PLC-Based Automatic Study Chair and Desk System Using Proximity Sensors

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Abstract

Many current chairs and study desks often do not meet the ergonomic needs of users, leading to significant physical discomfort and a decrease in productivity. This can cause issues like muscle tension in the neck, shoulders, and back, which ultimately impair concentration. To solve this, an adaptive automation system is proposed. This system is designed to intelligently adjust the height and distance of a chair and desk automatically. The core mechanism uses proximity sensors and a PLC (Programmable Logic Controller). Proximity sensors detect the user's presence and measure their body dimensions in real-time. This data is then processed by the PLC, which instantly calculates and implements the optimal ergonomic position. This innovative system provides a personalized solution, aiming to minimize physical fatigue, save manual adjustment time, and significantly boost user comfort and productivity. The device can serve as an effective tool for creating a healthier and more efficient learning or working environment.

Keywords : plc,proximity sensor,ergonomics,automatic desc,smart furnitur

INTRODUCTION

Modern work and study environments frequently present ergonomic challenges, as traditional furniture is not designed to adapt to individual user needs. This mismatch often leads to significant physical discomfort, including muscle tension in the neck, shoulders, and back, which negatively impacts concentration and overall productivity [1], [2]. The need for dynamic and adaptable furniture solutions is becoming increasingly crucial to support a healthier and more efficient working or learning environment.

Previous studies have explored automated furniture design, often focusing on simple height adjustments or using complex, expensive sensors. For instance, research by [3] investigated a system using ultrasonic sensors, while another study [4] explored a chair system with pneumatic actuators. However, these systems often lack the precision and real-time adaptability needed to create a truly ergonomic experience based on individual body dimensions.

This research addresses these limitations by proposing a novel, adaptive automation system for a study chair and desk. Our system integrates proximity sensors with a PLC (Programmable Logic Controller) to intelligently and automatically adjust the furniture's height and distance. The use of a PLC as the central control unit ensures robust and reliable operation, making the system suitable for long-term use in various settings. Unlike previous designs that rely on manual presets or less precise sensors, our system offers a personalized, real-time solution that significantly enhances user comfort and productivity.

METHOD

This section describes the experimental method focused on the design and implementation of the automatic study chair and desk system. Data collection was performed through direct testing of the prototype to validate its functionality and performance.

System and desain components

The study desk prototype was constructed from holong iron for its frame and a plywood tabletop for a durable, stable surface. The hardware components of the system include:

PLC (Programmable Logic Controller): A PLC Outseal V.2 was selected to act as the central control unit due to its compact size and efficiency.

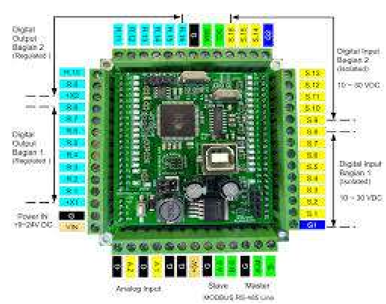


Figure 2.1.1 Outseal Plc

Proximity Sensors (Infrared Type E18-D80NK): These sensors were used to detect the user's presence and position without physical contact. Their operation relies on transmitting and receiving infrared light to determine the presence of an object [11].

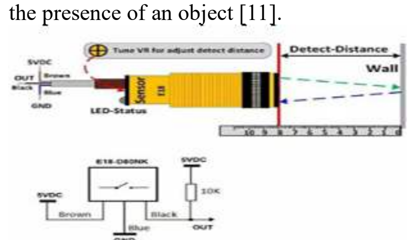
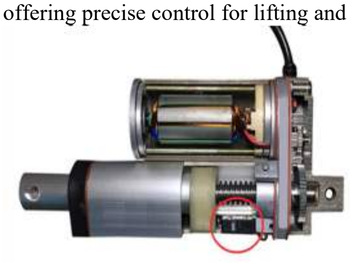


Figure 2.1.2 Proximity Sensor

Actuators: Linear actuators and a power window motor were implemented as the primary drive systems to adjust the height and position of the chair and desk. Linear actuators convert rotational motion into linear motion, offering precise control for lifting and positioning [12].



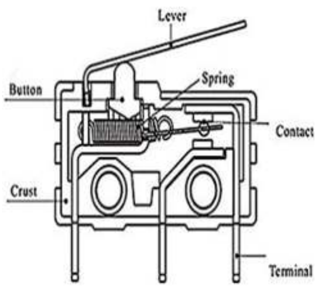
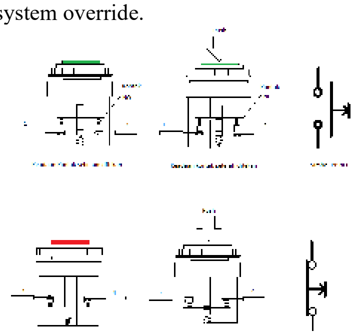


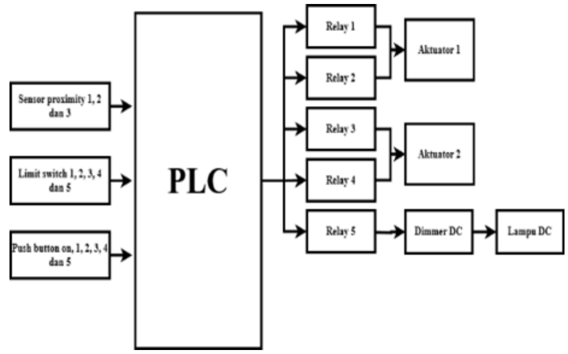
Figure 2.1.3 Limit Switches: These sensors act as safety features, detecting when a component has reached its maximum or minimum limit to prevent damage to the system [10].

5. Light and Push Buttons: A

LED light was included for adjustable illumination, and five push buttons were installed for manual control and system override.



2.2 System Diagram :
The system is controlled by a PLC, which manages 13 inputs (three proximity sensors, five limit switches, and five push buttons) and seven relay outputs to drive various components. Proximity sensors and limit switches work together to ensure accurate and safe automatic chair and desk movement, while push buttons allow for manual user control. The entire system is designed to create an optimal, safe, and efficient study environment using PLC and proximity sensor technology.



3. RESULTS AND DISCUSSION (Bold, 11pt)

This section presents the results of the system's development and testing, followed by an in-depth discussion and analysis
3.1 System Implementation
The prototype of the automated chair and desk system was successfully constructed. The Outsel Plc V.2 was integrated as the core control unit, effectively managing the data input from the proximity sensors and controlling the actuators. The system's functionality was validated through a series of tests, confirming its ability to detect the user's presence and automatically adjust the furniture's position.

3.2 Performance and Analysis
The system's performance was evaluated based on its accuracy in ergonomic adjustments and its response time.
Table I Linear actuator test(Forward- Backward movement)

No	Berat beban	Voltase		Ampere	
		Maju	Mundur	Maju	Mundur
1	54kg	12VDC	12VDC	0,63A	0,61A
2	46kg	12VDC	12VDC	0,66A	0,56A
3	42kg	12VDC	12VDC	0,69A	0,67A
4	40kg	12VDC	12VDC	0,76A	0,69A

Based on the test results in Table I, the motor's current consumption for linear actuator movement is influenced by the load being lifted. For forward movement, the required current increases as the load decreases (e.g., from 0.63 A at a 54 kg load to 0.76 A at a 40 kg load). Conversely, for backward movement, the current consumption pattern does not show a direct correlation with the load weight. These results indicate that the system has specific power consumption characteristics for each direction of movement.

Table II Linear actuator test (Up-Down Movement)

No	Berat beban	Voltase		Ampere	
		Naik	Turun	Naik	Turun
1	54kg	12VDC	12 VDC	2,80 A	0,64 A
2	46kg	12VDC	12VDC	2,7A	0,60 A
3	42kg	12VDC	12VDC	2,3A	0,56 A

4	40kg	12VDC	12VDC	1,82 A	0,52 A

No.	Komponen	Jumlah	Tegangan (V)	Daya (W)	Arus (A)
1	PLC	1 unit	12	1.2	0.1
2	Sensor Proximity	2 unit	5	0.8	0.08
3	Lampu	1 unit	12	10	0.83
4	Motor Power Window	1 unit	12	-	15
5	Linear Aktuator	2 unit	12	45	3.75
	Total Daya Sistem			282	

As shown in Table II, the test results for the linear actuator's up and down movements show a clear correlation between the load and current consumption. For upward movement, the lighter the load, the lower the required current. For example, a 54 kg load requires 2.80 A, while a 40 kg lod only needs 1.82 A. Similarly, for downward movement, curent consumption also decreases with a reduction in load, ndicating that the actuator works more efficiently when supporting a lighter load.

Table III Motor power window test (left-right Movement)

No	Berat beban	Voltase		Ampere	
		kanan	kiri	kanan	kiri
1	54kg	12VDC	12VDC	15,03A	15,09A
2	46kg	12VDC	12VDC	15,05A	14,73A
3	42kg	12VDC	12VDC	14,46A	13,60A
4	40kg	12VDC	12VDC	14,32A	13,20A

The test results in Table III show that the current consumption for the chair's left and right rotation is influenced by the load weight. For right-side rotation, the required current decreases from 15.03 A to 14.32 A as the load decreases from 54 kg to 40 kg. A similar pattern is observed for left-side rotation, where the current decreases from 15.09 A to 13.20 A with the decrease in load. This indicates that the motor works more efficiently when rotating a lighter load.

Table IV Dimmer Test

No	Kecahayaan lampu	Arus (Ampere)	Tegangan (VDC)
1	Redup	0,015	12
2	Medium	0,198	12
3	Terang	0,349	12

The dimmer test results in Table IV show a direct relationship between electrical current consumption and light brightness. The light intensity is proportionally dependent on the amount of current flowing. This finding proves the effectiveness of the dimmer system in controlling light intensity by varying the current supplied to the lamp.

Table V Overal System Power Comsumption

Based on the component specifications and power measurement results in Table V, the system is designed to operate with a total measured power consumption of 282 W. A detailed analysis shows that the Linear Actuators and Power Window Motor are the most significant contributors to the overall power load. This validates that the selection and integration of components have been optimized to achieve the intended system functionality.

CONCLUSION AND SUGGESTIONS

The “PLC Based Automatic Study Chair and Desk System Using Proximity Sensors” has been successfully implemented and tested. The main conclusions from this research are:

The prototype was successfully built in accordance with the specified design, and its key functions, such as automated movement and energy efficiency features, were validated through testing.

The test results on the linear actuators and power window motor confirm a direct correlation between the load and current consumption for most movements, indicating the system's ability to efficiently handle varying user weights.

The dimmer system effectively controls light intensity by modulating the supplied current, proving the functionality and efficiency of the lighting control.

The overall system power consumption of 282 W is primarily driven by the linear actuators and power window motor, which is a reasonable value for the mechanical functions performed.

This study has successfully demonstrated the feasibility and effectiveness of an automated, ergonomic study desk. However, there are some areas that can be improved in future research.

Suggestions for Further Research:

Conduct long-term durability tests to evaluate the performance and lifespan of the mechanical components under continuous use.

Explore the integration of a user-specific profile system to store and recall preferred ergonomic settings for different users.

Investigate the use of alternative materials for the desk frame and surface to reduce the overall weight and improve aesthetics.

Develop a mobile application to allow for remote control, real-time monitoring of power consumption, and customizable settings.

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