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Smart solar street light

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***Abstract*— A smart street lighting system, which represents a number of street lights are powered by a photovoltaic (PV) source and a charging ports is added to use the other devices like laptop, mobiles and other USB devices. A battery is added to store the energy of the solar panel, which can later be retrieved at night time, or whenever the sunlight is being obstructed by clouds or other forms of shading. A hybrid inverter is used to protect the battery from overcharging and to control the overall system operation. Furthermore, the system is expanded to include a Voltage Sensor to sense the Voltage from the battery for the continuous working of solar, if battery level is gone < 50% it automatically turn on the AC supply and a LDR sensor is added to know the Day and night time for on and off street lights. The Arduino board is used to control the overall operations. The overall result is a smart and efficient street lighting system, which can be implemented as a stand-alone off-grid system, or connected to the rest of the grid as part of a bigger system.**

***Index Terms*— Solar pannel , Renewable energy, Hybrid inverter, Audrino .**

I. INTRODUCTION

In the past few years, the Smart Grid has gained a lot of popularity, mainly due to the fact that it promises a more intelligent, efficient, and reliable use of the power resources, while also providing a better quality of service to the customers. The advances in the technology of renewable energy sources have also contributed to the increased dependence on renewable energy, Smart solar street lights are innovative lighting solutions that harness the power of solar energy and advanced technology to provide efficient and sustainable illumination for public spaces, roadways, and communities. These intelligent lighting systems are designed to optimize energy usage, enhance safety, and reduce environmental impact. Traditional street lights rely on grid-based electricity, which can be costly and often leads to carbon emissions. In contrast, smart solar street lights are equipped with solar panels that convert sunlight into electricity, making them self-sufficient and environmentally friendly. The stored solar energy is used to power the lights during the night, eliminating the need for a constant connection to the grid. The main application of solar energy is electrical generation through a photovoltaic (PV) system. This system consists of solar panels that can directly convert sunlight or solar energy into electricity. PV is one of the renewable energy sources with the greatest future projection due to its unique features such as simple installation, high reliability, low maintenance cost and zero fuel cost. To increase the total energy produced by a PV system, sufficient measures need to be taken on its installation. However, since a PV system is usually located in a remote or high location, there still be chances of failures or maintenance problem during its operation. Hence, a suitable frequent monitoring system is essential to ensure the efficiency of power delivery.

II. OPERATION

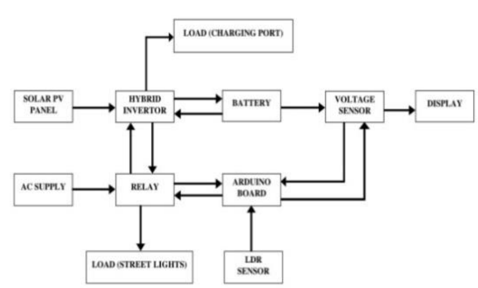

Fig 1: Block diagram of Smart solar street light

A.Daytime Operation:

LDR sensing ambient light: During daytime operation, the Light Dependent Resistor (LDR) continuously monitors the ambient light levels. The LDR's resistance varies depending on the intensity of light falling on it. In the presence of daylight, the LDR detects high light levels and indicates that it is daytime.

Solar panels converting sunlight into electricity: Solar panels, consisting of photovoltaic cells, are exposed to sunlight during the day. When sunlight hits the solar panels, the photovoltaic cells generate a direct current (DC) electrical current. This conversion process is based on the photovoltaic effect, where sunlight excites electrons in the semiconductor material of the cells, creating an electric current.

Charging the battery and powering the load: The generated DC electricity from the solar panels is directed towards charging the battery. The energy from the solar panels is stored in the battery for later use during night time or periods of low sunlight. Simultaneously, the battery powers the load, which includes components such as the Arduino microcontroller, current sensor, and other auxiliary electronics and Charging ports.

Monitoring current level using the current sensor: The current sensor continuously monitors the battery's current level. It provides feedback to the Arduino microcontroller, which can determine the state of charge of the battery. And it also ensure the working of solar pannel by Monitoring the battery level shouldn't go below 50%. If it is gone below it provide the feedback to audrino microcontroller to on the Ac supply for the battery. Monitoring the current helps ensure that the battery is not overcharged, which could lead to damage, or undercharged, which could result in insufficient energy availability during night-time operation.

B.Night-time operation:

LDR detecting darkness: As daylight fades and the ambient light levels decrease, the LDR detects the absence of sufficient light. It indicates that it is night-time or a low-light condition.

Activating the LED lights: Upon detecting darkness, the Arduino microcontroller receives the signal from the LDR and triggers the activation of the LED lights. The microcontroller controls the switching of the relay, allowing the LED lights to illuminate the surroundings.

Monitoring battery current to prevent over-discharge: Throughout the night-time operation, the Arduino microcontroller continues to monitor the battery current using the current sensor. It ensures that the battery does not discharge excessively, which could harm the battery's lifespan or lead to complete discharge and loss of lighting functionality.

Switching to grid power if battery current is low: In situations where the battery current drops below a predefined threshold(<50%), indicating a low charge level, the system may switch to grid power. This is achieved by the hybrid inverter, which detects the low battery current and activates the connection to the AC supply (grid connection). This switch ensures continuous lighting operation even if the battery charge is insufficient.

C. Hybrid mode operation:

Transitioning between solar and grid power: In hybrid mode operation, the smart solar street light system seamlessly transitions between solar power and grid power based on the energy availability. The hybrid inverter manages this transition, automatically switching between power sources depending on factors such as solar intensity, battery charge level, and demand for power.

Optimal utilization of available energy sources: The hybrid inverter optimizes the utilization of available energy sources to ensure efficient operation. When solar power is abundant, the system prioritizes using solar energy to charge the battery and power the load. However, if the solar power is insufficient or the battery charge is low, the system switches to grid power to compensate for the energy deficit. This intelligent energy management ensures reliable lighting operation while maximizing the use of renewable solar energy and minimizing reliance on grid power.

III. COMPONENTS USED

1. LDR (Light Dependent Resistor) sensor

The LDR sensor, also known as a Light Dependent Resistor or photo resistor, is an important component in the smart solar street light system. Its function is to detect the ambient light levels and provide input to the control system, specifically the Arduino microcontroller. The LDR sensor operates based on the principle that its resistance changes in response to the intensity of light falling on it.

2.Solar P-V (photovoltaic) pannel

The 50W solar panel is a crucial component of the smart solar street light system. Its function is to capture sunlight and convert it into electrical energy to power the system. Here's how it operates within the system.

3.Hybrid inverter

Conversion of DC to AC: The hybrid inverter converts the DC (direct current) power generated by the solar panels into AC (alternating current) power. This is necessary because the LED lights typically require AC power for operation.

Battery charging: The hybrid inverter charges the batteries in the system using the solar power generated by the solar panels. It ensures efficient charging by regulating the current and current supplied to the batteries.

Power source management: The hybrid inverter is responsible for managing the power flow between the solar panels, batteries, and grid supply. It intelligently switches between these power sources based on various factors such as solar energy availability, battery current, and load demand. This allows the system to optimize energy utilization and ensure continuous operation.

Grid interaction: In systems with a grid connection, the hybrid inverter enables interaction between the solar power system and the grid. It allows for two-way power flow, meaning that excess energy generated by the solar panels can be fed back into the grid, and the system can draw power from the grid when needed.

4.Audrino

The Arduino microcontroller serves as the control unit and brain of the smart solar street light system. Its primary function is to process inputs from various sensors, make decisions based on programmed logic, and control the operation of other components accordingly. The Arduino enables intelligent control and automation of the system, optimizing energy utilization and ensuring efficient lighting operations.

5.Current sensor

The current sensor in the smart solar street light system serves the function of monitoring the current level of the battery. Its primary role is to provide feedback to the Arduino microcontroller regarding the battery's state of charge. Here's a detailed explanation of its function and operation.

6.Relay

The relay in the smart solar street light system serves as an electromagnetic switch that controls the power supply to the LED lights and Ac supply to the hybrid inverter. Its primary function is to enable or disable the flow of electricity to the LED lights based on the inputs received from the Arduino microcontroller.

IV. AUDRINO PROGRAMMING

```
#include <LiquidCrystal.h>
ConstintldrPin = A0;
Constint led1 = 8;
Constintrs = 12, en = 11, d4 = 5, d5 = 4, d6 = 3, d7 = 2, ct=9;
LiquidCrystallcd(rs, en, d4, d5, d6, d7);
IntbatteryPercentage = 57;
Unsigned long previousMillis = 0;
Const long interval = 70000;
IntrelayPin = 6;
IntldrThreshold = 300;
Void setup() {
 analogWrite(ct,50);
 lcd.begin(16,2);
 pinMode(relayPin, OUTPUT);
 pinMode(led1, OUTPUT);
 Serial.begin(9600);
}
Void loop() {
 Unsigned long currentMillis = millis();
IntldrValue = analogRead(ldrPin);
 Serial.println(ldrValue);
 If (ldrValue < ldrThreshold) {
  digitalWrite(led1, LOW);
 }else{
  digitalWrite(led1, HIGH);
 if (currentMillis – previousMillis >= interval) {
  previousMillis = currentMillis;
  batteryPercentage--;
  lcd.setCursor(0, 0);
  lcd.print("Battery: ");
  lcd.print(batteryPercentage);
  lcd.print("% ");
  if (batteryPercentage < 50) {
```

```
    digitalWrite(relayPin, HIGH);
   }
   If (batteryPercentage == 0) {
    batteryPercentage = 57;
    digitalWrite(relayPin, LOW);
   }
  }
 Delay(1000); // Wait for 1 second
}
```

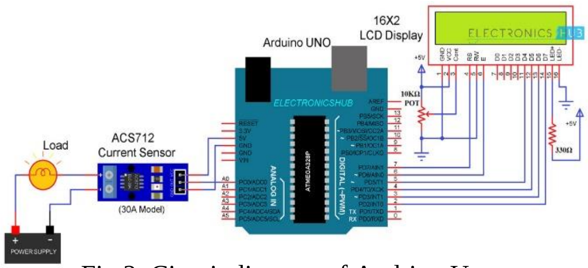

Fig 2: Circuit diagram of Audrino Uno

V. CIRCUIT CONNECTIONS AND FLOWCHATS

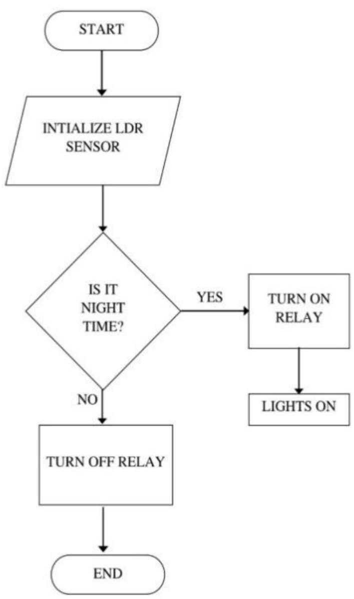

Fig 3: Flowchart of LDR sensor

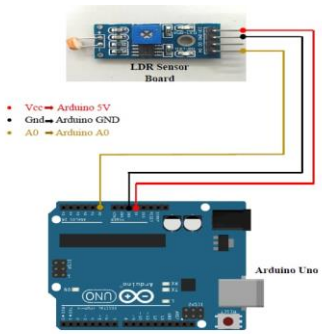

Fig 4 : Circuit diagram of Audrino Uno with LDR

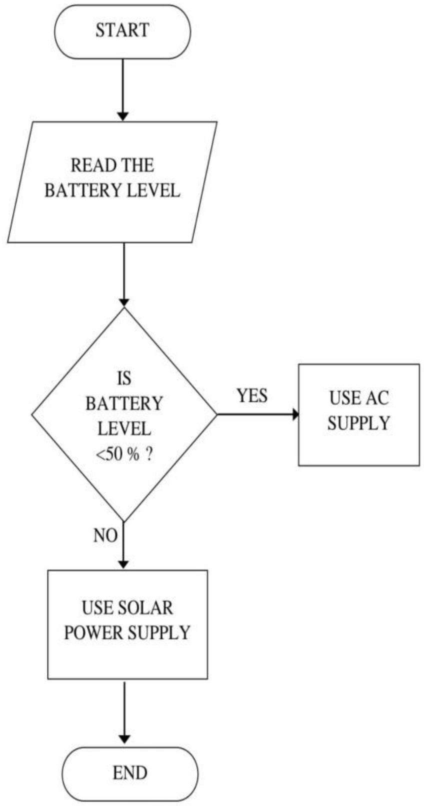

Fig 5: Flowchart of AC supply control

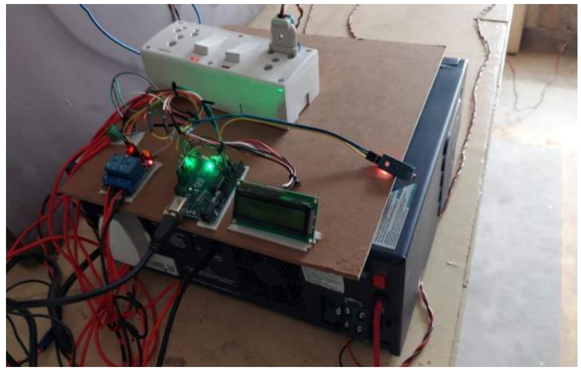

Fig 6: Working Models

VI. CONCLUSION

The smart solar street light system is an advanced lighting solution that harnesses solar energy to power street lights while incorporating intelligent control and monitoring features. It offers numerous benefits such as energy efficiency, cost savings, and environmental sustainability. The system consists of several key components working together to ensure effective operation. Firstly, there is a Light Dependent Resistor (LDR) which senses ambient light levels. During the daytime, when sufficient sunlight is available, the solar panels come into play. These panels convert solar energy into electricity, which is then used to charge a battery and power the street lights. To enable the system to operate even in the absence of sunlight, an additional power source is incorporated, which is typically an AC supply from the grid. This AC supply is connected to a hybrid inverter that manages the transition between solar and grid power seamlessly. The inverter ensures optimal utilization of available energy sources, reducing dependency on the grid and maximizing the use of solar power. To control and monitor the system, an Arduino microcontroller is employed. It acts as the brain of the system, processing inputs from the LDR and other sensors, and controlling the LED lights accordingly. During nighttime, when darkness is detected by the LDR, the microcontroller activates the LED lights, providing illumination for the street.

The audrino microcontroller also monitors the battery current levels to prevent over-discharge, which can damage the battery. In cases where the battery current drops below a certain threshold, the system can switch to the grid power supply, ensuring continuous operation of the street lights. To facilitate these switching operations, a relay is used. The relay controls the flow of power between the solar panels, battery, and grid, allowing for smooth transitions and efficient utilization of available energy sources. The smart solar street light system offers several advantages. Firstly, it relies on renewable solar energy, reducing dependence on fossil fuels and contributing to environmental sustainability. It also leads to significant cost savings by minimizing electricity consumption from the grid. Additionally, the intelligent control features ensure efficient operation, optimizing energy usage and extending battery life. Furthermore, the system can be equipped with communication and data logging capabilities. This enables remote monitoring, allowing authorities to track the performance of individual street lights, monitor energy consumption, and detect faults or malfunctions for timely maintenance and repairs.

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