All Sciences Proceedings
http://as-proceeding.com/

5th International Conference on Applied Engineering and Natural Sciences

July 10-12, 2023 : Konya, Turkey

https://www.icaens.com/

DESIGN OF TEMPERATURE REGULATOR OF A FISHPOND

Yusuf Bello Saleh*

[1]1Division of Agricultural Colleges Engineering Section, Ahmadu Bello University Zaria, Kaduna, Nigeria.

yusufbellosaleh@gmail.com

Abstract – This research is about a digital temperature regulator in the fishpond. Which is a circuit through which the temperature of the fishpond is linearly controlled depending on the temperature of the water or the environment. This device makes use of a heating element, which goes ON/OFF when the temperature in the water becomes high/low or reaches a temperature higher or lower than the present value. The temperature sensor used is LM35 with a Negative Temperature Coefficient (NTC) in which its resistance falls as the operating temperature increases. The LM35 is a very sensitive device to heat, such as it can be used in a way that an increase in temperature will lead to a change in its resistance. Fishes survive in natural water under the very conditions it is assumed that natural waters have natural temperature regulators but in fishponds nevertheless. They find it difficult to survive in harsh weather conditions like the cool season (winter). The temperature will be controlled between 24°C – 30°C which is the optimum survival temperature of the fish. This is because, so as the temperature of the environment changes, so that of the water too by convection.

Keywords – Temperature Regulator, Fishpond, Water, LM35, NTC.

I. INTRODUCTION

Agriculture is an important part of any country's economy. It entails the production of beneficial plants and livestock in an organized manner. It is the foundation of a country's food security. However, in order to have a healthy output, the agricultural process itself necessitates a significant amount of investment, particularly in terms of preventing and mitigating the consequences of changing climatic conditions [1]. Agricultural sustainability, which considers as proper use of agricultural resources in meeting human needs while maintaining environmental quality and conserving natural resources, has been a concern of conventional farming systems. Organic agriculture, often known as organic farming, was created to help increase sustainability in all three dimensions' economic aims, social aims, and ecological aims [2, 3]. Consumers throughout the world have increased their consumption of fish in recent years as the nutritious worth of the fish has been recognized; as a result, intensive aquaculture strives to enhance fish production capacity per cubic meter of water. When fish numbers are high, however, temperature, dissolved oxygen, and water quality have a greater impact on fish survival and growth rates [4]. Temperature is a crucial aspect in fish farming because most fish are ectotherms, and the temperature has a significant impact on their physiology. Their metabolic rate, and hence their energy balance and activity, including locomotor and eating behavior, is affected by temperature. The ability of fish to obtain food, as well as how they digest food, absorb nutrients in the gastrointestinal tract, and store surplus energy, is influenced by temperature. The impacts of temperature are complex and species-specific since fish have such a wide range of habitats, eating habits, and anatomical and physiological characteristics [5]. The temperature effect decreased the birth rate of fish in the fishpond during the winter period thereby increasing the death rate of the baby fish due to harsh weather normally fish survive in any condition under the natural water which assumed the natural water as a natural temperature regulator. The temperature effect was amplified since the fish developed early and at a tiny size, limiting their ability to support a growing gonad in the cold winter months. During the spawning season, the condition of the fish plummeted to dangerously low levels, accompanied by an increase in mortality. Surviving fish had to wait one or more years before spawning again, which lowered their productivity [6]. The temperature has the greatest impact on channel catfish reproduction. Because cold fronts are common in the winter and early spring, it was critical to keep pond temperatures above the spawning temperature range [7]. Almost every industry has a variety of heating and cooling functions. Temperature regulation is a critical responsibility for the proper operation of industries. When it comes to temperature control in the fishpond, each industry has its own set of requirements that must be met during the production period. The fish farming sector is no different [8]. The rapid development of today's technology is a result of the expansion in the field of engineering. In keeping with technological advancements in the world, most electrical appliances are being modified or improved to ensure the comfort of the users. In this paper temperature of a fishpond is regulated to fish's optimum survival temperature of 24°C to 30°C thereby increasing their egg hatching rate and reducing their death rate.

II. Materials and Method

This paper was about the method by which the temperature of the fishpond is controlled in order to promote fish breeding and food production. The various parts that make up the system's temperature controller are shown in Figure 1 below. When the system is connected to the power supply, the transformer regulates the voltage down from 240V/12V. This transformer is directly connected to the bridge rectifier which converts the Alternative Current (AC) to Direct Current (DC). A capacitor is connected to the output of the bridge rectifier to remove the ripple voltage. The input of the LM7805 voltage regulator is connected to the output of the capacitor to regulate the DC voltage from 12 V to 5 V for powering other components in the system. The temperature sensor used is an LM35. The output voltage of this sensor is proportional to the temperature and requires no external calibration. This sensor comes in different types, but in this research, an NTC sensor was used which measures the temperature below 0°C. This LM35 sensor is supplied with 5V from the controller. The output of this sensor was connected to the ADC pin of the PIC16F877A, which in turn is connected to the non-inverting terminal of the op-amp. The Liquid Cristal Display (LCD) was supplied with 5V from the voltage regulator and is also connected to the PIC microcontroller for displaying the current temperature values. The whole block diagram is shown in Figure 2. The temperature of the fish pond is measured by the LM35. As the LM35 outputs 10mV/°C when the voltage rises, the voltage at the inverting input of the op-amp falls below that of the non-inverting input, causing the output voltage of the op-amp to rise, the transistors (TR1) to turn on, the relay RL2 to activate and the heater to turn on. The same op-amp output from TR2 simultaneously turns on relay RL1 and the pump switches. When the current is quickly interrupted, a diode is connected in parallel with the relay to eliminate the reverse voltage generated by the relay coil. The 555 timers are used so that its output drives the pump even when the heater is off to maintain a constant water temperature. The LM35 is the main component that measures the temperature of the water in the pond, while the heater heats the water and the pump helps to circulate the water so that the temperature in the pond is consistent. The wiring diagram of the system is shown in Figure 3. The heater turns ON when the temperature drops and turns on OFF when the temperature rises. This means the water temperature is never too cold or too hot.

A. *The following equations are used for design of this system of temperature regulator circuit.*

Specifications for chosen the transformer at unity power factor are:

Input voltage Vin = 240V

Output voltage V r.m. s = 12V

Secondary current I r.m.s = 500mA

Frequency = 50Hz

The power rating transformer is calculated from equations (1) below.

P = IV = $500x10^{-3}x12 = 6.0w$ (1)
Therefore, power rating of the transformer is

P = 6.0W.

Full wave bridge rectification is calculated from the equations (2)

$V_{r.m.s} = \frac{V_m}{\sqrt{2}}$
(2.1) Vm
= $\sqrt{2}\ x\ V_{r.m.s}\ x = \sqrt{2}\ x\ 12$ = 16.97V

Neglecting resistance of the diode in the forward direction, the average across DC voltage across the lead resistance is given by equation (2.2) below
$V_{dc} = \frac{2V_m}{\pi}$
(2.2) $V_{dc} =$
$\frac{2\ x\ 16.97}{\pi}$ = 10.80V

The current through the load is

$i = I_m sinwt\ d(wt).$

The effective value of the current is calculated from equation (2.3) below r.m.s current is

$I_{r.m.s} = \frac{I_m}{\sqrt{2}}$ (2.3)

$$I_m = \sqrt{2}\ x\ I_{r.m.s} = \sqrt{2}\ x\ 500\ x\ 10^{-3} = 707.11mA$$

DC current through the full-wave rectifier circuit equation is in equation (2.4)

$I_{dc} = \frac{2I_m}{\pi}$ (2.4)
$I_{dc} = \frac{2\ x\ 707.11\ x\ 10^{-3}}{\pi} = 450.160mA$

Capacitor design

The choice of smoothing capacitor is determined with a supply frequency of 50Hz. The ripple voltage Vr is calculated using equation (3).

$V_r = V_m - V_{r.m.s}$ (3)

$V_r = 16.97 - 12 = 4.97V$

Furthermore, the capacitance of the capacitor is calculated from equation (3.1)

$C = \frac{I_{dc}}{2fV_r} = \frac{I_{dc}}{2f(V_m - V_{r.m.s})}$ (3.1)

Relay design

$V = 12V_{dc}$

$R = 400\Omega$

$I_{relay} = \frac{V}{R}$
(3.2)

$I_{relay} = \frac{12}{400} = 0.03A$

Transistor design

$I_{C(max)} = 800mA$

h_{fe}=70

$V_{CEO} = 50V$

Frequency = 150Hz

$V_{CE(sat)} = 0.6V$

Power dissipated = 0.4w

$V_{min} = 5V$

$V_{BE} = 1V$

$I_{C(sat)} = \frac{V_{cc} - V_{CE(sat)}}{R_L} = \frac{12-0.6}{400} = 0.0285A$ (4)
$I_{C(sat)} = 28.5mA$

$I_B = \frac{I_c}{h_{fe}} = \frac{28.5mA}{70} = 0.41mA$ (4.1)

$R_6 = R_B = \frac{V_{min} - V_{EB}}{I_B} = \frac{5-1}{0{,}41mA} = 9523.8\Omega$ = 9.5kΩ a standard value of 10KΩ resistor was used for R6

Timing circuit design

From figure 3 above the time of charging and discharging were calculated by considering resistor R4, R5 and C2 by using constant equation (5) below

$T_{charging} = 0.693(R_4 + R_5)C = 0.693(100k\Omega + 39k\Omega)47\mu F$ (5)

$$T_{discharging} = 0.693R_BC = 0.693\ x\ 39\ x\ 10^{-3} x\ 47\ x10^{-6} = 1.3s$$

$T = T_{charging} + T_{discharging} = 5 + 1.3 = 6.3s$

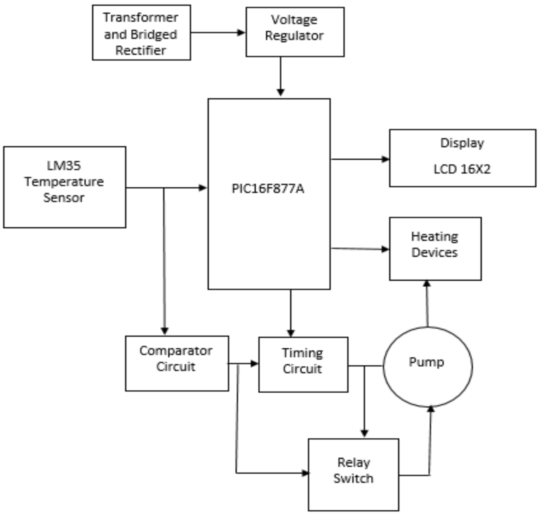

Figure 1. Various parts that made up the temperature regulator of the system

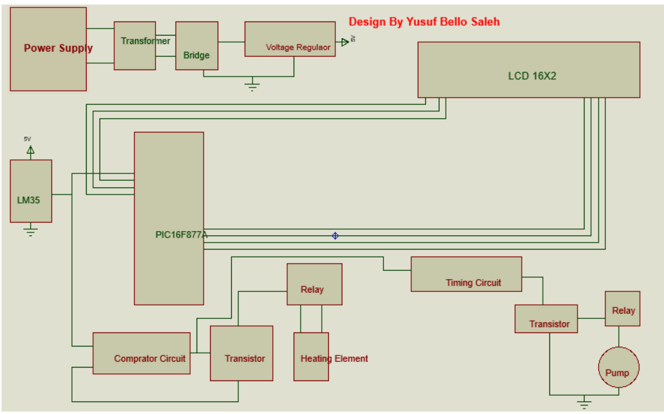

Figure 2 The General Circuit block diagram

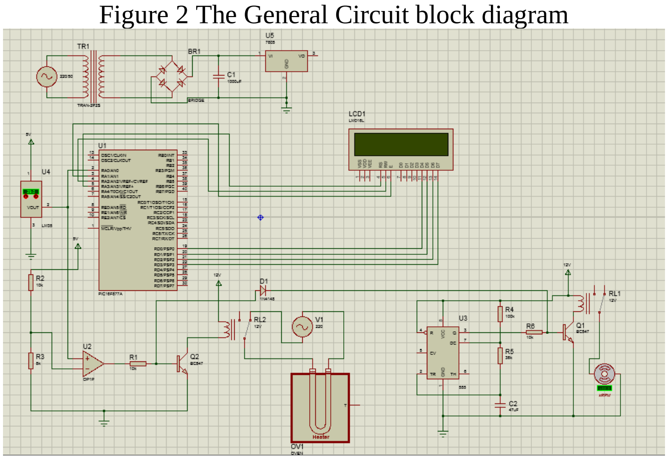
Figure 3. Circuit diagram

Table 1. Table 1.List of materials

S/ N	Components	Quantity
1	240/12 Center tapped transformer	1
2	Capacitor	5
3	Resistor	6
4	Diode	5
5	PIC16F877A microcontroller	1
6	LM35 sensor	1
7	Relay	2
8	Transistor	2
9	555 Timer	1
10	UA741 Op-Amp	1
11	Voltage regulator	1
12	Heating element	1
13	Variable resistor	1
14	Pump	1
15	Vero board	1

Table 2 Testing For Temperature Response With Time

S/N	Time (minute)	Temperature (°C)	Power (W)
1	0	19.1	20
2	10	21	20
3	20	22.7	20
4	30	24.5	20
5	40	26.9	20

III. Results

The result of the system shows that the system responds according to the desired specifications of the design. The volume of the tank used for this design is 0.0073m3 and the heater used is 20W. A heating element with a power of 5.8 kW is therefore suitable for heating a fish pond with a volume of 2.1 m3. The circuit records the temperature via the LM35, which supplies data to the comparator and the microcontroller. The comparator compares the input with the reference input and gives the trigger to switch the relay on or off when the temperature exceeds or falls below the desired value set by the reference voltage. The figure 4 and 5 showed that the temperature of the pond was regulated at every instant of time.

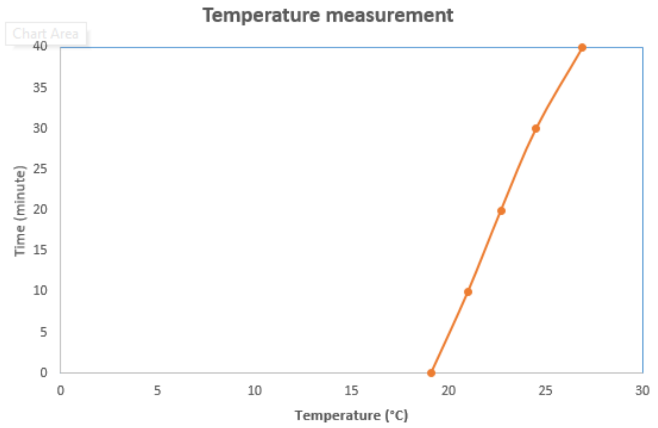

Figure 4. Circuit regulating the temperature to the optimum temperature of the fishes

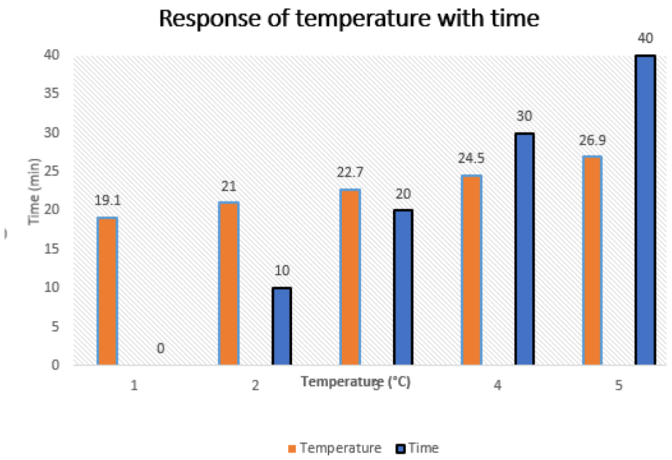

Figure 5. Temperature changes at every instance of time

IV. DISCUSSION

After connecting the circuit to the breadboard, the test was performed to ensure that the circuit worked as designed. In the first phase of the test, the output voltage of the circuit was measured to ensure that it was a 12 V DC power supply obtained from the 240 V main supply using a center-tapped step-down transformer, a bridge rectifier, and a voltage regulator. Then the sensor unit was tested separately to determine if the relay clicks when the water temperature drops. A test was also conducted to determine the time required to heat the water from a minimum temperature of 19°C to a maximum temperature of 25°C. For this purpose, a multimeter was used to obtain an estimate of the power of the heating element capable of heating a larger pond with a volume of approximately 2.1 m3. The two heating elements, each rated at 40W, are connected in series to the main supply. The resistance of each heating element is calculated using equations (6).

$$P = \frac{V^2}{R} \qquad (6)$$

To find the resistance R of each heating element with a power of 40V, at a voltage of 220V from equation (1)

$$40 = \frac{220^2}{R}; R = 1.210k\Omega$$

The resistance of each heating element is therefore 1.210kΩ. Since they are connected in series, the voltage across each heating element is calculated using equation (7) below.

$$V = \frac{R}{R_{eq}} V_s \qquad (7)$$

$$V = \frac{1210}{1210+1210} x\ 220 = 110V$$

Therefore, the power of each heating element is: $P = \frac{V^2}{R} = \frac{110^2}{1210} = 10W$

Hence the total power of the two heating elements is 20W. table 2 above shown the result obtain after carrying out the test.

From Table 2 it was observed the temperature of the water in the pond has been linearly controlled. After each 10 minutes, the temperature of the water has declined this change of temperature is noticed from the LCD screen and thermometer that was inserted in the water for validation. The temperature of the water was continually decreased for an initial 19.1°C – 26.9°C in 40 minutes which shows that the circuit is working according to the desired specification. For this larger fish pond with a volume of about 2.1m3, the power of the heater is calculated using the following equation (8).

$$P = \frac{2.1\ x\ 20}{0.0073} = 5.8Kw \qquad (8)$$

V. CONCLUSION

From the results, it is clear that the high-temperature coefficient, small size, and ability to operate in a wide temperature range are good features of LM35. In addition, the LM35's ability to withstand electrical and mechanical stresses results in accurate variations in comparator input. However, a small variation is a reasonable difference produced at the output of the Op-Amp. Thus, the instrument provides temperature control with a variation between 24°C and 30°C. The choice of comparator makes the circuit very stable as there is no feedback. In addition, the gain is very high compared to a closed-loop system. For high sensitivity, the LM35 should make good thermal contact. Therefore, it can be deduced that the objective of this research is achieved by keeping the temperature of the fish pond within the optimum temperature for the fish.

Acknowledgment

I would like to thank all my colleagues who's keep me motivated during this research, especially the staff of the College of Agriculture and animal science mando.

References

[1] Cruz, J.R.D., Magsumbol, J.-A.V., Dadios, E.P., Baldovino, R.G., Culibrina, F.B., and Lim, L.A.G. *Design of a fuzzy-based automated organic irrigation system for smart farm*. in *2017IEEE 9th International Conference on Humanoid, Nanotechnology, Information Technology, Communication and Control, Environment and Management (HNICEM)*. 2017. IEEE. Available at https://ieeexplore.ieee.org/stamp/stamp.jsp?tp=&arnumber=8269500

[2] Gomez, I. and Thivant, L., (2017). *Training manual for Organic Agriculture*, Scientific Publishers-UBP,.Available at https://books.google.com.tr/books?uid=107850138241594245826&hl=en

[3] Seufert, V., Ramankutty, N., and Mayerhofer, T. (2017). What is this thing called organic?–How organic farming is codified in regulations, *Food Policy*, C 68, 10-20. https://pdf.sciencedirectassets.com

[4] Soto-Zarazúa, G.M., Rico-García, E., and Toledano-Ayala, M. (2011). Temperature effect on fish culture tank facilities inside greenhouse, *International Journal of Physical Sciences*, C 6, 1039-1044. https://academicjournals.org/journal/IJPS/article-abstract/B5CD81627029

[5] Volkoff, H. and Rønnestad, I. (2020). Effects of temperature on feeding and digestive processes in fish, *Temperature*, C 7, 307-320. https://www.tandfonline.com/doi/full/10.1080/23328940.2020.1765950

[6] Sandström, O., Neuman, E., and Thoresson, G. (1995). Effects of temperature on life history variables in perch, *Journal of Fish Biology*, C 47, 652-670. https://onlinelibrary.wiley.com/doi/abs/10.1111/j.1095-8649.1995.tb01932.x

[7] Hall, S.G., Finney, J., Lang, R.P., and Tiersch, T.R. (2002). Design and development of a geothermal temperature control system for broodstock management of channel catfish Ictalurus punctatus, *Aquacultural Engineering*, C 26, 277-289. https://www.sciencedirect.com/science/article/pii/S0144860902000365

[8] Amin, M.R., Ghosh, A., and Hadi, A. (2018). Design and Implementation of Microcontroller Based Programmable Smart Industrial Temperature Control System: An Undergraduate Level Approach, *Int. J. Control Autom*, C. https://www.researchgate.net/publication/323688154