# Implementation of Automatic Roller Door for Ventilation Control at 275 fm Level


Prepared by: S. Suheerman

Trainee Mining Engineer

Bogala Graphite Lanka PLC


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# 1. INTRODUCTION

As a trainee mining engineer within the Department of Earth Resources Engineering at the University of Moratuwa, I have been engaged in a project aimed at addressing a significant operational challenge encountered at the 275 fm level of Bogala Graphite Lanka PLC's mining facility. The issue pertains to the difficulty experienced by underground workers, particularly when transporting trolleys, in manually operating the existing ventilation door. Recognizing the potential for enhanced efficiency and safety, I proposed the implementation of a motorized roller door system integrated with sensors capable of detecting human and trolley motion, thus automating the door operation process.

Through a systematic testing phase, we have successfully validated the feasibility of this proposed solution, affirming its efficacy in improving operational fluidity and mitigating physical strain on workers. Subsequently, the motorized roller door has been installed underground on a trial basis, accompanied by the temporary placement of sensors. Initial observations indicate promising results, prompting the progression towards the permanent installation of all sensors and associated circuitry.

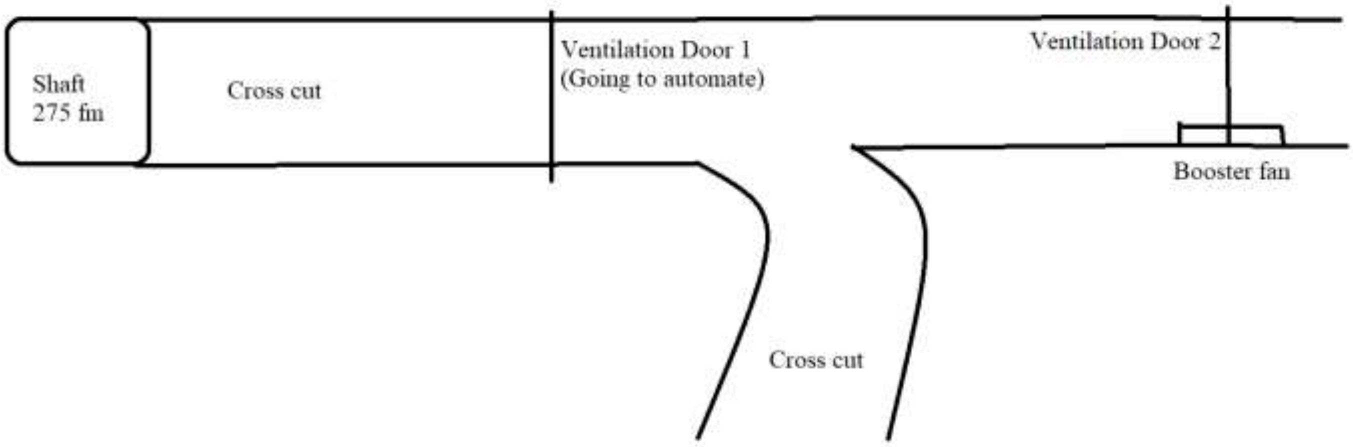
This report aims to provide a comprehensive overview of the project, detailing its objectives, background information, the current setup of the ventilation door, rationale for adopting an automatic roller door system, proposed design specifications, component selection criteria, installation plan, safety considerations, cost analysis, project timeline, expected benefits, conclusion, and recommendations. By documenting our approach and findings, this report seeks to inform stakeholders about the project's progress and outcomes, as well as provide insights for future endeavors in ventilation control within mining environments.

# 2. OBJECTIVES

1. Develop and integrate motion sensors capable of accurately detecting human presence and trolleys, with or without occupants, within the vicinity of the ventilation door.
2. Implement obstacle detection sensors beneath the door to identify any obstructions and prevent potential hazards during operation.
3. Ensure the functionality of sensors in challenging underground conditions, including variations in temperature and humidity, to maintain reliable performance.
4. Enable the circuit board to receive and process sensor outputs efficiently, initiating motorized door operation upon motion detection.

5. Implement an automated door closing mechanism activated after a predetermined period of inactivity, enhancing operational efficiency and safety.
6. Incorporate an alarm system, such as a buzzer, to alert personnel in the event of an obstacle detected under the door, ensuring prompt intervention and hazard mitigation.
7. Install visual indicators, including a green signal when the door is fully open and a red signal indicating closed, partially open, or in motion states, enhancing situational awareness for personnel.
8. Integrate a mechanical barrier mechanism to halt trolleys in case of door operation failures, preventing potential accidents and ensuring operational continuity.
9. Ensure that the motorized roller door system effectively blocks airflow, maintaining the desired ventilation control comparable to the previous manual door.
10. Incorporate fail-safe mechanisms to address potential system malfunctions, such as emergency stop functionalities or backup power sources, to uphold operational reliability and safety standards.

# 3. BACKGROUND INFORMATION




The ventilation system within the Bogala Graphite Lanka PLC mine plays a pivotal role in maintaining safe and conducive working conditions for underground operations. At the deepest level of the mine, 275 fm level, lies a critical juncture where efficient ventilation control is paramount. Currently, this level is outfitted with two manual ventilation doors, serving as primary conduits for regulating airflow and atmospheric conditions within the underground workspace.

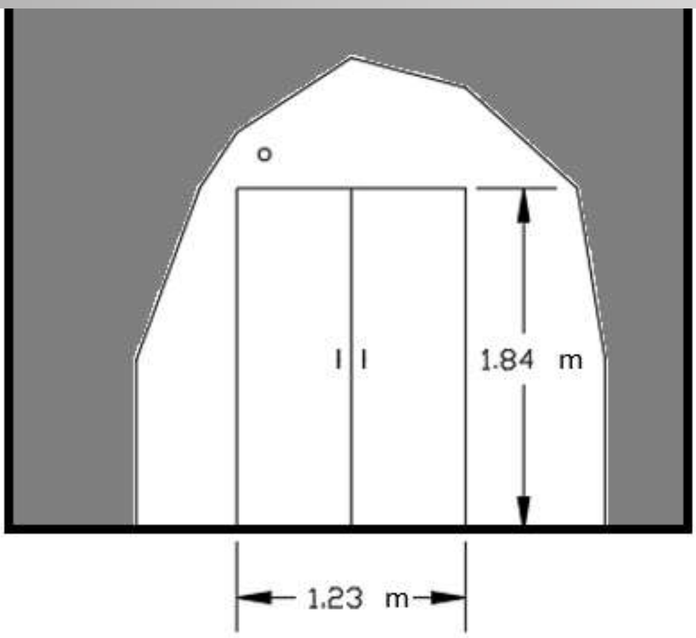
The prevailing operational challenge stems from the manual operation of these ventilation doors, particularly when confronted with the formidable force of wind, exacerbated by the transportation of trolleys. The high-pressure environment at this depth renders the task of opening and closing the doors arduous and labor-intensive, posing ergonomic strains on personnel and impeding operational fluidity.

Proper ventilation stands as an indispensable pillar in the realm of mining operations, serving multifaceted purposes beyond merely regulating airflow. Effective ventilation aids in dissipating heat generated by machinery and processes, mitigating the risk of overheating and creating a more comfortable working environment.

Furthermore, ventilation systems contribute significantly to dust suppression, vital for reducing respiratory health risks and maintaining optimal visibility underground. By facilitating the dispersion of airborne particulate matter, ventilation systems uphold air quality standards, aligning with regulatory requirements and industry best practices.

In essence, the efficacy of the ventilation system directly correlates with operational safety, productivity, and environmental stewardship within the mining domain. Enhancing the ventilation infrastructure, particularly at the 275 fm level, holds the potential to not only alleviate operational challenges but also elevate overall workplace safety and efficiency to new heights.

# 4. CURRENT VENTILATION DOOR




At present, the ventilation door installed at the 275 fm level of Bogala Graphite Lanka PLC's mining facility is characterized by a robust construction predominantly composed of steel. The door, designed as a double-door configuration, features two steel panels that can be opened unilaterally to facilitate ingress and egress of personnel and equipment.

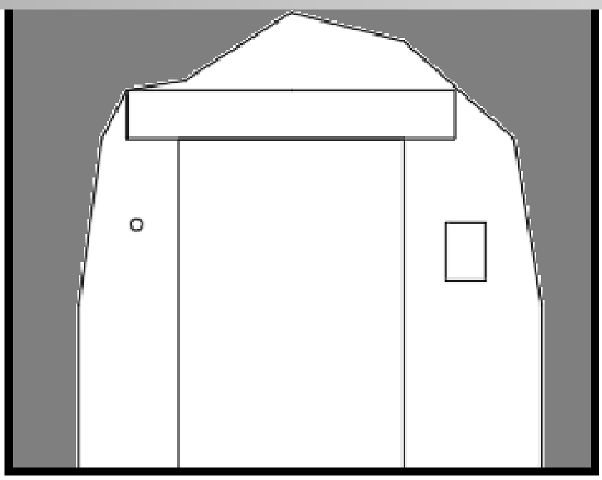
Each door panel is equipped with door latches, meticulously mounted into the floor, to prevent inadvertent closure due to the prevailing air pressure within the underground environment. The incorporation of these latches serves as a crucial safety measure, ensuring the secure retention of the doors in the open position, thereby mitigating the risk of sudden closure.

However, the operational dynamics associated with the current ventilation door present notable challenges for underground workers. Closing the doors necessitates considerable physical exertion and attention to prevent rapid closure and potential collision between the door panels. The formidable air pressure exerted within the mine accentuates the difficulty in managing the door's movement, thereby amplifying the risk of inadvertent damage and operational disruptions.

The manual manipulation required to operate the ventilation door, coupled with the inherent complexities of managing airflow dynamics, engenders a labor-intensive and potentially hazardous process for personnel. Consequently, the existing ventilation door setup not only compromises operational efficiency but also poses ergonomic concerns, impeding the seamless execution of underground activities.

In light of these operational limitations and safety considerations, there arises a compelling imperative to explore and implement innovative solutions aimed at enhancing the functionality and ergonomics of the ventilation door system. The transition towards an automatic roller door system, integrated with advanced sensor technologies, emerges as a promising avenue for addressing the prevailing challenges and optimizing operational performance within the mining environment.

# 5. RATIONALE FOR AUTOMATIC VENTILATION DOOR



The transition from a manual ventilation door setup to an automatic roller door system represents a strategic imperative rooted in the imperative of operational optimization and enhanced workplace safety within the mining environment. Several compelling factors underscore the rationale for embracing this technological advancement:

1. **Operational Efficiency**: The manual operation of the current ventilation door entails significant physical exertion and attention from underground workers, particularly when contending with the formidable air pressure within the mine. By automating the door operation process through the implementation of a motorized roller door system, the need for manual intervention is obviated, thereby streamlining operational workflows and minimizing personnel exertion.
2. **Enhanced Safety**: The utilization of an automatic roller door system mitigates inherent safety risks associated with manual door operation, particularly in high-pressure environments. Automation reduces the likelihood of human error and inadvertent mishaps during door manipulation, thereby fostering a safer working environment for underground personnel. Additionally, the integration of advanced sensor technologies enhances hazard detection capabilities, facilitating prompt intervention and mitigating potential accidents.
3. **Ergonomic Considerations**: The manual handling of the current ventilation door poses ergonomic challenges for underground workers, exacerbating physical strain and fatigue. By transitioning to an automatic roller door system, ergonomic concerns are alleviated, as personnel are relieved from the demanding task of manually operating heavy doors against substantial air pressure. This ergonomic enhancement not only enhances workforce well-being but also contributes to improved productivity and morale.
4. **Optimized Ventilation Control**: The automatic roller door system enables precise control over ventilation dynamics within the underground workspace, facilitating seamless adjustment of airflow as per operational requirements. The automated nature of the system ensures consistent and reliable ventilation management, thereby optimizing environmental conditions and supporting optimal working conditions for personnel.
5. **Operational Continuity**: Automation enhances the resilience and reliability of the ventilation door system, ensuring uninterrupted operational continuity even amidst challenging conditions. By reducing the reliance on manual intervention, the automatic roller door system mitigates the risk of operational disruptions due to personnel availability or human error, thereby bolstering overall operational resilience.

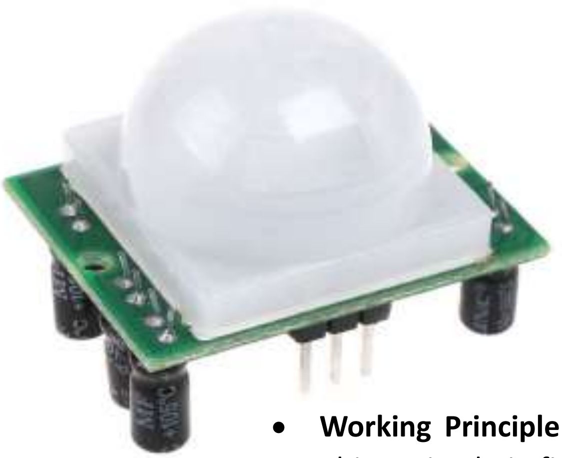
In essence, the adoption of an automatic roller door system transcends mere technological modernization; it embodies a strategic imperative aimed at elevating operational efficiency, enhancing workplace safety, and fostering a conducive and sustainable working environment within the mining domain. By embracing automation, Bogala Graphite Lanka PLC stands poised to unlock tangible benefits in terms of operational performance, workforce well-being, and environmental stewardship.

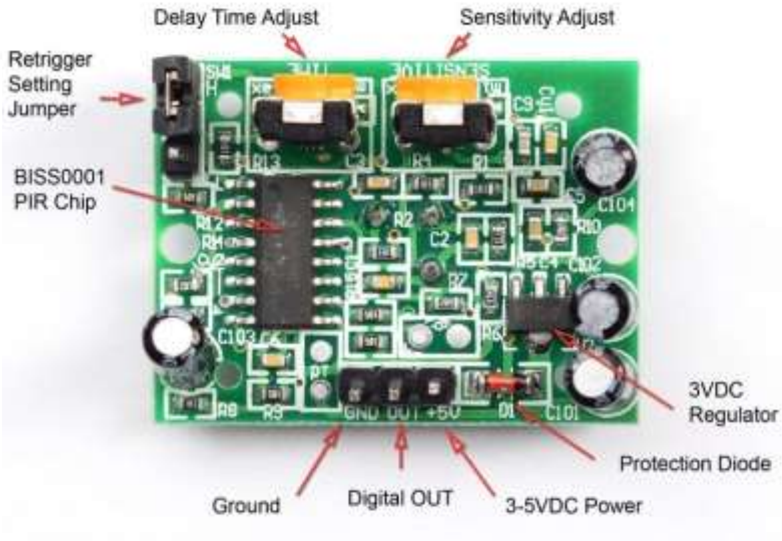
# 6. COMPONENTS AND SENSORS SELECTION

The selection of components and sensors for the automatic roller door system is a critical aspect of ensuring reliable and efficient operation within the underground mining environment. Each component was meticulously chosen based on its functionality, compatibility, and suitability for the intended application. Below is an overview of the selected components and sensors, along with their respective working principles:

1. **Roller Door**: Imported from THREE SINHA Industry, the roller door serves as the primary mechanism for regulating access and airflow within the ventilation system. Its operation is controlled by the motorized system, which is integrated with sensors and circuitry for automated functionality. (Details of the components are available as an attachment with this report).

2. **Passive Infrared (PIR) Sensors (5):**






- **Working Principle**: PIR sensors detect infrared radiation emitted by objects in their field of view. They consist of a pyroelectric sensor, which generates an electric charge when exposed to infrared radiation, and a Fresnel lens, which focuses the infrared radiation onto the sensor. When a human or object moves within the sensor's detection range, it causes a change in the infrared radiation pattern, resulting in a fluctuation in the electric charge generated by the pyroelectric sensor. This change is detected by the sensor's electronics, which then triggers an output signal indicating motion detection.
- **Application:** PIR sensors are commonly used in motion detection applications, such as security systems, automatic lighting controls, and occupancy sensing. In the context of the automatic roller door system, PIR sensors are positioned strategically near the door entrance to detect the presence of humans or trolleys. When motion is detected, the PIR sensor sends a signal to the control circuitry, initiating the door opening process.

- **Advantages:**
  - Low power consumption.
  - Fast response time.
  - Wide detection range.
  - Relatively inexpensive.
  - Suitable for battery-powered applications.
- **Limitations:**
  - Limited detection range in certain environmental conditions.
  - Susceptible to false triggers from sources of infrared radiation, such as sunlight and heating elements.

**3. Proximity Infrared (IR) Sensors(2):**


- **Working Principle:** Proximity IR sensors emit infrared light and measure the reflection to determine the presence of objects in their vicinity. They typically consist of an infrared light-emitting diode (LED) and a photodetector. The LED emits infrared light, which reflects off nearby objects and is detected by the photodetector. The distance to the object is determined based on the intensity of the reflected infrared light. When an object is detected within the sensor's proximity threshold, the sensor sends a signal to the control circuitry indicating the presence of an obstacle.
- **Application:** Proximity IR sensors are commonly used for object detection and proximity sensing in various applications, including robotics, automation, and industrial safety systems. In the context of the automatic roller door system, proximity IR sensors are installed beneath the door to detect any obstacles or obstructions in its path during operation. If an obstacle is detected, the sensor triggers an alarm and halts the door movement to prevent collisions and ensure personnel safety.
- **Advantages:**
  - Non-contact detection.
  - High reliability and accuracy.

- Suitable for detecting a wide range of materials.
- Fast response time.
- Compact and lightweight design.

- **Limitations:**
    - Limited detection range compared to other proximity sensors.
    - Susceptible to interference from ambient light sources.
    - Requires proper calibration and adjustment for optimal performance.

4. **Arduino Uno R3 Board**:


The Arduino Uno R3 board serves as the central control unit for the automatic roller door system. It receives input signals from the sensors and processes them according to predefined logic. Based on sensor inputs, the Arduino board controls the operation of the roller door motor and coordinates the activation of auxiliary components such as the buzzer and indicator bulbs.

5. **Relay Module**:


The relay module acts as an interface between the Arduino board and the roller door motor circuit. It receives control signals from the Arduino and switches the motor circuit on or off accordingly, enabling seamless integration and control of the motorized door system.

6. **Buzzers (3)**:

The buzzer is employed to provide audible alerts in the event of an obstacle detected by the proximity IR sensors. It emits a distinctive sound to alert personnel to potential hazards, ensuring timely intervention and hazard mitigation.

7. **Indicator Bulbs (Red and Green)**:

These bulbs serve as visual indicators of the door's status. The green bulb illuminates when the door is fully open, providing a clear indication of safe passage. Conversely, the red bulb signifies other states such as closed, partially open, or in motion, enhancing situational awareness for personnel.

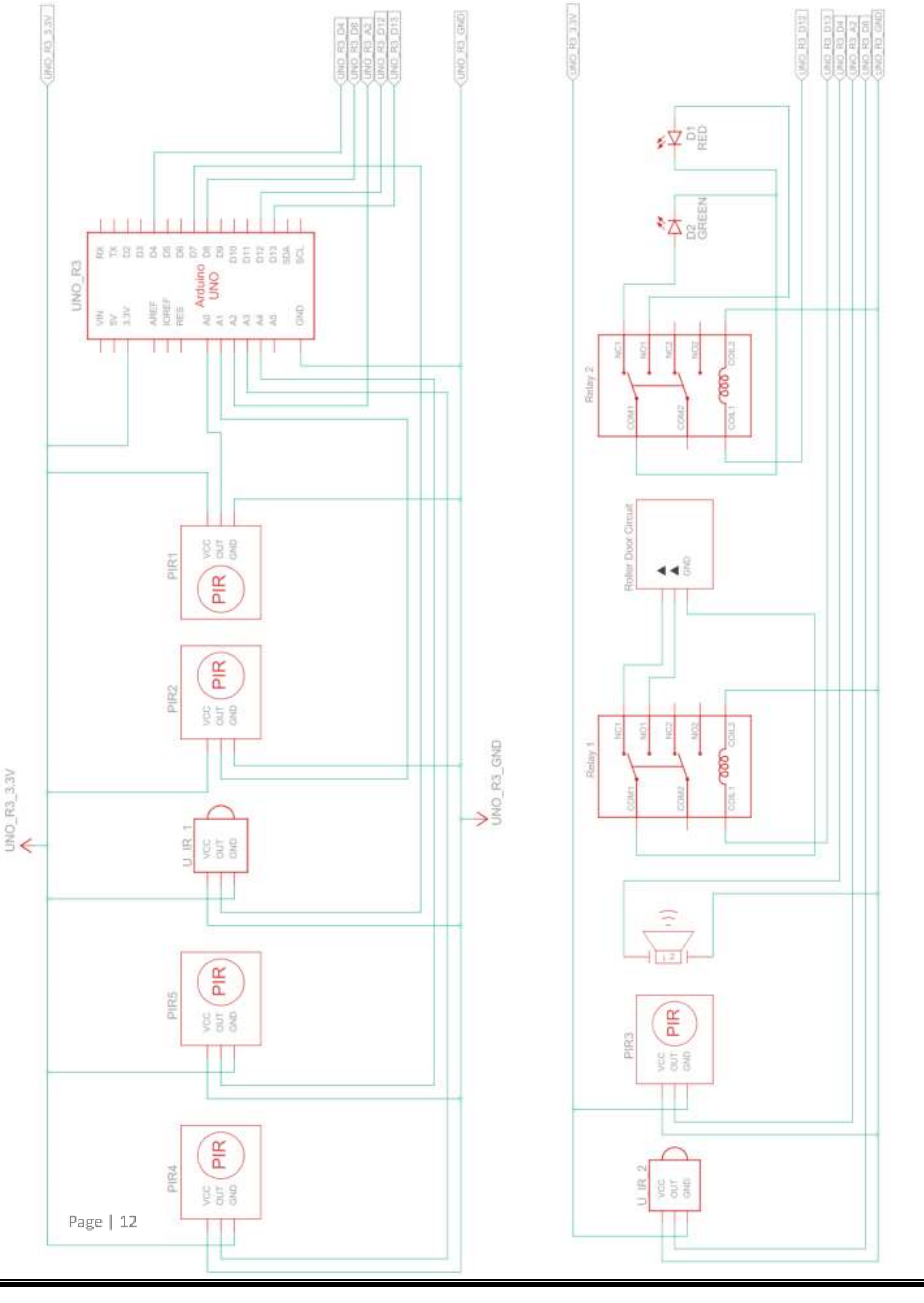
8. **Network Cables and Connectors**: Network cables and connectors are utilized to establish connectivity between electronic components, power sources, and circuit boards. They facilitate the transmission of signals and power, ensuring seamless communication and integration within the system.

9. **Conduit Pipes**: Conduit pipes are employed to protect network wires and cables from environmental factors such as moisture, dust, and mechanical damage. They provide a durable and secure housing for wiring, safeguarding against potential disruptions to system functionality.

10. **Plastic Enclosure Boxes**: These boxes serve as protective enclosures for the Arduino board and sensors, shielding them from environmental hazards such as humidity and dust. By enclosing sensitive electronic components, the plastic boxes enhance the reliability and longevity of the automatic roller door system, ensuring sustained performance in underground conditions.

The selected components and sensors are carefully chosen to facilitate the seamless operation of the automatic roller door system, enhancing operational efficiency, safety, and environmental control within the underground mining environment. Each component plays a crucial role in enabling automated functionality and ensuring reliable performance under challenging conditions.

## 7. PROPOSED SYSTEM DESIGN



## 7.1. Arduino Code

```
float sensor = A0;  //define PIR sensor 1
float sensor2 = A1;
float sensor3 = A2;
float sensor4 = A3;
float sensor5 = A4;

int ir1 = 7;  //define IR sensor 2
int ir2 = 8;

int relay1 = 13;  //define relay module 1
int relay2 = 12;

int buzzer = 4; //define buzzer

float sum = 0;
float val, val2, val3, val4, val5 = 0;  // variable to store the PIR sensor
status (value)
int val6, val7 = 1; // variable to store the IR sensor status (value)

void setup() {
  pinMode(sensor, INPUT);     // initialize PIR sensor 1 as an input
  pinMode(sensor2, INPUT);
  pinMode(sensor3, INPUT);
  pinMode(sensor4, INPUT);
  pinMode(sensor5, INPUT);

  pinMode(ir1, INPUT);     // initialize IR sensor 1 as an input
  pinMode(ir2, INPUT);

  pinMode(relay1, OUTPUT);    // initialize IR sensor 1 as an input
  pinMode(relay2, OUTPUT);

  pinMode(4, OUTPUT);   // initialize buzzer

  Serial.begin(9600);        // initialize serial

  digitalWrite(relay1, LOW);    //Door initial state close
  digitalWrite(relay2, LOW);    //Initiallly Red Bulb will be in on status
}

void loop(){

  val = analogRead(sensor);   // read PIR sensor 1 value
  val2 = analogRead(sensor2);
  val3 = analogRead(sensor3);
  val4 = analogRead(sensor4);
  val5 = analogRead(sensor5);
```

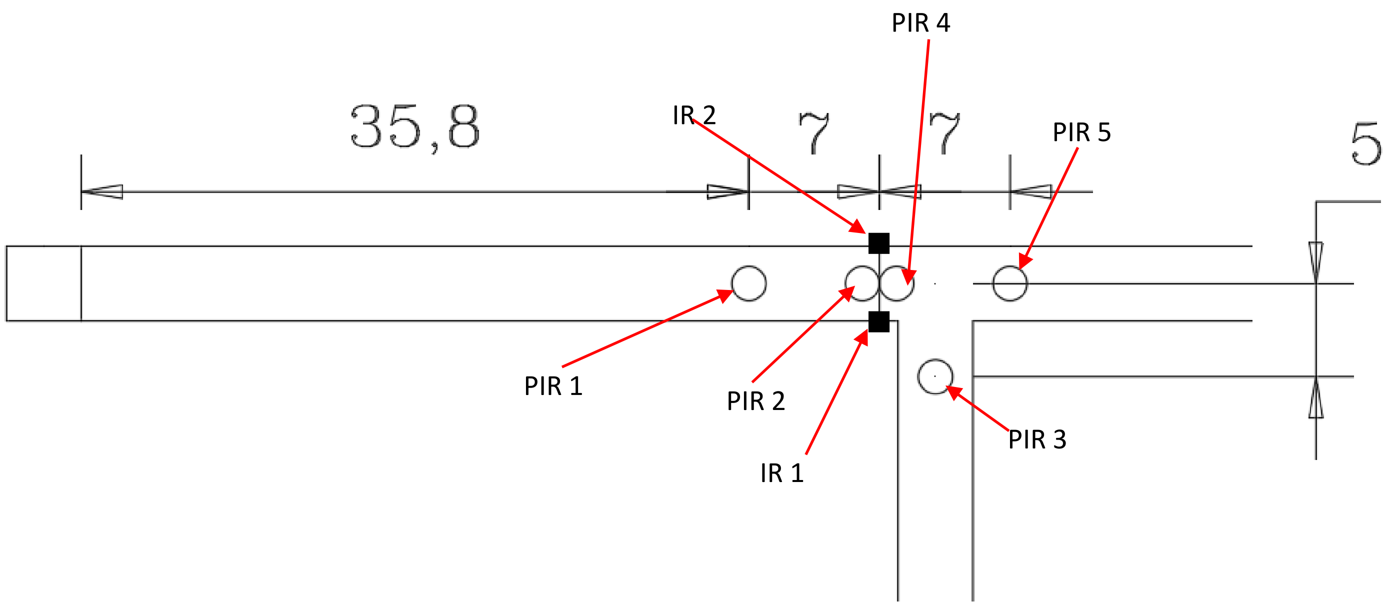
```
  val6 = digitalRead(ir1);    // read IR sensor 1 value
  val7 = digitalRead(ir2);

  float voltage = val * (5.0 / 1023.0);    //calculate the voltage input from
PIR sensor 1
  float voltage2 = val2 * (5.0 / 1023.0);
  float voltage3 = val3 * (5.0 / 1023.0);
  float voltage4 = val4 * (5.0 / 1023.0);
  float voltage5 = val5 * (5.0 / 1023.0);
  float sum = (voltage + voltage2 + voltage3 + voltage4 + voltage5);
 //calculate total voltage from all PIR sensors

  Serial.print(voltage);     //check PIR sensor 1 status in serial monitor
  Serial.print("       ");
  Serial.print(voltage2);
  Serial.print("       ");
  Serial.print(voltage3);
  Serial.print("       ");
  Serial.print(voltage4);
  Serial.print("       ");
  Serial.print(voltage5);
  Serial.print("       ");
  Serial.print(sum);

  if (ir1 == LOW || ir2 == LOW){      // If any obstacles are found under the
door, door will open and buzzer will be alarmed
    digitalWrite(relay1, HIGH);
    digitalWrite(buzzer, HIGH);
    delay(500);
  }
  else if (sum > 1){             // If any pir of the sensor dtects motion
    digitalWrite(relay1, HIGH);    // Door will open
    delay(15000);    // After 15s (Time preiod for fully open the door)
    digitalWrite(relay2, HIGH);      // Green Bulb Signal will turn on
    delay(500);
  }
  else{                                //Otherwise
    digitalWrite(relay1, LOW);       //Door will close
    digitalWrite(relay2, LOW);       //Red Bulb signal will turn on
    digitalWrite(buzzer, LOW);       //Buzzer will turn off
    delay(500);
  }
}
```

# 8. INSTALLATION PLAN




The installation plan for the automatic roller door system entails a systematic approach to integrating the various components and ensuring seamless functionality within the underground mining environment. Leveraging the expertise of Three Sinha Company's customer services, the installation of the motorized roller door has been successfully completed, laying the foundation for the subsequent installation tasks.

1. **Installation of Uninterruptible Power Supply (UPS):** A UPS unit will be strategically positioned in close proximity to the roller door to provide uninterrupted power supply to both the roller door circuit and sensor circuit. This critical component ensures continuous operation of the system, even in the event of power fluctuations or outages.

2. **Power Supply for Arduino Board:** To power the Arduino Uno R3 board and associated components, an external power pack will be utilized. This power pack will be connected to the Arduino board, supplying the necessary voltage and current for optimal performance.

3. **Component Integration:** All other components, including PIR sensors, proximity IR sensors, relay module, buzzer, and indicator bulbs, will be interconnected as per the proposed system design outlined in the report. Each component will be strategically positioned and securely mounted to ensure efficient operation and minimal interference.

4. **Wire Protection:** To safeguard the wiring and cables from environmental hazards and mechanical damage, conduit pipes will be utilized for encasing and routing the wires. These conduit pipes provide durable and secure housing, protecting the wiring infrastructure while maintaining a tidy and organized installation.

5. **Final Testing and Calibration:** Following the installation of all components and wiring, a comprehensive testing and calibration procedure will be conducted to verify the functionality and performance of the automatic roller door system. This includes testing the responsiveness of sensors, verifying the operation of the roller door motor and auxiliary components, and ensuring seamless integration with the control circuitry. Any necessary adjustments or fine-tuning will be performed to optimize system performance and reliability.

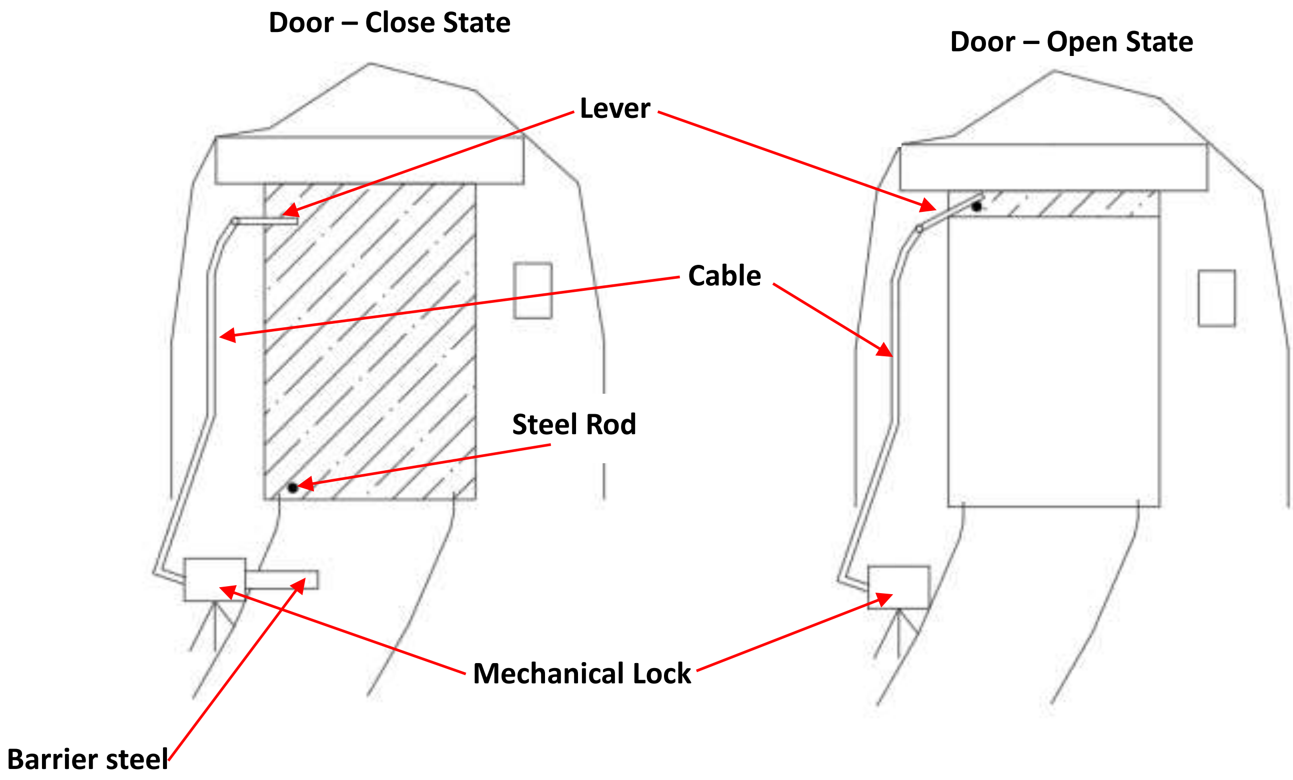
By adhering to the outlined installation plan, we aim to ensure the successful deployment of the automatic roller door system, enhancing operational efficiency, safety, and environmental control within the underground mining environment. Each step of the installation process is meticulously executed to uphold the highest standards of quality and reliability, ensuring the seamless integration and functionality of the system.

# 9. SAFETY CONSIDERATIONS

1. **Enclosure Boxes:** All sensors and circuits will be housed within proper enclosure boxes to protect them from environmental hazards and prevent accidental damage.
2. **Door Operation Timing:** The roller door takes approximately 15 seconds to open or close. This timing is carefully calibrated to ensure safe operation and prevent collisions.
3. **Response Time of PIR Sensors:** PIR sensors have a response time of 1.5 seconds for detecting motion. This parameter is crucial for ensuring timely activation of the door in response to human presence or trolley movement.
4. **Speed Measurements:** Maximum speeds of personnel and trolleys are considered during sensor placement and timing programming to prevent accidents and ensure safe clearance.
5. **Uninterruptible Power Supply (UPS):** A UPS unit is installed to provide continuous power supply, ensuring uninterrupted operation of the automatic roller door system and preventing sudden shutdowns or failures.
6. **Indicator Bulbs:** Red and green indicator bulbs are installed to provide visual status indication of the door from a distance, enhancing situational awareness for personnel.

7. **Mechanical Breaker System:** A mechanical breaker system is implemented for trolleys to halt their movement in case of system failure or emergency. Refer to the diagram for details.
8. **Manual Mode Activation:** In the event of a system failure, a manual mode can be activated by pulling a lever near the control box of the roller door. This allows manual operation of the door by hand.
9. **Power Off Procedure:** Workers are required to turn off the UPS power after completing work for the day while the door is in the open state. This prevents electricity flow to the circuit board, prolonging their lifespan.
10. **Obstacle Removal:** Before powering on the UPS, personnel must ensure all obstacles are removed from under the door to prevent potential collisions during startup.
11. **Sensor Awareness:** All underground workers must be aware of the sensor locations and exercise caution when carrying long objects such as timbers or steel bars to avoid triggering sensors inadvertently.

By adhering to these safety considerations, we aim to mitigate potential hazards and ensure the safe and efficient operation of the automatic roller door system within the underground mining environment.



## 10. COST ANALYSIS

| DESCRIPTION | NO OF UNITS | COST PER UNIT (Rs.) | TOTAL COST (Rs.) |
|---|---|---|---|
| **Motorized roller door** (other details are attached at the end of the report) | 1 | 172,800.00 | 172,800.00 |
| Arduino UNO R3 | 1 | 2,600.00 | 2,600.00 |
| PIR sensor HC-SR501 | 5 | 250.00 | 1,250.00 |
| Proximity IR sensor E18-D80NK | 2 | 580.00 | 1,160.00 |
| Network cable | 25 m | 314.00 | 3,144.00 |
| Relay module | 1 | 140.00 | 140.00 |
| Red indicator bulb | 2 | 80.00 | 160.00 |
| Green indicator bulb | 2 | 80.00 | 160.00 |
| Buzzers | 3 | 170.00 | 510.00 |
| **3-Pin 3-way Screw Terminal Block** | 10 | 25.00 | 250.00 |
| **Enclosure box for PIR sensor** | 5 | 60.00 | 300.00 |
| **Enclosure box for Arduino board** | 1 | 1,350.00 | 1,350.00 |
| Other | - | - | 1,176.00 |
| **Total** | - | - | **185,000.00** |

## 11. PROJECT TIMELINE

1. **Project Initiation and Planning (18/01/2024 - 01/02/2024)**
   - January 18, 2024: Strategy development and finalization of procedures for the automatic ventilation door project.
   - January 23, 2024: Dimension measurement of the ventilation door at 275 fm level.
   - January 30, 2024: Initiation of procurement with Three Sinha for the automatic ventilation door roller.
   - February 1, 2024: Receipt and verification of Arduino board, sensors, and essential equipment. Functionality verification and calibration of Arduino board and sensors.
2. **Model Development and Testing (02/02/2024 - 05/02/2024)**
   - February 2, 2024: Construction and testing of a model with PIR sensors and LED bulbs.

- February 3, 2024: Enhancement of C++ code for improved measurement precision.
- February 4, 2024: Integration of proximity IR sensors and relay modules into a unified system.
- February 5, 2024: Presentation of the model to the Engineer for feedback and refinement.

3. **Addressing Technical Challenges (05/02/2024 - 07/02/2024)**
    - February 5, 2024: Installation of PIR sensor at 275 fm level, encountering temperature-related detection issues.
    - February 6, 2024: Integration of sensors into existing surface automatic roller door system. Design and proposal of mechanical solutions for trolley safety in case of electronic device issues.
    - February 7, 2024: Collaboration with engineers to address technical challenges and implement temporary fixes.
4. **Preparation and Installation (07/02/2024 - 19/03/2024)**
    - February 7, 2024: Measurement of circuit board and control box dimensions for enclosure box fitting.
    - March 5, 2024: Modification of ventilation door at 275 fm level to create space for installation.
    - March 19, 2024: Receipt and installation of motorized roller door at 275 fm level. Calibration of PIR and proximity IR sensors. Drilling holes and routing wires for sensor mounting. Procurement of necessary materials and components for the project.
5. **Integration and Testing (19/03/2024 - 28/03/2024)**
    - March 21, 2024: Mounting of sensors and network cables at 275 fm level.
    - March 22, 2024: Conducting soldering and insulation of wiring connections.
    - March 26, 2024: Engineering of power supply for Arduino board and sensors. Integration of sensors with Arduino board and validation of sensor readings.
    - March 28, 2024: Resolution of issues with relay module and power supply during testing. Implementation of temporary fixes to address challenges and ensure project progress.

This timeline outlines the various phases of the automatic ventilation door project, from initial planning and procurement to installation, integration, and testing. Milestones and deadlines are specified for each phase, ensuring systematic progress towards the successful implementation of the ventilation door system at the 275 fm level. Additionally, it is noted that if the company decides to implement another door, certain steps may not be required, leading to potential adjustments in the timeline and project scope.

## 12. EXPECTED BENIFITS

1. **Enhanced Operational Efficiency:** The implementation of the automatic roller door system promises to streamline operational workflows within the underground mining environment. By automating door operation and reducing the need for manual intervention, the system will optimize personnel productivity and minimize downtime associated with door handling.
2. **Improved Safety:** One of the primary advantages of the automatic roller door system is its enhanced safety features. With sensors strategically positioned to detect human presence, trolleys, and obstacles, the system mitigates the risk of accidents and collisions during door operation. Additionally, the incorporation of visual indicators and audible alarms ensures heightened situational awareness for personnel, further enhancing overall safety within the mining environment.
3. **Enhanced Ventilation Control:** Effective ventilation control is critical for maintaining optimal working conditions and mitigating health risks associated with airborne contaminants in the mining environment. The automatic roller door system facilitates precise regulation of airflow by allowing seamless adjustment of door position based on operational requirements. This ensures consistent and reliable ventilation management, contributing to improved air quality and worker well-being.
4. **Reduced Physical Strain:** The labor-intensive nature of manually operating ventilation doors poses ergonomic challenges for underground workers, particularly in high-pressure environments. By automating door operation, the automatic roller door system alleviates physical strain and fatigue associated with door handling, promoting worker health and reducing the risk of musculoskeletal injuries.
5. **Enhanced System Reliability:** The integration of advanced sensor technologies and fail-safe mechanisms enhances the reliability and resilience of the ventilation door system. With features such as uninterrupted power supply (UPS) and mechanical breaker systems for trolleys, the system is equipped to withstand operational challenges and ensure continuous functionality even in adverse conditions.
6. **Improved Environmental Control:** The automatic roller door system contributes to effective environmental control within the underground mining environment by

facilitating precise regulation of airflow and temperature. By minimizing air leakage and optimizing ventilation dynamics, the system helps maintain stable environmental conditions, thereby enhancing operational efficiency and supporting optimal working conditions for personnel.

# 13. CONCLUSION

The implementation of the automatic roller door system at the 275 fm level of Bogala Graphite Lanka PLC marks a significant advancement in addressing longstanding operational challenges and enhancing workplace safety within the underground mining environment. The transition from manual ventilation doors to an automated system represents a strategic response to ergonomic strains, safety hazards, and operational inefficiencies associated with the existing setup. By integrating advanced sensor technologies and automation, the project aims to streamline door operation, optimize ventilation control, and reduce physical strain on underground workers. Moreover, meticulous planning and consideration of safety measures, such as component enclosure, timing calibration, and mechanical breaker systems, underscore the commitment to ensuring a safe and efficient working environment.

The anticipated benefits of the automatic roller door system extend beyond operational efficiency to encompass improved safety standards, enhanced environmental control, and heightened worker satisfaction. Through precise timing calibration, reliable sensor detection, and fail-safe mechanisms, the system is poised to mitigate accidents, minimize downtime, and optimize airflow dynamics within the mining environment. Ultimately, the successful execution of this project holds the promise of transformative impacts, positioning Bogala Graphite Lanka PLC at the forefront of technological innovation and sustainable mining practices. As the mining industry continues to evolve, the adoption of advanced automation solutions underscores the organization's commitment to operational excellence, worker well-being, and environmental stewardship.

# 14. RECOMMENDATIONS

While the implementation of the automatic roller door system represents a significant step towards improving operational efficiency and safety within the underground mining environment, there are several additional recommendations and suggestions that could further enhance the project's effectiveness:

1. **Regular Maintenance and Monitoring:** It is recommended to establish a routine maintenance schedule for the automatic roller door system, including periodic inspections, lubrication of moving parts, and testing of sensors and circuitry. This proactive approach will help identify potential issues early on and prevent unexpected downtime or failures.
2. **Employee Training and Awareness:** Providing comprehensive training programs for underground workers on the operation and safety protocols of the automatic roller door system is essential. Workers should be educated on the proper use of manual override mechanisms, emergency procedures, and the importance of adhering to safety guidelines when working near the door.
3. **Continuous Improvement:** Encouraging feedback from employees and stakeholders regarding their experiences with the automatic roller door system can provide valuable insights for ongoing improvement. Regularly evaluating system performance, identifying areas for enhancement, and implementing iterative upgrades will ensure the system remains adaptive and responsive to evolving operational needs.
4. **Integration with Monitoring Systems:** Consider integrating the automatic roller door system with broader monitoring and control systems used within the mining facility. This integration can enable real-time monitoring of door status, sensor data, and operational metrics, facilitating proactive decision-making and optimization of ventilation strategies.
5. **Exploration of Advanced Technologies:** Continuously exploring advancements in sensor technologies, automation techniques, and energy-efficient components can further optimize the performance and sustainability of the automatic roller door system. Investigating the feasibility of incorporating artificial intelligence (AI) algorithms or machine learning capabilities for predictive maintenance and adaptive control could unlock additional benefits.

Addressing these recommendations will help maximize the benefits of the automatic roller door system, mitigate potential challenges, and ensure its long-term effectiveness in enhancing operational efficiency, safety, and environmental control within the underground mining environment. By embracing a culture of continuous improvement and innovation, Bogala Graphite Lanka PLC can solidify its position as a leader in technological excellence and sustainable mining practices.

**Additional Recommendation: Sensor Replacement and Calibration**

In the event of any sensor malfunction identified within the automatic roller door system, it is imperative to promptly replace the faulty sensor with a new one to ensure continued functionality and safety. Before fixing the new sensor in place, it is crucial to undertake a comprehensive calibration process to ensure optimal performance and alignment with system requirements.