International Journal of Engineering Research & Technology (IJERT)
ISSN: 2278-0181
Vol. 15 Issue 05 , May - 2026

# Design and Development of an Automated Precision Cable Cutting and Measurement System using ESP32

Pooja B. Kote[1]*, Amit K. Mali[2], Dipesh B. Pardeshi[3], Vikas C. Wable[4]

[1], [2]UG Students, Department of Electrical Engineering, Sanjivani College of Engineering, Singnapur, Maharashtra, India.

[3]Head of Department, Department of Electrical Engineering, Sanjivani College of Engineering, Singnapur, Maharashtra, India.

[4]Assistant Professor, Department of Electrical Engineering, Sanjivani College of Engineering, Singnapur, Maharashtra, India.

**Abstract - Measuring and cutting cables accurately and precisely is an important operation in the electrical and electronic manufacture industries where the manual method can cause a lack of consistency in cable length, material wastage and lower productivity levels. The design and development of an Automated Precision Cable Cutting and Measurement System with an embedded real-time microcontroller (ESP32) is presented. The system proposed comprises of IR sensor, DC motor, servo motor, keypad, LCD display, and motor driver, which were used for the automation of cable feeding, measurement and cutting process. In order to achieve a high level of measurement accuracy and a reliable real-time operation while moving the cables an interrupt-based pulse counting method was employed. The prototype is developed in such a way that the required length of cable and the number of pieces of cable can be input by the user via the keypad interface, and then the cutting operation is automatically carried out with only a little human operation. Different lengths of the cables were tested to assess the accuracy and performance of the system. The experimental results indicated that the system has a high measurement accuracy of 98.4%, and small absolute error and repeatable performance under different test conditions. The developed system is effective in reducing manual effort, minimum material wastage and increase in operational efficiency. But, some minor measurement differences were noticed with longer cable length, caused by mechanical slip and limitations in sensor alignment. The proposed system mainly has the advantage of its small size and low hardware investment, which can be applied in small-scale industrial production equipment and workshops, and is suitable for small-scale and medium-sized educational laboratories.**

**Keywords: Automation, Cable Cutting, Embedded System, ESP32, IR Sensor, Measurement System, Motor Control, Real-Time Monitoring, Servo Motor.**

## 1. INTRODUCTION

The use of industrial automation has become a vital component of modern manufacturing systems, as it offers enhanced productivity, accuracy, efficiency, and operational reliability. The use of automated systems is growing in industries to cut human effort, reduce errors and maintain product quality [1]. Among the important operations in the field of Electrical and Electronic industries, cable cutting and measurement of the length of cable plays a significant role in ensuring proper installation of a cable and its reliability in the system [2].

Electrical cables are used in a variety of applications including the production of electrical panels, wiring harnesses for the automotive industry, consumer electronics, telecommunications and industrial machinery. Small differences in cable length in these applications can lead to mis-connections or installation problems, leading to higher material losses and less efficiency in operation. Hence, it is vital to have precise measurement of the cable and cutting off to ensure the quality of the products and minimize production losses [3], [4].

Traditional methods of cable cutting are mostly done by hand using measuring tape and manually operated cutting devices [5]. These techniques depend heavily on the operator and his/her concentration and are therefore time-consuming and subject to human error [6]. Manual process may result in variation in cable length, operator fatigue, reduced productivity and high material waste [7]. While semi-automatic systems can increase the speed of operation, many of these systems still do not have proper real-time measurement and control systems [8]. Moreover, the automatic cable cutting machines which are commercially available are very costly and not applicable for the small scale industries and educational laboratories [9], [10].

In recent years, the miniaturization of embedded systems and sensor technologies have led to the creation of automation solutions that are compact, intelligent and cost effective. Industrial automation systems can be implemented using microcontrollers like ESP32, STM32, and Arduino with sensors and motor control systems, which are effective ways to achieve accurate and reliable automation systems [11], [12], [13]. Several researchers have reported that interrupt-based sensing methods, real-time pulse counting, and embedded feedback control significantly improve measurement precision, automation flexibility, and system responsiveness in cable processing and automated cutting applications [4], [14], [15].

This paper presents an Automated Precision Cable Cutting and Measurement System which is made by the usage of

International Journal of Engineering Research & Technology (IJERT)
ISSN: 2278-0181
Vol. 15 Issue 05 , May - 2026

microcontroller ESP32, IR sensor, DC motor, servo motor, LCD display and keypad. The system is set to automatically measure, feed and cut cables according to user-defined lengths. A pulse counting technique based on the interrupt method is employed to measure the length of the cable to an accuracy of 1 cm in real time, and the servo motor is used to carry out accurate cutting operation. The purpose of the proposed system is to minimize human error, minimize material wastage, enhance the productivity, and also give a cost-effective automation solution, suitable for the small scale industrial as well as educational applications.

## 2. LITERATURE REVIEW

With the development of the industrial automation and embedded systems, cable cutting and measuring systems have been developed to enhance the accuracy, productivity, and efficiency of operation. Various approaches have been investigated with different types of microcontrollers, PLCs, sensors, motor control techniques and real-time measurement systems for automated cable processing applications. There have been a few studies that have centered on the improvement of cable length measurement accuracy, material wastage, minimizing human intervention, as well as cutting accuracy using embedded automation and sensor-based control mechanisms. The following Table 2 summarizes some of the important research contributions for the study of automated cable cutting systems, embedded control techniques, real time sensing techniques and industrial automation applications.

Table 1 Summary of recent studies

| Sr. No. | Author & Year | Methodology / Technology Used | Key Findings | Limitations |
|---|---|---|---|---|
| 1 | Nisar et al., 2024[1] | Automation with stepper motor and cutting actuator instead of a microcontroller | Reduced material waste and human error with improved automation efficiency | Limited industrial-scale validation |
| 2 | Zhao et al., 2022[3] | Servo motor, encoder feedback, PID control | High precision cable processing and adaptive motor control | Expensive industrial implementation |
| 3 | Chen et al., 2024[4] | STM32 controller with embedded motor control | Improved automation and control precision | Complex system architecture |
| 4 | Zhong et al., 2023[16] | Cascade PID and fuzzy PID motor control | Enhanced stripping accuracy and adaptive control | High control complexity |
| 5 | Martin et al., 2021[17] | Laser-based direct cable length measurement | Improved cable length measurement accuracy | Higher implementation cost |
| 6 | Feng et al., 2023[18] | Infrared imaging and automated detection | Accurate non-contact cable monitoring and inspection | Focused on damage detection rather than cutting |
| 7 | Massa et al., 2024[19] | Vision-based quality inspection system | Improved real-time quality monitoring in cable manufacturing | High computational requirement |
| 8 | Wang et al., 2022[20] | Intelligent cutting automation technologies | Identified future trends in smart cutting systems | Generalized industrial cutting focus |
| 9 | Xing et al., 2024[21] | Embedded sensors and IoT monitoring | Cost-effective monitoring for SMEs | Limited to monitoring applications |
| 10 | Hsu et al., 2023[22] | Digital twin and adaptive manufacturing | improvement of process optimization and predictive analysis | Not specifically focused on cable cutting |

Although several automated cables cutting and processing systems have been developed using PLCs, embedded controllers, and sensor-based measurement techniques, many existing systems are either expensive industrial solutions or prototype-level models with limited flexibility and real-time accuracy. Most available systems lack a low-cost embedded architecture capable of performing accurate cable length measurement, interrupt-based real-time pulse counting, automated cutting control, and user-friendly operation within a compact system. In addition, limited studies have focused on integrating ESP32-based control, IR sensor feedback, motor synchronization, and precise servo-actuated cutting into a single economical platform suitable for small-scale industries and educational applications. Therefore, there is a need to develop a cost-effective, accurate, and reliable automated precision cable cutting and measurement system that minimizes human error, reduces material wastage, and improves productivity through real-time embedded automation.

International Journal of Engineering Research & Technology (IJERT)
ISSN: 2278-0181
Vol. 15 Issue 05 , May - 2026

## 3. METHODOLOGY

The methodology of the proposed system focuses on automating cable feeding, measurement, and cutting operations using embedded control and real-time sensing techniques. The integration of ESP32, IR sensor, and motor control mechanisms ensures accurate cable length measurement and precise cutting operation with minimal human intervention.

1. The proposed system is based on embedded automation, real-time sensing, and motor control using ESP32, IR sensor, DC motor, servo motor, keypad, LCD display, and motor driver for automated cable feeding, measurement, and cutting operations.
2. The user enters the required cable length through the keypad, which is processed by the ESP32 and displayed on the LCD for confirmation. The ESP32 then activates the DC motor to feed the cable at a controlled speed.
3. During cable movement, the IR sensor generates pulses corresponding to cable displacement. These pulses are counted using interrupt-based programming and converted into actual cable length using a calibration factor.
4. The measured cable length is continuously compared with the target length. Once the required length is reached, the ESP32 stops the DC motor and activates the servo motor to perform the cutting operation.
5. After cutting, the servo motor returns to its initial position and the system resets automatically for the next cycle, ensuring accurate measurement, reduced material wastage, reliable operation, and improved productivity.

## 4. HARDWARE COMPONENTS

The proposed Automated Precision Cable Cutting and Measurement System consists of various hardware components integrated to perform automated cable feeding, measurement, and cutting operations efficiently. Each component plays an important role in ensuring accurate measurement, reliable control, and smooth system operation.

**ESP32 Microcontroller:**

ESP32 acts as the main control unit of the system. It processes user inputs, controls motor operations, counts sensor pulses, and manages the overall automation process.

**IR Sensor:**

The IR sensor is used to detect rotational movement and generate pulses corresponding to cable displacement for accurate cable length measurement.

**DC Motor:**

The DC motor is used for cable feeding operation. It moves the cable at a controlled speed during the measurement process.

**Servo Motor:**

The servo motor performs the cable cutting operation by actuating the cutting mechanism precisely when the required cable length is achieved.

**Motor Driver:**

The motor driver is used to control the speed and direction of the DC motor based on signals received from the ESP32 microcontroller.

**Keypad:**

The keypad allows the user to enter the desired cable length into the system.

**LCD Display:**

The LCD display is used to show user inputs, measured cable length, and system status during operation.

**Power Supply Unit:**

The power supply unit provides the required operating voltage and ensures stable power distribution to all system components.

## 5. SOFTWARE IMPLEMENTATION

The software implementation of the proposed system is developed using embedded programming techniques to achieve accurate cable measurement, motor control, and automated cutting operation. The ESP32 microcontroller is programmed to process sensor inputs, control motors, and manage the complete working sequence of the system.

**Arduino IDE: -** The Arduino IDE is used as the programming platform for writing, compiling, and uploading the program to the ESP32 microcontroller. It provides a simple and efficient environment for embedded system development.

**Embedded C Programming: -** The system software is developed using Embedded C language. The program controls user input processing, sensor interfacing, motor operation, LCD display functions, and automated cutting sequences.

**Interrupt-Based Pulse Counting: -** Interrupt-based programming is used to count pulses generated by the IR sensor during cable movement. This method improves real-time measurement accuracy and prevents pulse loss at higher operating speeds.

**Motor Control Logic: -** The motor control algorithm manages the operation of the DC motor and servo motor. The DC motor controls cable feeding, while the servo motor performs the cutting operation once the target cable length is reached.

## 6. EXPERIMENTAL SETUP

**International Journal of Engineering Research & Technology (IJERT)**
**ISSN: 2278-0181**
**Vol. 15 Issue 05 , May - 2026**

The experimental setup has been designed to test the performance, accuracy, reliability of the proposed Automated Precision Cable Cutting and Measurement System. The hardware setup of the prototype model was an ESP32 microcontroller, IR sensor, DC motor with motor driver, servo motor with cutting mechanism, keypad, LCD display, and power supply.

**Prototype setup:** The entire setup was created with a cable feeding mechanism powered by a DC motor and the servo motor was attached with the cutting mechanism. The IR sensor was placed close to the measurement wheel to detect the pulses when the cable moves to obtain the length measurement in real time. All sensing, measurement and cutting operations were controlled by the ESP32.

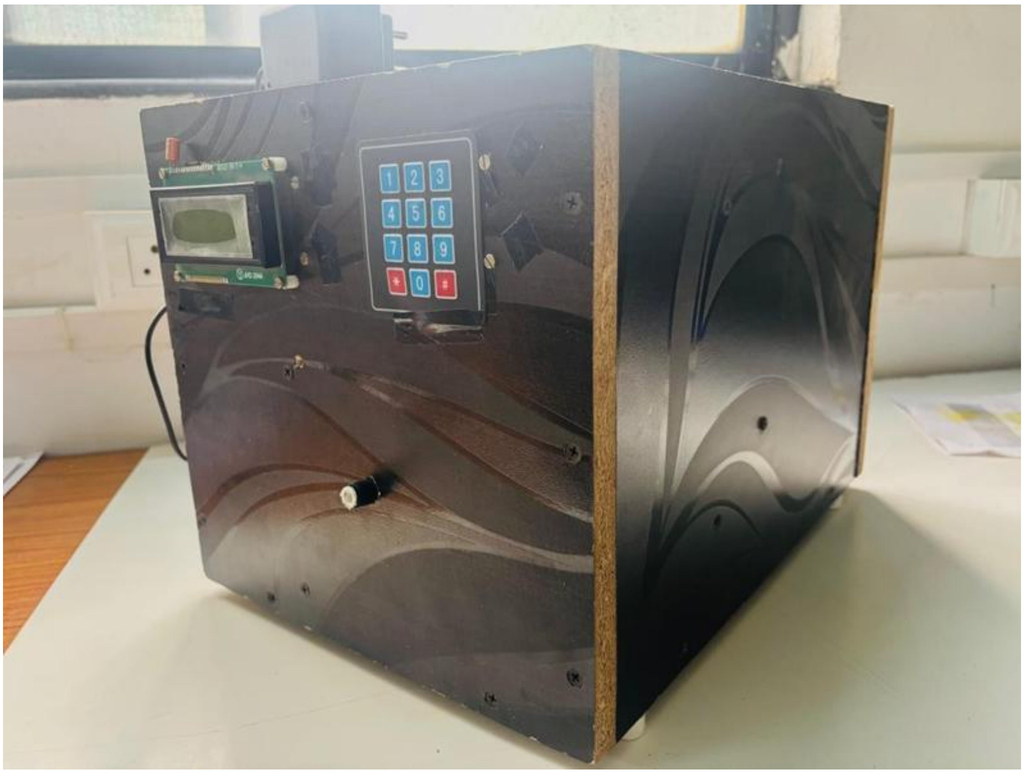

**Fig. 1 Project Model**

**Testing Conditions: -** The experimental trials were performed multiple times in the laboratory conditions to analyse the accuracy and repeatability of the system, the motor response and overall operational performance of the system. The cable lengths were entered via keypad on the machine, and the length of the tested cables were compared with the actual length of the cable which was cut after calibration.

**Experimental Cables: -** There were standard electrical insulated cables of different predefined lengths used during experimentation. It has been validated concerning the smooth feeding of the cable, the exactness of the cable pulses, and the cutting accuracy when the system is kept running.

## 7. RESULTS AND DISCUSSION

### 7.1 Calibration Results of Automated Cable Cutting System

The Automation Precision Cable Cutting & Measurement System was tested for performance with various cable lengths that had been pre-programmed in the system in a controlled laboratory setup. The system automatically measured and cut the cable according to the preset length and number of pieces of the user-defined cable. The study on the experimental analysis was carried out to validate the effectiveness of the developed system which were related to the measurement accuracy and absolute error. Table 2 shows the final results.

Table 2 Calibration Table

| Length Input [cm] | Number of Pieces | Measured Accuracy [%] | Absolute Error [cm] |
|---|---|---|---|
| 5 | 10 | 98.4 | 0.08 |
| 8 | 15 | 98.1 | 0.15 |
| 10 | 20 | 98.0 | 0.2 |
| 12 | 25 | 97.8 | 0.26 |
| 15 | 30 | 97.5 | 0.38 |
| 20 | 40 | 96.9 | 0.62 |

International Journal of Engineering Research & Technology (IJERT)
ISSN: 2278-0181
Vol. 15 Issue 05 , May - 2026

| | | | |
|---|---|---|---|
| 30 | 50 | 96.2 | 1.14 |

The experimental results showed that the developed system rendered high measurement accuracy for all the testing conditions. The system performed well for shorter cable lengths (from 5 to 12 cm) resulting in high levels of accuracy (more than 97.8%) and very low absolute error values. For increasing lengths of cable, a slight increase in the absolute error was noticed which was attributed to some cable slippage, and also to some cumulative variations in the pulse counts during cable feeding. The system showed accuracy of 97.5%, 96.9%, and 96.2% for 15, 20, and 30 cm lengths of the cable, respectively. As the length of the cable increased the absolute error slowly grew but remained near the desired values of the input, indicating reliable and repeatable system performance.

### 7.2 Calibration and Error Analysis of Automated Cable Cutting System

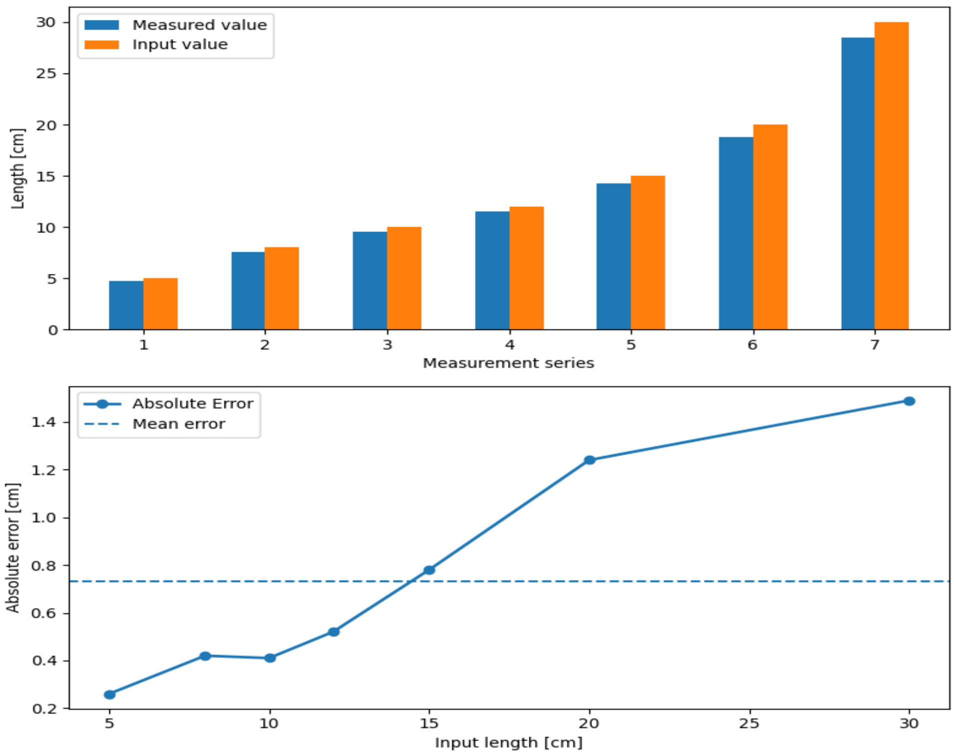


Fig 2 Calibration and Error Analysis

The output lengths of the cables and output lengths of the measured cables obtained from the developed system is shown in Fig.2. It is observed that during all the experimental trials, the measured values are very close to the desired input values and hence the proposed measurement technique is accurate. The bottom plot shows how the absolute error changes as a function of the length of the input cable. As the cable length increases the error is seen to increase slightly, which is attributable to mechanical slippage and variations in sensor alignment. The mean error, however, remains relatively small, confirming the good performance of interrupt-based pulse counting and real-time embedded control achieved with the ESP32 microcontroller.

## 8. CONCLUSION

In the present study, an Automated Precision Cable Cutting and Measurement System is successfully developed and implemented using an ESP32 microcontroller, IR sensor, DC motor, servomotor, keypad and LCD display. This proposed system was able to perform the process of cable feeding, measurement and cutting automatically by adopting interrupt-based pulse counting and real time embedded control techniques. Experimental results showed that the system has high accuracy and low absolute error, and the measurement results were repeatable and stable for different lengths of the cable. The conventional cable cutting process is greatly improved by the manual effort, material wastage and human error reduced by the developed system. Using sensor-based measurement and automatic motor control ensured the operation is more efficient, precision, and productivity. The system also offers a low cost, compact automation solution for small scale industries, workshops and educational laboratories. But there are some drawbacks to the existing system. Some small inaccuracies in measurement could be caused by mechanical slippage, sensor alignment and cable thickness changed during

International Journal of Engineering Research & Technology (IJERT)
ISSN: 2278-0181
Vol. 15 Issue 05 , May - 2026

measurement. Furthermore, the prototype is primarily intended for low and medium-rated insulated electrical cables and might need to be mechanically strengthened for heavy industrial applications and high-speed cable processing.

## REFERENCE

[1] M. D. Nisar, A. Waleed, M. Basit, M. A. Ahmad, M. Shahid, and S. M. S. Haider, "Innovative Wire Cutting Automation: Reducing Material Waste and Human Error," in *2024 3rd International Conference on Emerging Trends in Electrical, Control, and Telecommunication Engineering (ETECTE)*, IEEE, Nov. 2024, pp. 1–6. doi: 10.1109/ETECTE63967.2024.10823712.

[2] S. Pawar, "Automatic Wire Cutting Machine," *Indian Sci. J. Res. Eng. Manag. ,2025.*, vol. 09, no. 01, pp. 1–9, Jan. 2025, doi: 10.55041/IJSREM40803.

[3] Y. Zhao and W. Ma, "Research and Application of Intelligent Integrated Equipment for Cable Processing in Distribution Network Engineering," in *Proceedings of the 7th International Conference on Cyber Security and Information Engineering*, New York, NY, USA: ACM, Sep. 2022, pp. 126–133. doi: 10.1145/3558819.3558841.

[4] H. Chen, H. Liu, X. Mu, and C. Wang, "Design of electrical cabinet wire cutting machine based on STM32," *J. Phys. Conf. Ser.*, vol. 2797, no. 1, p. 012040, Jul. 2024, doi: 10.1088/1742-6596/2797/1/012040.

[5] D. G. Gahane, P. Katole, P. Naidu, R. Dhoke, and S. Kore, "AUTOMATIC PIPE-WIRE CUTTING MACHINE," *Int. J. Eng. Appl. Sci. Technol.*, vol. 5, no. 1, pp. 454–456, May 2020, doi: 10.33564/IJEAST.2020.v05i01.078.

[6] M. A. Abdullah, S. MAT, S. A. SHAMSUDIN, and F. R. RAMLI, "SMART WIRE CUTTER MECHANISM," *J. Mech. Eng. Technol.*, vol. 17, no. 1, pp. 21–38, Sep. 2025, doi: 10.54554/jmet.2025.17.01.002.

[7] D. Figueiredo, F. J. G. Silva, R. D. S. G. Campilho, A. Silva, C. Pimentel, and J. C. O. Matias, "A new concept of automated manufacturing process for wire rope terminals," *Procedia Manuf.*, vol. 51, pp. 431–437, 2020, doi: 10.1016/j.promfg.2020.10.061.

[8] V. F. C. Sousa, F. J. G. da Silva, R. D. S. G. Campilho, A. G. Pinto, L. P. Ferreira, and N. Martins, "Developing a Novel Fully Automated Concept to Produce Bowden Cables for the Automotive Industry," *Machines*, vol. 10, no. 5, p. 290, Apr. 2022, doi: 10.3390/machines10050290.

[9] N. Martins, F. J. G. Silva, R. D. S. G. Campilho, and L. P. Ferreira, "A novel concept of Bowden cables flexible and full-automated manufacturing process improving quality and productivity," *Procedia Manuf.*, vol. 51, pp. 438–445, 2020, doi: 10.1016/j.promfg.2020.10.062.

[10] E. Eiras, F. J. G. Silva, R. D. S. G. Campilho, R. C. M. Sales-Contini, A. F. V. Pedroso, and N. P. V. Sebbe, "A Novel Fully Automatic Concept to Produce First Subset of Bowden Cables, Improving Productivity, Flexibility, and Safety," *Machines*, vol. 11, no. 11, p. 992, Oct. 2023, doi: 10.3390/machines11110992.

[11] N. Almtireen, Z. Ateh, M. Eltallaa, Y. Alhendawy, M. Ryalat, and H. Elmoaqet, "Real Time Infrared Distance Sensor for Cyber Physical Systems Using Arduino-LabVIEW Integration," in *2025 International Conference on Communication, Computing, Networking, and Control in Cyber-Physical Systems (CCNCPS)*, IEEE, Jun. 2025, pp. 31–36. doi: 10.1109/CCNCPS66785.2025.11135902.

[12] Z. Zhu and X. Cao, "Research on the Automatic Stripping Technology of Cable Sheath and Shield Layer Assisted by Multi-Sensor System," *J. Eng. Syst.*, vol. 2, no. 4, pp. 62–65, Dec. 2024, doi: 10.62517/jes.202402410.

[13] G. Liang *et al.*, "Control System of Bamboo Splitting Machine Based on STM32 and HMI," in *2024 IEEE 3rd International Conference on Electrical Engineering, Big Data and Algorithms (EEBDA)*, IEEE, Feb. 2024, pp. 30–36. doi: 10.1109/EEBDA60612.2024.10485741.

[14] R. Chen, "Design and Implementation of an Adaptive Embedded System with Real-Time Feedback Control and Intelligent Calibration," in *2025 International Conference on Communication, Computer, and Information Technology (IC3IT)*, IEEE, Oct. 2025, pp. 1–6. doi: 10.1109/IC3IT66137.2025.11341165.

[15] H. Prayogo and R. Hartayu, "Design and control of an automatic cable-cutting machine with the implementation of a stepper control program using PLC," *Gema Wiralodra*, vol. 14, no. 3, pp. 1281–1291, Oct. 2023, doi: 10.31943/gw.v14i3.498.

[16] J. Zhong, W. Ai, Z. Wang, S. Hu, and H. Zhang, "A Novel High-Voltage-Cable Stripping Robot," *Actuators*, vol. 12, no. 5, p. 201, May 2023, doi: 10.3390/act12050201.

[17] C. Martin, M. Fabritius, J. T. Stoll, and A. Pott, "A Laser-Based Direct Cable Length Measurement Sensor for CDPRs," *Robotics*, vol. 10, no. 2, p. 60, Apr. 2021, doi: 10.3390/robotics10020060.

[18] J. Feng, J. Li, K. Gao, G. Wu, J. Tian, and Y. Zou, "Portable automatic detection system with infrared imaging for measuring steel wires corrosion damage," *Autom. Constr.*, vol. 156, p. 105150, Dec. 2023, doi: 10.1016/j.autcon.2023.105150.

[19] L. M. Massa, B. G. Ferreira, and T. F. Vieira, "Real-Time Visual Quality Inspection System for Automotive Cable Manufacturing," in *Anais Estendidos do XIV Simpósio Brasileiro de Engenharia de Sistemas Computacionais (SBESC 2024)*, Sociedade Brasileira de Computação - SBC, Nov. 2024, pp. 21–24. doi: 10.5753/sbesc_estendido.2024.243634.

[20] Y. Wang, Y. Zhang, D. Tan, and Y. Zhang, "Key Technologies and Development Trends in Advanced Intelligent Sawing Equipments," *Chinese J. Mech. Eng.*, vol. 34, no. 1, p. 30, Dec. 2021, doi: 10.1186/s10033-021-00547-6.

[21] K. Xing, X. Liu, Z. Liu, J. R. R. Mayer, and S. Achiche, "Low-Cost Precision Monitoring System of Machine Tools for SMEs," *Procedia CIRP*, vol. 96, pp. 347–352, 2021, doi: 10.1016/j.procir.2021.01.098.

[22] C.-H. Hsu, G.-J. Su, W.-L. Li, and H.-C. Yang, "A Digital Twin Trinity for Adaptive Evaluation of Machining Process," in *2025 IEEE 21st International Conference on Automation Science and Engineering (CASE)*, IEEE, Aug. 2025, pp. 1662–1668. doi: 10.1109/CASE58245.2025.11163758.