

Servo motor angle control in an automatic droplet system for quantum dot sintesis

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ABSTRACT

This research aims to develop an automation system in the synthesis process of core-shell quantum dots using the Arduino-based hot injection method. The system is designed to resemble an automatic syringe pump consisting of an Arduino UNO microcontroller, servo motor, LCD, and toggle switch to control the rate of solution injection precisely within a certain time range. The servo motor regulates the movement of the syringe to produce drops of solution according to the selected duration, ranging from 1 to 24 hours. The test results show that the system can execute 21 servo rotations forward at an angle of 22° per rotation and 4 backward at an angle of 115° per rotation, with high accuracy and time stability. The time display on the LCD showed good agreement with the real time, proving the effectiveness of the monitoring and control system. The system was able to improve the efficiency and precision of the QD synthesis process compared to the manual method, and showed great potential in automation applications in the field of materials chemistry.

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1. INTRODUCTION

Technological developments in the field of chemistry have progressed rapidly, especially in terms of synthesizing nanoscale particles such as quantum dots (QDs). Since the 1980s, researchers began to reveal that the optical and electronic properties of QDs depend on particle size, thus triggering various innovations in their manufacturing methods [1]. One of the developing synthesis methods is hot injection, which is a technique of injecting compounds into a hot solution to produce uniform nanocrystals [2]-[4]. The hot injection method in general still relies on manual systems in injecting using syringes or syringes. However, innovations in the field of automation allow this process to be more efficient and precise. In this research, the author developed an automated system to control the syringe using an Arduino UNO microcontroller. Automation itself is defined as the automatic execution of procedures to maximize the efficiency and effectiveness of machine work [5].

The system is designed to resemble a syringe pump, a medical device used to inject liquids in a precise and automatically controlled manner [6]. The advantages of using an automated system in this hot injection method include increased volume accuracy, reaction stability, and timeliness of injection. The main components of this system include Arduino UNO, servo motor, and LCD. Arduino UNO is an ATmega328-based microcontroller board that is capable of controlling various electronic devices both simple and complex [7]-[8]. The servo motor plays an important role in moving the syringe because it uses a closed feedback system that ensures position accuracy [9]-[10]. Meanwhile, the LCD serves to visually display system information, using transparent electrode technology on a layer of glass [11]-[13]. The entire system is designed to monitor the volume of fluid dispensed and the varying time span of injection, ranging from 1 to

24 hours. The monitoring process is supported by Arduino UNO and Arduino IDE software, resulting in a real-time and efficiently controlled system [14]-[15].

2. METHOD

When this tool is run, the first step is to prepare the system components to be ready to operate, marked by the STANDBAY display on the LCD. Furthermore, the operator can select the time interval on the available switches, when the switch has been selected, the system will operate, the servo motor will operate with the time range displayed on the LCD, after which the servo motor will move to push the gear and rack gear so as to cause the syringe plunger to be pushed and produce drops of solution. When the motor fails, the buzzer will sound. However, if there is no failure, the servo motor will continue to work according to the selected time. When the solution in the syringe has run out, the servo motor will return to the starting position, and the rotation cycle is complete, but if the solution in the syringe has not run out due to an error, the buzzer will sound indicating a failure. For more details, it can be explained in the flowchart in Figure 1.

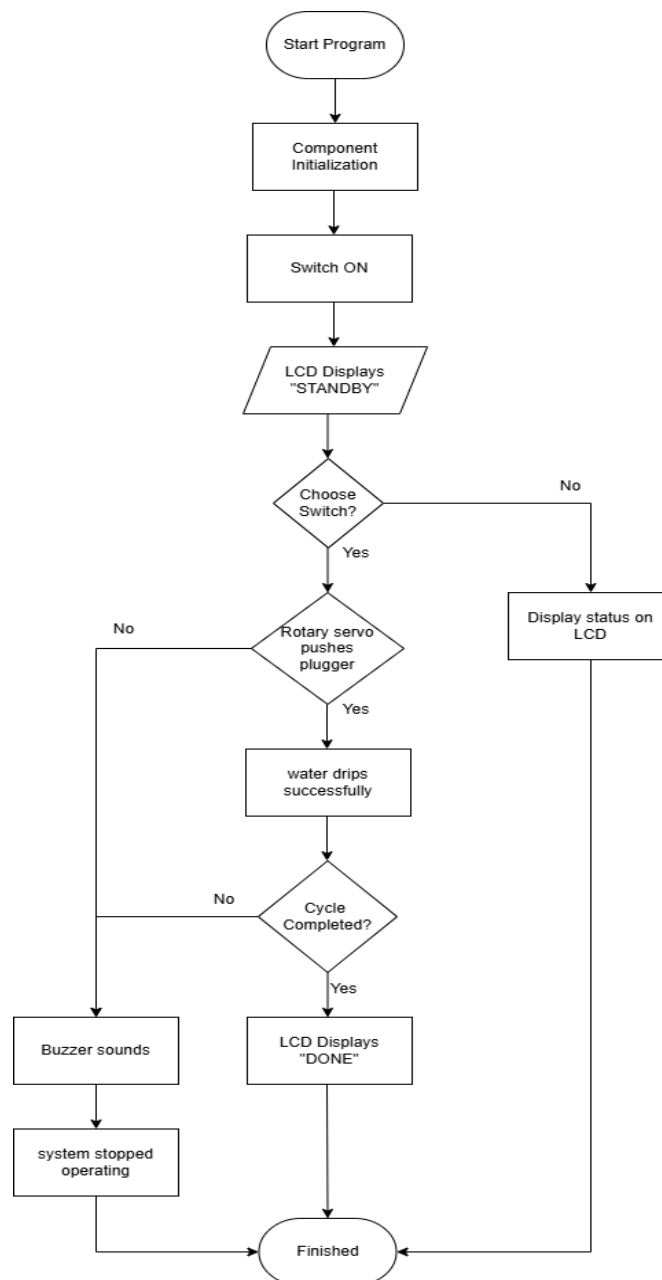


Figure 1. Flowchart System

3. RESULTS AND DISCUSSION

After conducting data program testing through hardware, the test results have been presented in table form. The following is data from the system results after conducting testing, including testing servo motor and timer program on LCD. Figure 2(a) shows the LCD display when the start/stop switch is activated. Figure 2(b) shows the LCD display in one hour testing of servo motor and timer. In this test, the servo motor will move with a time span of 1 hour according to what is displayed on the LCD.



Figure 2. LCD display in experiment

The servo motor rotation angle was observed over various time periods, from 1 hour, 3 hours, 5 hours, 8 hours, to 24 hours. Figure 3 shows a graph of the servo motor rotation angle over various time periods. Figure 3(a) shows the servo rotation angle over a 1-hour period, and Figure 3(b) over a 3-hour period.

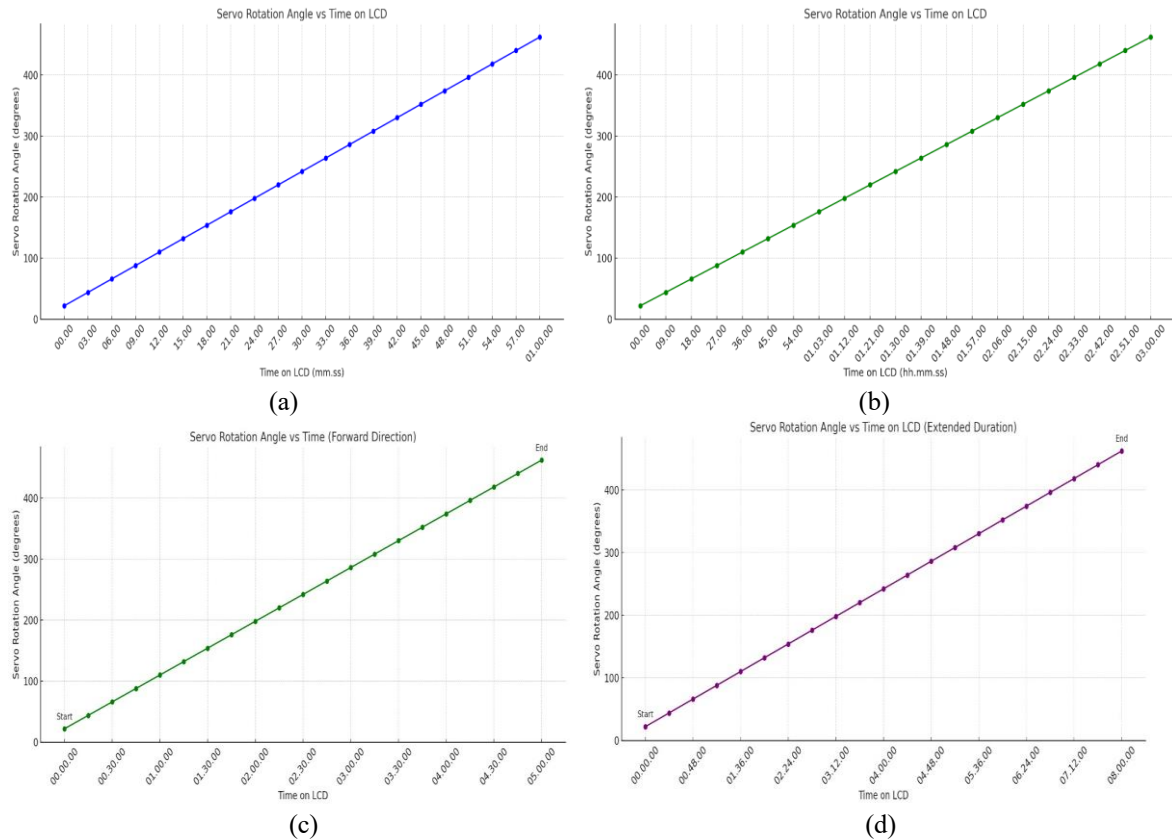


Figure 3. Angle rotation of servo motor for 1 hour, 3 hour, 5 hour and 8 hour

The graph in the image displays the relationship between the servo rotation angle (degrees) and the time displayed on the LCD (mm/ss) during the test. The graph shows that the servo rotation angle increases linearly with time. At the beginning of the test (00:00), the servo is at an angle of approximately 22°. Subsequently, with each time increment of approximately 3 minutes, 9 minutes, 15 minutes, 24 minutes, 36 minutes, and 72 minutes, the servo angle increases by approximately 22°. This pattern persists until the end of the observation at 1 hour, 3 hours, 5 hours, 8 hours, 12 hours, and 24 hours, when the servo has reached an angle approaching 462°. This indicates that the control system used is capable of moving the servo gradually and proportionally to the elapsed time. In other words, the longer the operating time, the greater the rotation angle achieved by the servo. This linear pattern indicates that the rotation command is applied stably, with no uncontrolled spikes or decreases in the angle. Since servos are typically only physically capable of 180° of rotation, the data suggests that the servo in question is likely a continuous rotation servo, or that there is a mechanism for calculating cumulative angles beyond normal physical rotation. Thus, the graph also confirms that the implemented time-based servo angle calculation logic is working properly

4. CONCLUSION

Based on the test results and discussion of the solution dropper automation system regarding the influence of the servo motor and timer on the LCD, it can be concluded that: during the test (1, 3, 5, 8, 12 and 24 hours), the servo motor can move forward 21 times with an angle of 22° per rotation and backward 4 times with an angle of 115° per rotation. With a total angle of forward rotation is 462° and backward is 460°, indicating that the system has worked systematically and precisely, and is able to return the servo position to the starting point accurately. The timer on the LCD runs according to a programmed amount of time and the comparison of the time on the LCD with the real time is not much different.

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