International Journal Of Latest Technology In Engineering & Management (IJLTEM)
Volume 11 - Issue 3 {May-June 2026} {Page: 26-31}

Simulation of an Electronic Single-Needle Sewing Machine Using a DC Servo Motor via the Arduino Library

Trung Ngo Kien
Faculty of Mechanical and Electrical Engineering, Hanoi Industry and Trade University, Hanoi, Viet Nam

ABSTRACT: *Servo motors are widely utilized in industrial machinery, particularly in garment manufacturing systems, due to their high positioning accuracy and flexible speed control capability. In electronic sewing machines, the primary control objective is the regulation of motor speed to achieve accurate needle movement. The servo motor transfers rotational motion to the main shaft through a belt transmission mechanism, thereby determining the operation of critical machine functions such as needle positioning, forward and reverse stitching, and stopping control. This study presents the integration of the Arduino library within the MATLAB environment and demonstrates its application in the development of a servo motor control system for sewing machine operations.*

Keywords: *Servo motor, controller, sewing machine, arduino library, matlab*

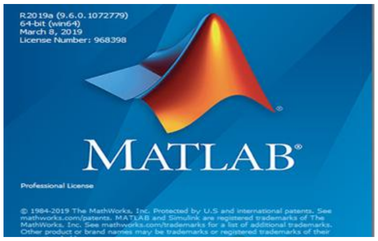
INTRODUCTION

The advancement of mechatronic technologies has significantly contributed to the modernization of industrial automation systems. In the textile and garment sector, microcontroller- and PLC-based control systems have become essential components for improving operational efficiency, precision, and production flexibility. Among these technologies, servo motor systems play a critical role in electronic sewing machines, where accurate motion and position control are required for stable sewing performance. In a servo-driven sewing machine, the encoder feedback signal is employed to monitor the actual motor position and compare it with the desired reference value. Based on the resulting error, the control algorithm adjusts the motor input to achieve precise shaft positioning and smooth operation of sewing mechanisms. Therefore, the modeling and simulation of servo motor behavior provide an important foundation for the development of reliable control strategies in sewing applications. This paper introduces the integration of the Arduino library with the MATLAB environment and presents its application in the design and implementation of a servo motor control system for a single-needle electronic sewing machine.

ARDUINO LIBRARY AND SERVO MOTOR

2.1 Matlab and arduino library

MATLAB (Matrix Laboratory) is a high-level technical computing environment developed by MathWorks for numerical analysis, algorithm development, programming, and data visualization. The platform provides a comprehensive set of built-in functions and computational tools that support matrix operations, mathematical modeling, and scientific simulations. Beyond its standard computational capabilities, MATLAB includes numerous specialized toolboxes designed for specific engineering and scientific applications. These toolboxes extend the functionality of the software and enable efficient implementation of advanced techniques in areas such as digital signal processing, image processing, control systems, power electronics, machine learning, and fuzzy logic. Owing to its flexibility and extensive library support, MATLAB has become one of the most widely used software platforms in research, education, and industrial engineering applications.



R2019a (9.6.0.1072779)
64-bit (win64)
March 8, 2019
License Number: 968398

© 1984-2019 The MathWorks, Inc. Protected by U.S and international patents. See mathworks.com/patents. MATLAB and Simulink are registered trademarks of The MathWorks, Inc. See mathworks.com/trademarks for a list of additional trademarks. Other product or brand names may be trademarks or registered trademarks of their

Fig.2.1. MATLAB startup interface

Arduino is a microcontroller development platform commonly used for embedded control and hardware interfacing applications. It supports communication with external devices such as sensors, actuators, and motor drivers, making it suitable for a wide range of automation and control systems. Owing to its low implementation cost, user-friendly programming environment, and open-source architecture, Arduino has gained significant popularity in both academic research and industrial prototyping. The platform has continuously evolved through contributions from a large global development community, enabling improvements in hardware design, software libraries, and application support. Arduino boards are typically programmed using the C/C++ language through the Arduino IDE, where source code is compiled into executable machine code for the onboard microcontroller. In addition, Arduino can be integrated with engineering software tools such as MATLAB and LabVIEW, allowing real-time data acquisition, system monitoring, and rapid implementation of control algorithms. This capability makes Arduino an effective platform for experimental validation and practical development of embedded control systems.

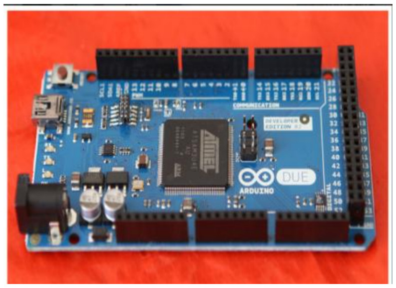
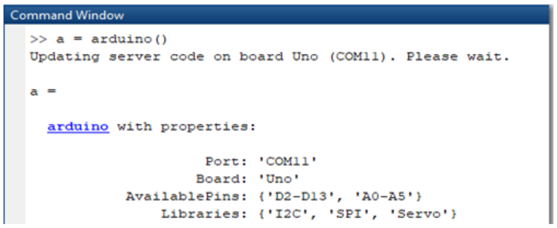


Fig.2.2. Arduino Board

Verification and initialization of the Arduino library are performed through commands entered in the MATLAB Command Window. In systems where multiple microcontrollers are connected to the computer, the assigned communication port must first be identified. This can be accomplished by accessing the Control Panel and selecting *Devices and Printers* to determine the corresponding COM port number of the Arduino board. After identifying the active COM port, the port configuration in the MATLAB code must be updated accordingly prior to code compilation and execution: **a=arduino ()**



```
>> a = arduino()
Updating server code on board Uno (COM11). Please wait.

a =

  arduino with properties:

                    Port: 'COM11'
                   Board: 'Uno'
           AvailablePins: {'D2-D13', 'A0-A5'}
               Libraries: {'I2C', 'SPI', 'Servo'}
```

Fig.2.3. Validation of Arduino Setup

2.2. Servo motor in sewing machines

Nowadays, servo motors are widely used in manufacturing equipment, including the garment industry, due to their high precision and superior performance. Typical advantages include lower noise compared to conventional motors, reduced power consumption, lighter weight than mechanical motors, and easy speed control. A servo motor is an essential component of the motion control system in sewing machines, available in various designs and sizes for different machine types. During operation, both speed and position are continuously fed back to the control circuit through an encoder. If any disturbance causes deviation from the desired speed or position, the feedback system sends corrective signals to the controller. Based on these signals, the servo controller compares the feedback with the reference input and generates appropriate adjustments to ensure that the motor operates accurately according to the required conditions, achieving precise speed and position control.

Servo motors are generally classified into two main types: AC servo motors and DC servo motors. AC servo motors are capable of handling higher current levels and are therefore commonly used in industrial machinery. In contrast, DC servo motors are not designed for high-current applications and are more suitable for smaller-scale systems. DC motors are further divided into brushed DC motors and brushless DC motors.

Electronic single-needle sewing machines are manufactured by various companies and brands; however, they generally share similar operating principles and transmission mechanisms.

- **Main shaft motor:** This motor drives the key mechanical components of the machine, such as the hook mechanism, fabric feeding system, and needle bar. Due to advantages such as high speed, easy speed adjustment from high to low and vice versa, and energy efficiency, most electronic single-needle machines use either AC or DC servo motors. These motors are controlled by electronic circuits to drive the main shaft at an average speed of approximately 3000–4500 revolutions per minute.
- **Electromagnetic actuators:** These are solenoid valves used to control mechanical actions such as thread trimming, backstitching, and thread release by activating mechanical mechanisms.
- **Sensors:** These are used to measure and determine the stopping position of the main shaft and to ensure accurate position control.

In practice, most single-needle sewing machines use AC servo motors with power ratings ranging from 400 to 450 W as the main drive motor. Needle positioning is controlled in combination with sensors and mechanical mechanisms, while backstitching functions are controlled through electromagnetic actuators. Speed adjustment is typically achieved via a variable resistance control system. The power control mechanism of AC servo motors differs significantly from that of DC servo motors. Within the scope of this study, a DC servo motor is used in place of an AC servo motor to simulate the operating functions of an electronic single-needle sewing machine, including needle stopping position control and sewing speed determination based on motor rotational speed in both forward and reverse directions.

Fig.2.4. DC servo for experiment

CONTROLLER DESIGN FOR A SINGLE NEEDLE SEWING MACHINE

3.1. Control Problem in a Single-Needle Sewing Machine

Precise Stop Position Control: Electronic sewing machines utilize a speed sensor to determine the needle position, combined with an electromagnetic system to drive the main shaft and bring the needle bar to the desired stopping position. In the experimental setup, the signal from the encoder is compared with the reference input and fed into a PID controller, which computes the required stopping position and generates control signals to adjust the motor shaft to the desired position.

Speed control: A potentiometer is used to set a specific rotational speed. A potentiometer is also used to adjust the rotational speed (i.e., fast or slow needle motion). The foot pedal (control signal via a potentiometer) is used to regulate the speed. Accordingly, the controller output governs the motor operation in two states: stop and run with gradually increasing speed. The controller adjusts the motor speed through an analog signal from the potentiometer, similar to how pressing the pedal increases speed and releasing it decreases speed. Block diagram of the foot pedal control system shown in Fig. 3.1:

Fig. 3.1. Block diagram of the foot pedal control system

Forward and Reverse rotation control: the motor rotates forward, then reverses for a specified number of revolutions (which can be adjusted), and subsequently continues rotating forward. When a stop command is issued, the motor performs a forward rotation followed by a reverse rotation for a specified number of revolutions (adjustable), and then resumes forward rotation until reaching the predefined number of revolutions before coming to a complete stop. The controller is programmed to regulate the motor speed flexibly. Upon receiving stop or reverse commands, the motor must stop and change direction precisely at the required position. As Fig. 3.2 illustrates following: **Bold line (**forward stitching direction), **Thin line (**reverse stitching direction).

Fig. 3.2. Illustration of needle motion direction**.**

3.2. Control structure design

- The control objective in this system is to achieve precise position control through a servo motor. In the presence of any deviation, the position signal from the encoder is fed back and compared with the reference input of the system. Based on this comparison, the controller generates appropriate control signals to drive the motor such that the output closely tracks the reference signal. The control structure of the system is illustrated in Fig. 3.3.

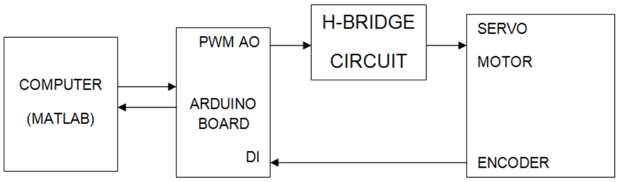


Fig. 3.3. Control structure of the system.

- The controller employs a PID control algorithm to regulate the motor speed according to the reference value (Fig. 3.4), corresponding to the desired needle motion.

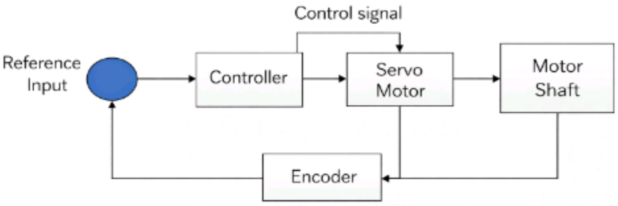


Fig. 3.4. Motor speed control structure.

- The control of motor rotation direction (Fig. 3.5) describes the forward and reverse motion of the needle. It is defined that if signal A leads signal B, the rotation is in the clockwise (CW) direction. In this case, when the encoder shaft rotates clockwise, signal A leads signal B by a phase difference of 90 degrees. Conversely, if the encoder shaft rotates in the counterclockwise (CCW) direction, signal B leads signal A. At this point, signal B has a phase lead of 90 degrees relative to signal A.

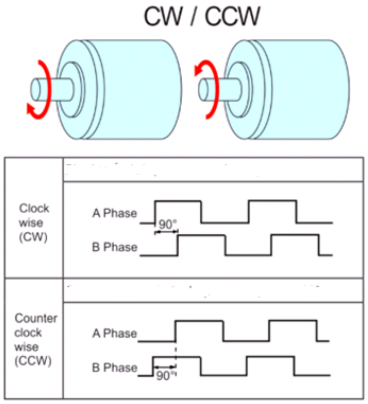


Fig. 3.5. Forward and reverse control of the motor.

3.3. Experimental result

The controller was developed in the MATLAB environment and implemented using an Arduino board, which interfaced with the system through input signals representing the needle position in the sewing machine as shown in the fig. 3.6. The corresponding experimental results are illustrated in the fig. 3.7 - fig. 3.9:

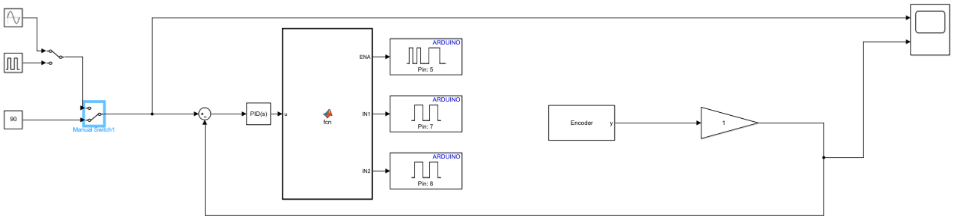


Fig. 3.6. The controller with input signals

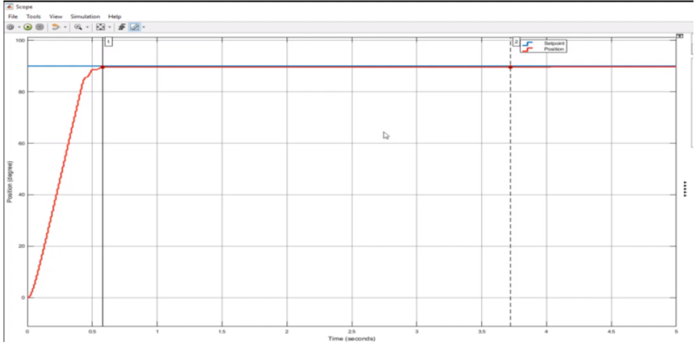


Fig. 3.7. Experimental results with a preset input angle of 90°.

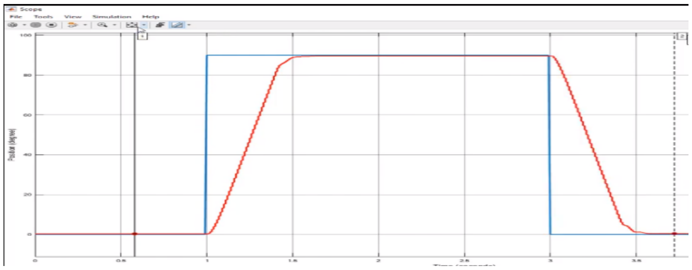


Fig. 3.8. Experimental results with a square wave input.

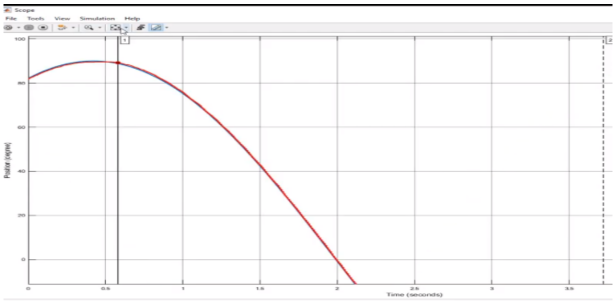


Fig. 3.9. Experimental results with a sin wave input signal.

Remark: Needle motion in a sewing machine is controlled via a DC servo motor drive system that ensures compliance with the required performance standards. Based on multiple input signals, the controller produces a corresponding control output to regulate the motor operation, ensuring that the system output accurately follows the reference input signal.

CONCLUSION

Servo motors are extensively utilized across various industrial sectors, particularly in the textile industry, including applications such as electronic sewing machines, buttonhole sewing machines, and keyhole sewing machines. This study presents simulation results of needle motion in an electronic single-needle sewing machine, implemented through an experimental DC servo control system using the Arduino library within the MATLAB environment. The obtained experimental results satisfy the specified performance requirements, confirming the feasibility of developing effective control systems for electronic sewing machines and demonstrating potential applicability to other industrial automation systems.

REFERENCES

[1] Amol More et al., 2025, Modified Sewing Machine for Disabled People - An IOT and Arduino-Based Approach: Review, International Journal of Scientific Research in Engineering and Management, Vol. 9, Iss. 11.

[2] Hung N. T. et al., 2021, Industrial Sewing Equipment, *Science and Technology Publishing House.*

[3] Hari K. K. et al., 2021, A systematic literature review on prototyping with Arduino: Applications, challenges, advantages, and limitations, Computer Science Review, Vol.40- 100364.

[4] Quang N. P., 2006, Simulink MATLAB Textbook, Science and Technology Publishing House.

[5] Truong D. N. et al., 2018, Microcontrollers and Applications (Arduino User Guide), Youth Publishing House.

[6] Vu Q. H., 2011, Electric Motor Control Engineering, Education Publishing House.

[7] Trento D. et al., 2020, Application of Arduino-Based Systems as Monitoring Tools in Indoor Comfort Studies, International Journal of Architectural Engineering Technology, 2020, Vol.7.

[8] Jinzhu Shen et al., 2025, Autonomous Sewing Technology and System: A New Strategy by Integrating Soft Fingers and Machine Vision Technology, Textiles 2025, Vol.5, Is. 45.