International Journal of Research in Engineering and Science (IJRES)
ISSN (Online): 2320-9364, ISSN (Print): 2320-9356
www.ijres.org Volume 11 Issue 9 ǁ September 2023 ǁ PP. 179-182

Implementation of Fuzzy Logic Controller for Oxygen Control In Aquaculture Using Dissolved Oxygen

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ABSTRACT: *This paper presents the real-time implementation of a fuzzy coordinated classical PI control scheme for controlling the Dissolved Oxygen (DO) control of the aquarium system. The fuzzy system has been designed to track the variation parameters in a feedback loop and tune the classical controller to achieve a better control action for load disturbances and set point changes. The error and process inputs are chosen as the inputs of fuzzy system to tune the conventional PI controller according to the process condition. This online conventional controller tuning technique will reduce the human involvement in controller tuning and increase the operating range of the conventional controller. The proposed control algorithm is experimentally implemented for the real-time temperature control for sensitive system. The Proposed system validated using a high-speed 32-bit MSP430 Microcontroller. To demonstrate the performance of the fuzzy coordinated PI control scheme, results are compared with a classical PI and PI-type fuzzy control method. It is observed that the proposed controller structure is able to quickly track the parameter variation and perform better in load disturbances and also for set point changes. The proposed system implemented using MSP430 to validate the system.*

Keywords: *PID,MEMS,LSVR,DO.*

Date of Submission: 11-09.2023 Date of acceptance: 25-09-2023

I. INTRODUCTION:

One of the most crucial elements affecting water quality is dissolved oxygen (DO). Both wastewater treatment facilities (WWTPs) and aquaculture benefit greatly from maintaining the DO concentration at a desired level. Future industrial farming will mostly use recirculating aquaculture since it has several benefits, including high breeding effectiveness and water resource conservation. Recirculating aquaculture has traditionally placed a high importance on accurate water quality control, with DO being the most crucial water quality indicator for assessing the caliber of a water body. The DO content is within a healthy range, which is good for aquatic items' ideal growth and development and boosts breeding effectiveness. Relevant research have demonstrated that an excessively low DO level will substantially impede the healthy development of aquatic goods and, in extreme situations, even result in widespread demise. To improve the detection of amperometric current in the three-electrode Clark dissolved oxygen (DO 2) Microelectromechanical systems (MEMS) sensors, a novel strategy is presented. According to the suggested method, the counter electrode (CE) in a traditional concentric three-electrode sensor is modified to permit a significant amount of static electric current in an electrochemical solution [1]. This paper reports on a geometrically optimized implantable three-electrode Clark microsensor for measuring dissolved oxygen concentration. The sensor is based on a conventional concentric three electrode structure [2]. We looked at the cathode and anode reaction rates first using the electrochemistry reaction mechanism. The reaction rates of the cathode and anode under stable polarization were then related mathematically[3]. We present a self-powered, biodegradable sensor for measuring dissolved oxygen in the body. At the cathode of an electrochemical pair that is corroding, an oxygen reduction reaction competes with the typically dominating hydrogen reduction event. The output voltage of the pair is influenced by the local oxygen concentration because the relative contribution of the oxygen reduction reaction to the overall electrochemical reaction depends on the local oxygen concentration[4]. The wastewater treatment operations are the only applications for the widely used soft sensor model known as least square support vector regression (LSSVR)[5]. This study describes the integration of a physical sensor and many electrochemical sensors using amperometric and potentiometric approaches on a single chip. The prototype includes six sensors for in-situ monitoring of key bioprocess parameters, including temperature, dissolved oxygen, cell density, glucose, lactate, and PH[6]. This document reports an analysis of different thicknesses (0.1-2.5 mm), different solvents (toluene and THF), and indicator concentrations (363, 545, 727 ppm) and their relationship to the absorption spectrum[7]. Photonic-based sensors have recently become the subject of great attention for oxygen measurements due to their highly promising characteristics. These include the lack of requirement for repetitive calibrations and replacement of parts, being contactless, their accuracy, and fast response, and the potential to fabricate such sensors in small sizes[8]. This work presents a miniaturized electrochemical sensor-integrated bioprocess monitoring pod (bPod) that wirelessly monitors local dissolved oxygen (DO) saturation within bioreactors in real-time. The system comprises a compact printed circuit board (PCB) that integrates a potentiostat analog-front-end (AFE) and a Bluetooth Low Energy (BLE) microcontroller with an electrochemical DO sensor [9].

I. Design of a fuzzy logic controller

In complex, nonlinear, or undefinable systems for which sound practical information is available, fuzzy logic controllers typically perform better than other controllers. The foundation of fuzzy logic controllers is fuzzy sets, which are classes of objects where the change from membership to nonmembership is gradual rather than sudden.

- **Fuzzy Tuning of PI Controller:**

In the hybrid control structure, the fuzzy system is used to modify either the system set point or scaling factor of a conventional controller. The present method focuses the input scaling factor modification of a classical PI controller. The PI controller is usually implemented as follows:where are the proportional andintegral gains. The controller output, process output, and the set point are denoted as respectively.

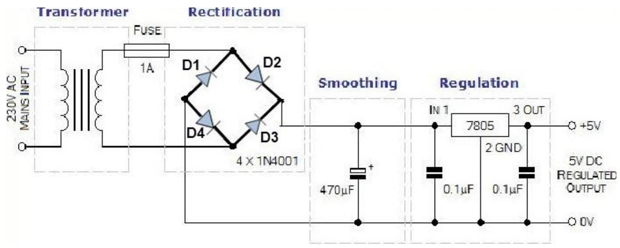
II. HARDWARE DESIG

- **Power supply unit:**

The step-down converter in their power supply circuit must convert the AC 230V to 5V DC because these microcontrollers demand a 5V DC supply.

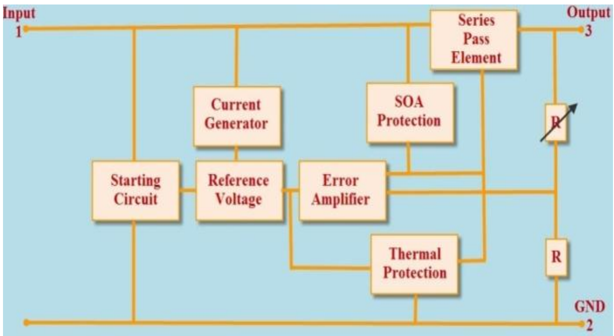
- **Step Down the Voltage Level:**

High voltage is changed into low voltage using step-down converters. Step-down converters have output voltages that are lower than their input voltages, while step-up converters have output voltages that are higher than their input voltages. Transformers that step up or down the voltage levels are known as step-up and step-down transformers.



- **Voltage Regulator:**

15V DC voltage can be stepped down to 5V DC voltage using a DC step-down converter called as voltage regulator IC7805. The first two digits '78' of IC7805 voltage regulator represent positive series voltage regulators and the last two digits '05' represents the output voltage of the voltage regulator.



- **MSP430 microcontroller:**

The MSP430 from TI has a potent 16-bit RISC processor, 16-bit registers, and constant generators that contribute to the highest possible code efficiency. Wake-up from low-power mode to active mode is possible in less than 6 s thanks to the digitally regulated oscillator. For a variety of low power and portable applications, the MSP430TM 16-bit microcontroller platform of ultra-low power RISC mixed-signal microprocessors from TI offers the ideal solution.

- **Software development environment:**

Software development tools are another service that TI offers, both directly and in collaboration with partners (see the complete list of compilers, assemblers, and IDEs). The IAR C/C++ compiler and Integrated development environment, or IDE, are two examples of such tool chains. Freely available from TI or IAR, the Kickstart edition's compiler and debugger can only handle 8 KB of C/C++ code; however, applications written in assembly language of any size can be created and debugged using this free tool chain.

III. CONCLUSION

In this project, the stability, fast tracking capability for parameter variation, and robustness of different controller algorithms were studied experimentally for a precious Dissolved Oxygen (DO) control system. The experimental analysis proved that the proposed fuzzy-coordinated PI control scheme maintains the tank temperature at set level without any steady-state error unlike PI-type fuzzy controller. By keeping the merits of PI and FLC, the proposed control scheme makes the system output to reach the set level faster than PI and PI-type controllers. However, the performance of the PI and PI-type fuzzy controller was not good enough for load disturbances because of the poor tracking capability. It was found that from the demonstrated results, the proposed fuzzy logic-based hybrid control scheme is well suited to temperature control and other types of dynamic processes. Further, the microcontroller-based embedded controller proved to be better tool for implementing the hybrid control algorithm with low cost and simple design technique. During the Phase-I MSB430 based design is completed for proposed system. Temperature controller of the proposed system will be implement using MSB430 Controller.

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