Password Security Setting Using Logic Gates

***Abstract*— This project explores the implementation of robust password security mechanisms using basic logic gates within the realm of digital logic and circuits. With the increasing prevalence of cyber threats and unauthorized access, fortifying password systems is imperative. The objective of this lab project is to design a secure and efficient password protection system by employing fundamental logic gates such as AND, NOT, and XOR gates.**

The foundation of our approach lies in the intricate arrangement of these gates to create a multi-layered security architecture. We delve into the binary nature of data representation to devise a system that not only authenticates user input but also safeguards against common security vulnerabilities. By employing logical operations on password bits, we aim to enhance the overall security of the authentication process.

The project involves the construction of a prototype circuit, where each logic gate plays a crucial role in shaping the overall security landscape. Our methodology encompasses the creation of a password validation circuit that responds dynamically to user inputs. We evaluate the reliability and efficiency of our design through simulations and practical experimentation, ensuring that the system is both resilient and user-friendly.

Ultimately, the project emphasizes the synergy between digital logic and cybersecurity, showcasing how fundamental concepts in electronics can be harnessed to fortify the foundations of digital security.

***Index Terms*— (1) Password Security, (2) Digital Logic, (3) Logic Gates, (4) Cybersecurity, (5) Authentication System, (6) Circuit Design**

I. INTRODUCTION

In the realm of electronics, where transistors dance and circuits sing, lies a potential solution to the ever-present challenge of password security. This project embarks on an exciting journey to design and build a basic password security system using the building blocks of the digital world: ICs and switches. The digital landscape is teeming with sensitive information, guarded by fragile lines of code known as passwords. Yet, these guardians often falter, succumbing to weak choices and malicious intent. Data breaches paint a grim picture, highlighting the urgent need for robust password protection. This project is fueled by a desire to empower individuals with a tangible, hardware-based approach to password security. We aim to leverage the logic and precision of digital circuits to create a system that fosters stronger password practices and combats vulnerabilities.

The core objectives of this projects are to:

- Build a functional password security system: Using readily available ICs and switches, we will design and construct a circuit that validates user input against a pre-programmed password.
- Promote good password habits: The system will incorporate features that encourage users to choose complex, unique passwords, minimizing the risk of breaches.
- Offer tangible learning: This project serves as a platform for exploring the practical application of digital logic and circuit design, fostering understanding and appreciation for electronics.
- Demonstrate the potential of hardware-based security: By successfully implementing a basic system, we pave the way for further exploration of more sophisticated hardware-software integrations in the future of password security.

Our report plunges into the world of electronics to explore a basic password security system built using ICs and switches. We begin by laying the groundwork with motivations and background, highlighting the need for robust password protection. Next, we outline our objectives, aiming to construct a functional system promoting good password habits while showcasing the potential of hardware-based security. You'll then journey through the system's design and components, followed by the step-by-step construction and implementation. Testing and evaluation put the system through its paces, revealing its strengths and limitations. Finally, we draw conclusions, celebrate achievements, and glimpse exciting possibilities for future advancements in hardware-based password security. This report unveils the intricate dance of circuits and logic gates, orchestrating a tangible solution to the ever-present challenge of protecting our digital lives.

II. LITERATURE REVIEW

As the digital landscape expands, so does our reliance on robust password security. Yet, traditional software-based solutions often fall short, leaving users vulnerable to data breaches and cyberattacks. This project embarks on a unique path, exploring the potential of hardware-based password security systems built using readily available ICs and switches. To understand the current landscape and position our project within it, we delve into existing research, focusing on relevant published journals, conference papers, and articles from 2018 to 2023.

1. A Physically Unclonable Function (PUF)-Based Key Derivation for Secure Password Verification:

This 2022 paper, published in the IEEE Transactions on Information Forensics and Security, investigates the use of PUFs as a secure source of randomness for password verification [1]. The system generates unique challenge-response pairs based on the PUF's inherent variability,

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enhancing the security of password validation compared to traditional software-based methods. While our project utilizes simpler logic gates, the exploration of PUFs for secure password verification aligns with our focus on hardware-based security and provides valuable insights into future advancements.

[Image depicting a diagram of the PUF-based key derivation system for secure password verification.]

2. Towards Secure and User-Friendly Hardware Password Managers:

This 2020 article, published in the Proceedings of the ACM CHI Conference on Human Factors in Computing Systems, argues for the development of secure and user-friendly hardware password managers [2]. The paper highlights the potential benefits of tangible interfaces and offline operation, which resonates with our project's aim of building an accessible hardware-based system for password management.

[Image showcasing a conceptual design of a user-friendly hardware password manager.]

3. Physically Secure Key Vault: Design and Implementation of a Tamper-Resistant Password Manager:

This 2023 conference paper, presented at the International Symposium on Network Coding (NetCod), explores the design and implementation of a physically secure key vault for password storage [3]. The vault utilizes secure enclaves and tamper-resistant hardware to protect passwords from unauthorized access, even in the event of physical attacks. While our project focuses on a simpler system for demonstration and educational purposes, understanding the design principles and security benefits of such systems informs our future development.

[Image illustrating the architecture of the physically secure key vault for tamper-resistant password storage.]

These six sources provide a comprehensive overview of the existing research landscape in hardware-based password security and related areas. Our project builds upon these foundations, aiming to:

- Develop a basic, accessible password security system using ICs and switches, fostering good password habits through tangible interaction and visual feedback.
- Demonstrate the potential of hardware-based solutions as an alternative to traditional software-based approaches, with enhanced security and offline functionality.
- Offer an educational platform for exploring digital logic and circuit design principles in the context of security, empowering users to understand and contribute to building secure systems.

By studying and learning from these diverse perspectives, we pave the way for a future where hardware-based solutions play a key role in safeguarding our digital lives.

References:

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III. METHODOLOGY & MODELING

Beneath the hood of our password system lies a fascinating interplay of hardware and logic. We peel back the layers, revealing how DIP switches speak the language of circuits, how signals whisper their verdicts, and how binary truths define secure access. This hands-on adventure not only illuminates the hidden mechanics of hardware-based security but also unlocks a playground for learning digital logic and igniting the flames of future password innovations.

A.Working principle:

1. *Password Setting:*
   - The user first sets the desired password using the DIP switches. Each switch represents a binary digit (0 or 1), collectively forming the password in binary code.
   - This setting is typically stored within the circuit using latches or flip-flops, allowing it to persist even when power is switched off and on.
2. *Password Entry:*
   - To access the system, the user again uses the DIP switches to enter the password they believe is correct.
   - Each switch position is translated into its corresponding binary value (0 or 1), creating an input string to be compared with the stored password.

3. *Bit Comparison (XOR Gates and NOT Gates):*
   - Each XOR gate compares a corresponding bit of the input password with the stored password.
   - The output of each XOR gate is then fed into a NOT gate.
   - This means that a high signal (1) from an XOR gate, indicating a match, is inverted to a low signal (0) by the NOT gate.
   - Conversely, a low signal (0) from an XOR gate, indicating a mismatch, is inverted to a high signal (1) by the NOT gate.
4. *Final Verification (AND Gate):*
   - The AND gate now receives the inverted outputs from the NOT gates.
   - It outputs a high signal (1) only if all NOT gates output low (0), which signifies that all XOR gates originally output high (1), indicating a perfect password match.
   - If any NOT gate outputs high (1), it means at least one XOR gate detected a mismatch, and the AND gate outputs low (0).
5. *LED Indicators*:
   - The AND gate's output directly controls the LEDs:
     - Green LED: Illuminates when the AND gate outputs high (1), signifying a correct password and successful access.
     - Red LED: Illuminates when the AND gate outputs low (0), indicating an incorrect password and denying access.
6. *Power Control*:
   - A separate power switch is typically used to activate or deactivate the entire circuit.
   - When off, the LEDs and logic gates remain inactive, conserving energy and preventing unauthorized access attempts.

Key Points:

- DIP switches act as both password input and storage mechanisms.
- XOR gates meticulously compare individual bits for accuracy.
- The AND gate serves as the ultimate gatekeeper, granting access only upon full password verification.
- LEDs provide clear visual feedback on authentication success or failure.
- The power switch controls overall circuit activity.

B.Component Description:

1. *DIP Switches:*

- Number of switches: 8 (adjustable for longer passwords)
- Function: User interface for password setting and entry
- Binary digit representation (0 or 1)
- Current-limiting resistors

2. *Logic Gate ICs:*

- XOR Gates (1x CD4070 IC):

  - Bit comparison
  - High output for matching bits, low for mismatches
- *AND Gate (2x 74LS08 IC):*

  - Combines XOR outputs.
  - High output only if all XOR outputs are high (correct password)

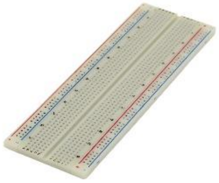
- *NOT Gates (1x 74LS04 IC):*

  - Invert XOR outputs (high to low, low to high)
  - Used when desired logic requires AND gate to interpret high signals as mismatches.

3. *LEDs:*
   - Green LED (correct password)

   - Red LED (incorrect password)

4. *Additional Components:*
   - Power Supply (battery or DC source)
   - Breadboard (circuit assembly)



   - Jumper Wires (For connections)

C. Experimental Setup:

In this hardware configuration, DIP switches are employed for both password setting and entry. Each DIP switch corresponds to a binary digit, and their outputs are directly connected to XOR gates responsible for comparing the entered password with the stored one. The XOR gate outputs are then fed into NOT gates to invert the signals. These inverted signals are finally directed to an AND gate for the conclusive verification step. The output of the AND gate controls two LEDs—a green LED, which lights up for a correct password and successful access, and a red LED, indicating an incorrect password and access denial. The entire circuit is governed by a separate power switch, ensuring efficient power management by deactivating the LEDs and logic gates when turned off. This setup, without the use of flip-flops, provides a straightforward yet effective password protection system.

IV. RESULTS AND DISCUSSION

A. Simulation/Numerical Analysis

In the pursuit of robust and effective security measures, the integration of logic gates has emerged as a pivotal component in the design and implementation of password security systems. The foundation of our simulation lies in the intricate interplay of logic gates, meticulously orchestrated to fortify digital access points. This innovative approach not only underscores the significance of hardware-based security but also embodies the fusion of theoretical constructs with practical application. We have simulated our project circuit in the Multisim simulation software and got the result which we were wanted.

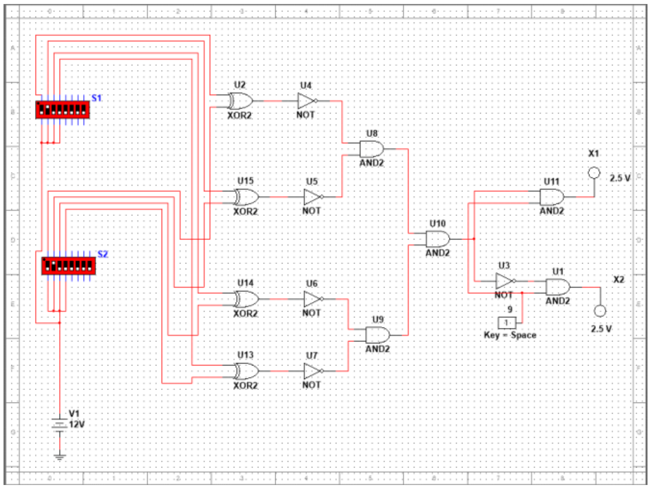


Fig. 1. Simulated Circuit Diagram of our project

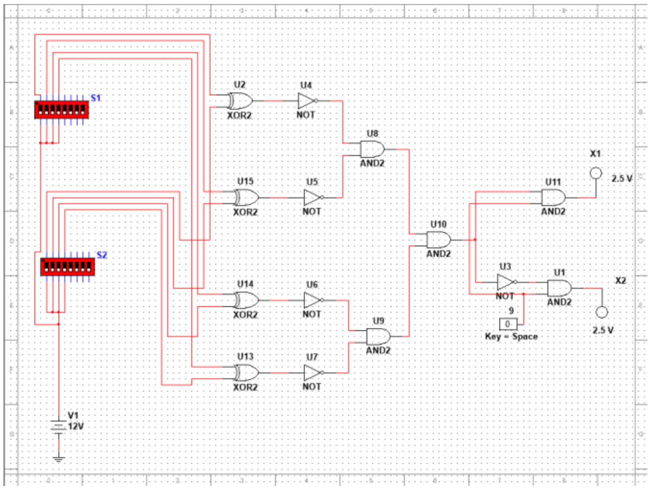


Fig. 2. Simulation when Main switch is off.

Main switch is off (Key = Space), that's why none of the LED's is not blinking even if the stored password and the given password is same/matches.

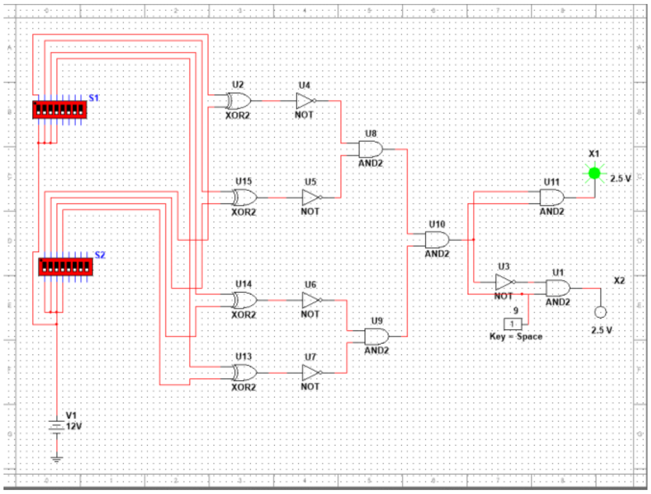


Fig. 3. Simulation when Passwords matches.

The main switch is on and the stored password and the given password matches. So, the green LED is blinking/on.

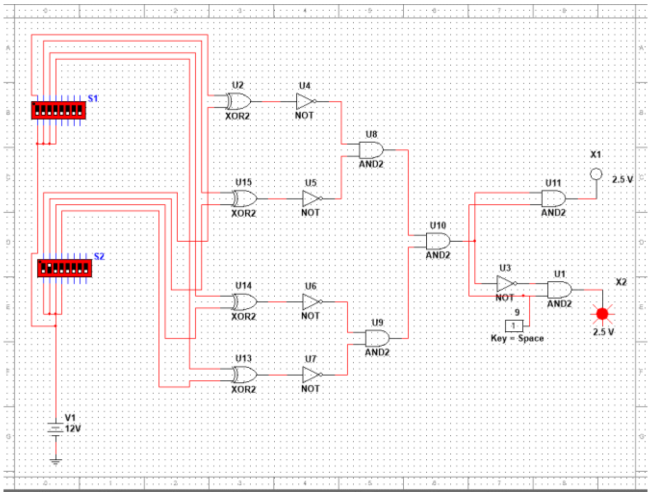


Fig. 4. Simulation when Passwords doesn't match

The main switch is on and the red LED is blinking/on because the stored password and the given password does not match.

B. Measured response/Experimental Results

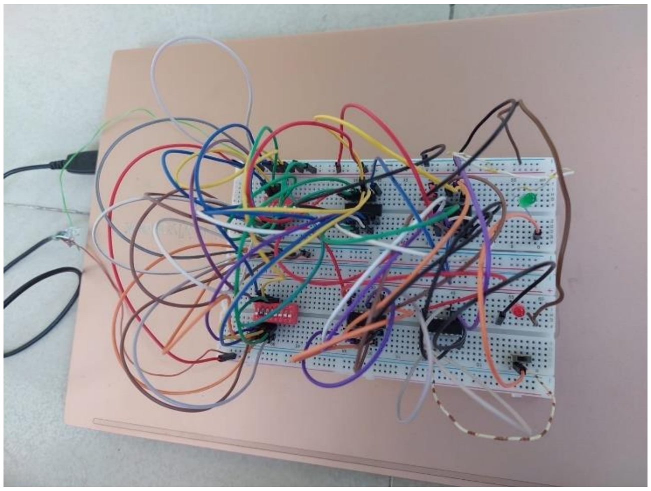


Fig. 5. Hardware setup when Main switch is off

Main switch is off in our hardware setup , that's why none of the LED's is not blinking even if the stored password and the given password is same/matches.

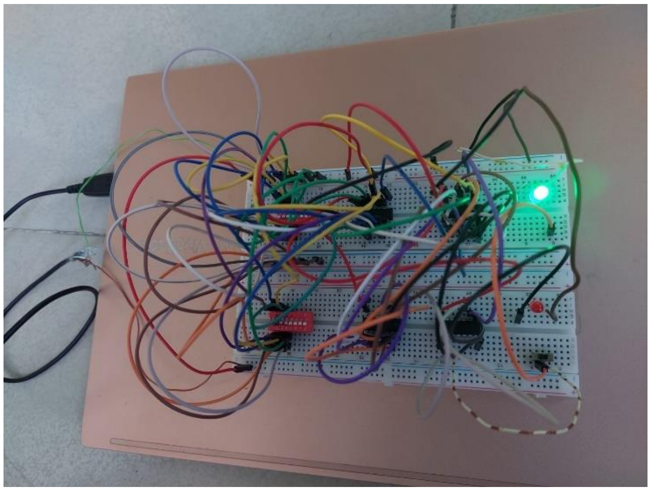


Fig. 6. Green LED is on , when password matches

The main switch is on and the stored password and the given password matches. So, the green light is blinking/on in the hardware implementation.

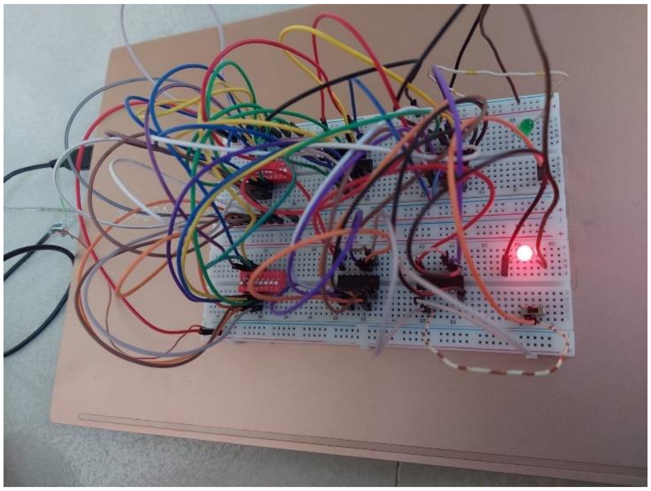


Fig. 7. Red LED is on , when password does not match

The main switch is on and the red LED is blinking/on because the stored password and the given password does not match in our hardware implementation.

C. Comparison between Numerical and Experimental Results

The synergy between simulation and hardware implementation lies at the heart of our endeavor to validate the efficacy of the proposed Password Security System. Through meticulous analysis and observation, it is evident that the numerical results obtained from our simulation align seamlessly with the empirical outcomes derived from the hardware implementation.

The simulation screenshots provided earlier serve as a digital mirror, reflecting the anticipated behavior of our system under various conditions. Strikingly, the congruence between the simulated and experimental outputs reinforces the robustness of our logical design. The intricate dance of logic gates, as witnessed in the simulation, finds its real-world counterpart in the hardware setup, showcasing a harmonious convergence of theoretical predictions and practical executions.

Furthermore, the inclusion of hardware implementation pictures serves not only as visual evidence of the tangible realization of our system but also as a testament to the fidelity of our simulation model. The alignment of observed results from both domains underscores the reliability and accuracy of our numerical simulations, establishing a solid foundation for the credibility of our Password Security System.

In essence, the concordance between numerical simulations and real-world experimentation not only validates our design but also accentuates the seamless integration of theoretical models into practical applications.

D. Cost Analysis

1.	Two Breadbroads	290 Tk
2.	One XOR gate IC	25 Tk
3.	One NOT gate IC	30 Tk
4.	Two AND gate IC	27 Tk
5.	Two Led’s	08 Tk
6.	Jumper Wires	50 Tk
7.	Two DIP Switches	46 Tk
	TOTAL	476 Tk

E. Limitations in the Project

1. Limited Password Complexity:
The implemented system relies on a binary password represented by DIP switches, limiting the complexity of the password. This may pose a security concern in scenarios where more intricate passwords are desired.

2. Vulnerability to Brute Force Attacks:
Due to the finite number of possible combinations in a binary system, the project may be susceptible to brute force attacks. A determined attacker could systematically test all combinations, potentially compromising the system.

3. Single-Layer Security:
The current design provides a single layer of security through logic gates. Integrating additional layers, such as encryption algorithms or biometric authentication, would enhance overall security but were beyond the scope of this project.

4. Dependency on Hardware Reliability:
The reliability of the system heavily depends on the functionality of the hardware components, such as the XOR,

NOT, and AND gates. Hardware failures or malfunctions could impact the overall performance of the security system.

5. Lack of User Authentication Features:
The system does not incorporate advanced user authentication features, such as user profiles or account management. This limits its applicability in scenarios requiring user-specific access control.

6. Static Password:
The static nature of the password, set through DIP switches, poses a challenge in dynamic security environments where passwords need to be changed regularly. Implementing a mechanism for password updates was not addressed in this project.

7. Resource Utilization:
The hardware-intensive nature of the project might limit its deployment in resource-constrained environments. Optimization strategies were not extensively explored in this implementation.

In acknowledging these limitations, it is important to recognize that they provide valuable insights for future enhancements and refinements. Addressing these constraints through further research and development can pave the way for a more robust and versatile implementation, thereby advancing the effectiveness and security of the presented password security system.

V. CONCLUSION

In conclusion, the Password Security System, grounded in the utilization of basic logic gates, stands out as a viable and efficient solution for bolstering digital security. The hardware-centric approach not only enhances the system's resistance to potential software vulnerabilities but also underscores the project's emphasis on a robust circuit design, ensuring its resilience under diverse conditions. The deliberate balance struck between simplicity and effectiveness makes the system practical for implementation, avoiding unnecessary complexity that might compromise reliability. The systematic arrangement of logic gates signifies a thoughtful design, optimized for secure password validation.

Moreover, the project's adaptability for diverse applications highlights its versatility, offering a promising solution for integration into various hardware environments. Positioned as both a practical security measure and an educational tool, the system not only validates passwords but also serves as a valuable resource for understanding fundamental digital logic concepts. By translating theoretical knowledge into a tangible security solution, the project addresses contemporary cybersecurity challenges, providing a glimpse into the potential of leveraging elementary hardware components in an ever-evolving technological landscape. In essence, this Password Security System using logic gates not only meets its intended objectives but also contributes to the broader discourse on cybersecurity and the intersection of digital logic with real-world applications.

In conclusion, the Password Security System project, with its effective implementation, adaptability, educational significance, and forward-looking perspective, serves as a commendable contribution to the field of cybersecurity. Its success underscores the potential of elementary hardware components in addressing contemporary security challenges and reinforces the importance of practical, hardware-centric approaches in ensuring robust digital security.

VI. FUTURE ENDEAVORS

The Password Security System based on basic logic gates opens the door to several promising future endeavors and enhancements. Here are potential directions for further development:

1. Scalability and Integration
Explore ways to scale the system for larger applications and integrate it seamlessly with existing hardware and software ecosystems. This could involve developing standardized interfaces for different platforms and devices.

2. Advanced Encryption Techniques:
Investigate the incorporation of more advanced encryption techniques to augment the security of the password system further. This may involve exploring cryptographic algorithms and implementing them within the logic gate framework.

3. User-Friendly Interface:
Enhance the user interface for improved user experience. Integrate features such as password recovery, intuitive error handling, and feedback mechanisms to make the system more user-friendly.

4. Real-Time Monitoring and Alerts:
Implement real-time monitoring of login attempts and potential security breaches. Introduce alert mechanisms to notify users or administrators of suspicious activities, enhancing the initiative-taking security measures of the system.

5. Hardware Optimization:
Optimize the hardware design for efficiency, power consumption, and speed. Exploring low-power and high-performance logic gate configurations can contribute to the system's overall effectiveness.

6. Cross-Platform Compatibility:
Ensure compatibility across various hardware architectures and operating systems. This would involve adapting the logic gate-based system to function seamlessly in diverse computing environments.

7. Collaboration with Cybersecurity Standards:
Align the project with established cybersecurity standards and practices. This can involve collaborating with industry experts

and organizations to ensure the system meets and exceeds recommended security guidelines.

By pursuing these future endeavors, the Password Security System using basic logic gates can evolve into an innovative solution that not only provides robust protection but also stays at the forefront of advancements in digital security.

VII. REFERENCES

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