Abstract:

The Automatic Street Light Control system delivers energy optimization through automatic street light operation management that depends on ambient light and detection of vehicles and pedestrians in the area. An 8051 microcontroller operates together with Light Dependent Resistors and Infrared (IR) sensors to automate street light operations. The system utilizes LDRs to detect daylight so the streetlights stay switched off during daytime hours then operates IR sensors for road monitoring to activate lighting only when needed at night. The method achieves sustainable energy saving and increases street light durability. The system shows affordability alongside high reliability alongside scalability thus making it an ideal choice for contemporary smart cities. The developed system proves to be a dependable and green solution to automatic street lighting control compared to manual operation methods.

Introduction:

Urban development advancement makes energy conservation one of the most essential priorities. Cities lose large amounts of their electrical power to street lights because their manual control systems operate inefficiently. The Automatic Street Light Control system resolves lighting problems through engineering a sensor-based smart control solution for street lighting with built-in environmental light detectors and motion sensors.

The system uses an 8051 microcontroller along with LDR (Light Dependent Resistor) in addition to IR (Infrared) sensors for monitoring movement by pedestrians or vehicles. The LDR operates in daytime hours to maintain street lights off because ambient natural light is sufficient. The lighting system activates its illumination at night only through detected movement before automatically deactivating upon losing detection of movement. Both increased power efficiency and reduced human operation combined with improved safety result from this system.

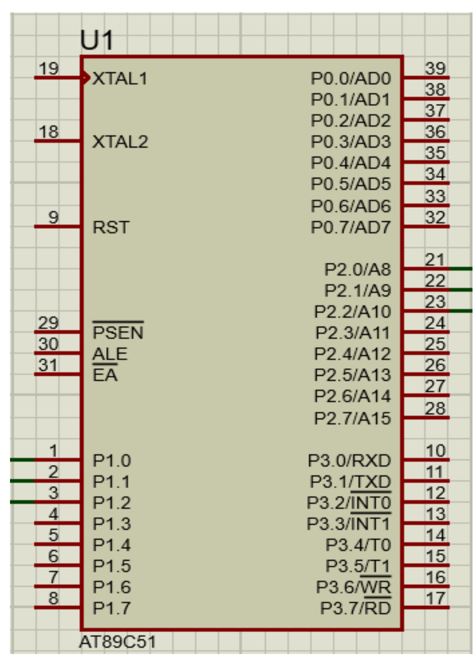
Objective:

The primary objective of this technical report is to present the development and implementation of an Automatic Street Light Control System that operates based on environmental light intensity or motion detection. The system is designed to enhance energy efficiency by automatically turning street lights ON in low-light conditions (such as during nighttime or cloudy weather) and OFF during daylight. Additionally, it aims to reduce human intervention, lower electricity costs, and contribute to smart city infrastructure by integrating sensor-based automation techniques.

Components and Tools Used:

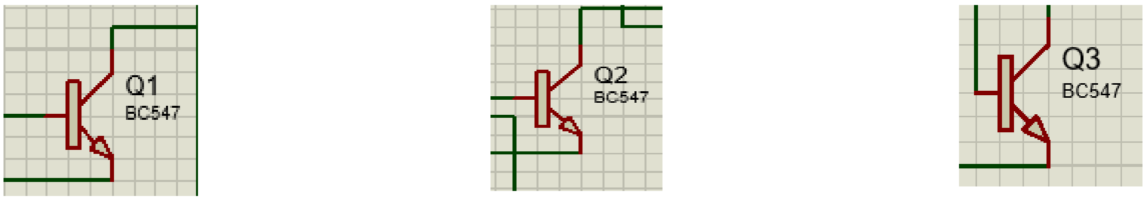
1. AT89C51 Microcontroller:

Used as the brain of the system to process input from sensors and control the output accordingly.



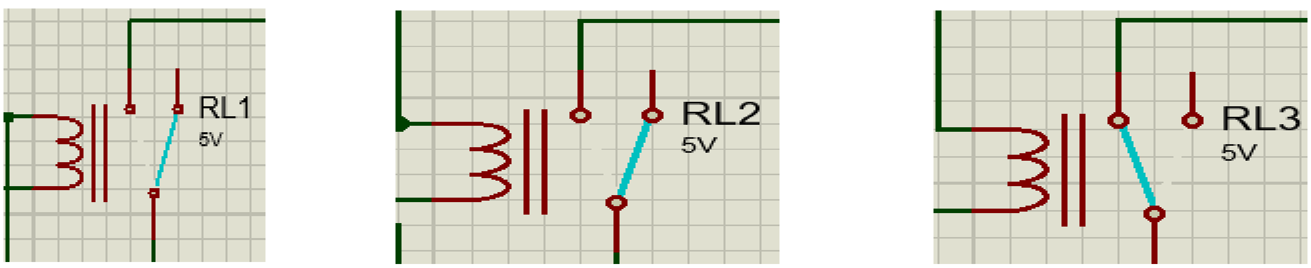
2. BC547 Transistor:

A general-purpose NPN transistor used for switching and amplification in the circuit.



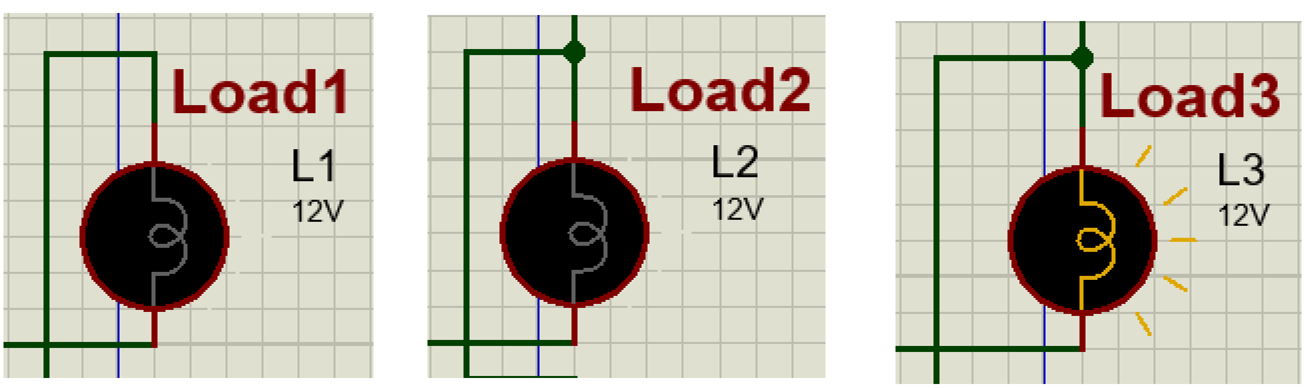
3. Relay Module:

Acts as a switch to control the high-voltage street lamp using signals from the microcontroller.



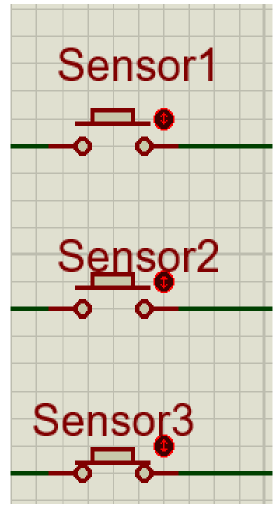
4. Lamp:

Represents the street light which is turned ON or OFF based on the control signals.



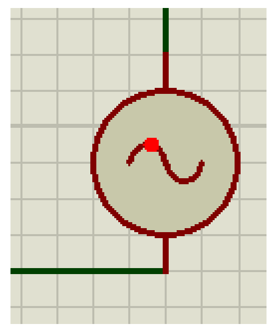
5. Button:

Used for manual control or testing of the circuit during development.



6. Alternator:

Simulates or supplies power in some testing scenarios or for backup purposes.



System Design:

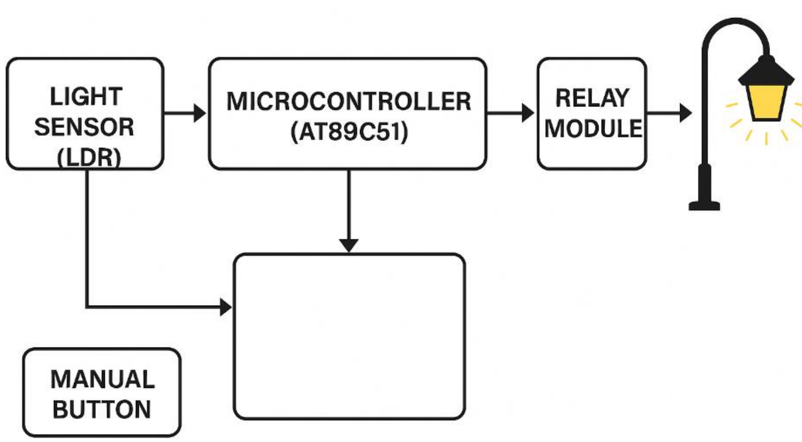
The **Automatic Street Light Control System** is engineered to automate the operation of street lighting using a sensor-based approach. It eliminates the need for manual switching by utilizing real-time environmental conditions, thereby promoting energy efficiency and sustainability.

1.System Architecture:

The system is composed of four major units:

- **Input Unit:**
  This includes a **Light Dependent Resistor (LDR)** that detects ambient light levels and a **manual push button** for test or override purposes.
- **Control Unit:**
  The heart of the system is the **AT89C51 microcontroller**, which reads sensor data and makes control decisions based on programmed logic.
- **Driver Circuit:**
  A **BC547 transistor** is used as a switch to drive the relay, allowing the microcontroller to control higher power devices.
- **Output Unit:**
  A **relay module** that physically turns the **lamp** (street light) ON or OFF depending on the signal received from the microcontroller.

2.Block Diagram:



3.Operational Description:

- **During Daytime**:
  The LDR senses high light intensity and sends a corresponding voltage level to the microcontroller. The microcontroller interprets this as daylight and keeps the relay OFF, ensuring the lamp remains OFF.
- **During Nighttime**:
  As ambient light decreases, the LDR's resistance increases, altering the voltage sent to the microcontroller. This triggers the microcontroller to send a signal through the BC547 transistor to energize the relay, turning the lamp ON.
- **Manual Control**:
  A push button is included to simulate or override automatic control for testing or emergency lighting needs.

4.System Features:

- Automatic switching based on real-time lighting conditions
- Simple design with low power consumption
- Manual override functionality
- Easy integration into urban or rural infrastructure
- Cost-effective and scalable solution

Working Principle:

The **Automatic Street Light Control System** functions by detecting environmental light intensity and switching the street lamps ON or OFF accordingly. This smart control mechanism is built around a Light Dependent Resistor (LDR), a microcontroller (AT89C51), a relay, and other basic electronic components.

1.Principle of Operation:

- The core component for sensing light is the **LDR**, whose resistance varies based on the intensity of ambient light.
- The **AT89C51 microcontroller** continuously monitors the voltage from the LDR. This voltage is used to determine whether it is day or night.
- Based on the programmed threshold, the microcontroller makes decisions:
    - **High Light Intensity (Daytime)**: The LDR resistance is low, producing a voltage that indicates sufficient daylight. The microcontroller keeps the relay OFF, and the lamp remains OFF.
    - **Low Light Intensity (Nighttime)**: The LDR resistance increases, leading to a voltage drop that signifies darkness. The microcontroller turns the relay ON through the BC547 transistor, thus powering the lamp.

2.Additional Control:

- A **manual push button** is included to simulate darkness or override automatic control. This is useful for testing or in emergency situations.
- The **relay** acts as an electronic switch that connects or disconnects the power supply to the lamp based on the microcontroller's output.

3.Summary of Operation:

Time of Day	LDR Condition	Microcontroller Action	Relay Status	Lamp Status
Day	Low resistance	Relay remains OFF	OFF	OFF
Night	High resistance	Relay is activated	ON	ON
Manual Test	Button pressed	Forces relay activation	ON	ON

Circuit Explanation:

The circuit of the **Automatic Street Light Control System** is designed to detect ambient light levels and control the street light accordingly using simple electronic components. The key elements of the circuit include the **LDR**, **AT89C51 microcontroller**, **BC547 transistor**, **relay**, and **lamp**.

1.Main Components and Their Roles:

- **LDR (Light Dependent Resistor):**
  Acts as a sensor to detect the level of ambient light. Its resistance decreases with increasing light intensity and increases in darkness.
- **AT89C51 Microcontroller:**
  Processes the input voltage from the LDR and makes logical decisions to control the street light. It is programmed to turn the light ON in the absence of light and OFF when enough light is detected.
- **BC547 Transistor:**
  Works as a switching device. It receives the output signal from the microcontroller and activates the relay by allowing current to pass through its collector-emitter path.
- **Relay:**
  A mechanical switch that turns ON or OFF the lamp by controlling the high voltage AC circuit based on the low voltage signal from the transistor.
- **Lamp:**
  The final output device (street light) that is turned ON or OFF automatically depending on the time of day.
- **Push Button:**
  Allows manual testing of the circuit by simulating night conditions to trigger the lamp manually.

2.Working Flow:

1. Daytime:

- The LDR detects high light levels.
- Its resistance is low, and the voltage at the microcontroller input remains above the threshold.
- The microcontroller keeps the transistor OFF → the relay remains de-energized → the lamp stays OFF.

2. Nighttime:

- The ambient light decreases.
- The LDR resistance increases, lowering the voltage at the microcontroller input.
- The microcontroller turns ON the transistor → the relay is energized → the lamp turns ON.

3. Manual Control:

- When the button is pressed, it simulates low light input.
- This forces the microcontroller to turn ON the lamp regardless of LDR reading.

3.Power Supply:

- A regulated **5V DC power supply** is used to power the microcontroller and control circuit.
- The relay is designed to operate on 5V or 12V depending on its specification, and it controls the **AC-powered lamp** using its Normally Open (NO) and Common (COM) terminals.

Programming Logic:

The programming logic for the **Automatic Street Light Control System** is built around the **AT89C51 microcontroller**. It uses **three sensors** (sensor1, sensor2, and sensor3) to detect motion or light levels in different zones of the street. Each sensor controls its corresponding street light (load1, load2, load3), allowing only one light to be ON at a time based on sensor input.

1.Working Logic:

- **Sensor Inputs:**
  - The sensors are connected to Port 1 (P1.0, P1.1, and P1.2) and are read as digital input values (HIGH = 1, LOW = 0).
- **Street Light Outputs:**
  - The street lights are connected to Port 2 (P2.0, P2.1, and P2.2). A HIGH output (1) turns a light ON, and a LOW output (0) turns it OFF.

2.Logic Flow:

1. The microcontroller continuously monitors the state of the three sensors.
2. If sensor1 detects presence or darkness (sensor1 == 1), only load1 (Street Light 1) is turned ON, and the others are OFF.
3. If sensor2 == 1, only load2 (Street Light 2) is ON.
4. If sensor3 == 1, only load3 (Street Light 3) is ON.
5. If none of the sensors are active, all lights remain OFF.

This logic ensures **energy-efficient lighting** by only illuminating areas where activity or darkness is detected.

Results:

The automatic street light control system was successfully simulated using Proteus. The results are as follows:

- When **Sensor 1** is activated, **Light 1** turns ON while the others remain OFF.
- When **Sensor 2** is activated, **Light 2** turns ON while the others remain OFF.
- When **Sensor 3** is activated, **Light 3** turns ON while the others remain OFF.
- If **no sensors are triggered**, all lights stay **OFF**.

This confirms that the system works as intended, turning ON the corresponding light only when motion or presence is detected, helping conserve energy.

3.Pseudocode:

```
while (1)
{

        if (sensor1 == 1) {
            load1 = 1;    // street light 1 on
            load2 = 0;    // street light 2 off
            load3 = 0;    // street light 3 off
        } else if (sensor2 == 1) {
            load1 = 0;
            load2 = 1;    // street light 2 on
            load3 = 0;
        } else if (sensor3 == 1) {
            load1 = 0;
            load2 = 0;
            load3 = 1;    // street light 3 on
        } else {
            // If none of the sensors are high, turn off all lights (optional)
            load1 = 0;
            load2 = 0;
            load3 = 0;
        }
    }
}
```

The pseudocode shows how the system works step-by-step:

- At the start, all lights are turned OFF.
- The microcontroller keeps checking the sensors in a loop.
- If **sensor1** detects something, **light 1** turns ON.
- If **sensor2** is triggered, **light 2** turns ON.
- If **sensor3** is triggered, **light 3** turns ON.
- If no sensors detect anything, all lights stay OFF.

This logic helps save electricity by turning ON lights only when needed.

Advantages:

- **Energy Efficient**: Lights are only turned ON when needed, reducing electricity consumption.
- **Automatic Operation**: No manual control is required, making the system fully autonomous.
- **Cost-Effective**: Minimizes power bills and extends the life of street lights.
- **Environment Friendly**: Reduced power usage leads to lower carbon emissions.
- **Scalable**: The system can be easily expanded by adding more sensors and lights.
- **Low Maintenance**: Simple design ensures easy installation and minimal upkeep.

Limitations:

- **Limited Range**: Sensors may have a restricted detection range, affecting light activation timing.
- **Single Sensor Response**: The system handles one sensor at a time; simultaneous detection isn't managed.
- **No Ambient Light Detection**: It does not distinguish between day and night unless a light-dependent resistor (LDR) is added.
- **False Triggers**: Sensors may activate lights due to animals or other non-human movements.
- **No Smart Monitoring**: The system lacks connectivity features like remote monitoring or data logging.

Future Enhancements:

- **Add LDR Sensor**: Integrate a Light Dependent Resistor (LDR) to ensure the system works only at night.
- **Wireless Control**: Use IoT modules like Wi-Fi or Bluetooth for remote monitoring and control.
- **Smart Detection**: Implement advanced motion detection using infrared or ultrasonic sensors.
- **Simultaneous Sensor Handling**: Improve logic to allow multiple sensors to activate multiple lights at once.
- **Data Logging**: Store usage and sensor data for analysis and optimization.
- **Solar Power Integration**: Power the system using solar panels for greater energy efficiency and sustainability.

Code Explanation:

```c
#include <reg51.h>

sbit sensor1 = P1^0;
sbit sensor2 = P1^1;
sbit sensor3 = P1^2;
// sensors on street//
sbit load1 = P2^0;
sbit load2 = P2^1;
sbit load3 = P2^2;
// street light connections//
```

In this section, the sensors and street lights are mapped to specific pins of the 8051 microcontroller.

#include <reg51.h>

This line includes the header file for the 8051 microcontroller. It gives access to all the **SFRs (Special Function Registers)** like P1, P2, P3, etc.

The sbit keyword is used to define individual bits (pins):

- sensor1, sensor2, and sensor3 are connected to pins P1.0, P1.1, and P1.2 respectively, representing the input sensors placed on the street.
- load1, load2, and load3 are connected to pins P2.0, P2.1, and P2.2 respectively, which are used to control the output street lights.

This setup allows the microcontroller to read sensor inputs from Port 1 and control the lights through Port 2.

// sensors on street//

This comment indicates that the pins defined above are for **street sensors**.

// street light connections//

This comment clarifies that the load pins are connected to **street lights**.

So, this section is essentially **initializing inputs (sensors)** and **outputs (lights)** using sbit for easier and readable pin control in your embedded C program.

```
12 void main() {
13     load1 = 0;
14     load2 = 0;
15     load3 = 0;
16     // All loads initialized to OFF
17
18      sensor1 = 0;
19      sensor2 = 0;
20      sensor3 = 0;
21     // Optional logic based on input - sensors are inputs, so assigning them 0 might not be what you intend.
22
```

Inside main() function:

1. **load1 = 0; load2 = 0; load3 = 0;**
   - These lines **turn OFF all the street lights** at the start.
   - load1, load2, and load3 are connected to output pins on Port 2, and setting them to 0 means the lights are off.
2. **sensor1 = 0; sensor2 = 0; sensor3 = 0;**
   - These lines are **optional** and not really needed.
   - sensor1, sensor2, and sensor3 are connected to input pins on Port 1, meant to read sensor data.
   - Setting them to 0 doesn't make sense because **sensors give input** to the microcontroller—you don't control them by assigning values.
3. **Comment on line 21:**
   - It explains this: sensors are inputs, so assigning them a value like 0 might not be the correct approach.

This section of the code continuously monitors three sensors using an infinite loop. When a specific sensor detects activity (sensor1, sensor2, or sensor3), the corresponding street light (load1, load2, or load3) is turned on, while the other two lights remain off. If none of the sensors detect activity, all street lights are turned off. This ensures that only one street light is active at any given time based on the detected input.

```
while (1)
{

        if (sensor1 == 1) {
            load1 = 1;     // street light 1 on
            load2 = 0;     // street light 2 off
            load3 = 0;     // street light 3 off
        } else if (sensor2 == 1) {
            load1 = 0;
            load2 = 1;     // street light 2 on
            load3 = 0;
        } else if (sensor3 == 1) {
            load1 = 0;
            load2 = 0;
            load3 = 1;     // street light 3 on
        } else {
            // If none of the sensors are high, turn off all lights (optional)
            load1 = 0;
            load2 = 0;
            load3 = 0;
        }
    }
}
```

This section of the code continuously monitors three sensors using an infinite loop. When a specific sensor detects activity (sensor1, sensor2, or sensor3), the corresponding street light (load1, load2, or load3) is turned on, while the other two lights remain off. If none of the sensors detect activity, all street lights are turned off. This ensures that only one street light is active at any given time based on the detected input.

Conclusion:

The Automatic Street Light Control System was successfully designed and simulated. The system effectively uses sensors to detect motion and activate the corresponding street light, ensuring energy is used only when necessary. This project demonstrates a practical solution for reducing power consumption in public lighting systems. With further enhancements like LDR integration and IoT capabilities, the system can become more intelligent, efficient, and suitable for real-world deployment.

References:

1. **8051 Microcontroller Datasheet** – Atmel Corporation.
2. **Proteus Simulation Software** – https://www.labcenter.com
3. Raj Kamal, *Microcontrollers: Architecture, Programming, Interfacing and System Design*, Pearson Education, 2005.
4. Mazidi, Muhammad Ali, *The 8051 Microcontroller and Embedded Systems*, Prentice Hall, 2nd Edition.
5. Online tutorials and documentation on automatic street light projects – https://www.engineersgarage.com
6. Educational resources from YouTube, blogs, and electronics forums for circuit simulation and coding assistance.

Appendices:

Appendix A: Circuit Diagram

- Includes the complete schematic of the automatic street light system as simulated in Proteus.

Appendix B: Source Code

```
#include <reg51.h>

sbit sensor1 = P1^0;
sbit sensor2 = P1^1;
sbit sensor3 = P1^2;
// sensors on street//
sbit load1 = P2^0;
sbit load2 = P2^1;
sbit load3 = P2^2;
// street light connections//

```

```
void main() {
    load1 = 0;
    load2 = 0;
    load3 = 0;
    // All loads initialized to OFF

     sensor1 = 0;
     sensor2 = 0;
     sensor3 = 0;
    // Optional logic based on input - sensors are inputs, so assigning them 0 might not be what you intend.

```

```
while (1)
{

        if (sensor1 == 1) {
            load1 = 1;     // street light 1 on
            load2 = 0;     // street light 2 off
            load3 = 0;     // street light 3 off
        } else if (sensor2 == 1) {
            load1 = 0;
            load2 = 1;     // street light 2 on
            load3 = 0;
        } else if (sensor3 == 1) {
            load1 = 0;
            load2 = 0;
            load3 = 1;     // street light 3 on
        } else {
            // If none of the sensors are high, turn off all lights (optional)
            load1 = 0;
            load2 = 0;
            load3 = 0;
        }
    }
}
```

Appendix C: Component List

- IR Sensors – 3 pcs
- LEDs or Bulbs – 3 pcs
- 8051 Microcontroller
- Resistors, wires, breadboard
- Power supply
- Simulation Software: Proteus