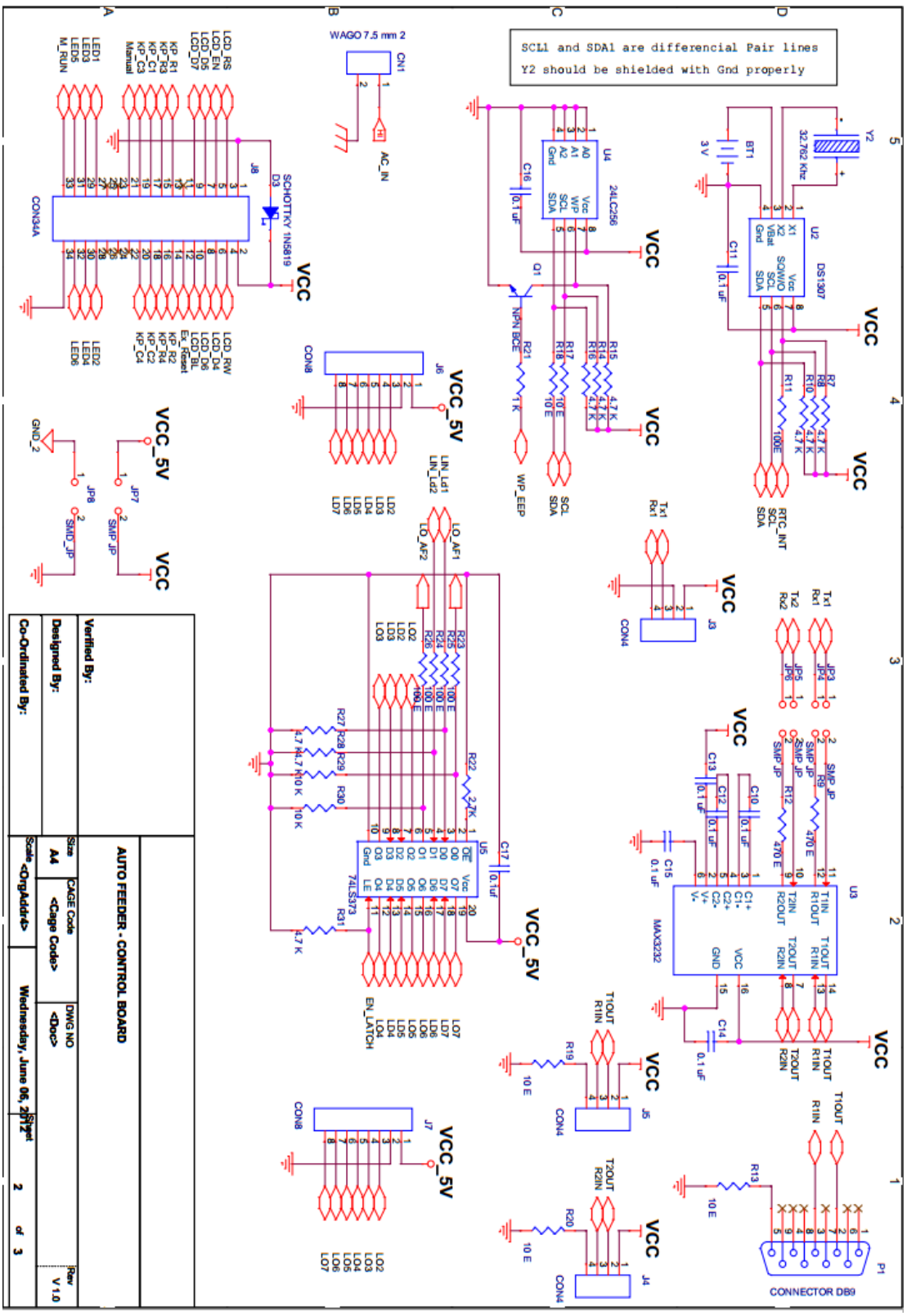


Figure 3. Implemented PCB Design



(a)



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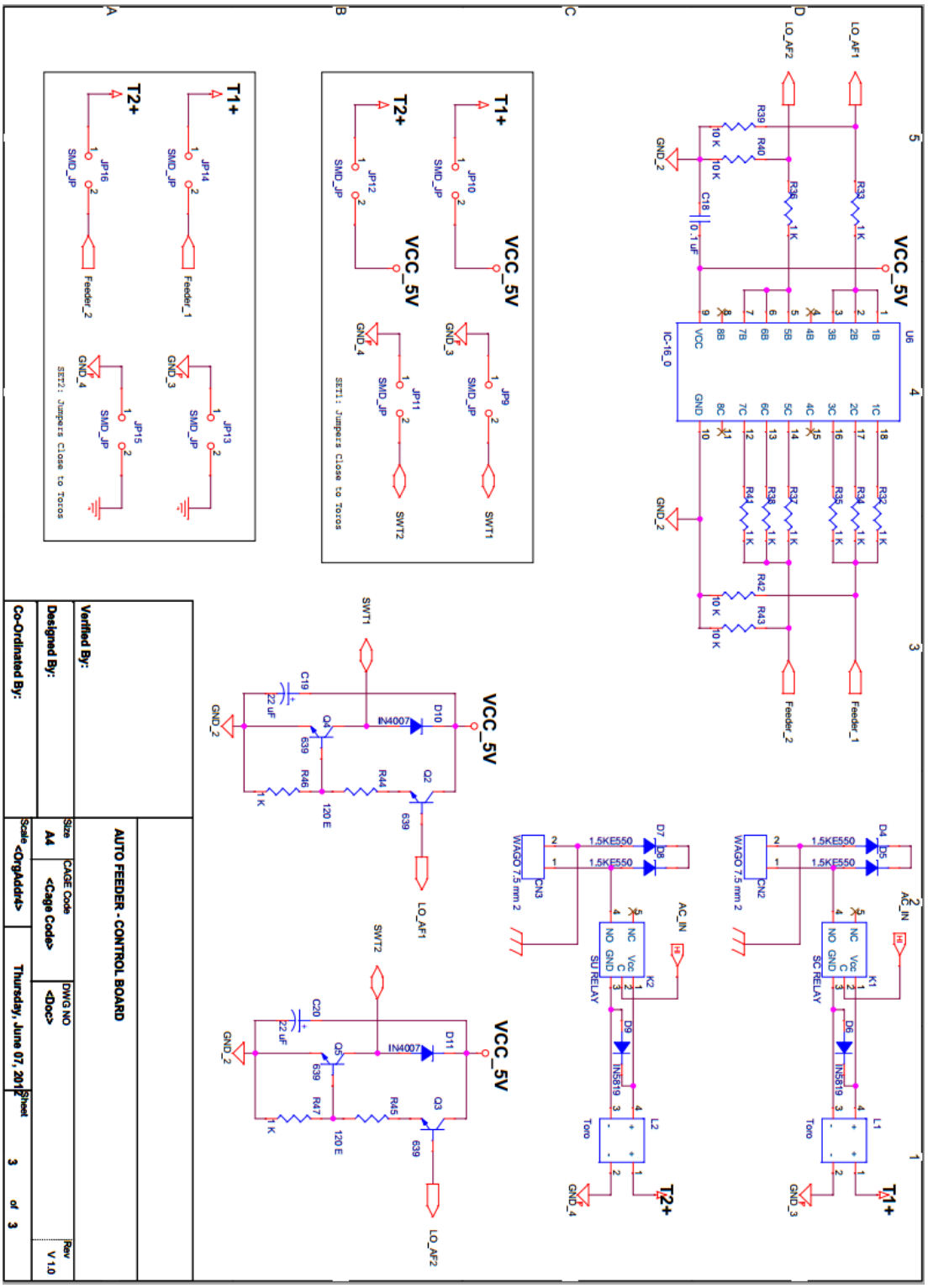

(c)

Figure 4. PCB Layout

4. User Interface Design for Controller

ASAF1 is controlled by an electronic unit which hosts a microcomputer, located in a panel control, and integrates all feed related information, such as type, amount, time and interval between rations. These values will be automatically determined by the microcomputer system from the total feed quantity and operating hours.

We have introduced two menu systems called master menu and user menu, with both menus being password protected. Options for changing the users' menu password is provided once the authentication is obtained by master password. Any modifications in the setting for both menus are stored in the external eeprom. Detail descriptions for both the menus are given below.

4.1. Master Menu:

To enter Master menu, a long press of menu button is required (normally 3 seconds). If the user enters correct master password, they can enter this menu. For security reasons, if the password is entered three times wrong simultaneously, the user has to wait for 15 minutes for next attempt. The values that can be changed in this menu are mentioned in this section. Second step of authentication is required with a master password for saving any changes in the menu, as the numerical values used in this menu are very critical for correct functioning of the feeder.

4.1.1 SET TIME: In this menu, options to change time in hours and minutes are provided. For the changes in time, the user has to select either 24 or 12 hours' format according to the user's convenience. The format will be in HH:MM and HH:MM AM/PM respectively. While editing, blinking cursor shows what the user is updating. The time can be entered by pressing the numeric buttons. By using up and down arrows, the user can interchange between hours and minutes. The user can then enter values in range of 00 - 23 in former format and 00 - 11 in later format for hours, and 0 - 59 for minutes. When the user is in edit mode, it displays the current time, any modifications can be started from that point. Any changes can be updated in RTC using the save button and the seconds are automatically rounded to zero. If the changes are made while the feeder is in running mode, the timer controls are updated with immediate effect.

4.1.2. SET DATE: This portion contains the options to change date and month. The format for entering the date is DD: MM. The blinking cursor shows what the user is updating on edit. The range of values that can be entered by user for data is 1- 30/31 based on the month entered, and data that can be entered for month is in the range of 1 to 12. Though the changes are updated in RTC, upon saving it does not affect any timer controls as this menu is currently only used for developer purpose which is reserved for future use for updating information when connected remotely on complete pond management system.

4.1.3. NO OF SEC/KG: As there are different sizes of feeds, the user can calibrate the time required to dispense the feed for a particular size. Default values are already set based on the popular sizes of feed available in the market. User can enter a max time of 99 seconds for each type. All modifications are done from the default values with direct press of numeric numbers. Up and down arrows modifies the position value. The time entered for a particular type is assumed as the time required for 1 kg and the feeder running time calculations for dispensing feed are made based on this inputs. Defaults can be read from eeprom and for feed type 3 is 30, 3P is 45, 4 is 60, 4S is 75, 5 is 90, 6 is 105 in seconds respectively. Modifications are also saved in eeprom.

4.1.4 AUTO RELOAD: This is a special option provided where the user can select if user wants to reload all the parameters without any modifications even if the date is changed. Enabling and disabling can be done with up and down arrows. The user must be cautious, if this mode is enabled the system assumes feed is added to feeding drum every day with same quantity and the feed values are reloaded without re-entering in the user menu. Changes made are saved to eeprom. The default is kept as disabled.

4.1.5. STARTUP FEED: When it comes to first time feeding in the day, the shrimp will be hungrier as the feed is not supplied during night time and the time duration between the previous and the current feed time is longer. Though the feeder is designed as feed will be thrown with some pauses in the scheduled time shift, some experienced farmers are looking for special options for some continuous cycles without any pauses during the first shift feed throw of day. So we have introduced this option considering their opinions. Once you enable this menu, if the system is auto+ mode, it asks for which time shift you want to apply this setting based on the time allocations that you made in the users menu and number of non-stop or start cycles required. Enabling and disabling can be done using up and down arrows. The default start cycles are 1. We have limited the max cycles to 4. If the mode is auto or manual, the system ignores the shift that users have entered. Usually this mode is not used commonly so the default is set as disabled.

4.1.6 RESET CROP FEED: Crop Feed values can be reset using this menu option. The range of the crop feed values are set from 0 -9999 (kgs). Once the crop feed exceeds the limit it automatically resets to 0.

4.1.7 RESET PASSWORD: This option restores the user password to the default. The default password is ‘0000’.

4.1.8 DEFAULT SETTING: Restores all setting to default.

4.2 User Menu:

A user can enter this menu by single press of Menu button which then prompts for user password and upon entering correct password; the user can enter this menu. The default is ‘0000’. This menu is used for regular and routine inputs that are required for feeder.

4.2.1 OPERATION MODE: Choice of the mode can be done between Manual, Auto and Auto + modes. The calculation for feeder run time is done automatically based on feed size, feed availability, and feed in kgs that to be dispensed, pause time between the cycles and number of start-up cycles in that particular shift. When the user changes mode of operation even when the feeder is running, it prompts with running status and error that can occur in feed calculations. Feeder running status is immediately updated when the user saves the mode of operation. By default the setting is auto. In Manual, the user has to switch on the feeder manually, the stop time is calculated based on the feed available, or else the user can switch off the feeder manually. The start and stop operation can be done by manual button in the keypad. In Auto mode, the user can pre-set the switch on time of feeder, but only for one shift whereas in Auto+ mode, he can manage different setting for different time shifts for a particular day.

4.2.2 NUMBER OF SHIFTS: User can enter the start time of the shift when he desires to start the feeder. The stop time is automatically calculated based on the factor mentioned in operation mode. We have limited the maximum number of shifts per day to 9. The default shifts are 5. The shift timings are available only in Auto+ mode. Once the shifts are selected, it prompts the user to enter the corresponding timing for each shift. The

timing can be entered in hours and minutes, where the seconds are taken zero as default. The values with limits of its ranges can be entered either by pressing numeric keys directly or by using up and down arrows. These shift time setting are not effected and are not enabled if the feeder is in Manual Mode or Auto Mode. Any changes are updated in eeprom after saving.

4.2.3 FEED TYPE: Choice can be made between different feed sizes that are filled in the feed container. The Feed types are named as 3, 3P, 4, 4S, 5, 6. Based on the operation mode chosen, the menu navigates for user to enter the feed in kgs to be dispensed in that particular shift. If the mode is auto+, the user has the options to enter what kgs of feed can be fed through feeder in that particular shift and amount of feed is added. It has intelligence to show all corresponding previously saved values for that particular shift that are available in a certain mode. Moreover, it can prompt for exceeding limits with messages like invalid kgs, exceeding feed drum capacity also. When the feeder is in a manual mode its prompts only feed sizes. The values can be modified by numeric keys. The functionality of up and down arrows move in the place value from right to left or left to right. Saved changes will automatically update all the settings.

4.2.4. NUMBER OF KGS/CYCLE: User can modify kgs of feed that can be dispersed in a particular shift. The stop timing of the feeder will be modified if any modifications are done. Default kgs/cycles is 5. The range is 1- 99 kgs.

4.2.5. CYCLE-CYCLE INTERVAL: When the feed is dispersed, we need some time for the shrimp to consume food and also some time intervals between feeding the shrimps. The user can choose the interval ranging from 1 to 99 minutes. The default time is 2 minutes.

4.2.6. FEED DETAILS: The user can see the details of the feed available in the feeder drum and the total feed that is distributed for this season. These values can be reset using the option in master menu. The user is not provided for editing this menu option.

4.2.7. CHANGE PASSWORD: User can change password for user menu. Modifications are protected by master password.

When you start the controller, it starts with a welcome screen which displays the name of the product and version of the product for 5 seconds. It first reads the mode and based on that the screens are interchanged after every 5 seconds. If the mode is auto+, the screen appears based on the shifts number. Each screen will show first line with shift number and current time, second line with on time of that particular shift in hours, minutes and seconds. However, the seconds will be zero. Third line shows the computed off timing. When the shift is interrupted the off timings are automatically updated as the feeder when in running condition writes the current status in eeprom every 15 seconds. When the power is interrupted the timings are affected by 15 seconds maximum and the error maximum for the 15 seconds miscalculations. Fourth line of the screen displays the left over feed information. For this mode, the maximum numbers of screen are the number of shifts saved. If the mode is in auto or manual, the first line remains same as mode and current time being displayed, the fourth line with left over feed. But in auto mode, the second and third lines shows the start and end timing respectively, whereas in manual when the feeder is switched on, the second line shows the start time and the corresponding computed off time. But when the feeder is off, it shows the previous start and off time on second and third line respectively. When the user enters menu options, it automatically navigates to the corresponding screen and returns to the same when user exists.

5. Results

Test run of this demo systems are done from last four years which includes 8 farming seasons from year 2011 across various farms in coastal region of Andhra Pradesh, India. After the significant changes now the user interface is very friendly, understandable and convenient to farmers. The feeder is able to make calculation in minute and seconds with respect to time factor but when power failure occurs, these systems are prone to error of 15 seconds to maximum as the restart of the timer resets to last saved time on EEPROM. The system is stable and able to restore all the settings as well as previous running status from the disturbance occurred due to power failure. All three modes are efficient with 99.8% accuracy. The life time of the write cycles for EEPROM that we used lasted for 4 years for the operating conditions (16 hours a day maximum in the field) by the farmers. It is able to distribute the feed up to 20-meter radius based on the farmer's requirement varying the length of the dispenser pipe the spread area is reduced or increased. Figure 5 shows time for distribution in seconds for different types of feed with cycle to cycle interval of 5 minutes and 2 Kgs feed per cycle in each shift. Table 1 shows dispensed quality of feed type 3 with cycle to cycle interval of 5 minutes and 2 Kgs feed per cycle in each shift.

Comparisons are made between the traditional manual feeding systems and our automated feeding system. The results are accumulated based on hourly-hourly reports and day-by-day reports on that activity. It improved feed conversion ratios by 30% and growth rate up to 30%. It reduced the amount of feed fed by 30%.

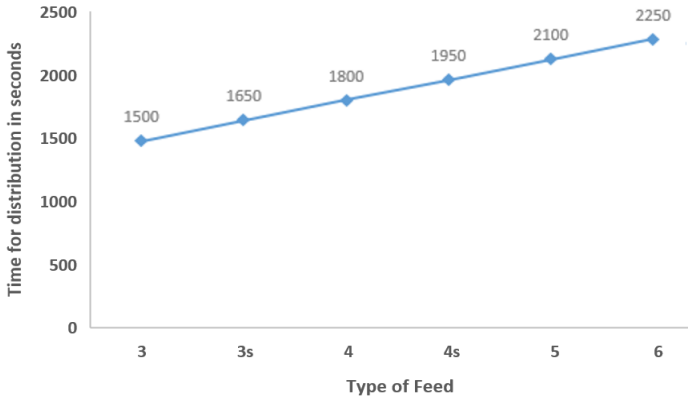

Figure 5. Time for Distribution in Seconds for Different Types of Feed with Cycle to cycle interval of 5 Minutes and 2 Kgs Feed per Cycle in each Shift

There has been significant reduction in labor force by 80% and increase in the harvest size of the shrimp by 30% and finally prevented leaching of nutrients. It showed a significant reduction in degradation of water quality by preventing feed wastes from accumulating on the pond bottom. The salinity and PH value of water was found out to be 28-35ppt and 7.8 -8.5 respectively. Furthermore, total ammonia and nitrate present in water was less than ½ ppm. The ionic composition was found out to be similar to sea water and there was no presence of heavy metals or pesticides which ensured that the water is prevented from deterioration.

Table 1. Dispensed Quantity of Feed Type 3 with Cycle to Cycle Interval of 5 Minutes and 2 Kgs Feed per Cycle in each Shift

Test	Running time of Feeder in Seconds	Dispensed Quantity in Kgs
1	740	2.66
2	500	2
3	50	1.65

6. Future Work

Using auto feeder (ASAF1) helped to increase shrimp growth rate and make shrimp healthier by living in the high water quality and were continuously fed. ASAF1 relieves shrimp and hence reduces risks from disease infections. This system has proved to have minimized feed and labor costs and thus maximizing profits for farms. This system can be integrated to the pond management system that will comprise of automated aerators, controller which would be updated with advanced factors like weather condition alert, depleted oxygen content in pond and salination. Further a mobile based app will be added which can update the information of the feeder remotely through a mobile network.

Acknowledgments

Development of complete product is sponsored by Enersys Energy Solutions Private Limited, India. And we are very thankful to Mr. Ravi Kumar Gangumolu for providing opportunity to work under your supervision.

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Authors

Dileep Kumar Appana, received B.E degree in Electronics and Communication Engineering from Anna University, India in year 2005 and M.Sc. degree in Electrical Engineering from Blekinge Institute of Technology, Karlskrona, Sweden in year 2009. Currently, he is working on his PhD in Embedded and Ubiquitous Lab, University of Ulsan, South Korea. He is an experienced professional as Project Engineer working on Embedded Systems at Enersys Energy Solutions and as Associate Engineer at High Point

Technologies. He research interests are in field of Image Processing, Memory Management in devices, Embedded Systems, and Artificial Intelligence.

Mohammad Wajih Alam, received B.Sc. degree in Electrical and Electronic Engineering from Chittagong University of Engineering and Technology (CUET), Bangladesh. Currently, he is completing his M.Sc. degree from University of Ulsan, South Korea. His research interest includes Embedded Systems, MRI, Image Processing, Biomedical Engineering, Sensors, Renewable Energy, Power System and Artificial Intelligence.

Bigyan Basnet, received B.E degree in Electrical Engineering from Advanced College of Engineering and Management under the affiliation of Tribhuvan University, Nepal. Currently, he is working toward the M.Sc. degree in department of Electrical Engineering at University of Ulsan, South Korea. His research interests include Electric Machine, Embedded Systems, Motor Drives, Renewable Energy and Power System.