Circuit: Jurnal Ilmiah Pendidikan Teknik Elektro
Volume 9 No. 1 September 2024 - February 2025
ISSN: 2549-3698; E-ISSN: 2549-3701
DOI: 10.22373/crc.v9i1.26454

Hospital Sterilization Room Door Interlock System Prototype Using Electric Contactors

Suhir Ardiansyah[a], Muhammad Rizal Fachri[a], Fathiah[b]

[a]Universitas Islam Negeri Ar-Raniry Banda Aceh, Indonesia

[b]KABA Academic Society, Indonesia

E-mail: suhirardiansyahsukses@gmail.com

Submission: 16-10-2024 Accepted: 23-02-2025 Published: 01-03-2025

Abstract

Controlling access to sterile hospital rooms can be effectively managed using a secure and reliable interlock system based on electrical contactors, which ensures that only one door is open at a time to prevent cross-contamination. This study aims to design and test a prototype of an interlock system for sterile room doors using an electrical contactor as the main controller. The research follows stages of design, testing, and performance evaluation. The system utilizes solenoid door locks controlled by contactors to automate door locking and opening. Testing focuses on measuring the output current of the contactors and the solenoid's response time during door operations. Results show that contactor 1 outputs 7.63 mA, and contactor 2 outputs 7.64 mA. Solenoid door lock 1 has an average operating time of 0.80 seconds with a delay of 0.89 seconds, while solenoid 2 operates at 0.96 seconds with a 0.97-second delay. The system demonstrates stable performance and complies with sterile room safety standards. It is suitable for hospital implementation and can be further enhanced with remote monitoring and automatic alarm features to improve operational supervision.

***Keywords**: Contactor, interlock, Solenoid, Sterile Room.*

Abstrak

Pengendalian akses ruang steril rumah sakit membutuhkan sistem kunci yang aman dan andal untuk mencegah kontaminasi silang. Salah satu solusinya adalah sistem interlock berbasis kontaktor listrik yang mengatur agar hanya satu pintu terbuka pada satu waktu. Penelitian ini bertujuan untuk merancang dan menguji prototipe interlock pintu ruang steril rumah sakit dengan menggunakan kontaktor listrik sebagai pengontrol utama melalui tahapan perancangan, pengujian, dan evaluasi kinerja. Sistem ini menggunakan solenoid door lock yang dikendalikan oleh kontaktor untuk mengunci dan membuka pintu secara otomatis. Pengujian dilakukan untuk menilai arus keluaran kontaktor dan respons cepat solenoid saat proses buka-tutup pintu. Hasil pengujian menunjukkan bahwa kontaktor 1 menghasilkan arus keluaran sebesar 7,63 mA, sedangkan kontaktor 2 sebesar 7,64 mA. Solenoid door lock 1 memiliki waktu operasi rata-rata 0,80 detik dengan jeda (delay) 0,89 detik, sedangkan solenoid door lock 2 beroperasi dengan waktu 0,96 detik dan jeda 0,97 detik. Sistem interlock berbasis kontaktor listrik menunjukkan kinerja yang stabil, memenuhi standar keselamatan ruang steril, dan dapat diadopsi oleh rumah sakit dengan potensi peningkatan seperti alarm otomatis dan pemantauan jarak jauh untuk meningkatkan pengawasan.

Kata Kunci: Kontaktor, interlock, Solenoid, Ruang Steril.

1. Introduction

Today's quick technological advancements inspire people to think imaginatively and innovatively, not just when developing new items but also when enhancing current systems. Technological innovation includes not only physical products but also systems and infrastructure that enhance efficiency and quality of life. One sector that has been greatly impacted by technological advancements is the healthcare sector, where technology plays a significant role in enhancing the quality of medical services and patient safety. Technology is required in hospitals not just for medical diagnosis and treatment but also for the administration of hospital infrastructure and facilities, especially in relation to room sterilization [1].

Sterile rooms, which are specifically designed to maintain cleanliness and prevent contamination, are crucial in medical procedures such as surgeries or medication storage. Uncontrolled contamination from external air can lead to infections or other health issues. Therefore, the management of sterile rooms must be highly prioritized. An effective door locking system that allows only one door to open at a time is crucial for maintaining the cleanliness and safety of sterile rooms [2]. Currently, many hospitals still rely on manual locking systems for sterile room doors. Manual door systems are less effective as they rely on staff discipline and are prone to human error, such as improper or delayed locking. A study conducted at the Saka Bhayangkara Hospital in Banda Aceh found that the use of manual door locks in sterile rooms still requires further innovation to ensure a safer and more controlled environment [3].

One potential solution to address these issues is the application of an interlock door system, which can automatically control the doors. Only one door can be open at a time thanks to the interlocking door system, which keeps outside air from entering and jeopardizing the room's sterility. This technology can be integrated with electronic control systems, such as contactors and solenoids, which ensure more reliable and controlled locking operations. Previous research has shown that the use of solenoid-based interlock systems can enhance the efficiency and safety of hospital sterile rooms [4][5].

Interlock systems based on solenoid technology and other electronic controllers offer several advantages, such as increased safety, reduced risk of human error, and the ability to precisely control door operation times. Therefore, this system not only provides comfort and efficiency but also improves the overall quality of the hospital environment [6]. This research aims to design and test a contactor and solenoid-based interlock system that can be applied to hospital sterile rooms, in order to improve access control and the safety of these rooms. The system is designed to ensure that only one door can be opened at a time, thereby preventing cross-contamination and maintaining the sterile environment.

Method

The prototype design of the electric contactor-based interlock system for hospital sterile room doors that was modified to meet the researcher's requirements during the study is referred to as this research technique. The following is a flowchart image depicting the prototype of an interlock system for sterile room doors in a hospital, based on electric contactors, which will be developed by the researcher:

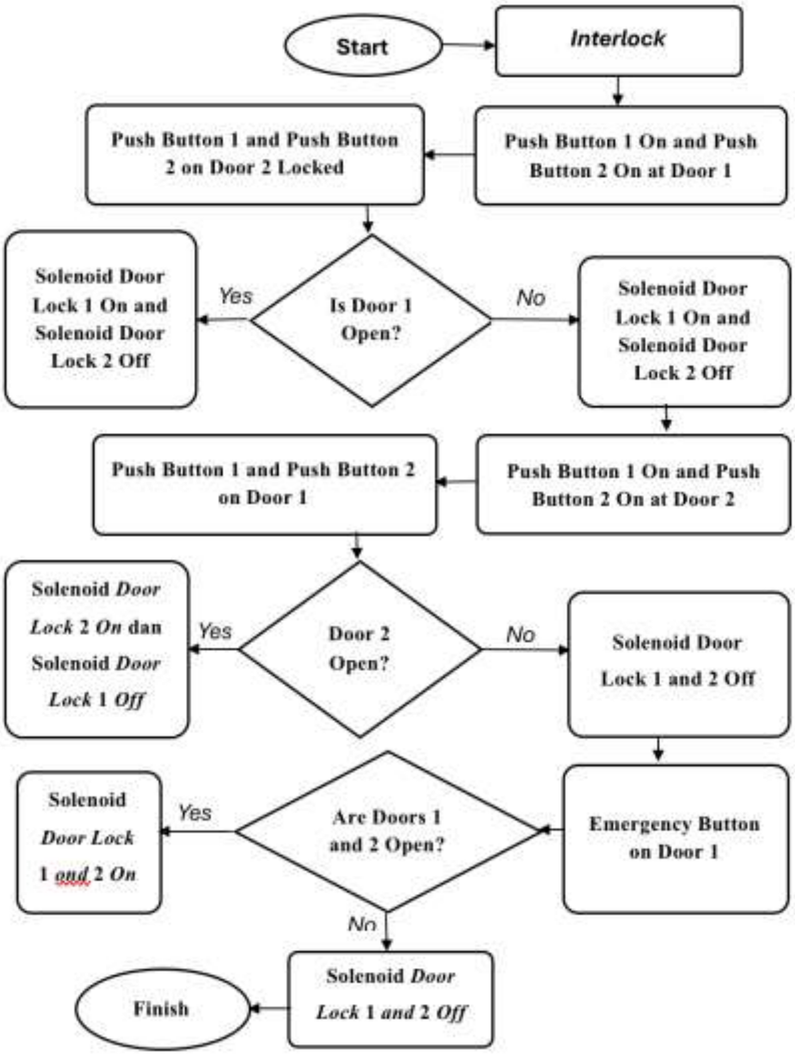


Figure 1. Flowchart for Opening the Door

A brief explanation or description of the flowchart for opening the door in the interlock system prototype for sterile room doors in a hospital based on electric contactors is as follows:

1. Start

   The researcher initiates the operation of the interlock system prototype for the sterile room doors in the hospital after connecting the system to the electrical power supply from the PLN (State Electricity Company). Once powered, the system begins to operate door access automatically, ensuring that only one door can open while monitoring the response of the contactor and solenoid components.

2. Interlock System Ready

   Once the electrical power from PLN is supplied, the interlock system becomes operational, as indicated by the illumination of the yellow pilot lights 1 and 2 on Door 1 and Door 2.

3. Activation of Push Button 1 and Push Button 2 on Door 1

   When both Push Button 1 and Push Button 2 on Door 1 are pressed (activated), the green pilot lights 1 and 2 on Door 1 will light up.

4. Push Button 1 and Push Button 2 on Door 2 Locked

   At the same time, Push Button 1 and Push Button 2 on Door 2 will be locked (unable to operate), and the pilot lights 1 and 2 on Door 2 will remain off.

5. Check Door 1 Status

   Check whether Door 1 is open. If Door 1 is open, verify if Door 2 remains closed.

6. Solenoid Door Lock 1 On and Solenoid Door Lock 2 Off

   If Door 1 is open and Door 2 is still closed, Solenoid Door Lock 1 will be activated (on) while Solenoid Door Lock 2 remains deactivated (off).

7. Both Solenoid Door Locks Off

   If Door 1 is not open, both Solenoid Door Lock 1 and Solenoid Door Lock 2 will be deactivated (off).

8. Activation of Push Button 1 and Push Button 2 on Door 2

   When both Push Button 1 and Push Button 2 on Door 2 are pressed (activated), the green pilot lights 1 and 2 on Door 2 will light up.

9. Push Button 1 and Push Button 2 on Door 1 Locked

   Consequently, Push Button 1 and Push Button 2 on Door 1 will be locked (unable to operate), and the pilot lights 1 and 2 on Door 1 will remain off.

10. Check Door 2 Status

    Check whether Door 2 is open. If Door 2 is open, verify if Door 1 remains closed.

11. Solenoid Door Lock 2 On and Solenoid Door Lock 1 Off

    If Door 2 is open and Door 1 is still closed, Solenoid Door Lock 2 will be activated (on) while Solenoid Door Lock 1 remains deactivated (off).

12. Both Solenoid Door Locks Off

    If Door 2 is not open, both Solenoid Door Lock 1 and Solenoid Door Lock 2 will be deactivated (off).

13. Emergency Button on Door 1

    When the emergency button on Door 1 is pressed (activated), the red pilot lights 1 and 2 on both Doors 1 and 2 will light up.

14. Check if Both Doors are Open

    If both Door 1 and Door 2 are open, verify whether the emergency button is still activated.

15. Solenoid Door Lock 1 and 2 On

    If both Doors 1 and 2 are open and the emergency button is still activated, both Solenoid Door Lock 1 and Solenoid Door Lock 2 will be activated (on).

16. Both Solenoid Door Locks Off

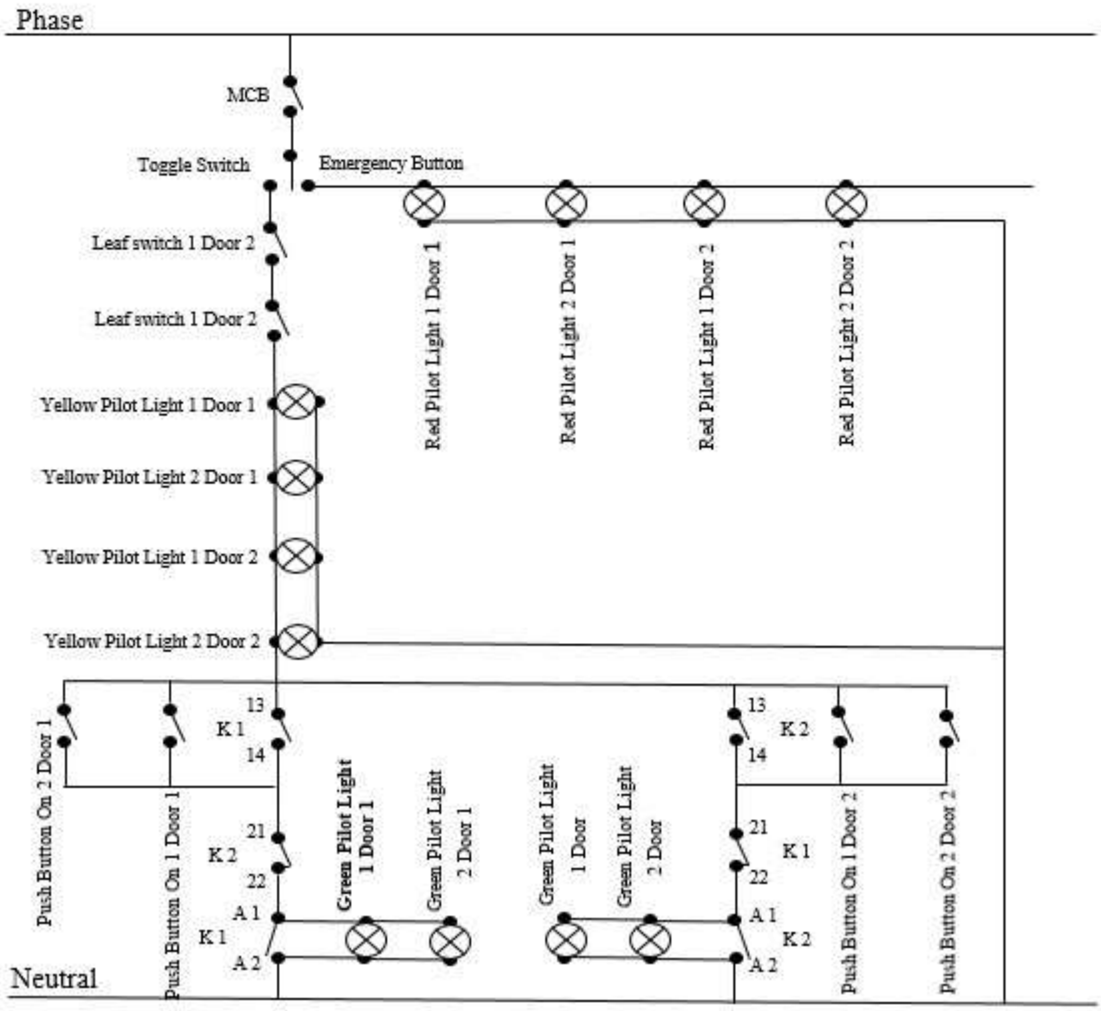
    If both Doors 1 and 2 are not open, both Solenoid Door Lock 1 and Solenoid Door Lock 2 will be deactivated (off).

17. Finish

    The system operation concludes when all conditions are satisfied, and the system returns to its initial or standby state.

a. Tool Design

In this study, the researcher designs a hardware prototype of the interlock system for the sterile room doors in hospitals, based on electric contactors. Figure 2 below shows the tool design that will be used by the researcher.



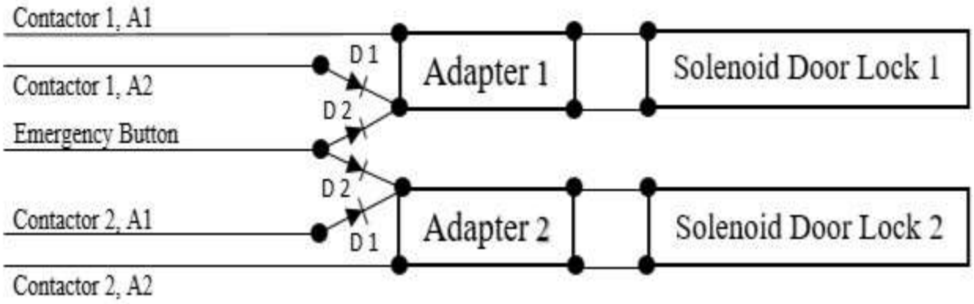


Figure 2. Interlock System Prototype Circuit

The descriptions for the interlock system prototype circuit diagram above are as follows; Fassa refers to the electrical flow rate in the electrical cable, Neutral refers to the electrical return flow in the electrical cable, MCB (Miniature Circuit Breaker) interrupts the flow of electricity and has 3 different poles, although each pole is interconnected. Then, it continues by Pushing Button On 1 and 2 are simple switches that are active only when the button is pressed, intended to connect a momentary electrical current from 13 to 14 on the electric contactor. Toggle Switch is a mechanical component that functions to open or close an electrical circuit, aimed at connecting or disconnecting the electrical circuit to the interlock or emergency system on the sterile room door. Life Switch is a button switch with three pins used to connect as NO (normally open) and disconnect the electrical circuit as NC (normally closed), used to connect or disconnect the electrical circuit to the contactor. Pilot Lamp 1 and 2 (red, yellow, and green) are indicator lights serving as markers in the design.

Contactors 1 and 2 are magnetic switches intended to transmit and disconnect electrical power magnetically to the power adapter. Item 13 and 14 are auxiliary contacts on the contactor intended for NO (normally open) on the electric contactor. While 21 and 22 are auxiliary contacts on the contactor intended for NC (normally closed) on the electric contactor. A1 and A2 are copper coils on the contactor that have electromagnetic properties or serve as voltage current conductors. D1 and D2 are diodes intended to convert AC (alternating current) to DC (direct current). Adapters 1 and 2 are portable devices designed to change or convert one form of electrical voltage, aiming to convert 220 volts AC (alternating current) to 12 volts DC (direct current). Solenoid Door Lock 1 and 2 are types of doors locking systems that use solenoids to automatically operate the locking mechanism, intended to automatically lock or unlock the sterile room door with an electrical signal.

b. Data Collection

The information gathered for this study was divided into two primary categories: information about the study sites and information on the equipment and supplies utilized to create the hospital sterile room door interlock system prototype, which was based on electric contactors. The research was conducted at the Electrical Engineering Education Laboratory of UIN Ar-Raniry. This location was used for designing, assembling, and partially testing the interlock system prototype in a controlled academic environment. The tools and materials employed in this study were carefully selected to support the design, assembly, and testing of the interlock system prototype. These items are detailed in the following tables.

Table 1. List of Tools

NO	TOOL	QUANTITY
1	Screwdriver	1 (One) Piece
2	Pliers	1 (One) Piece
3	Cutting Pliers	1 (One) Piece
4	Test Pen	1 (One) Piece
5	Multimeter	1 (One) Piece
6	Solder	1 (One) Piece

Table 1 presents a list of essential tools used in the project or experiment. The table includes the tool names and the quantity required for each. All items listed are needed in single units, indicated by “1 (One) Piece” to avoid ambiguity.

Table 2. List of Materials

NO	MATERIAL	QUANTITY
1	MCB	1 (One) Piece
2	Toggle Switch	1 (One) Piece
3	Contactor	2 (Two) Pieces
4	Push Button On	4 (Four) Pieces
5	Leaf switch	2 (Two) Pieces
6	Adapter	2 (Two) Pieces
7	Solenoid Door Lock	2 (Two) Pieces
8	Small Door	2 (Two) Pieces
9	Green Pilot Lamp	4 (Four) Pieces
10	Red Pilot Lamp	4 (Four) Pieces
11	Yellow Pilot Lamp	4 (Four) Pieces
12	Diode	4 (Four) Pieces
13	Tin Wire	As Needed
14	Wood	As Needed
15	Installation Cable	As Needed
16	Screws	As Needed
17	Insulation	As Needed
18	Nails	As Needed

Table 2 outlines the materials required for constructing or assembling the system, likely an electrical prototype or control system involving door access (based on previous context such as the interlock system). This structured list ensures the clarity and completeness of the equipment and materials needed for prototype development and testing, supporting the replicability and reliability of the study.

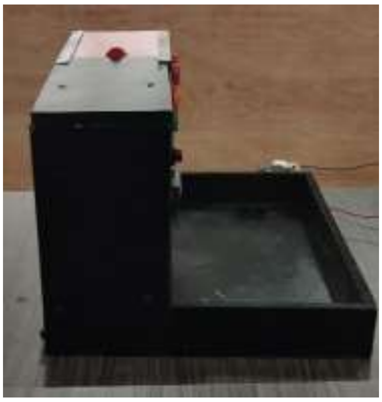
Result and Discussion

a. Results of the Interlock System Prototype Tool Design

The prototype design for the hospital sterile room door includes a toggle switch at door 2 as an interlock and emergency button, and leaf switches near doors 1 and 2 to control the electrical current based on the doors open or closed position. The contactor is located inside the control equipment room as the main controller for operating the interlock system for the sterile room doors. The solenoid door lock is placed at the front side of doors 1 and 2 as the locking mechanism for the sterile room doors. The adapter is situated in the control equipment room to convert AC electrical current to DC. Push button 1 and push button 2 are positioned next to doors 1 and 2 as buttons for the sterile room doors, and pilot lights are placed next to doors 1 and 2 as indicators for the operational system of the sterile room doors. The following is the overall form of the researcher's design results for the interlock system prototype for the sterile room doors in hospitals based on electric contactors:

(a)

(b)



(c)

(d)

Figure 3. (a) View from Outside, (b) View from Inside, (c) Left Side View, and (d) Right Side View

b. Results of Prototype Testing

The prototype testing evaluated the performance of the contactor-based interlock system using three indicators: component operation during button activation, voltage and current measurements on contactors, and solenoid door lock response time. The detailed results are presented in Tables 3, 4, and 5.

Table 3. Prototype Testing Results

Button Operation	**Contactor 1 Status**	**Contactor 2 Status**	**Adapter 1 Status**	**Adapter 2 Status**	**Solenoid Door Lock 1 Status**	**Solenoid Door Lock 2 Status**	**Door 1 Condition**	**Door 2 Condition**
Push Button 1 and Push Button 2 on Door 1	Operating	Not Operating	Operating	Not Operating	Operating	Not Operating	Open	Closed
Push Button 1 and Push	Not Operating	Operating	Not Operating	Operating	Not Operating	Operating	Closed	Open

Button 2 on Door 2								
Emergency on Door 2	Not Operating	Not Operating	Operating	Operating	Operating	Operating	Open	Open

Table 4. Results of Current and Voltage Testing on the Contactor Output

	Condition of Contactor 1			**Condition of Contactor 2**		
Operation Button	V	A	VA	V	A	VA
Push Button 1 and Push Button 2 at Door 1	236,1 Volt	7,63 mA	1,801 VA	0,227 Volt	0 mA	0VA
Push Button 1 and Push Button 2 at Door 2	0,246 Volt	0 mA	0 VA	237 Volt	7,64 mA	1.81VA
Emergency at Door 2	0 Volt	0 mA	0 VA	0 Volt	0 mA	0 VA

Table 4 presents the contactor-based interlock system works as designed: only one contactor is active when one door is opened. The emergency button successfully cuts off the electric current to both contactors. The measured voltage and current are within the safe range and prove the stability of the system.

Table 5. Results of Testing the Response Time of the Solenoid Door Lock

Experiment	**Response of Solenoid Door Lock for Door 1 (Operation of Push Button 1 at Doors 1 and 2)**	**Response of Solenoid Door Lock for Door 2 (Operation of Push Button 1 at Doors 1 and 2)**	**Response of Solenoid Door Lock for Door 1 (Emergency Operation at Door 2)**	**Response of Solenoid Door Lock for Door 2 (Emergency Operation at Door 2)**
1	0.89 seconds	0.96 seconds	1.04 seconds	1.04 seconds
2	0.88 seconds	0.97 seconds	0.96 seconds	0.97 seconds
3	0.89 seconds	0.96 seconds	0.96 seconds	1.04 seconds
4	0.88 seconds	0.96 seconds	1.04 seconds	0.97 seconds
5	0.80 seconds	0.97 seconds	0.96 seconds	0.97 seconds
Total	4.34 seconds	4.82 seconds	4.96 seconds	4.99 seconds
Average	**0.868 seconds**	**0.964 seconds**	**0.992 seconds**	**0.998 seconds**

Table 3 presents the response behavior of the prototype under various operational scenarios. When Push Button 1 and Push Button 2 on Door 1 are pressed, the system allows only Door 1 to unlock and open, while Door 2 remains securely locked. This condition is confirmed through the activation of Contactor 1, Adapter 1, and Solenoid Door Lock 1. Conversely, when Push Button 1 and Push Button 2 on Door 2 are pressed, the system triggers the unlocking of Door 2 while Door 1 remains closed, showing that the interlock logic operates selectively and prevents both doors from being open at the same time. In contrast, when the Emergency Button is pressed on Door 2, the system bypasses the normal interlock logic, allowing both solenoid locks to be activated simultaneously, which enables both doors to open for emergency evacuation purposes.

In the meantime, Table 4 demonstrates that the control system effectively manages the distribution of electrical loads. When Door 1 is activated, Contactor 1 successfully transmits 236.1 V with a current of 7.63 mA, while Contactor 2 remains inactive, registering no significant voltage or current flow. When Door 2 is activated, the process is reversed, with Contactor 2 supplying 237 V and 7.64 mA, while Contactor 1 stays idle. During emergency scenarios, both contactors are deactivated, indicating that the system redirects control to a dedicated safety path for solenoid activation, independent of the contactor circuit. This safety mechanism ensures the doors can be opened without delay during critical conditions. Furthermore, Table 5 summarizes the solenoid door lock response times during normal and emergency operations. Under normal conditions, when the doors are operated using push buttons, the Door 1's solenoid lock consistently responded slightly faster than Door 2's, a difference that could be attributed to variations in wiring distance or electrical resistance. During emergency testing, the response time for both solenoids slightly increased, although all activation times remained under 1.05 seconds, which is within the acceptable range for medical and hospital safety standards. Overall, these test results validate the reliability and efficiency of the prototype, confirming its capability to perform well under both routine and emergency conditions, and making it suitable for real-world application in sterile room environments.

The data analysis concludes that the electric contactor-based interlock system prototype for hospital sterile room doors is suitable for operation. The interlock system prototype for the sterile room doors designed by the researcher functions as intended. Key features of the interlock system for the sterile room doors are that only one push button on either door 1 or door 2 can be pressed at the same time. At the time of interlock, only one sterile room door can be opened (the doors cannot be opened simultaneously). The interlock system for these sterile room doors can only operate when both doors 1 and 2 are closed, indicated by the yellow pilot light being on at both doors. If either door 1 or door 2 is open, the interlock system cannot operate, and thus push button 1 or push button 2 cannot be pressed (operated). The researcher also added an emergency operation feature so that both doors 1 and 2 can be opened simultaneously, indicated by the red pilot light being on, which is intended for emergencies, such as admitting or discharging patients from the sterile room.

When push button 1 or 2 at door 1 is pressed, the green pilot light at door 1 turns on, indicating the door can be opened, while door 2 remains locked with its pilot light off. The interlock system activates contactor 1, sending 7.63 mA to adapter 1 and unlocking door 1. Solenoid door lock 1 operates in 0.80 seconds with a 0.89-second delay. When push button 1 or 2 at door 2 is pressed, the green pilot light at door 2 turns on, indicating the door can be opened, while door 1 remains locked with its pilot light off. The interlock system activates contactor 2, sending 7.64 mA to adapter 2, which powers solenoid door lock 2 to unlock door 2. Contactor 1 remains inactive, keeping door 1 locked. Solenoid door lock 2 operates in 0.96 seconds with a delay of 0.97 seconds. During the emergency test at door 2, both doors 1 and 2 can be opened, indicated by red pilot lights on and yellow lights off. This occurs because AC current bypasses the contactors and directly powers both adapters, activating solenoid door locks 1 and 2. Solenoid 1 operates in 0.96 seconds with a 1.04-second delay, and solenoid 2 operates in 0.97 seconds with the same delay.

Conclusion

Based on the research on the prototype interlock system for the sterilization room doors in hospitals using electric contactors. Therefore, it can be said that the design incorporates a number of electrical parts, including pilot lights, contactors, solenoid door locks, toggle switches, leaf switches, and adapters. This design has been successfully operated effectively, ensuring the desired functionality. The testing reveals that this interlock system maintains the security and cleanliness of the sterilizing chamber, limiting air contamination between rooms by ensuring that only one door may be opened at a time. The output current is 7.63 mA for contactor 1 and 7.64 mA for contactor 2, with operational speeds of 0.80 seconds for solenoid door lock 1 and 0.96 seconds for solenoid door lock 2. In conclusion, the contactor-based interlock system shows stable performance with nearly balanced output currents (7.63 mA and 7.64 mA) and fast solenoid response time, making it suitable for use in sterile room door access control.

References

[1] A. Nugroho, "Technology Innovation to Support Work Efficiency in the Digital Era," Journal of Technology and Information Systems, vol. 11, no. 2, pp. 45-52, 2022.

[2] World Health Organization, Infection Prevention and Control during Health Care when COVID-19 is Suspected: Interim Guidance, Geneva: WHO Press, 2020.

[3] H. Siregar and T. Rachman, "Design of an Interlock Door System for Cleanroom Applications Using PLC and Solenoid Locks," Journal of Industrial System Engineering, vol. 9, no. 1, pp. 25-34, 2021.

[4] L. P. Johnson and J. K. Smith, "Application of Interlock Systems in Hospital Cleanrooms," International Journal of Automation and Control Engineering, vol. 14, no. 2, pp. 56-63, 2018.

[5] M. H. Clark, "Development of an Automated Door Interlock System for Hospital Sterile Environments," Journal of Healthcare Engineering, vol. 15, no. 3, pp. 112-120, 2019.

[6] S. R. Gupta and A. R. Das, "Enhancing Sterile Room Safety with Electric Contactor-Based Interlock Systems," IEEE Transactions on Industrial Electronics, vol. 67, no. 11, pp. 9876-9884, Nov. 2020.

[7] Akbar, Gilang Lailul. (2021). "*Rancang Bangun Alat Wiring Diagram Thrust Reverse Engine System Boeing 737-200 Sebagai Media Pembelajaran Di Politeknik Penerbangan Surabaya*". Jurnal Teknologi Penerbangan, Vol. 5, No. 2.

[8] Arzaq Haris Mastain, dkk. (2021). "Kendali Motor Induksi Tiga Fasa Menggunakan Programmable Logic Controller Dengan Metode Star". Procedia of Engineering and Life Science, Vol.1, No. 1.

[9] BAB%202. (nd), dari http://repository.unimar amni.ac.id/1880/2/BAB%202.pdf. [Accessed: agust. 13, 2024]

[10] Faishal, Ahmad Nur, dkk. (2023). "*Implementasi Google Voice Pada Sistem Smart Door Lock Berbasis Arduino*". Jurnal Dipanegara Komputer Teknik Informatika, Vol. XVI, No. 2.

[11] Hidayati, Nurleli, dkk. (2017). “*Sistem Kontrol Kestabilan Suhu Penghangat Nasi Menggunakan Metode* Fuzzy Logic”. jurnal.umj.ac.id/index.php/semnastek, e-ISSN : 2460 – 8416.
[12] Markus dan Firman Iman. (2021). “*Perancangan Sistem Tata Udara pada Instalasi Ruang Farmasi RSAB Harapan Kita Jakarta*”. Jurnal Energi, Vol. 11, No. 2.
[13] Sanci, Maria Alfonsia dan Ardelia Astriany Rizky. (2022). “*Perancangan Kunci Pintu Otomatis Pada Ruang Sentral Telekomunikasi (Sto) Di Telkom Menggunakan* Solenoid Door Lock *dan* Touch Sensor *Berbasis Arduino Uno*”. Jurnal Informatika dan Komputer (INFOKOM), Vol. 10, No. 2.
[14] Sander, Alex, dkk. (2022). “*Membangun Perangkat Bilik Masker Otomatis Untuk Pencegahan* Covid-19”. Jurnal Teknik Informatika Mahakarya (JTIM), Vol. 5, No. 1.
[15] Septyan, Panji, dkk. (2017). “*Sistem* Interlocking *Persinyalan Berbasis PLC dengan Metode HSB (*hot standby*) Local Control Panel (LCP)*”. Jurnal teknik elektro politeknik negeri Bandung, Vol. 1, No.1.
[16] Subawani, Wahyu. (2019). “*Sistem Pengunci Pintu Otomatis Berbasis Arduino Menggunakan*”. Password. Journal Engineering And Technology International, Vol. 1, No. 1.
[17] Umam, Faikul Dkk (2017), Motor Listrik. Malang: Media Nusa Creative
[18] Utomo, Bambang Tri Wahyo. (2006). “*Perancangan Pengendali Model Tangan Robot Menggunakan Volume Suara Manusia*”. Jurnal Ilmiah Teknologi dan Informasi ASIA, Vol. 1 No. 1.
[19] Yosua, Paul dkk. (2021) “*Rancang Bangun* Automatic Washing *and* Drying System *untuk Mesin Pencuci* Cylinder Block Motor”. Jurnal Ilmiah Wahana Pendidikan,Vol. 7, No. 4.
[20] Datasheet for component [Solenoid doorlock]," Farnell, [Online]. Available: https://www.farnell.com/datasheets/2865763.pdf. [Accessed: agust. 13, 2024].
[21] Schneider Electric, "LC1D806K7 - IEC contactor, TeSys Deca, nonreversing, 80A, 60HP at 480VAC, 3 phase, 3 pole, 3 NO, 100VAC 50/60Hz coil, open style," Apr. 12, 2023. [Online]. Available: https://media.distributordatasolutions.com/schneider_synd/2023q2/documents/9a20de8e4cf68327a20250425ff6c2898896cf90.pdf. [Accessed: Agust. 13, 2024].