
DEVELOPMENT OF AN AUTOMATIC COIL WINDING MACHINE

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ABSTRACT

This article presents the development of an automatic coil winding machine. The proposed technique provides an efficient solution for a wide range of coiling operations in electrical and electronic manufacturing. The system significantly reduces the physical effort and time consumption associated with manually operated winding machines, thereby eliminating common inconveniences faced by coil winders. The primary objective of the machine is to overcome the inherent challenges of manual winding, such as overwinding, coil misalignment, non-uniform winding patterns, inaccuracy in turn counts, and slow operational speed. In addition, the proposed system aims to minimize manufacturing costs, reduce technician workload, and enhance overall productivity in small-scale and educational production environments. The coil winding or rewinding machine is commonly employed to transfer wire from a spool onto a former (winding fixture) and accurately attach it to the winding head. The developed system is also suitable for instructional purposes, enabling students to practically learn the winding of small transformers, electric motors, and relay coils. This article incorporates Arduino-based programming to automate the winding process and ensure precise control of operational parameters. The main components of the automatic coil winding machine include a liquid crystal display (LCD) for displaying the number of turns, push buttons for user input, an infrared (IR) sensor for turn counting, and a DC motor to drive the winding mechanism. Experiment was conducted, and the results showed that the developed automatic coil winding machine performed better of about 95% in terms of high precision and accuracy of achieving the desired number of coils turns. The system therefore proves to be reliable, efficient, and suitable for both educational and small-scale industrial applications.

Keywords: DC Motor; Liquid Crystal Display (LCD); Infrared Sensor; Arduino Uno; Motor Speed Controller

1. INTRODUCTION

Coil winding is a fundamental process in various industries, particularly in electronics and electrical engineering, where it plays a critical role in the production of components like transformers, inductors, and solenoids. These components are essential for numerous applications, ranging from power supplies and electric motors to telecommunications equipment and consumer electronics. The quality and performance of these devices heavily rely on the accuracy and precision of the coils used within them (Shafiq *et al.*, 2022).

Traditionally, the coil winding process has been predominantly manual, with skilled operators responsible for winding wire onto cores or spool. This manual approach, while effective to some extent, comes with inherent limitations. Firstly, it is a time-consuming and labor-intensive process, making it unsuitable for high-volume production. Secondly, human operators may introduce errors into the winding process, leading to variations in coil dimensions and electrical characteristics (Kepalas, 2024).

These limitations are particularly problematic as modern manufacturing trends shift towards customization, small-scale production, and just-in-time manufacturing. Manufacturers are increasingly required to produce coils tailored to specific designs or prototypes promptly. Consequently, there is a growing need for automated solutions that can eliminate errors, reduce production time, and enhance the precision of coil winding processes (Kusnadi & Amir, 2025).

To address these challenges, this project aims to design and construct an automatic coil winding machine that leverages modern technologies and automation techniques. By automating the coil

winding process, this machine will significantly enhance productivity and precision, making it suitable for both large-scale production and small-scale, customized manufacturing (Hassanen *et al.*, 2026).

The automatic coil winding machine will be controlled by an Arduino Uno Board, which will serve as the brain of the system, coordinating the various components required for precise winding. The integration of sensors, motors, and a user-friendly control interface will ensure that the machine can wind coils accurately and consistently, meeting the demands of modern manufacturing (Malik & Masood, 2026).

The outline of this article is structured as follows; section one is the introduction, while section two gives the literature review that is related to this area. Section three describes the materials used in developing this article, and section four is the results and discussion. Section five is the conclusion and the references is given lastly.

2. LITERATURE REVIEW

This subsection gives a literature review of works that have been done which are similar to this article; Ebuehi *et al.*, (2021) developed a portable automatic coil-winding machine using an AT89C52 microcontroller and DC motors. The prototype demonstrated accurate and stable winding while reducing the time and effort associated with manual coil production. Korbu *et al.*, (2021) developed a microcontroller-based automatic coil-winding machine to replace manual motor-coil production. The system reduced winding time and operator requirements while providing automatic turn counting. Ge *et al.*, (2021) developed a highly integrated automatic winding system for fiber-optic gyroscope sensing coils. The study focused on integrating the winding processes to achieve improved automation and precision in sensing-coil manufacturing. (Farnsworth *et al.*, 2022) proposed an augmented machine-learning approach for classifying electrical coil-winding defects. The study demonstrated the potential of computer vision and machine learning for automatically identifying winding defects and improving manufacturing quality. (Ilahi *et al.*, 2023) developed an automatic coil-winding machine for water-pump motors using an ATmega8 controller. The study focused on improving winding speed and accuracy while overcoming the inconsistent operation associated with manual winding. (Han *et al.*, 2025) developed a fuzzy-PID strategy for tension regulation in a winding machine. The controller improved disturbance rejection and reduced tension fluctuations compared with conventional PID control. Ajayi *et al.*, (2025) investigated the design and optimization of renewable-energy-powered automated transformer coil-winding machines. The study combined winding automation with energy optimization, highlighting the potential for more sustainable coil-manufacturing systems. Asari *et al.*, (2025) developed a safe and user-friendly winding machine for manufacturing sensing coils used in magnetic flux and core-loss measurements. The machine optimized winding performance based on load, rotational speed, and coil-to-coil distance, with an optimal distance of 24 cm achieving a completion time of 51 seconds. The results demonstrate improved winding efficiency and reduced repetitive manufacturing errors. However, further validation is required to establish the accuracy and robustness of the optimized parameters. Sun *et al.*, (2026) The study proposed a Hamiltonian-based tension–speed coordinated control strategy incorporating a nonlinear disturbance observer and command-filtered backstepping control. The proposed approach improved tension regulation, disturbance rejection, and dynamic response compared with conventional PID control.

3. MATERIALS AND METHODS

The components used in developing the automatic coil winding machine is giving in this section.

3.1 Arduino Uno Board: The Arduino Uno Board serves as the central control unit for the machine, responsible for executing the control algorithm, managing sensors and motors, and ensuring precise coil winding. This is shown in Figure 3.1.

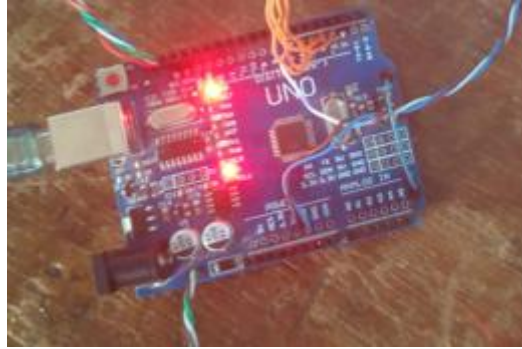


Figure 3.1: Arduino Uno Board (Ebuehi *et al.*, 2021)

3.2 Infrared Sensor: Infrared sensors are utilized for detecting the position of the winding process. They play a critical role in monitoring and controlling the rotation of the coil winding arm, ensuring accurate and consistent winding. This is shown in Figure 3.2.



Figure 2.2: Infrared Sensor (Ni, 2026)

3.3 Motor Speed Controller: Motor speed controllers regulate the rotational speed of the motor responsible for winding the wire onto the core. This component is vital for achieving the desired winding speed and maintaining uniformity.



Figure 3.3: Motor Speed Controller (Shenbagalakshmi *et al.*, 2025)

3.4 Liquid Crystal Display: A liquid-crystal display (LCD) is a flat-panel display or another electronically modulated optical device that uses the light-modulating properties of liquid crystals. Liquid crystals do not emit light directly, instead of using a backlight or reflector to produce images in colour or monochrome. LCDs are available to display arbitrary images (as in a general-purpose computer display) or fixed images with low information content, which can be displayed or hidden, such as preset words, digits, and 7-segment displays, as in a digital clock. This is shown in Figure 3.4.



Figure 3.4: Liquid Crystal Display (LCD) (Dashdavaa *et al.*, 2026)

3.5 Circuit Design: this gives the process in which the circuit for the automatic coil winding machine was designed. A well-designed circuit was crucial for the machine's functionality and safety, as explained subsequently. The process involved integrating various components, including the Arduino Uno board, infrared sensor, motor speed controller, 12V DC motor, 12V relay, power supply, DC power jack, resistor, LCD, capacitor, 5V regulator, heat sink, switches, terminal blocks, PCB, sensor arm, transistor, and diode.

3.5.1 Power Supply: A suitable power supply was incorporated into the circuit to provide power to the entire system. It was capable of supplying the necessary voltage and current for all components.

3.5.2 Motor Control: The 12V DC motor was controlled using a motor speed controller and a relay. The motor speed controller allowed precise control of the winding process, while the relay provided an interface between the Arduino and the motor.

3.5.3 Sensor Integration: The infrared sensor was used to detect the position of the coil during winding. It sent signals to the Arduino to ensure precise winding control.

3.5.4 User Interface: The LCD and switches were integrated to create a user-friendly control interface. The LCD displayed relevant information, while the switches allowed the user to start, stop, and configure the winding process.

3.5.5 Voltage Regulation: A 5V regulator was used to ensure stable power for the Arduino and other sensitive components.

The circuit diagram for the implementation of the system is given in Figure 3.5.

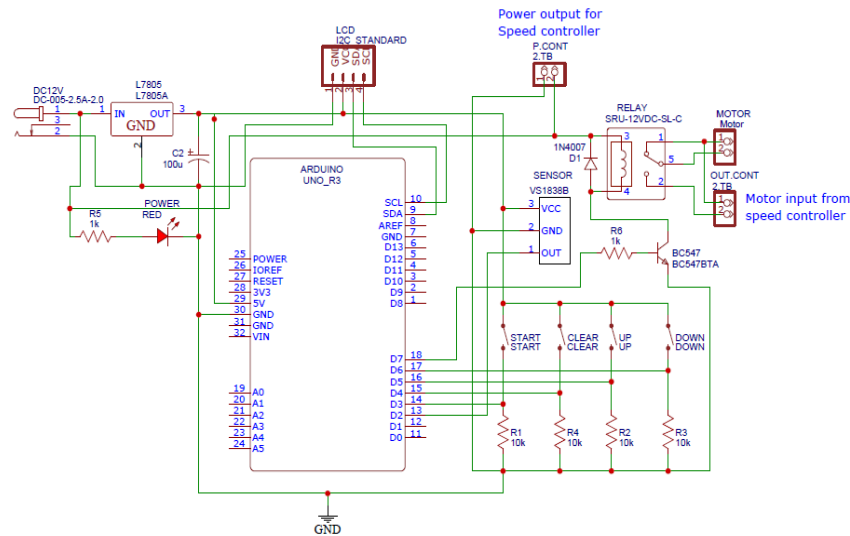


Figure 3.5: Circuit Diagram

Also, the flowchart used for the implementation of this article is given in Figure 3.6.

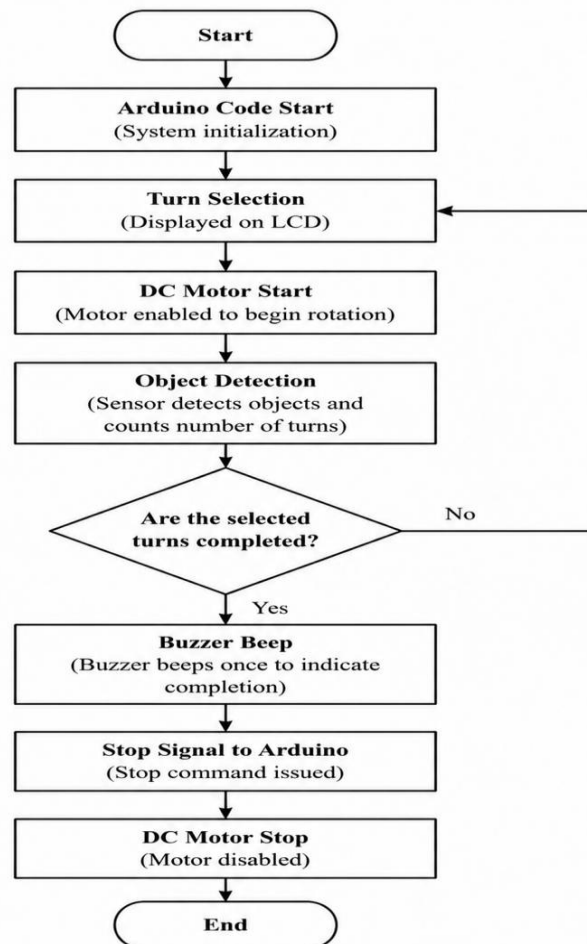


Figure 3.6: Flowchart of the Automatic Coil Winding Machine

However, the complete setup for the automatic coil winding machine is shown in Figure 3.7.

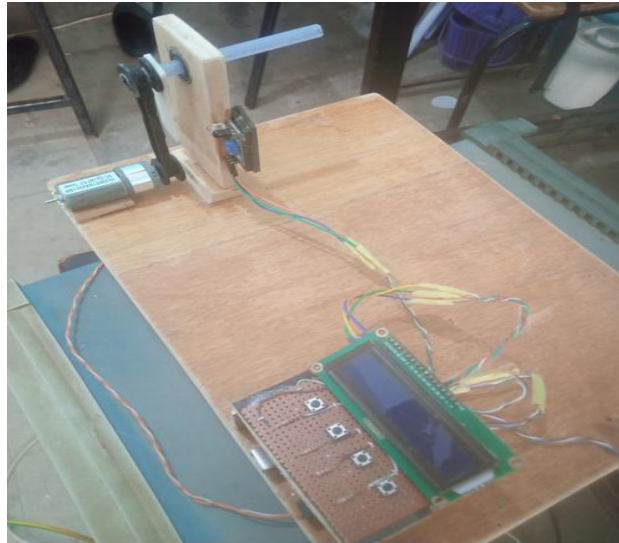


Figure 3.7: Complete Setup for the Automatic Coil Winding Machine

4 RESULTS AND DISCUSSION

This section discusses the results that was obtained in the development of the automatic coil winding machine. They are itemized into subsections.

4.1 Standby Mode

In a standby mode, denoted by a backlight indicated on LCD and the user get set to input the number of turns, the machine remains in a state of readiness as shown in figure 4.3. During this phase, the machine advanced sensor system operates continuously, actively monitoring its surroundings for any user interaction. This is shown in Figure 3.8.

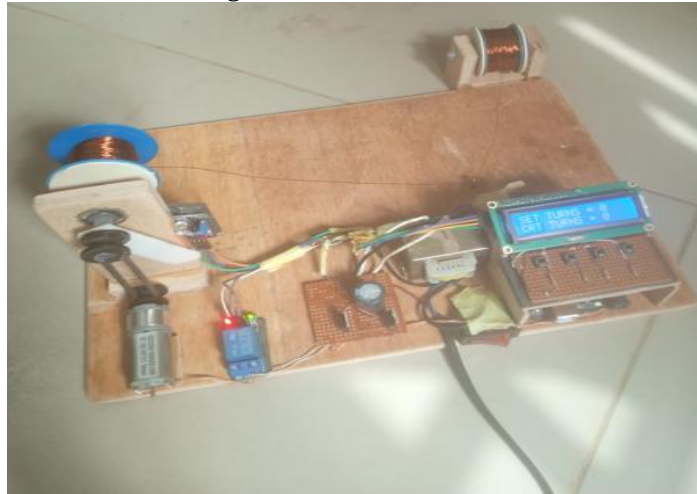


Figure 3.8: Prototype Working in Standby Mode

From Figure 3.8, which is the standby mode, the IR sensor stands prepared to detect the presence of a wire within its proximity. The standby mode serves as the default state, ensuring that the machine is primed for immediate use while conserving power when not in operation.

4.2 Counting Mode

Upon detecting the presence of a wire by IR sensor within its proximity range, the machine seamlessly transitions into the counting mode. The initiation of the counting mode is indicated by a

change in the number of turns displayed on the LCD when the presence of wire is sensed by IR sensor. Figure 4.4 shows the prototype operating before and after counting mode.

4.3 Performance and Accuracy Evaluation

The accuracy of the automated turn-counting system was evaluated by running experimental trials across set turn values (N_{target}) of 100, 250, 500, 1,000, and 3,000 turns. The actual turns wound on the former (N_{actual}) were counted manually and compared with the LCD counts registered by the optical IR sensor. This is given in Table 4.1

Table 4.1: Empirical Performance Data

Trial	Set Target Turns (N_{target})	Actual Wound Turns (N_{actual})	Turn Error (ΔN)	Accuracy (%)
1	100	98	2	98.0
2	250	244	6	97.6
3	500	481	19	96.2
4	1000	948	52	94.8
5	3000	2835	165	94.5
Mean				96.2

Percentage accuracy was derived using equation (4.1)

$$\text{Accuracy (\%)} = \left(1 - \frac{|N_{\text{target}} - N_{\text{actual}}|}{N_{\text{target}}} \right) \times 100 \quad (4.1)$$

As shown in Table 4.1, the machine achieved an average accuracy of 96.2%. Discrepancy between set and actual turns increased with target count due to mechanical inertia when the threshold N_{target} is met, the relay cuts power, but DC motor coasting causes minor overrun before reaching a full stop

5 CONCLUSION

This study presented the design and development of an Arduino-based automatic coil winding machine for improving the accuracy and efficiency of coil winding operations. The integration of the IR sensor, LCD, push buttons, and DC motor enabled automated turn counting, user input, and controlled winding of the coil. Experimental testing verified a mean turn-counting accuracy of 96.2% across target counts up to 3,000 turns. The prototype effectively eliminates common manual winding errors such as turn miscounts and uneven coil geometry, providing an efficient solution for instructional and small-scale production environments. The machine also reduces the time, physical effort, and errors associated with manual winding, particularly overwinding, inaccurate turn counting, and non-uniform winding. The developed system therefore provides a reliable, cost-effective, and efficient solution for small-scale coil winding and educational applications. Future improvements may focus on incorporating advanced speed control, enhanced sensing mechanisms, and wireless monitoring to further improve the performance and versatility of the system.

6. REFERENCES

Ajayi, A. O., Tochukwu, M. F. C., Emmanuel, A., & Jonah, K. (2025). Design and optimization of renewable energy-powered automation transformer coil winding machines. In: ResearchGate.

- Asari, A. R., Fotoni, M. A. A. S., & Guo, Y. (2025). Arduino-Based Coil Winding Machine. *Journal of Advanced Research Design*, 147(1), 87-93.
- Dashdavaa, E., Erdenebat, M.-U., Bayarsaikhan, E., Seo, J.-H., Kim, M.-S., Do, J., *et al.* (2026). Continuous eyebox expansion in holographic near-eye displays using a liquid crystal tunable active beam deflector. *Optics Lasers in Engineering*, 196, 109407.
- Ebuehi, A. A., Eric, G. O., & Akinloye, B. (2021). Design and fabrication of a portable automatic coil winding machine. *World Journal of Engineering*, 18(6), 851-860.
- Farnsworth, M., Tiwari, D., Zhang, Z., Jewell, G. W., & Tiwari, A. (2022). Augmented classification for electrical coil winding defects. *International Journal of Advanced Manufacturing Technology*, 119(11), 6949-6965.
- Ge, S.-C., Yang, R.-F., & Guo, C.-X. (2021). A highly integrated automatic fiber optical gyroscope sensing coil winding system. *International Journal of Control, Automation Systems*, 19(2), 1041-1053.
- Han, P., Wang, W., Li, Z., Zhang, W., & Pu, J. (2025). Research on unwinding mechanism design and tension control strategy for winding machines. *Processes*, 13(8), 2612.
- Hassanen, S. M., Seid Ahmed, Y., Al Momani, B., & Milani, A. (2026). A review of additive manufacturing techniques for wind turbine blade production: capabilities, AI integration, and Scale-Up Potential. *Frontiers in Mechanical Engineering*, 12, 1781579.
- Ilahi, N. A., Musyafiq, A. A., Rahmat, S., Dewi, R. P., & Purnata, H. (2023). Performance Process of Coil Winding Machine Based on Accuracy and Speed for Water Pump Motor. *Jurnal Nasional Teknik Elektro*, 13-19.
- Kepalas, A. (2024). *Automatic machine for induction coil production*. Kauno technologijos universitetas.,
- Korbu, R. D., Gatara, A. A., Nirwane, D. M., & Khot, A. A. (2021). Automatic Coil Winding Machine. *International Journal of Research in Engineering, Science and Management*, 4(9), 53-55.
- Kusnadi, H., & Amir, F. (2025). Innovative Automatic Winding for Transformers: An Efficient Solution for Modern Transformer Production. *ELECTRON Jurnal Ilmiah Teknik Elektro*, 6(1), 39-46.
- Malik, A. A., & Masood, T. (2026). Adaptive human–robot collaboration in wind turbine manufacturing using digital twins. *Scientific Reports*, 16(1), 11205.
- Ni, J. (2026). *Development of a Low-Power Indoor Inspection and Alert Robot Based on Multi-Modal Sensing*. Paper presented at the 2026 6th International Conference on Electronics, Circuits and Information Engineering (ECIE).
- Shafiq, M., Stewart, B. G., Hussain, G. A., Hassan, W., Choudhary, M., & Palo, I. (2022). Design and applications of Rogowski coil sensors for power system measurements: A review. *Measurement*, 203, 112014.
- Shenbagalakshmi, R., Mittal, S. K., Subramaniyan, J., Vengatesan, V., Manikandan, D., & Ramaswamy, K. (2025). Adaptive speed control of BLDC motors for enhanced electric vehicle performance using fuzzy logic. *Scientific Reports*, 15(1), 12579.
- Sun, K., Fan, C., Xu, J., Meng, L., & Yue, Y. (2026). Tension–speed control for transformer insulation-layer winding based on Hamiltonian theory. *Transactions of the Institute of Measurement Control Engineering Practice*, 01423312261424567.