DESIGN AND CONSTRUCTION OF MICROCONTROLLER-BASED AUTOMATIC FISH FEEDING DEVICE

[1]E. N. Onwuka, [2]Achonu O. Adejo
and
Ibrahim U. Joseph

Department of Telecommunication Engineering,
Federal University of Technology, Minna, Niger state – Nigeria
Email: [1]onwukaliz@futminna.edu.ng, [2]achonu@futminna.edu.ng

Abstract:
This paper presents the design, construction and demonstration of an automatic fish feeder. It is a microcontroller-based system. This system is designed to dispense a predetermined amount of fish feed into an aquarium at a particular time each day. The device consists of a cylindrical can, distributing tubes and a stand. The dispensing of food is controlled by the use of a stepper motor, which is situated under the canister. A timer controlled switch is used to control the time at which the motor rotates, by a program burned into the microcontroller. The fish feeder was successfully fabricated and tested. It dispenses food automatically at set preset times. It is expected that this device will enhance the fish farming efforts of the local farmers, especially the armature farmers who combine fish farming with other businesses.

Introduction

Fishes are cold blooded animals that live in water of relatively different sizes. They are usually found in large banks of water and later brought into homes and reared in fish ponds, pyramids, and other enclosures. Over the years, several materials have been used to create the enclosures for fishes kept in homes such as marble tanks, glass panes, and porcelain tubs (Brunner, 2003). Aquaculture is the farming activity of freshwater, marine plants and animals, carried out inside water, ponds, lakes, oceans .

Fish farming involves raising fish commercially in tanks, containers or enclosures. Due to the high demand and widespread consumption of fish by man, this business has the potential to be profitable and lucrative if proper measures are taken in the development of the fish farm. Feeding is a vital component of the development of fishes and is therefore crucial to effective management of fish farms. The adjustment of quantity of feed delivery to match fish appetite plays a key role in maximizing the income of the aqua industrialist. Several problems arise when proper feeding is not carried out in a fish farm and the adjustment of food delivery does not match the variation in fish demand. These problems include wastage and environmental pollution caused by overfeeding fish and growth loss caused by underfeeding fish (Mohd, 2008). Also armature farmers who combine fish farming with other businesses may not have the time required for regular feeding of fish.

The discovery that manual feeding of fish was inadequate for effective fish rearing gave rise to the invention of fish feeding machines generally called fish feeders, which provide better measurement and dispensation of feeds. Fish feeders are very useful in ensuring a proper feeding plan in a fish farm. They aid reduction in cost, time and labor and can be designed with consideration of the size of the pond, fish size and fish species.

Historically, fish feeders were developed since the 1960's. Walter E. Malek built the first fish feeder in 1962 using springs and actuating wheels. It was meant to dispense a predetermined amount of fish food from a standard canister into an aquarium at regular time periods and in regular amounts determined by the user. The device was useful but some of its limitations included high cost, big size, poor flexibility and difficulty in movement (Walter, 1962). David (1984) made some improvements on the original design and built an automatic fish feeder mechanism that utilized water filled in a water container to induce rotational movement and dispense feeds from a pan with precise control of the frequency of dispensing. Limitations of this design included complete dependence on availability of water, feed wastage due to splashing of water on feeds, electro-circuit and complexity in timing frequency adjustment (David, 1986).

Several designs using various materials and technology have been made over time, with the aims of minimizing the limitations met in previous devices. Some of them used electrical motors in combination with gear boxes, but these designs followed the same mechanical principles governing the earlier constructions and had the attending limitations (Davet & Davet, 1998). External water clocks were also used extensively for timing; these had precision problems due to difficulty in controlling the rate of flow of water (Chan, 2009). Due to problems of size and other limitations described associated with the mechanical rotating motors, electrical alternatives were exploited. One such design used a simple mechanically built structure, a microcontroller, sensor, LED, robotic motors, bifilar motors, multiphase motors and other sophisticated devices e.t.c. The design allows moisture to seep into the food hopper. This can cause clumping, resulting in the failure of the mechanism (Wikipedia, 2010), it is quite expensive and so will not be easily affordable by average Nigerians. Another design was made to dispense frozen fish feed into an aquarium. It used microcontroller and stepper motor but incorporated thermoelectric cooling devices (Audet & Martin, 2005).

This paper presents the design of a low-cost automatic fish feeding system as an alternative to manual feeding of fish. The design is simplified to cut cost and therefore be affordable to average Nigerian fish farmer. Components that are easily available in our local environment were used for the design.

Design

This section presents the design of the device. As shown in the block diagram of Fig 1, a modular design approach was used:

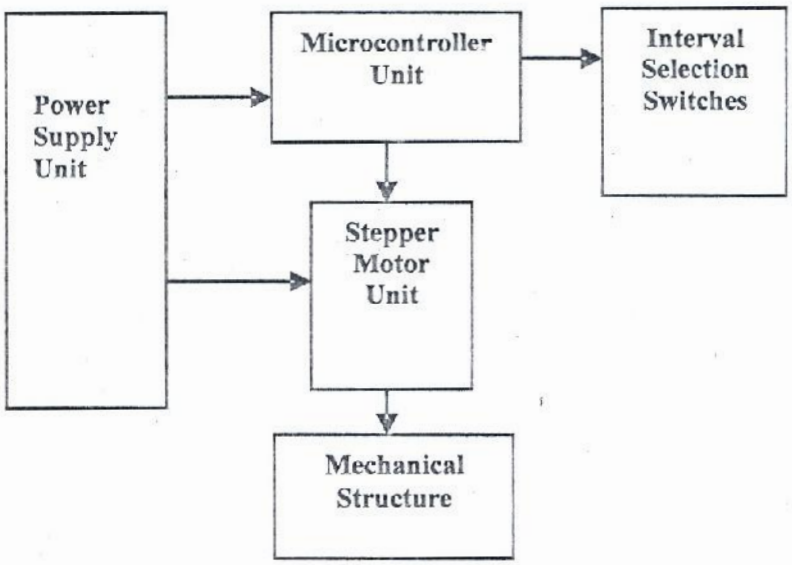

Fig 1: Block diagram of Automatic fish feeder

In this design, portions of feeds are automatically released by the device at specified time intervals within a 24-hour period. To serve different fish sizes and different quantity of feed, the design allows adjustable timing of the intervals for release of the feed portions. This flexibility is made possible in the device design by incorporating a stepper motor controlled by a programmed PIC microcontroller, and a potentiometer. The microcontroller is the brain of the device, which interprets the different timing interval of feeding via instructional codes. The time interval selection switch achieves easy access and control of timing selection. The feeder is powered by AC mains.

The various units of the design are explained below:

(i) Power Supply Unit

This unit supplies the required DC power to drive the device. The power source is the AC mains. The power circuit comprises a transformer with rating of 240/12 Volts, rectifier circuit, a filter capacitor and a voltage regulator. AC power is converted to DC through rectification; full wave rectification is achieved through a combination of four discrete diodes in a bridge network. A pair of the diodes conducts in each half cycle of

AC supply voltage. At the next stage, a filter capacitor smoothens the pulsating DC voltage from the rectifier and produces a constant DC voltage; ripples are filtered off to ensure steady supply of clean DC to the device. Finally, a 7805 voltage regulator IC (integrated circuit) is used at the last stage of the power supply circuit to provide a nearly constant DC output voltage of 5V irrespective of possible variations in the load or input voltage.

(ii) Stepper Motor Unit

Stepper motors are electromechanical devices that convert electrical pulses into discrete mechanical movements. When electrical command pulses are applied in proper sequence to the shaft or spindle of a stepper motor, it rotates in discrete step increments. The direction, speed and length of motor shafts rotation is directly related to the sequence of the applied pulses, frequency of input pulses and number of input pulses applied respectively. The stepper motor is responsible for controlling the motion of the device as the current in each motor winding is switched on and off. The circuitry is controlled by the microcontroller, which determines when the switches are turned on or off. A unipolor stepper motor which has one winding and a center tap per phase was used in this design [9].

(iii) Interval Selection Switches

In this unit, the time interval selection of the device (which determines the periods at which the feeds are dispensed) is controlled. Switching is carried out with the aid of variable resistors, which are useful as panel controls or internal adjustments in circuits.

(iv) Microcontroller unit

The Microcontroller, which is programmed to control the operation of the circuit is the PIC 16F876A, which belongs to the mid range family of PIC microcontroller devices. It is available as a 28-pin packaged device with a program memory of 14.3 k bytes, data SRAM of 368 bytes, EEPROM of 256 bytes and, has 2 comparators (Microchip, 2003). The program burned into the microcontroller is the generated instructions that controls the timing intervals, and triggers the motion of the stepper motor.

(v) Mechanical Structure

This is the wooden casing used to house all the various electronic components and circuitry. It is rectangular shaped and provides protection from water and other external barriers. The food container is positioned on top of the casing.

The circuit diagram is shown in Fig 2.

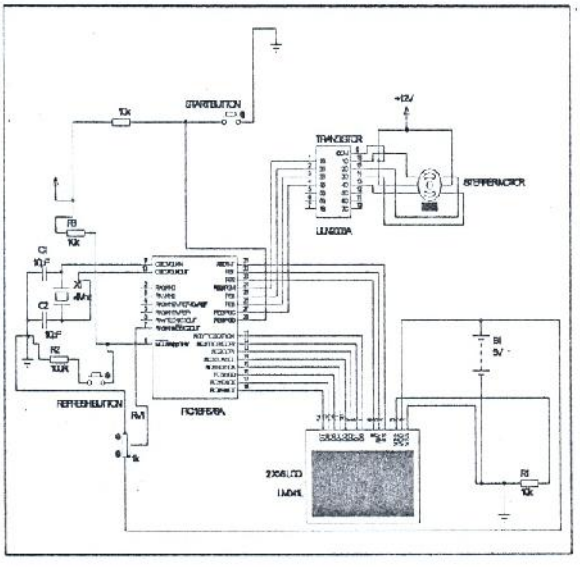

Fig 2: Circuit diagram of Automatic fish feeder

Construction and Testing

After designing the different modules, an electronic simulation package was used to simulate the entire circuit design and test its functionality. When it was determined that the various parts of the circuit were functioning, the system was hardwired to a Vero board with a 12 V DC power supply. It was again tested. Then the system is assembled in a protective casing. The canister attached to the device was partitioned into four with four outlets attached, to enable release of feed. The potentiometer is used to set the set feeding time, such that a user can set the feeding time as desired. (Figures 3 and 4)

The device was tested and it was observed that as the stepper motor rotated, the plate rotated as desired. At the appropriate time, food is released into the pond. A funnel placed under the canister ensures that food is released to a central area in the pond to enhance even distribution.

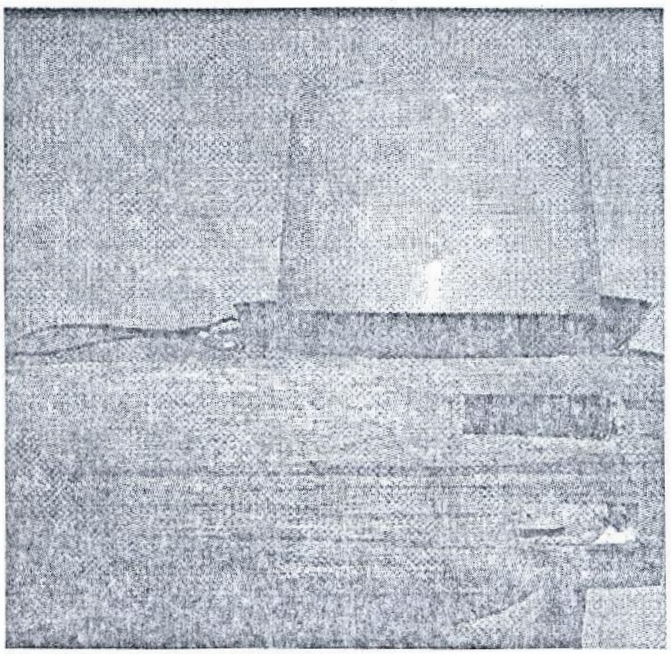

Fig 3. Front view of the fish feeder

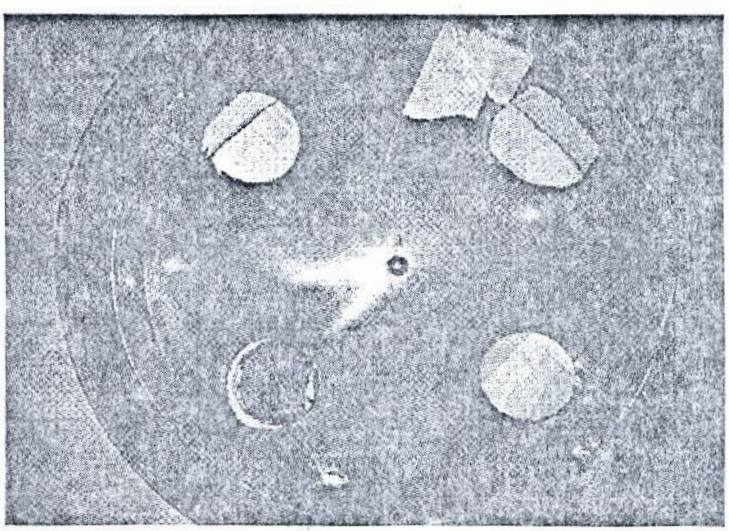

Fig 4 Top view of the fish feeder

Conclusion

The design of a microcontroller-base automatic fish feeder, with an option to control the timing intervals of feed dispensation has been presented. This device provides a reliable means of minimizing costs in fish farms by reducing labour required to feed the fish manually and controlling the amount of feeds dispensed and the periods of feeding. It is also designed to reduce the problems of limited pellet distribution, spilling of moisture content on the food hopper and other problems associated with mechanical fish feeders. It is a simple, easy to use, convenient and cost effective tool that would be suited for fish farmers in a developing country such as Nigeria.

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