Design Project EEG 331

Solar-Powered Smart Street Lighting with Motion Detection

Background and Motivation:

Street lighting plays a critical role in enhancing safety and security. Traditional streetlights consume significant energy, leading to high operating costs and carbon emissions. A solar-powered system addresses these concerns by utilizing renewable energy, while motion detection further enhances efficiency by activating the lights only when needed. This system is ideal for urban and rural areas, offering energy savings, reduced maintenance, and sustainable lighting solutions.

Objectives:

1. Determine the required solar panel size, solar charge controller (Maximum Power Point Tracking) / BMS (Battery Management System) and battery storage capacity to ensure continuous operation of 12 V, Q Watts, street lighting system for a minimum of 12 hours under low sunlight conditions (note Q is the group number).
2. Design and simulate a complete solar power circuit (including solar panel, charge controller, battery, and lighting system) that automatically switches the LED street lights on during dark or low light conditions. The system should incorporate energy-efficient components, such as LEDs and PIR motion sensors, with a switching mechanism (using diodes or transistors). The goal is to achieve at least a 30% reduction in energy consumption compared to conventional systems without motion detection.
3. Develop and test a working prototype of the system that guarantees efficient operation according to the designed system.

System Features:

1. Solar Power:
    - A solar panel charges a battery during the day.
    - At night, the battery powers the LED streetlight.
2. Motion Detection:
    - PIR sensors detect movement within a specified range.
    - Lights brighten to full intensity upon detecting motion and dim or turn off after a set period of inactivity.
3. Energy Efficiency:
    - Use high-efficiency LED lights to minimize power consumption.
    - Implement a battery management system for optimal performance.

Tasks for Students:

Phase 1: Design and Simulation Solar Power System:

Design the solar panel, charge controller, and battery setup.

- Lighting and Motion Detection Circuit:
- Use a PIR sensor to detect motion and control the brightness of the LED lights.
- Simulate the system in LTSPICE to verify functionality.

Phase 2: Hardware Implementation

- Assemble the solar panel, battery, PIR sensor, and LEDs on a prototype board.
- Test the motion detection mechanism and adjust the sensitivity and delay.
- Verify the system's functionality in both sunlight and low-light conditions.

Phase 3: Optimization and Testing

- Optimize the circuit for maximum energy efficiency.
- Test the system for durability and performance in various conditions.

Deliverables:

1. Design Report:

- Solar power calculations (panel and battery sizing).
- Circuit design and simulation results.

2. Prototype:

- A working model of the solar-powered street light system with motion detection.

3. Demonstration:

- Show how the system responds to motion and operates using solar power.

4. Final Report:

- Include challenges, lessons learned, and potential improvements.

Grading Rubric (Out of 100):

1. Design and Simulation (30 points): Completeness and accuracy of the design.
2. Implementation (30 points): Functionality of the prototype.
3. Innovation and Optimization (20 points): Efficiency and creative enhancements.
4. Report and Documentation (10 points): Clarity and thoroughness of reports.
5. Presentation (10 points): Quality and professionalism of the presentation.