

Jack Spillett

Student - 2307227

U.W.T.S.D. Swansea Campus

BEng - Part Time - Electrical and Electronic Engineering

Individual Project Proposal

Working Title - The Design, Construction and Analysis of the Enhancement of an Electrical Locking System for Access Control in Eastman.

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Introduction

This proposal outlines the design, construction, and analysis of an electronic lock system utilising a keypad, LED indication, and PIC microcontroller. The project aims to create a secure, user-friendly access control system for a D.C.S Server Room. It will address the limitations of traditional mechanical locks, key card systems, and biometric security systems currently used within Eastman Chemical Company, Newport, and enhance the system.

Rationale and Problem Statement

Eastman Chemical Company, Newport, is an Upper Tier COMAH Site, meaning the site stores, handles and processes significant quantities of hazardous substances, including PCL3 and HCl [5]. Recent issues at the site have revealed a flaw in the current Access Control System resulting in a lack of access to a D.C.S. (Digital Control System) Room by E.R.T. (Emergency Response Team) members during an incident.

Currently, access to the D.C.S. Room is solely given to members of the D.C.S. Team, however, during the incident (which occurred out of hours) none were on site. Existing access is limited using a Key Card System to reduce potential security breaches, which could result in a major incident.

The incident underscores the necessity for a more adaptable access control solution. Existing electronic lock systems often suffer from high costs, complex installation processes, and a lack of user adaptability.

This project aims to design, construct, and analyse an electronic lock system that utilises a keypad, existing magnet system, LED indication, and PIC microcontroller to enhance the system. The system will provide a secure and programmable locking system, enhancing the existing system. The project will utilise the Waterfall Development Methodology to progress. It will also include producing two presentations, a written report, a poster and a project handbook, outlining the steps and choices made.

Initial Research

Existing Literature

Access control handles every request for resources and data within a system, to determine whether the request should be granted or denied, typically enforced by a mechanism established by a security policy [1]. 60% of organisations use ID badge access control [3]. Within Eastman, access control is employed to control access to critical areas, where major incidents could occur if the equipment is tampered with i.e. SIS, CCTV, etc. A project with a similar scope was undertaken by researchers at San Juan de Letran, automating room access. The scope also included the control of the utilities such as lighting and air-conditioning units [2]. Although this project considers convenience and ease of access, 66% of organisations prioritise security over convenience [3].

Relevant Papers:

- [2] D. D. Geralde, M. M. Manaloto, D. E. D. Loresca, J. D. Reynoso, E. T. Gabion, and G. R. M. Geslani, "Microcontroller-based room access control system with professor attendance monitoring using fingerprint biometrics technology with backup keypad access system," IEEE Xplore, Dec. 01, 2017.
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Requirements and Security Considerations

Discussions with the D.C.S. Team and E.R.T. at Eastman have highlighted several other considerations: battery backup should be added to the system, as power dips and power cuts are likely; the existing electromagnet locking system should continue to be used; also, the microcontroller and other components should be housed within the D.C.S. Room for added security. Similarly to existing systems, the system should withstand brute-force entry, tampering, and hacking. Some existing systems feature time delays after incorrect entries. The system must operate consistently, to compete with existing off-the-shelf systems [6]. As a result of the incident, in times of emergency, the keypad must allow for quick code entry and the system should provide feedback (audible or visual) to confirm successful access.

Existing Technology

Electronic Locking Systems are common in domestic, commercial, and industrial applications. Existing solutions offer a wide range of technologies, i.e. keypad locks, biometrics and smart systems. Common features in these systems include user programmability, multiple access modes (e.g., codes, RFID, or biometrics), and remote-control options. A range of existing systems is displayed below:

Cost: £141.80	Cost: £195.00	Cost: £270.12
		
Figure 1: Existing Technology Example One [6]	Figure 2: Existing Technology Example Two [7]	Figure 3: Existing Technology Example Three [8]
Pros: Battery Back Up and Mains LCD Display on KeyPad Lower Cost Key Card and Key Pad	Pros: Integrated Relay Small Size Easy to Mount	Pros: Lock Included Robust Easy to Mount
Cons: Large Enclosure Battery-Powered Key Pad	Cons: High Cost No Battery Back Up	Cons: High Cost Large Size No Battery Back Up Limited Customizability

Table 4: Comparing Existing Systems

Some advanced security systems feature wireless communication or cloud integration [6]. Though a useful feature, this project will offer a cost-effective yet practical approach

using a keypad. In the event of an emergency, this ensures a balance between security, affordability and access. The research into existing systems highlights their strengths and limitations, helping to define the individual objectives for this project.

Environmental Considerations

The project will consider the environmental impact, by following sustainable design practices i.e. selecting energy-efficient components and recyclable materials. Rechargeable batteries and efficient power management systems will help lower energy consumption over the system's lifespan [9]. The most common rechargeable batteries used within electronic systems are lithium-ion (Li-ion) batteries, known for their high energy density, long cycle life, and low weight. Battery capacity is a key consideration, with existing systems offering battery backup systems that last for days [10].

Battery Type	Energy Density (Wh/kg)	Life Cycle	Toxicity
Li-Ion	126-190	500-1,000	Low
Ni-Cd	45-80	1000	High
Ni-MH	100	300-500	Low
Li-ion polymer	185	300 – 500	Low
Lead Acid	30-50	200-300	High
Lithium-Sulfur	55	50-100	Non- Toxic

Figure 5 - Comparison of Batteries [9]

Legal Considerations

When designing the system, the following standards and regulations will be required as a minimum: BS EN 50133-1:1997 – Alarm Systems: Access Control (covering the design and installation of electronic access control systems, to ensure the system's performance, reliability, and resistance to external factors like tampering or power issues) [11]; BS 7671:2018 – IET Wiring Regulations (to ensure the safe installation of electrical systems, including low-voltage circuits) [12]; BS EN 62368-1:2020 – Safety of ICT Equipment; BS EN 60839-11-1:2013 – Security Systems (covering how security systems securely handle data, protect user credentials and methods of preventing unauthorised access, with encryption and privacy safeguards) [13]; BS EN 60529:1992 – Ingress Protection (IP) Code (defines the sealing required to protect the system from dust, water, and other environmental hazards) [14]. Thought will also be given to meeting UK GDPR [15], RoHS & WEEE Directives [16] as well as BS EN 61000-6-3:2007 – Electromagnetic Compatibility (EMC) [17]. Adhering to these standards should ensure the system is safe, secure, environmentally friendly, and legally compliant for use in the UK.

Ethics

During the construction and evaluation of the system, all materials and components should be sourced ethically i.e. sustainable or recycled components to minimise environmental harm; and be chosen to reduce energy consumption. Where this is not possible, research should be conducted on the manufacturers of the components, considering their labour practices and environmental and sustainability policies. Considerations for the end-of-life should be made i.e. disposal of the battery and recycling of components. If gold-plated components are used, ensure they are correctly recycled as e-waste contains 10 times more precious metals than the corresponding natural minerals [18].

All aspects of this project will comply with legal standards governing electronics i.e. Electrical Equipment (Safety) Regulations 2016 [19], access control systems [11], and data protection [15]; as well as adhering to site procedures. The system will be designed, constructed and tested following industry best practices [12], and there will be a commitment to continuously improving the system to adhere to updated laws and regulations. Care will be taken to ensure that the mains supply, and battery backup are integrated safely, with appropriate considerations being made to prevent electrical hazards such as short circuits, overloading, and accidental shocks, thus ensuring the safety of users [12].

The microcontroller will be housed inside the D.C.S. Room, preventing unauthorised access and reducing the risk of hacking and data breaches. No access logs will be kept, so the ethical handling of user information will not be a great concern. The system will be designed and installed to accommodate a range of users, including those with disabilities i.e. the keypad will be mounted so individuals with limited mobility, visual impairments, or other challenges can easily access it when needed. Considerations will be made to ensure usability by all individuals, regardless of their physical abilities [21].

The data gathered through the course of this project will be recorded by the researcher. No participants are used within the scope of the project, thus little thought needs to be given to the ethical storage and deletion of data. The only information gathered will be the system's performance, which will be filed into a report as part of the project. The design process will be transparent, with design decisions being documented so that vulnerabilities or defects identified in the system can be addressed immediately.

SMART Objectives

For the project to be a success:

- The Key Pad must switch a contact, releasing a magnet, opening the door.
- The system must be able to be installed in less than an hour.
- The system must allow for the PIN to be changed.
- The system must work off mains power but have a battery backup.
- The battery backup should last more than 12 hours.
- The project should cost below £115.
- The project should be completed before May 2025.

Optional Objectives:

- Display the charge of the battery.
- Alter the PIN using the keypad.

Analysis of Evaluation

To evaluate project success, the performance needs to be tested. Primary data will be gathered on the installation time, ease of programming and longevity of the battery backup, all gathered by the researcher, within the D.C.S. Room multiple times to ensure accuracy.

Budget

The budget is set at £115, consisting of the microcontroller, keypad, battery, mains power supply transformer, enclosure, circuit board and assorted miscellaneous components. Based on the initial research, existing systems meeting the specifications set out in this project are upwards of £120 [6]. Although the project going over budget would not be ideal, providing the cost remains under £180, the project can still be deemed successful as this is the threshold where existing systems meet the required specifications.

Component	Division of Cost Based on Initial Research
Microcontroller	£5
Key Pad	£20
Mains Supply Cable and Transformer	£15
Battery	£15
LEDs	£10
PCB or Circuit Board	£10
Electronics Enclosure	£20
Miscellaneous Components	£20

Figure 6: Assumed allocated of Budget

Time Schedule

Several considerations have been made so that the project is completed on schedule:

- A GANTT chart has been produced, with contingency time displayed.
- A 5-step Risk Management Process will be followed to mitigate risks.
- All required components and materials will be researched to guarantee they can be sourced from multiple vendors if the primary vendor can't meet the expected deadline.



Resources

People:

- Researcher - Sole Person Responsible for Project.
- UWTSD Correspondent - To assist with the project when required.

Software:

- Proteus - To produce the Electrical Drawing.
- SketchUp - To produce the enclosure layout drawings.
- Easy PC - To produce the PCB layout if used.
- Chrome - Research and ordering of components.
- Google Drive - To create documents and store data.

Tools:

- Computer - Using the Software stated above.
- Soldering Station - Soldering of Components.
- Hand Tools - Construction of the Enclosure.

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