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# DEVELOPMENT AND TESTING OF A SMART MODULAR ERGONOMIC DESK WITH ELECTRIC ADJUSTABILITY

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**Abstract:** *This paper presents the design, development, and implementation of a functional prototype for a smart modular ergonomic desk. The primary goal of the project was to create a system that ensures user comfort, adaptability, and improved productivity by focusing on ergonomics and advanced control mechanisms. Building on the findings and concepts established in the first part of the study, this second and final phase focuses on the practical realization of the proposed systems and demonstrates their proof of concept. The desk incorporates electrically adjustable features such as height modification, monitor positioning, and motion systems for user-specific customization. These adjustments aim to promote proper posture and cater to diverse user requirements.*
*The prototype integrates cutting-edge technologies, including microcontroller-based control systems (ESP32 and Arduino NANO), to enable precise motion control and user interaction through a control panel and a digital display. The paper also discusses the design of electrical and mechanical subsystems, as well as the challenges faced and improvements implemented during the development process. Future enhancements, such as smart home connectivity and aesthetic upgrades, are outlined to broaden the desk's functionality and user appeal. This work concludes with the validation of the prototype and its potential applications in both personal and professional environments.*

**Key words:** Smart-Desk, Health, Productivity.

## 1. INTRODUCTION

The present work, titled "Design and Implementation of a Modular Ergonomic Desk with Electric Adjustment," aimed to create a desk that seamlessly combines functionality, comfort, and the specific needs of users. The primary objective was to design a system that ensures proper and healthy posture by addressing key ergonomic principles. This includes adjustable height and monitor positioning to promote correct leg and neck placement for individuals, accommodating a wide range of user needs and preferences [1, 13].

The project draws inspiration from advancements in smart home and workplace technologies, as highlighted in the literature. For instance, studies like those by Mashal et al. emphasize the increasing acceptance of interconnected devices in everyday environments, which opens the door to ergonomic desks that integrate seamlessly into smart ecosystems [1]. Additionally, research shows that posture changes, facilitated by adjustable desks, significantly improve worker productivity and comfort while reducing health risks associated with prolonged sedentary behavior [4, 5, 6].

Foundational work, such as El Murr's exploration of smart desk designs, highlights the critical role of combining mechanical adjustability with advanced control systems. Innovations in stepper motor position control, as described by Parmar et al., have provided key insights into achieving precise motion adjustments necessary for ergonomic functionality [2, 3]. These technologies inspired the modular and adaptable design of the current project.

Ergonomic principles and user needs were further informed by studies on height-adjustable desks and anthropometric design considerations. Lin et al. propose that modular and scalable designs not only ensure comfort but also enhance usability across diverse user demographics [7, 8, 11]. Similarly, Serratos-Perez and Qutubuddin et al. stress the importance of tailoring workstation designs to accommodate a wide range of physical characteristics, ensuring inclusivity and effectiveness [10, 13].

Finally, efforts to integrate aesthetic and functional enhancements, such as those proposed by Vandoorne-Feys et al., inspired future-oriented features of this desk, including potential smart home connectivity and aesthetic upgrades [8, 9]. The convergence of these insights led to the development of a versatile and efficient desk prototype, setting a foundation for further innovations in ergonomic workspace design.

## 2. ELECTRICAL DIAGRAMS

To simplify the working domain, a base board was created to connect all the electrical components in the system. Additionally, for each motor, this board is equipped with fuses to prevent the risk of circuit overload.

The electrical diagram in Figure 1 highlights how the first type of control and command system works. In this case, an ESP32 is used, which has two roles: the first role is as a master, facilitating communication and control between the secondary systems and itself. The second role is to control adjustable motion systems. Furthermore, this ESP is also responsible for the digital display. [2]

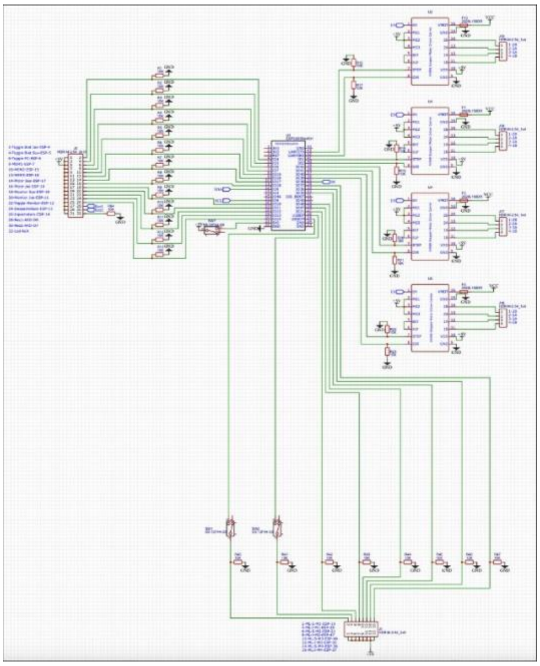

Figure 1: ESP electrical diagram

The secondary systems are made up of Arduino NANO development boards [2]. These act as slaves and are directly controlled by the ESP. These systems interpret and analyze the state of the motion system and send the data to the ESP. The Arduino systems are responsible for controlling the movement of binary motion systems (either extended or retracted, with no ability to control height).

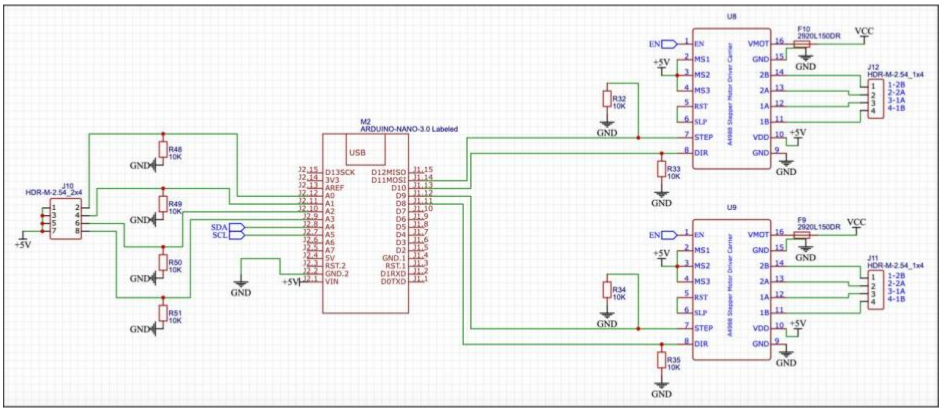


Figure 2: Arduino NANO electrical diagram

After developing these concepts, they were implemented on a base board. This board was populated with components and integrated into the functional system as follows:

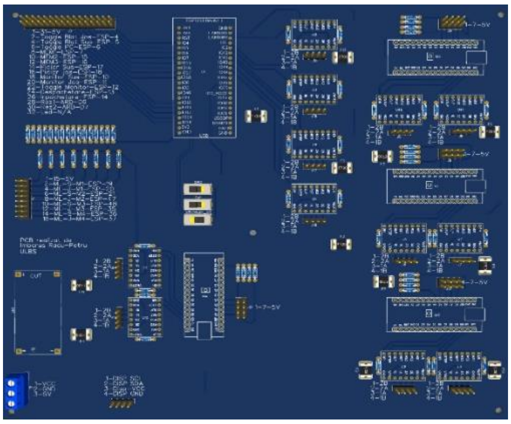

Figure 3: 3D model of the PCB

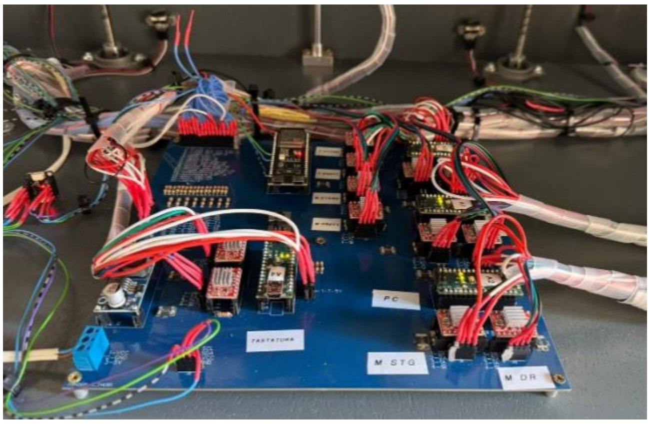

Figure 4: PCB layout and wiring

## 3. EXPERIMENTAL PART

### 3.1. Functional prototype of the tabletop motion systems

The lower tabletop is designed to support the keyboard and mouse, while the upper one is designed as a cover to fill the empty space when the keyboard is extended. The way these move forward and backward is due to the nuts attached via a support. The nuts are pressed into the supports, which are attached to extensions designed in the construction of the tabletops for mounting the ball-bearing slides. Thus, when the T8 threaded rod rotates, it propels the nut forward and backward. The threaded rod is connected to the motor via a flexible coupling, and on the other side, there is a support with a blind hole. On both sides of the rod, microswitches are attached to limit the travel.

Figure 3: Tabletop motion systems

### 3.2. Functional prototype of the leg lifting system

Using the same principle as the tabletops, the nuts were pressed into the leg support, and in this case, a linear guide is also required on each. The T8 threaded rod was connected to the motor in the same way as with the tabletops and operates on the same principle. Microswitches were attached to the upper and lower parts of the rod to limit the travel. On the lower part of the rod, two bearings were mounted, within which a shaft support made of aluminum is located.

Figure 4: Leg lifting system

### 3.3. Functional prototype of the monitor lifting system

In the case of this system, to achieve the proper height for a user, it was necessary to create two stages of elevation. The first stage is facilitated only by the ability to be raised or lowered to the maximum, while the second can be adjusted according to the user's preferences.

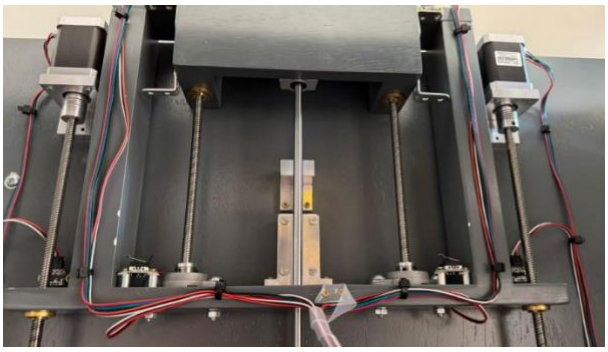

Figure 7: Monitor lifting system extended

Figure 8: Monitor lifting system retracted

### 3.4. Functional prototype of the computing unit lifting system

In this system, the motors are attached to the bottom of the frame via an aluminum support, and the T8 rods are connected to the motor shafts through flexible couplings. The nuts are secured with wood screws to the bottom of the lift, and the lift is equipped with a linear guide on the left side to facilitate the system's balance. The microswitches are positioned in front of each motor and will be directly activated by the bottom plate of the lift.

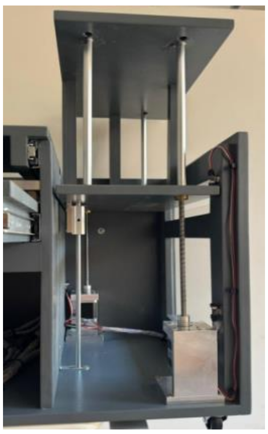

Figure 5: Computing unit lifting system

### 3.5. Control panel

This panel is equipped with 15 normally open push buttons without latching, allowing user interaction with the system. For the systems that can be adjusted in height, there are two buttons provided. These allow the system to move up or down [3]. For the other systems, there is one button for changing the state. Additionally, there is a button for packing and unpacking all systems. To enhance the user experience, a configurable memory button (MEM 1) has been included. By pressing this button, the user can store the current position of all systems, and later, this function can be accessed to return to the selected settings. To facilitate functions implemented in future revisions, two spare buttons, R1 and R2, are included. These can be configured with functions in subsequent product updates.

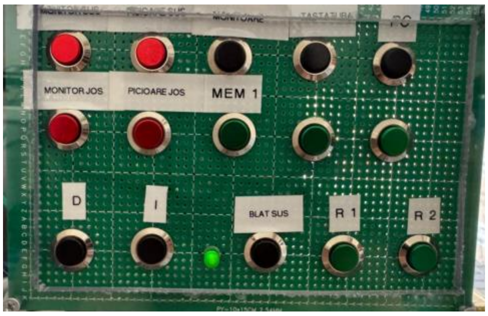

Figure 6: Control panel

### 3.6. Display

In the case of the display, the goal is to show the states of the systems and the current height of the adjustable systems.

Figure 7: Display

Due to all the systems listed, the following prototype was created and put into operation:


Figure 8: Functional prototype

## 4. IMPROVEMENTS THAT CAN BE MADE TO THE SYSTEM

The system developed above can be improved in several ways. The simplest integration that enhances user comfort is the implementation of a connection between the desk and the Home Assistant system. One utility of this system is the activation of the ESP's Wi-Fi antenna. This way, the desk can connect to a server, enabling both geolocation functions and remote access, among others. In practice, if this feature is implemented, the desk can store the users' locations, and when one of them is nearby, it will start the computer unit and adjust to their preferred height. Additionally, if the system remains on and the user is not at home, the remote shutdown function can be activated.

Another improvement could involve the spare buttons already implemented in the system. Since the desk was initially equipped with three memory buttons and only one was used, there are four spare buttons available. In the next revision of the system, the two remaining memory buttons can be implemented along with the two spare buttons. Additionally, an RGB strip could be integrated for aesthetic purposes.

Furthermore, there is the possibility of integrating cable trays. These can be used to refresh the system both aesthetically and practically.

## 5. CONCLUSION

Based on the conducted research and experimental work, the project successfully met the specified requirements. By utilizing an integrated approach, a functional prototype of a smart modular ergonomic desk was developed, demonstrating the intended use outlined in the project proposal. This prototype combines advanced technological solutions with ergonomic design to cater to diverse user needs.

The developed prototype validates the foundational concept of the project. It is equipped with essential features, including height adjustment, monitor positioning, and motorized systems for user-specific customization. The practical demonstration of these features confirmed that the project offers a viable solution for enhancing comfort and productivity.

A custom-designed baseboard was created to integrate all electrical and mechanical systems into a unified structure. This approach streamlined the implementation process and reduced overall production costs by minimizing the complexity of wiring and component assembly.

The prototype served as a tangible proof of concept, showcasing the feasibility of implementing smart technologies, such as microcontroller-based control (ESP32 and Arduino Nano), in ergonomic furniture. The design ensures a balance between functionality, adaptability, and cost-effectiveness.

The modular nature of the system allows for scalability and further enhancements. Proposed upgrades, such as smart home integration, RGB lighting, and cable management systems, were identified to improve both the user experience and the aesthetic appeal of the desk.

In conclusion, the project successfully achieved its objectives, demonstrating the practical applicability of a smart ergonomic desk and providing a strong foundation for future developments in this field.

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