International Journal of Scientific Research in Engineering and Management (IJSREM)
Volume: 10 Issue: 11 | Nov - 2026 SJIF Rating: 8.659 ISSN: 2582-3930

Smart Classroom Energy Management System

Sakshi Kondekar[1], Gaurav Jadhav[2], Ravi Shinde[3] and Vaishnavi Patil[4]

[1]student, M S Bidve Engineering College, Latur, Maharashtra

[2]student, M S Bidve Engineering College, Latur, Maharashtra

[3]student, M S Bidve Engineering College, Latur, Maharashtra

[4]professor, M S Bidve Engineering College, Latur, Maharashtra

Abstract-The Smart Classroom Energy Management System is designed to reduce electricity consumption in classrooms by automatically controlling electrical appliances according to room occupancy and surrounding light conditions. The system uses an 8051 microcontroller, two IR sensors, an LDR sensor, an LCD display, and relay-based switching circuits. The IR sensors detect the movement of people entering and leaving the classroom and help estimate the number of occupants. The LDR sensor measures the surrounding light intensity and helps control the classroom lighting automatically.

When the classroom is empty, the system automatically switches OFF the lights and fans to avoid unnecessary energy consumption. When people are present, the lights are controlled according to the available natural light, while the fan operates based on occupancy. The LCD displays the classroom occupancy and system status. This automation reduces manual operation, prevents electricity wastage, and improves energy efficiency.

INTRODUCTION

Electricity is one of the most important resources used in educational institutions. Classrooms require electrical appliances such as lights and fans to provide a comfortable learning environment for students and teachers. However, these appliances are often left switched ON even when the classroom is empty or when sufficient natural light is available.

This results in unnecessary electricity consumption and increases electricity costsTwo IR sensors are used to detect people entering and leaving the classroom. By monitoring the sequence of sensor activation, the system estimates the number of people present inside the room. An LDR sensor is used to detect the intensity of natural light. Based on the sensor inputs, the microcontroller makes decisions to switch electrical appliances ON or OFF through relay circuits.

When the classroom is empty, the system automatically switches OFF the lights and fans. When people are present, the lighting system operates according to the surrounding light intensity. The LCD display provides information about the number of occupants and the current system status.

The proposed system helps reduce unnecessary electricity consumption, minimizes manual operation, and provides an efficient way to manage classroom energy. It is a simple and cost-effective solution that can be implemented in schools, colleges, and other educational institutions.

Objectives of the Project

1. To reduce unnecessary electricity consumption in classrooms.
2. To automatically control lights and fans based on classroom occupancy.
3. To detect people entering and leaving using IR sensors.
4. To control classroom lighting according to natural light intensity using an LDR sensor.
5. To display the occupancy count and system status on an LCD.
6. To develop a simple, economical, and energy-efficient classroom automation system.

Problem Statement

In traditional classrooms, electrical appliances are generally controlled manually. This can lead to electricity wastage when lights and fans remain ON in unoccupied rooms. There is a need for an automatic system that detects classroom occupancy and environmental light conditions to control electrical appliances efficiently. The proposed system addresses this problem using sensors and a microcontroller-based control mechanism

HARDWARE COMPONENTS USED

The Smart Classroom Energy Management System consists of various electronic components that work together to control classroom electrical appliances automatically.

1. 8051 Microcontroller (AT89C51): The 8051 microcontroller is the main controlling unit of the system. It receives signals from different sensors, processes the information, and controls the operation of classroom lights and fans. It manages the overall functioning of the system.

2. IR Sensors: Infrared sensors are used to detect the movement of people entering and leaving the classroom. Two IR sensors are placed near the entrance to identify the direction of movement. The signals from these sensors help the microcontroller maintain an approximate count of people inside the classroom.

3. LDR Sensor: A Light Dependent Resistor (LDR) is used to detect the intensity of natural light inside the classroom. Its resistance changes according to the amount of light falling on it. The system uses this information to control classroom lighting and avoid unnecessary electricity consumption.

4. LCD Display: A 16×2 LCD display is used to show important system information, such as the number of people present in the classroom and the operating status of electrical appliances. It provides a simple interface for monitoring the system.

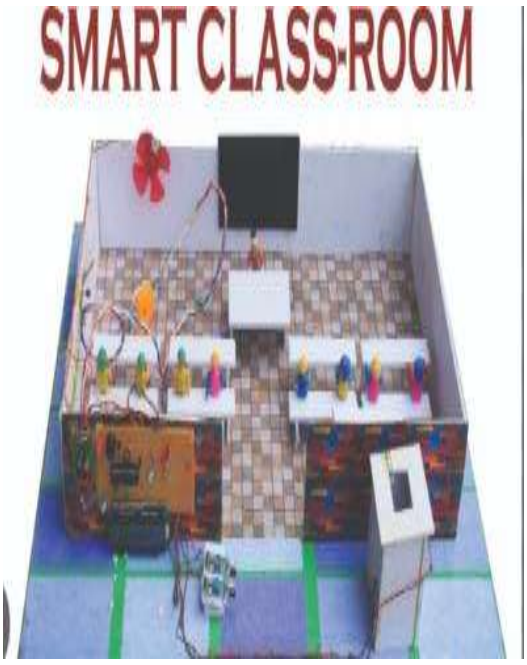
5. Relay Module: The relay module acts as an electrically controlled switch for classroom appliances. It receives control signals from the microcontroller and switches the lights and fans ON or OFF according to the system conditions.

6. Buzzer: The buzzer is an audio-output component used to generate sound indications during selected system operations. It helps provide an audible indication of specific events.

7. Power Supply: The power supply provides the required electrical energy to operate the microcontroller and other electronic components. A regulated DC supply helps maintain stable operation of the system.



8. Resistors and Connecting Wires: Resistors are used to control current and support the proper operation of electronic circuits. Connecting wires establish electrical connections between the microcontroller, sensors, display, and other components.measure bus voltage and current. It communicates with the ESP32 through the I2C interface and provides electrical measurements for monitoring and detecting abnormal voltage conditions The LDR sensor continuously monitors the intensity of natural light.



When sufficient natural light is available, the system keeps the classroom lights switched OFF. When the surrounding light level is low and people are present, the microcontroller switches ON the lights through the relay module.

The system also controls the fans according to classroom occupancy. When at least one person is present, the fans can be switched ON. When the classroom becomes empty, the microcontroller automatically switches OFF both lights and fans.

The LCD display shows the current occupancy count and appliance status. The buzzer provides an audio indication during selected operations.

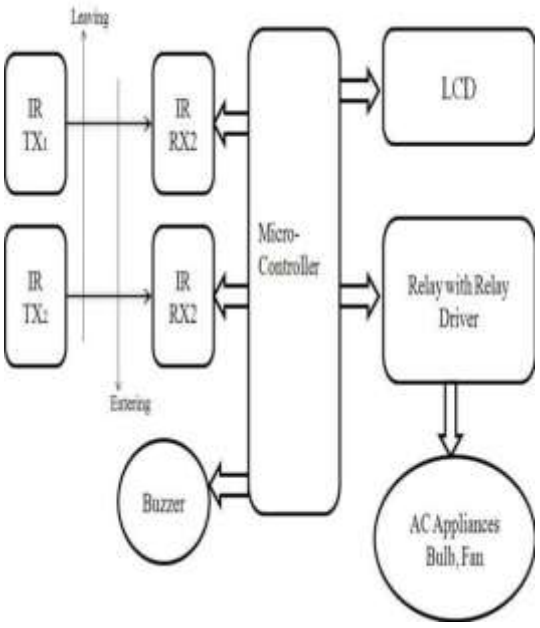
In this way, the system automatically manages classroom electrical appliances, reduces manual effort, and helps save electricity.

ADVANTAGES OF THE SYSTEM

1. Reduces unnecessary electricity consumption.
2. Automatically controls classroom lights and fans.
3. Reduces manual operation.
4. Detects classroom occupancy using IR sensors.
5. Uses natural light efficiently.
6. Provides system information through an LCD display.
7. Offers a simple and cost-effective automation solution

BLOCK DIAGRAM OF THE SYSTEM

The block diagram represents the connection between the sensors, microcontroller, display, and electrical appliances



APPLICATIONS OF THE SYSTEM

The Smart Classroom Energy Management System can be used in various educational and commercial environments where automatic control of electrical appliances is required.

1. Schools: Used to automatically control lights and fans in classrooms and reduce electricity wastage.

2. Colleges: Helps manage electrical appliances in lecture halls, laboratories, and seminar rooms.

3. Universities: Can be implemented in large classrooms and academic buildings for efficient energy management.

4. Computer Laboratories: Automatically controls lighting and fans according to room occupancy.

5. Libraries: Helps reduce electricity consumption by controlling appliances based on occupancy and natural light.

6. Training Centres: Provides automatic energy management in training rooms and conference halls.

7. Office Buildings: Can be used in meeting rooms and workspaces to avoid unnecessary electricity consumption.

SYSTEM ARCHITECTURE

The system architecture explains how different hardware components communicate with the 8051 microcontroller. The IR sensors and LDR sensor act as input devices, while the LCD, relay module, buzzer, lights, and fans perform the output operations.

The 8051 microcontroller receives the sensor signals, processes the information according to the programmed conditions, and controls the connected electrical appliances.

Main architecture:

- Input section: Two IR sensors and LDR sensor.
- Processing section: AT89C51 microcontroller.
- Display section: 16×2 LCD.
- Output section: Relay module, lights, fans, and buzzer.
- Power section: Regulated DC power supply.

SYSTEM IMPLEMENTATION

The Smart Classroom Energy Management System is implemented using an AT89C51 microcontroller and different input and output devices. The two IR sensors are installed near the classroom entrance to detect the movement of

people. The LDR sensor is placed inside the classroom to monitor natural light intensity.

All sensor outputs are connected to the microcontroller, which processes the input signals according to the programmed logic. The LCD display is connected to show the number of occupants and the operating status of the system.
The relay module is connected to the lighting and fan circuits to control their ON and OFF operations.

The buzzer is used to provide an audio indication during selected operations. A regulated power supply provides the required DC voltage to the electronic components.

The complete system is programmed using Embedded C language. The program continuously reads sensor inputs and controls the appliances according to classroom conditions.

Working sequence:

1. Start the system.
2. Initialize the microcontroller and LCD.
3. Read the IR sensor and LDR sensor inputs.
4. Check the classroom occupancy.
5. If the classroom is empty, switch OFF lights and fans.
6. If people are present, check the light intensity.
7. If natural light is sufficient, switch OFF the lights.
8. If natural light is insufficient, switch ON the lights.
9. Control fans according to occupancy.
10. Update the LCD display and repeat the process

WORKING PRINCIPLE

The Smart Classroom Energy Management System works on the principle of automatic detection of classroom occupancy and surrounding light intensity. The system uses an AT89C51 microcontroller to process the signals received from the sensors and control electrical appliances according to the classroom conditions.

Two IR sensors are installed near the classroom entrance to detect the movement of people. When a person enters or leaves the classroom, the sensors detect the movement through infrared signals. The sequence of sensor activation helps the microcontroller identify the direction of movement and update the occupancy count.

The LDR sensor continuously monitors the intensity of natural light inside the classroom. When sufficient natural light is available, the system keeps the artificial lights OFF. When the light intensity is low and people are present, the microcontroller switches ON the lights through the relay module.

The fans are controlled according to classroom occupancy. When one or more people are present, the fans are switched ON. When the classroom becomes empty, both lights and fans are automatically switched OFF to prevent unnecessary electricity consumption.

The 16×2 LCD display shows the number of people inside the classroom and the current operating status of the electrical appliances. The buzzer provides an audio indication during selected system operations.

The microcontroller continuously monitors the sensor inputs and repeats the control process. This automatic operation reduces manual effort, improves energy efficiency, and helps maintain an effective classroom environment.

ENERGY SAVING ANALYSIS

The system helps save electricity by automatically switching OFF lights and fans when they are not required.

For example, consider a classroom containing four 20-watt LED lights and four 60-watt fans.

Electrical Appliance	Quantity	Power	Total
LED Lights	4	20 W	80 W
Fans	4	60 W	240 W
Total Load	8		320 W

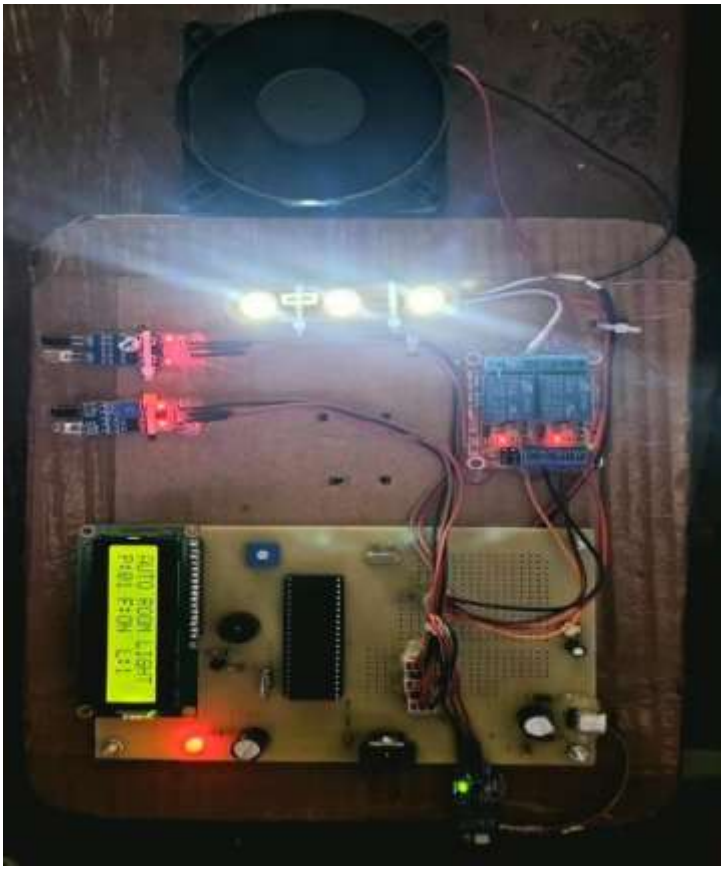
If the system avoids two hours of unnecessary operation per day:

- Total load = 320 W
- Energy saved = 320 × 2 = 640 Wh
- Daily energy saving = 0.64 kWh
- Monthly energy saving (30 days) = 19.2 kWh

RESULTS AND DISCUSSION

The proposed system is designed to control classroom electrical appliances according to occupancy and natural light conditions. The expected operation under different classroom conditions is shown in the following table.

Sr. No.	Classroom Condition	Occupancy	Lights	Fans
1	Classroom empty	0	OFF	OFF
2	One person, low light	1	ON	ON
3	Multiple people, low light	5	ON	ON
	One person,			



FUTURE SCOPE

The proposed system can be further improved by integrating advanced technologies to make classroom energy management more efficient.

1. IoT Integration: The system can be connected to the internet for remote monitoring and control.
2. Temperature Monitoring: Temperature sensors can be added to control fans automatically according to room temperature.
3. Mobile Application: A mobile application can be developed to monitor classroom occupancy and appliance status.
4. Energy Monitoring: Electricity consumption can be measured and displayed in real time.
5. Wireless Communication: Wireless technology can be used to connect multiple classrooms to a central monitoring system.

LIMITATIONS OF THE SYSTEM

Although the Smart Classroom Energy Management System provides an efficient solution for reducing electricity consumption, it has some limitations.

1. Sensor Accuracy: IR sensors may sometimes fail to detect people correctly due to improper positioning, obstacles, or simultaneous movement.
2. Occupancy Counting: The system may calculate an incorrect number of people when multiple persons enter or leave together.
3. Light Detection: The LDR sensor may give inaccurate readings if it is exposed to direct sunlight or artificial light from nearby sources.
4. Power Dependency: The system requires a continuous power supply. A power failure may interrupt its operation and reset the occupancy count.
5. Limited Automation: The proposed system controls lights and fans based on occupancy and light intensity. It does not automatically adjust fan speed according to room temperature.

6. Maintenance Requirements: Sensors, relay modules, and electrical connections require regular inspection to ensure proper operation.
7. Installation Cost: Initial installation of sensors, microcontroller, relay modules, and wiring may increase the overall project cost.
8. Manual Intervention: In certain situations, manual control may be required if sensors malfunction or the occupancy count becomes incorrect.

CONCLUSION

The Smart Classroom Energy Management System provides a simple, economical, and effective solution for reducing electricity wastage in educational institutions. The proposed system uses an AT89C51

microcontroller, IR sensors, an LDR sensor, an LCD display, and relay modules to automate the operation of classroom electrical appliances.

The system detects the movement of people entering and leaving the classroom and monitors the surrounding light intensity. Based on the sensor inputs, it automatically controls classroom lights and fans. When the classroom is empty, all connected appliances are switched OFF, while the lighting system operates according to the availability of natural light.

This project reduces manual effort, avoids unnecessary electricity consumption, and improves energy management. It can be implemented in schools, colleges, laboratories, libraries, and other educational institutions.

In the future, the system can be improved by adding IoT technology, temperature sensors, mobile application control, and real-time energy monitoring. Overall, the proposed system is a useful step towards developing smart, energy-efficient, and environmentally friendly classrooms.

REFERENCES

1. X. Guo et al., “The Performance of Occupancy-Based Lighting Control Systems: A Review,” Lighting Research & Technology, 2010. DOI: 10.1177/1477153510376225.
2. B. Von Neida et al., “Energy and Cost Savings Potential of Occupancy Sensors,” Journal of the Illuminating Engineering Society, 2001. DOI: 10.1080/00994480.2001.10748357.
3. Atmel Corporation, AT89C51 Microcontroller Datasheet.
4. Hitachi, HD44780U LCD Controller Datasheet.