Application of air conditioner (AC) automation system on Arduino platform-based vehicle

Randis¹ and S H Wijaya²
Heavy Equipment Study Program, Mechanical Engineering Department, Balikpapan State Polytechnic, Balikpapan Indonesia
Email: randis@poltekba.ac.id

Abstract. This study aims to design and create a safety device and automation system in the use of air conditioner (ac) use in-vehicle units, especially in four-wheeled vehicles based on Arduino UNO microcontroller Atmega 328. The safety device system created in this study used Arduino UNO as its microcontroller, a tool was equipped with a PIR sensor that was positioned in the cabin and a limit switch placed at the door of the vehicle. If there are humans inside the vehicle unit, the PIR sensor will detect movement, and if the unit door is in the closed position, the limit switch will be depressed. The principle used the AND logic gate principle where both inputs both the PIR sensor and the limit switch must work together to turn on the AC, but if only one input works, then the AC will not turn on. The results of this study indicated the tool could work under the design that has been done, and the programming of the safety device can work well according to the desired working principles through the programming commands on the Arduino UNO microcontroller.

1. Introduction
The energy-saving behavior is being promoted by the government to ensure the fulfillment of energy achievements, especially electricity that is increasing. Saving electricity consumption is considered very important; research is developed in order to design and implement the system to be able to save energy consumption on the electrical devices used [1–6].

The role of the human is the biggest factor in the context of saving electrical energy waste. Generally, it is caused mostly by human factors and a small portion by technical factors. Examples of electrical energy waste that often occurs in the community are the use of Air Conditioners (AC), both the use of Air Conditioners on buildings and air conditioners on vehicles that are still turned on even though they are no longer needed.

Various ways and efforts have been made in order to save electrical energy, one of which is by saving electricity by turning off air conditioners and other electrical devices when they are no longer needed, but these savings are seen to be less effective because of the limitations of people who often forget or are lazy to turn off AC when the device is no longer used.
One alternative solution in the problem caused by forgetting or lazy someone turns off the AC in the vehicle by designing a system that can work automatically. With this system, the AC in the vehicle can be turned on or off by utilizing the Passive Infrared (PIR) sensor to detect human movements and limit switches placed installed on the vehicle door, if the door is closed, the AC will turn on and when the door is open the AC will turn off.

Systems built and developed using Arduino board microcontroller devices and Passive Infrared (PIR) sensors as sensors are considered capable of overcoming these problems because the use of Arduino and PIR sensors as a system capable of reducing the use of electrical energy and used as a security system has been developed before [7–12]. The tools in [7] use Arduino and PIR in order to conserve the use of electrical energy in the use of light lamps with the help of lithium tantalate (LiTaO3), while in research [8] Arduino and PIR sensors are used on their tools not to reduce the use of street lights with automation techniques. In the security system, the PIR sensor and the Arduino microcontroller are used in [9] to detect and give warnings of theft in a house. While in [10], the vehicle safety system uses Arduino to develop a warning and feedback system for children in vehicles.

The system to be built and developed is different from [1,2,7,8,11,12], with the application of tools only on simulations and prototypes, but in this study, the system will be applied directly to the four-wheeled vehicle units that use the most devices Air conditioner. The system will be developed using inputs in the form of PIR sensors and limit switches and using LCD devices and relays that are connected to the Air Condition (AC) / magnetic clutch to save electricity consumption in vehicle AC.

2. Research Method

2.1. Block Diagram

The system block diagram is shown in Figure 1. Simply put, this block diagram shows the working system where the 12-volt battery power supply will be reduced by a step-down device in accordance with the input voltage of Arduino. PIR sensor and Limit Switch as input to Arduino Uno before relay and magnetic clutch. Arduino UNO is a data processing center that will provide information to the output in the form of LCDs and relays that function to activate the magnetic clutch. This tool uses the AND gate, so the two inputs used must work together so that the AC is on.

Figure 1. System Block Diagram
2.2. Flow Chart

The system flow chart is made for the procedures and work processes of tools and algorithms in making programs as in [13–17]. The flow chart of the instrument developed is shown in Figure 2, starting with the reading of the Arduino input variable. In the variable reading, there are two inputs, the first, the limit switch, and the second, the PIR sensor. Both inputs enter the AND gate variable, if all variables are 1 then the AC will turn on and the LED will turn off while the LCD gives a sign (closed-door / "AC On"), if one of the variables is 1 then the AC will turn off, and the LED lights will be on while the LCD gives a sign (the door is open / "AC Off"). When the second condition does not work, it will return to the initial process, if one of the variables does not work, the Ac is not alive. The difference between the two input variables includes the limit switch working when the door is closed while the PIR sensor works when detecting human movement.

![Flow Chart System](image)

Figure 2. Flow Chart System

3. Result and Discussion

3.1. Implementation of Electrical Systems

The electrical system developed in this study is shown in figure 3. The electrical system shows the wiring and layout arrangement of all components used. Arduino Uno becomes the center for processing information from sensors and is processed into information so that it can be sent to the output to move the actuator. The application of the program to the Arduino microcontroller uses Sketch and C language as in [18–20]. Arduino board is a microcontroller device that gets input voltage from the battery to the vehicle, which is first lowered by the operating voltage step down the device. After Arduino gets power, the device will be active, then the PIR sensor and the limit switch as input will be supplied by the VCC and GND currents. The red and black lines indicate the VCC and Ground power connected in parallel to the device, and the yellow lines indicate that the input signal current on the microcontroller, if one of
the PIR sensors and the limit switch gets a signal, then the LED and the relay (magnetic clutch) will be activated based on the command received by the microcontroller.

Figure 3. Implementation of Electrical system

3.2 Implementation of mechanical systems
The mechanical system shown in Figure 4, this system shows the placement of sensor components and tools that are developed and applied to four-wheeled vehicle units. Shown in the first picture is a description of the position of the PIR sensor in the cabin that will detect movement with an angle of 45º in the cabin area. The second picture is the position of the limit switch that exists between the cabin and the door, shown in Figure 5, the position of the limit switch. The third image description is the placement of the toolbox of the system tools, which contains a microcontroller and contains other components. The fourth image is a magnetic clutch (air conditioner) that will be connected to the relay in the toolbox. The relay is connected to an AC magnetic clutch via normally closed (NC) and COM.

Figure 4. Implementation of Mechanical System
3.3. Sensor Testing

3.3.1. Limit Switch Testing. Limit switch testing aims to determine the limit switch can work well or not. The limit switch component is installed in the NO (Normally Open) position according to the needs of the device, where the limit switch is placed at the door in a depressed/closed door position so that the limit switch is connected.

![Figure 5. Closed Door Limit Switches](image1.jpg)

Figure 5 shows the limit switch works when the door is closed because the limit switch is installed in NO (Normally Open) so that when pressed, the limit switch will close and send a signal to the microcontroller and the output on the LCD will give the sign "AC On."

Figure 6 shows the limit switch does not work because the door is open so that the limit switch is not depressed, which causes the limit switch not to be connected so that there is no signal to the microcontroller and the output on the LCD will give the sign "AC Off."

![Figure 6. Open Door Limit Switches](image2.jpg)

3.3.2. PIR Sensor Testing

PIR sensor testing (Passive Infrared Receiver) aims to determine the distance from the PIR sensor that can detect human movement. Testing is done by connecting the PIR sensor to the PORT B 0 microcontroller and the output in the form of an LCD to display the display is human or not. If there is detected a human movement, then the LCD will display "H = 1" if no human movement is detected, then the LCD will display "H = 0". The experiments were conducted at a distance of 1-8 meters, and the results are shown in Table 1, while the placement of the PIR sensor (Passive Infrared Receiver) is shown in Figure 7. Overall the testing process, the use of this PIR sensor can be used well on this tool because the sensor reading distance can reach a distance of 4 meters while in the cabin of the vehicle, the maximum range is only 2 meters so that the system can work just as expected.

| Table 1. PIR Sensor Testing |
|-----------------------------|
| PIR and Human Sensor        | LCD Display |
| Distance (meters)           |             |
| 1                           | H=1         |
| 2                           | H=1         |
| 3                           | H=1         |
| 4                           | H=1         |
| 5                           | H=2         |
3.4. Overall component testing

After testing each input and output device, the whole system is tested, which is by combining all input and output devices into a system that can control electrical equipment automatically. Table 2 shows the results of testing the behavior of the electronic equipment controlling system automatically from a number of circumstances.

| No. | PIR sensor | Limit Switch | LCD | Air Conditioner |
|-----|------------|--------------|-----|-----------------|
| 1   | Detect movement (Human) | On | Displays “AC on” | AC on |
| 2   | Detect movement (Human) | Off | Displays “AC off” | AC off |
| 3   | Does not detect movement (human) | On | Displays “AC off” | AC off |
| 4   | Does not detect movement (human) | Off | Displays “AC off” | AC off |

4. Conclusion

This research succeeded in designing and applying an automation system on the use of air conditioners on four-wheeled vehicles to save electricity consumption in vehicles by using the Arduino UNO AT mega 328 as an information processing center and utilizing the PIR sensor as a sensor to detect movement and limit switches to identify door openings on the vehicle. Output in the form of character display on the LCD and relay connected to the magnetic clutch can work well with the unit with a 12-volt working voltage and is able to provide automation on the basis of AND logic gates that can save the use of electrical energy in vehicles, especially on four-wheeled vehicles.

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