

## ATMEGA MICROCONTROLLER 2560 BASED SAFETY SYSTEM OF MONITOR PANEL AND CONTROL- LER ON A SMALL EXCAVATOR

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*This study aimed to design and build an Atmega Microcontroller 2560 based safety system on a monitor panel and a controller on a small excavator. Atmega 2560 Microcontroller-based alarm technology is the right choice as a solution to prevent theft of monitor panels and controllers on small excavator units, using Passive Infra-Red (PIR) sensor number 1 in the cabin room, PIR sensor number 2 on the battery, and door switch that is between the cabin and the door, if there is theft in the cabin room, then the alarm will be active, if a theft occurs in the battery then the alarm will be active. The alarm indicator system uses a buzzer (horn) unit, and there is additional lighting in the cabin room with a 24V Light Emitting Diode (LED) lamp if the alarm is active. Using an alarm, the risk of losing the monitor panel and controller due to theft on the unit can be prevented. The study results showed that the tool could work appropriately according to the standard testing tool, PIR sensors number 1 and 2 could detect movement or radiation so that the alarm would be active for 15 seconds. The door switch was tested by looking at the alarm condition, if the cabin door were closed when it was in the locked position, the alarm would not be active, but if the door was locked and forcibly opened, then the alarm would be active continuously without stopping until the door was closed again.*

**Keywords:** Monitor Panel and Controller, Atmega 2560 Microcontroller, Small Excavator, PIR sensor, Door Switch

## 1. INTRODUCTION

The hydraulic excavator is a tool that can be used to dig the ground (digging), load material into a dump truck (loading), lift material (lifting), scrape the rock (scraping), and grade the ground (grading) [1]. The excavator is widely used for mining, river excavation, and road opening or maintenance [2]. Among the various types of work performed by the hydraulic excavator, excavation has the highest percentage. The hydraulic excavator is used in various locations where easy use makes it accessible [3].

Based on [4], small excavators often experience component theft, especially monitor panels and controllers. The loss caused billions of rupiah in losses, where per unit reached up to hundreds of millions. Small excavators often experience the risk of loss on plantations, road construction, and river excavation because the work is always performed until the evening.

The use of Arduino microcontroller as a safety system has been widely developed [5-10]. Mowad, et al. [5] and Ohsung and Ilkyu [6] used Arduino Uno microcontroller as hardware and Android as software. They combined both as an automation system for smart home and door lock systems. Meanwhile, in [7], [9] Arduino was used as a microcontroller to simulate a DC motor, and in [8] was used to monitor radiation. In [10], Arduino and GSM Cards were used for power system protection. In its application, Arduino, as a microcontroller, is also applied to the heavy equipment industry as in [11-14].

Meanwhile, various security systems with PIR sensors and Arduino as microcontrollers have been developed [15-17]. In [15], the system uses PIR sensors to detect motion in smart home applications and provides short message output via GSM devices. PIR sensor was used to detect the movement of thieves and send a signal to the microcontroller which will then be processed to activate the servo motor to open and close

the computer laboratory door on [16] and the safety system in the garage used PIR sensor with output in the form of sliding camera in [17].

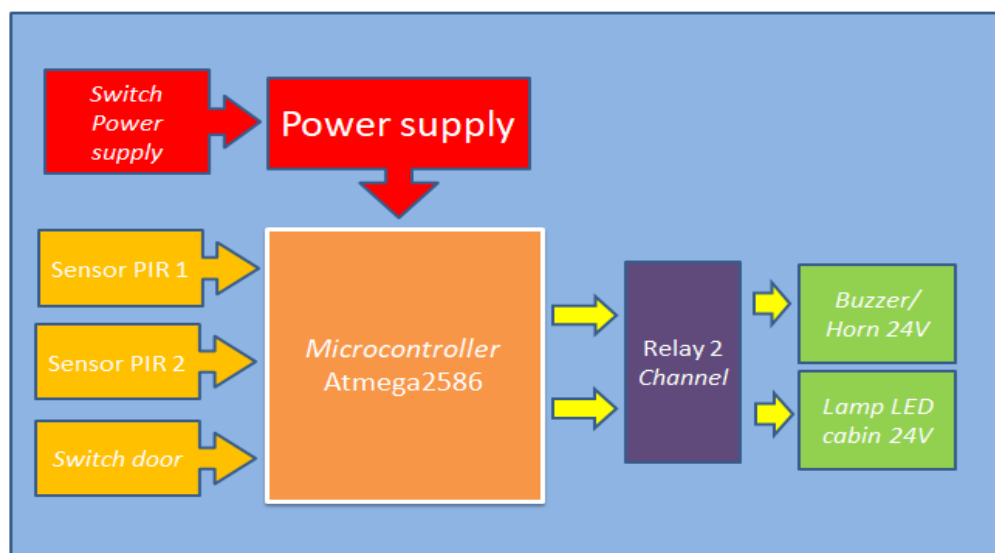
In contrast to [5-10], the system's development was only on simulations and prototypes. Still, in this study, it was directly applied to small excavators as mostly used heavy equipment in the mining and plantation industries. The developed system used buzzer and LED as outputs with the 24-volt power source to alert the owner and warn the thief.

## 2. MATERIAL AND METHOD

### 2.1 Block Diagram

In this study, the block diagram is used to determine the components as the input, controller, and output. Also, the block diagram serves to show the workflow of a system simply.

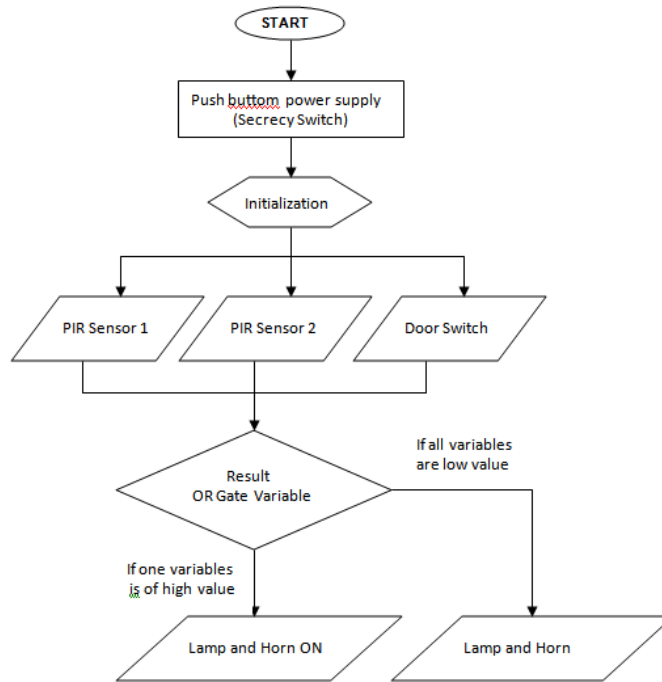
The Block diagram of the system can be seen in Figure 1. A Block diagram is used to map the workflow of tools as a safety system. It aims to make it easier to recognize the function of tools. There are three sub-components in a block diagram that have different roles. The input consists of a power supply switch, PIR1 sensor, PIR2 sensor, door switch, controller in the form of Arduino Mega ATmega 2560, and the output consists of 24-volt buzzer and LED lamp.



**Figure 1:** block diagram of the system.

### 2.2 Flow chart

Flow chart functions to determine how to work, process, and the algorithm as in [16,18,19]. The developed device is a safety system that will be applied to small excavator unit with inputs in the form of PIR sensor to detect movement, and door switches with limit switches, Arduino Mega (Microcontroller IC Atmega 2560) is used as a data and information processing center as shown in Figure 2. Arduino output will be set based on the sensor's input and process it with a program uploaded to the microcontroller. When there is a signal from the PIR sensor or door switch, the microcontroller will produce an output in the form of an alarm from the horn unit and an LED lamp as an indicator to provide lighting in the cabin with 1 second and 0.5-second timer off-delay.



**Figure 2:** Flow chart of the system

For safety control, there is a process that is passed as follows:

1. The power supply for this microcontroller is set on/off automatically with 24 V Normally closed (NC) Relay.
2. If the door locks lock, the relay power supply is in the NC position, and the current will flow through the battery to the microcontroller.
3. If the door lock is open, the relay will go to the Normally Open (NO) position, and the current will be cut off.
4. The secret button installed is used to disconnect the power supply from the battery to the relay power supply. During maintenance, the alarm can be turned off and does not interfere with mechanical activity.
5. There are three sensor components in the system: PIR 1, PIR 2, and door switch. PIR 1 is located on the battery deck, PIR 2 is in the operator cabin area, and the door switch is between the cabin door and the cabin frame.
6. The logic gate used in this small excavator's safety system is the OR gate and is shown in Table 1. If one of the sensors or switches has an input, the alarm, and LED, the lamp will be active.

**Table 1:** Truth Table

PIR sensor 1 (Variable 1)	PIR sensor 2 (Variable 2)	Door switch (Variable 3)	Relay (output)
0	0	0	0
1	0	0	1
0	1	0	1
0	0	1	1

7. When the unit is locked, the safety system will be active. If there is movement caught by the PIR sensor on the battery deck with a set distance, the alarm will immediately activate with a delay time set.
8. When there is a break in the cabin door with a scribe, the door is opened, the door switch between the door and the cabin frame will send a signal to the microcontroller, and the alarm will be active.
9. When there is a break in the cabin glass, the PIR sensor will capture movement around in the cabin with the specified distance and send a signal to the microcontroller to automatically activate the buzzer alarm.

### 3. RESULTS AND DISCUSSION

#### 3.1 Implementation of an electrical system

The electrical systems developed can be seen in Figure 3. In this system, there is a wiring and distribution of each electrical component to provide a clear picture related to the way the electrical system works.

The system used Arduino Atmega 2560 microcontroller, which has many pins, namely 54 digital input/output pins. The programming language used to build and develop this tool was the C program language as in [10,17,20] with the basis of the algorithm followed the flow chart in Figure 2.

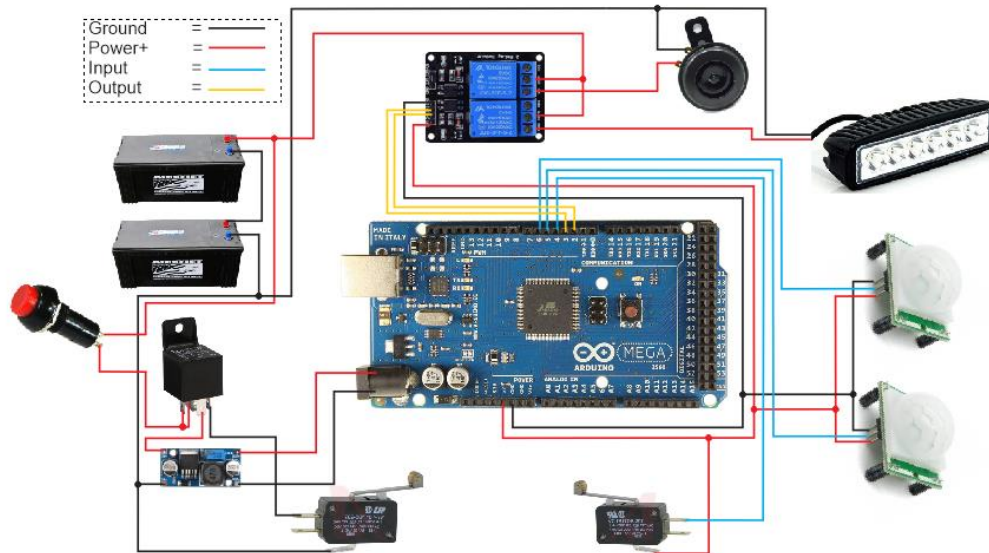


Figure 3: Electrical System

Figure 3 shows the monitor panel security system's electrical circuits and controller tools on a small excavator. Power is supplied from (+) 24VDC battery units. Before the current is connected to the microcontroller, several components are passed namely 24VDC power supply relay, and LM2596 DC to DC step down, the relay power supply is regulated based on the condition of the power supply switch that exists in the mechanical locking door system as can be seen in Figure 4. If the cabin door's condition is unlocked, the switch is closed, in this condition, the relay will cut the current from the battery to the microcontroller system. If the door is locked, the switch will be open, and the relay will connect the current from the battery to the microcontroller system. In this tool, there is a secret on/off button that is only known by certain people such as mechanics and supervisors to disconnect and connect the power supply current to the safety system tools, so that when the mechanic wants to perform maintenance or other activities on the unit, the alarm does not interfere with work.

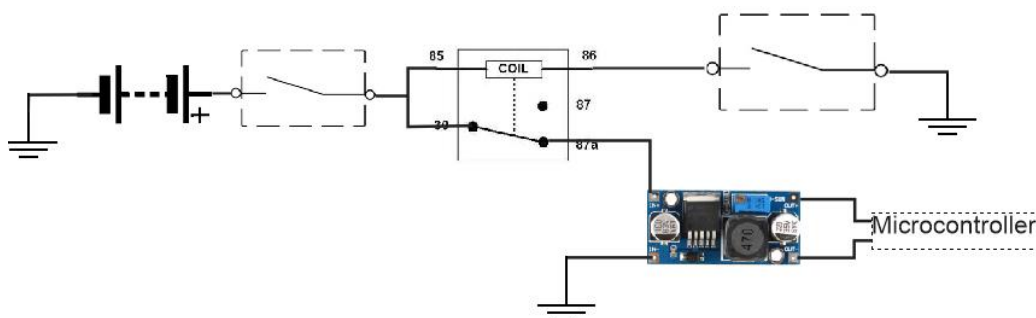


Figure 4: Power Supply Circuit in Open Condition

After the microcontroller is passed by the current, the tools will be active, then each sensor and actuator will be supplied with VCC and GND currents. Figure 3 shows that the red and black lines indicate the VCC and GROUND connected in parallel to the system tools. The yellow lines indicate the input signal current on the microcontroller, if one of the PIR sensors and door switches gets a signal, then the light alarm and buzzer will activate based on commands received by the microcontroller relay with a purple line.

### 3.2 Implementation of a mechanical system

The mechanical system shows each component and tool's position as a whole, which is placed in the unit as in [13,14]. The PIR 1 and PIR 2 sensors are placed on the battery deck and cabin area, which will detect movement angles of 110° (1) and (2) in Figure 5 and Figure 6.

While the door switch is placed between the cabin and the door (3), the output is a 24 volt Light Emitting Diode (LED) lamp that will provide lighting to the cabin (4) and an alarm or buzzer as an indicator if the sensor detects movement (5). Number (6) shows the switch's position on/off of power supply or a secret switch for the mechanic to turn off the safety tools when doing maintenance. Number (7) shows the placement of the case of the system tools that contain a microcontroller and other components.

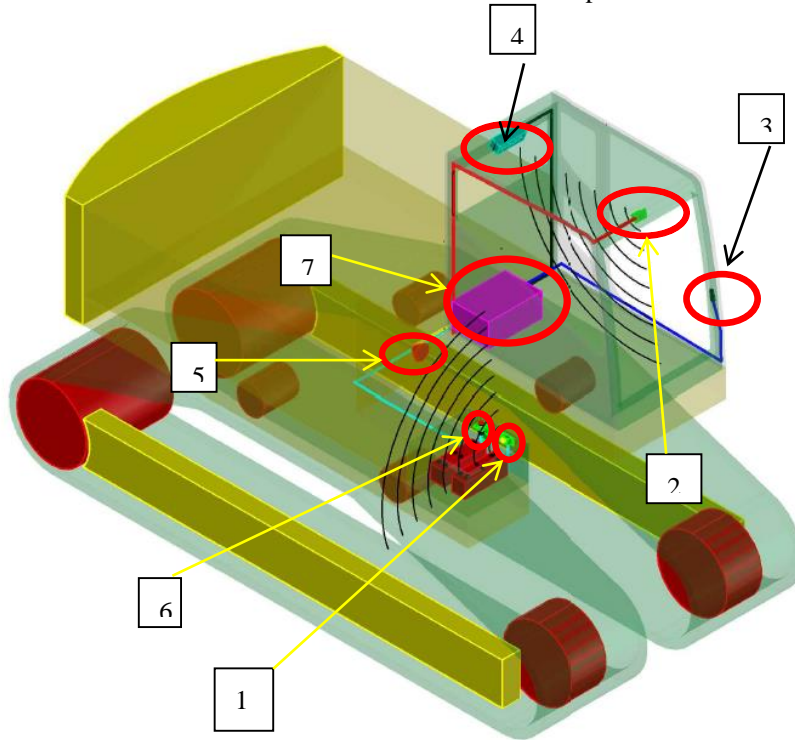


Figure 5: Mechanical system

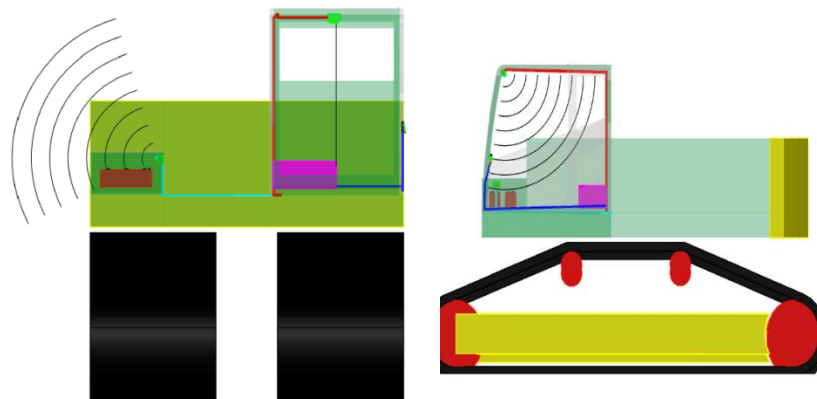


Figure 6: Installation of tools in front view and side view

### 3.3 Implementation of a wiring system

The connection between the horn unit and the alarm (Figure 7) aims to provide notification in the form of an alarm sound connected to the horn unit to be a sign if there is movement in the cabin unit or on the battery deck.



**Figure 7:** Horn Cable Connection

The B + connection from the starting switch to the Arduino power supply is shown in Figure 8. This connection takes the B + power from the battery in the starting switch terminal, which is useful as a source of power from the safety tool system. When the starting switch is off, the safety system tool is not off if the operator leaves the cabin.



**Figure 8:** B+ Starting Switch Installation

### 3.4 Overall system testing

Data were taken based on testing on PC 200-7 small excavators.

**Table 2:** Testing data

No.	Readings	Condition	LED Lamp+Alarm	Active Time
1	Movement in Cabin PIR1	Once detection	ON	15 seconds
		Continuous detection	ON	No limit
		No detection	OFF	OFF
2	Movement in Battery Deck PIR2	Once detection	ON	15 seconds
		Continuous detection	ON	No limit
		No detection	OFF	OFF
3	Door switch	Close	ON	No limit
		Open	OFF	OFF

Based on the above data, the tools can work as expected. Table 2 shows that during the PIR2 sensor experiment on the battery deck and PIR1 sensor in the cabin when the sensor detects movement or radiation, the alarm will be active for 15 seconds if the sensor detects radiation continuously alarm will be active until it does not detect movement. If it does not detect movement or radiation, then the alarm will no longer be active. For door switch, when the cabin door is closed, and the lock is locked, the alarm will not be active, if the condition of the door is locked but is forced open, then the alarm will be active continuously without stopping until the door is closed.

#### 4. CONCLUSIONS

This study has succeeded in designing and applying a safety system on small excavators to prevent theft of controller devices and monitor panels by using the Arduino ATmega 2560 as an information processing center and using the PIR sensor as a sensor detect movement. The outputs were alarms and LED lights that can be well integrated to the unit with a working voltage of 24 volts and can provide warnings to prevent theft of valuable devices on small excavator units.

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